Service and Maintenance Manual

Model
450A
450AJ

3120749

November 22, 2000

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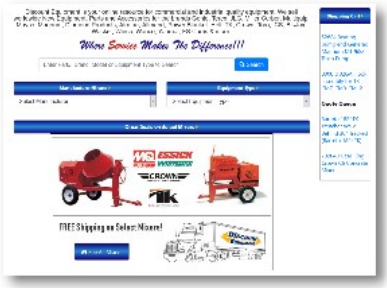

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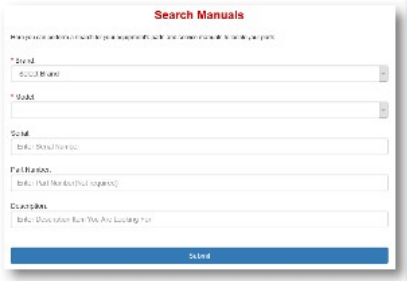

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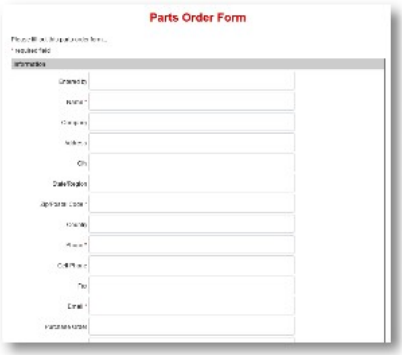

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SECTION A. INTRODUCTION - MAINTENANCE SAFETY PRECAUTIONS

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 OF THE MACHINE WITHOUT CERTIFICATION BY A RESPONSIBLE AUTHORITY THAT THE MACHINE IS AT LEAST AS SAFE AS ORIGINALLY MANUFACTURED, IS A SAFETY VIOLATION.

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 MAY RESULT IN MACHINE DAMAGE, PERSONNEL INJURY OR DEATH AND IS A SAFETY VIOLATION.

- 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.

REVISON LOG

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SECTION 1. SPECIFICATIONS

1.1 CAPACITIES

Fuel Tank - 16.5 gallons (62.5 liters)

Hydraulic Oil Tank - 28 gallons (106 liters)

Hydraulic System -

Torque Hub - 17 ounces (0.5 liters)

NOTE: *Torque hubs should be one half full of lubricant.*

Engine Crankcase (Ford LRG425) - 5 qts. (4.5 L)

Engine Crankcase (Deutz F3M1011F) - 6.3 qts. (6 L)

1.2 COMPONENT DATA

Engine - Ford LRG-425

Fuel - Gasoline

No. of Cylinders - 4

BHP at Max. RPM - 66

RPM Setting (No Load) - Mid - 1500

Engine - Deutz F3M1011F

Fuel - Diesel

No. of Cylinders - 3

BHP at Max. RPM - 48

RPM Setting (No Load) - Mid - 1500

Engine - Isuzu 4LE1

Fuel - Diesel

No. of Cylinders - 4

BHP at Max. RPM - 45

RPM Setting (No Load) - Mid - 1500

1.3 TIRES

12x16.5

- Pneumatic - 90 psi (6 Bar)
- Weight: 128 lbs. (58 kg)

12x16.5

- Foam-Filled
- Weight: 328 lbs. (149 kg)

33/1550x16.5

- Pneumatic - 90 psi (6 Bar)
- Weight: 135 lbs. (61 kg)

33/1550x16.5

- Foam-Filled
- Weight: 395 lbs. (179 kg)

33/16LL x 16.1

- Pneumatic - 40 lbs. (3 bar)
- Weight: 91.5 lbs. (41.5 kg)

33/16LL x 16.1

- Foam-Filled
- Weight: 426 lbs. (193 kg)

1.4 SPECIFICATIONS AND PERFORMANCE DATA

Max. Platform Height - 45ft. (13.8 M)

Max. Horizontal Reach - 24ft. (7.3 M)

Unrestricted Rated Capacity - 500lb. (230kg)

Maximum Capacity - 500lb. (230 kg)

Maximum Tire Load (450A) - 7120 lbs. (3230 kg)

Maximum Tire Load (450AJ) - 7400 lbs. (3357 kg)

Overall Width - 6ft. 6in. (1.98 m)

Tailswing - Zero

Stowed Height - 7ft. 4in. (2.24 m)

Stowed Length - 20ft. 2in. (6.15 m)

Wheelbase - 6ft. 6in. (1.98 m)

Ground Clearance - 11in. (28 cm)

Platforms - 30" x 48" (0.76m x 1.22M)
30" x 60" (0.76m x 1.52M)
30" x 72" (0.76m x 1.83M

Rated Gradeability - 2WD -30%
4WD - 40%

System Voltage - 12 Volts

Max. Hydraulic System Operating Pressure - 3000 psi (207 bar)

Travel Speed (2WD) - 4.5 mph

Travel Speed (4WD) - 2.25 mph

Ground Bearing Pressure (450A)

12x16.5 pneu. - 46 psi (3.23 kg/cm^2)
12x16.5 FF - 56 psi (3.93 kg/cm^2)
33/1550x16.5 pneu. - 35 psi (2.46 kg/cm^2)
33/1550x16.5 FF - 50 psi (3.51 kg/cm^2)

Ground Bearing Pressure (450AJ)

12x16.5 pneu. - 48 psi (3.37 kg/cm^2)
12x16.5 FF - 58 psi (4.07 kg/cm^2)
33/1550x16.5 pneu. - 36 psi (2.53 kg/cm^2)
33/1550x16.5 FF - 52 psi (3.65 kg/cm^2)

1.5 TORQUE REQUIREMENTS

Table 1-1.Torque Requirements

Description	Torque Value	Interval Hours
Wheel Lugs	170 ft. lbs. (231 Nm)	150
Semi-Track Wheel Lugs	90 ft. lbs. (122 Nm)	150
Swing Bearing (Dry)	220 ft. lbs. (298 Nm)	50/600*
Swing Bearing ((Loctite)	240 ft. lbs. (326 Nm)	50/600*

* Check swing bearing bolts for security after first 50 hours of operation and every 600 hours thereafter.

1.6 LUBRICATION

Hydraulic Oil

Table 1-2.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. JLG Industries recommends Mobilfluid 424 hydraulic oil, which has an SAE viscosity index of 152.*

NOTE: *When temperatures remain consistently below 20 degrees F. (-7 degrees C.), JLG Industries recommends the use of Mobil DTE11.*

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 Mobilfluid 424 is desired, contact JLG Industries for proper recommendations.

Lubrication Specifications

Table 1-3.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. API Service Classification GL-3, SAE 10W-20, Viscosity Index 152, e.g. Kendall Hyken 052.
EO	Engine (crankcase) Oil. Gas - API SF/SG class, MIL-L-2104. Diesel - API CC/CD class, MIL-L-2104B/MIL-L-2104C.

NOTE: *Refer to Lubrication Chart for specific lubrication procedures..*

Table 1-4. Mobil EAL Envirosyn H 46 Specs

Type	Synthetic Biodegradable
ISO Viscosity Grade	46
Specific Gravity	.910
Pour Point, Max	-44 F (-44 C)
Flash Point, Min.	500 F (260 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

1.7 PRESSURE SETTINGS - PSI (BAR)

Main Relief

Main Relief - 3000 (207)

Lift Up - 3000 (207) - Governed by Main Relief

Lift Down - 2500 (172) - Governed by Level Down Relief

Level Down - 2500 (172)

Level Up - 2500 (172)

Swing (Right & Left) - 1750 (121)

Drive

Drive - Pre-Set 4500 (310)

1.8 MAJOR COMPONENT WEIGHTS

Table 1-5.Major Component Weights

Component	LB.	KG.
6 ft Platform	160	73
5 ft. Platform	145	66
4 ft. Platform	130	59
Jib	230	104
Upper Boom (450A)	985	447
Upper Boom (450AJ)	1250	567
Upper Upright	212	96
Tower Boom	515	234
Lower Upright	100	45
Tower Link	150	68
Turntable	3560	1615
Engine Tray	890	404
Hydraulic Tray	225	102
Tail Counterweight	3410	1547
Bolt-on T/T Cwt. (AJ)	487	221
Chassis (12x16.5 pneu. tires)	4200	1905
12x16.5 pneu. Tire & Wheel	130	59
12x16.5 F/F Tire & Wheel	305	138
33/15.5x16.5 pneu. Tire & Wheel	150	68
33/15.5x16.5 F/F Tire & Wheel	374	170
33/16LL x 16.1 pneu Tire & Wheel	91.5	41.5
33/16LL x 16.1 F/F Tire & Wheel	426	193.4

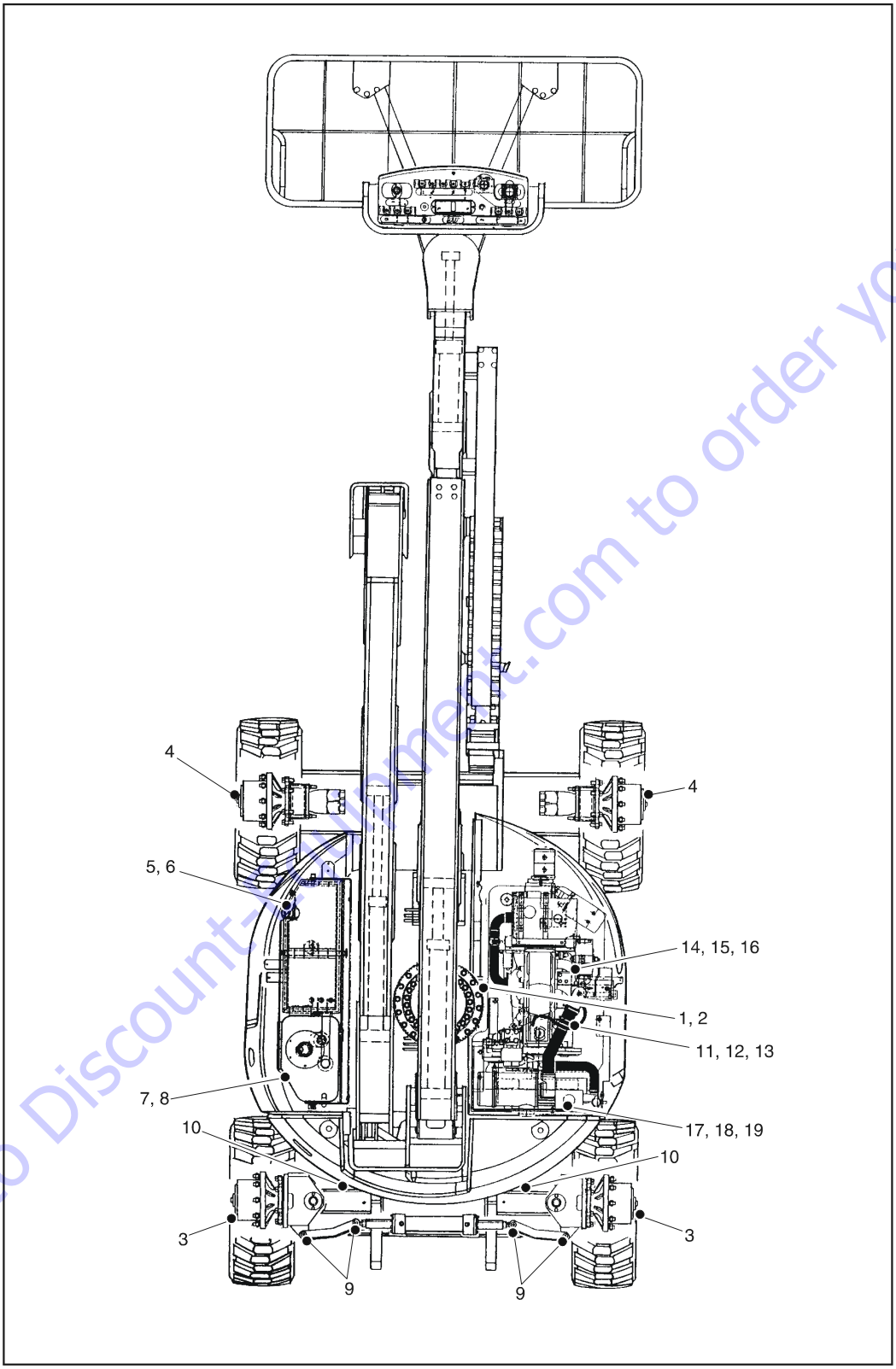


Figure 1-1. Lubrication Diagram

Table 1-6. Lubrication Chart

	Components	Number/Type Lube Points	Capacity	Lube	Interval		Hours		Comments
					3 Months 150 hrs	6 Months 300 hrs	1 Year 600 hrs	2 Years 1200 hrs	
Lubrication									
1	Swing Bearing - Internal Ball Bearing	2 Grease Fitting	A/R	MPG	X				
2a	Swing Bearing - Teeth	Spray On	A/R	OGL	X				More frequent lubrication intervals may be required.
2b	End Bearings - Worm Gear*	2	A/R	MPG				X	Remove grease fittings and install plugs after greasing.
3	Wheel Bearings (2WD Only)	Repack	A/R	MPG				X	
4	Wheel Drive Hub	Level/Fill Plug	0.5 liters (1/2 full)	EPGL				X	Change after first 150 hours then every 1200 hours of operation.
5	Hydraulic Return Filter	N/A	N/A	N/A		X			Change after first 50 hours and every 300 hours thereafter or as indicated by condition indicator.
6	Hydraulic Charge Filter	N/A	N/A	N/A		X			Change after first 50 hours and every 300 hours thereafter or as indicated by condition indicator.
7	Hydraulic Oil	Fill Cap	116 liters Tank 124 liters System	HO				X	Check level daily. Change every 1200 hours.
8	Suction Strainers (In Tank)	2	N/A	N/A				X	Remove and clean at time of hydraulic oil change.
9	Steer Cylinder	4	A/R	MPG	X				
10	Oscillation Cylinders	2	A/R	MPG	X				
Engines									
11	Oil Change w/Filter - Ford	Fill Cap/Spin-on Element	5 Quarts (4.7 L)	EO	X				Check level daily; change every 150 hours. Adjust final oil level by mark on dipstick.
12	Oil Change w/Filter - Deutz	Fill Cap/Spin-on Element	6 liters crankcase **4. 5 liters cooler	EO	X				Check level daily; change every 600 hours. Adjust final oil level by mark on dipstick.
13	Oil Change w/Filter - Isuzu	Fill Cap/Spin-on Element	5.6 liters crankcase 6.1 liters w/cooler	EO	X				Check level daily; change every 150 hours. Adjust final oil level by mark on dipstick.
14	Fuel Filter - Ford	Replaceable Element	N/A	N/A			X		
15	Fuel Filter - Deutz	Replaceable Element	N/A	N/A			X		
16	Fuel Filter - Isuzu	Replaceable Element	N/A	N/A			X		
17	Air Filter - Ford	Replaceable Element	N/A	N/A		X			Or as indicated by condition indicator
18	Air Filter - Deutz	Replaceable Element	N/A	N/A		X			Or as indicated by condition indicator

Table 1-6. Lubrication Chart

	Components	Number/Type Lube Points	Capacity	Lube	Interval		Hours		Comments
					3 Months 150 hrs	6 Months 300 hrs	1 Year 600 hrs	2 Years 1200 hrs	
19	Air Filter - Isuzu	Replaceable Element	N/A	N/A		X			Or as indicated by condition indicator

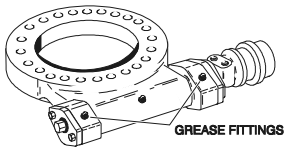
NOTES:

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.

* If necessary install grease fittings into worm gear housing and grease bearings.

⚠ CAUTION

DO NOT OVERGREASE BEARINGS. OVERGREASING BEARINGS WILL RESULT IN BLOWING OUTER SEAL IN HOUSING.



**When changing oil in the Deutz oil cooled engine, drain both the crankcase and the cooler. When refilling it is acceptable to overfill crankcase (10.5 L), capacity of both crankcase and cooler combined). Start engine, allow the engine to run until the thermostat opens (approximately 105 degrees C) cooler will fill up within minutes; shut down and wait for approximately two minutes. Check oil level, fill oil to max marking on dipstick.

KEY TO LUBRICANTS

EO	Engine Oil
EPGL	Extreme Pressure Gear Lube
HO	Hydraulic Fluid (Mobil DTE-11M)
MPG	Multi-Purpose Grease
OGL	Open Gear Lubricant - Mobiltac 375 or equivalent

1.9 CRITICAL STABILITY WEIGHTS

Table 1-7.Critical Stability Weights

Component	LB.	KG.
Ford Engine	339	154
Deutz Engine	441	200
Isuzu Engine	389	176
6 ft Platform	160	73
5 ft. Platform	145	66
4 ft. Platform	130	59
Bolt-on T/T Cwt. (AJ)	487	221
12x16.5 pneu. Tire & Wheel	130	59
12x16.5 F/F Tire & Wheel	305	138
33/15.5x16.5 pneu. Tire & Wheel	150	68
33/15.5x16.5 F/F Tire & Wheel	374	170
33/16LL x 16.1 pneu Tire & Wheel	91.5	41.5
33/16LL x 16.1 F/F Tire & Wheel	426	193.4

1.10 CYLINDER SPECIFICATIONS

Table 1-8.Cylinder Specifications

Cylinder	Bore	Stroke	Rod Dia.
Oscillation	2.5 in. (63.5 mm)	4.125 in. (104.8 mm)	1.75 in. (44.45 mm)
Lower Lift	4.5 in. (114.3 mm)	21.5 in. (546.1 mm)	2.5 in. (63.5 mm)
Mid Lift	4.0 in. (101.6 mm)	18.8 in. (479.5 mm)	2.0 in. (50.8 mm)
Upper Lift	3.5 in. (88.9 mm)	24.4 in. (619.4 mm)	2.5 in. (63.5 mm)
Telescope	2 in. (50.8 mm)	83.75 in. (2127.25 mm)	1.25 in. (31.75 mm)
Level	4.0 in. (101.6 mm)	10.9 in. (277.5 mm)	1.25 in. (31.75 mm)
Jib	3.0 in. (76.2 mm)	18.4 in. (467.4 mm)	1.5 in. (38.1 mm)
Rotate	1.5 in. (38.1 mm)	9.3 in. (236.2 mm)	0.75 in. (19 mm)

1.11 FUNCTION SPEEDS (IN SECONDS)

450A

Main Boom Lift Up - 22-38

Main Boom Lift Down - 12-24

Tele In - 12-24

Tele Out - 20-32

Swing - 85-110

Rotate (Left & Right) - 16-25

450AJ

Main Boom Lift Up - 22-38

Main Boom Lift Down - 12-24

Tele In - 9-20

Tele Out - 14-30

Swing - 85-110

Rotate (Left & Right) - 16-25

E-A-R Up - 9-24

E-A-R Down - 12-24

1.12 SERIAL NUMBER LOCATION

A serial number plate is affixed to the left rear 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.

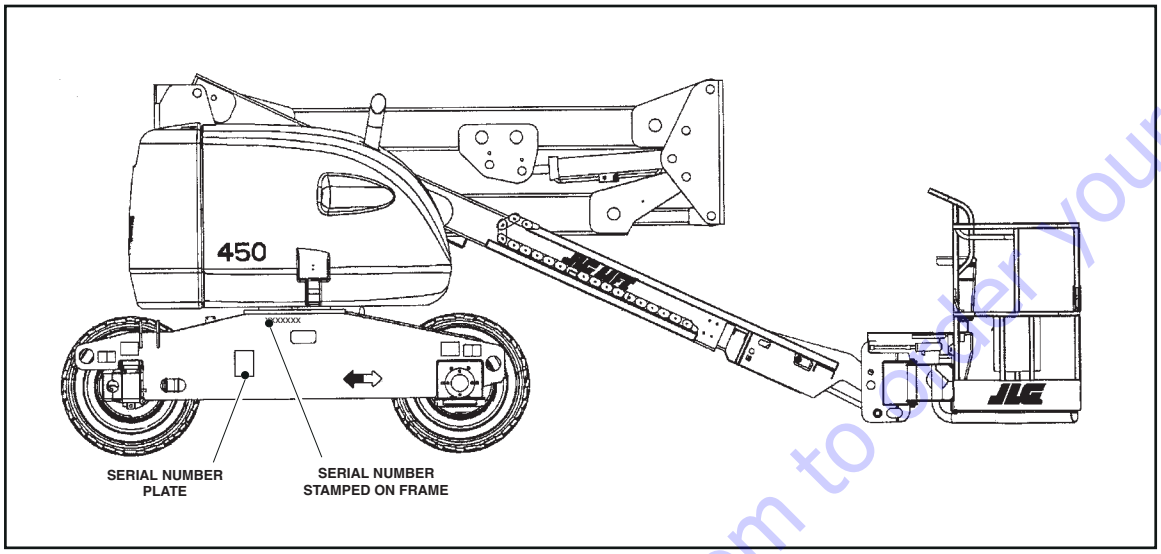


Figure 1-2. Serial Number Locations

VALUES FOR ZINC PLATED BOLTS ONLY													UNPLATED CAP SCREWS	
SIZE	THD	BOLT DIA. (IN.)	THREAD STRESS AREA (SQ. IN.)	SAE GRADE 5 BOLTS & GRADE 2 NUTS					SAE GRADE 8 BOLTS & GRADE 8 NUTS					UNBRAKO 1960 SERIES SOCKET HEAD CAP SCREW WITH LOC-WEL PATCH	
				CLAMP LOAD (LB.)	TORQUE (DRY OR LOC. 263)	TORQUE (LUB.)	TORQUE (LOCTITE 262)	TORQUE (LOCTITE 242 OR 271)	CLAMP LOAD (LB.)	TORQUE (DRY OR LOC. 263)	TORQUE (LUB.)	TORQUE (LOCTITE 262)	TORQUE (LOCTITE 242 OR 271)	CLAMP LOAD (LB.)	TORQUE (as received)
					LB. IN.	LB. IN.	LB. IN.	LB. IN.		LB. IN.	LB. IN.	LB. IN.	LB. IN.		LB. FT.
4	40	0.1120	0.00604	380	8	6	—	—	540	12	9	—	—	—	—
	48		0.00661	420	9	7	—	—	600	13	10	—	—	—	—
6	32	0.1380	0.00909	580	16	12	—	—	820	23	17	—	—	—	—
	40		0.01015	610	18	13	—	—	920	25	19	—	—	—	—
8	32	0.1640	0.01400	900	30	22	—	—	1260	41	31	—	—	—	—
	36		0.01474	940	31	23	—	—	1320	43	32	—	—	—	—
10	24	0.1900	0.01750	1120	43	32	—	—	1580	60	45	—	—	—	—
	32		0.02000	1285	49	36	—	—	1800	68	51	—	—	—	—
1/4	20	0.2500	0.0318	2020	96	75	—	105	2860	144	108	—	160	3180	13
	28		0.0364	2320	120	86	—	135	3280	168	120	—	185	3640	14
					LB. FT.	LB. FT.	LB. FT.	LB. FT.		LB. FT.	LB. FT.	LB. FT.	LB. FT.		
5/16	18	0.3125	0.0524	3340	17	13	16	19	4720	25	18	22	30	5240	25
	24		0.0580	3700	19	14	17	21	5220	25	20	25	30	5800	27
3/8	16	0.3750	0.0775	4940	30	23	28	35	7000	45	35	40	50	7750	45
	24		0.0878	5600	35	25	32	40	7900	50	35	45	55	8780	50
7/16	14	0.4375	0.1063	6800	50	35	45	55	9550	70	55	63	80	10630	70
	20		0.1187	7550	55	40	50	60	10700	80	60	70	90	11870	75
1/2	13	0.5000	0.1419	9050	75	55	68	85	12750	110	80	96	120	14190	110
	20		0.1599	10700	90	65	80	100	14400	120	90	108	135	15990	115
9/16	12	0.5625	0.1820	11600	110	80	98	120	16400	150	110	139	165	18200	155
	18		0.2030	12950	120	90	109	135	18250	170	130	154	190	20300	165
5/8	11	0.6250	0.2260	14400	150	110	135	165	20350	220	170	180	240	22600	210
	18		0.2560	16300	170	130	153	190	23000	240	180	204	265	25600	220
3/4	10	0.7500	0.3340	21300	260	200	240	285	30100	380	280	301	420	33400	365
	16		0.3730	23800	300	220	268	330	33600	420	320	336	465	37300	400
7/8	9	0.8750	0.4620	29400	430	320	386	475	41600	600	460	485	660	46200	585
	14		0.5090	32400	470	350	425	520	45800	660	500	534	725	50900	635
1	8	1.000	0.6060	38600	640	480	579	675	51500	900	680	687	990	60600	865
	12		0.6630	42200	700	530	633	735	59700	1000	740	796	1100	66300	915
1-1/8	7	1.1250	0.7630	42300	800	600	714	840	68700	1280	960	1030	1400	76300	1240
	12		0.8560	47500	880	660	802	925	77000	1440	1080	1155	1575	85600	1380
1-1/4	7	1.2500	0.9690	53800	1120	840	1009	1175	87200	1820	1360	1453	2000	96900	1750
	12		1.0730	59600	1240	920	1118	1300	96600	2000	1500	1610	2200	107300	1880
1-1/2	6	1.500	1.1550	64100	1460	1100	1322	1525	104000	2380	1780	1907	2625	115500	2320
	12		1.3150	73000	1680	1260	1506	1750	118100	2720	2040	2165	3000	131500	2440
1-1/2	6	1.500	1.4050	78000	1940	1460	1755	2025	126500	3160	2360	2530	3475	140500	3040
	12		1.5800	87700	2200	1640	1974	2300	142200	3560	2660	2844	3925	158000	3270

Note: These torque values do not apply to cadium plated fasteners.

SAE GRADE 5

SAE GRADE 8

Figure 1-3. Torque Chart

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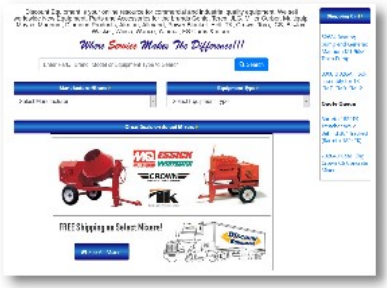

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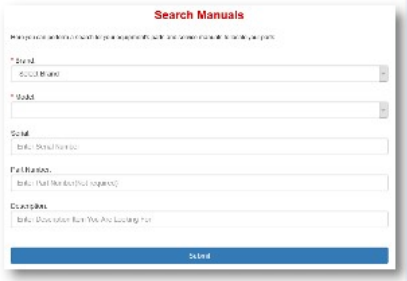

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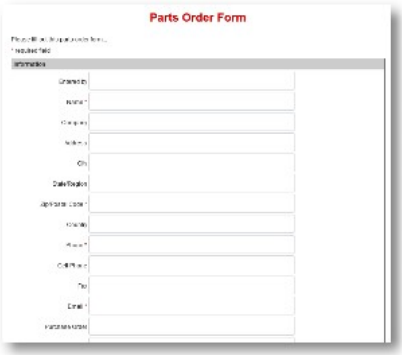

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SECTION 2. PROCEDURES

2.1 GENERAL

This section provides information necessary to perform maintenance on the aerial platform. Descriptions, techniques and specific procedures are designed to provide the safest and most efficient maintenance for use by personnel responsible for ensuring the correct installation and operation of machine components and systems.

⚠ CAUTION

WHEN AN ABNORMAL CONDITION IS NOTED AND PROCEDURES CONTAINED HEREIN DO NOT SPECIFICALLY RELATE TO THE NOTED IRREGULARITY, WORK SHOULD BE STOPPED AND TECHNICALLY QUALIFIED GUIDANCE OBTAINED BEFORE WORK IS RESUMED.

The maintenance procedures included consist of servicing and component removal and installation, disassembly and assembly, inspection, lubrication and cleaning. Information on any special tools or test equipment is also provided where applicable.

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 chapter.

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 eyebolt 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 Mobilfluid 424 hydraulic oil, which has an SAE viscosity of 10W-30 and a viscosity index of 152.

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).*

3. The only exception to the above is to drain and fill the system with Mobil DTE 11 oil or its equivalent. This will allow start up at temperatures down to -20 degrees F (-29 degrees C). However, use of this oil will give poor performance at temperatures above 120 degrees F (49 degrees C). Systems using DTE 11 oil should not be operated at temperatures above 200 degrees F (94 degrees C) under any condition.

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 CYLINDERS - THEORY OF OPERATION

Systems Incorporating Double Acting Cylinders

Cylinders are of the double acting type. Systems incorporating double acting cylinders are as follows: Slave Level, Master Level, Lift, Telescope, Axle Lockout 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 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.

Systems Incorporating Holding Valves

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

2.5 VALVES - THEORY OF OPERATION

Solenoid Control Valve

Control valves used are four-way three-position solenoid valves of the sliding spool design. When a circuit is activated and the control valve solenoid energizes, the spool is shifted and the corresponding work port opens to permit oil flow to the component in the selected circuit with the opposite work port opening to reservoir. Once the circuit is deactivated (control returned to neutral) the valve spool returns to neutral (center) and oil flow is then directed through the valve body and returns to reservoir. A typical control valve consist of the valve body, sliding spool, and two solenoid assemblies. The spool is machine fitted in the bore of the valve body. Lands on the spool divide the bore into various chambers, which, when the spool is shifted, align with corresponding ports in the valve body open to common flow. At the same time other ports would be blocked to flow. The spool is spring loaded to center position, therefore when the control is released, the spool automatically returns to neutral, prohibiting any flow through the circuit.

Relief Valves

Relief valves are installed at various points within the hydraulic system to protect associated systems and components against excessive pressure. Excessive pressure can be developed when a cylinder reaches its limit of travel and the flow of pressurized fluid continues from the system control. The relief valve provides an alternate path for the continuing flow from the pump, thus preventing rupture of the cylinder, hydraulic line or fitting. Complete failure of the system pump is also avoided by relieving circuit pressure. The relief valve is installed in the circuit between the pump outlet (pressure line) and the cylinder of the circuit, generally as an integral part of the system valve bank. Relief pressures are set slightly higher than the load requirement, with the valve diverting excess pump delivery back to the reservoir when operating pressure of the component is reached.

2.6 BOOM MAINTENANCE

⚠ CAUTION

IF PERFORMING MAINTENANCE ON THE BOOM, DO NOT USE A LIFTING DEVICE TO LIFT THE BOOMS UNLESS THE HOLDING VALVES HAVE BEEN REMOVED FIRST. FAILURE TO DO SO WILL RESULT IN SEVERE DAMAGE TO THE BOOM.

Removal of the Boom Assembly

1. Remove the platform and platform support as follows:
   a. Disconnect electrical cable from control console.
   b. Tag and disconnect the hydraulic lines running to the rotate cylinders. Cap the hydraulic lines and ports.
   c. Using an overhead crane or suitable lifting device, use nylon support straps to support the platform/support.

NOTE: *When removing the retaining pin from the rod end of the level cylinder, make sure the cylinder is properly supported.*

   d. Remove bolts and keeper pins that secures the retaining pins. Using a suitable brass drift and hammer, remove the retaining pins from the platform support.

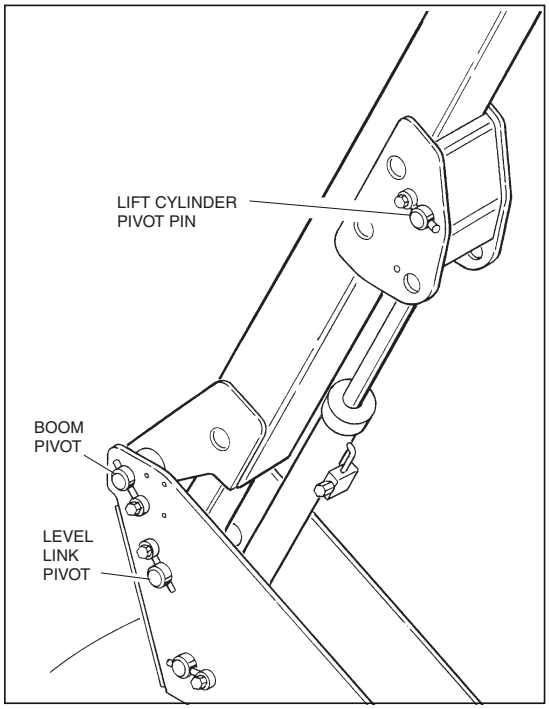


Figure 2-1. Location of Components - Boom Removal

2. Remove the boom from the turntable as follows:

   a. Disconnect wiring harness from ground control harness connector.

⚠ CAUTION

HYDRAULIC LINES AND PORTS SHOULD BE CAPPED IMMEDIATELY AFTER DISCONNECTING LINES TO AVOID ENTRY OF CONTAMINANTS INTO SYSTEM.

   b. Tag and disconnect hydraulic lines from boom to control valve. Use a suitable container to retain any residual hydraulic fluid. Cap all hydraulic lines and ports.

   c. Using a suitable lifting equipment, adequately support boom weight along entire length.

   d. Remove the bolts and keeper pins securing the lift cylinder pivot pin. Using a suitable brass drift and hammer, remove the pivot pin from the lower boom.

NOTE: *To gain access for removal of the pivot pins, it may be necessary to remove the ground control box, hydraulic and fuel tanks, and the counterweight.*

   e. Remove hardware securing the level link pivot pin. Using a suitable brass drift and hammer, remove the pin from the level link and turntable.

   f. Remove hardware securing the lower boom pivot pin. Using a suitable brass drift and hammer, remove pin from the turntable.

   g. Using all applicable safety precautions, carefully lift boom assembly clear of turntable and lower to ground or suitable supported work surface.

Disassembly of the Main Boom

1. Loosen jam nuts on aft end of fly boom wear pad adjustment and loosen adjustments.
2. Using a portable power source, attach hose to telescope cylinder port block. Using all applicable safety precautions, activate hydraulic system and extend cylinder to gain access to cylinder rod retaining pin. Shut down hydraulic system.
3. 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.
4. Remove hardware securing telescope cylinder to the fly boom section, then remove pin from fly.
5. Remove hardware securing telescope cylinder to the base boom section.

⚠ CAUTION

WHEN REMOVING TELESCOPE CYLINDER FROM BOOM SECTIONS. CARE SHOULD BE TAKEN NOT TO LEAVE CYLINDER REST ON POWERTRACK WHICH COULD CAUSE DAMAGE TO POWERTRACK.

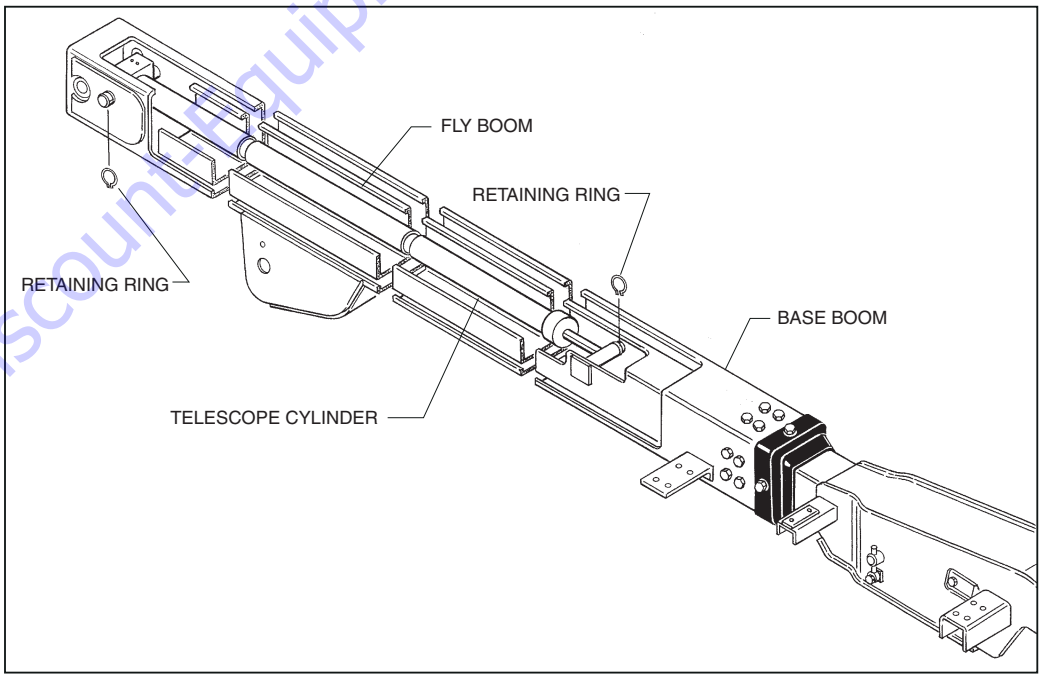


Figure 2-2. Location of Components - Removal of Telescope Cylinder

6. Using a suitable lifting device, remove telescope cylinder from boom sections.
7. Using a piece of tape, mark the length of hoses and wires from front of fly boom and bottom of base boom for reassembly.
8. Remove hardware securing the front wear pads on base boom section, remove wear pads.

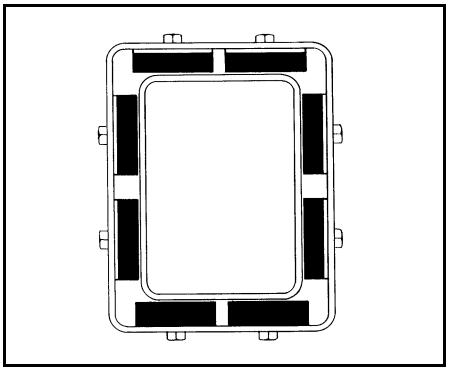


Figure 2-3. Location of Components - Front Wear Pads

9. Remove hardware securing the powertrack to the aft end of the fly boom section.
10. Using a suitable lifting device, remove fly boom from boom section.
11. Remove hydraulic lines and electrical cables from powertrack.
12. Remove hardware securing powertrack to the base boom section. Remove powertrack.

Inspection

1. Inspect all boom pivot pins for wear, scoring or other damage, and for tapering or ovality. Replace pins as necessary.
2. Inspect lift cylinder pins for wear, scoring or other damage, and for tapering or ovality. Ensure pin surfaces are protected prior to installation. Replace pins as necessary.
3. Inspect telescope cylinder rod attach pin for wear, scoring or other damage. Replace pin as necessary.
4. Inspect inner diameter of boom pivot bushings for scoring, distortion, wear or other damage. Replace bushings as necessary.
5. Inspect wear pads for wear.
6. Inspect all threaded components for damage such as stretching, thread deformation, or twisting. Replace as necessary.
7. Inspect structural units of boom assembly for bending, cracking, separation of welds, or other damage. Replace boom sections as necessary.

Assembly of the Main Boom

1. Install power track to the attach point on the base boom section. Secure power track with the attaching hardware.
2. Install hydraulic lines and electrical cables into the power track.
3. Install wear pads to the aft end of the fly section.
4. Using suitable lifting equipment, slide fly section into the base section until power track attach point aligns with holes in side of base section.
5. Attach the power track to the aft end of fly boom section. Secure power track with the attaching hardware.
6. Using suitable lifting equipment, slide fly boom section out to gain access to telescope cylinder attach pin hole.
7. Measure the distance between the telescope cylinder port block attach point on base boom section and the attach point on fly boom section.
8. Connect a suitable auxiliary hydraulic power source to the telescope cylinder port block.
9. Extend the telescope cylinder the distance of the two attach points.
10. Secure the sling and lifting device at the telescope cylinder's approximate center of gravity, and lift the cylinder to the aft end of the boom assembly.

⚠ CAUTION

WHEN INSERTING THE TELESCOPE CYLINDER INTO THE BOOM, CARE MUST BE TAKEN NOT TO DAMAGE THE POWER TRACK ASSEMBLY.

11. Slowly slide the telescope cylinder into boom assembly, align rod end with attach point in fly section. Insert pin and secure with retaining ring.
12. Align bolt holes at aft end of base boom section with telescope cylinder port block. Secure telescope cylinder with hardware.

13. Install wear pads at end of base boom section. Using shims, adjust the adjustable wear pads to zero clearance. Adjust pads alternately side to side, so that fly boom section is centered in base boom section.
14. Retract boom section fully. Using shims, adjust wear pads at aft end of boom section to zero clearance. Adjust pads alternately side to side, so that fly boom section is centered in base boom section.
15. Disconnect auxiliary power source from telescope cylinder.

Installation of the Boom Assembly.

1. Using suitable lifting equipment, position boom assembly on turntable so that boom pivot holes in both boom and turntable are aligned.
2. Install boom pivot pin, ensuring that location of the hole in pivot pin aligns with attach point on upright.
3. Using all applicable safety precautions, operate lifting equipment in order to position boom lift cylinder and level link so that holes in cylinder rod end and level link are aligned with the one in the turntable. Insert cylinder pins.
4. If necessary, gently tap pins into position with a soft headed mallet, ensuring that attach holes in pins are aligned with attach holes in boom structure. Secure with hardware.
5. Connect all hosing and wiring.
6. Install the platform to the boom assembly.
7. Connect all hosing and wiring at platform control station.
8. Using all safety precautions, operate machine systems and extend and retract boom for four or five cycles.
9. Shut down machine systems and check for leakage.

2.7 CYLINDER CHECKING PROCEDURE

⚠ CAUTION

IF PERFORMING MAINTENANCE ON THE BOOM CYLINDERS, DO NOT USE A LIFTING DEVICE TO LIFT THE BOOMS UNLESS THE HOLDING VALVES HAVE BEEN REMOVED FIRST. FAILURE TO DO SO WILL RESULT IN SEVERE DAMAGE TO THE BOOM.

NOTE: *Cylinder check must be performed anytime a system component is replaced or when improper system operation is suspected.*

Cylinders Without Counterbalance Valves - Master Cylinder and Steer Cylinder

1. Using all applicable safety precautions, activate engine and fully extend cylinder to be checked. Shut down engine.
2. Carefully disconnect hydraulic hoses from retract port of cylinder. There will be some initial weeping of hydraulic fluid which can be caught in a suitable container. After the initial discharge, there should be no further drainage from the retract port.
3. Activate engine and extend cylinder.
4. If cylinder retract port leakage is less than 6-8 drops per minute, carefully reconnect hose to port and retract cylinder. If leakage continues at a rate of 6-8 drops per minute or more, cylinder repair must be made.
5. With cylinder fully retracted, shut down engine and carefully disconnect hydraulic hose from cylinder extend port.
6. Activate engine and retract cylinder. Check extend port for leakage.
7. If extend port leakage is less than 6-8 drops per minute, carefully reconnect hose to extend port, than 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 Dual Counterbalance Valves - Slave Level, Lift, and Telescope

⚠ IMPORTANT

OPERATE ALL FUNCTIONS FROM GROUND CONTROL STATION ONLY.

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

⚠ WARNING

IF WORKING ON THE PLATFORM LEVEL CYLINDER, STROKE PLATFORM LEVEL CYLINDER FORWARD UNTIL PLATFORM SITS AT A 45 DEGREES ANGLE.

2. Shut down hydraulic system and allow machine to sit for 10-15 minutes. If machine is equipped with bang-bang or proportional control valves, turn IGNITION SWITCH to ON, move control switch or lever for applicable cylinder in each direction, then turn IGNITION SWITCH to OFF. If machine is equipped with hydraulic control valves, move control lever for applicable cylinder in each direction. 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 be no further leakage from the ports. If leakage continues at a rate of 6-8 drops per minute or more, the counterbalance valve is defective and must be replaced.
4. To check piston seals, carefully remove the counterbalance valve from the retract port. After initial discharge, there should be no 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.
5. If no repairs are necessary or when repairs have been made, replace counterbalance valve and carefully connect hydraulic hoses to cylinder port block.
6. If used, remove lifting device from upright or remove prop from below main boom, activate hydraulic system and run cylinder through one complete cycle to check for leaks.

2.8 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

⚠ IMPORTANT

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.

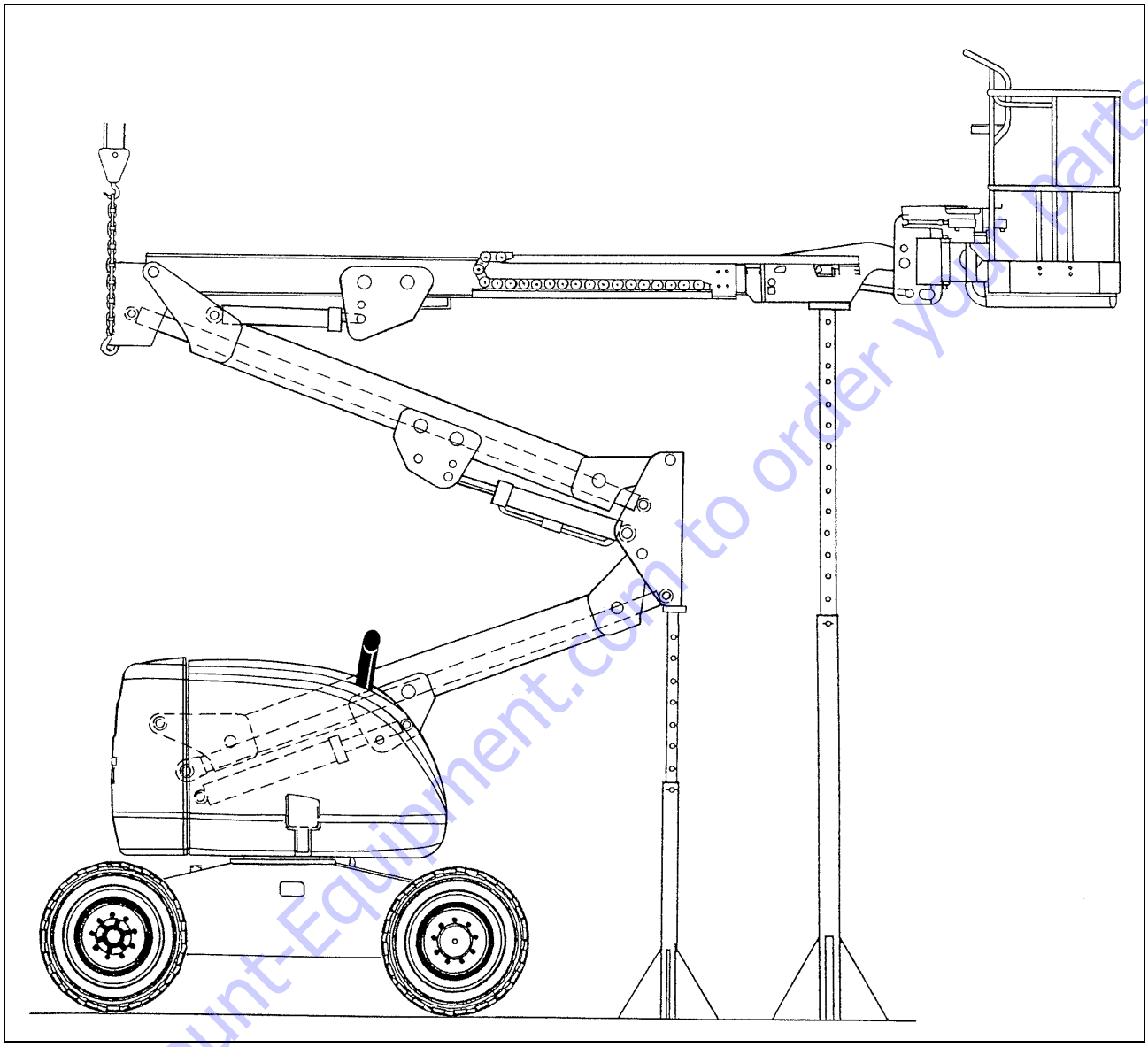


Figure 2-4. Boom Prop Configuration

4. Place the cylinder barrel into a suitable holding fixture.

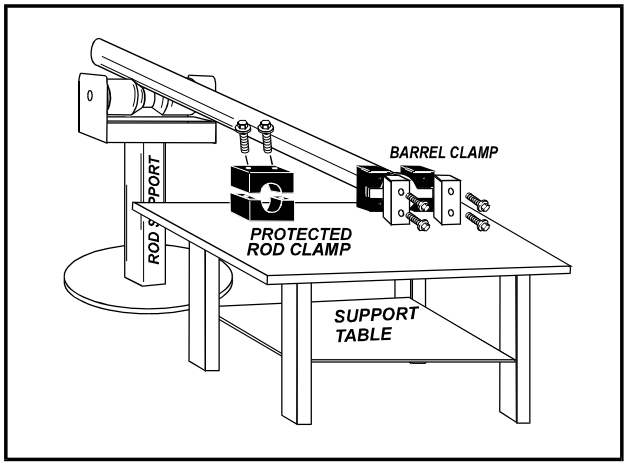


Figure 2-5. Cylinder Barrel Support

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.

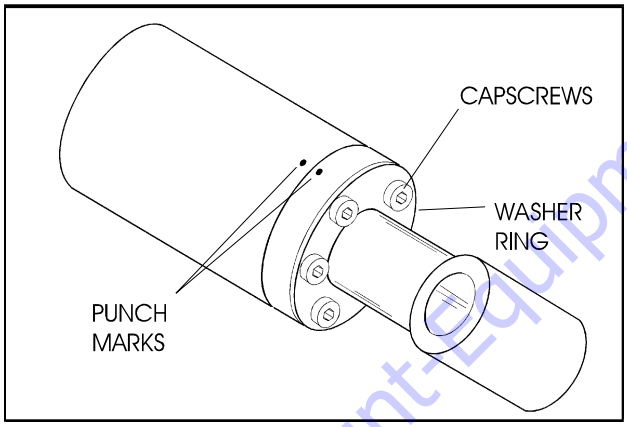


Figure 2-6. Capscrew Removal

NOTE: *Steps 6 applies only to the lower lift and 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.

⚠ IMPORTANT

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.

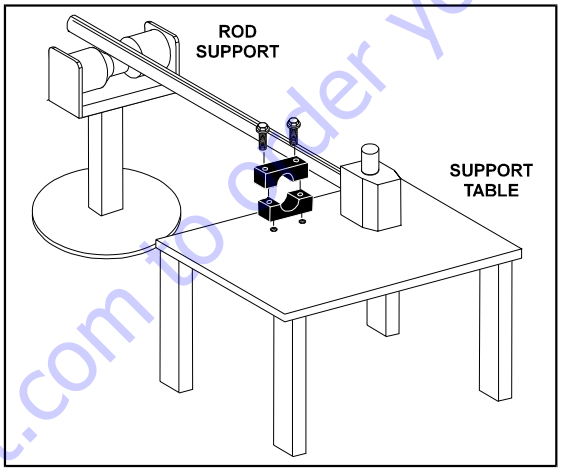


Figure 2-7. Cylinder Rod Support

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.

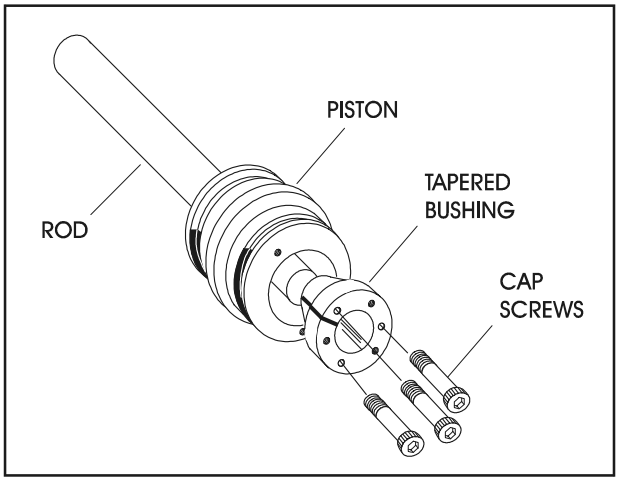


Figure 2-8. Tapered Bushing Removal

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.*

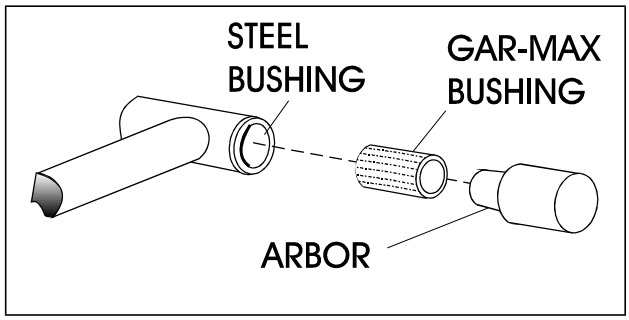


Figure 2-9. Gar-Max Bearing Installation

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.

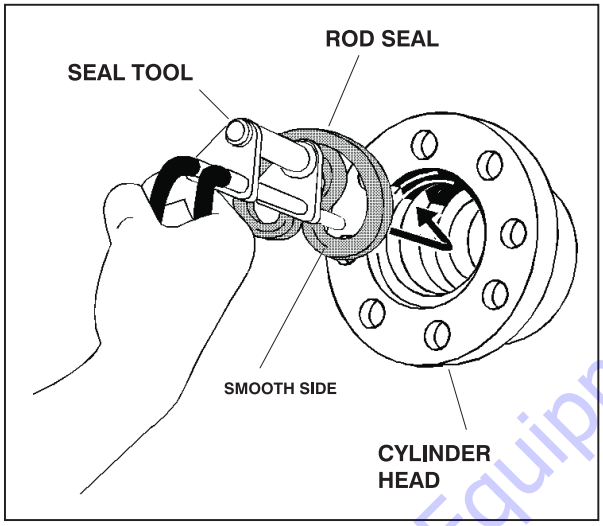


Figure 2-10. Rod Seal Installation

⚠ IMPORTANT

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.

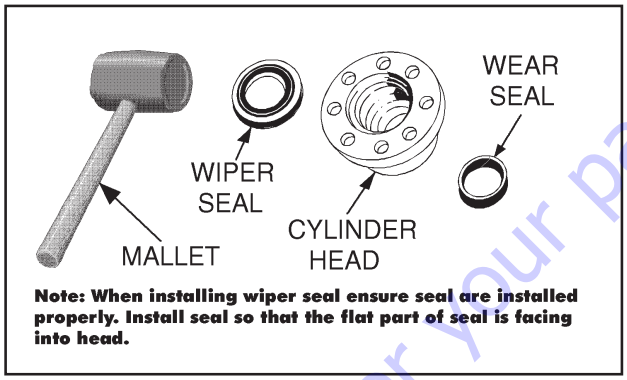


Figure 2-11. Wiper Seal Installation

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

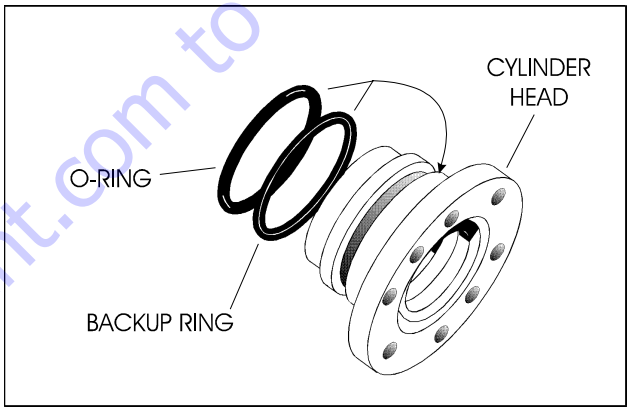


Figure 2-12. Installation of Head Seal Kit

4. 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.
5. Carefully slide the piston spacer on the rod.
6. If applicable, correctly place new o-ring in the inner piston diameter groove. (The backup ring side facing the O-ring is grooved.)

7. 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 2-13.)The split of seals and backup rings are to be positioned so as not to be in alignment with each other.*

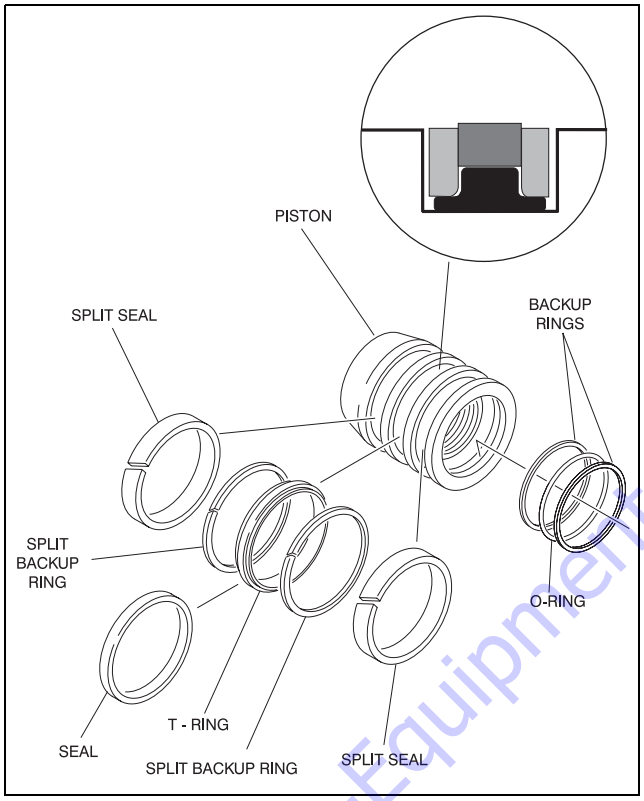


Figure 2-13. Piston Seal Kit Installation.

8. Using suitable protection, clamp the cylinder rod in a vise or similar holding fixture as close to piston as possible.
9. Carefully thread the piston on the cylinder rod hand tight, ensuring that the o-ring and back-up rings are not damaged or dislodged.
10. 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, AXLE OSCILLATION, LOWER LIFT, LEVEL CYLINDER, UPPER LIFT CYLINDER, OR E.A.R. CYLINDERS, TIGHTEN SECURELY. (SEE TABLE 2-1 AND 2-2. TORQUE SPECIFICATIONS).

11. Assemble the tapered bushing loosely into the piston and insert JLG capscrews (not vendor capscrews) through the drilled holes in the bushing and into the tapped holes in the piston.

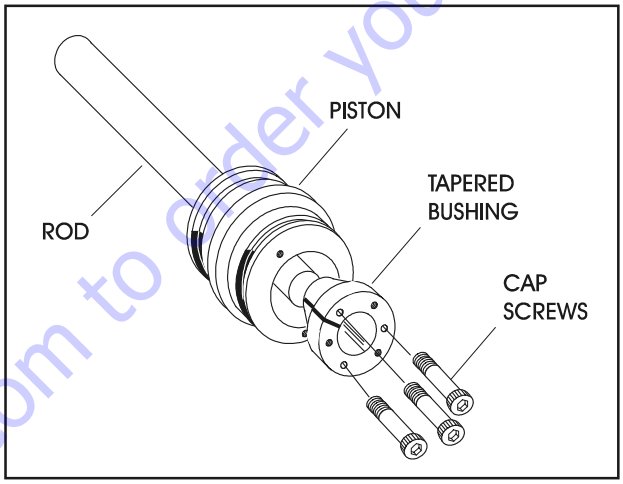


Figure 2-14. Tapered Bushing Installation

12. Tighten the capscrews evenly and progressively in rotation to the specified torque value. (See Table 2-1, 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.

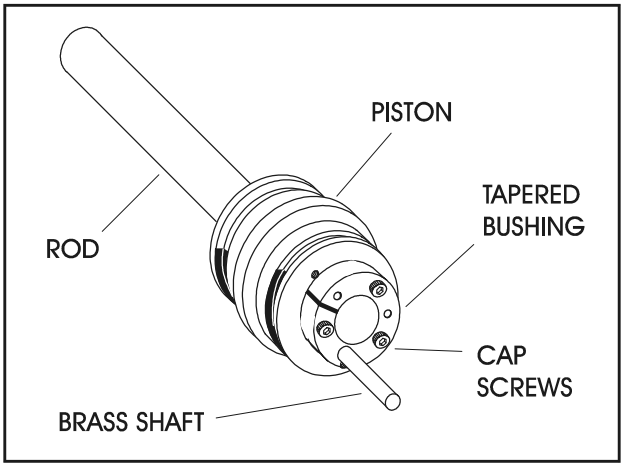


Figure 2-15. Seating the Tapered Bearing

14. Retorque the capscrews evenly and progressively in rotation to the specified torque value. (See Table 2-1, 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 2-28. Piston Seal Kit Installation.)

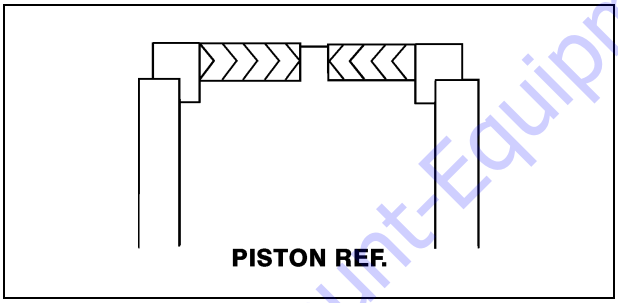


Figure 2-16. Poly-Pak Piston Seal Installation

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

⚠ IMPORTANT

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. See Table 2-1 and 2-3. Torque Specifications.)(

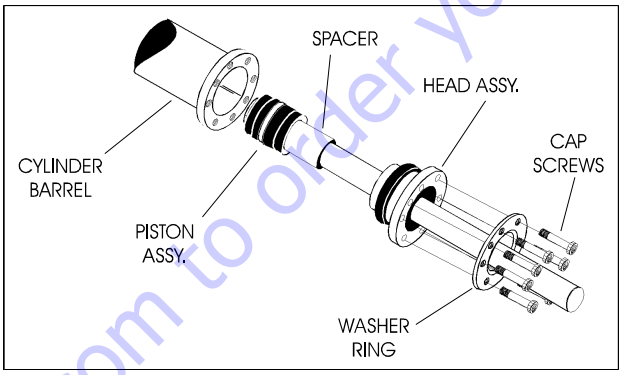


Figure 2-17. Rod Assembly Installation

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 2-2. Holding Valve Torque Specifications).

Table 2-1.Cylinder Head and Tapered Bushing Torque Specifications

Description	Head Torque Value (Wet)	Tapered Bushing Torque Value (Wet)
Upper Lift Cylinder	50 ft. lbs. (68 Nm)	9 ft. lbs (12 Nm)
Upper Lift Cylinder (AJ)	80 ft. lbs. (109 Nm)	9 ft. lbs (12 Nm)
Mid Cylinder	80 ft. lbs. (109 Nm)	9 ft. lbs (12 Nm)
Lower Cylinder	N/A	9 ft. lbs (12 Nm)
E.A.R. Cylinder	30 ft. lbs (41 Nm)	5 ft. lbs. (9 Nm)
Tele Cylinder	N/A	5 ft. lbs. (9 Nm)
Level Cylinder	80 ft. lbs. (109 Nm)	5 ft. lbs. (9 Nm)
Axle Oscillation Cylinder	30 ft. lbs. (41 Nm)	N/A
Steer Cylinder	30 ft. lbs. (41 Nm)	N/A

Table 2-2.Holding Valve Torque Specification

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)

⚠ 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.

2.9 MID AND LOWER LIFT CYLINDER BLEEDING PROCEDURE

NOTE: *Bleeding procedure should only be necessary if rebuilding or replacing lift cylinder.*

1. Check oil level in the hydraulic oil tank (all booms must be retracted). Lay an oil drip pan under the rod end port block (Mid Cylinder) and crack bleeder open from the fitting in the port block.
2. From the platform, turn the speed control knob to the slow position.
3. Lift up very slowly. This will force any air out of the circuit. If the lower boom is not extending, turn the speed control up very slowly until the lower boom starts to move.
4. Raise the lower boom approx. 1 foot (30.5 cm), then close bleeder while the boom is still moving.
5. Lift down all the way.
6. Repeat this procedure until all air has been purged from the circuit. Re-check the hydraulic oil level.
7. To test, cycle the lower lift function 3-4 times to see if both cylinders stop at the same time when fully extended.

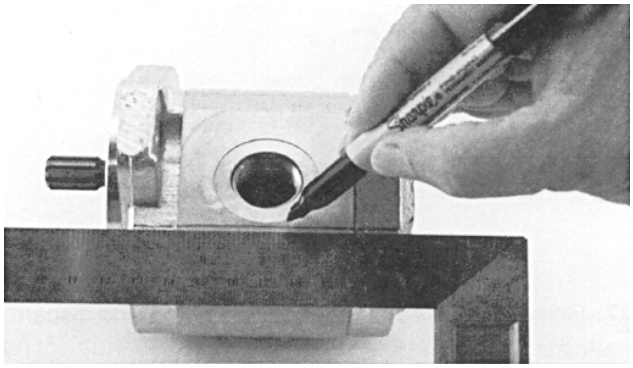
2.10 HYDRAULIC PUMP (GEAR)

Disassembly

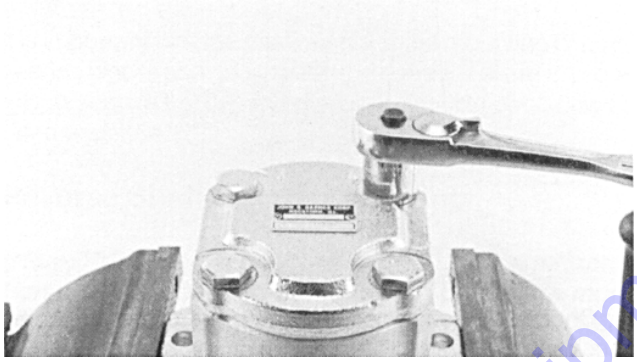
NOTE: *The following general instructions also apply to multiple section gear pumps, the only extra parts are the coupling between the drive shafts and the center distance plate which divides the two pump sections. This repair procedure also applies to the "W" series Gear Motors.*

1. It is very important to work in a clean work area when repairing hydraulic products. Plug ports and wash exterior of pump with a proper cleaning solvent before continuing.

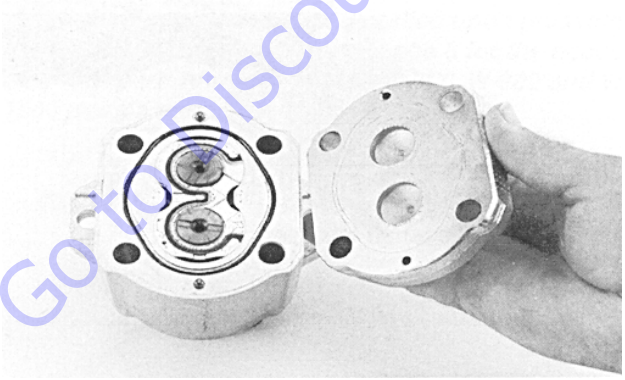
2. Remove port plugs and drain oil from pump.



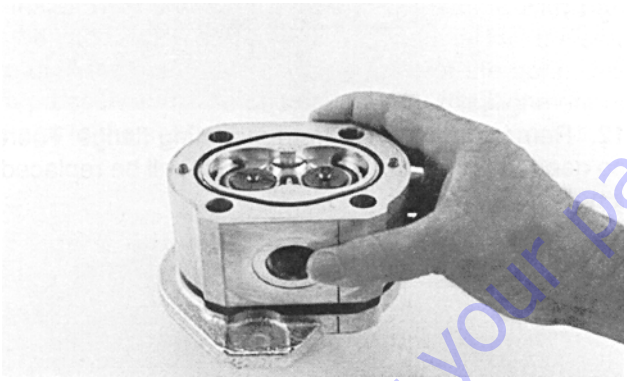
3. Use a permanent marker pen to mark a line across the mounting flange, gear housing and end cover. This will assure proper reassembly and rotation of pump.
4. Remove key from drive shaft if applicable.



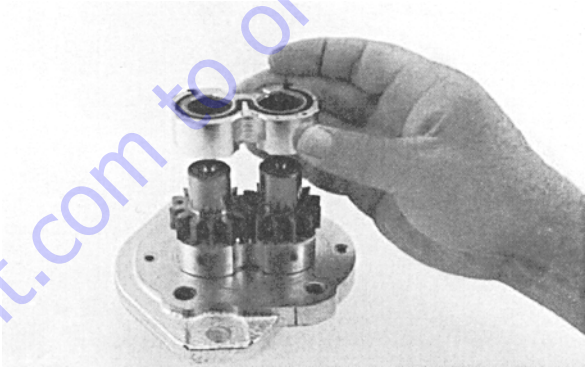
5. Clamp the mounting flange in a protected jaw vise with the pump shaft facing down.
6. Loosen the four metric hex head bolts.
7. Remove pump from vise and place on clean work bench, remove the four hex head bolts and spacers if applicable.



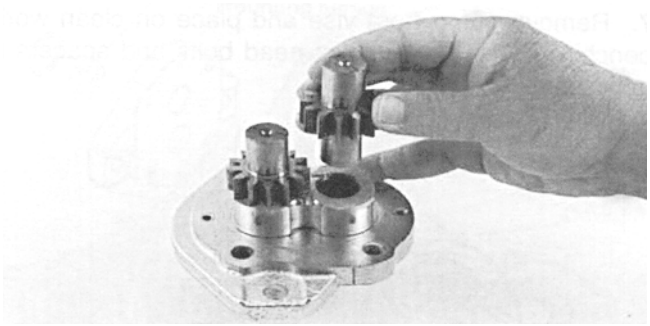
8. Lift and remove end cover.



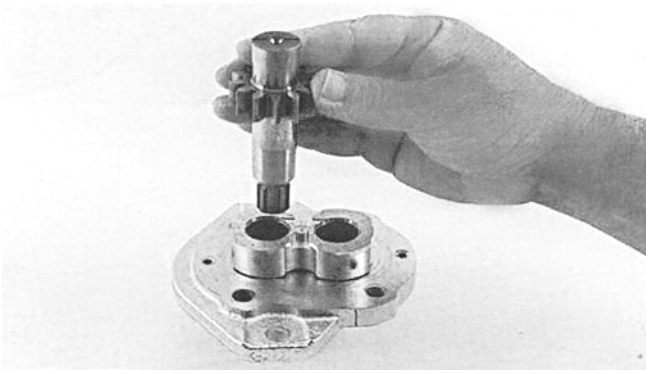
9. Carefully remove gear housing and place on work bench. Make sure the rear bearing block remains on the drive and idler shafts.



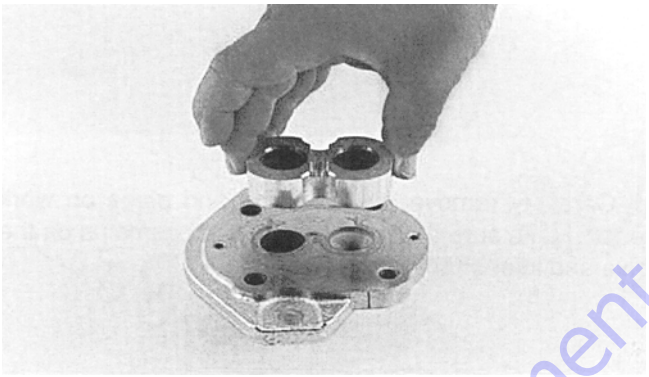
10. Remove rear bearing block from drive and idler shafts.



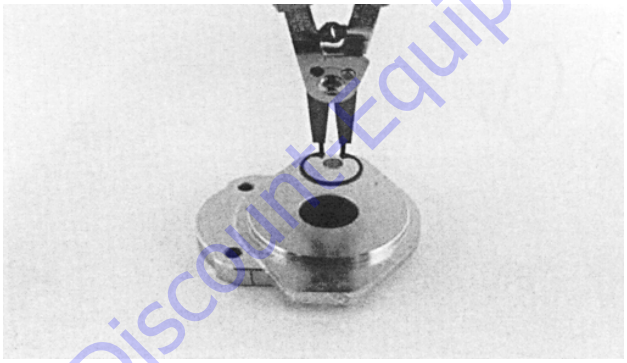
11. Remove idler shaft from bearing block.



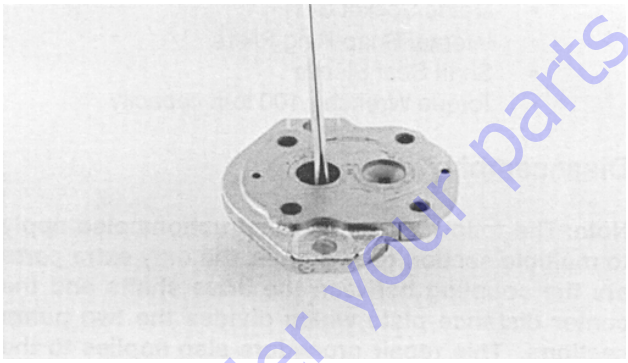
12. Remove drive shaft from mounting flange. There is no need to protect the shaft seal as it will be replaced as a new item.



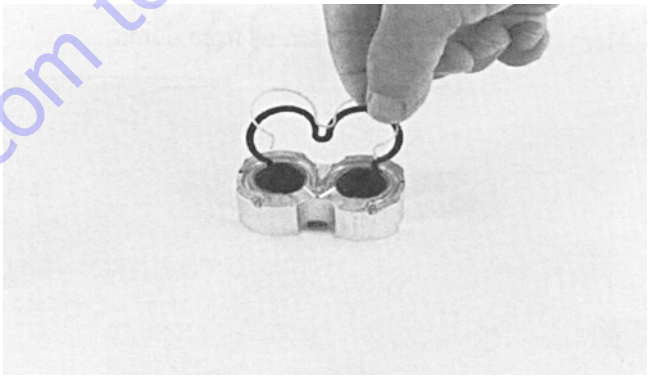
13. Remove the front bearing block.



14. Turn the mounting flange over, with the shaft seal up, and remove the retaining ring with proper snap ring pliers.



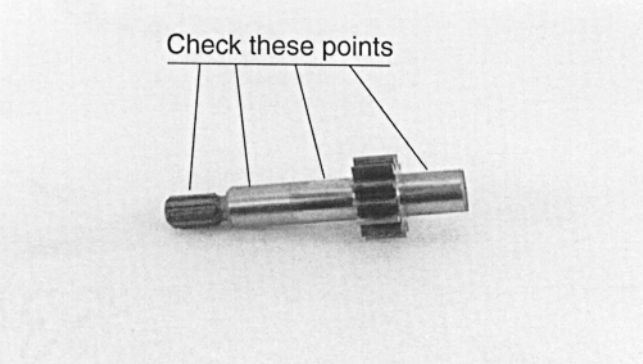
15. Remove the oil seal from mounting flange, be careful not to mar or scratch the seal bore.
16. Remove the dowel pins from the gear housing. Do not lose pins.



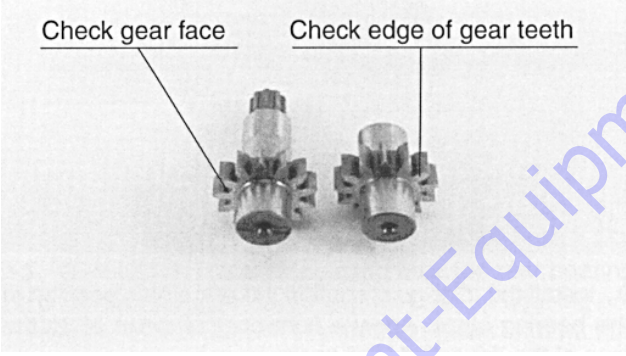
17. Remove seals from both bearing blocks and discard.

Inspect Parts For Wear

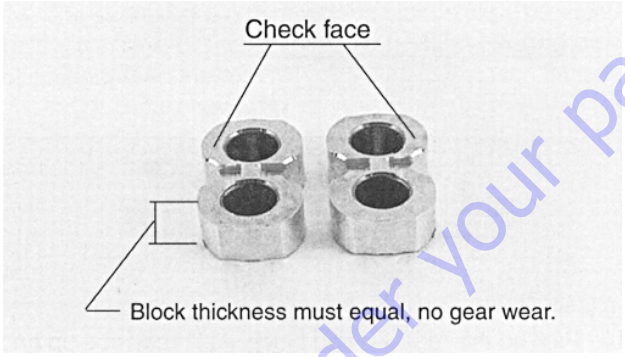
1. Clean and dry all parts thoroughly prior to inspection. It is not necessary to inspect the seals as they will be placed as new items.



2. Check drive shaft spine for twisted or broken teeth, check keyed drive shaft for broken or chipped keyway. No marks or grooves on shaft in seal area, some discoloration of shaft is allowable.
3. Inspect both the drive gear shaft and idler gear shafts at the bearing points and seal area for rough surfaces and excessive wear.



4. Inspect gear face for scoring or excessive wear. If the face edge of gear teeth are sharp, they will mill into the bearing blocks. If wear has occurred, the parts are unusable.



5. Inspect bearing blocks for excessive wear or scoring on the surfaces which are in contact with the gears. Also inspect the bearings for excessive wear or scoring.
6. Inspect the area inside the gear housing. It is normal for the surface inside the gear housing to show a clean "wipe" on the inside surface on the intake side. There should not be excessive wear or deep scratches and gouges.

General Information

It is important that the relationship of the mounting flange, bearing blocks and gear housing is correct. Failure to properly assemble this pump will result with little or no flow at rated pressure.

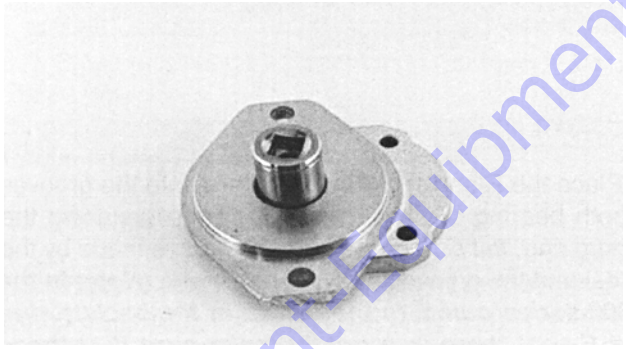
Reverse Shaft Rotation of Pump

NOTE: *This pump is not bi-rotational, if the shaft rotation must be changed the following procedure must be followed.*

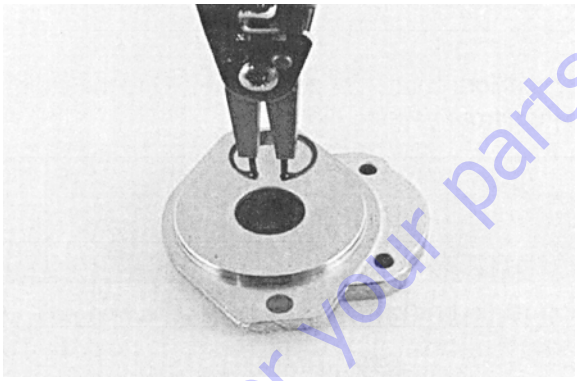
Reversing the shaft rotation of the "W" series gear pump may be accomplished by rotating, as a group, the two bearing blocks and the gear housing 180° in relationship to the remaining parts of the pump. This procedure will place the pressure port on the opposite side of the pump from its original position.

Assembly

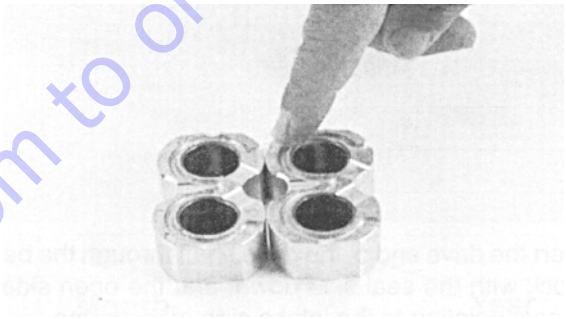
NOTE: *New seals should be installed upon reassembly of pump or motor. deter to page 8 for the necessary kit part numbers for the W-600, W-900 and W-1500 pumps and motors.*



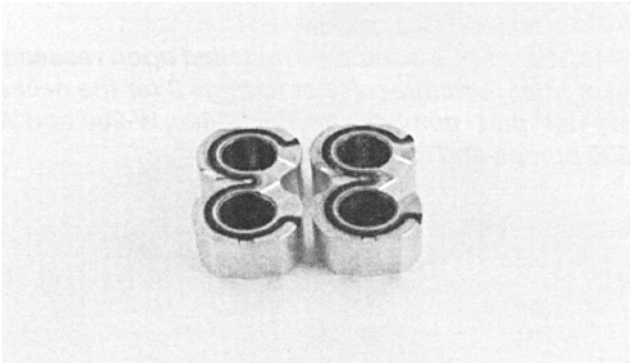
1. Install new shaft seal in mounting flange with part lumber side facing outboard. Press the seal into the seal lore until the seal reaches the bottom of the bore. Uniform pressure must be used to prevent misalignment or damage to the seal.



2. Install retaining ring in groove in seal bore of mounting flange.

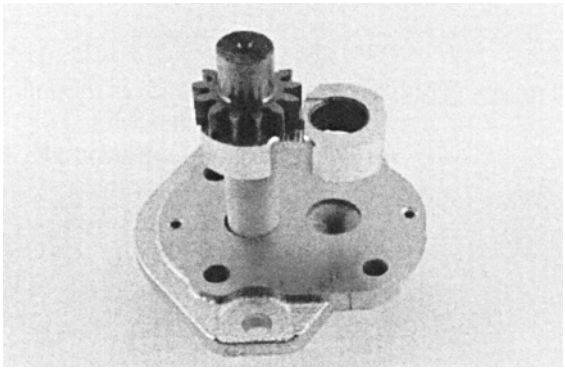


3. Place front and back bearing blocks on a clean surface with the E-seal grooves facing up. Apply a light coating of petroleum jelly in the grooves. Also coat the E-seal and backup with the petroleum jelly, this will help keep the seals in place during reassembly.

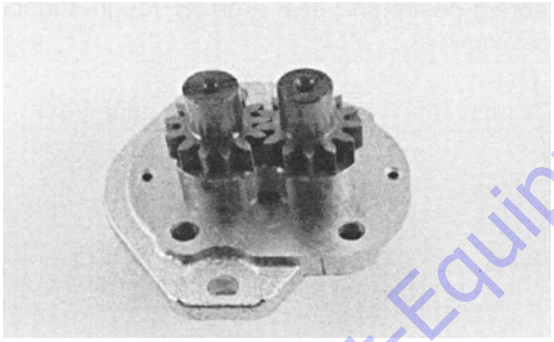


4. Place the E-seals, *flat side outward,* into the grooves in both bearing blocks. Follow by *carefully* placing the backup ring, *flat side outward,* in the groove made by the E-seal and the groove in the bearing block. *(Note: in the W900 series pump, in the center of the backup ring and E-seal there is a notch make sure that these notches line up so the backup ring will set flush with the E-seal).* The backup ring in the W1500 pump is symmetrical.

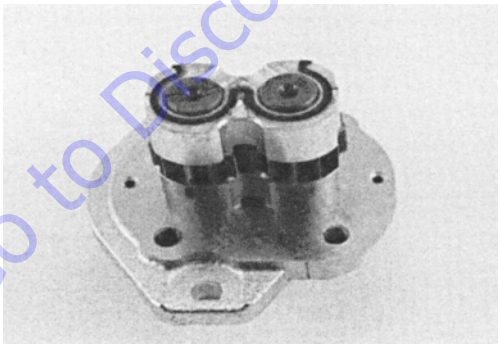
5. Place mounting flange, with shaft seal side down, on a clean flat surface.
6. Apply a light coating of petroleum jelly to the exposed face of the front bearing block.



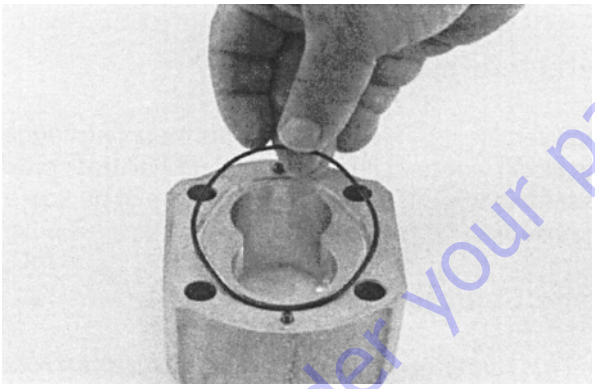
7. Insert the drive end of the drive shaft through the bearing block with the seal side down, and the open side of the E-seal pointing to the intake side of the pump.
8. Install the seal sleeve over the drive shaft and carefully slide the drive shaft through the shaft seal. Remove the seal sleeve from shaft.



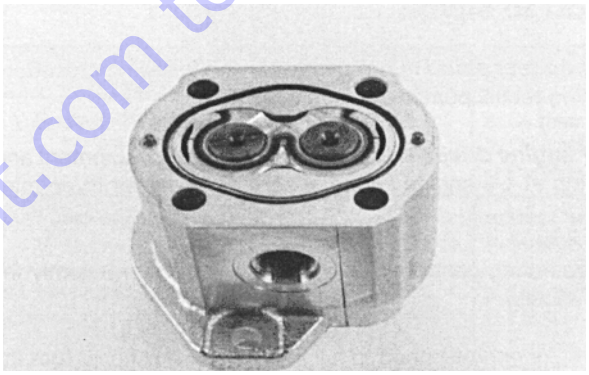
9. Install the idler gear shaft in the remaining position in the bearing block. Apply a light coat of clean oil to the face of the drive and idler gears.



10. Pick up the rear bearing block, with seal side up and with open end of the E-seal facing the intake side of the pump, place over the drive and idler gear shafts.
11. Install two dowel pins in the holes in the mounting flange or two long dowel pins through gear housing if pump is a multiple section pump.

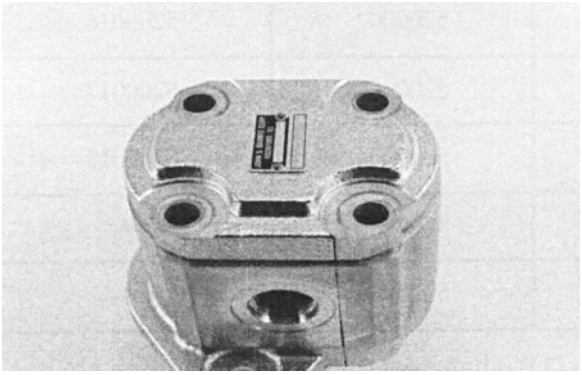


12. To install the O-rings in the gear housing, apply a light coating of petroleum jelly in the grooves on both sides of the gear housing. Also coat the new O-rings and install them in the grooves.

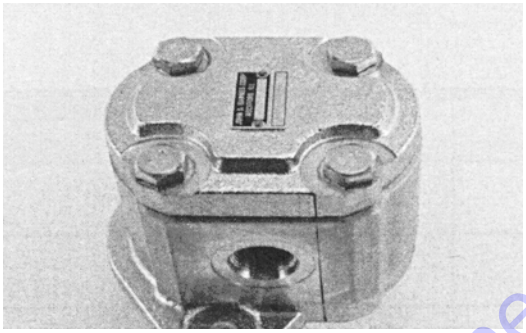


13. Gently slide the gear housing over the rear bearing block assembly, slide housing down until the housing engages the dowel pins. Press firmly in place with hands, do not force or use any tool. Check to make sure the in-take port in the housing is on the same side as the open end of the E-seal and that the marked lines on the mounting flange and gear housing are in alignment.
14. The surface of the rear bearing block should be slightly below the face of the gear housing. If the bearing block sits higher then the rear face of the gear housing then the E-seal or o-ring have shifted

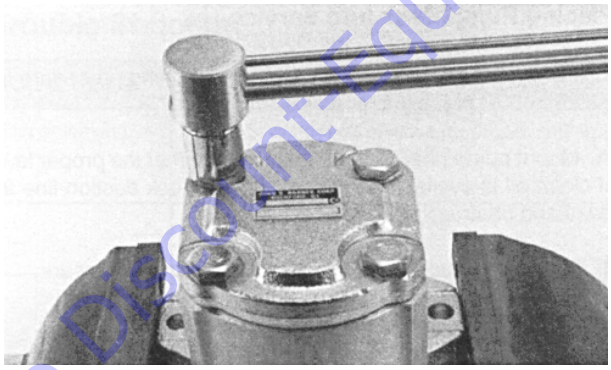
out of the groove. If this is the case, remove the gear housing and check for proper seal installation.



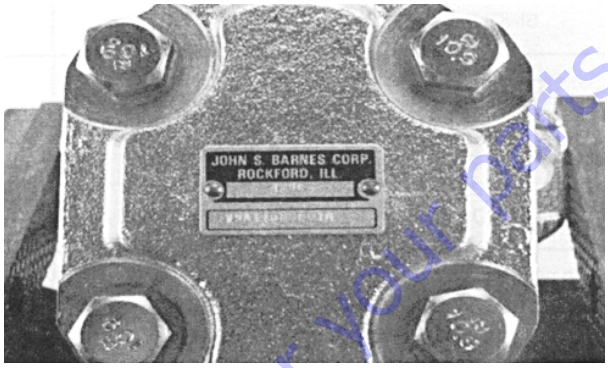
15. Install the two remaining dowel pins in the rear of the gear housing, if applicable, and place the end cover over the back of the pump.



16. Install the four spacers, if applicable, and hex head bolts through the bolt holes in the end cover, hand tighten.



17. Place mounting flange of the pump back in the protected jawed vise and alternately torque the bolts to the torque specifications in the torque chart. All torque figures are for "dry torque" bolts.
18. Remove pump from vise.
19. Place a small amount of clean oil in the inlet of the pump and rotate the drive shaft away from the inlet one revolution. If the drive shaft binds, disassemble the pump and check for assembly problems, then reassemble the pump.



20. The name plate located on the end cover contains the build date code and the model number. Please refer to this information when corresponding with the J.S. Barnes Service Department.

Table 2-3.Hydraulic Pump Bolt Torque Chart

Pump Series	Thread Size	Torque Values, Black Oxide End Cover	Torque Values, Zinc Plated End Cover
W-600	M 8 x 1.25	18-21 ft.lb. 24-30 Nm	16-18 ft.lb. 21.7-24.4 Nm
W-900	M 10 x 1.5	50-55 ft.lb. 68-75 Nm	38-43 ft.lb. 51.5-58.3 Nm
W-1500	M 12 x 1.75	80-85 ft.lb. 108-115 Nm	68-73 ft.lb. 92.2-99 Nm

Placing Pump Back Into Service

1. *If shop test stand is available,* the following procedure for testing rebuilt pumps is recommended:
   a. Mount pump on test stand making sure that the proper level of clean oil is available in the reservoir. Check suction line for leaks and obstructions.
   b. Start pump and run for three minutes at zero pressure.
   c. Intermittently load pump to 500 P.S.I. for three minutes.
   d. Intermittently load pump to 1000 P.S.I. for three minutes.
   e. Intermittently load pump to 2000 P.S.I. for three minutes.
   f. Remove pump from test stand and check for freeness of drive shaft. Check pump for signs of external leakage.
2. *If shop test stand is not available,* the following procedure for testing rebuilt pumps is recommended:
   a. *For engine driven pumps,* mount pump on equipment and run pump at 1/2 engine speed at zero pressure for three minutes.
   b. By operating control valve, build pressure intermittently for three minutes.
   c. Increase engine speed to full throttle and build pressure intermittently for three minutes.
   d. Stop engine and check pump for external leaks.

2.11 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 70 degrees (full elevation).
2. At the positions indicated on the figure titled Swing Bearing Tolerance Boom Placement. Try and insert the 0.0015" feeler gauge between the bolt head and hardened washer at the arrow indicated position.
3. Assure that the 0.0015" feeler gauge will not penetrate under the bolt head to the bolt shank.
4. Swing the turntable 90 degrees, and check some selected bolts at the new position.
5. 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 70 degrees (full elevation).
2. At the positions indicated in the figure below, try and insert the 0.0015" feeler gauge between the bolt head and hardened washer at the arrow indicated position.

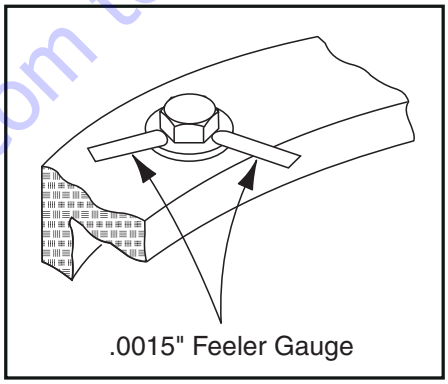


Figure 2-19. Swing Bearing Feeler Gauge Check

3. Lower the boom to horizontal and fully extend the boom.
4. At the position indicated on Figure 2-30. try and insert the 0.0015" feeler gauge between the bolt head and hardened washer at the arrow indicated position.

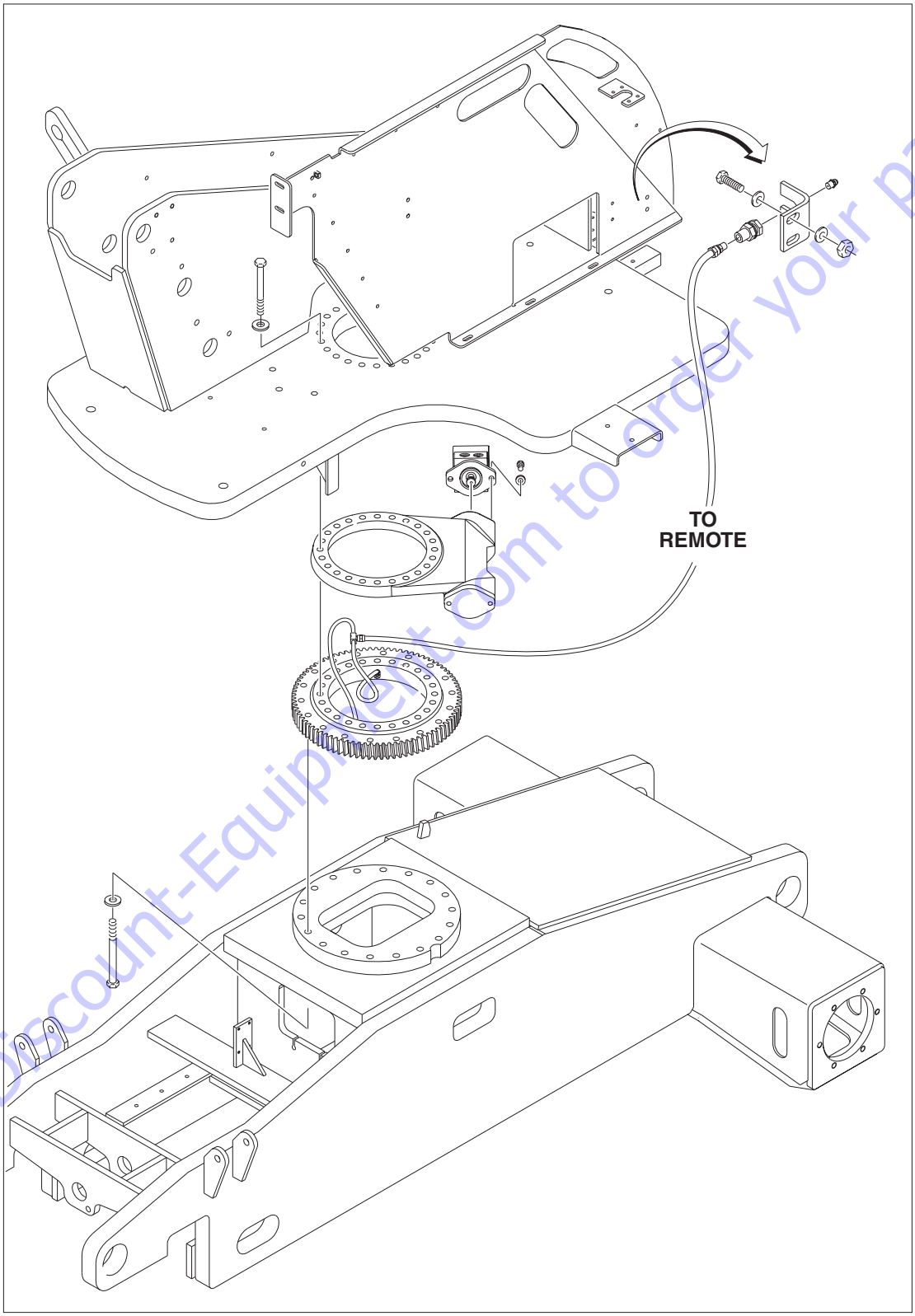


Figure 2-18. Swing Bearing Installation

Wear Tolerance

1. With the boom positioned over the side of the machine, the Upper Boom horizontal with telescope fully extended and Mid/Lower Boom stowed, using a magnetic base dial indicator, measure and record the distance between the swing bearing and turntable.
2. At the same point, with the boom positioned over the side of the machine, the Upper Boom fully elevated and the Mid/Lower Boom fully elevated, using a magnetic base dial indicator, measure and record the distance between the swing bearing and turntable.

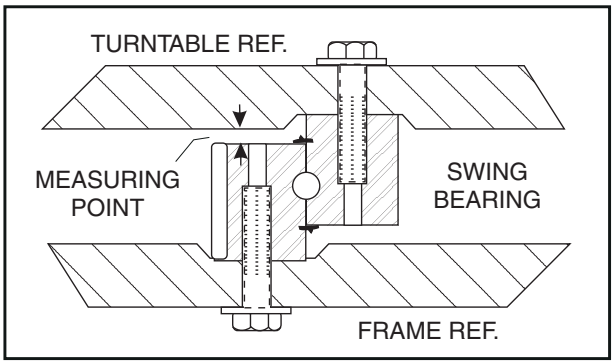


Figure 2-20. Swing Bearing Tolerance Measuring Point

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.

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.
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 and rotation box assembly from the frame; move to a clean, suitably supported work area.
8. Remove the two capscrews securing the bearing to the rotation box to separate the two for inspection.

Installation of the swing bearing is as follows:

1. Install bearing to rotation box with two capscrews, so that fill plug of bearing is as close to gear as bolt pattern will allow. Do not tighten capscrews.
2. Line up high spot (blue) of bearing with center tooth of worm gear. Set backlash to 0.008 - 0.010 inch (0.20 - 0.25 mm). Tighten capscrews as shown in Figure 2-21., Swing Bearing Torque Sequence.

3. Apply Tribol Molub-Alloy 936 Open Gear Compound to bearing and worm gear teeth.
4. Grease bearing with Mobilith SHC Bearing Grease. Grease fitting is on inside wall of inner race of bearing.

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

5. Using suitable lifting equipment, install bearing/rotation box 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 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.

6. 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.

7. Following the torque sequence diagram shown in Figure 2-21., Swing Bearing Torque Sequence, tighten the bolts to an initial torque of 175 ft. lbs. (237 Nm). Then following the same sequence, tighten to a final torque of 240 ft. lbs. (326 Nm).
8. Remove lifting equipment from bearing.
9. Use suitable lifting equipment to carefully position the turntable assembly above the machine frame.
10. 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.
11. Apply a light coating of Loctite 271 to the new bearing bolts and install through the turntable and inner race of bearing.
12. Following the torque sequence shown in Figure 2-21., Swing Bearing Torque Sequence, tighten the bolts to an initial torque of 175 ft. lbs. (237 Nm). Then following the same sequence, tighten the bolts to 240 ft. lbs (326 Nm).
13. Remove the lifting equipment.
14. Route hydraulic lines through center of turntable and frame and connect as tagged prior to removal.
15. Using all applicable safety precautions, activate the hydraulic system and functionally check swing system for proper and safe operation.

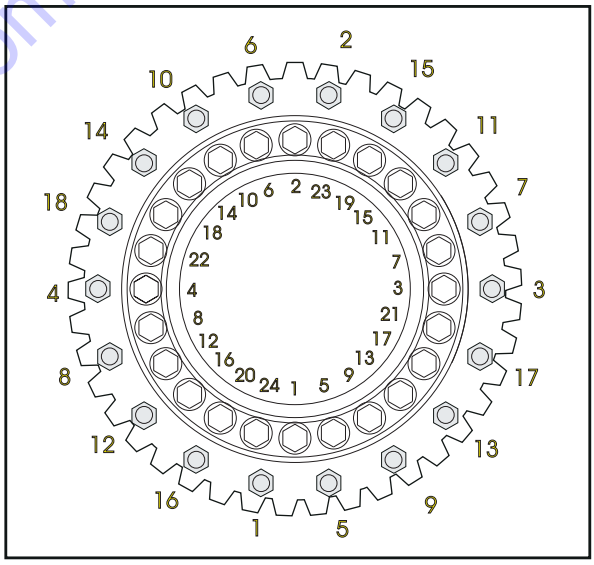


Figure 2-21. Swing Bearing Torque Sequence

Swing Bearing Torque Values

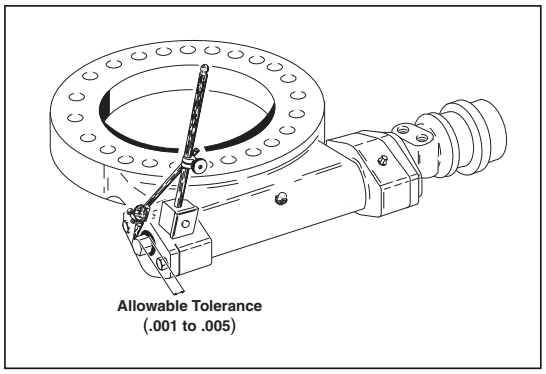
1. Dry - 220 ft. lbs. (298 Nm).
2. Loctite - 240 ft. lbs. (326 Nm).

2.12 WORM GEAR

Checking Worm Gear End Play

NOTE: *JLG Industries requires that a annual inspection be performed on the worm gear end play.*

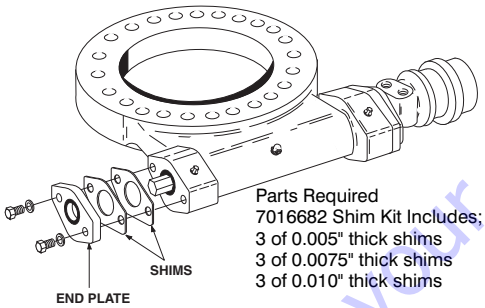
1. Using a dial indicator, measure end play of worm gear, by applying side to side movement by hand to platform.
2. If tolerance exceeds 0.010", reduce end play to less than 0.005". Refer to Adjusting End Play.



Adjusting End Play

1. Remove end plate.
2. Measure and record total thickness of existing shim pack.
3. Determine thickness of shim pack required to obtain 0.001" - 0.005" end play.
4. Adjust shim pack thickness as required to obtain proper end play. Reduce end play by removing thicker shims and replacing with thinner shims, included in kit.
5. Replace end plate and torque bolts to 90 ft. lbs. (122 Nm).
6. Recheck end play.

Fig 2 Adjusting End Play.



2.13 BOOM SYNCHRONIZING PROCEDURE

NOTE: *If the Lower Boom assembly does not fully lower:*

1. Remove all personnel from the platform.
2. Pull the red knob located under the main control valve.
3. From Ground Control, activate the lift control switch, raise Lower Boom 6 feet (1.83m).
4. After raising Lower Boom, release the red knob.
5. Activate Lower Boom Down, fully lower boom.
6. Repeat step 1 thru 5 if necessary.

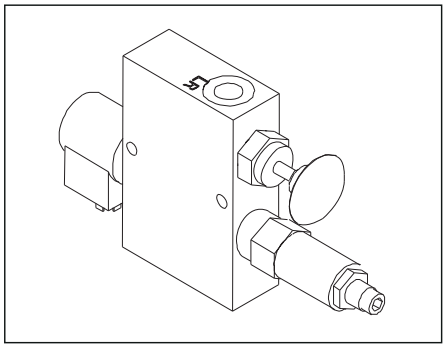


Figure 2-22. Synchronizing Valve

2.14 JIB

Removal

1. Place the Jib in a horizontal position and support the complete assembly with adequate blocking.
2. Remove the Platform as follows:
   a. Disconnect the electrical connectors going into the platform control box.
   b. Remove the bolts, nuts, and washers connecting the platform basket to the platform support.
   c. Using a suitable lifting device, remove the platform basket from the platform support.
3. Tag and disconnect the hydraulic lines running to the jib. Use a suitable container to collect any residual fluid. Cap the hydraulic lines and ports.
4. Remove the hardware securing the jib pivot pin at the boom. Using a suitable brass drift and hammer, remove the pin from the fly boom. Use a suitable lifting device and remove the jib.

2.15 BLEEDING OSCILLATION CYLINDERS

1. Drive the machine up onto a six inch (15 cm) block, to extend an oscillation cylinder.
2. Flip the end caps on the drive hubs to disengage the hubs. Activate the drive function to be sure the hubs are disengaged.
3. Crack the bleeder screw at the bottom of the cylinder.
4. Operate the drive function until no air is coming out of the bleeder valve.
5. Close the bleeder valve.
6. Engage the hubs and repeat steps 1 thru 5 for the opposite side of the machine.
7. Perform the Oscillation Axle Lockout Test. If necessary, bleed the cylinders again.

2.16 OSCILLATING AXLE LOCKOUT TEST

⚠ IMPORTANT

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 cm) high block with ascension ramp in front of left front wheel.
2. From platform control station, start engine.
3. Place the DRIVE SPEED control switch to the LOW position.

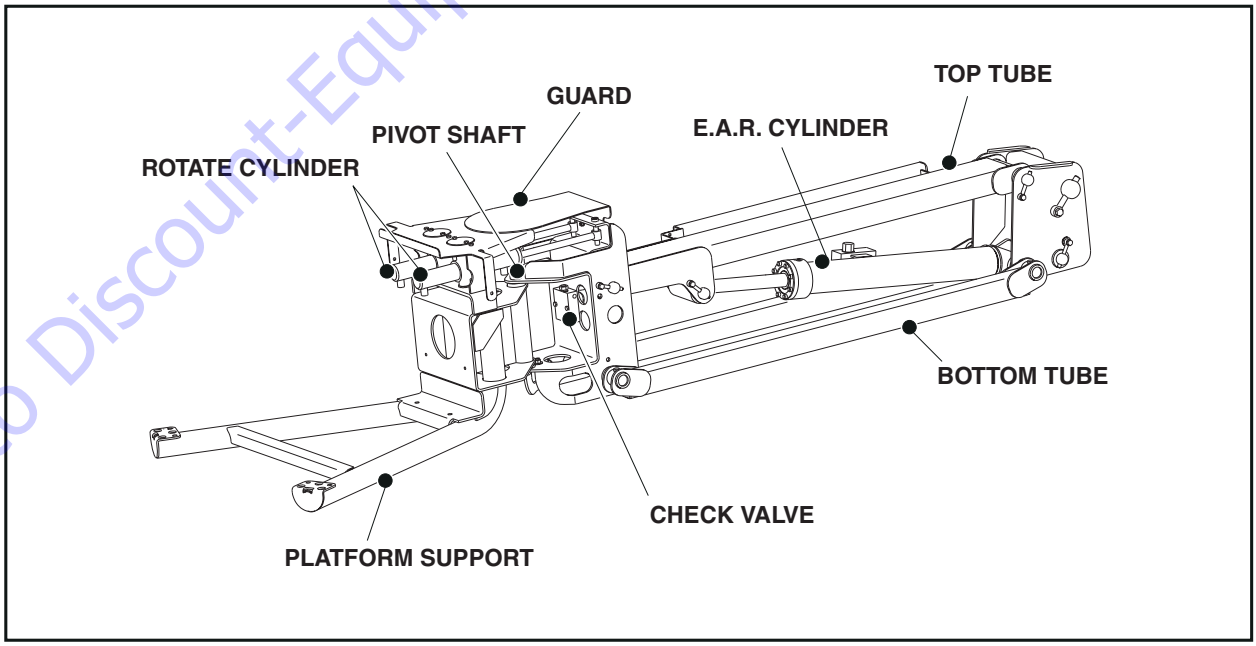


Figure 2-23. Jib

4. Place DRIVE control lever to FORWARD position and carefully drive machine up ascension ramp until left front wheel is on top of block.
5. Carefully activate SWING control lever and position boom over right side of machine.
6. With boom over right side of machine, place DRIVE control lever to REVERSE and drive machine off of block and ramp.
7. Have an assistant check to see that left front wheel remains locked in position off of ground.
8. 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.
9. Place the 6 inches (15 cm) high block with ascension ramp in front of right front wheel.
10. Place DRIVE control lever to FORWARD and carefully drive machine up ascension ramp until right front wheel is on top of block.
11. Carefully activate SWING control lever and position boom over left side of machine.
12. With boom over left side of machine, place DRIVE control lever to REVERSE and drive machine off of block and ramp.
13. Have an assistant check to see that right front wheel remains locked in position off of ground.
14. 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.
15. If lockout cylinders do not function properly, have qualified personnel correct the malfunction prior to any further operation.

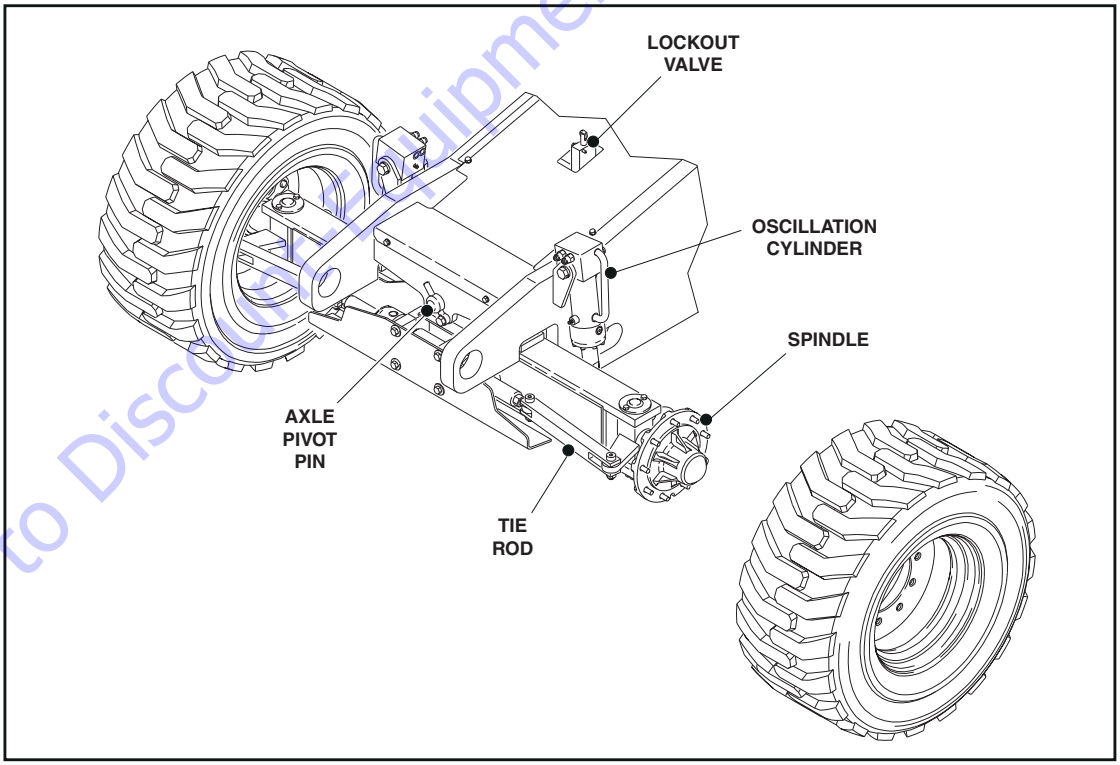
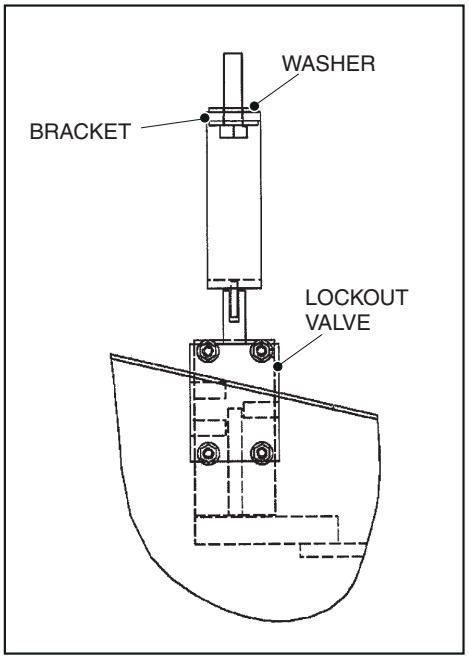


Figure 2-24. Front Axle

2.17 ADJUSTMENT PROCEDURE FOR LOCKOUT VALVE

1. With the turntable centered, adjust the bracket with the washers to push the plunger in 5/16" ± 1/16".



2. The ideal adjustment is 3/8". Do not push the plunger in more that 3/8". The extra adjustment is needed for the turntable bearing play.

2.18 TORQUE HUB (PRIOR TO S/N 39594)

Ring Gear/Cover Disassembly

1. Loosen the bolts (1) holding the disengage cap (2) in place. Remove the disengage cap.
2. Remove the disengage rod (3) from the ring gear/cover (4).
3. Take out the O-ring (5) from the ring gear/cover.
4. Remove the pipe plugs (6) from the ring gear cover.

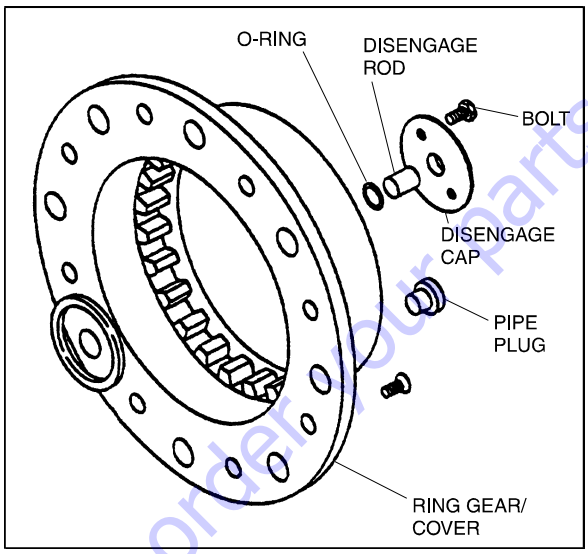


Figure 2-25. Ring Gear/Cover

Carrier Disassembly

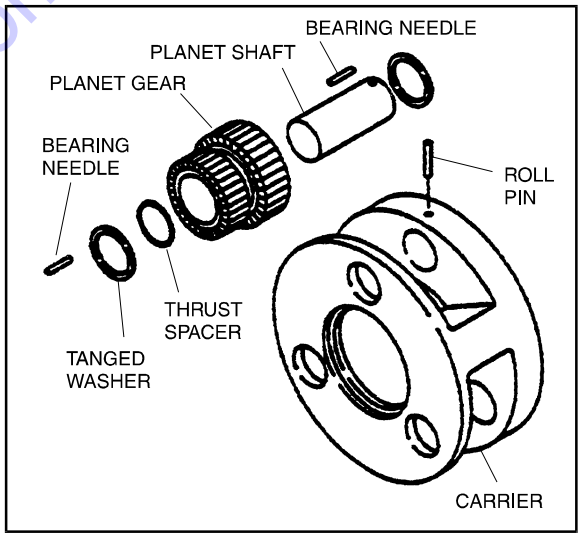


Figure 2-26. Carrier

1. Stand the carrier (8) on its side.
2. Take a punch and a hammer amid drive the roll pin (9) into the planet shaft (10). Make sure that the pin is in enough to slide the planet shaft (10) out of the carrier (8).
3. Rotate the planet shaft (10) 180 degrees, then drive the roll pin (9) out of the planet shaft (10) and discard the roll pin (9).
4. Remove the planet gear (11) and the flat tanged washers (12) from the carrier.

5. Repeat steps 2 thru 4 for the remaining two planet gears.
6. Remove the bearing needles (13) and the thrust spacer (14) from the planet gear (11).

Hub-Spindle Disassembly

NOTE: *If your unit does not have studs, then skip step 1.*

1. Hammer the studs (15) out of the flange of the housing (16).

⚠ WARNING

SAFETY GLASSES MUST BE WORN DURING THIS STEP.

2. Remove the retaining ring (17) from spindle counterbore.
3. Remove the spacer (18) and the spring (19).
4. Using retaining ring pliers, remove the retaining ring (20) from the spindle (21) discard the retaining ring at this time. Remove the thrust spacer (22) from the spindle (21).
5. Place on I-beams and press the top of the spindle through the housing.

NOTE: *The outboard bearing and seal will have to be removed from the spindle. You will have to scrap out the seal and bearing to remove them from the spindle.*

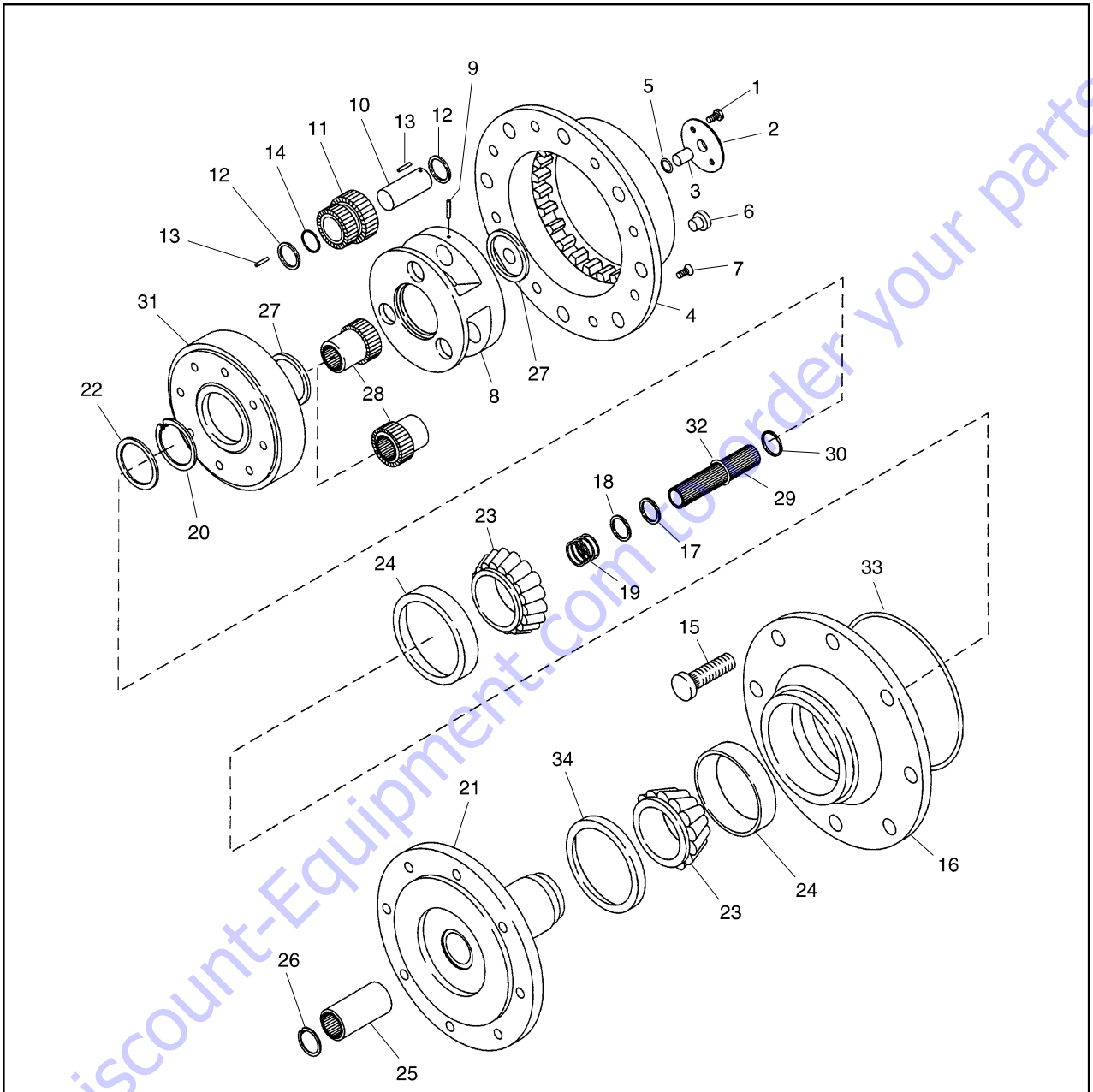
6. Remove the inboard bearing (23) from the inboard cup (24).
7. Using a hammer and a thin barstock punch, drive the cups out of the housing.

Main Disassembly

1. Remove coupling (25) from spindle (21).
2. Remove retaining ring (26) from coupling (25).
3. Remove the hex socket screws (7) from the ring gear cover (4).
4. Remove the ring gear cover (4) from the housing (16).
5. Remove the thrust washer (27) from the counterbore of the carrier (8).
6. Remove the carrier (8) along with the sun gear (28).
7. Remove the input shaft (29). Take out the bottom thrust washer (27).
8. Take off the thrust washer (30) from the spindle counterbore.
9. Remove the internal gear (31) from the spindle (21).
10. Remove the retaining ring (32) from the input shaft (29), and discard the retaining ring.
11. Take the O-Ring (33) out of the 0-Ring groove on the spindle (21).

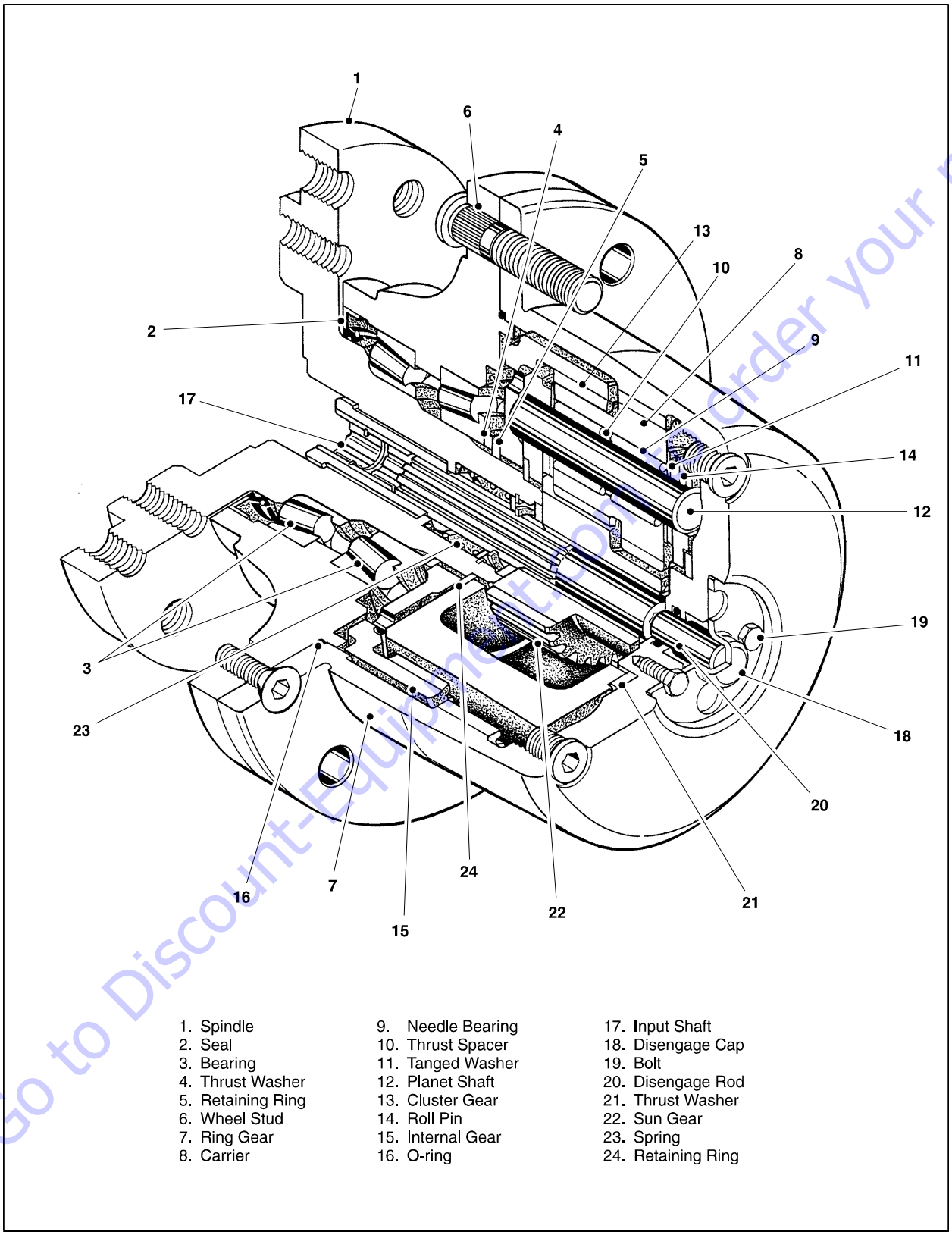
Carrier Sub-Assembly

1. Put a generous amount of grease into the planet gear (11).
2. Line the inside of the planet gear (11) with sixteen bearing needles (13). Put thrust spacer (14) on top of bearing needles (13), then place 16 more bearing needles (13) on top of the thrust Spacer (14).
3. Repeat step 2 for the two remaining planet gears.
4. Stand carrier on its side. Insert planet shaft (10) into the hole on the side of the carrier (8) with roll pin last.
5. Place flat tanged washer (12) onto the planet shaft so that the bump on the flat tanged washer is located towards the interior of the carrier, and is lined up with the slot on the carrier (8).



1. Bolt
2. Disengage Cap
3. Disengage Rod
4. Ring Gear/Cover
5. O-ring
6. Pipe Plugs
7. Screw
8. Carrier
9. Roll Pin
10. Planet Shaft
11. Planet Gear
12. Tanged Washer
13. Bearing Needle
14. Thrust Spacer
15. Stud
16. Housing
17. Retaining Ring
18. Spacer
19. Spring
20. Retaining Ring
21. Spindle
22. Thrust Spacer
23. Bearing
24. Bearing Cup
25. Coupling
26. Retaining Ring
27. Thrust Washer
28. Sun Gear
29. Input Shaft
30. Thrust Washer
31. Internal Gear
32. Retaining Ring
33. O-ring
34. Seal

Figure 2-27. Torque Hub (Prior to S/N 39594) - Exploded View



1. Spindle
2. Seal
3. Bearing
4. Thrust Washer
5. Retaining Ring
6. Wheel Stud
7. Ring Gear
8. Carrier
9. Needle Bearing
10. Thrust Spacer
11. Tanged Washer
12. Planet Shaft
13. Cluster Gear
14. Roll Pin
15. Internal Gear
16. O-ring
17. Input Shaft
18. Disengage Cap
19. Bolt
20. Disengage Rod
21. Thrust Washer
22. Sun Gear
23. Spring
24. Retaining Ring

Figure 2-28. Torque Hub (Prior to S/N 39594) - Cutaway View

6. Place the assembled planet gear (11), large end towards the roll pin onto the planet shaft (10).
7. Push the planet shaft (10) through until it reaches the other side of the planet gear (11). Place the other flat tanged washer (12) onto the shaft so that the bump is on the internal side of the carrier, and is lined up with the slot on the carrier.
8. Push the planet shaft (13) all the way through the carrier (8) until the roll pin holes line up.
9. Using an alignment punch, align the roll pin holes in the carrier (8) with the roll pin holes in the planet shaft (10) and drive the roll pin (9) into the hole until it is flush with the carrier housing.
10. Repeat steps 4 to 10 for the remaining two planet gears.
11. At this point the carrier sub-assembly is complete.

Ring Gear/Cover Sub-Assembly

1. Grease and install O-Ring (5) into ring gear/cover (4).
2. Place disengage cap (2) on ring gear/cover (4) with the nipple facing out.
3. Fasten disengage cap (2) with two bolts (1). Torque bolts to 70-80 in-lbs.
4. Insert disengage rod (3) into ring gear/cover (2).
5. Install pipe plugs (6) into ring gear/cover (4).

Hub-Spindle Sub-Assembly

NOTE: *If your unit does not have studs, skip this step.*

1. Place the hub with the large diameter up on a flat surface. Using a bearing cup pressing tool press the inboard cup (24) into the housing (16). Turn the unit over.
2. Using a stud fixture and a hammer, carefully press studs (15) into the housing (16). If there is not a stud fixture available anything that can suspend the housing in the air can be used.
3. With the unit still in the fixture, press in the outboard cup (24).
4. Place outboard bearing (23) into the outboard cup.
5. With the housing still in the stud fixture, with a seal pressing fixture, press the seal (34) with the closed face up into the small diameter of the housing.
6. Place spindle (21) on a flat surface with large diameter down. Coat the seal shoulder with grease.
7. Place the hub onto spindle. Press bearing cone (23) onto the spindle.
8. Press the inboard bearing cone (23) onto the spindle until you get slight drag when rotating the hub.
9. Place the spacer (18) on the bearing cone. Install retaining ring (17) onto spindle (21). Do not use retaining ring pliers.

⚠ WARNING

SAFETY GLASSES MUST BE WORN DURING THIS STEP.

10. Insert Spring (15) into spindle (1A) counterbore. Place Spacer (16) on top of spring. Install retaining ring (17) into spindle counterbore using retaining ring pliers.

Main Assembly

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

1. Place hub-spindle sub-assembly on a flat surface.
2. Grease and install O-Ring (33) onto hub pilot.
3. Install retaining ring (32) onto input shaft (29) using retaining ring pliers.
4. Install input shaft (29) into spindle (21).
5. Install internal gear (31) onto spindle (21) spline.
6. Place thrust washer (27) on spindle (21) pilot.
7. Place thrust washer (20) into spindle (21) counterbore.
8. Time the assembled carrier with the large diameter of the cluster gears facing up. Make sure that all three punch marks on the gears are in the 12 o'clock position and secure the gear teeth.
9. Install the sun gear (28) into the cluster gears (11). Be sure that the punch marks remain in their correct location.

10. Install carrier sub-assembly with sun gear (28) onto input shaft (29) and into internal gear (31). Rotate the carrier to insure that the timing is correct.
11. Place second washer (27) into the counterbore of the carrier(8).
12. Install Ring gear/cover (4) sub-assembly onto the hub making sure that the holes on the ring gear/ cover (4) match up with the holes on the hub.
13. Secure ring gear/cover (4) to hub using three hex socket screws (7). Torque screws to 15-20 ft-lbs.
14. Install retaining ring (26) into coupling (25) using retaining ring pliers.
15. Insert coupling (25) into spindle (21) counterbore.
16. Roll check unit. To do this, you would turn the number of turns in each direction that the unit is being reduced. For example a 19 to 1 reduction would require 19 turns to the left and 19 turns to the right.
17. Air check unit by plugging up the input diameter of the spindle and filling the unit with air. If the unit retains all of the air after 15 minutes then it is good.

2.19 TORQUE HUB (S/N 39594 TO PRESENT)

NOTE: *All index number references in parentheses in the following paragraphs are in reference to Figure 2-29., Torque Hub (S/N 39594 to Present) - Cutaway View*

Main Disassembly

1. Turn hub (1G) over on its side. Remove coupling (14) from the wide end of the spindle (1A).
2. Mark the location of the shoulder bolt holes on outside of ring gear and hub for easy re-alignment when rebuilding. Remove the four shoulder bolts (13) and twelve bolts (12) from cover (6).
3. Remove the 16 flatwashers (16) from cover (6).
4. Lift cover sub assembly (6) off of ring gear (4), and set cover on the table, interior side facing up.

⚠ WARNING

BEWARE OF SHARP EDGES IN THE COUNTERBORE WHEN REMOVING THE O-RING.

5. Remove o-ring (5) from the counterbore around the edge of cover (6A). Discard the o-ring.

NOTE: *If o-ring is not in the cover counterbore, it is in the ring gear counterbore. Remove it from the hub and discard it.*

6. Remove thrust washer (11) from the counterbore in top of carrier (3A).
7. Remove input gear (8) from the middle of carrier sub-assembly.
8. Lift ring gear (4) off of hub (1G).
9. Lift carrier sub-assembly (3) out of hub (1G).
10. Remove the thrust spacer (9) from input shaft (7) in the middle of spindle (1A).
11. Lift input shaft sub-assembly (7) out of middle of spindle (1A), and stand input shaft (7A) on its splined end.

⚠ WARNING

WEAR SAFETY GLASSES DURING THIS STEP BEING AWARE THAT SPRING AND SPACERS COMPRESSED BY RETAINING RING MAY POP SUDDENLY OFF SHAFT WHEN REMOVING THE RETAINING RING.

12. Using retaining ring pliers, remove the retaining ring (7B) from the groove on the input shaft (7A).
13. Remove one spacer (7D), one spring (7C), and other spacer (7D) from input shaft (7A) on its splined end.
14. Remove thrust washer (11) from around spindle (1A).
15. Lift internal gear (2) out of hub (1G).

⚠ WARNING

BEWARE OF SHARP EDGES IN THE COUNTERBORE WHEN REMOVING THE O-RING.

16. Remove o-ring (5) from the counterbore in hub (1G). Discard o-ring.

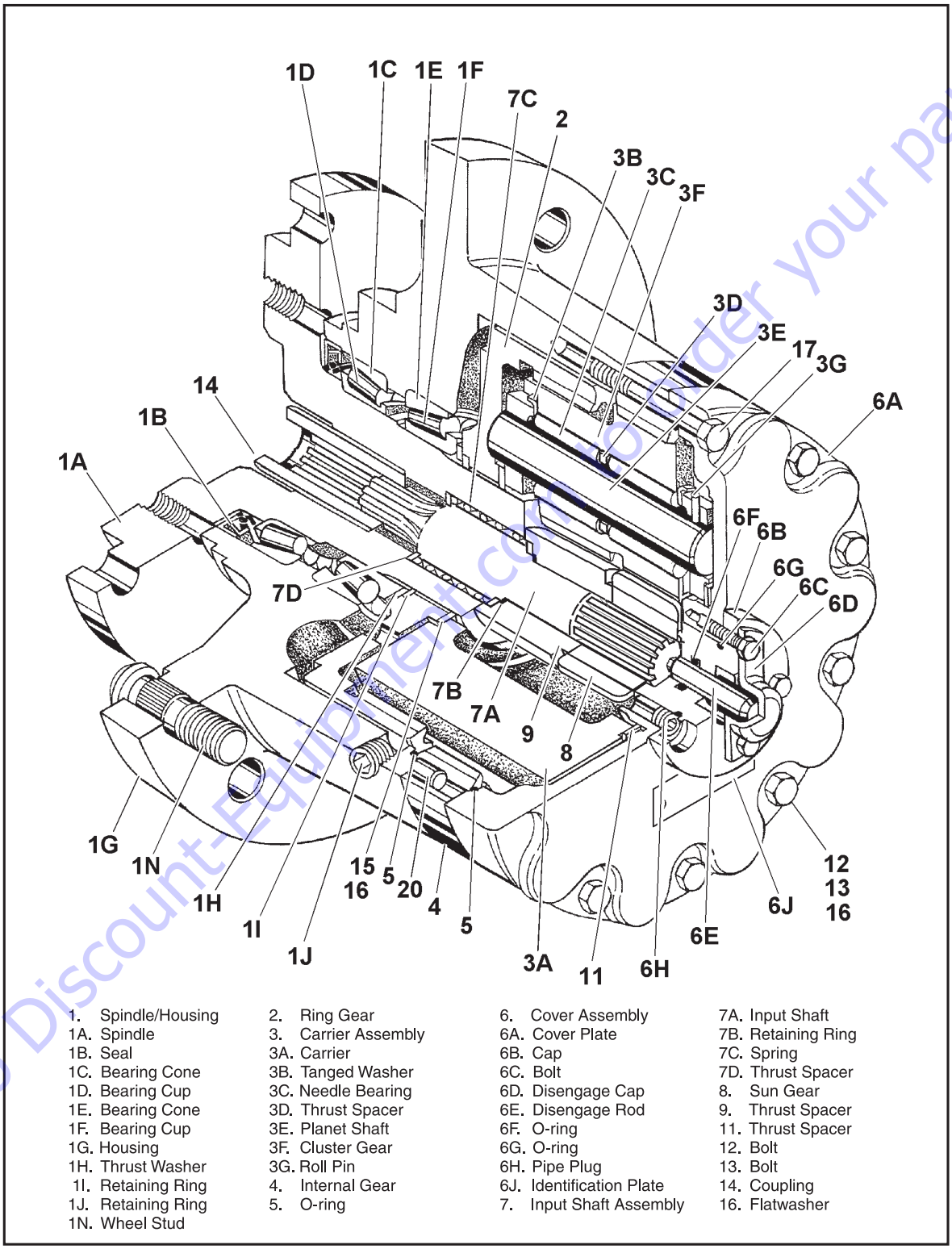
Hub-Spindle Disassembly

NOTE: *Start with the large end of hub facing up, large end of spindle facing down.*

⚠ WARNING

WEAR SAFETY GLASSES DURING STEP ONE.

1. Remove retaining ring (1I) from around spindle (1A) in hub (1G).
2. Remove spacer (1H) from around the spindle (1A) in hub (1G).



1. Spindle/Housing
1A. Spindle
1B. Seal
1C. Bearing Cone
1D. Bearing Cup
1E. Bearing Cone
1F. Bearing Cup
1G. Housing
1H. Thrust Washer
1I. Retaining Ring
1J. Retaining Ring
1N. Wheel Stud
2. Ring Gear
3. Carrier Assembly
3A. Carrier
3B. Tanged Washer
3C. Needle Bearing
3D. Thrust Spacer
3E. Planet Shaft
3F. Cluster Gear
3G. Roll Pin
4. Internal Gear
5. O-ring
6. Cover Assembly
6A. Cover Plate
6B. Cap
6C. Bolt
6D. Disengage Cap
6E. Disengage Rod
6F. O-ring
6G. O-ring
6H. Pipe Plug
6J. Identification Plate
7. Input Shaft Assembly
7A. Input Shaft
7B. Retaining Ring
7C. Spring
7D. Thrust Spacer
8. Sun Gear
9. Thrust Spacer
11. Thrust Spacer
12. Bolt
13. Bolt
14. Coupling
16. Flatwasher

Figure 2-29. Torque Hub (S/N 39594 to Present) - Cutaway View

3. Set hub (1G), small end/spindle facing down, up on something that will support the hub's flange while it lifts hub up so spindle is not resting on anything. Carefully press or hammer spindle (1A) down out of hub (1G).

NOTE: *If seal (1B) and bearing cone (1D) come out of hub and rest on spindle, remove these parts from the spindle and set them aside. Discard the seal.*

4. If seal and bearing cone did not come out of the small end of hub (1G) when the spindle was pressed out of the hub, remove seal (1B) and bearing cone (1D) from the small end of hub (1G). Discard the seal.
5. Bearing cone (1F) should be lying loose in wide end of hub (1G). Remove the bearing cone (1F) from inside of the hub (1G).

NOTE: *If using a punch and hammer, make sure not to strike the counterbore with the punch when removing the bearing cup.*

6. Remove the bearing cup (1C) from the counterbore in the small end of the hub (1G).

NOTE: *If using a punch and hammer, make sure not to strike the counterbore with the punch when removing the bearing cup.*

7. Turn hub (1G) over and lift it out of the flange-support. Remove the bearing cup (1E) from the counterbore in the wide end of hub (1G).
8. Turn hub (1G) over onto it's small end. Remove two pipe plugs (1J) from the two pipe plug holes in the side of the hub (1G)
9. Press the studs (1N) out of the hub (1G).

Cover Disassembly

1. Remove the two bolts (6C) holding the disconnect cap (6D) to the cover (6A).
2. Remove the disconnect cap (6D) from on top of cover cap (6B) and cover (6A).
3. Remove the two bolts (6C) holding the cover cap (6B) and cover (6A).
4. Remove cover cap (6B) from cover (6A).
5. Remove disconnect rod (6E) from cover cap (6B).
6. Pry o-ring (6F) out of the groove inside cover cap (6B). Discard the o-ring.
7. Remove o-ring (6G) from the flange of cover cap (6B). Discard the o-ring.
8. Remove pipe plug (6H) from cover (6A).

Carrier Disassembly

NOTE: *When you remove the needle rollers from the cluster gears, discard the old needle rollers and use new ones during re-assembly.*

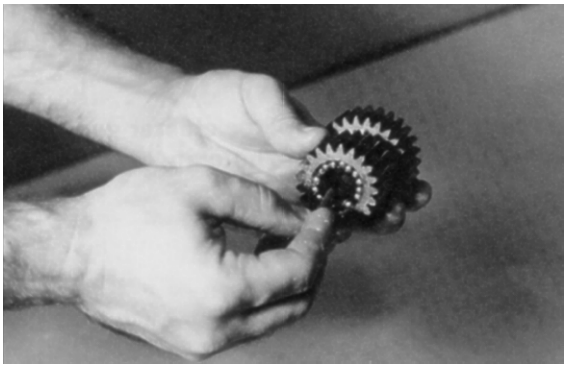
1. Using a punch and hammer, drive roll pin (3G) into planet shaft (3E).

NOTE: *If the roll pin is not driven all the way into the planet shaft, the carrier could be damaged when removing the planet shaft from the carrier.*

2. Using a punch and hammer, drive planet shaft (3E) out of the planet shaft hole in the carrier housing (3A).
3. When removing planet shaft (3E) from the carrier housing, one thrust washer (3B), one cluster gear (3F), and one more thrust washer (3B) will come off of the planet shaft and come to rest inside the carrier. Remove these parts from inside the carrier.
4. Remove 16 needle rollers (3C) from inside one end of cluster gear (3F). Discard the needle rollers.
5. Remove one spacer (3D) from inside the cluster gear (3F).
6. REmove the remaining 16 needle rollers (3C) from the other side of cluster gear (3F). Discard the needle rollers.
7. Repeat steps 1 thru 6 to remove and disassemble the two remaining clusters.

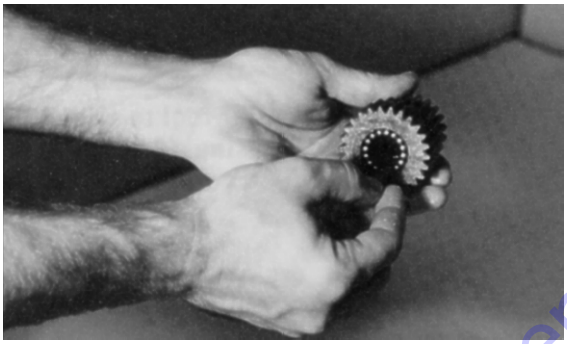
Assembly of the Carrier

1. Apply grease to the inside of one cluster gear (3F) and line one half of cluster gear with 16 needle rollers (3C).

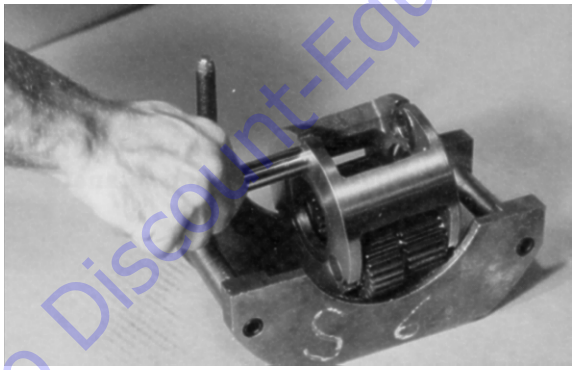


2. Place one spacer (3D) inside cluster gear (3F) so that it rests on top of the needle rollers.

3. Line the remaining half of cluster gear (3F) with 16 needle rollers.



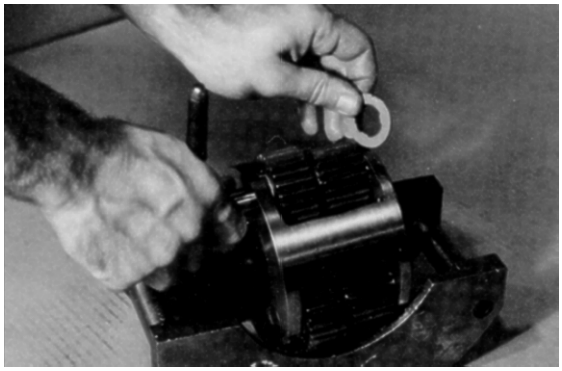
4. Set carrier housing (3A) on table, sideways. Insert a planet shaft (3E), roll pin hole last, into one of the planet shaft holes from roll-pin-holed side of carrier housing (3A).



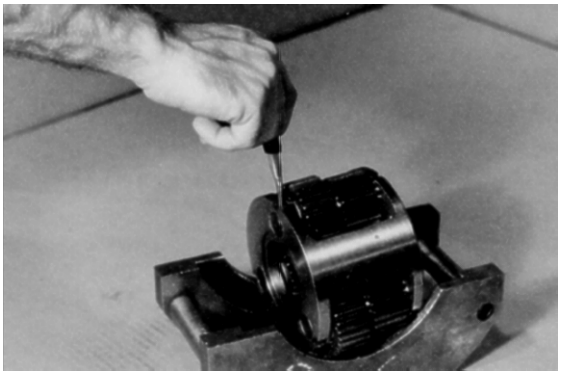
5. Place one thrust washer (3B) onto the end of planet shaft (3E) inside carrier. Fit tang of thrust washer into the slot on the inside edge of the planet shaft hole.

6. Following the thrust washer, place the cluster gear (3F), large end toward roll pin hole in carrier housing, onto the planet shaft (3E).

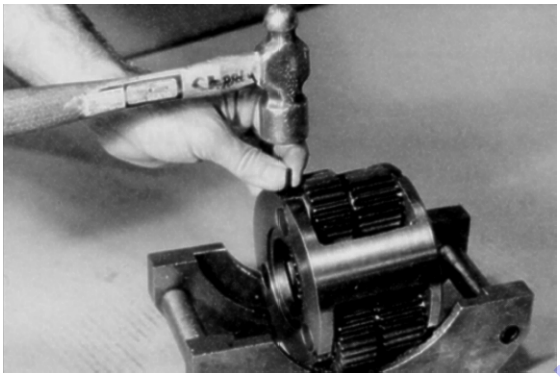
7. Following the cluster gear, place one more thrust washer (3B) onto planet shaft (3E) through the opposite planet shaft hole in carrier housing (3A).



8. Use an alignment punch or similar tool to align the roll pin holes in carrier housing (3A) and planet shaft (3E).



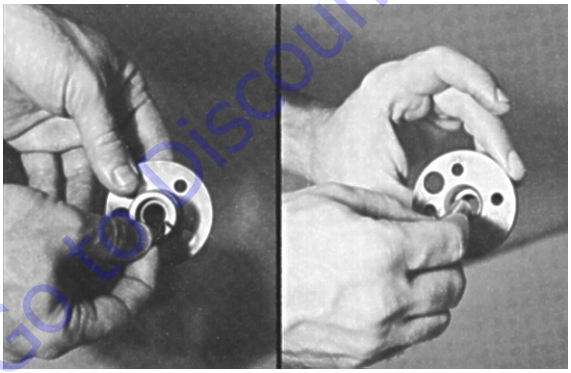
9. Drive roll pin (3G) down into the aligned roll pin holes in carrier housing (3A) and planet shaft (3E).



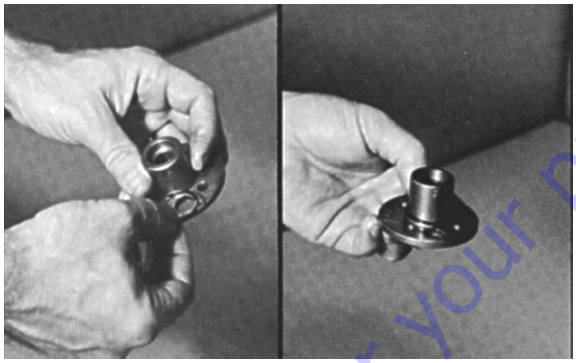
10. Repeat steps 1 thru 9 to assemble and install the two remaining cluster gears.

Assembly of the Cover

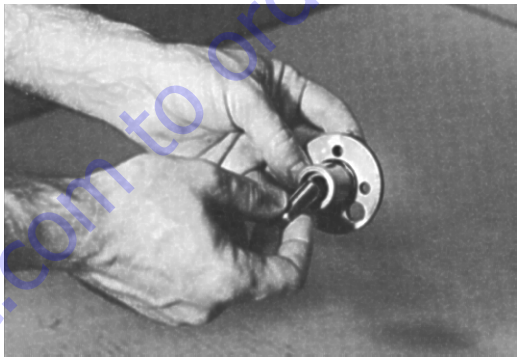
1. Using the disconnect rod, push o-ring (6F) into the groove inside the cover cap (6B).



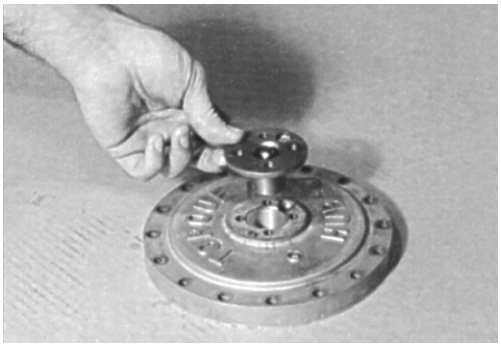
2. Place the o-ring (6G) onto the cover cap (6B) so that it rests against the flange of the cover cap.



3. Insert disconnect rod (6E) into cover cap (6B).

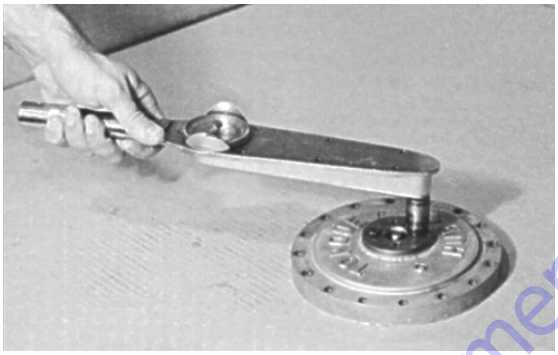


4. Set cover (6Aon table, exterior side up. Place cover cap (6B) onto cover (6A), aligning the pipe plug hole in the cover cap over the pipe plug hole in the cover.



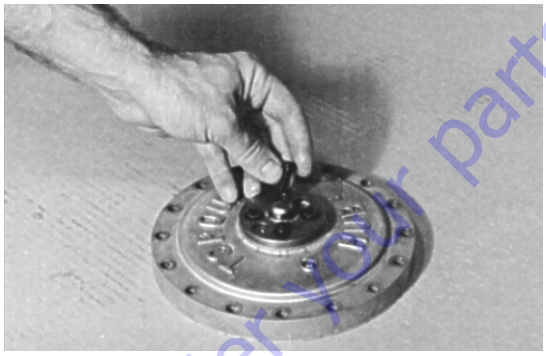
5. Place two of the cover cap bolts (6C) into any two bolt hoes that are 180° apart on the cover cap (6B) and tighten bolts.

6. Using a torque wrench, apply 36 to 49 in. lbs. (4 to 5 Nm) of torque to both bolts (6C).

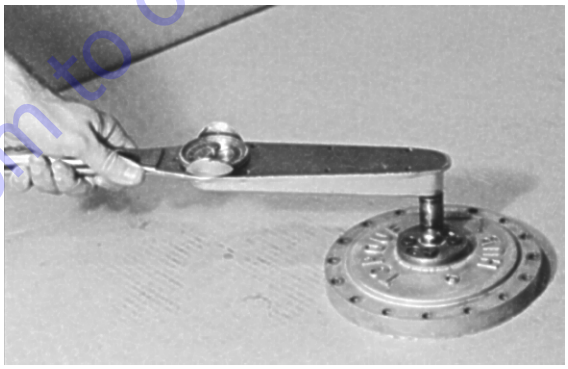


7. With the large end down, place the disconnect cap (6D) onto the cover cap (6B), aligning the pipe plug hole in the disconnect cap over the pipe plug hole in the cover cap.

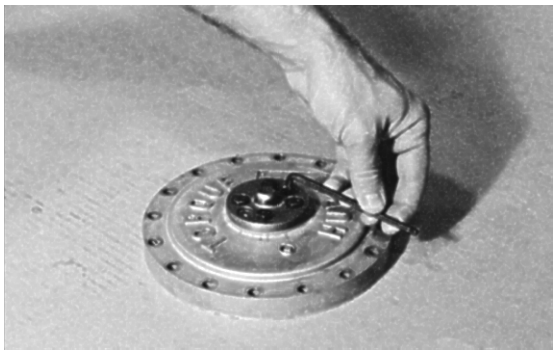
8. Place the two remaining bolts (6C) into the bolt holes in the disconnect cap (6D), and tighten the bolts.



9. Using a torque wrench, apply 36 to 49 in. lbs. (4 to 5 Nm) of torque to both bolts (6C).



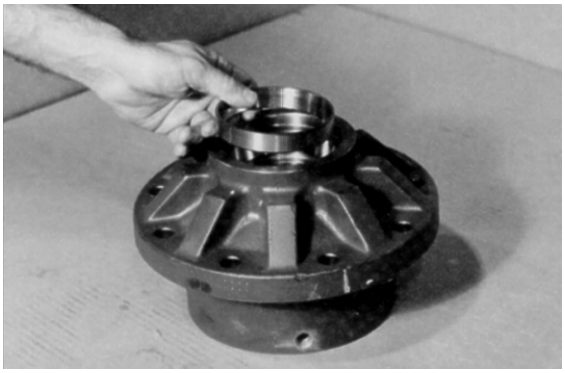
10. Apply a light coat of "Never-Seize" to pipe plug (6H) and tighten it into the pipe plug hole in the cover (6A).



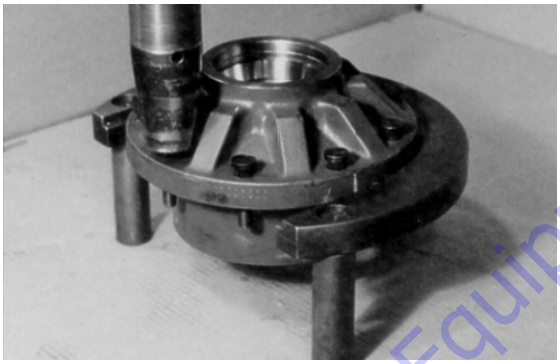
Hub-Spindle Sub-Assembly

NOTE: *Make sure the cup sits square with the counterbore before pressing.*

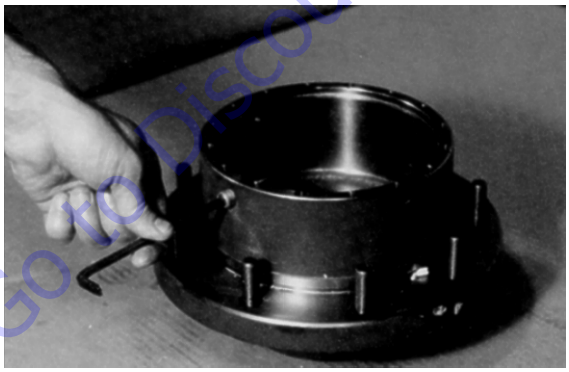
1. Set hub (1G) onto its large end. Press bearing cup (1C) into the counterbore in the small end of the hub (1G).



2. *Press the nine studs (1N) into the stud holes in hub (1G).*

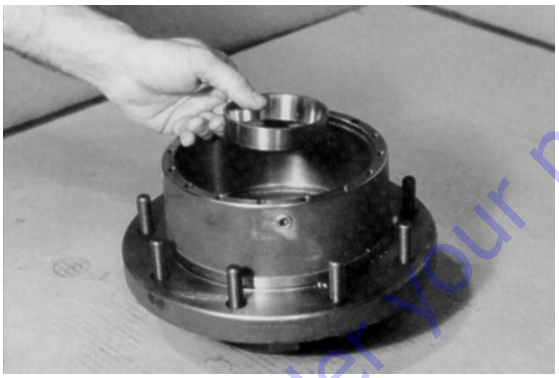


3. Apply a light coat of "Never-Seize" to two pipe plugs (1J) and tighten them into the two pipe plug holes in the side of the hub (1G).

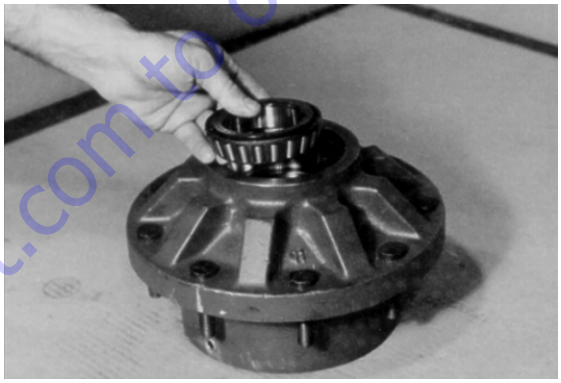


NOTE: *Make sure the cup sits square with the counterbore before pressing.*

4. Turn hub (1G) over onto its small end. Press bearing cup (1E) down into the counterbore in the deep end of the hub (1G).



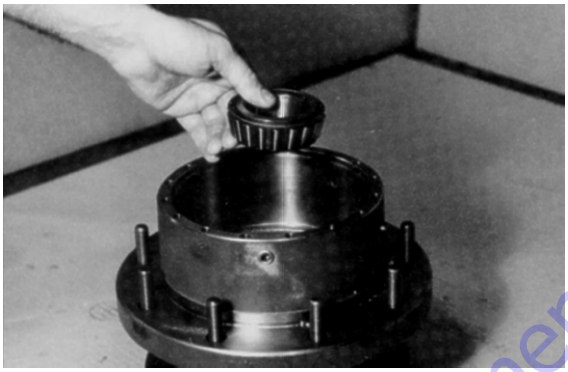
5. Set hub (1G) onto its large end. Place bearing cone (1D) into bearing cup (1C).



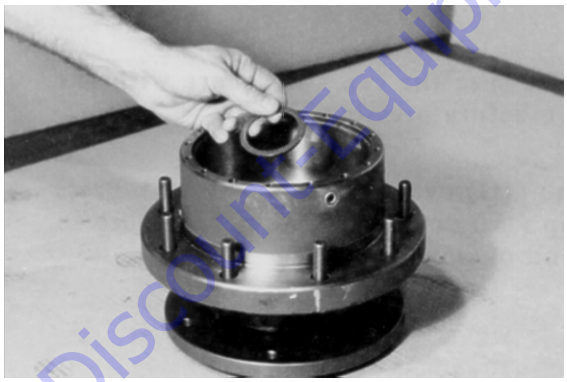
6. Press seal (1B) into the small end of hub (1G).

7. Oil spindle, then lower hub (1G), small end down, onto spindle (1A).

8. Press bearing cone (1F) onto spindle (1A) in hub (1G).



9. Place spacer (1H) onto spindle (1A) in hub (1G).



NOTE: *Make sure the retaining ring is securely seated in the groove.*

10. Place retaining ring (1I) over the spacer onto spindle (1A) in hub (1G).

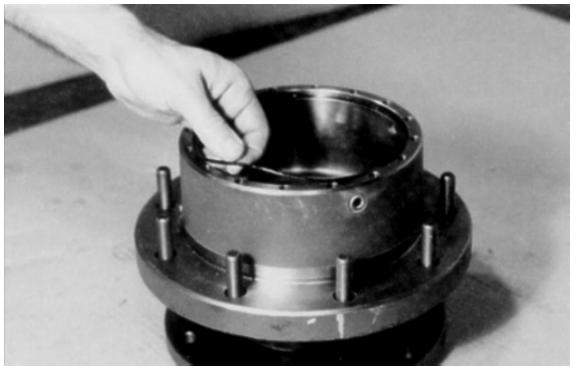
Main Assembly

⚠ WARNING

BEWARE OF SHARP EDGES IN COUNTERBORE WHEN INSTALLING THE O-RING

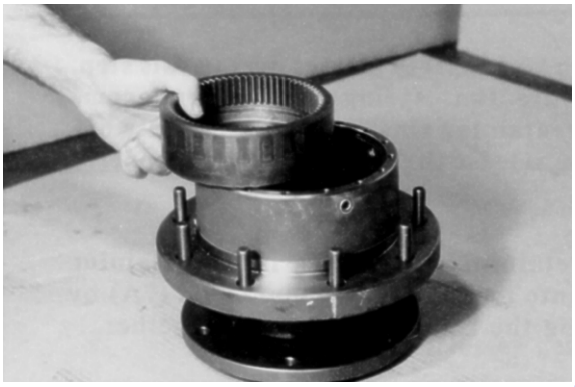
1. Grease o-ring (5) and place it into the counterbore in hub (1G).

NOTE: *O-ring may be stretched or pinched together to make it fit the counterbore exactly.*

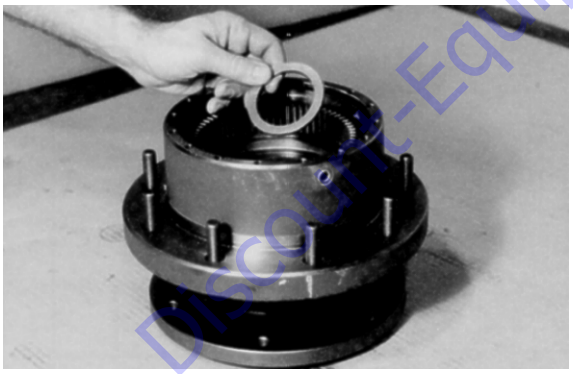


2. Oil all exposed surfaces inside hub (1G).

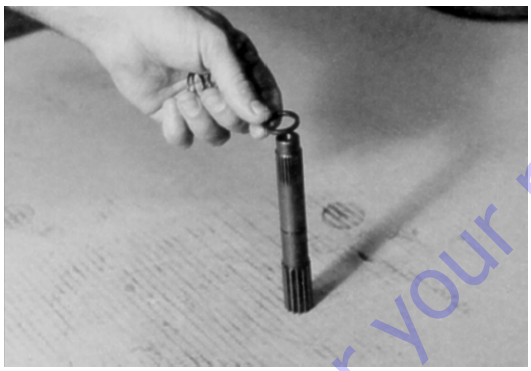
3. Place internal gear (2) into hub (1G) so that its internal splines mesh with the external splines of spindle (1A). Oil internal gear (2).



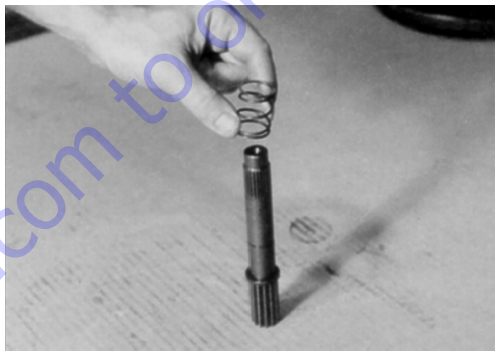
4. Place thrust washer (11) around spindle (1A) so it rests on the bottom of the internal gear (2).



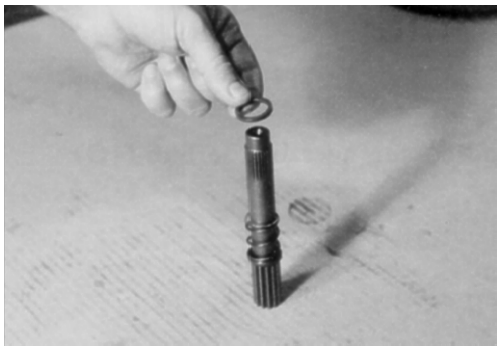
5. Stand input shaft (7A) on its splined end. Place one spacer (7D) onto the smooth end of input shaft (7A).



6. Place one spring (7C) onto the smooth end of input shaft (7A).



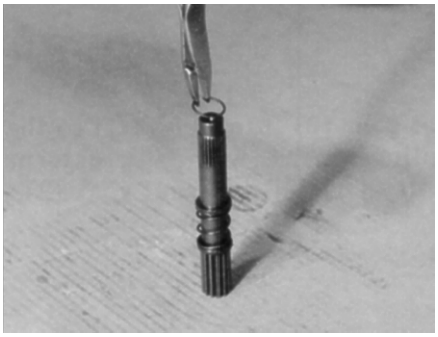
7. Place other spacer (7D) onto the smooth end of input shaft (7A).



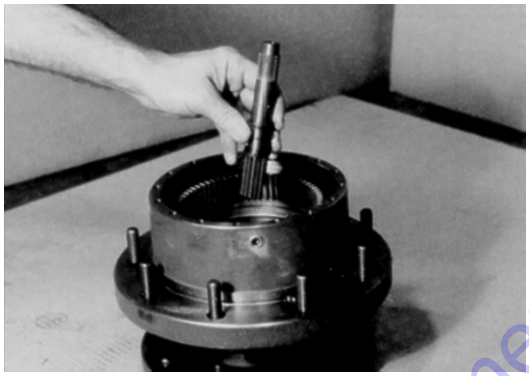
⚠ WARNING

WEAR SAFETY GLASSES DURING THIS STEP, AND BE AWARE THAT SPRING AND SPACERS, COMPRESSED BY RETAINING RING, MAY POP SUDDENLY OFF SHAFT IF THE RING IS RELEASED BEFORE IT IS PROPERLY IN PLACE.

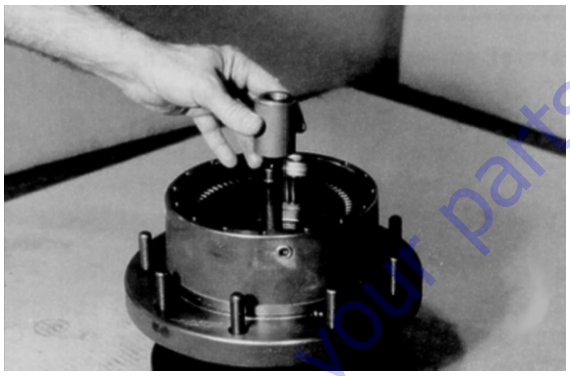
8. Using retaining ring pliers, insert retaining ring (7B) into the groove on input shaft (7A) by compressing the spring and spacers together.



9. With large splined end down, place input shaft sub-assembly (7) into spindle (1A).



10. Place thrust spacer (9) onto input shaft (7).



11. Set carrier sub-assembly (3) on a flat work surface so the large ends of cluster gears (3F) face up. Locate the punch marks on the face of each cluster gear (3F) and position them at 12 o'clock.

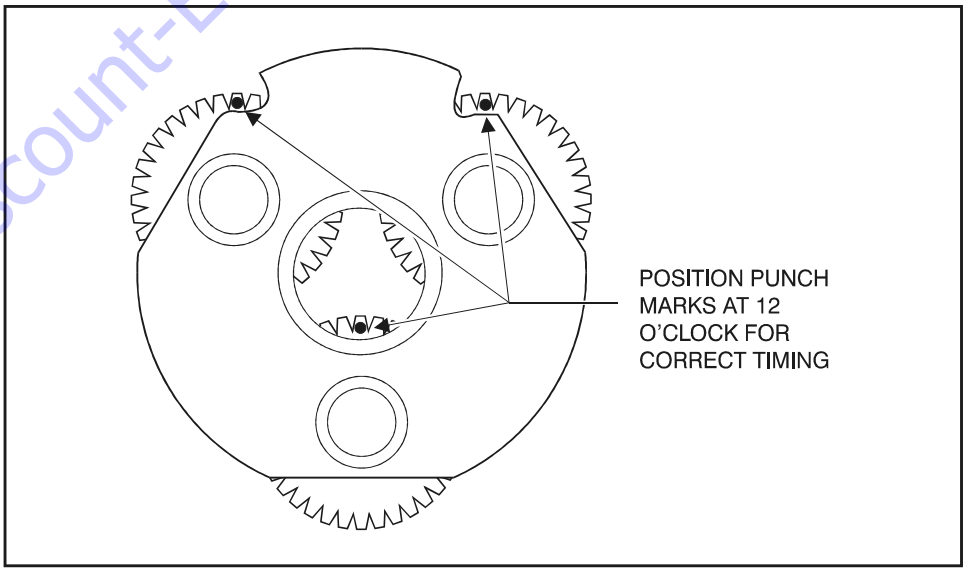
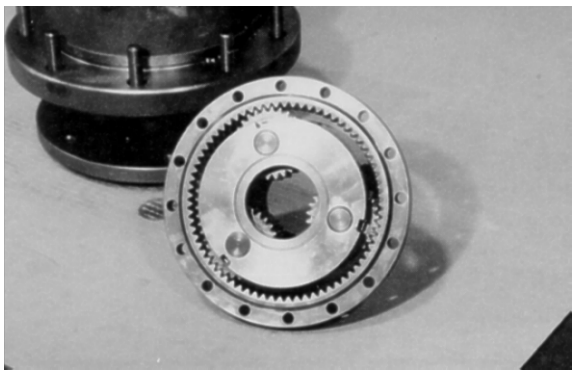


Figure 2-30. Cluster Gear Punch Marks

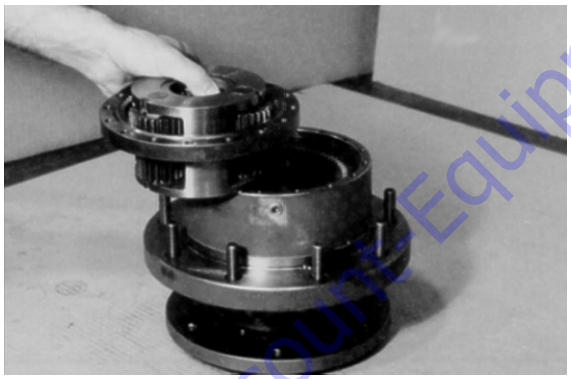
12. With "X" marked side facing up, place the ring gear (4) around cluster gears (3F).

NOTE: *This will hold the punch marks in position while installing the carrier into the hub.*

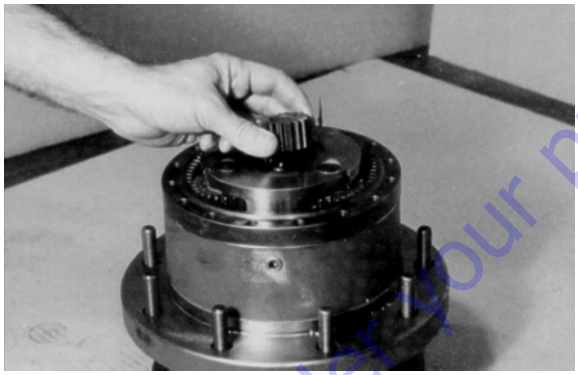


13. Place the carrier sub assembly (3) and ring gear (4) together into mesh with internal gear (2), aligning the "X" marked shoulder bolt hole in the ring gear (4) over one of the shoulder bolt holes in the hub. Mark the location of shoulder bolt holes on the outside of ring gear and hub.

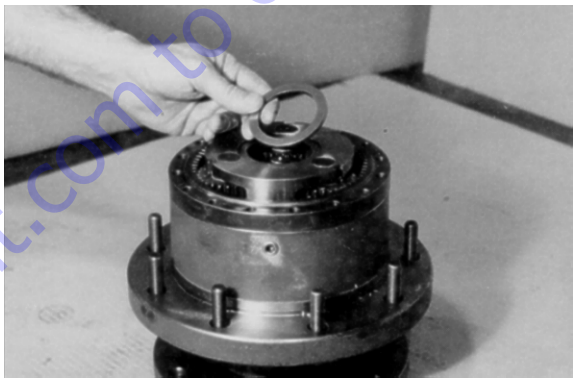
NOTE: *You may lift the ring gear off the hub to align the shoulder bolt holes. The ring gear and carrier are installed together only to keep the punch marks on the carrier in place.*



14. With the internal splines facing up (counterbore end facing down), place input gear (8) into mesh with carrier sub-assembly (3).



15. Oil all exposed surfaces inside the hub (1G). Place thrust washer (11) into the counterbore in top of the carrier.

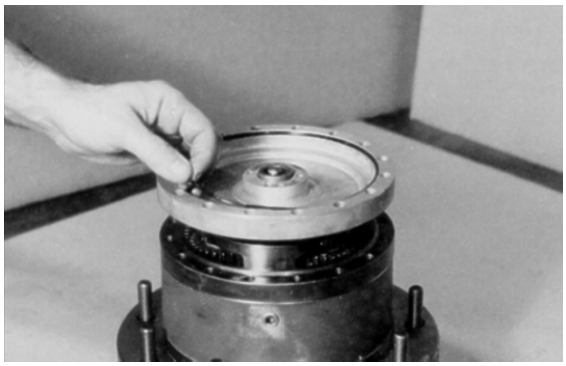


⚠ WARNING

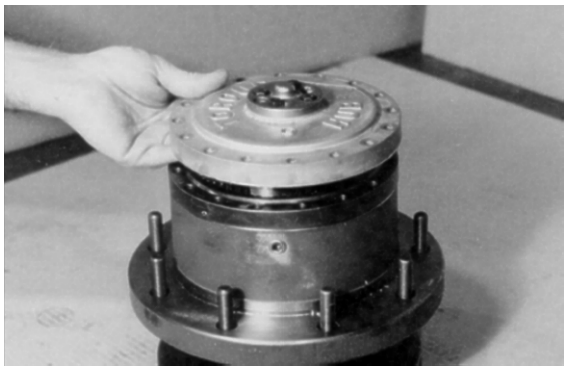
BEWARE OF SHARP EDGES IN THE COUNTERBORE WHEN YOU INSTALL THE O-RING.

16. Set the cover (6A) on table, interior side up. Grease o-ring (5) and place it into the counterbore around the edge of cover (6A).

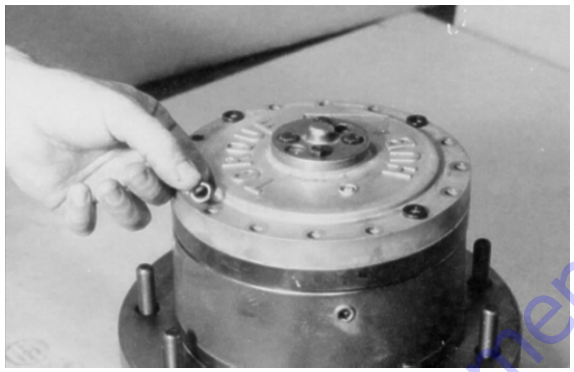
NOTE: *The o-ring may be stretched or pinched together to make it fit the counterbore exactly.*



17. Place cover sub-assembly (6) onto ring gear (4), aligning the pipe plug holes according to the alignment prior to disassembly.



18. Place four flatwashers (16) on top of the bolt holes in the cover sub-assembly.



19. Place shoulder bolts (13) into the four shoulder bolt holes in cover (6) and tighten by hand.

20. Place the remaining 12 flatwashers (16) onto the remaining bolt holes in cover (6).
21. Place the 12 bolts into the remaining bolt holes in cover (6) and tighten.
22. Torque the shoulder bolts (13) 18 to 25 ft.lbs. (25 to 34 Nm). Torque bolts (12) 18 to 25 ft.lbs. (25 to 34 Nm).
23. Turn hub (1G) over onto its side. Insert coupling (14) into the end of the spindle (1A).
24. Roll test the unit in both clockwise and counterclockwise directions. Perform the same number of turns in each direction as the ratio of the unit. The ratio is the last two digits of the model number on the unit's ID tag.
25. Leak test the unit at a pressure of 5 psi for 2 to 3 minutes.

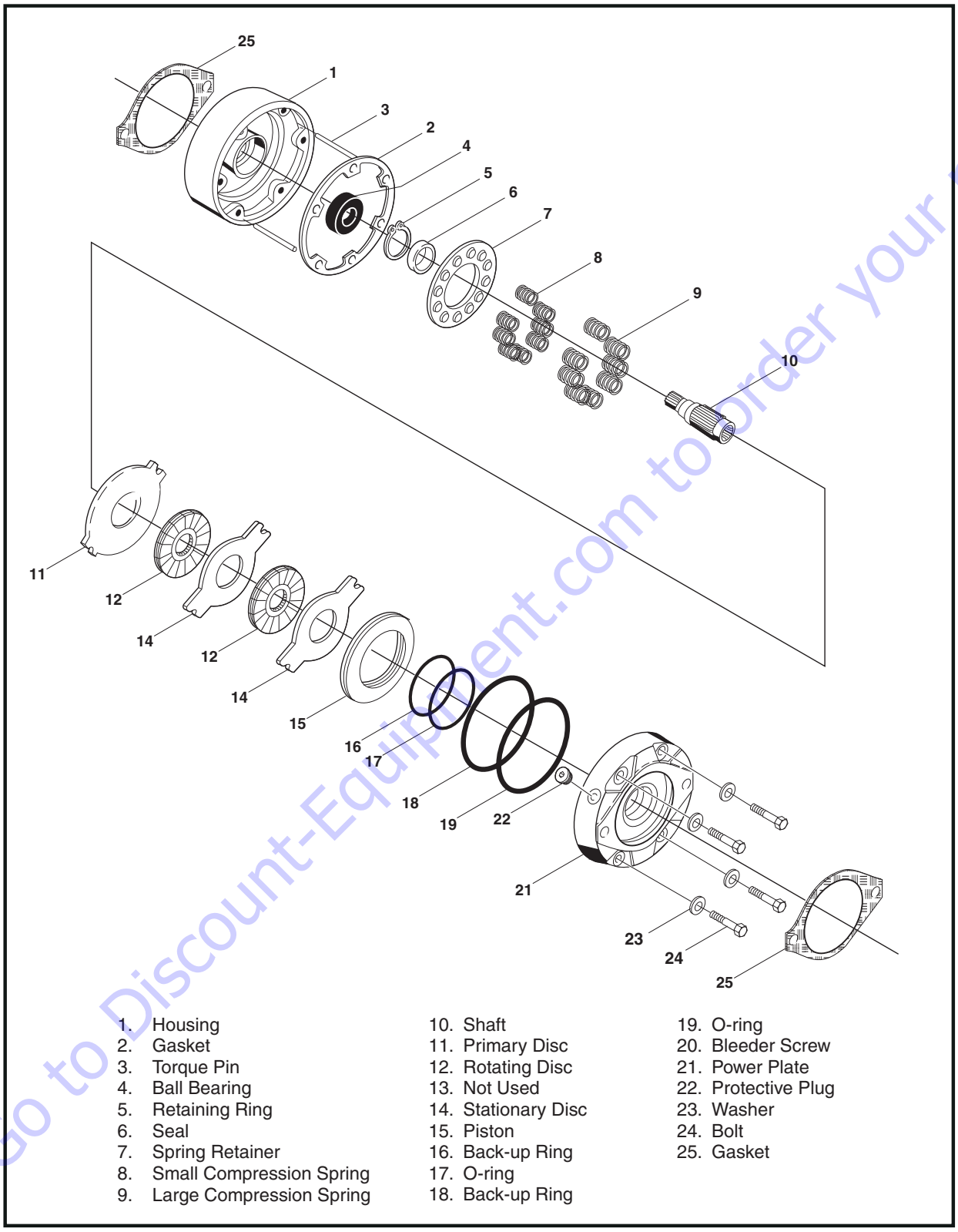
2.20 DRIVE BRAKE (AUSCO)

Disassembly

1. With the shaft protrusion downward, disassemble the parts in the following order; bolts (24) alternately, washers (23), power plate (21), and gasket.
2. Remove the following parts; stationary discs (14), rotating discs (12), primary disc (11), torque pins (3), springs (8&9), and the spring retainer (7).

NOTE: *If the bearing and seal are removed for any reason both must be replaced.*

3. Further disassembly is not recommended and should not be attempted unless necessary to replace the bearing (4), the seal (6), or the shaft (10). If further disassembly is needed, proceed as follows;
   a. The shaft (10) may be removed by pressing on the end of the shaft with a shop press.
   b. Using an appropriate tool, pry the seal (6) out from the inside of the brake. Take care not to damage the bore. Remove the retaining ring (5). Tap the bearing (4) out with a plastic mallet.
4. Remove the piston (15) from the power plate (21) by introducing low pressure air into the hydraulic inlet and make sure the piston is directed away from the operator. Remove the o-rings (17&19) and backup rings (16 & 18) from the piston O.D. and I.D. grooves. Do not remove backup rings (16 & 18) unless replacement is necessary because they will be damaged.



1. Housing
2. Gasket
3. Torque Pin
4. Ball Bearing
5. Retaining Ring
6. Seal
7. Spring Retainer
8. Small Compression Spring
9. Large Compression Spring
10. Shaft
11. Primary Disc
12. Rotating Disc
13. Not Used
14. Stationary Disc
15. Piston
16. Back-up Ring
17. O-ring
18. Back-up Ring
19. O-ring
20. Bleeder Screw
21. Power Plate
22. Protective Plug
23. Washer
24. Bolt
25. Gasket

Figure 2-31. Drive Brake (Ausco)

Assembly

⚠ IMPORTANT

THERE MAY BE MORE PARTS IN A SERVICE KIT THAN YOUR BRAKE REQUIRES. CHECK THE PARTS LIST CAREFULLY FOR THE EXACT QUANTITY. IN THE CASE OF SPRINGS, SPACE THE SPRINGS AS SHOWN IN THE FIGURE.

5. Worn o-rings and damaged or worn Teflon backup rings must be replaced prior to assembly.
6. The cylinder of the power plate, piston, and o-rings must be clean prior to assembly and pre-lubed with the system hydraulic fluid.

⚠ CAUTION

THE DEPTH THE PISTON IS INSTALLED INTO THE POWER PLATE IS CRITICAL. THE SURFACE OF THE PISTON AT THE CUTOUTS MUST BE FLUSH TO 0.120 IN BELOW THE SURFACE OF THE POWER PLATE. DO NOT EXCEED THE 0.120 DEPTH OR THE PISTON WILL COCK RESULTING IN A COMPLETE LOSS OF BRAKING.

7. Assemble the piston (15) into the power plate (21) using a shop press, being careful not to damage the o-rings or Teflon back-up rings. Visually align the center of the cutouts in the piston with the torque pin (3) holes in the power plate (21).
8. For replacement of the seal;
   a. Use a shop press to install the bearing (4) into the housing. Press on the outer surface of the bearing only. Install the retaining ring (5) into the groove.
   b. Press the seal (6) into the housing (1) until it is flush with the face of the housing. The lip of the seal must face towards the bearing.
9. Press the shaft into the housing until it stops on the bearing. Support the inner race of the bearing during the press operation.
10. Rotating discs must be clean and dry. The lining material and mating surfaces of the stationary discs must be thoroughly clean and free of debris. Worn or scored rotating discs must be replaced.
11. Install bolts (24) with washers (23) in the power plate (21). Tighten sequentially, one turn at a time, until the power plate is properly seated. Torque 105 to 115 foot-pounds.

2.21 BOOM LIMIT SWITCHES

There are no adjustments to be made to the two boom limit switches which bolt in place on the uprights.

2.22 LIFT UP AND PLATFORM LEVEL DOWN DISABLE SWITCH

The purpose of the disable switch is to prevent lift up when the boom is near full elevation and the platform is out of level.

Adjustment

1. Position the proximity switch so that it is just flush with the mounting bracket to ensure that it will not come in contact with the contact plate.

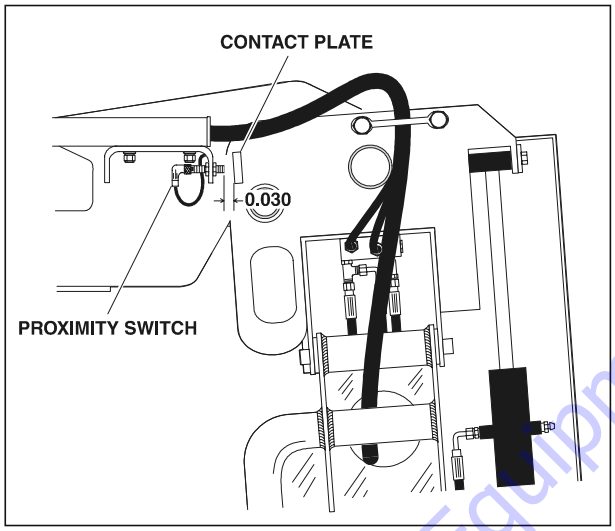


Figure 2-32. Switch Adjustment

2. Using the ground controls, activate level down until the platform basket is under the boom in a position to line up the contact plate with the limit switch.
3. Adjust the proximity switch so there is 0.030 inch (0.8 mm) clearance between the end of the switch and the contact plate or until the light comes on.

Functional Check

⚠ IMPORTANT

DISABLE SWITCH FUNCTIONAL CHECK MUST BE PERFORMED QUARTERLY, ANY TIME A SYSTEM COMPONENT IS REPLACED, OR WHEN IMPROPER SYSTEM OPERATION IS SUSPECTED.

1. Tape a small piece of metal to the end of the limit switch (e.g. a coin).

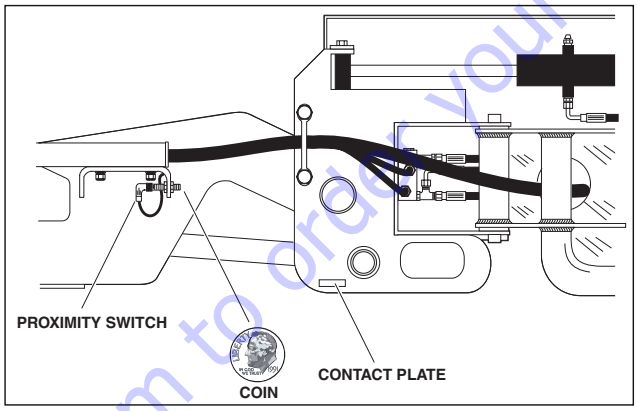


Figure 2-33. Functional Check

2. Using the controls in the platform basket, test the lift up and platform level down functions. Both operations should be locked out and not function.
3. Remove metal (coin) and return machine to service.

2.23 ELECTRIC GOVERNOR INSTALLATION AND ADJUSTMENTS - FORD ENGINE (PRIOR TO S/N 46089)

General

These instructions presume no electrical test equipment other than a multimeter for making the electrical measurements called for on the following pages. If no suitable meter is available, an inexpensive but adequate meter, part number 22-188 is available from any local Radio Shack store.

Many governor problems turn out to be installation problems, particularly in first-time applications. Careful attention to the directions provided will go far toward a successful installation made in the least amount of time.

Quick-start Installations

If you are experienced in installing and adjusting Electric Governor, follow these steps. Otherwise, refer to the more detailed instructions starting with MOUNTING-ACTUATOR.

1. Mount Actuator rigidly to engine location which will permit a short, straight linkage to the carburetor or fuel valve. Avoid very hot areas.
2. Mount controller in a dry, fairly cool location. Accessibility for adjusting is required.
3. Wire per appropriate included schematic, using #16 wire.
4. Set up fuel linkage. This is critical, so review the section titled LINKAGE.
5. Hold linkage for safety, and start engine.
6. Adjust engine speed to desired valve using High Engine pot. Turn CW to increase, CCW to decrease speed. (See diagram on page 43 E-331 Electronics - Adjustment Locations.)

Mounting-Actuator

The Actuator may be mounted in any attitude; there is no preferred orientation.

With no power applied, the Actuator is spring-loaded to the minimum fuel position. The Actuator output shaft rotates toward the maximum fuel position against this spring through electrical power from the controller. This rotation is CW (clockwise) on one side of the Actuator, and CCW (counterclockwise) on the other. If necessary, reverse the Actuator on its mounting plate so that the desired direction of rotation is on the desired side to match the fuel system direction of travel.

Before selecting the mounting location, consider the linkage that will be required to connect the Actuator output arm to the butterfly or fuel valve. Read the following section on linkages before deciding on a mounting location!

1. Mount Actuator rigidly to engine location which will permit a short, straight linkage to the carburetor or fuel valve. Avoid very hot areas.

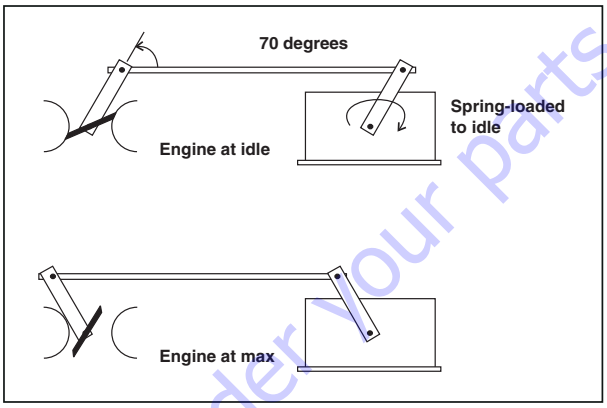
Linkage

1/4" -28 threaded rod and low friction rod-end bearings are recommended for linkage materials.

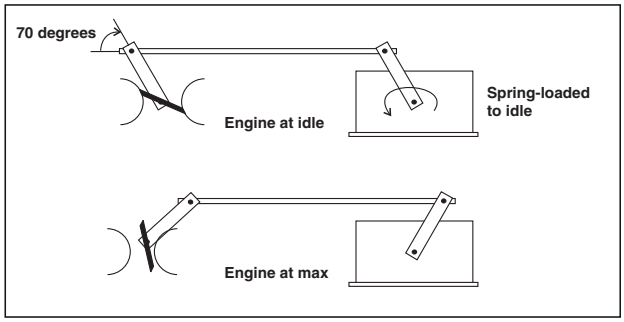
Keep the linkage as short and as straight as possible.

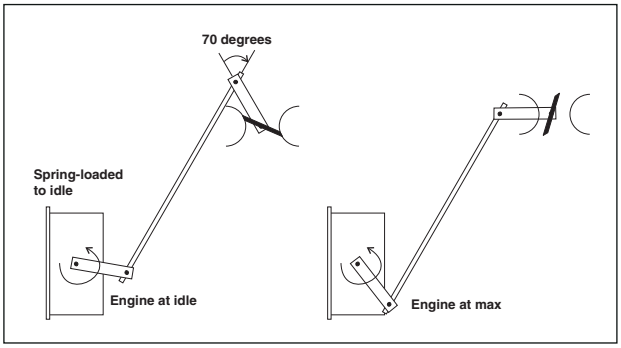
The linkage must not rub against the engine, brackets, hoses, etc. The linkage must be free of friction and lost motion or slop.

The following sketch indicates the proper linkage geometry for most installations.



Note that the angle between the carburetor arm and the rod is 70 degrees with the engine at idle. This is highly desirable! Note also that the Actuator arm travels equally on either side of a 90 degree angle with the rod. This angular arrangement will give the proper mechanical gain for good stability and performance. It may be necessary to rotate the carburetor arm relative to the butterfly to achieve this. This can usually be done, and is usually worth the effort! Below are some workable installations, with good linkages. Remember, the Actuator can be turned 180 degrees on its mounting to reverse the spring-loaded direction. Also, the Actuator can be mounted in any attitude.





The needed travel of the carburetor determines how far out on the Actuator arm the rod is to be attached. In most cases, the carburetor should be moved from closed to above 10 degrees from full open as the Actuator is moved min. to max. THEN ALTER THE LENGTH OF THE ROD SLIGHTLY (PERHAPS 0.030"), SO THAT THE ACTUATOR IS JUST OFF ITS INTERNAL STOP, AND IS PULLING THE BUTTERFLY AGAINST ITS STOP. This insures that the carburetor can fully close to idle on load dumps, minimizing overspeeds.

Examine the system for springs, such as carburetor return springs. These should be removed. Some automotive carburetors (as opposed to industrial carburetors) contain internal springs for accelerator pumps, etc. These may make good governing difficult, or even impossible. For this, and other reasons, industrial carburetors are much to be preferred.

Move the linkage slowly through its travel, and look for any binding or unexplained forces. Correct any before going further.

Many governing problems are really caused by binding of the butterfly and its shaft in the carburetor. This is caused by loading due to vacuum under the butterfly and atmospheric pressure above when the engine is running. These forces cannot be felt when the engine is not running. Therefore, start the engine while carefully controlling the speed by hand, and feel for binding or airload forces. Needle bearings on the butterfly shaft are available on many industrial carburetors to deal with this problem. Any tendency on the butterfly stick must be corrected.

Mounting-Controller

Select a reasonably cool, dry, and vibration free location.

The rear cover will probably need to be removed during set-up in order to make adjustments for speed setting and gain. You may wish to defer final installation until this is done.

After completing these adjustments, replace cover. Mount so that water cannot pool on this cover. Always mount the controller with the strain relief down. This will prevent water from entering thru the cable, also place the vent hole in the bottom of the controller down.

Wiring

See wiring diagram for details of hook-up.

Use #16 wire minimum.

Keep all wiring to the Governor as short as is practical.

Go directly from the controller ground terminal (B of the 8 pin connector) by dedicated wire, to the battery minus terminal. If this cannot be done, for some reason, go by dedicated wire to a very good engine ground.

A properly functioning engine electrical system will supply 13.5 - 14.8 VDC when the engine is running. If wiring size is adequate, with good connections and proper grounds, you will get this reading between the wires terminals A & B of the 8 pin connector when the Governor is controlling engine speed. Verify this.

Improper hook-up can damage electronics. Re-check wiring before applying power.

Check-Out and Initial Start-Up Procedures

Before proceeding, familiarize yourself with the locations of the various adjustment pots. There are two types of adjustment pots.

Multi-Turn Adjustment (High Engine, Mid Engine, Overspeed, Starter Lockout)

This adjustment is made by turning the 1/8" brass screw clockwise (CW) to increase speed, and counterclockwise (CCW) to decrease speed. The adjustment range of the pot is 25 turns, and one full turn will change speed about 100-200 rpm. This pot is protected by a slip clutch at each end, and will not be harmed by moderate over-adjustment. However, the Governor will not function while the pot is past full travel. If you suspect you may have over-adjusted the High Engine pot, or have lost track of where you are, turn the pot 25-30 turns CCW, then back 10-12 turns CW to get back into the range of normal adjustment.

Single-Turn Adjustment (Gain, Factory Adjust)

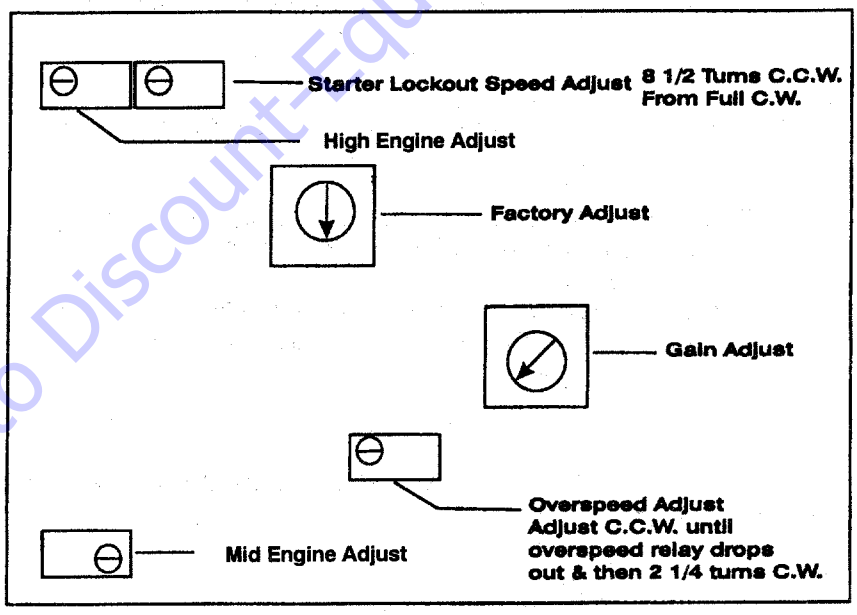
This pot is 3/8" square and has a 1/8" plastic screw in its center. Be gentle! This pot turns 270 degrees, and overturning will break the internal stops, making adjustment impossible. Turning this pot CW increase Governor sensitivity. On most applications, best operation is achieved with the pot set as shown in diagram below.

NOTE: *These settings are factory set, Start Lockout, Factory Adjust and Overspeed. They are conformally coated by P.G. and should not need to be reset.*

Assuming that the Actuator and Controller are mounted, the wiring is run and checked, and that the linkage is properly installed, proceed as follows:

1. Turn ignition switch on. Do not start engine. Actuator should kick toward max. fuel once, and then immediately return to min. fuel. If not, see Troubleshooting.
2. Use multimeter to check battery voltage at battery terminals, and record. Now check voltage at the machine connection points for terminals A & B of the 8 pin connector on the E-331 (A is +, B is -). Voltage reading should be the same as at battery. If not, shut down, and correct wiring.
3. Hold the linkage back by hand, so as to control engine speed manually. Start engine, set vehicle controls to obtain High Engine speed, gradually release the linkage, and adjust the speed-set as needed to set the speed as desired. If engine speed surges, reduce Gain a little, as required (CCW).
4. Re-check voltage between terminal A & B as in step 2. Voltage reading should be between 13.5 - 14.6 VDC.
5. Carefully adjust Gain. You are looking for the best compromise between quick response and good stability. Make very small adjustments, then load and unload engine, or pull linkage back slightly and release. Usually, a good set-up is one that makes 1 to 3 small bounces and then steadies down after a large change. Too much Gain shows up as a rapid (once per second) instability, most commonly at light loads. Too little Gain shows up in large overshoots on start-up or large load changes, and generally sluggish operation.
6. Make final adjustment to the High Engine Pot.
7. Set machine controls to obtain the mid-engine speed. Adjust the mid-engine pot as needed to obtain the speed desired.
8. The start lockout adjustment is factory set. If necessary, he starter lockout pot may be adjusted to obtain dropout of the starter as the engine attains running speed. Normally this is around 500 RPM.

Part No. 1600211



Connections

A Power
B Ground
C Ignition Signal
D Ignition Signal
E Actuator
F Actuator
G Starter Relay GND
H Overspeed Relay GND

A Elevation Switch
B Drive Control Switch
C Mid-Speed Switch
D Starter Switch

Set Main Speed Before Setting Overspeed

Directional arrows ⊘ Indicate normal settings.

9. The overspeed adjustment is factory set. If necessary, it may be readjusted to shut off ignition power at a different engine speed by means of the overspeed adjustment pot. The overspeed is simply to shut down an over revving engine.

NOTE: *Overspeed to be set at 4000 - 4500 RPM's. This is not a function we test for correct settings. The High Engine speed must be set before setting the overspeed.*

10. Re-install the back cover on the E-331. Final mount the controller.

Troubleshooting

We will discuss Troubleshooting in two general categories:

a. Governor won't work.
b. Governor works, but can't be set up to give satisfactory performance.

There is, of course, some overlap between these categories. Read both sections and apply the fixes that seem appropriate.

NOTE: *During troubleshooting, be prepared to control the engine manually to prevent overspeeds, etc.*

Governor won't work.

No reaction from Governor. Actuator output arm never moved, engine off or engine running. Can be caused by: No power, Incorrect linkage, preventing movement, Incorrect electrical hook-up, No speed signal to Governor, Damaged Controller or Actuator.

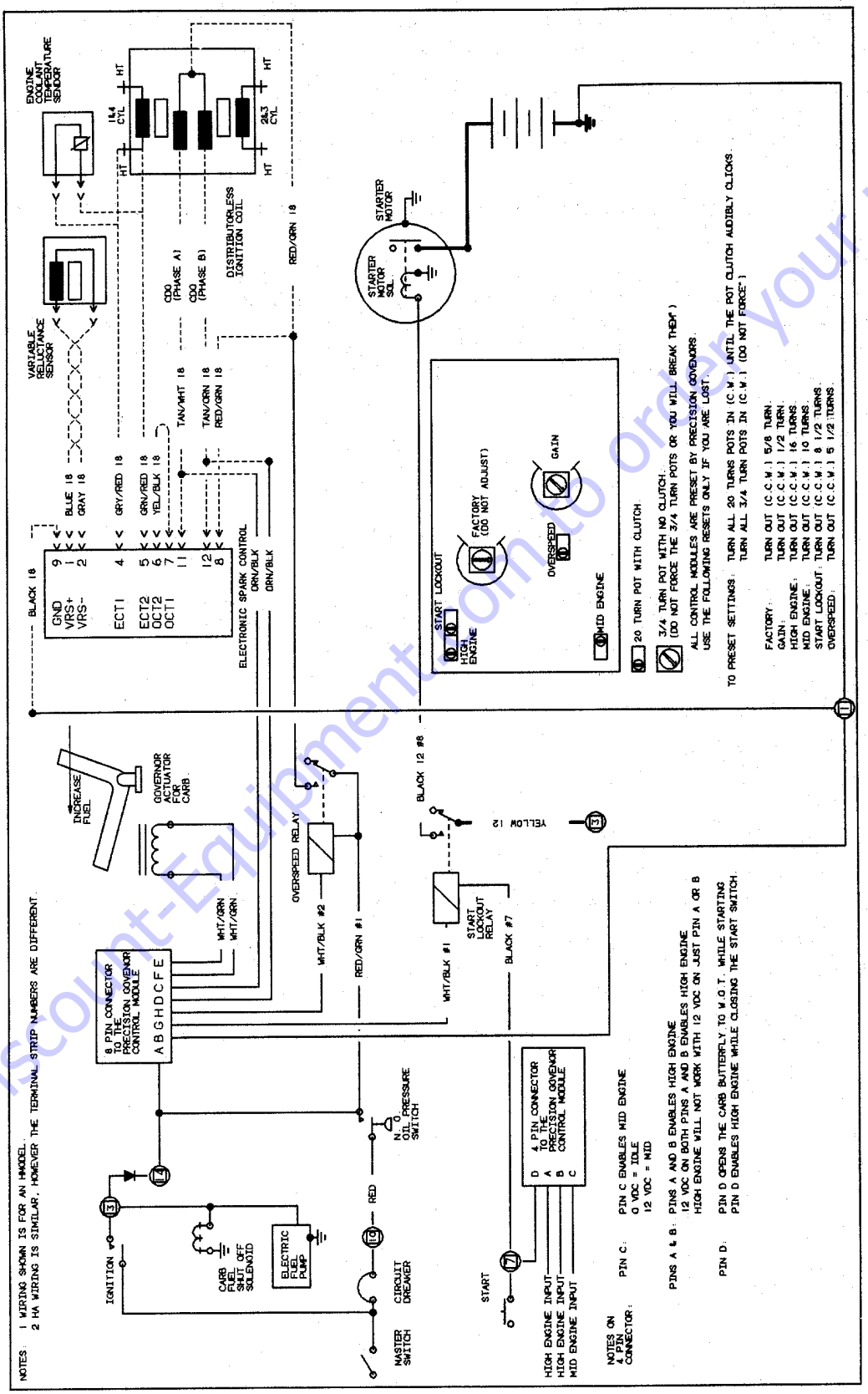
1. **No power** - Use a multimeter to check for 12-15 VDC between terminals A & B on the controller. Check during engine off and engine running conditions. If voltage is absent or low, check for:
   a. Wiring error.
   b. Hook-up on wrong side of ballast resistor.
   c. Low battery.
   d. Bad voltage regulator.
   e. Bad ground connection.
   f. Corroded terminals.
   g. Undersized wiring.
2. **Incorrect Linkage** - Re-check linkage as discussed on page 40 and 41. Freedom of movement and lack of play are important.
3. Incorrect Electrical Hook-up - Re-check all wiring and connections to the Actuator and Controller against the supplied schematic.
4. **No speed signal to Controller.**
   a. Check the voltage between terminals C and ground and D and ground of the 8 pin connector with the engine running. You should see 5 - 30 VDC.
   b. The above checks do not guarantee a good speed signal, but their absence proves that there is a problem.
5. Incorrect Electrical Hook-up - If steps 1 - 4 above have not revealed the problem, the governor may have been damaged, either in shipping or during hook-up and test.

Governor reacts, but can't be set up to give proper performance.

This kind of trouble usually falls into three main categories: Actual Governor malfunction, Governor installation problems and improper installation, or Governor not tuned or adjusted for engine/application.

NOTE: *Assure the engine is operating properly by running engine manually. The Governor will not control any poor running engine.*

1. **Actual Governor Malfunction** - The Governor was engine-tested for proper operation just prior to being shipped. Unless damaged in shipment or by improper handing, it should be serviceable. To check for proper operation proceed as follows:
   a. Once again, disconnect fuel system linkage from Governor output arm and control engine manually.
   b. Start engine, hold at a low speed, Governor arm should move to full-fuel position.
   c. Increase engine speed carefully. At some engine speed, Governor arm should move to low-fuel position.



d. By carefully varying engine speed, you should be able to cause the Governor arm to pause momentarily near the middle of its travel. This engine speed is the speed for which the Governor is adjusted. If grossly incorrect, reset High Engine Pot.

e. With the engine running at low speed, move the Governor arm throughout its stroke by hand. You should feel a constant smooth force in the on direction. No binding or rubbing should be felt within the Governor.

If steps 1a. thru 1e. can be accomplished as described, the Governor is probably OK. It recognizes underspeed, overspeed, onspeed and is not binding internally.

If the above steps cannot be accomplished satisfactorily, there is probably an actual Governor malfunction.

2. Installation and adjustment problems.

Governor is unable to move fuel system freely (not enough Actuator force available). If Governor doesn't move fuel system to on far enough to provide sufficient fuel but Governor arm moves far enough when disconnected look for:

a. Linkage binding or misadjusted.

b. Low voltage at Governor during operation.
*Measure the voltage as discussed previously and observe voltage during operation. If Governor fails to move full on and voltage dips over 1 volt, check for undersize wire (should be #16 minimum).

c. Excessive forces at Governor during running, particularly on carburetor engines.
*Carburetor butterfly valves are loaded by engine vacuum during running, which can add considerable force not present when engine isn't running.
*Springs in the system; carburetor return springs, acceleration pump springs, etc., are not usually needed and can cause governing problems.

Governor is unstable at light-load or no-load. See Linkage for carbureted engines.c.

Governor experiences sudden, momentary spikes toward max. at random intervals, then recovers.

a. Look for loose wiring or momentary shorts in wiring.

b. Noise or occasionally missing speed signal.

Speed seems to slowly wander (5-15 second periods) around at speed, particularly at higher loads. See item 2a. 3 concerning excessive loads on Governor.

3. Governor not tuned or adjusted for engine/application.

The basic adjustment to set sensitivity/stability is the Gain pot. A good starting point for many engines is full CCW, then CW 1/3 turn. (See Governor adjustment section). To increase stability, turn CCW. If satisfactory governing cannot be achieved with this one adjustment, the factory adjustment may be needed. Normal starting point for this adjustment is fully CCW, then CW 1/4 turn. (Before changing this pot, mark the original position).

NOTE: *If problems occurs with the Governor overshooting when a large load is released from the engine, such as driving up a hill and stopping. There is usually one of two things:*
1. Gain adjustment is to far CCW.
2. Mechanical preload between the carburetor and actuator is to large, this should be no greater than 1/2 to 1 ball dia.

2.24 FORD EFI ENGINE (MACHINES AFTER S/N 46089)

Performing Diagnostics

1. Verify the complaint and determine if it is a deviation from normal operation.
2. Once the complaint has been verified, preliminary checks can be done. Conduct a thorough visual inspection, be alert for unusual sounds or odors, and gather diagnostic trouble code information.
3. Perform a system check that will verify the proper operation of the system in question and check for recent information updates.
4. If a diagnostic trouble code (DTC) is stored, contact a JLG distributor to make an effective repair.
5. If no DTC is stored, select the symptom from the symptom tables and follow the diagnostic path or suggestions to complete the repair.
6. After the repair has been made and validated for proper operation, the old part should be momentarily re-installed to verify that it was indeed the source of the problem.

If no matching symptom is available, analyze the complaint and develop a plan for diagnostics utilizing the wiring diagrams, technical assistance, and repair history.

Intermittent conditions may be resolved by using a check sheet to pinpoint the circuit or electrical system component. Some diagnostic charts contain Diagnostic Aids which give additional information about a system. Be sure to use all of the information that is available to you.

VISUAL/PHYSICAL ENGINE INSPECTION CHECK

Perform a careful visual and physical engine inspection before performing any diagnostic procedure. Perform all necessary repairs before proceeding with additional diagnosis, this can often lead to repairing a problem without performing unnecessary steps. Use the following guidelines when performing a visual/physical inspection check:

- Inspect engine for modifications or aftermarket equipment that can contribute to the symptom; verify that all electrical and mechanical loads or accessory equipment is "OFF" or disconnected before performing diagnosis.
- Inspect engine fluids for correct levels and evidence of leaks.
- Inspect vacuum hoses for damage, leaks, cracks, kinks and improper routing, inspect intake manifold sealing surface for a possible vacuum leak.
- Inspect PCV valve for proper installation and operation.
- Inspect all wires and harnesses for proper connections and routing; bent or broken connector pins; burned, chafed, or pinched wires; and corrosion. Verify that harness grounds are clean and tight.
- Inspect engine control module (ECM), sensors, and actuators for physical damage.
- Inspect ECM grounds for cleanliness, tightness, and proper location.
- Inspect fuel system for adequate fuel level, and fuel quality (concerns such as proper octane, contamination, winter/summer blend).
- Inspect intake air system and air filter for restrictions.
- Inspect battery condition and starter current draw.

If no evidence of a problem is found after visual/physical engine check has been performed, proceed to MIL DTC retrieval procedure.

EFI Diagnostics

The EFI diagnostics are designed to assist in locating a faulty circuit or component. When a malfunction is detected by the Engine Control Module (ECM), a diagnostic trouble code (DTC) is set and the Malfunction Indicator Lamp (MIL) will be illuminated.

MIL DTC RETRIEVAL

Diagnostic trouble codes (DTCs) can be retrieved by pushing and holding the test button on the side of the ground control box. The Malfunction Indicator Light will illuminate for 2-3 seconds when the key is positioned to the on position to act as a self-test. If a DTC is present, the light will illuminate and stay on.

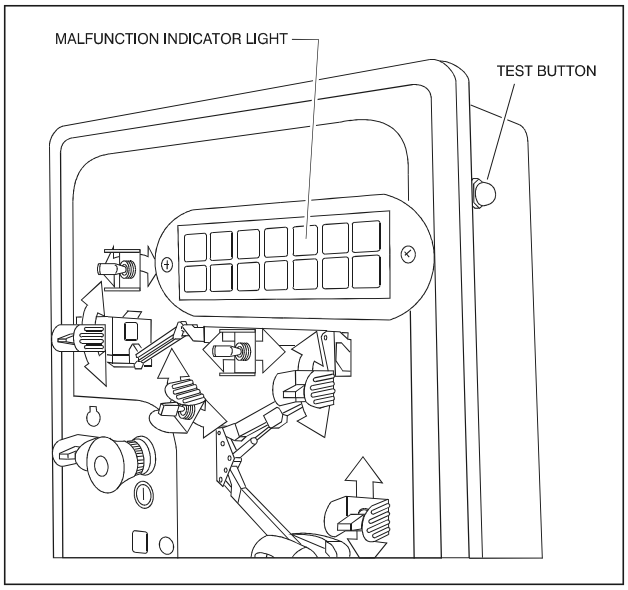


Figure 2-34. Malfunction Indicator Light and Test Button

When reading Diagnostic Trouble Codes thru the MIL, the following conditions apply:

- The flashing MIL is on for 0.4 second and off for 0.4 second.
- The MIL is off for 1.2 seconds between digits of two digit DTCs.
- The MIL is off for 2.4 seconds between DTCs.
- Each DTC repeats 3 times before the next stored DTC begins flashing.
- Up to 6 DTCs can be stored.
- Once all stored DTCs are flashed, the process repeats with the first stored DTC.
- DTCs are stored in the order in which they were set.

CLEARING TROUBLE CODES

To clear the trouble codes from the ECM, the electrical current running to the ECM must be shut off. To do this, disconnect the negative terminal from the battery for a period of approximately 15 minutes.

ECM AND SENSORS

CRANKSHAFT POSITION (CKP) SENSOR

The crankshaft position (CKP) sensor provides a signal used by the engine control module (ECM) to calculate the ignition sequence. The CKP sensor initiates the reference pulses which the ECM uses to calculate RPM and crankshaft position.

CAMSHAFT POSITION (CMP) SENSOR AND SIGNAL

The camshaft position (CMP) sensor sends a CMP signal to the ECM. The ECM uses this signal as a "sync pulse" to trigger the injectors in the proper sequence. The ECM uses the CMP signal to indicate the position of the #1 piston during its power stroke. The CMP uses a Hall Effect sensor to measure piston position. This allows the ECM to calculate true sequential fuel injection (SFI) mode of operation. If the ECM detects an incorrect CMP signal while the engine is running, DTC 53 will set. If the CMP signal is lost while the engine is running, the fuel injection system will shift to a calculated sequential fuel injection mode based on the last fuel injection pulse, and the engine will continue to nun. As long as the fault is present, the engine can be restarted. It will run in the previously established injection sequence.

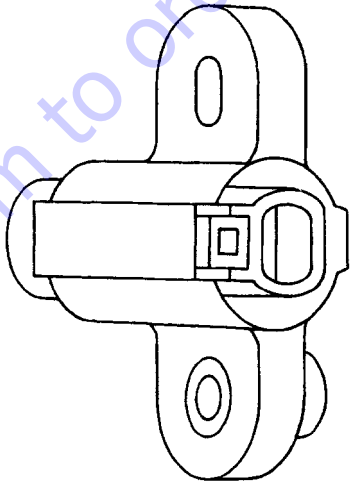


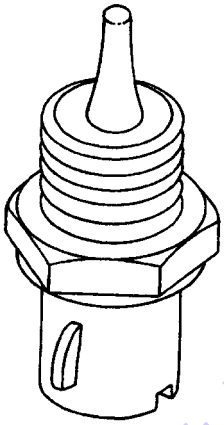
Table 2-4. ECM Diagnostic Trouble Codes

Diagnostic Trouble Code	Description
11	All Systems OK
12	Throttle Position (TP) Sensor Low Voltage
14	Manifold Absolute Pressure (MAP) Low Voltage
21	Overspeed
22	Throttle Position (TP) Sensor High Voltage
24	Manifold Absolute Pressure (MAP) High Voltage
31	Fuel Pump Low Voltage
32	Heated Oxygen Sensor (HO2S) Low Voltage
33	Engine Coolant Temperature (ECT) Sensor High Voltage
35	Intake Air Temperature (IAT) Sensor High Voltage
41	Fuel Pump High Voltage
42	Heated Oxygen Sensor (HO2S) High Voltage
43	Engine Coolant Temperature (ECT) Sensor Low Voltage
45	Intake Air Temperature (IAT) Sensor Low Voltage
51	Low Oil Pressure
52	Crankshaft Position (CKP) Sensor Extra/Missing Pulses
53	Camshaft Position Sensor (CMP) Sensor Illegal Pattern
54	Engine Control Module (ECM) Fault Illegal Operation
55	Engine Control Module (ECM) Fault Illegal Interruption
56	Engine Control Module (ECM) Fault COP (Computer Operating Properly) Failure
61	System Voltage Low
62	System Voltage High

ENGINE COOLANT TEMPERATURE (ECT) SENSOR

The engine coolant temperature (ECT) sensor is a g thermistor (a resistor which changes value based on temperature) mounted in the engine coolant stream. Low coolant temperature produces a high resistance of 100,000 ohms at -40°C (-40°F). High temperature causes a low resistance of 70 ohms at 130°C (266°F). The ECM supplies a 5-volt signal to the ECT sensor through resistors in the ECM and measures the voltage. The signal voltage will be high when the engine is cold and low when the engine is hot. By measuring the voltage, the ECM calculates the engine coolant temperature. Engine coolant temperature affects most of the systems that the ECM controls.

After engine start-up, the temperature should rise steadily to about 85°C (185°F). it then stabilizes when the thermostat opens. If the engine has not been run for several hours (overnight), the engine coolant temperature and intake air temperature displays should be close to each other. A fault in the engine coolant sensor circuit will set DTC 33 or DTC 43.



ELECTRICALLY ERASABLE PROGRAMMABLE READ ONLY MEMORY (EEPROM)

The electrically erasable programmable read only memory (EEPROM) is a permanent memory chip that is located within the ECM. The EEPROM contains the program and the calibration information that the ECM needs to control engine operations.

If the ECM is replaced, the new ECM will need to be programmed. An IBM-compatible computer and software containing the correct program and calibration for the application are required to program the ECM.

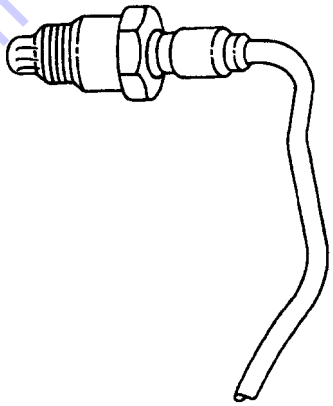
HEATED OXYGEN SENSOR

The heated oxygen sensor is mounted in the exhaust stream where it can monitor the oxygen content of the exhaust gas. The oxygen present in the exhaust gas reacts with the sensor to produce a voltage output. This voltage should constantly fluctuate from approximately 100 mV to 900 mV. The heated oxygen sensor voltage can be monitored on an IBM PC-compatible computer with diagnostic software. By monitoring the voltage out-put of the oxygen sensor, the ECM calculates the pulse width command for the injectors to produce the proper combustion chamber mixture.

Low HO2S voltage indicates a lean mixture which will result in a rich command to compensate.

High HO2S voltage indicates a rich mixture which will result in a lean command to compensate.

A constant voltage below 200 mV for 10 consecutive seconds will set OTC 32. A constant voltage above 650 mV for 10 consecutive seconds will set OTC 42.



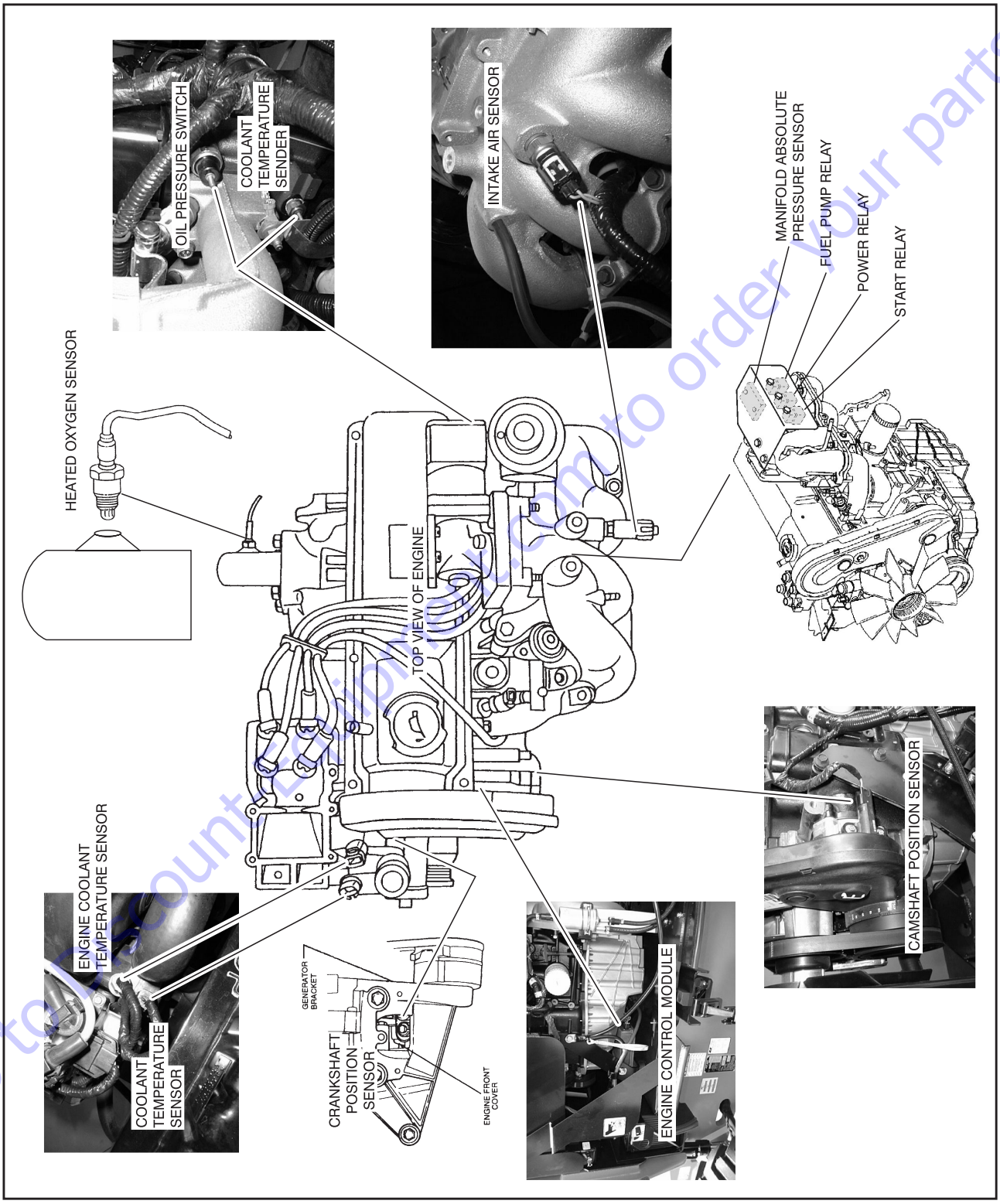
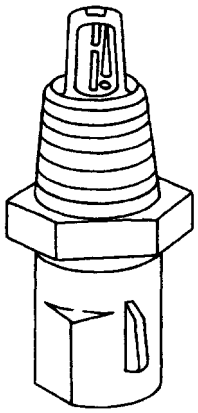


Figure 2-35. EFI Component Location

INTAKE AIR TEMPERATURE (IAT) SENSOR

The intake air temperature (IAT) sensor is a thermistor which changes its resistance based on the temperature of air entering the engine. Low temperature produces a high resistance of 100,000 ohms at -40°C (-40°F). High temperature causes a low resistance of 70 ohms at 130°C (266°F). The ECM supplies a 5-volt signal to the sensor through a resistor in the ECM and monitors the signal voltage. The signal voltage will be high when the incoming air is cold and low when the incoming air is hot. By measuring the voltage, the ECM calculates the incoming air temperature. The IAT sensor signal is used to adjust spark timing according to the incoming air density. An IBM PC-compatible computer with diagnostic soft-ware can be used to display the temperature of the air entering the engine. The temperature should read close to the ambient air temperature when the engine is cold, and rise as engine compartment temperature increases. If the engine has not been run for several hours (overnight), the IAT sensor temperature and engine coolant temperature should read close to each other. A failure in the IAT sensor circuit will set DTC 35 or DTC 45.



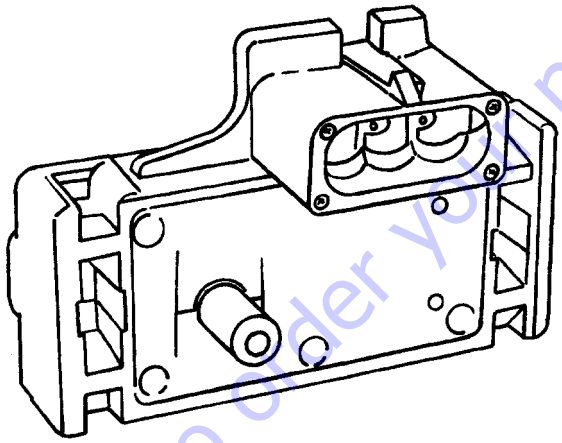
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

The manifold absolute pressure (MAP) sensor responds to changes in intake manifold pressure (vacuum). The MAP sensor signal voltage to the ECM varies from below 2 volts at idle (high vacuum) to above 4 volts with the ignition ON, engine not running or at wide-open throttle (low vacuum).

The MAP sensor is used to determine the following:

- Engine vacuum level for engine control purposes.
- Barometric pressure (BARO)

If the ECM detects a voltage that is significantly lower than the estimated MAP value for 2 or more consecutive seconds, DTC 14 will be set. A signal voltage significantly higher than the estimated MAP value for 2 or more consecutive seconds will set DTC 24.



ENGINE CONTROL MODULE (ECM)

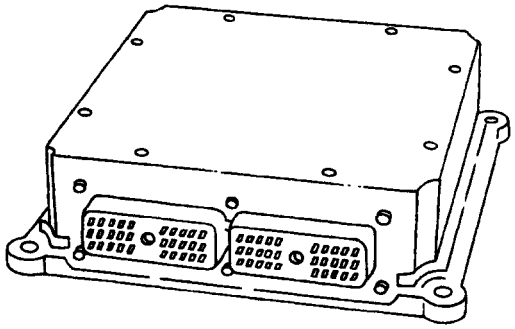
The ECM controls the following:

- Fuel metering system
- Ignition timing
- On-board diagnostics for engine functions

The ECM constantly observes the information from various sensors. The ECM controls the systems that affect engine performance. The ECM performs the diagnostic function of the system. It can recognize operational problems, alert the operator through the Malfunction Indicator Lamp (MIL), and store diagnostic trouble codes (DTCs). DTCs identify the problem areas to aid the technician in making repairs.

The ECM supplies either 5 or 12 volts to power various sensors or switches. The power is supplied through resistances in the ECM which are so huh in value that a test light will not light when connected to the circuit. In some cases, even an ordinary shop voltmeter will not give an accurate reading because its resistance is too low. Therefore, a digital voltmeter with at least 10 meg ohms input impedance is required to ensure accurate voltage readings. The ECM controls output circuits such as the fuel injectors, electronic governor, etc., by control ling the ground or the power feed circuit through transistors or other solid state devices.

The ECM is designed to maintain exhaust emission levels to government mandated standards while providing excellent operation and fuel efficiency. The ECM monitors numerous engine functions via electronic sensors such as the throttle position (TP) sensor and the heated oxygen sensor (HO2S).



ECM INPUTS/OUTPUTS

Inputs—Operating Conditions

- Engine Coolant Temperature
- Crankshaft Position
- Exhaust Oxygen Content
- Manifold Absolute Pressure
- Battery Voltage
- Throttle Position
- Fuel Pump Voltage
- Intake Air Temperature
- Camshaft Position

Outputs - System Controlled

- Fuel Control
- Idle Air Control
- Electric Fuel Pump
- Diagnostics:
  - Malfunction Indicator Lamp
  - Data Link Connector (DLC)

ECM SERVICE PRECAUTIONS

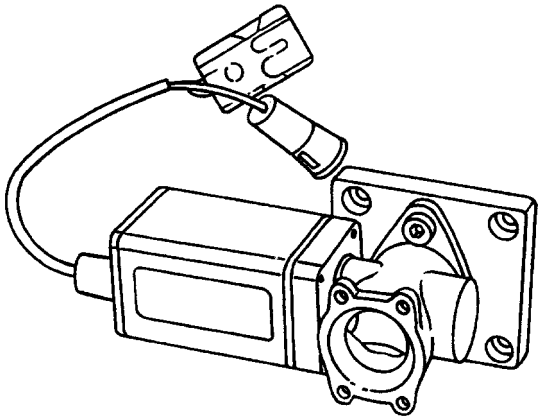
The ECM is designed to withstand normal current draws associated with engine operation. When servicing the ECM, observe the following guidelines:

- Do not overload any circuit.
- Do not probe wires for testing. This can cause a voltage drop that would be critical to the operation of the ECM.
- When testing for opens and shorts, do not ground or apply voltage to any of the ECM's circuits unless instructed to do so.
- When measuring voltages, use only a digital voltmeter with an input impedance of at least 10 megohms.
- Do not jump start with more than 12 volts. This could cause damage to the electronic components.
- Do not employ any non-standard practices such as charging the battery with an arc welder.
- Take proper precautions to avoid static damage to the ECM. Refer to "Electrostatic Discharge Damage" for more information.

THROTTLE POSITION (TP) SENSOR

The throttle position (TP) sensor is a potentiometer connected to the throttle shaft on the throttle body which is built into the electronic governor. The ECM monitors the voltage on the signal line and calculates throttle position. As the throttle valve angle is changed, the TP sensor signal also changes. At a closed throttle position, the output of the TP sensor is low. As the throttle valve opens, the output increases so that at wide open throttle (WOT), the output voltage should be above 4 volts.

The ECM calculates fuel delivery based on throttle valve angle (operator demand). A broken or loose TP sensor may cause intermittent bursts of fuel from an injector and unstable idle because the ECM thinks the throttle is moving. A hard failure in the TP sensor 5-Volt reference or signal circuits for greater than 2 consecutive seconds will set either a DTC 12 or DTC 22. A hard failure with the TP sensor ground circuit for more than two consecutive seconds may set DTC 22. If either DTC 12 or DTC 22 are set, the throttle will be forced to a 6% (idle) position.



USE OF CIRCUIT TESTING TOOLS

Do not use a test light to diagnose the engine electrical systems unless specifically instructed by the diagnostic procedures. A test light can put an excessive load on an ECM circuit and result in component damage. For voltage measurements, use only a digital voltmeter with an input impedance of at least 10 megohms.

ELECTROSTATIC DISCHARGE DAMAGE

Electronic components used in the ECM are often designed to carry very low voltage. Electronic components are susceptible to damage caused by electrostatic discharge. Less than 100 volts of static electricity can cause damage to some electronic components. By comparison, It takes as much as 4000 volts for a person to feel the spark of a static discharge.

There are several ways for a person to become statically charged. The most common methods of charging are by friction and induction.

An example of charging by friction is a person sliding across a seat.

Charge by induction occurs when a person with well-insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges can cause damage, therefore it is important to-use care when handling and testing electronic components.

To prevent possible electrostatic discharge damage, follow these guidelines:

- Do not touch the ECM connector pins or soldered components on the ECM board.
- Do not open the replacement part package until the part is ready to be installed.
- Before removing the part from the package, ground the package to a known good ground on the equipment.
- If the part has been handled while sliding across a seat, while sitting down from a standing position, or while walking a distance, touch a known good ground before installing the part.

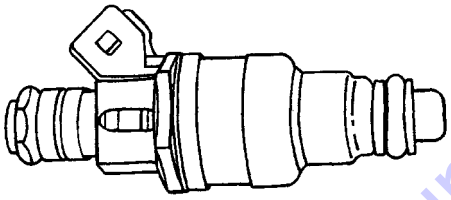
Fuel System

FUEL INJECTOR

The Electronic Fuel Injection (EFI) fuel injector is a solenoid-operated device controlled by the ECM. The ECM energizes the solenoid, which opens a valve to allow fuel delivery.

The fuel is injected under pressure in a conical spray pattern at the opening of the intake valve. Excess fuel not used by the injectors passes through the fuel pressure regulator before being returned to the fuel tank.

A fuel injector which is stuck partly open will cause a loss of fuel pressure after the engine is shut down, causing long crank times.



FUEL METERING SYSTEM COMPONENTS

The fuel metering system is made up of the following parts:

- The fuel injectors
- The fuel rail
- The fuel pressure regulator/filter assembly
- The electronic governor
- The ECM
- The crankshaft position (CKP) sensor
- The camshaft position (CMP) sensor
- The fuel pump
- The fuel pump relay

BASIC SYSTEM OPERATION

The fuel metering system starts with the fuel in the fuel tank. The fuel is drawn up to the fuel pump through a prefilter. The electric fuel pump then delivers the fuel to the fuel rail through an inane fuel filter. The pump is designed to provide fuel at a pressure above the pressure needed by the injectors. A fuel pressure regulator in the fuel filter assembly keeps fuel available to the fuel injectors at a constant pressure. A return line delivers unused fuel back to the tank.

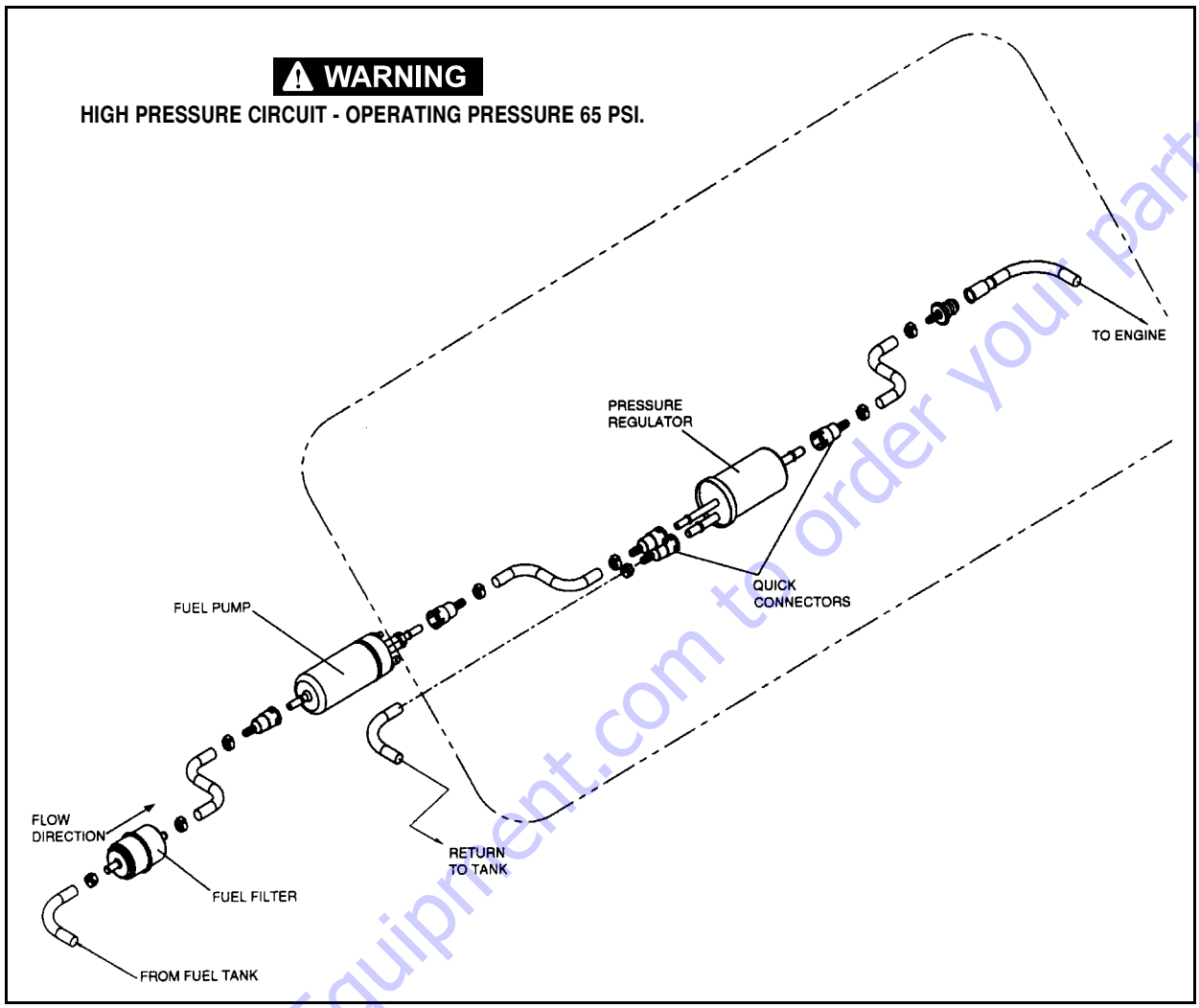


Figure 2-36. Typical Fuel System

FUEL METERING SYSTEM PURPOSE

The basic function of the air/fuel metering system is to control the air/fuel delivery to the engine. Fuel is delivered to the engine by individual fuel injectors mounted in the intake manifold near each intake valve.

The main control sensor is the heated oxygen sensor (H02S) located in the exhaust system. The H02S tells the ECM how much oxygen is in the exhaust gas. The ECM changes the air/fuel ratio to the engine by control-ling the amount of time that the fuel injector is "ON." The best mixture to minimize exhaust emissions is 14.7 parts of air to 1 part of gasoline by weight, which provides the most efficient combustion. Because of the constant measuring and adjusting of the air/fuel ratio, the fuel injection system is called a "closed loop" system.

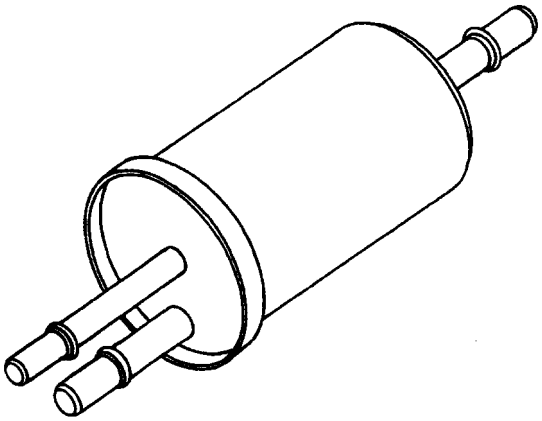
The ECM monitors signals from several sensors in order to determine the fuel needs of the engine. Fuel is delivered under one of several conditions called "modes." All modes are controlled by the ECM. Refer to "Open Loop and Closed Loop Operation" for more information.

FUEL PRESSURE REGULATOR

The fuel pressure regulator is a relief valve mounted in the fuel filter. It provides a constant fuel pressure of 441 kPa (64 psi).

If the pressure is too low, poor performance and a DTC 32 will set. If the pressure is too high, excessive odor and/or a DTC 42 will result.

When replacing the fuel filter, be sure to use an identical filter/regulator assembly. A standard fuel filter does not regulate pressure and could cause engine problems or component damage.



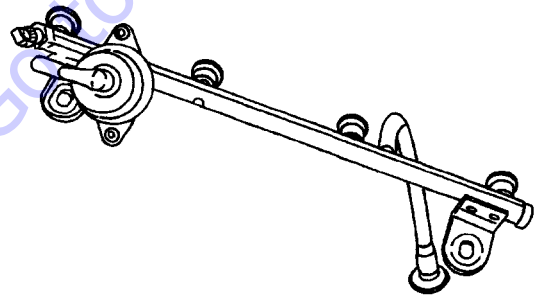
FUEL PUMP ELECTRICAL CIRCUIT

When the key is first turned "ON," the ECM energizes the fuel pump relay for two seconds to build up the fuel pressure quickly. If the engine is not started within two seconds, the ECM shuts the fuel pump off and waits until the engine is cranked. When the engine is cranked and crankshaft position signal has been detected by the SECM, the ECM supplies 12 volts to the fuel pump relay to energize the electric fuel pump.

An inoperative fuel pump will cause a "no-start" condition. A fuel pump which does not provide enough pressure will result in poor performance.

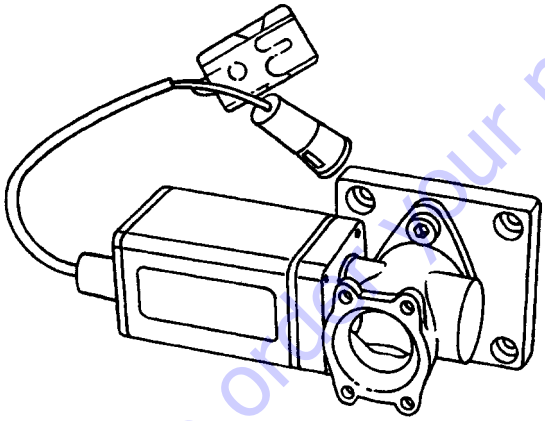
FUEL RAIL

The fuel rail is mounted to the top of the engine and distributes fuel to the individual injectors. Fuel is delivered to the fuel inlet tube of the fuel rail by the fuel lines.



ELECTRONIC GOVERNOR AND THROTTLE BODY

In the 2.5L EFI industrial engine, throttle control is achieved by using an electronic governor which is controlled by the engine control module (ECM).



The electronic governor consists of a throttle body, an electronically-actuated throttle plate, and a built-in throttle position (TP) sensor. There are two pigtails that exit the governor body. The 3-wire pigtail connects the TP sensor to the ECM. Refer to "Throttle Position (TP) Sensor" for more information.

The 2-wire pigtail carries the throttle signal from the ECM to the governor. Desired engine speeds are stored in the configuration program for each specific application, and can be changed with the ECM calibration software. When an engine speed is selected with the toggle switch, the ECM sends the appropriate signal to the governor. This is a pulse-width modulated (PWM) signal which cannot be read with conventional diagnostic tools such as a voltmeter. A 12-volt signal is pulsed on and off at a high rate of speed. The width of the "on" pulse determines the amount of throttle opening. The ECM sends a signal with the appropriate pulse width to the governor based on the operator's choice of switch settings.

The electronic governor also acts as an idle air control (IAC) valve. Changes in engine load are detected by the ECM by comparing manifold absolute pressure (MAP) with throttle position. When the ECM detects a change in engine load, it can adjust idle speed by changing the PWM signal to the governor.

OPEN LOOP AND CLOSED LOOP OPERATION

The ECM will operate in the following two modes:

- Open loop
- Closed loop

When the engine is first started, the system is in "open loop" operation. In open loop, the ECM ignores the signal from the heated oxygen sensor (HO2S). it uses a pre-programmed routine to calculate the air/fuel ratio based on inputs from the TP, ECT, and MAP sensors.

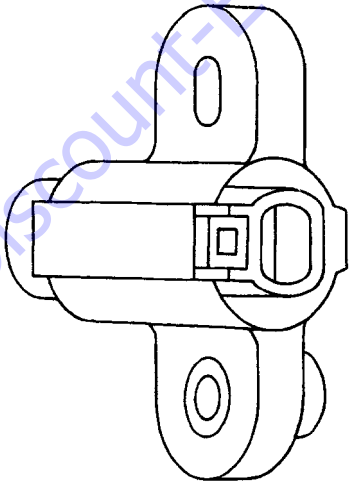
The system remains in open loop until the following conditions are met:

- The HO2S has a varying voltage output showing that it is hot enough to operate properly (this depends on temperature).
- The ECT has reached 160°F (71°C).
- Seven minutes has elapsed since starting the engine.

After these conditions are met, the engine is said to be operating in "closed loop." In closed loop, The ECM continuously adjusts the air/fuel ratio by responding to signals from the HO2S (except at wide-open throttle). When the HO2S reports a lean condition (low sensor signal voltage), the ECM responds by increasing the "on" time of the fuel injectors, thus enriching the mixture. When the HO2S reports a rich condition (high sensor signal Voltages the ECM responds by reducing the "on" time of the fuel injectors, thus leaning out the mixture.

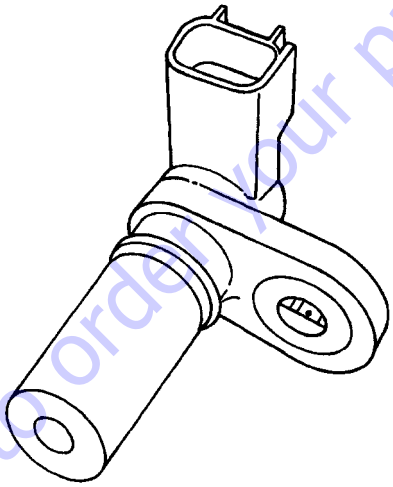
CAMSHAFT POSITION (CMP) SENSOR

The CMP sensor uses a variable reactor sensor to detect camshaft position. The CMP signal is created as piston #1 is a predetermined number of degrees after top dead center on the power stroke.



CRANKSHAFT POSITION (CKP) SENSOR

The crankshaft position (CKP) sensor provides a signal used by the engine control module (ECM) to calculate the ignition sequence. The sensor initiates the reference pulses which the ECM uses to calculate RPM and crankshaft position.



ELECTRONIC IGNITION

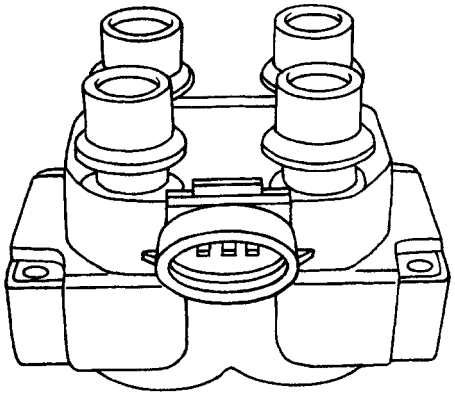
The electronic ignition system controls fuel combustion by providing a spark to ignite the compressed air/fuel w mixture at the correct time. To provide optimum engine performance, fuel economy, and control of exhaust emissions, the ECM controls the spark advance of the ignition system. Electronic ignition has the following advantages over a mechanical distributor system:

- No moving parts
- Less maintenance
- Remote mounting capability
- No mechanical load on the engine
- More coil cooldown time between firing events
- Elimination of mechanical timing adjustments
- Increased available ignition coil saturation time

IGNITION COIL

The electronic ignition system uses a coil pack with one ignition coil for each two cylinders in the engine. Each cylinder is paired with its opposing cylinder in the firing order, so that one cylinder on compression fires simultaneously with the opposing cylinder on exhaust. The spark that occurs in the cylinder on the exhaust stroke is referred to as a "waste spark."

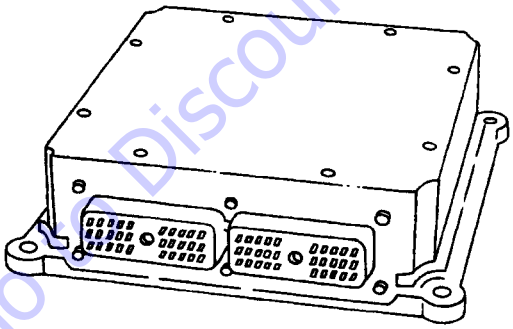
The primary coils in the coil pack are triggered by the "Ignition Coil Feed #1" and "Ignition Coil Feed #2" Signals from the ECM.



ENGINE CONTROL MODULE (ECM)

The ECM is responsible for maintaining proper spark and fuel injection timing for all operating conditions. To provide optimum operation and emissions, the ECM monitors the input signals from the following components in order to calculate spark timing:

- Engine coolant temperature (ECT) sensor
- Intake air temperature (IAT) sensor
- Throttle position sensor
- Crankshaft position sensor



2.25 DRIVE AND STEER CONTROLLER

Controller Theory & Definitions

This controller is specifically designed and manufactured to provide a proportional output to a SUNDSTRAND Dual Coil electro-hydraulic valve. The controller you are about to calibrate has the following features:

PWM Output (Pulse \Width Modulation)

The SUNDSTRAND valve being driven by this controller requires an electrical current, between 20 and 130 milliamps in order to shift the valve spool from minimum to maximum flow. Because of the mass of the spool, shifting it a very small distance would be very difficult to do without overshooting the mark. This overshoot is called hysteresis and makes precise control of the function very difficult. PWM output provides a pulsed current to the spool which actually vibrates the spool so that it is never at rest and very easy to shift. This controller pulses the spool 100 times (cycles) per second and as you move the handle, the electronics change the time period the pulse is on within that cycle. As you move the handle away from center, the on time period or width of the cycle pulse will increase and as you move the handle back towards the center, the pulse will decrease. The percentage of on time to off time of the PWM signal is called the Duty Cycle, if it is on for 80% we call that an 80% duty cycle.

Current Regulated Output

This controller output is also current regulated. This controller was designed to output from 20 to 130 milliamps through a 17 Q coil using a 12 volt supply. Ohms Law dictates that the Current is always equal Voltage divided by Resistance. If the supply voltage or the coil resistance should change, Ohms Law dictates that the output current must also change which will affect the speed of the function accordingly. Because this controller is equipped with a current regulated output, it senses a change in voltage or resistance in the circuit and adjusts the duty cycle of the PWM signal so that the output current remains a constant current. Because the Current is constant and Resistance is machine dependent, the duty cycle will vary in an attempt to supply the required level of output. This feature ensures that the function speed the operator wishes to select always remains the same, within the limits of Ohms Law.

Dual Range

This controller is capable of providing two, independently adjustable, maximum output ranges with the same amount of handle travel. The Hi Range would normally be adjusted for full flow (maximum function speed) of the valve at full handle travel. The LO Range would provide some potion of the Hi Range setting, providing reduced oil flow to the valve, with the handle at full travel. LO Range provides the operator with excellent control of the proportional function with increased resolution for precise maneuverability.

Both outputs are linear between the Threshold setting and their respective setting. The controller is in the Hi Range mode when 12 volts is applied to the (R) terminal. As a fail safe, when system voltage is removed from the (R) terminal, the Lo Range feature is active.

I.R.S (Integrated Ramp System)
This controller is calibrated to provide a maximum ramp time of 2 seconds. This feature limits the rate of change of the output, eliminating a jerky response associated with sudden handle movements. Any change in handle position will result in a smooth change in function speed. The 2 seconds is measured between the Threshold and Hi or LO range setting.

R.T.O. (Ramp Thru Off)
This controller is configured with an enhanced ramp feature that allows the handle to released or moved from one handle extreme to the other without canceling the ramp duration. The RTO duration is factory set to 2 seconds

Adjustment Procedures

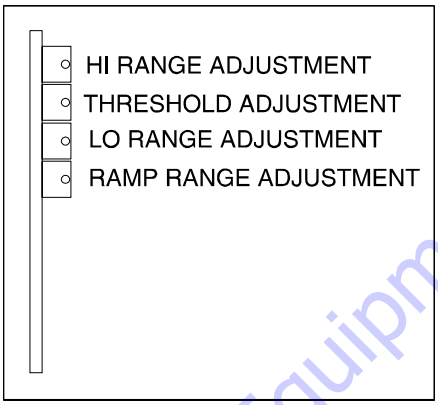


Figure 2-37. Drive and Steer Adjustment

NOTE: *The following procedures are for a preliminary adjustment. Final Adjustments are to be based on the function speed of the operation.*

NOTE: *The trimpot adjustment screws are multi turn devices. No harm can come to the trimpot if it is turned too much. The trimpot will "click" when the wiper is at the end of the element. It may be necessary to turn the adjustment screw several turns to observe a change in the output.*

The most reliable measure of the performance of the function you are fine tuning is to monitor your adjustments until the desired speed is achieved. Have the machine fully operational in an area where obstacles are not present. Use your meter to monitor the current output, and record that number once you have set the function to the proper speed.

The EMS4M11100 is equipped with a ramping option. Adjustment and calibration may be difficult due to outputs ramping up to their set level. When making adjustments, let the output stabilize before recording that setting.

The Drive/Steer controller is set by Milliamps. To adjust the Drive/Steer controller, turn the trimpots clockwise to increase and counterclockwise to decrease milliamps. All of the trimpots are 25 turn type.

1. At the platform control box install an amp meter inline between the orange wires at terminal #10 for forward and terminal #11 for reverse.
2. The threshold trimpot is set at 15 to 25 ma. The Low Range trimpot is set at 60 ma. The High range trimpot is set at 130 ma. To set the Threshold trimpot, stroke the joystick until the red LED glows. With the function speed control off of the snail position, adjust the trimpot to 15 to 25 ma. This should be just enough amperage to start the drive wheels moving.
3. Adjust the High Range trimpot. Stroke the joystick fully with the function speed control off of the snail position. Turn the trimpot until 130 ma is displayed on the meter.
4. Adjust the Low Range trimpot. With the joystick fully stroked and the function speed control at the snail position, adjust the Low Range trimpot until the meter reads 60 ma.

NOTE: *Milliamp readings should be the same for Drive forward and reverse.*

5. Adjust Ramp to provide a smooth start and stop function.

2.26 LIFT AND SWING CONTROLLER

Adjustment

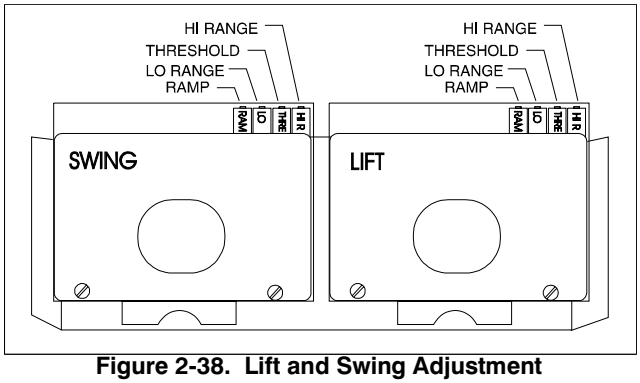


Figure 2-38. Lift and Swing Adjustment

NOTE: *The following procedures are for a preliminary adjustment. Final Adjustments are to be based on the function speed of the operation.*

Lift Swing and function speed control are all adjusted to the same values. Threshold 300ma, Low Range 800 ma, and Hi Range 1200 ma.

1. To adjust Lift and Swing Threshold, and Hi Range trimpots, Pin 5 on the control card requires 12 volts.
2. To adjust the Low Range trimpot, Pin 5 requires no voltage.
3. The function control switch turns power on and off at Pin 5.
4. To check and adjust milliamps on Lift Up and Down, connect an amp meter inline between the tan lines at terminal strip #8.
5. Turn the function speed switch past the snail position, operate the Lift joystick just past the Off position in both directions.
6. Adjust the Threshold trimpot to 300 ma.
7. Fully stroke the joystick and adjust the Hi Range trimpot to 1200 ma.
8. Turn the function speed control to snail position and fully stroke the joystick and adjust Lo Range trimpot to 800 ma.
9. To adjust swing left and right connect the amp meter inline between the white wires at terminal #9. Perform adjustment steps the same as outlined for Lift.

2.27 FUNCTION CONTROL

Rotary Selector Controller Theory & Definitions

This Rotary Selector Controller is specifically designed and manufactured to provide a proportional output to a HYDRAFORCE flow control electro-hydraulic valve. The Rotary Selector Controller you are about to calibrate has the following features:

PWM Output (Pulse Width Modulation)
The HYDRAFORCE valve being driven by this Rotary Selector Controller requires an electrical current, between 360 and 1400 milliamps in order to shift the valve spool from minimum to maximum flow. Because of the mass of the spool, shifting it a very small distance would be very difficult to do without overshooting the mark. This overshoot is called hysteresis and makes precise control of the function very difficult. PWM output provides a pulsed current to the spool which actually vibrates the spool so that it is never at rest and very easy to shift. This Rotary Selector Controller pulses the spool 130 times (cycles) per second and as you move the handle, the electronics change the time period the pulse is on within that cycle. As you move the handle away from center, the on time period or width of the cycle pulse will increase and as you move the handle back towards the center, the pulse will decrease. The percentage of on time to off time of the PWM signal is called the Duty Cycle, if it is on for 80% we call that an 80% duty cycle.

Current Regulated Output
This Rotary Selector Controller output is also current regulated. This Rotary Selector Controller was designed to output from 360 to 1400 milliamps through a 4.7 ohm coil using a 12 volt supply. Ohms Law dictates that the Current is always equal to Voltage divided by Resistance. If the supply voltage or the coil resistance should change, Ohms Law dictates that the output current must also change which will affect the speed of the function accordingly. Because this Rotary Selector Controller is equipped with a current regulated output, it senses a change in voltage or resistance in the circuit and adjusts the duty cycle of the PWM signal so that the output current remains a constant current. Because the Current is constant and Resistance is machine dependent, the duty cycle will vary in an attempt to supply the required level of output. This feature ensures that the function speed the operator wishes to select always remains the same, within the limits of Ohms Law.

Dual Range

This Rotary Selector Controller is capable of providing two, independently adjustable, maximum output ranges with the same amount of handle travel. The Hi Range would normally be adjusted for full flow (maximum function speed) of the valve at full handle travel. The LO Range would provide some portion of the Hi Range setting, providing reduced oil flow to the valve, with the handle at full travel. LO Range provides the operator with excellent control of the proportional function with increased resolution for precise maneuverability. Both outputs are linear between the Threshold setting and their respective setting. The Rotary Selector Controller is in the Hi Range mode when 12 volts is applied to the (R) terminal. As a fail safe, when system voltage is removed from the (R) terminal, the Lo Range feature is active.

I.R.S (Integrated Ramp System)

This Rotary Selector Controller is calibrated to provide a maximum ramp time of 3 seconds. This feature limits the rate of change of the output, eliminating a jerky response associated with sudden handle movements. Any change in handle position will result in a smooth change in function speed. The 3 seconds is measured between the Threshold and Hi or LO range setting.

Adjustment Procedure

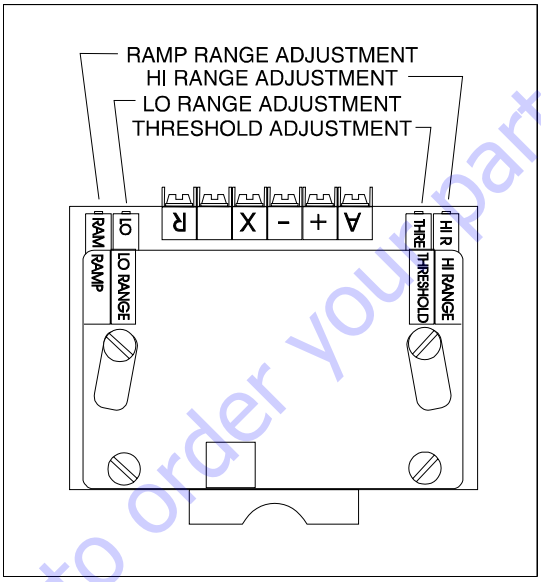


Figure 2-39. Function Control Card Adjustment

NOTE: *The trimpot adjustment screws are multi turn devices. No harm can come to the trimpot if it is turned too much. The trimpot will "click" when the wiper is at the end of the element. It may be necessary to turn the adjustment screw several turns to observe a change in the output.*

1. Disconnect the output wire from the card to terminal 12. Install a volt-ohmmeter in series in this wire and set the volt-ohmmeter to mA.
2. Turn on all power; engine does not need to be running.
3. With the function speed switch turned to the fully CCW position, activate the Telescope out switch and adjust Threshold to 300 mA.
4. With the function speed switch turned to the fully CW position, activate the Telescope out switch and adjust Hi Range to 1100 mA.
5. With the function speed switch turned to the fully CW position, activate the Platform Rotate switch and adjust Lo Range to 800 mA.
6. Set Ramp about 10 turns CW from the fully CCW position.

2.28 THROTTLE CHECKS AND ADJUSTMENTS - DEUTZ ENGINE

General

The throttle control system on the Deutz engine includes the positional controller and the actuator.

Four LEDs are incorporated in the controller. They are as follows:

- Red - failure: signals a problem with the system - needs service or adjustment
- Green - clutch engaged; operation normal while system is powered.
- Amber - motor extend
- Amber - motor retract

The controller is designed so that when the system voltage reaches 10.5 volts, the actuator clutch will be released and the motor drive turned off in order to prevent unpredictable operation from occurring.

When a failure condition occurs (i.e. position time-out) the controller will release the clutch and turn off the actuator motor. This will prevent unnecessary motor wear.

Table 2-5.Position Controller Truth Table

Control Wiring				Actuator Position
Black	Red	White	Green	
GND	OFF	X	X	OFF POSITION (Freewheel)
GND	+12 VDC	OFF	OFF	POSITION 1 (See Adjustments)
GND	+12 VDC	+12 VDC	OFF	POSITION 2 (See Adjustments)
GND	+12 VDC	OFF	+12 VDC	POSITION 3 (See Adjustments)
GND	+12 VDC	+12 VDC	+12 VDC	POSITION 4 (See Adjustments)

GND = POWER SUPPLY OR BATTERY GROUND
OFF = GROUND OR OPEN CIRCUIT
X = DON'T CARE
+12 VDC = +12 VOLT POWER SUPPLY OR BATTERY SYSTEM, VIA A 5 AMP FUSE OR CIRCUIT BREAKER

TRIMMER ADJUSTMENTS	LED INDICATORS
1 - POSITION 1 CW=RETRACT	R - RETRACT INDICATOR (AMBER)
2 - POSITION 2 CW=RETRACT	E - EXTEND INDICATOR (AMBER)
3 - POSITION 3 CW=RETRACT	C - CLUTCH INDICATOR (GREEN)
4 - POSITION 4 CW=RETRACT	F - FAILURE INDICATOR (RED)

Procedure

NOTE: *Never run fuel tank dry. Diesel engines cannot be restarted after running out of fuel until fuel system has been air-vented or bled of air. See Deutz Instruction Manual for procedure.*

1. Power the ignition switch at the ground control panel. Set the mid rpm.
2. Supply 12 volts of power to the white wire on the controller. Set the high engine rpm.

NOTE: *Actuator rod travel must stop slightly before lever makes contact with throttle lever stop. Failure to do so will burn out actuator.*

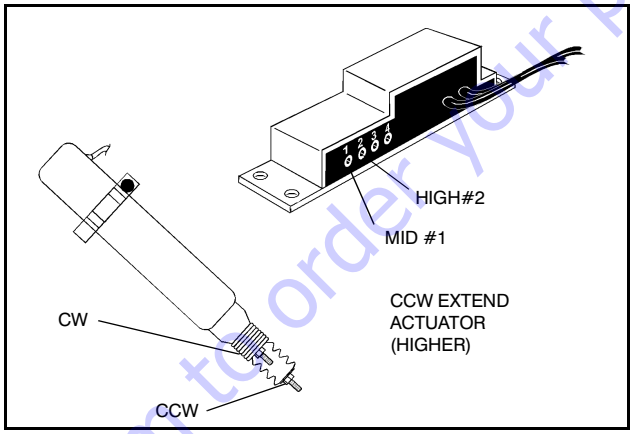
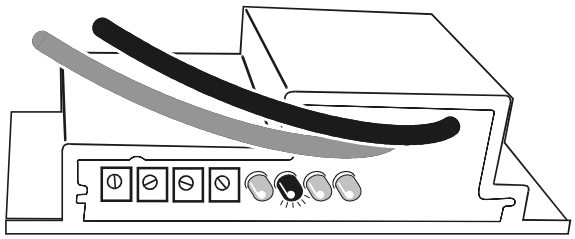


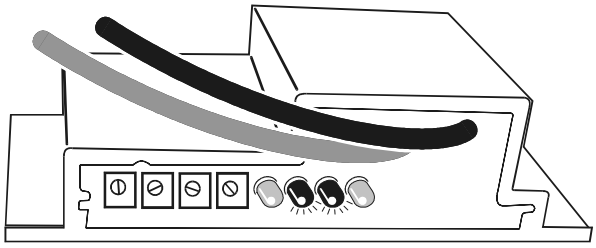
Figure 2-40. Addco Adjustments - Deutz

Controller Status

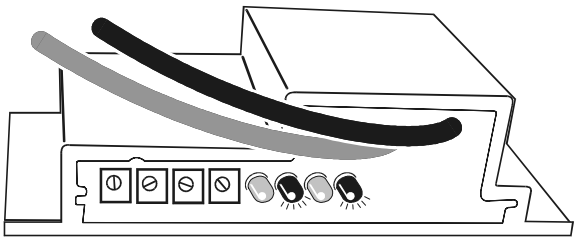
Clutch engaged no actuator movement



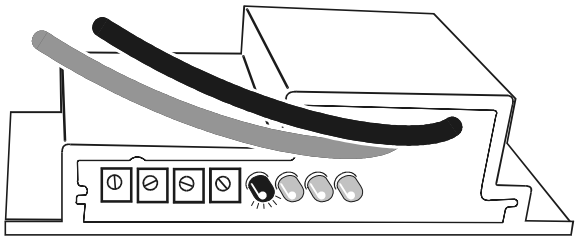
Clutch engaged actuator extending



Clutch engaged actuator retracting

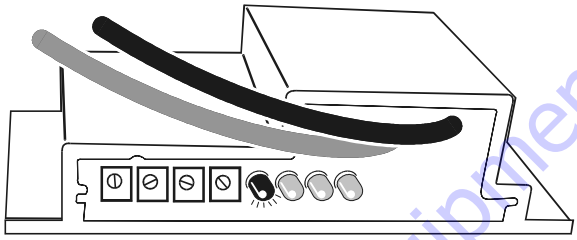


Controller fault - clutch disengaged and no actuator movement



Failure Modes

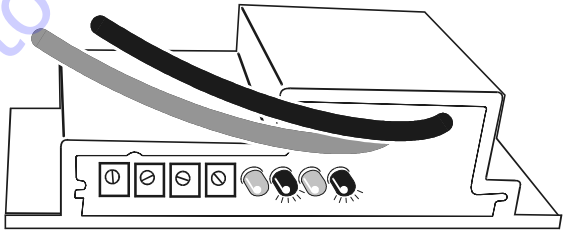
Immediate Red Light



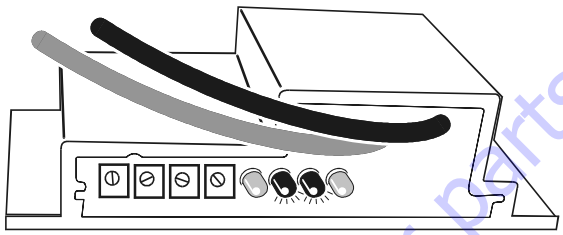
Action:

1. Recycle power to determine if the problem is intermittent.
2. The input voltage must be greater than 10.5 Vdc.
3. Check wiring for any damage and correct.
4. Disconnect engine harness and actuator connnections.
5. If problem reoccurs return unit.

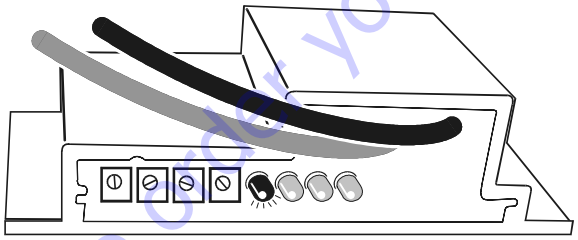
Green and either Amber light followed by a red light



or



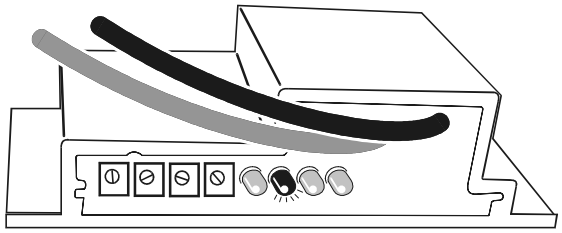
then



Action:

1. Inspect and clean wiring connections.
2. Examine throttle linkage for any damage or bent components and correct.
3. With linkage disconnected, check each potentiometer for operation.
4. Reconnect linkage and reset each potentiometer for correct operation.
5. If failure continues to occur, replace unit.

Only green light on and no actuator movement

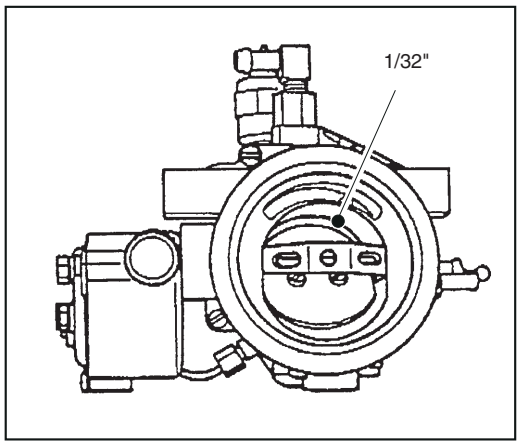


Action:

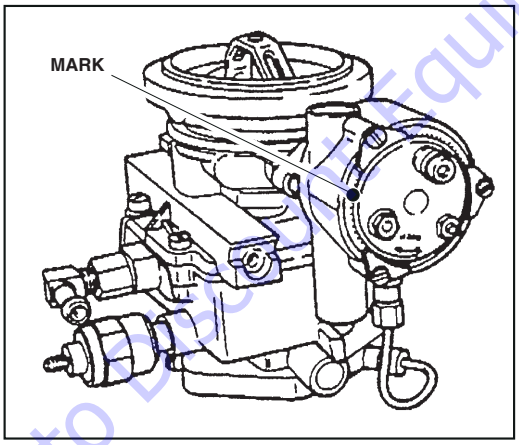
1. Adjust trim potentiometers.
2. If problem continues, replace unit.

2.29 AUTOMATIC CHOKE ADJUSTMENT - FORD ENGINE

1. At 70°F the choke plate should be open 1/32" (not touching the choke bore).
2. If the ambient temperature is not 70°F, an additional adjustment is required.
   a. Loosen the three cover plate screws.
   b. Adjust the cover to open the choke plate 1/32".



   c. Readjust for ambient temperature by rotating the cover one (1) mark per 5°F from 70°F. Rotate CCW (lean) if warmer than 70°, CW (rich) if colder than 70°. (If actual temperature is 80°, set at 1/32" and rotate two (2) marks CCW [lean] direction.)



   d. Tighten the three cover plate screws and check for free rotation (no sticking or binding) of the choke shaft.

2.30 COLD WEATHER STARTING DIFFICULTY

Machines equipped with carbureted Ford LRG-425 engines in weather conditions of 15 to 20° F (-9.5 to -6.5 C) or colder may encounter difficulty in starting.

After 10 unsuccessful attempts of starting the engine follow the troubleshooting procedures below to locate the cause of the starting difficulty.

Most Cold weather starting issues fall into the following categories which will be addressed separately:

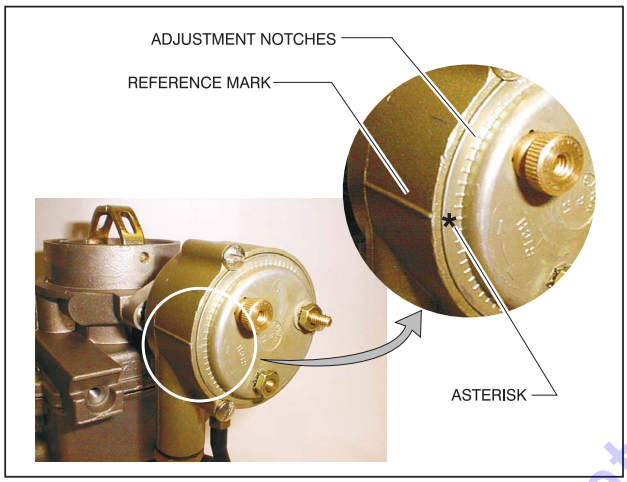
- Carburetor
- Ignition
- Fuel

1. **Engine Receiving Fuel** - After cranking the engine for a period of time, there may be white smoke noticed coming out of the exhaust tube. This is an indication that the engine is in a "flooded" condition. If the engine is flooded and will not start, follow the procedures under Checking the Carburetor. If after following those procedures the engine still does not start, continue with Checking the Ignition.
2. **Engine Not Receiving Fuel** - If after cranking the engine for a period of time, and there is no white smoke coming out of the exhaust tube, follow the procedures under Checking the Fuel.

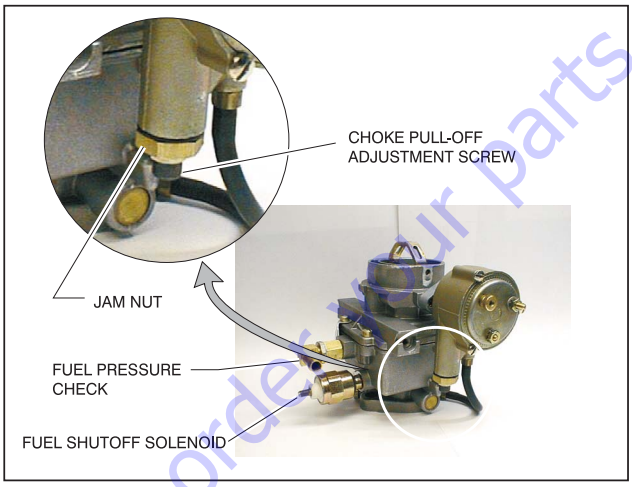
Checking the Carburetor

After cranking the engine for a period of time there may be white smoke noticed coming out of the exhaust tube. This is an indication the engine is receiving fuel and is in a “flooded” condition.

NOTE: *Make sure the choke is adjusted using the asterisk (*). There is also a zero (0) stamped on the choke. The zero (0) is used for assembly purposes and is not to be used as an adjustment reference.*



1. Check the choke for ambient temperature setting. The default ambient temperature setting is 70° F (21° C), which aligns the asterisk (*) on the choke face with the reference mark on the side of the choke housing. The choke should be set at one notch “clockwise” past the (*) asterisk for every 5 degrees below 70° F (one notch “clockwise” past the (*) asterisk for every 2.8 degrees below 21° C). This adjustment will "richen" the fuel mixture.
2. Check if the choke “butterfly” is stuck by manually opening and closing by hand.
3. Check the choke pull-off (butterfly stop) screw for proper adjustment as follows:



   a. Loosen jam nut
   b. Screw the adjustment screw all the way in, then back out 1/2 turn.
   c. Tighten jam nut.

   Try to start the engine.

NOTE: *If EMS switch is pulled on for an extended period of time, i.e. 1 to 2 minutes, without attempting to start the engine, the choke will start to open due to electrical heating.*

Checking the Ignition

If the engine tries to start but spits and sputters:

1. Check the Oil Pressure Switch:
   a. Check for voltage from N.C. (normally closed) terminal to common ground while cranking the engine. (what should the voltage be?)
   b. Jump all three posts at the oil pressure switch, then see if the engine will start.
   c. If the engine starts after jumping the posts, replace oil pressure switch (JLG p/n: 4360405)
2. Check the Spark Plugs for presence of spark. If there is no spark at the plugs during cranking:
   a. Overspeed relay not activating.
   b. Check the ignition module red/green wire for 12 volts.
   c. Check the white/black wire coming from the 8-pin connector (pin-H) that runs to the overspeed relay on terminal 85 for proper ground.
3. Ignition module may have failed.

a. Ignition module series: AA, AB and FA prior to date code-1889 may need replaced. (refer to: Ford Technical Bulletin # FF-91-99)

b. Check the vacuum advance tube attached to the ignition module for secure connection.

Try to start the engine.

2.31 CHECKING THE FUEL

The engine may not be getting fuel to the carburetor

1. Check the fuel shutoff solenoid
   a. Must have 12 volt while cranking the engine.
2. Check the electric fuel pump
   a. Must have 12 volts or be able to hear the pump running while cranking the engine.
   b. Check fuel pressure, must have a minimum of 2-4lbs.
3. Check Fuel Filter:

NOTE: *Some JLG machines have a fuel return line between the fuel pump and carburetor, if this return line is pinched and the fuel pressure increases this indicates a clogged fuel filter.*

4. Check the fuel pump supply line for any obstruction.

Try to start the engine.

NOTE: *JLG Industries Inc. recommends the use of engine block heaters and or cold weather packages for machines intended for use in 0° F (-18° C) or colder conditions. Refer to the JLG Parts Manual for specify options for your machine.*

(Machines equipped with non-hydrostatic gear pump or non-proportional drive systems, i.e. H models, 60HA should consider having block heaters and or cold weather packages installed for use in 20° F (-6.5° C) and colder conditions.

2.32 TILT ALARM SWITCH

⚠ CAUTION

PERFORM TILT ALARM SWITCH LEVELING PROCEDURE A MINIMUM OF EVERY SIX MONTHS TO ENSURE PROPER OPERATION AND ADJUSTMENT OF SWITCH.

Manual Adjustment

1. Park the machine on a flat, level surface. Ensure machine is level and tires are filled to rated pressure.

NOTE: *Ensure switch mounting bracket is level and securely attached.*

2. Level the base of the indicator by tightening the three flange nuts through approximately one quarter of its spring travel. DO NOT ADJUST THE "X" NUT DURING THE REMAINDER OF THE PROCEDURE.
3. With the electrical connections complete, using bubble level on top of indicator, slowly tighten or loosen the three flange nuts until indicator is level.
4. Individually push down on one corner at a time; there should be enough travel to cause the switch to trip. If the switch does not trip in all three tests, the flange nuts have been tightened too far. Loosen the "X" nut and repeat steps (2). through (4).

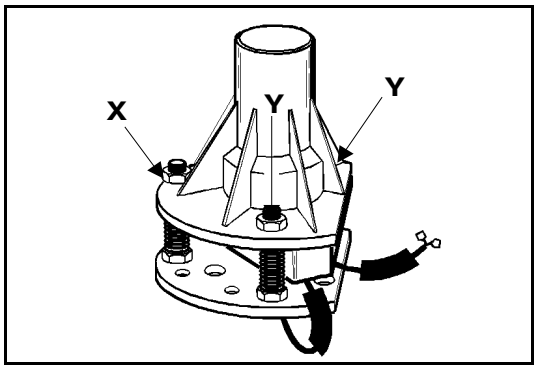


Figure 2-41. Tilt Switch Adjustment

2.33 PRESSURE SETTING PROCEDURES

Proportional Sequence Valve

1. Install a pressure gauge at port G1 on the Main Valve and start the engine.
2. The gauge should read between 230 and 325 psi (16 and 22.5 bar). This valve is non-adjustable.

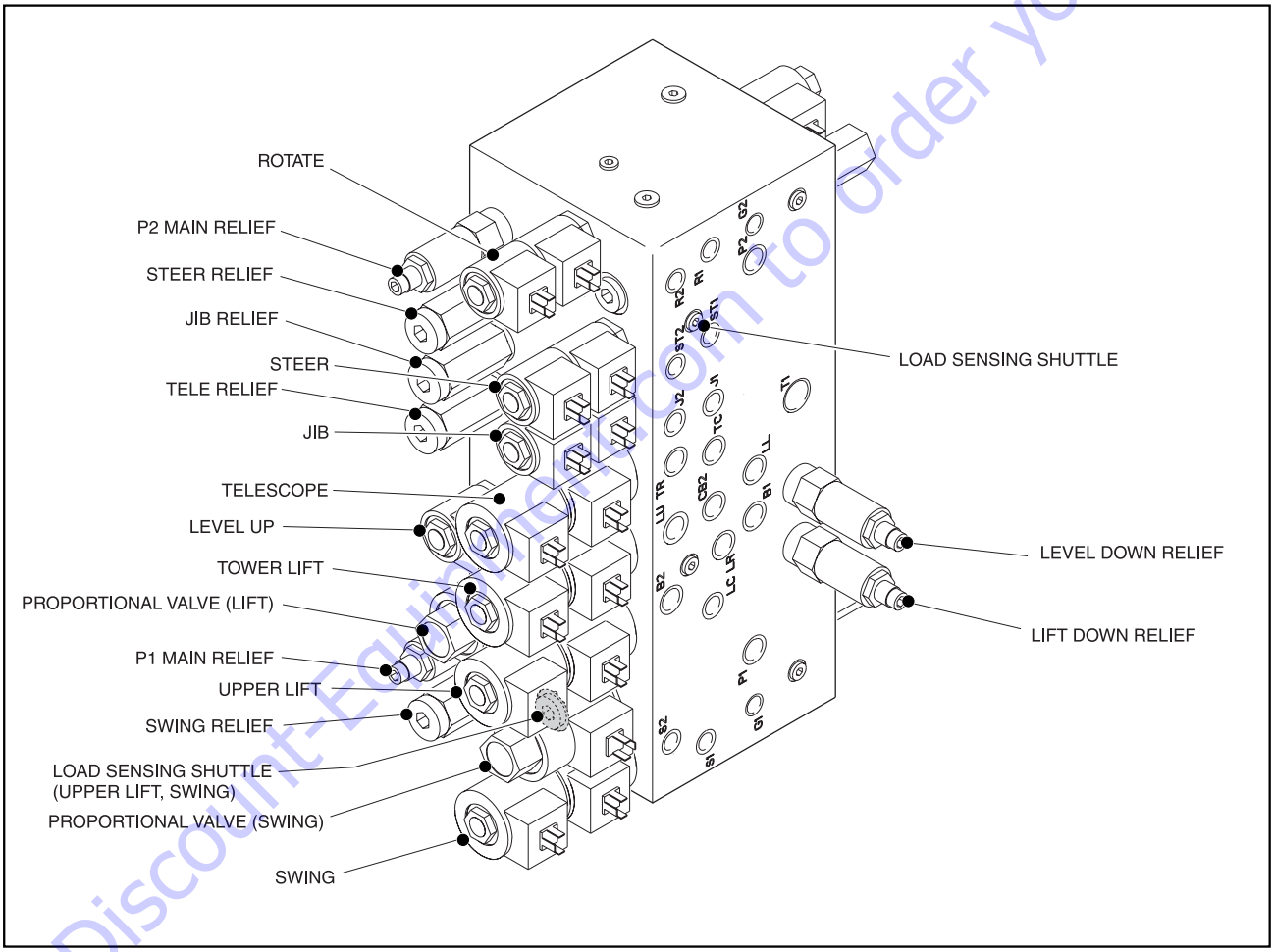


Figure 2-42. Main Valve (Proportional Controls) - Sheet 1

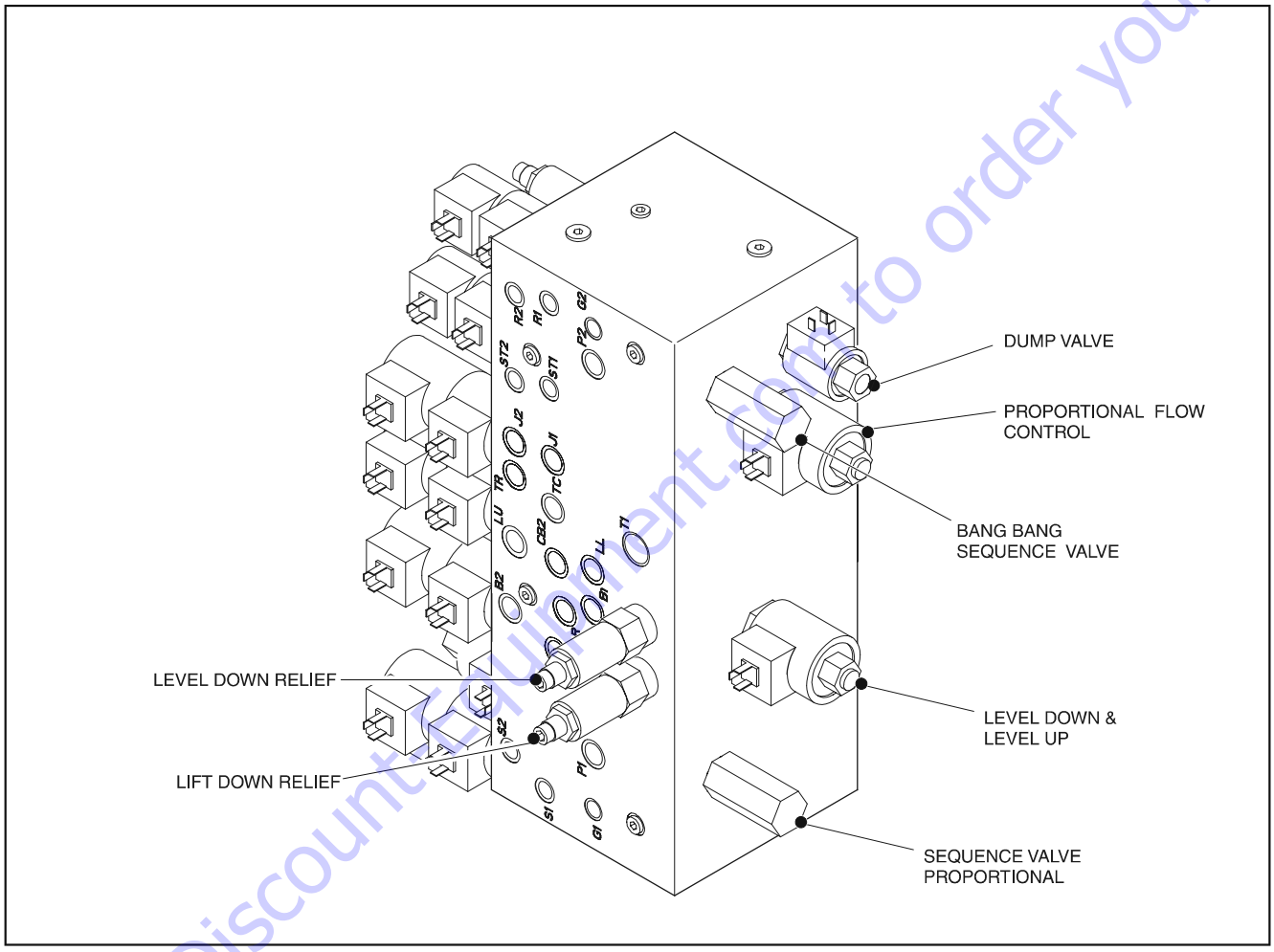


Figure 2-43. Main Valve (Proportional Controls) - Sheet 2

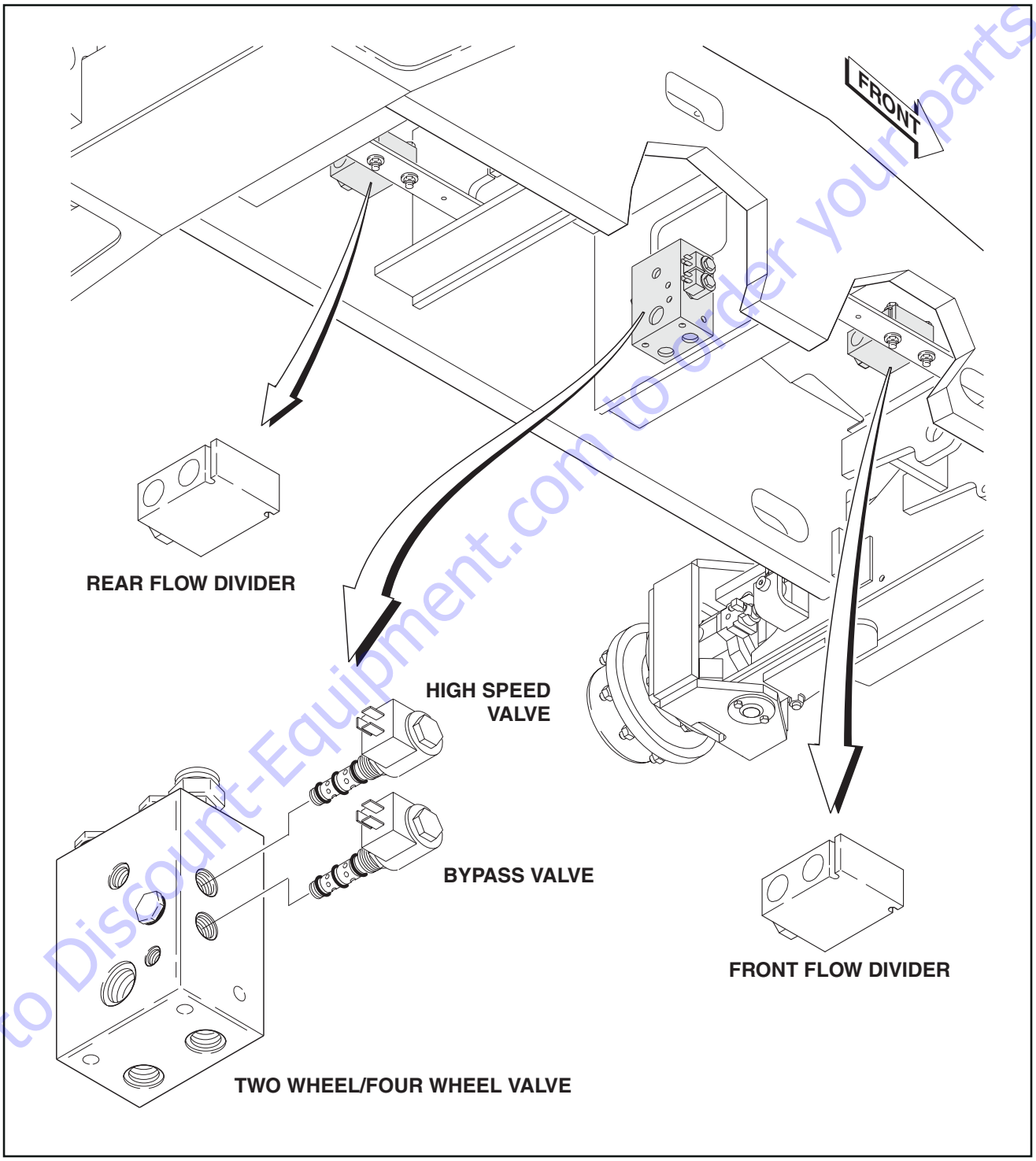


Figure 2-44. Valve Location - Chassis

Bang-Bang Sequence Valve

1. Install the pressure gauge at port G2 on the Main Valve.
2. Energize the main dump valve by applying 12 volts to pin 14 at the ground control box. The gauge should read between 230 and 325 psi (16 and 22.5 bar). This valve is non-adjustable.

P1 Main Relief Valve

1. Install the pressure gauge at port G1 on the Main Valve.
2. Remove the hose from port LC. Plug the hose and cap the fitting on the valve block.
3. Activate Lift Up and hold.
4. The pressure gauge should read 3000 +200, -50 psi (207 +14, -3.5 bar).

P2 Main Relief Valve

1. Install the pressure gauge at port G2 on the Main Valve.
2. Activate Tower Lift Down and hold.
3. The pressure gauge should read 3200 +200, -50 psi (220 +14, -3.5 bar).

Swing

1. Remove the hoses at ports S1 and S2 on the Main Valve and plug both hoses.
2. Install pressure gauges into both port S1 or S2.
3. Activate swing fully left or right. Adjust the valve to 1750 +200, -0 psi (121 +14, -0 bar).

Upper Lift Down

1. Remove the hoses at port B2 on the Main Valve and plug the hose.
2. Install pressure gauges into port B2.
3. Activate lift down and hold.
4. The pressure gauge should read 2500 +200, -0 psi (172 +14, -0 bar).

Platform Level Retract

1. Remove the hose from port B1 on the Main Valve and cap it.
2. Install a pressure gauge into port B1.
3. Activate the level down function and hold.
4. The pressure gauge should read 2500 +200, -0 psi (172 +14, -0 bar).

Telescope Relief

1. Remove the hoses at ports TC and TR and plug.
2. Install pressure gauges into both ports TC and TR.
3. Activate Telescope In and Out.
4. The pressure gauge should read 2000 +200, -0 psi (138 +14, -0 bar).

Jib Relief

1. Remove the hoses at ports J1 and J2 and plug.
2. Install pressure gauges into both ports J1 and J2.
3. Activate the Jib up and down.
4. The pressure gauge should read 1500 ±100 psi (103 ± 7 bar).

Steer Relief

1. Remove the hoses at ports ST1 and ST2 and plug.
2. Install pressure gauges into both ports ST1 and ST2.
3. Activate the steer left and right.
4. The pressure gauge should read 2000 ±100 psi (138 ± 7 bar).

2.34 HYDRAULIC COMPONENT START-UP PROCEDURES AND RECOMMENDATIONS

From a hydrostatic component standpoint, the goal at system start up is to put into functional operation, the hydrostatic system in such a way as to preserve the designed life span of the system. The following start-up procedure should be adhered to whenever a new pump or motor is initially installed into a machine, or a system is restarted after either a pump or motor has been removed and/or replaced.

⚠ WARNING

THE FOLLOWING PROCEDURE MAY REQUIRE THE MACHINE TO BE DISABLED (WHEELS RAISED OFF THE GROUND, WORK FUNCTIONS DISCONNECTED, ETC.) WHILE PERFORMING THE PROCEDURE IN ORDER TO PREVENT INJURY. TAKE NECESSARY SAFETY PRECAUTIONS BEFORE MOVING THE VEHICLE/MACHINE.

Prior to installing the pump and/or motor, inspect the unit(s) for damage that may have been incurred during shipping and handling. Make certain that all system components (reservoir, hoses, valves, fittings, heat exchanger, etc.) are clean prior to filling with fluid.

Fill the reservoir with recommended hydraulic fluid. This fluid should be passed through a 10 micron (nominal, no bypass) filter prior to entering the reservoir. The use of contaminated fluid will cause damage to the components, which may result in unexpected vehicle/machine movement.

NOTE: *If a pump or motor is being replaced due to internal damage, the remaining units (pump or motors) need to be inspected for damage and contamination, and the entire hydraulic system will need to be flushed and the fluid replaced. Failure to do so may cause considerable damage to the entire system.*

The inlet line leading from the reservoir to the pump must be filled prior to start-up. Check the inlet line for property tightened fittings and make sure it is free of restrictions and air leaks.

NOTE: *In most cases, the reservoir is above the pump inlet so that the pressure head created by the higher oil level helps to keep the inlet pressures within an acceptable range and prevent high vacuum levels. However, due to hose routing or low reservoir locations, there may be air trapped within this line. It is important to assure that the air is bled from this line. This can be accomplished by loosening the hose at the fitting closest the pump. When oil begins to flow, the line is full, the air has been purged, and the fitting can be retightened to its specified torque. If the tank needs to be pressurized in order to start the flow of oil, a vacuum reading should be taken at the inlet of the pump during operation in order to verify that the pump is not being asked to draw an inlet vacuum higher than it is capable of.*

Be certain to fill the pump and/or motor housing with clean hydraulic fluid prior to start up. Fill the housing by pouring filtered oil into the upper case drain port.

NOTE: *It is highly recommended to use the highest possible case drain port, this ensures that the housing contains as much oil as possible and offers the greatest amount of lubrication to the internal components.*

NOTE: *In initial start-up conditions, it may be convenient to fill the housing, just prior to installing the case drain line. Component, (especially motor), location may be such that access to the case drain port after installation is not realistic.*

NOTE: *Make certain that the oil being used to fill the component housing is as clean as possible, and store the fill container in such a way as to prevent it from becoming contaminated.*

Install a 60 bar (or 1000 psi) pressure gauge in the charge pressure gauge port in order to monitor the charge pressure during start-up.

It is recommended that the external control input signal, (electrical connections for EDC), be disconnected at the pump control until after initial start-up. This will ensure that the pump remains in its neutral position.

⚠ WARNING

DO NOT START THE ENGINE UNLESS PUMP IS IN THE NEUTRAL POSITION (0 DEGREES SWASHPLATE ANGLE). TAKE PRECAUTIONS TO PREVENT MACHINE MOVEMENT IN CASE PUMP IS ACTUATED DURING INITIAL START-UP.

"Jog" or slowly rotate the engine until charge pressure starts to rise. Start the engine and run at the lowest possible RPM until charge pressure has been established. Excess air should be bled from the system lines as close to the motors as possible.

NOTE: *With the engine on low idle, "crack", (loosen-don't remove), the system lines at the motor(s). Continue to run the engine at low idle and tighten the system lines as soon as oil is observed to leak from them. When oil is observed to "leak" at the motor the line is full, the air has been purged, and the system hoses should be retightened to their specified torque.*

Once charge pressure has been established, increase speed to normal operating RPM. Charge pressure should be as indicated in the pump model code. If charge pres-

sure is inadequate, shut down and determine the cause for improper pressure.

⚠ WARNING

INADEQUATE CHARGE PRESSURE WILL AFFECT THE OPERATOR' S ABILITY TO CONTROL THE MACHINE.

Shut down the engine and connect the external control input signal. Also reconnect the machine function(s), if disconnected earlier. Start the engine, checking to be certain the pump remains in neutral. With the engine at normal operating RPM, slowly check for forward and reverse machine operation.

Charge pressure may slightly decrease during forward or reverse operation. Continue to cycle slowly between forward and reverse for at least five minutes.

Shut down engine, remove gauges, and plug ports. Check reservoir level and add filtered fluid if needed.

The machine is now ready for operation.

2.35 SEMI-TRACK

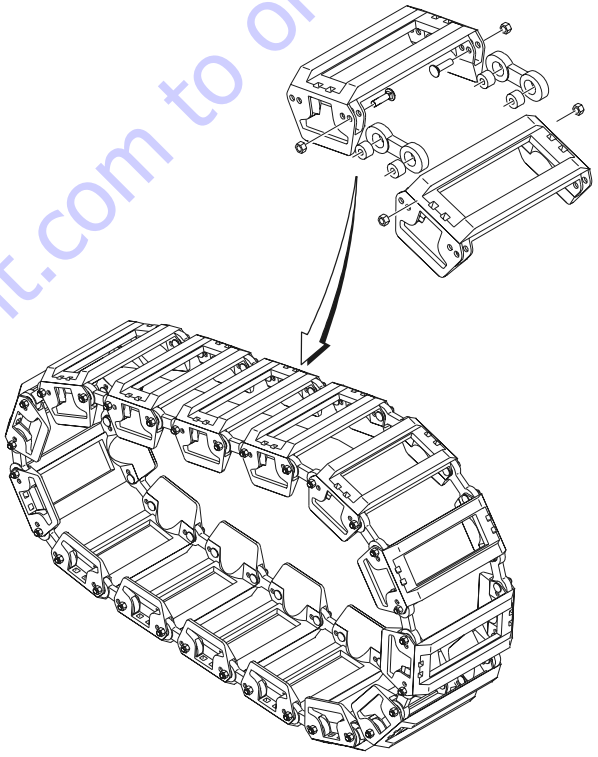
The semi-track option is available in either soft or hard track configurations. The semi-track provides increased traction in rough terrain applications.

Testing the Track

With both sides installed, drive the machine slowly in both directions to see that the track does not catch or hit any part of the machine. Test the machine until it can be driven at top speed and on side slopes without the tracks hitting. In the first few days after use, check the track frequently to see that all bolts are staying tight and that no damage is being caused to the tires or machine.

Removing the Track

If the tracks are muddy, it is a good idea to wash them off or drive the loader through water before removing. If the tracks are going to be stored in the laid out position just as they come off the machine, then move the machine to the storage area to remove the tracks. If the tracks are going to be rolled up and put on a pallet, it is best to remove them on a hard surface. Remove the bolts that hold the track together. These bolts are accessible over the front tires. After the nuts are removed, pound them flush with the pad. Drive the machine ahead until the bolts are at the bottom between tires. Remove the inside bolts by turning them out with a wrench and punch out the outside bolts. Drive the machine ahead and take off the tracks. If the track is to be rolled up, it is best to set the track on edge and roll it. Secure the end of the track and put the loose hardware in the end of the track.



Assuming Normal Wear

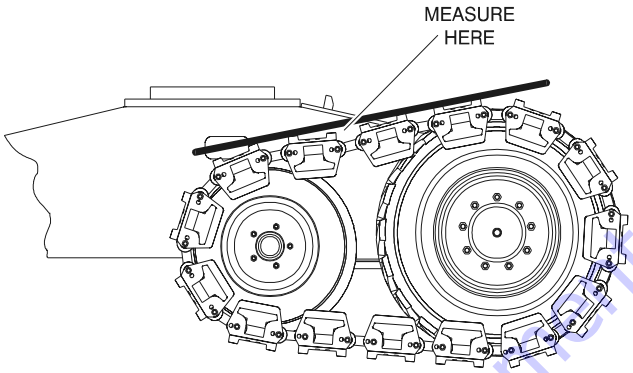
It is normal for the bushing to wear down to the bolt and for the link hole to wear oblong till it is ready to break out the end.

Adjustment

⚠ CAUTION

IMPROPER SLACK ADJUSTMENT COULD CAUSE TRACK PARTS TO BREAK.

Place a straight edge long enough to reach from the idler to the drive wheel on the tracks. Measure the maximum amount of track sag from the high point of the track segment to the bottom of the straight edge. Properly adjusted track will have approximately 1 to 2 inches (25 to 50 mm) slack.



To adjust the slack measurement, move the bolts from the first hole to the second to create less slack, or from the second to the first to create more slack.

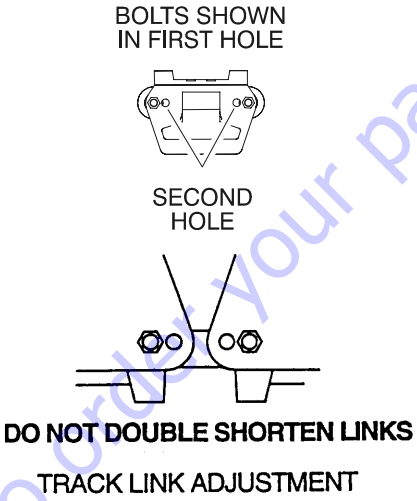


Table 2-6.Adjustment Chart

Move	1 Hole	2 Holes	3 Holes	4 Holes	5 Holes	6 Holes	7 Holes	8 Holes	9 Holes	10 Holes	11 Holes	12 Holes
Equals	0.81 in (20.5 mm)	1.62 in (41 mm)	2.43 in (62 mm)	3.25 in (82.5 mm)	4.06 in (103 mm)	4.87 in (124 mm)	5.68 in (144 mm)	6.50 in (165 mm)	7.31 in (186 mm)	8.12 in (206 mm)	8.93 in (227 mm)	9.75 in (248 mm)

2.36 HOSE AND CABLE INSTALLATION AND ROUTING

When installing replacment hoses or cable, it is important that the new hoses and cables are routed as shown to ensure maximum service life.

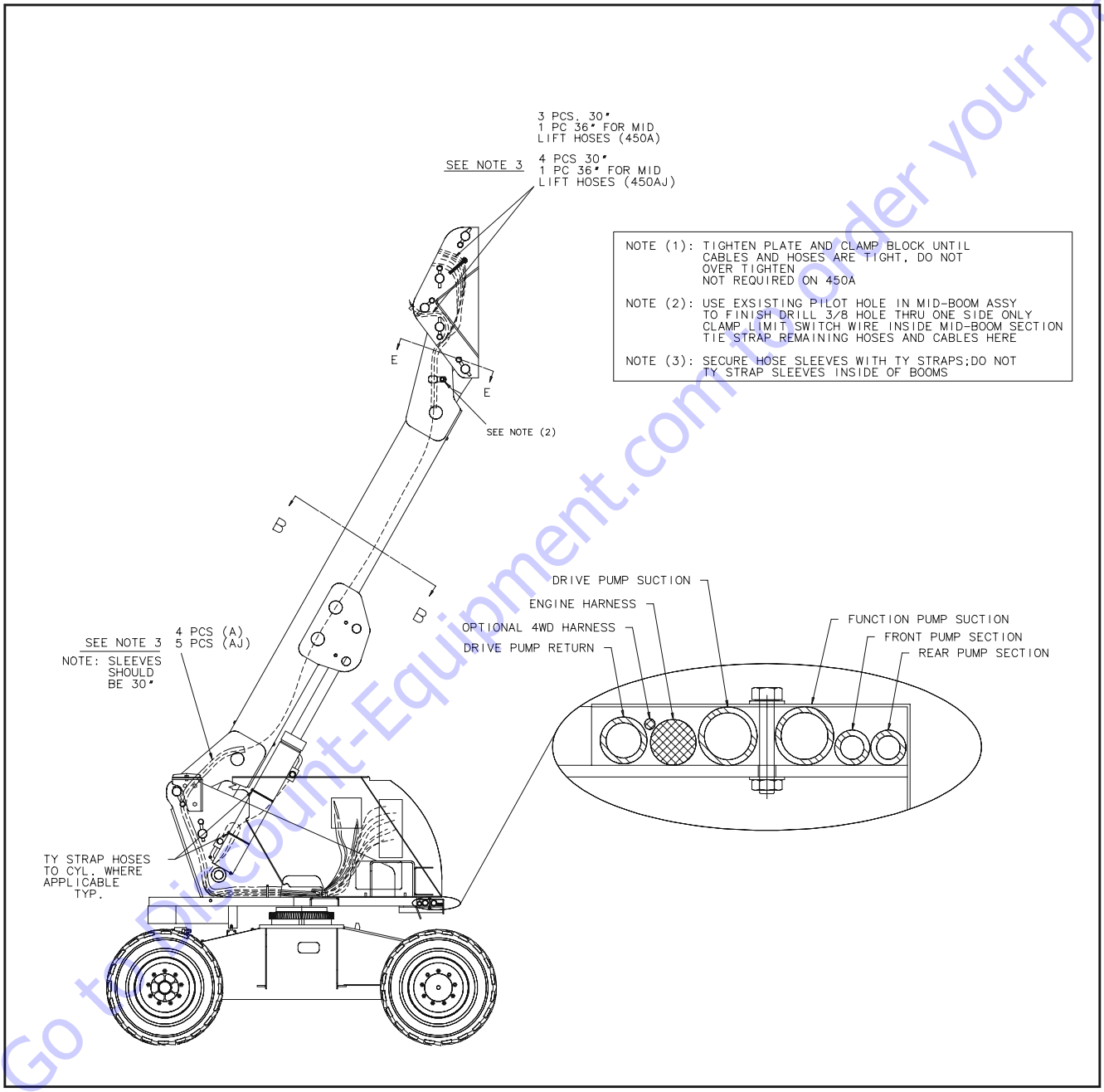


Figure 2-45. Hose and Cable Installation and Routing - Sheet 1 of 5

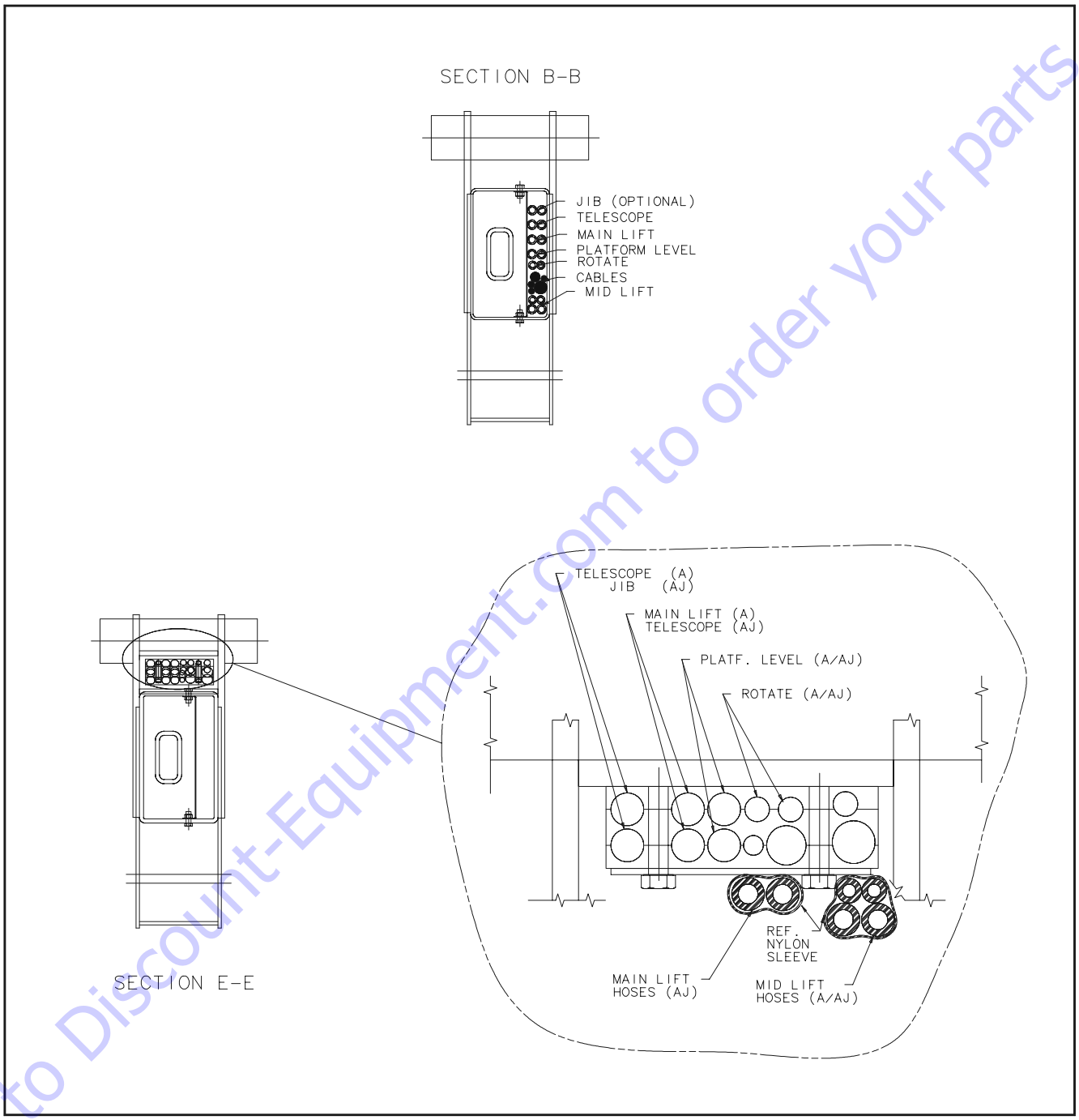


Figure 2-46. Hose and Cable Installation and Routing - Sheet 2 of 5

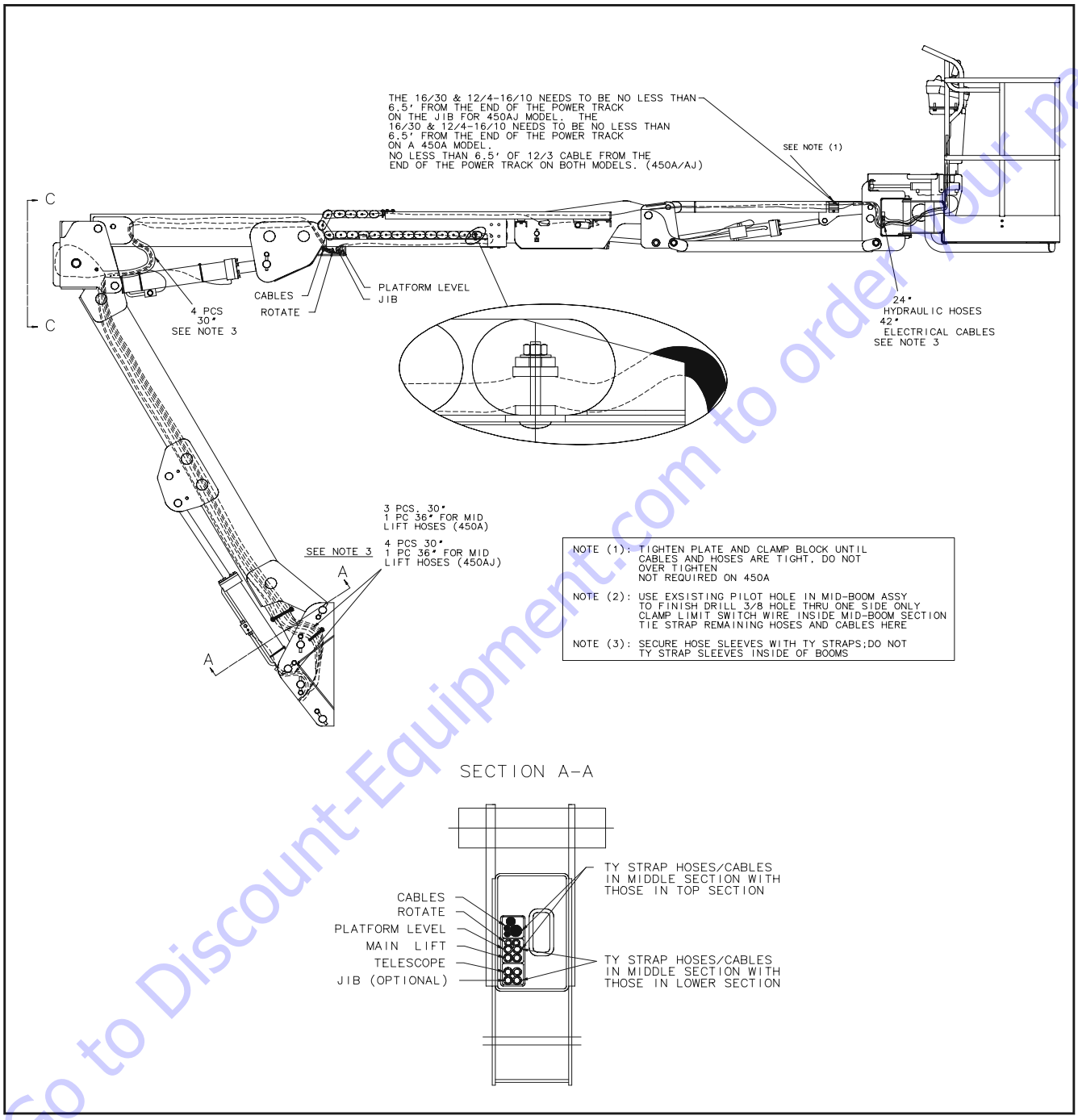


Figure 2-47. Hose and Cable Installation and Routing - Sheet 3 of 5

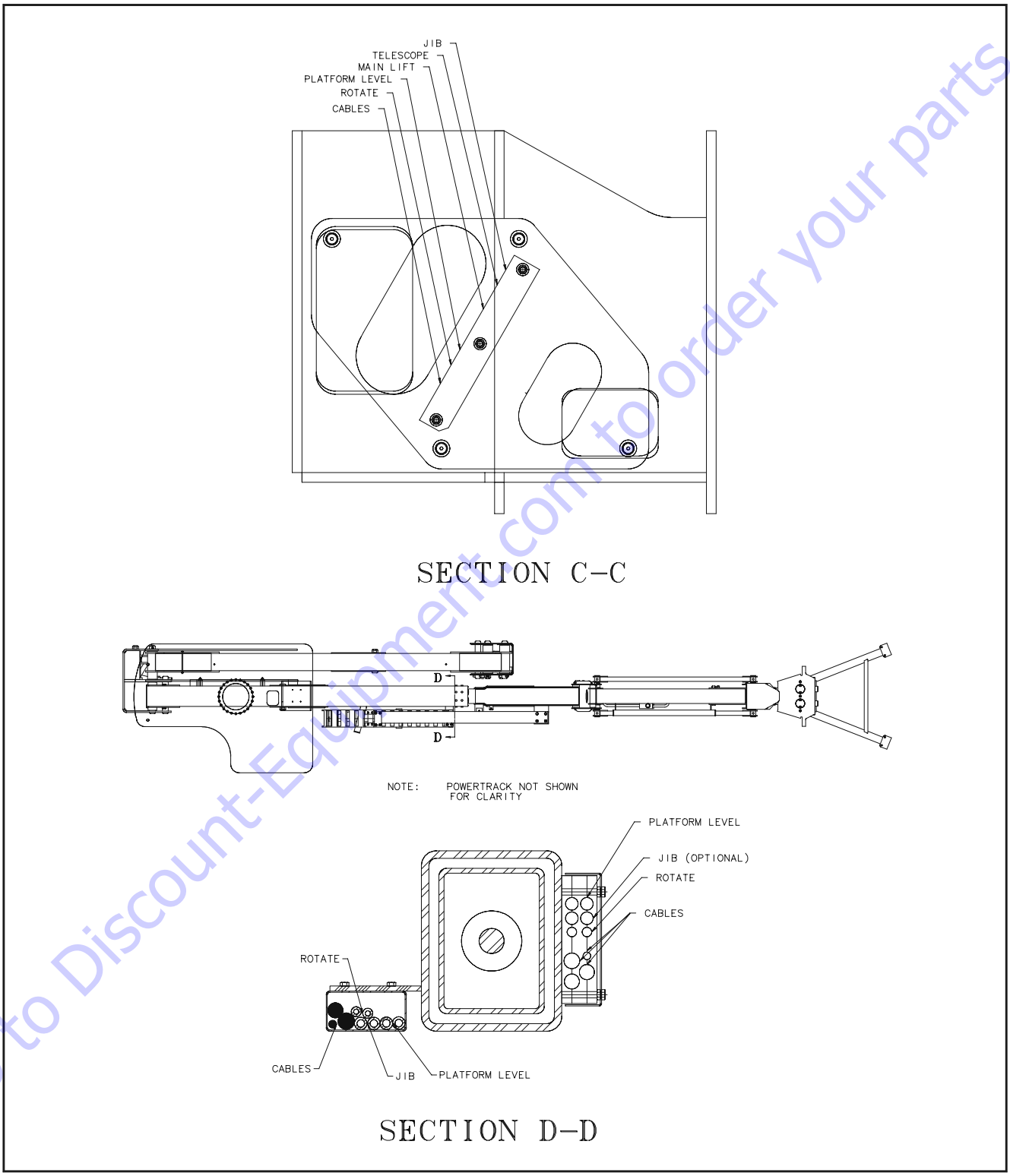


Figure 2-48. Hose and Cable Installation and Routing - Sheet 4 of 5

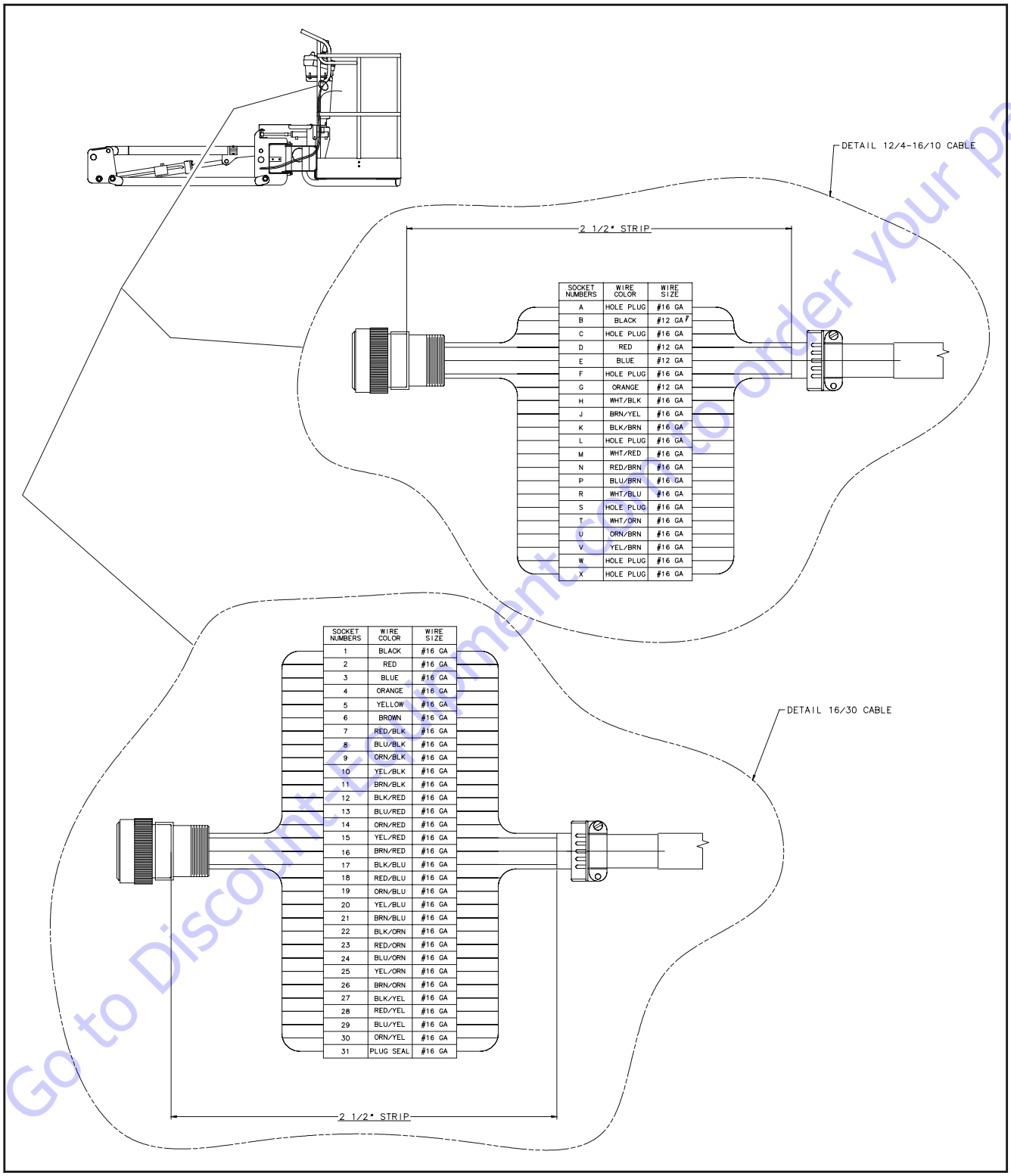


Figure 2-49. Hose and Cable Installation and Routing - Sheet 5 of 5

2.37 PREVENTIVE MAINTENANCE AND INSPECTION SCHEDULE

The preventive maintenance and inspection checks are listed and defined in the following table. This table is divided into two basic parts, the "AREA" to be inspected, and the "INTERVAL" at which the inspection is to take place. Under the "AREA" of the table, the various systems along with components that make up that system are listed. The "INTERVAL" portion of the table is divided into five columns representing the various inspection time periods. The numbers listed within the interval column represent the applicable inspection code for which that component is to be checked.

The checks and services listed in this schedule are not intended to replace any local or regional regulations that may pertain to this type of equipment nor should the lists be considered as all inclusive. Variances in interval times may occur due to climate and/or conditions and depending on the location and use of the machine.

JLG Industries requires that a complete annual inspection be performed in accordance with the "Annual Machine Inspection Report" form. Forms are supplied with each new machine and are also available from JLG Customer Service. Forms must be completed and returned to JLG Industries.

⚠ IMPORTANT

JLG INDUSTRIES REQUIRES THAT A COMPLETE ANNUAL INSPECTION BE PERFORMED IN ACCORDANCE WITH THE "ANNUAL MACHINE INSPECTION REPORT" FORM.

This machine requires periodic safety and maintenance inspections by a JLG Dealer. A decal located on the turntable affords a place to record (stamp) inspection dates. Notify dealer if inspection is overdue.

The inspection and maintenance code numbers are as follows:

1. Check for proper and secure installation.
2. Check for visible damage and legibility.
3. Check for proper fluid level.
4. Check for any structural damage; cracked or broken welds; bent or warped surfaces.
5. Check for leakage.
6. Check for presence of excessive dirt or foreign material.
7. Check for proper operation and freedom of movement.
8. Check for excessive wear or damage.
9. Check for proper tightness and adjustment.
10. Drain, clean and refill.
11. Check for proper operation while engine is running.
12. Check for proper lubrication.
13. Check for evidence of scratches, nicks or rust and for straightness of rod.
14. Check for condition of element; replace as necessary.
15. Check for proper inflation.
16. Clean or replace suction screen.
17. Drain and clean.

* To be performed quarterly.

** Inspection and Maintenance Code 10, 12, 16 to performed every two years.

Table 2-7.Preventive Maintenance and Inspection Schedule

AREA		INTERVAL					
		DAILY	WEEKLY	MONTHLY	3 MONTH	6 MONTH	YEARLY
	BOOM						
1.	Platform	1,4					
2.	Platform Gate	1,4		12			
3.	Platform Rotator		5,11				
4.	Footswitch	1,11					
5.	Controllers	1,11					
6.	Switches	1,11					
7	Lift Up/Platform Down Disable Switch*				1,7,9		
7.	Placards and Decals	1,2					
8.	Control Tags	1,2					
9.	Valves	1,11	5,6				
10.	Carrier (Hoses and Cables)	1	4,8				
11.	Lockout Cylinders (If equipped)	1	5				
12.	Pins			8			
13.	Bushings			8			
14.	Wear Pads			8			
15.	Cylinders		1,5,6,13				
17.	Drift Test*						

Table 2-7.Preventive Maintenance and Inspection Schedule

AREA		INTERVAL					
		DAILY	WEEKLY	MONTHLY	3 MONTH	6 MONTH	YEARLY
	TURNTABLE						
1.	Engine Oil (see mfg. manual)	3	5				
2.	Battery	3	5				
3.	Radiator	3	5				
4.	Air Cleaner	1	14				
5.	Exhaust System	1		1,5			
6.	Spark Arrester	1		1,5	17		
7.	Engine Mount			1			
8.	Ground Controls	1,2,11					
9.	Main Hydraulic Pump	1	5				
10.	Auxiliary Power Pump	1	5				
11.	Valves	1,11	5				
12.	Hydraulic Filters	14	5				
13.	Hydraulic Hoses	1	5				
14.	Hydraulic Oil Tank**	3	5	4			
15.	Breather Hydraulic Tank		6,14				
16.	Fuel Tank	3,5		4			
17.	Cylinders		1,5,6,13	4			
18.	Hood Doors	1					
19.	Turntable Locking Pin	1,7					
20.	Horizontal Limit Switch	1,7					
21.	Oil Coupling		5				
22.	Placards and Decals	1,2					
23.	Swing Bearing		1		9, 12		
24.	Swing Brake		1,5,6	8			
25.	Swing Hub				3,9		

Table 2-7.Preventive Maintenance and Inspection Schedule

	AREA	INTERVAL					
		DAILY	WEEKLY	MONTHLY	3 MONTH	6 MONTH	YEARLY
	CHASSIS						
1.	Wheel and Tire Assembly	1	8,9,15				
2.	Drive Motors		1,5,6				
3.	Drive Torque Hubs**		1,5,6		3		
4.	Drive Brakes		1,5,6				
5.	Steer Cylinders	1	1,5,6,13				
6.	Steer Components	1	4,6	8			
7.	Lockout Cylinders (if equipped)*	1	5,13	8			
8.	Hydraulic Hoses	1					
9.	Placards and Decals	1,2					
10.	Wheel Bearings			8			
11.	Swing Bearing/Worm Gear		1		9,12		

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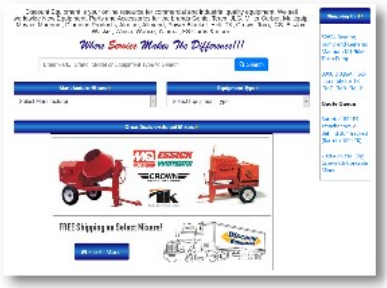

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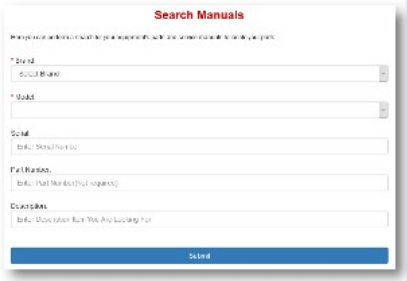

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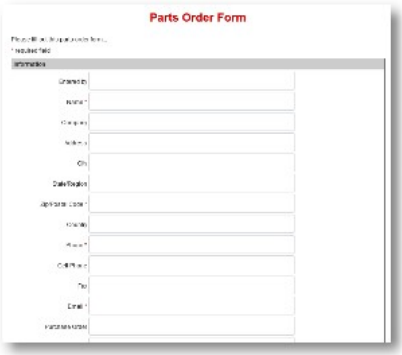

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SECTION 3. TROUBLESHOOTING

3.1 GENERAL

This section contains troubleshooting information 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.

3.2 TROUBLESHOOTING.

The troubleshooting procedures applicable to the aerial platform are listed and defined in Tables 3-1 through 3-6. As an aid to table use, the aerial platform is divided into four major groups, each covered separately within this section. These groups are as follows: elevation system, chassis assembly, hydraulic system and electrical system.

Each malfunction within an individual group or system is followed by a listing of probable causes which will enable determination of the applicable remedial action. The probable causes and the remedial action should, where possible, be checked in the order listed in the tables.

It should be noted that there is no substitute for a thorough knowledge of the equipment and related systems.

It should be recognized that the majority of the problems arising in the machine will be centered in the hydraulic and electrical systems. For this reason, every effort has been made to ensure that all likely problems in these areas are given the fullest possible treatment. In the remaining machine groups, only those problems which are symptomatic of greater problems which have more that one probable cause and remedy are included. This means that problems for which the probable cause and remedy may be immediately obvious are not listed in this section.

The first rule for troubleshooting any circuit that is hydraulically operated and electrically controlled is to determine if the circuit is lacking hydraulic oil and electrical control power. This can be ascertained by overriding the bypass valve (mechanically or electrically) so that oil is available to the function valve, then overriding the function valve mechanically. If the function performs satisfactorily, the problem exists with the control circuit.

3.3 HYDRAULIC CIRCUIT CHECKS.

The reference for improper function of a hydraulic system, where the cause is not immediately apparent, should be the Troubleshooting Chart. The best place to begin the problem analysis is at the power source (pump). Once it is determined that the pump is serviceable, then a systematic check of the circuit components, beginning with the control, would follow. For aid in troubleshooting, refer to the Illustrated Parts Manual for hydraulic diagrams of the various circuits

Table 3-1.Platform Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
Automatic leveling inoperative.		
	Hydraulic system oil low.	Replenish oil as necessary.
	Dual check valves dirty/inoperative.	Clean or replace as necessary.
	Restricted or broken hydraulic line or fitting on slave cylinder or main lift cylinder.	Clean, repair, or replace line or fitting.
	Worn seal(s) in slave level or main lift cylinder.	Replace seal(s).
	Counterbalance valve in slave cylinder defective.	Replace counterbalance valve.
	Slave level or main lift cylinder not functioning properly.	Slave level or main lift cylinder not functioning properly.
Platform will not maintain level attitude.		
	Counterbalance valve on slave leveling cylinder improperly adjusted or not functioning properly.	Replace valve.
	Worn seal(s) in slave level or main lift cylinder.	Replace seal(s).
	Damaged slave level or main lift cylinder.	Repair or replace cylinder.
No response to platform leveling controls.		
	Level function not activated within 7 seconds after footswitch was depressed.	Recycle footswitch.
	Level control switch inoperative.	Repair or replace control switch lever.
	Hydraulic system oil low.	Replenish oil as necessary.
	System orifice plugged/dirty.	Clean orifice.
	Restricted or broken hydraulic line or fitting.	Clean, repair, or replace line or fitting.
	Control valve not functioning properly.	Repair or replace valve.
	No electric to dump or control valve.	See proper wiring diagram.
	Slave cylinder not functioning properly.	Repair or replace pump.
Platform will not adjust "up" or "down" to level.		
	Hydraulic pump not functioning properly.	Repair or replace pump.
	Restricted or broken hydraulic line or fitting.	Clean, repair, or replace line or fitting.
	Slave cylinder not functioning properly.	Repair or replace cylinder.
	Electrical failure.	See proper wiring diagram.
	Orifice plugged.	Clean orifice.

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Table 3-2.Boom Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
	CONTROL VALVES	
Valve spool sticking.		
	Dirt in oil causing excessive temperature build-up.	Flush system and change oil using recommended viscosity
	Moisture in oil.	Flush system and change oil using recommended viscosity
	Incorrect valve mounting causing warping of the unit.	Loosen valve and check mounting. Repair as necessary.
	Valve spool scored.	Remove valve and repair or replace as necessary.
	Tie-bolts in valve over torqued.	Correctly torque bolts.
	Return spring weak or broken.	Remove valve and repair or replace as necessary.
	Relief valve malfunctioning causing excessive pressure within valve.	Check pressure delivery to and from valve and repair or replace as necessary.
Valve leaking.		
	Dirt or other foreign material under seal.	Remove and repair valve as necessary.
	Valve spool scored.	Remove valve and repair or replace as necessary.
	Excessive back pressure caused by restricted return line to reservoir.	Remove line and clear obstruction or replace line as necessary.
	Damaged valve seals.	Remove valve and repair or replace as necessary.
	BOOM ELEVATION SYSTEM.	
No response to lift control switch.		
	Lift function not activated within 7 seconds after footswitch was depressed.	Recycle footswitch.
	Lift control switch inoperative.	Repair or replace control switch.
	Lift cylinder holding valve inoperative.	Repair or replace holding valve.
	Dump valve (bypass) not operating.	Determine cause and repair or replace valve.
	Electrical malfunction.	See wiring diagram.
	Hydraulic system oil low.	Replenish oil as necessary.
	Restricted or broken supply line on valve bank or hydraulic pump.	Clean or replace line.

Table 3-2.Boom Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
	Control valve not functioning properly.	Repair or replace valve.
	Lift cylinder not functioning properly.	Repair or replace cylinder
Boom will not raise.		
	Lift function not activated within 7 seconds after footswitch was depressed.	Recycle footswitch.
	Load capacity exceeded (personnel or equipment on platform).	Reduce load.(Refer to capacity placard.)
	Hydraulic system oil low.	Replenish oil as necessary.
	Electrical failure to valves.	See proper wiring diagram.
	Restricted or broken hydraulic line or fitting.	Clean, repair, or replace line or fitting.
	Control valve not functioning properly.	Repair or replace valve.
	Pressure relief valve not functioning properly.	Re-adjust or replace valve.
	Bypass valve (dump) not functioning.	Repair or replace valve.
	Lift cylinder not functioning properly.	Repair or replace cylinder.
	Binding lift cylinder or boom pivot pin.	Repair or replace cylinder or pin.
Boom will not lower.		
	See: Boom will not raise.	
	Pressure relief valve not functioning properly.	Re-adjust or replace valve.
	Holding valve not functioning properly.	Re-adjust or replace valve.
Boom raises and lowers erratically.		
	Hydraulic system oil low.	Replenish oil as required.
	Restricted or broken hydraulic line or fitting.	Clean, repair, or replace line or fitting.
	Counterbalance valve on lift cylinder improperly adjusted or not functioning properly.	Replace valve.
	Control valve not functioning properly.	Repair or replace valve.
	Worn seals in lift cylinder.	Replace seals.
	Cylinder not functioning properly.	Repair or replace cylinder.
Boom drifts down.		
	Worn seals in lift cylinder.	Replace seals.

Table 3-2.Boom Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
Function Speed, Drive Speed and High Engine does not operate below horizontal.		
	Damaged wiring on level limit switch.	Repair or replace wiring.
	Solenoid failure.	Replace solenoid.
	Tripped circuit breaker.	Reset circuit breaker.
	Damaged level limit switch.	Replace switch, repair or replace holder.
	Defective relay, main terminal box.	Replace relay.
	Defective platform switch.	Replace switch.
LOWER LIFT FUNCTION.		
If the boom assembly does not fully lower.		
	The Mid and Lower Booms are out of synchronization.	Refer to synchronize procedure.
MAIN TELESCOPE SYSTEM.		
No response to telescope control.		
	Telescope function not activated within 7 seconds after footswitch was depressed.	Recycle footswitch.
	Telescope control switch inoperative.	Repair or replace control switch.
	Hydraulic system oil low.	Replenish oil as necessary.
	Damaged wiring on control switch or solenoid valve.	Repair or replace wiring.
	Control valve not functioning properly.	Repair or replace valve.
	Restricted or broken supply line on valve bank or hydraulic pump.	Clean or replace line.
	Telescope cylinder not functioning properly.	Repair or replace cylinder.
	Hydraulic pump not functioning properly.	Repair or replace pump.
Boom will not extend.		
	Telescope function not activated within 7 seconds after footswitch was depressed.	Recycle footswitch.
	Control valve not functioning properly.	Repair or replace control valve.
	Restricted or broken hydraulic line or fitting.	Clean, repair, or replace line or fitting.
	Pressure setting incorrect.	Check pressure/re-adjust as necessary.
	Telescope cylinder not functioning properly.	Repair or replace cylinder.

Table 3-2.Boom Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
Boom extends and retracts erratically.		
	Hydraulic system oil low.	Replenish oil as necessary.
	Wear pads worn.	Replace pads as required.
	Restricted or broken hydraulic line or fitting.	Clean, repair, or replace line or fitting.
	Control valve not functioning properly.	Repair or replace valve.
	Worn seals in telescope cylinder.	Replace seals.
	Cylinder not functioning properly.	Repair or replace cylinder.
	Counterbalance valve not functioning properly.	Replace counterbalance valve.
BOOM SWING SYSTEM		
No response to swing control.		
	Swing function not activated within 7 seconds after footswitch was depressed.	Recycle footswitch.
	Hydraulic system oil low.	Replenish oil as necessary.
	Swing control switch not functioning.	Repair or replace swing control switch.
	Restricted or broken supply line on valve bank or hydraulic pump.	Clean or replace line.
	Control valve not functioning properly.	Repair or replace valve.
	Swing motor not functioning properly.	Repair or replace motor.
	Restrictor valve(s) plugged.	Clean or replace restrictor valve.
	Foreign objects(s) wedged between swing motor pinion and swing gear.	Remove objects, check for damage, and repair or replace component(s) as required.
	Pressure reducing valve in swing circuit malfunctioning.	Repair or replace pressure reducing valve.
	No electric power to valve.	See proper wiring diagram.
Boom will swing in one direction only.		
	Restricted or broken hydraulic line or fitting.	Clean, repair, or replace line or fitting.
	Control valve not functioning properly.	Repair or replace valve.
	Foreign object(s) wedged between swing motor pinion and swing gear.	Remove object(s), check for damage and repair or replace component(s) as required.
	Swing control switch not functioning properly.	Repair or replace swing control switch.

Table 3-2.Boom Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
Boom swings erratically in either direction.		
	Hydraulic system oil low.	Replenish oil as necessary.
	Lack of lubricant on swing gear or speed reducer pinion.	Lubricate as required. (See Lubrication Chart.)
	Swing motor not functioning properly.	Repair or replace swing control switch.
	Worn or broken teeth on swing gear or swing motor pinion.	Replace gear(s) as required.
	Restrictor valves(s) plugged.	Clean or replace restrictor valve.

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Table 3-3.Turntable Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
CONTROL VALVE.		
Valve Spool Sticking.		
	Dirt in oil causing excessive temperature built-up.	Change oil using recommended viscosity and flush system.
	Incorrect valve mounting causing warping of the unit.	Loosen valve and check mounting.Repair as necessary.
	Valve spool scored.	Remove valve and repair or replace as necessary.
	Return spring weak or broken.	Remove valve and repair or replace as necessary.
	Relief valve malfunctioning causing excessive pressure within valve.	Check pressure delivery to and from valve and repair or replace as necessary.
Valve leaking.		
	Dirt or other foreign material under seal.	Remove and replace valve as necessary.
	Valve spool scored.	Repair or replace valve.
	Excessive back pressure caused by restricted return line to reservoir.	Remove line and clear obstruction or replace line as necessary.
	Damaged valve seals.	Repair or replace valve as necessary.

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Table 3-4.Chassis Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
POWER PLANT.		
Engine will not start.		
	Station power selector switch not in required position.	Actuate switch as required.
	Circuit breaker open.	Determine and correct cause; reset circuit breaker.
	Defective starter motor.	Replace starter motor.
	Damaged wiring in ignition circuit (broken wire on starter).	Repair, replace wiring.
	Ignition switch not functioning properly.	Replace switch.
	Ignition relay not functioning properly.	Replace relay.
	Ignition circuit shorted to ground.	See proper wiring diagram.
	Battery cable(s) not making contact.	Clean and tighten cable(s).
	Start lockout not working.	See wiring diagram. Check relay.
Engine will not start (ignition OK).		
	No fuel.	Replenish fuel as necessary.
	Clogged fuel filter.	Replace fuel filter.
	Choke solenoid malfunction.	Replace choke solenoid.
	Restricted or broken fuel line.	Clean or replace fuel line.
	Fuel shut-off valve in carburetor stuck or frozen.	Repair or replace fuel shut-off. Check for electrical power.
	Battery discharged.	Charge battery, replace if defective.
	Fuel pump not working.	Replace fuel pump.
	Cam timing belt jumped time or broken.	Repair or replace timing belt.
	Ignition timing slipped.	Repair timing.
Engine will not accelerate above low.		
	Damaged wiring on speed control switch or high engine solenoid.	Repair or replace wiring.
	Drive controller not functioning properly.	Replace controller.
	Actuator not functioning properly.	Repair or replace solenoid.
	Excessive load on engine.	Reduce load.

Table 3-4.Chassis Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
	Engine worn badly.	Rebuild engine.
	Engine improperly timed.	Time engine.
	Engine overheating.	Determine cause of overheating and remedy.
	Dirty fuel filter.	Replace filter.
	Fuel line pinched.	Replace fuel line.
	Throttle governor not working properly.	Repair or replace governor.
Engine surges.		
	Governor not adjusted properly.	Correctly adjust governor.
Strong fuel odor.		
	Fuel tank overfilled.	Check fuel tank and immediately wipe up spilled fuel.
	Fuel tank damaged.	Drain all fuel from tank and remove tank for replacement or repair.
	Fuel line from tank damaged.	Replace fuel line.
	Carburetor flooding.	Repair, replace or adjust carburetor.
FRONT FRAME AXLE AREA.		
One or both wheels will not steer.		
	Steering link or tie rod broken or attaching hardware missing.	Replace steering link, tie rod or hardware as necessary.
One or both front wheels will not rotate or rotate erratically.		
	Wheel hub or bearings damaged or not lubricated.	Replace hub or bearings as necessary and repack bearings with approved grease.
REAR FRAME AXLE AREA.		
Difficulty encountered when moving machine.		
	Load capacity exceeded.	Reduce load. Apply loads only in accordance with load capacity indicator.
	Flow divider sticking.	Repair or replace flow divider.
	Machine being moved up too steep a grade.	Remove machine from grade and check that drive system operates correctly.
	Grade too steep.	See WARNING Placard on platform for specified grades and sideslopes.
	Towing valve not closed.	Close towing valve.

Table 3-4.Chassis Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
	Drive wheel tire treads worn smooth.	Replace tires as necessary and inflate to specified pressure.
	Drive brakes "dragging".	Re-adjust pressure.
	System pressure too low.	Re-adjust pressure.
	Drive hub(s) defective.	Repair or replace hub.
	Engine RPM's not set.	Correctly set engine RPM.
	Drive motors worn.	Repair or replace drive motors.
	Counterbalance valve defective.	Replace counterbalance valve.
	Low amperage on controller.	Correctly adjust controller.
DRIVE SYSTEM.		
No response to control.		
	Drive function not activated within 7 seconds after footswitch was depressed.	Recycle footswitch.
	Hydraulic system oil low.	Replenish oil as necessary.
	Hydraulic pump not functioning properly.	Repair or replace pump.
	Restricted or broken pump supply line.	Clean, repair or replace line.
	Restricted or broken line on valve bank.	Clean, repair or replace line.
	Drive motor(s) not functioning properly.	Repair or replace motor(s).
	Air in wheel brake circuit.	Bleed circuit, determine and correct cause.
	Fuse is blow-out on control card.	Replace fuse.
	Damaged wiring on control switch.	Repair or replace wiring.
	Control switch not functioning properly.	Replace switch.
	Brake(s) not releasing.	Determine cause and repair or replace.
Machine will not travel in forward.		
	Hydraulic system oil low.	Replenish oil as necessary.
	Restricted or broken hydraulic line or fitting.	Clean, repair or replace line or fitting.
	Control valve not functioning properly.	Repair or replace valve.
	Drive motor(s) not functioning properly.	Repair or replace motor(s).
	Circuit breaker open.	Determine and correct cause; reset circuit breaker.
	Counterbalance valve sticking on return side.	Adjust return counterbalance out 3 turns - cycle drive - return to original position.

Table 3-4.Chassis Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
Motor turns slowly in the direction of the last command.		
	Valve not returning to neutral.	Check neutral springs.
	Function speed switch malfunction.	Replace function switch.
	Sticking spool due to contamination.	Remove end cap and check spool freedom. Repair as necessary.
Motor turns slowly at maximum command.		
	Valve spool is not traveling far enough due to:	Repair or replace drive motor(s).
	Worn, leaking drive motor(s).	Repair or replace drive motor(s).
	Engine RPM's set too low.	Properly adjust engine RPM's.
	Low control pressure supply.	Replace pressure regulator if necessary.
	Function speed switch malfunction.	Replace switch.
	Amperage too low on controller.	Correctly adjust controller.
	Defective pump, low oil volume.	Repair or replace pump.
Poor response, function shuts off slowly when command is removed.		
	Low spool spring preload.	Check for correct spring and shims in end caps.
	Sticking spool due to contamination.	Remove end cap and check spool freedom.
	Ramp set too high in controller.	Adjust controller.
	Sticking control handle.	Repair or replace controller.
STEERING SYSTEM.		
No response to steer control.		
	Circuit breaker open.	Determine and correct cause; reset circuit breaker.
	Hydraulic system oil low.	Replenish oil as necessary.
	Hydraulic system pressure too low.	Adjust pressure.
	Damaged wiring on control switch or solenoid valve.	See proper wiring diagram.
	Control switch not functioning properly.	Replace switch.
	Restricted or broken hydraulic line on valve bank, hydraulic pump or rotary coupling. (If equipped.)	Clean, repair or replace line.

Table 3-4.Chassis Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
	If equipped, swivel coupling leaking internally. (Seals defective.)	Repair or replace coupling.
	Steer control valve not functioning properly.	Repair or replace valve.
	Steer cylinder not functioning properly.	Repair or replace cylinder.
Machine hard to steer or steering is erratic.		
	Hydraulic system oil low.	Replenish oil as necessary.
	Restricted hydraulic line or fitting.	Clean, repair or replace line or fitting.
	Restricted crossover relief valve.	Clean or replace valve.
	Steer system pressure low.	Adjust pressure.
	Bent linkage (tie rods).	Repair or replace linkage as required.
	Hydraulic pump not functioning properly.	Repair or replace pump.
	Steer cylinder not functioning properly.	Repair or replace cylinder.
Steering inoperative.		
	Damaged wiring on control switch or solenoid valve.	See proper wiring diagram.
	Solenoid valve not functioning properly.	Repair or replace valve.
	Control switch not functioning properly.	Replace switch.
	Relief valve improperly set or not functioning properly.	Reset, repair or replace valves as required.
	Steer cylinder not functioning properly.	Repair or replace cylinder.
Machine will not steer left or to the right.		
	Wiring on control switch is damaged.	See proper wiring diagram.
	Wiring on solenoid valve damaged.	Repair or replace wiring.
	Coil in solenoid damaged.	Replace coil.
	No oil flow or pressure to steer circuit.	Take pressure reading at steer valve and adjust as necessary.
	Bent cylinder rod.	Repair or replace cylinder.
	Damaged tie rod.	Replace tie rod.
	Crossover relief valve sticking.	Repair crossover relief valve.
	Cylinder packing defective.	Repair or replace cylinder.

Table 3-4.Chassis Assembly - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
Machine wanders; steering not firm.		
	Crossover relief valve set too low or not functioning properly.	Reset, repair or replace valve as required.
	Steer linkages loose.	Tighten linkage.
	Steer wheel toe-in not set properly.	Adjust toe-in for 1/4 inch overall.
	Spindle bushings badly worn.	Replace bushings.

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Table 3-5.Hydraulic System - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
HYDRAULIC SYSTEMS - GENERAL.		
Hydraulic pump noisy.		
	Air entering system through broken line or fitting. (Suction Side.)	Repair or replace line or fitting.
	Suction screen dirty.	Clean suction screen.
	Air bubbles in oil. (Reservoir oil too low.	Replenish oil as required.
	Suction hose squeezed shut.	Determine cause and repair.
	Oil filter dirty.	Replace hydraulic filter.
	Wrong type of hydraulic oil.	Replace hydraulic oil.
Pump cavitating. (Vacuum in pump due to oil starvation.)		
	Restricted suction line.	Clean, repair, or replace line.
	Restricted reservoir air vent.	Clean or replace vent.
	Oil viscosity too high.	Drain system and replace with recommended oil. (Refer to Hydraulic Oils.)
	Air leak in suction side of tank.	Repair leak.
	Restricted suction strainer.	Clean strainer.
System overheating.		
	Oil viscosity too high.	Drain system and replace with recommended oil. (Refer to Hydraulic Oils.)
	Bypass valve not operating properly.	Repair or replace valve.
	Main relief valve set too low.	Reset valve as required.
	Hydraulic system oil low.	Replenish oil as necessary.
	Port relief set too high.	Reset valve as required.
	Restricted or blocked return line.	Repair or replace line.

Table 3-5.Hydraulic System - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
Pump not delivering oil.		
	Restricted suction line.	Clean, repair, or replace line.
	Air entering system through broken line or fitting.	Repair or replace line or fitting.
	Broken pump drive shaft/pump coupling.	Repair or replace pump/pump coupling. **Note: Any time pump or pump drive coupling is removed coat pump and drive coupling splines with Lithium Soap Base Grease (TEXACO CODE 1912 OR EQUIVALENT).**
Function sluggish during operation. (System pressure too low.)		
	Main relief valve set too low.	Reset valve as required.
	Pump section not delivering sufficient oil.	Repair or replace pump section or pump.
	Main relief valve stuck in open position.	Clean, repair, or replace valve. (Check system oil for contamination.)
	Oil viscosity too low.	Drain system and replace with recommended oil. (Refer to Hydraulic Oils.)
	Leak in component, line or fitting.	Repair or replace component, line or fitting.
	Scored valve spool; scored cylinder.	Replace valve; replace cylinder.
	Amperage too low on controller.	Correctly adjust controller.
	Low sequence pressure.	Reset valve as required.
	Low pilot pressure.	Reset valve as required.
	Wrong/defective spool in drive section.	Repair or replace drive section.
	Shuttle balls leaking in proportional valve.	Repair or replace valve.
	Low voltage in electrical system.	Correct low voltage problem.
System(s) operate erratically.		
	Sticking or binding valve spools, pistons.	Clean, repair, or replace components as required.
AUXILIARY HYDRAULIC SYSTEM.		
Auxiliary hydraulic pump inoperable.		
	Circuit breaker open.	Determine and correct cause; reset circuit breaker.
	Engine is running.	Shut down engine.
	Check valve in system leaking.	Repair or replace check valve.
	Battery requires charging or will not hold a charge.	Charge or replace battery as required.

Table 3-5.Hydraulic System - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
	Damaged wiring on control switch or auxiliary pump.	See proper wiring diagram.
	Control switch not functioning properly.	Replace switch.
	Restricted or broken hydraulic line or fitting.	Clean, repair or replace line or fitting.
	Pump motor solenoid not functioning properly.	Replace solenoid.
	Pump motor not functioning properly.	Repair or replace motor.

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Table 3-6.Electrical System - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
PLATFORM CONTROLS.		
No power to platform controls.		
	15 Amp self-reset circuit breaker open.	Check footswitch to ensure that both switches are making contact when pedal is depressed. Repair or replace footswitch as necessary.
	Contact block in footswitch malfunctioning.	Repair, replace or adjust contact block as required.
	Faulty power circuit wiring.	Check wiring continuity. Refer to proper wiring diagram.
	Select switch in wrong position.	Place select switch to correct position.
ENGINE STARTER SYSTEM.		
Starter will not crank.		
	Discharged battery or loose battery terminals.	Check and charge battery or replace battery as necessary. Clean and secure battery terminals.
	Starter relay faulty or faulty relay connections.	Using a test meter, check relay coil terminals for presence of electrical power and for energization of relay coil. Also check relay terminals for correct switching of contacts. Replace relay as necessary.
	Malfunctioning starter solenoid or motor.	Replace solenoid or motor in accordance with applicable manufacturer's manual.
	Malfunctioning ignition switch.	Using a test meter, check ignition switch for correct switching of contacts. Replace switch as necessary.
	Faulty ignition and/or starter circuit wiring.	Check wiring continuity. See proper wiring diagram.
	Faulty start lockout system.	See correct wiring diagram.
	Faulty start switch.	Replace switch.
Engine continues to crank.		
	Faulty ignition and/or starter circuit wiring.	Check wiring continuity. See proper wiring diagram.
	Malfunctioning starter solenoid or motor.	Replace solenoid or motor in accordance with applicable manufacturer's manual.
	Faulty start switch.	Replace switch.

Table 3-6.Electrical System - Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
INSTRUMENTS AND INDICATORS.		
Travel warning horn inoperative.		
	Circuit breaker open.	Determine and correct cause; reset circuit breaker.
	Damaged wiring in horn circuit.	Repair or replace wiring.
	Damaged horn.	Replace horn.
Hourmeter inoperative.		
	Damaged wiring in hourmeter circuit.	Repair or replace wiring.
	Defective pressure switch.	Replace pressure switch.
	Inoperative hourmeter.	Replace hourmeter.
Tilt alarm circuit.		
	Damaged wiring in tilt alarm circuit.	Repair or replace wiring. See proper wiring diagram.
	Tilt alarm inoperative.	Replace tilt alarm.
	Tilt alarm not adjusted properly.	Adjust tilt alarm.
	Defective bulb in tilt light.	Replace bulb.
High engine speed will not function.		
	Boom above horizontal.	Lower boom.
	Horizontal limit switch malfunctioning.	Repair or replace limit switch.
	Drive controller defective.	Replace controller.
	High engine solenoid malfunctioning.	Repair or replace solenoid valve.
	Drive pressure switch malfunctioning.	Replace pressure switch.
	Electrical malfunction.	See wiring diagram.
	Defective engine governor.	Repair or replace governor.
Function speed control will not function.		
	Boom above horizontal.	Lower boom.
	Horizontal limit switch malfunctioning.	Repair or replace limit switch.
	Defective pump section.	Repair or replace pump section.
	Electrical malfunction.	See correct wiring diagram.

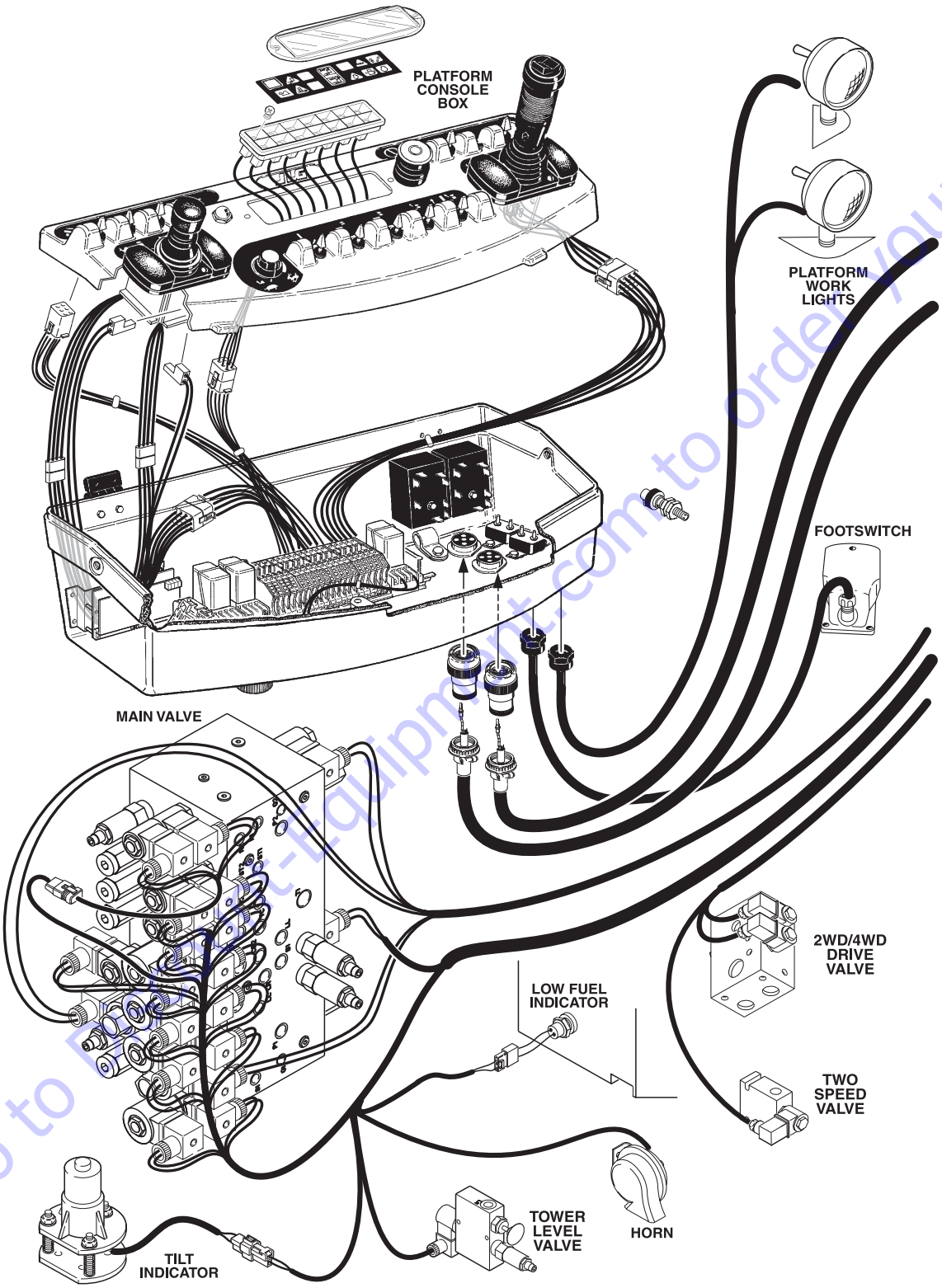

Figure 3-1. Electrical Components Installation - Sheet 1

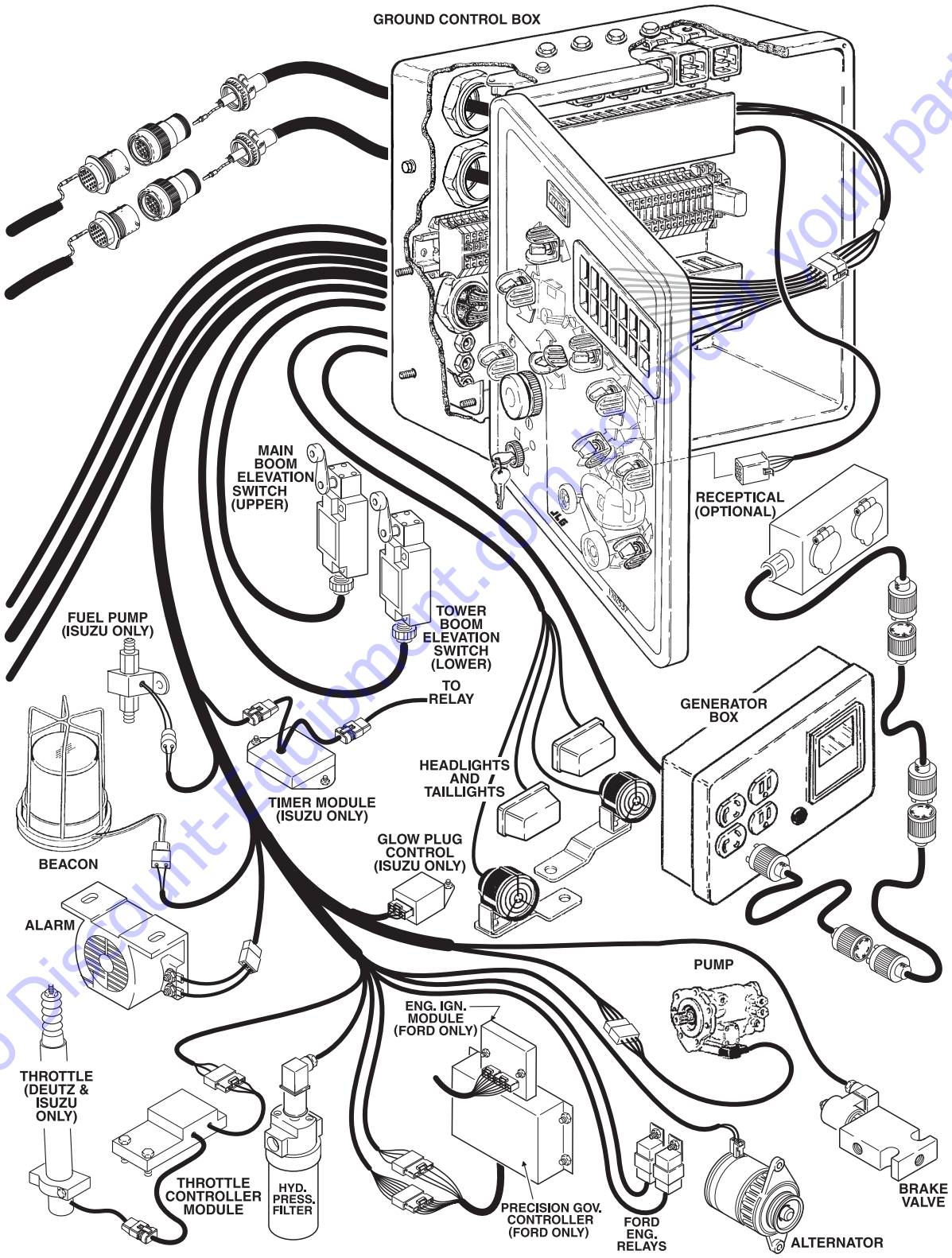

Figure 3-2. Electrical Components Installation - Sheet 2

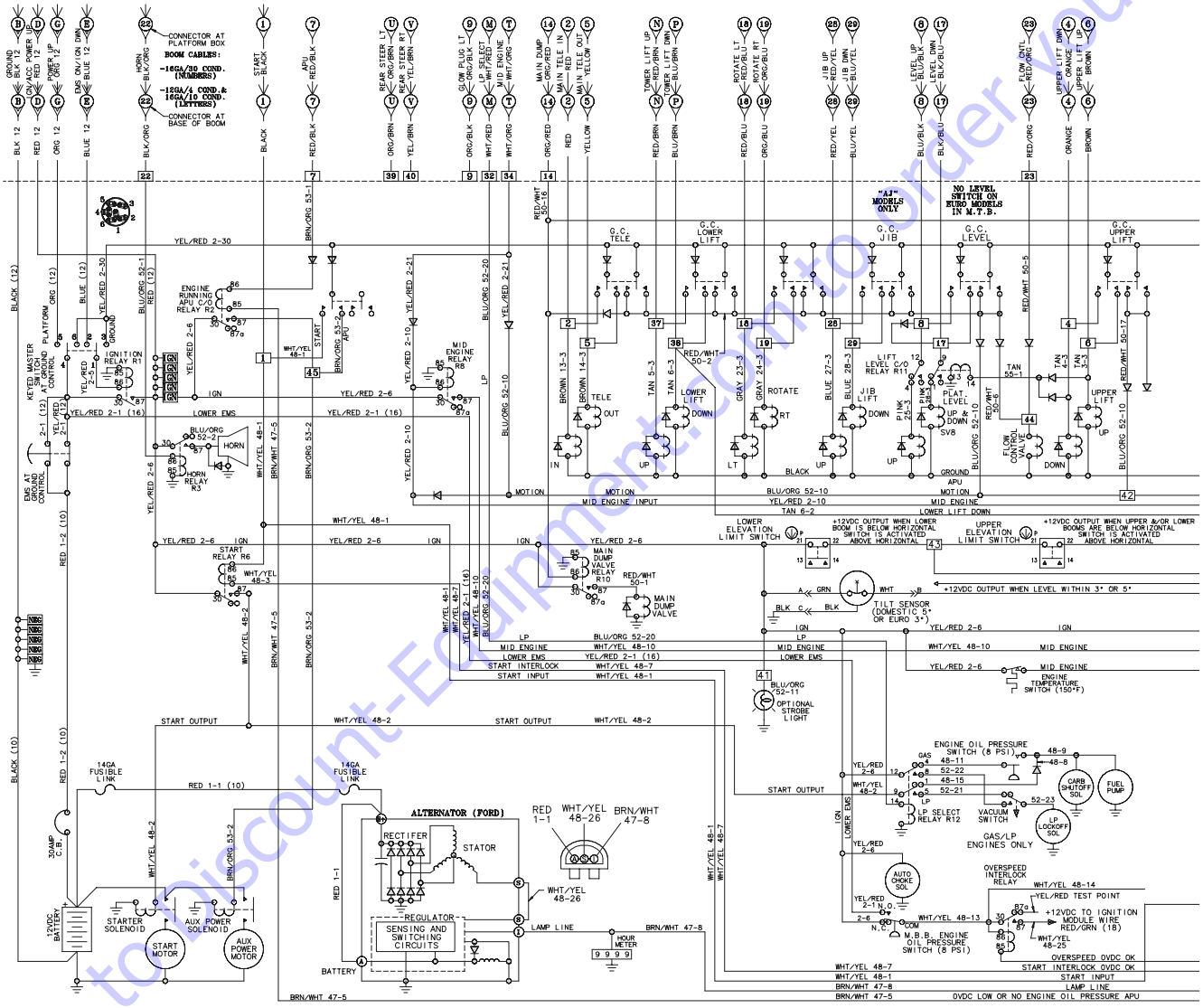

Figure 3-3. Electrical Schematic - Boom, Turntable, Chassis -Ford (Prior to S/N 46089) - Sheet 1

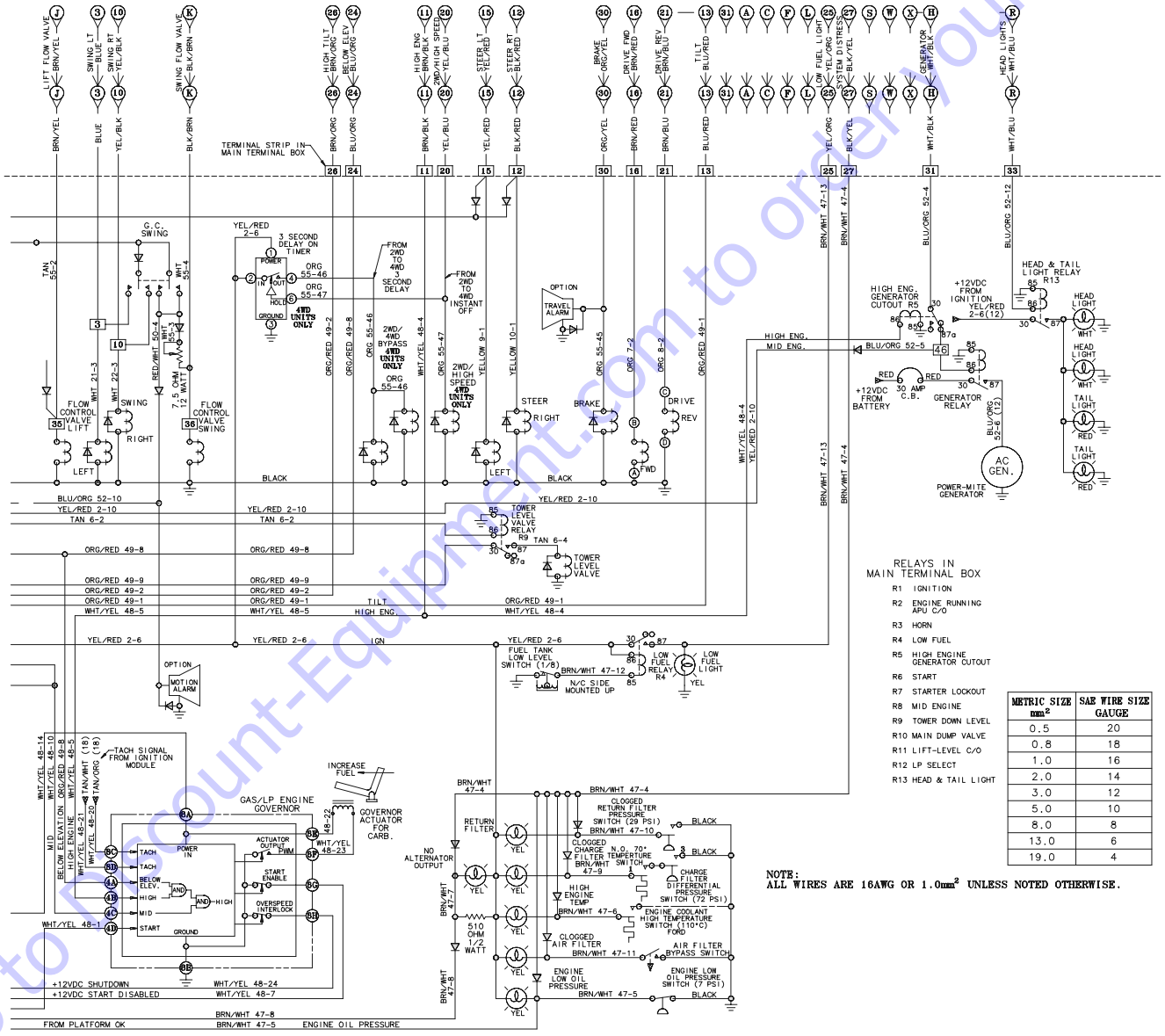

Figure 3-4. Electrical Schematic - Boom, Turntable, Chassis -Ford (Prior to S/N 46089) - Sheet 2

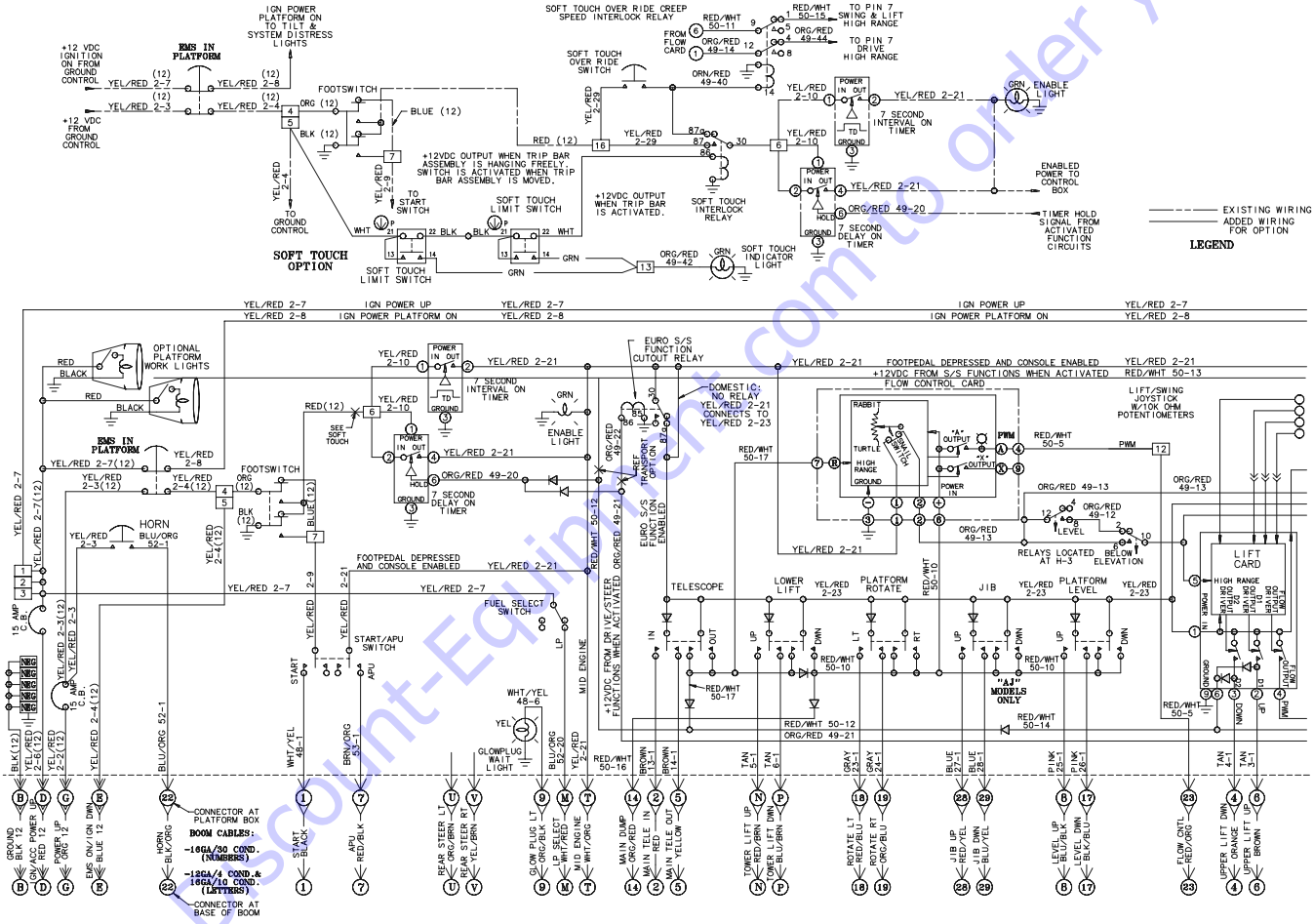

Figure 3-5. Electrical Schematic - Platform -Ford (Prior to S/N 46089) - Sheet 1

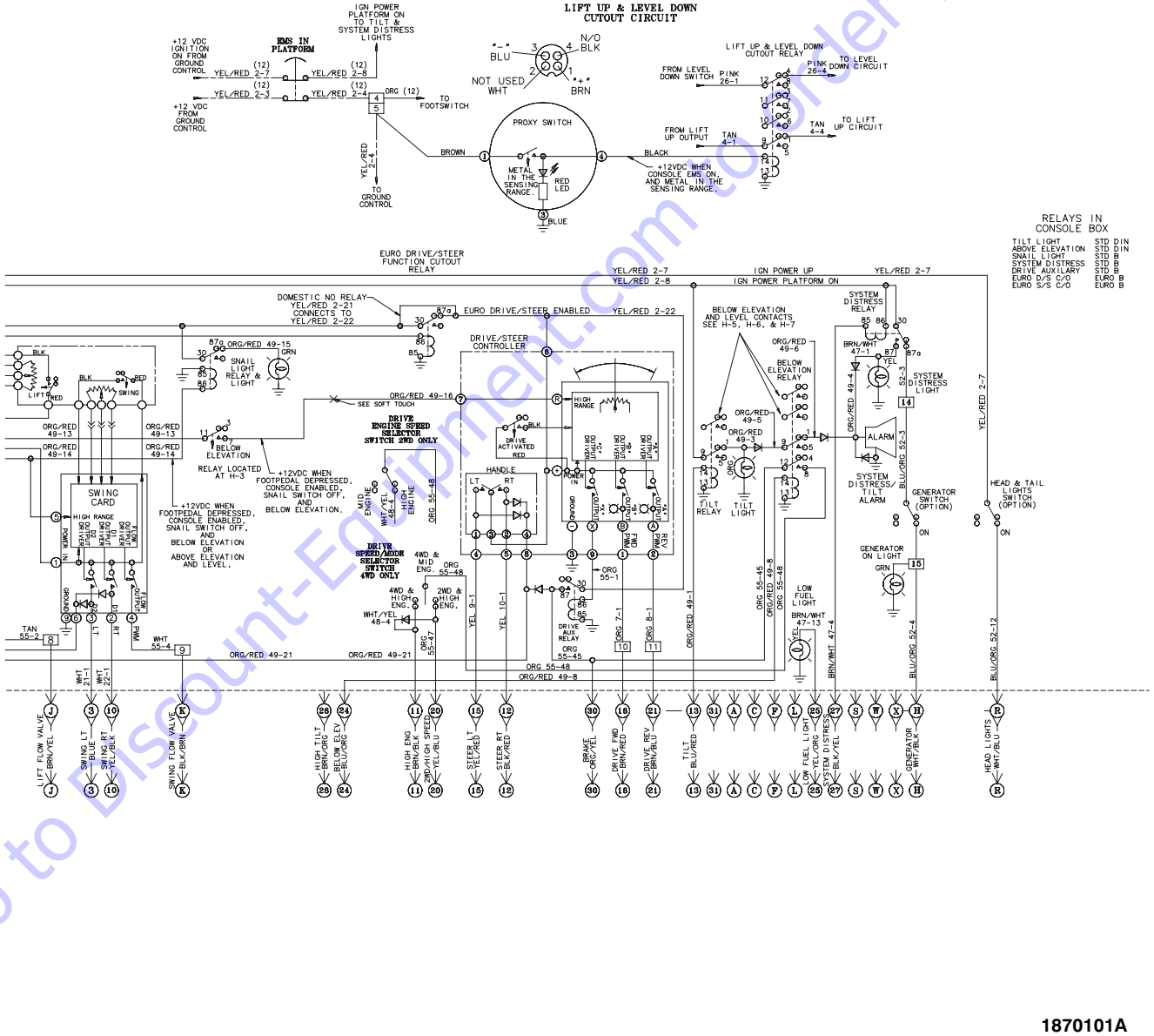

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Figure 3-6. Electrical Schematic - Platform -Ford (Prior to S/N 46089) - Sheet 2

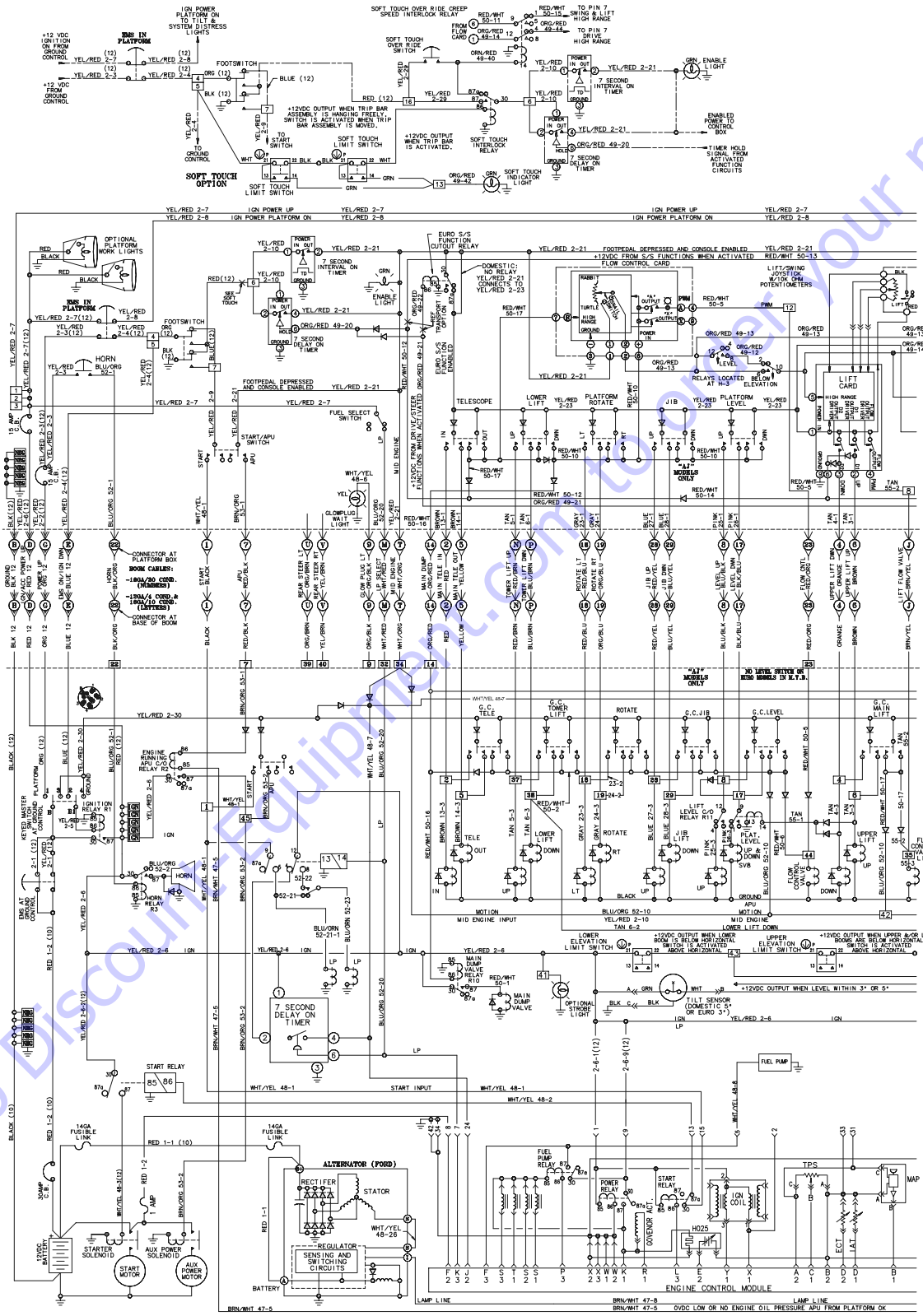

Figure 3-7. Electrical Schematic - Ford EFI (After S/N 46089) Sheet 1

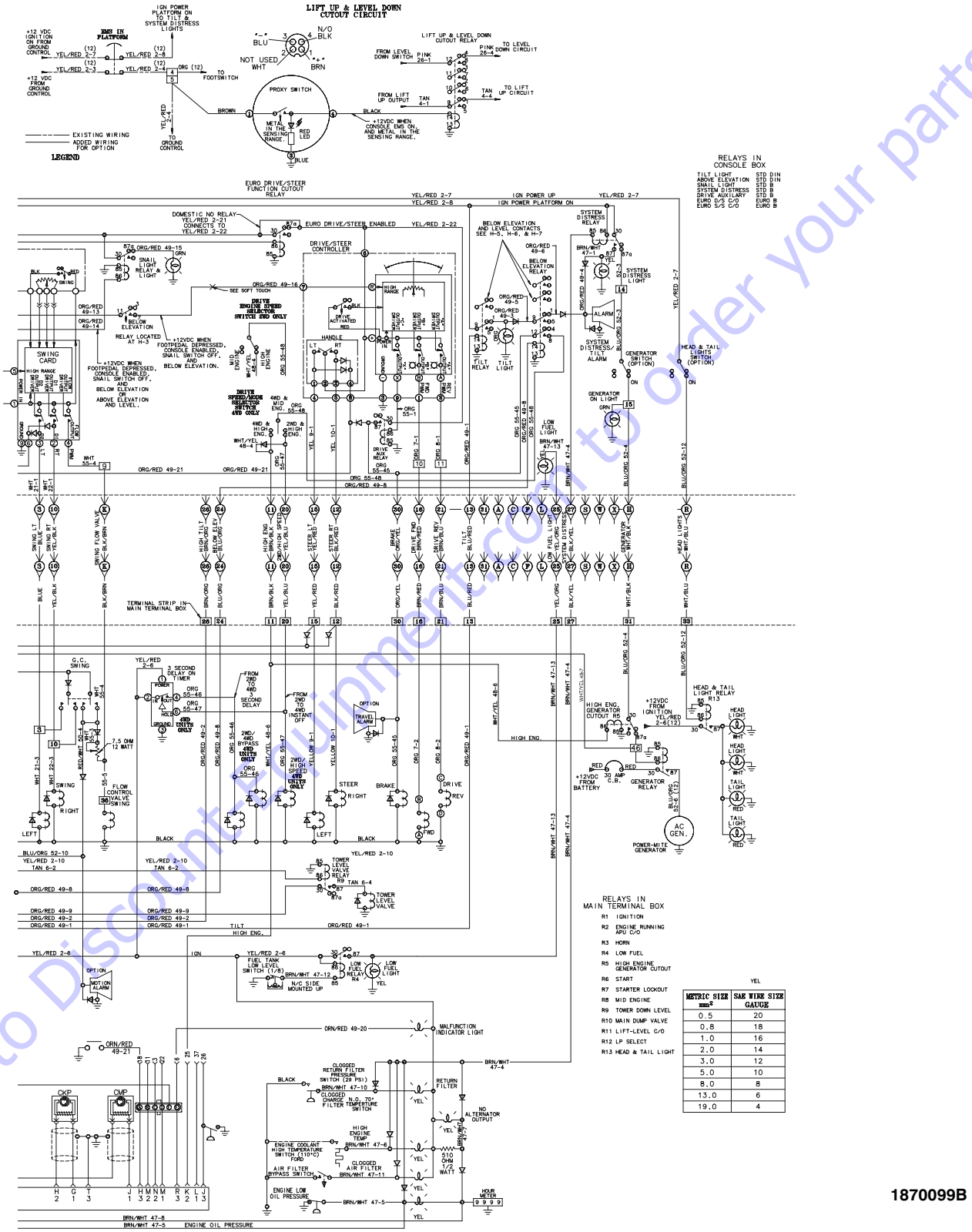

Figure 3-8. Electrical Schematic - Ford EFI (After S/N 46089) - Sheet 2

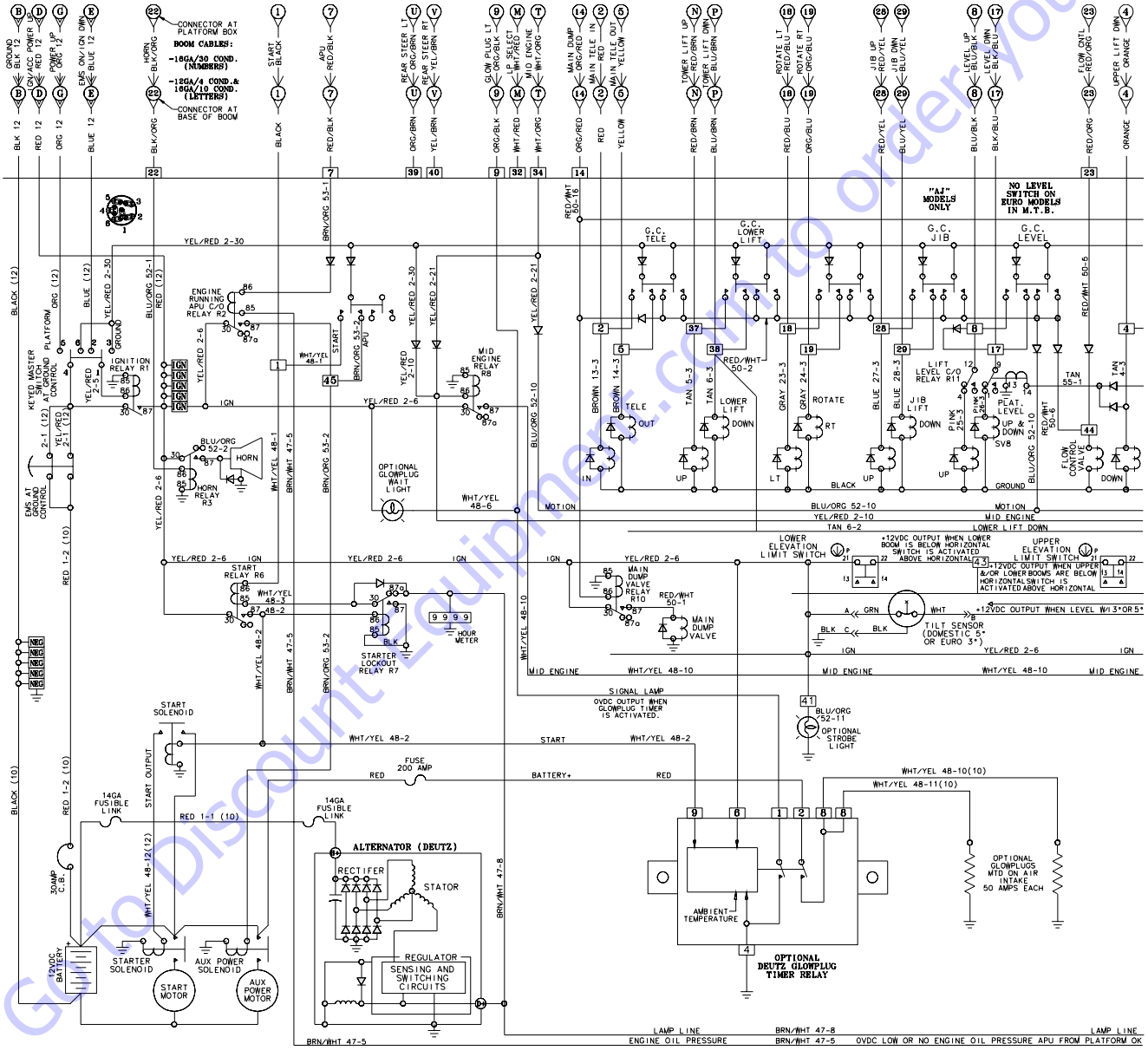

Figure 3-9. Electrical Schematic - Boom, Turntable, Chassis - Deutz - Sheet 1

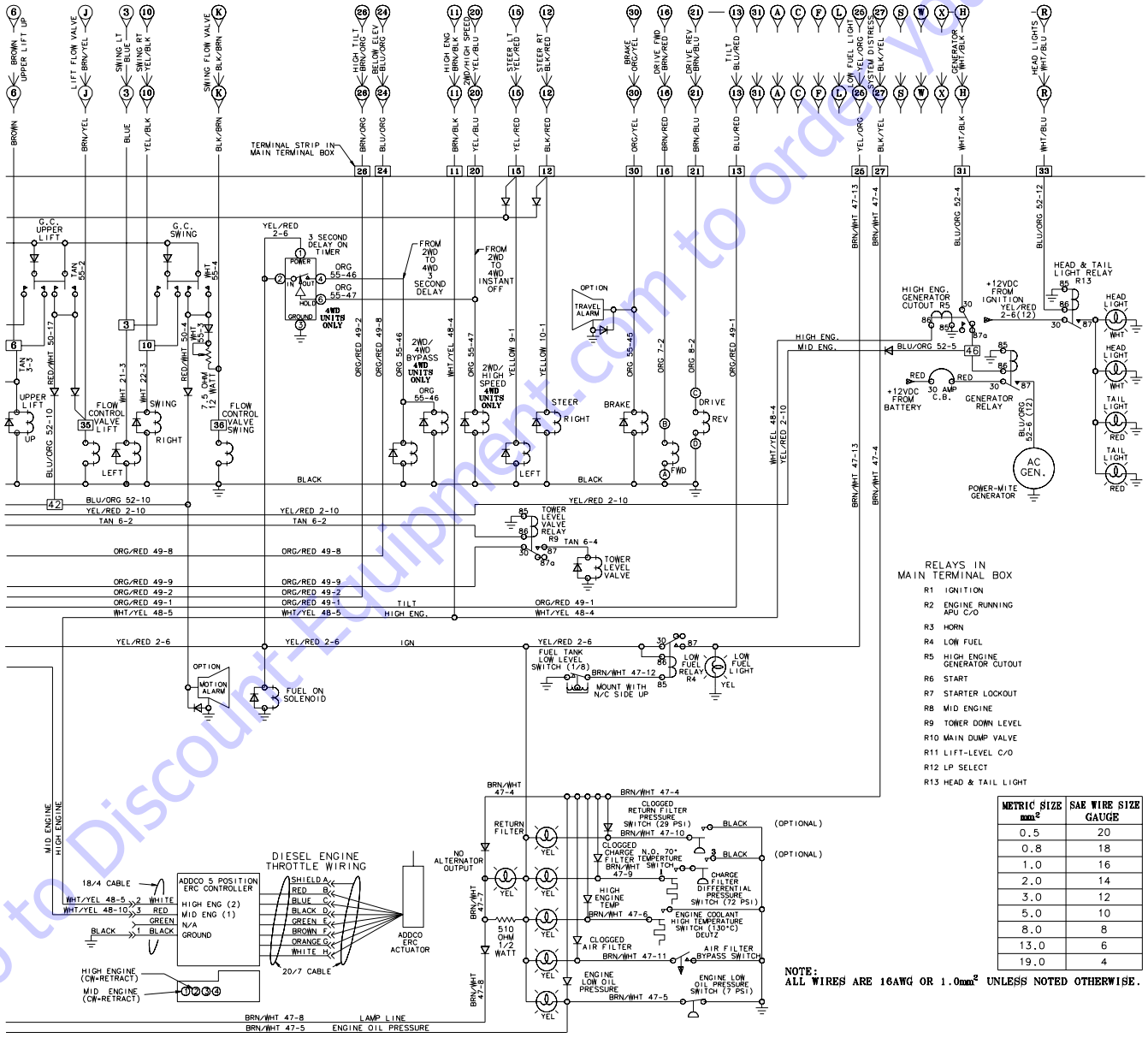

Figure 3-10. Electrical Schematic - Boom, Turntable, Chassis - Deutz - Sheet 2

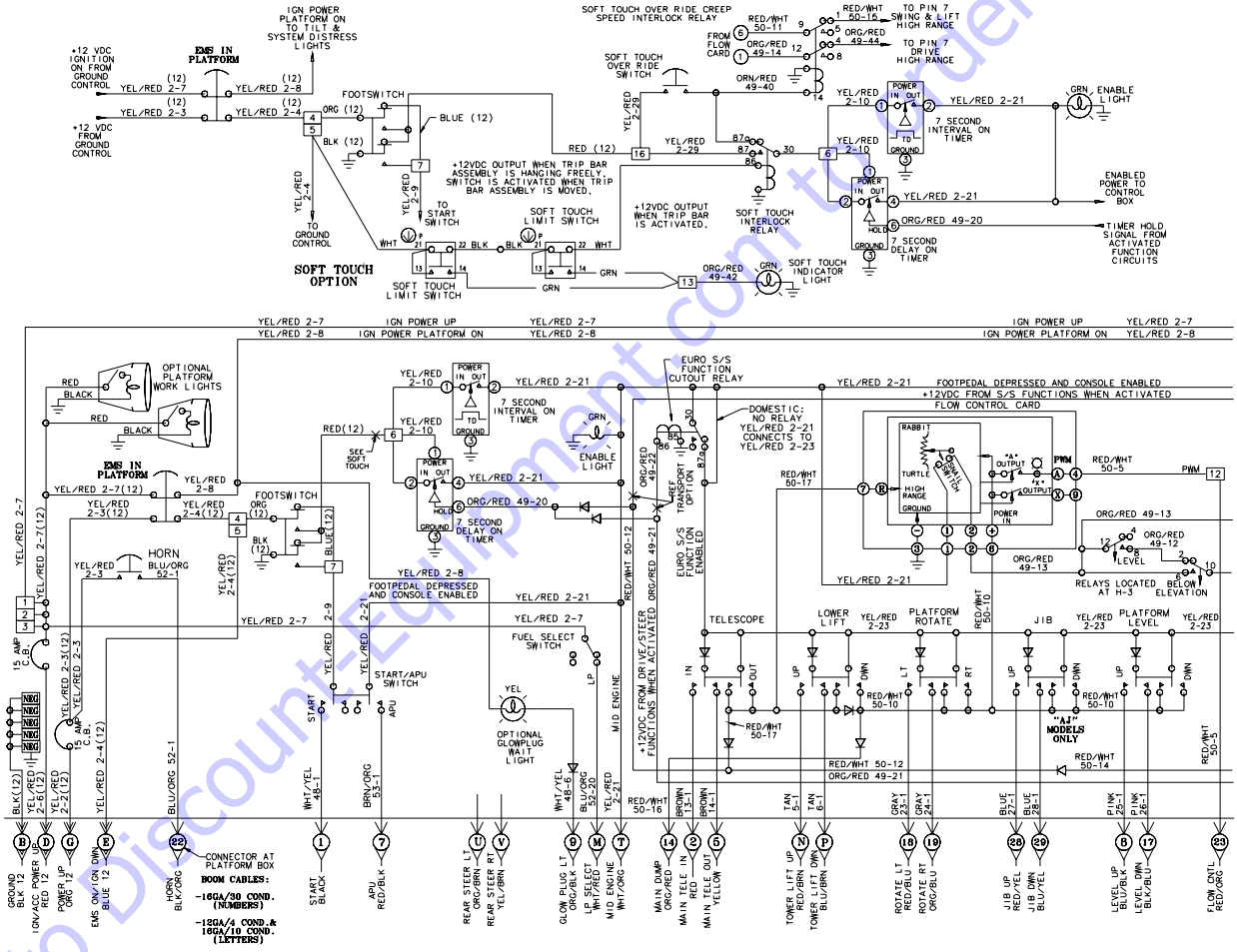

Figure 3-11. Electrical Schematic - Platform -Deutz - Sheet 1

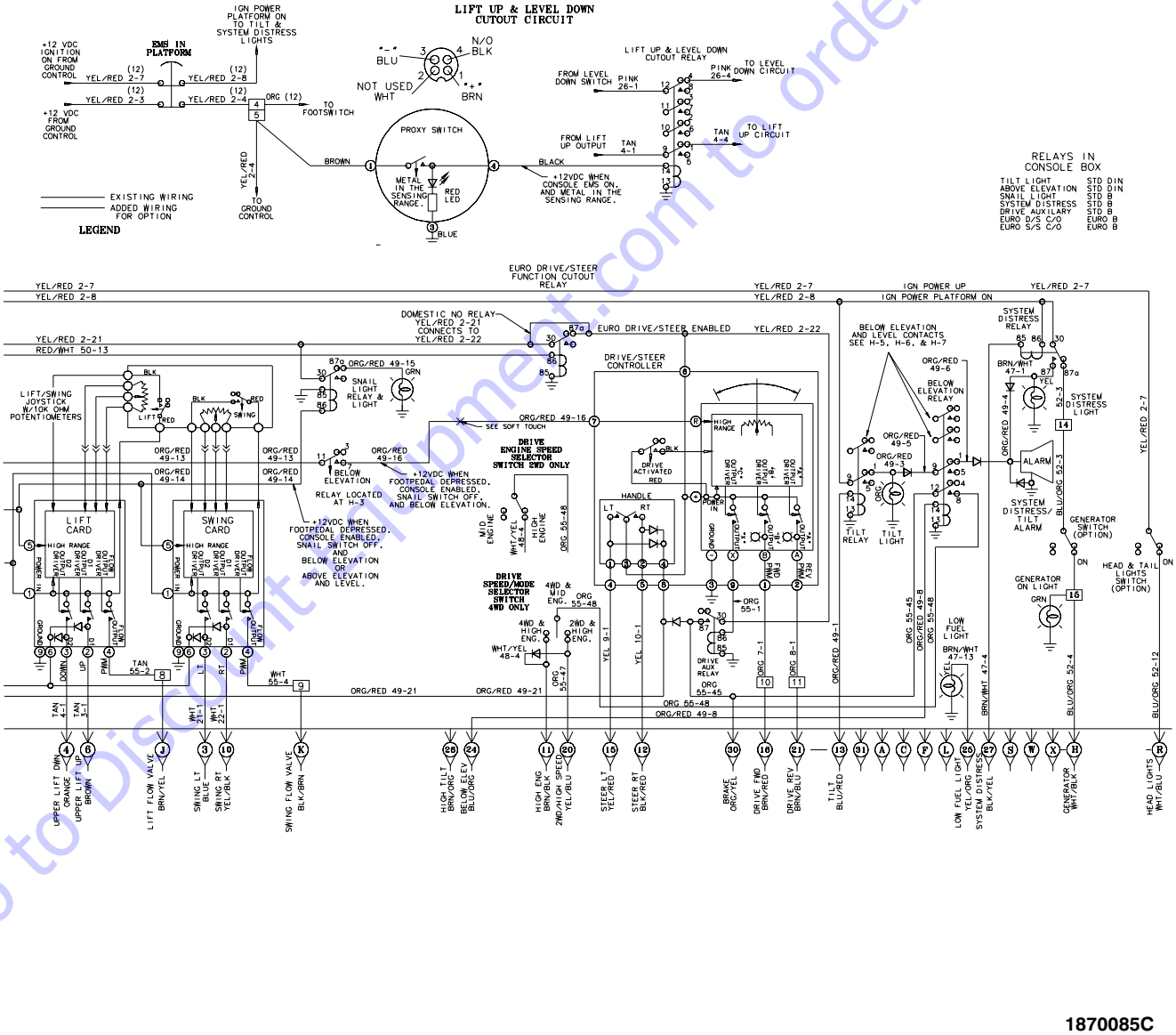

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Figure 3-12. Electrical Schematic - Platform -Deutz - Sheet 2

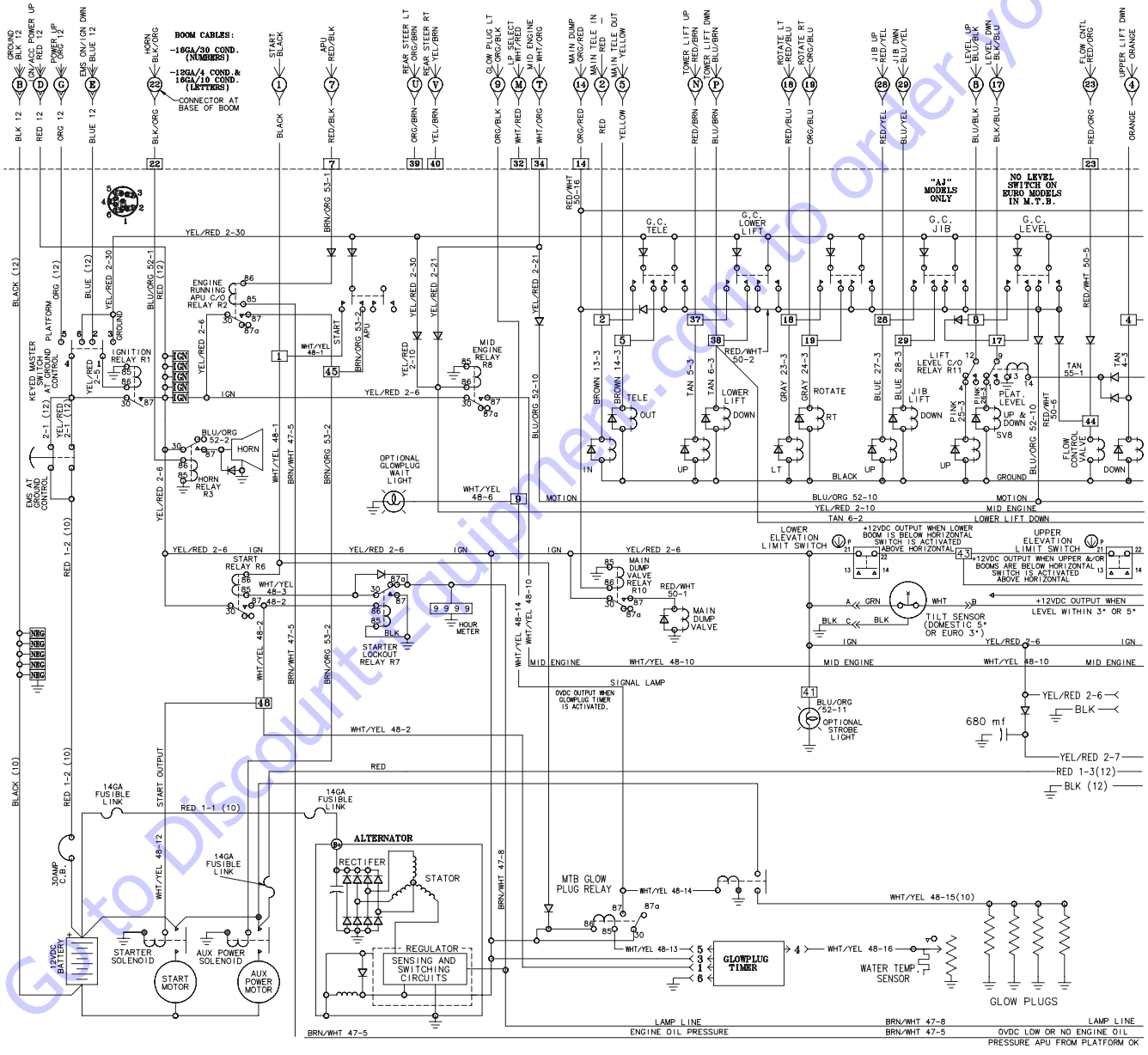

Figure 3-13. Electrical Schematic - Boom, Turntable, Chassis - Isuzu - Sheet 1

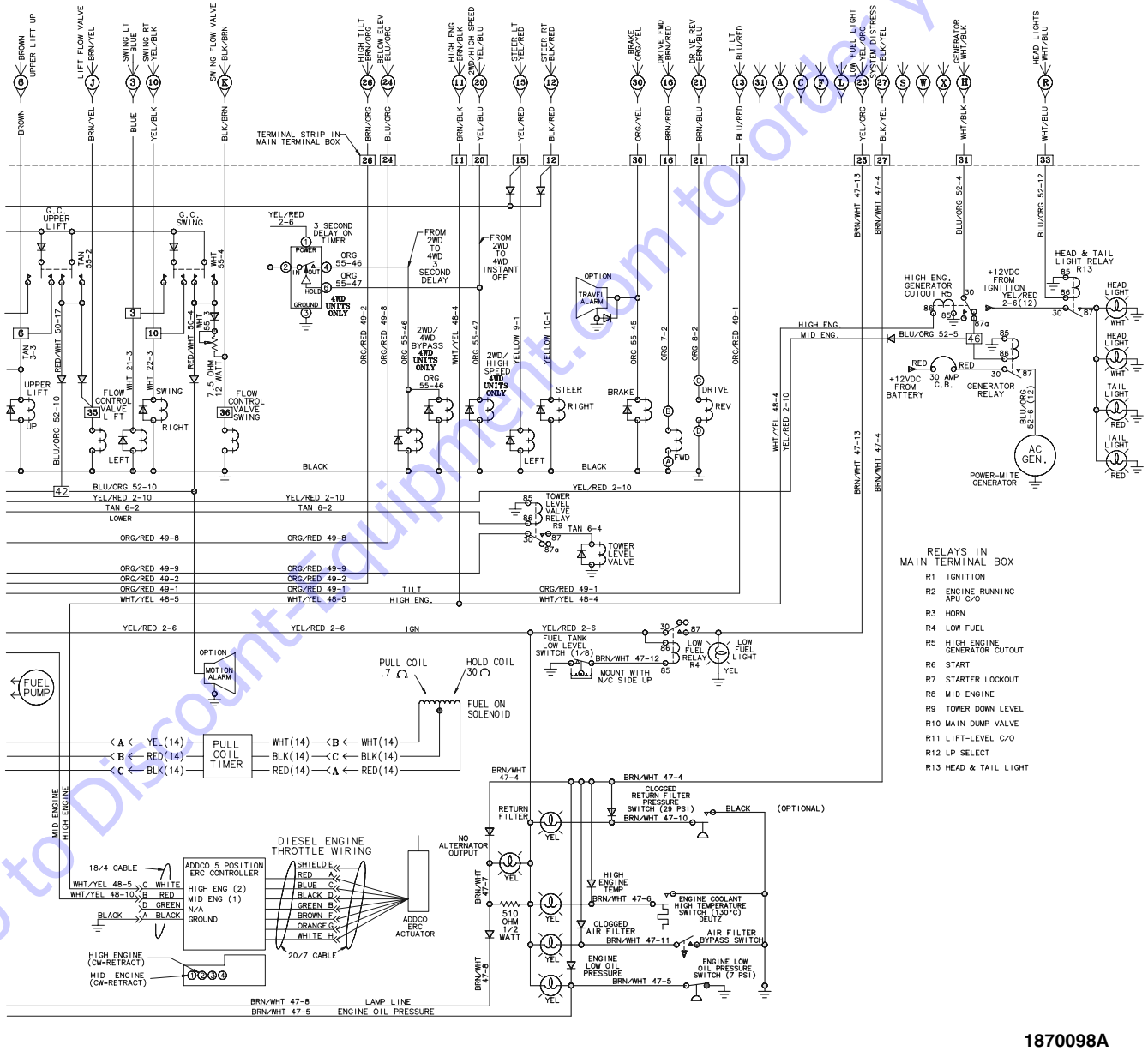

Figure 3-14. Electrical Schematic - Boom, Turntable, Chassis - Isuzu - Sheet 2

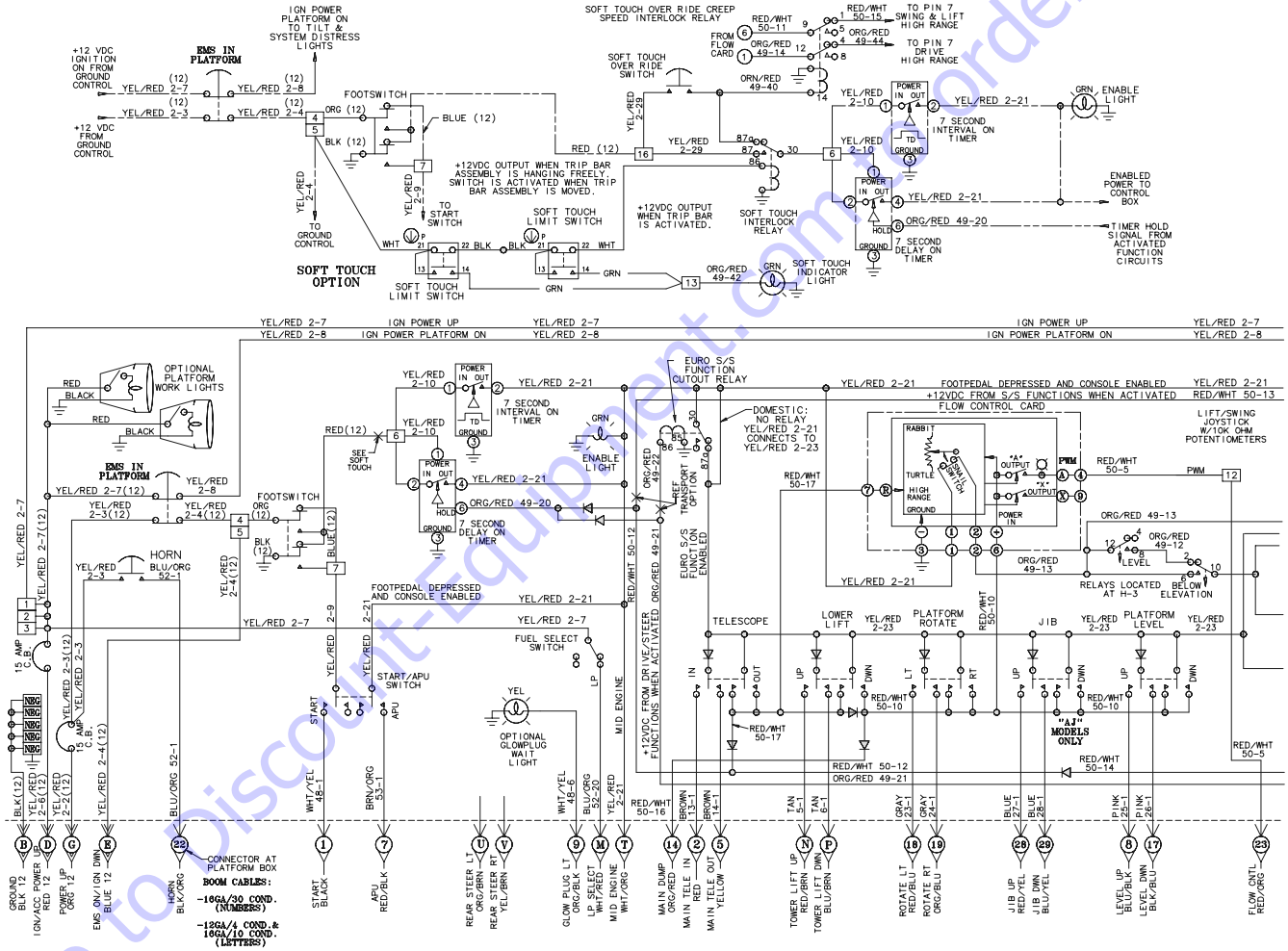

Figure 3-15. Electrical Schematic - Platform - Isuzu - Sheet 1

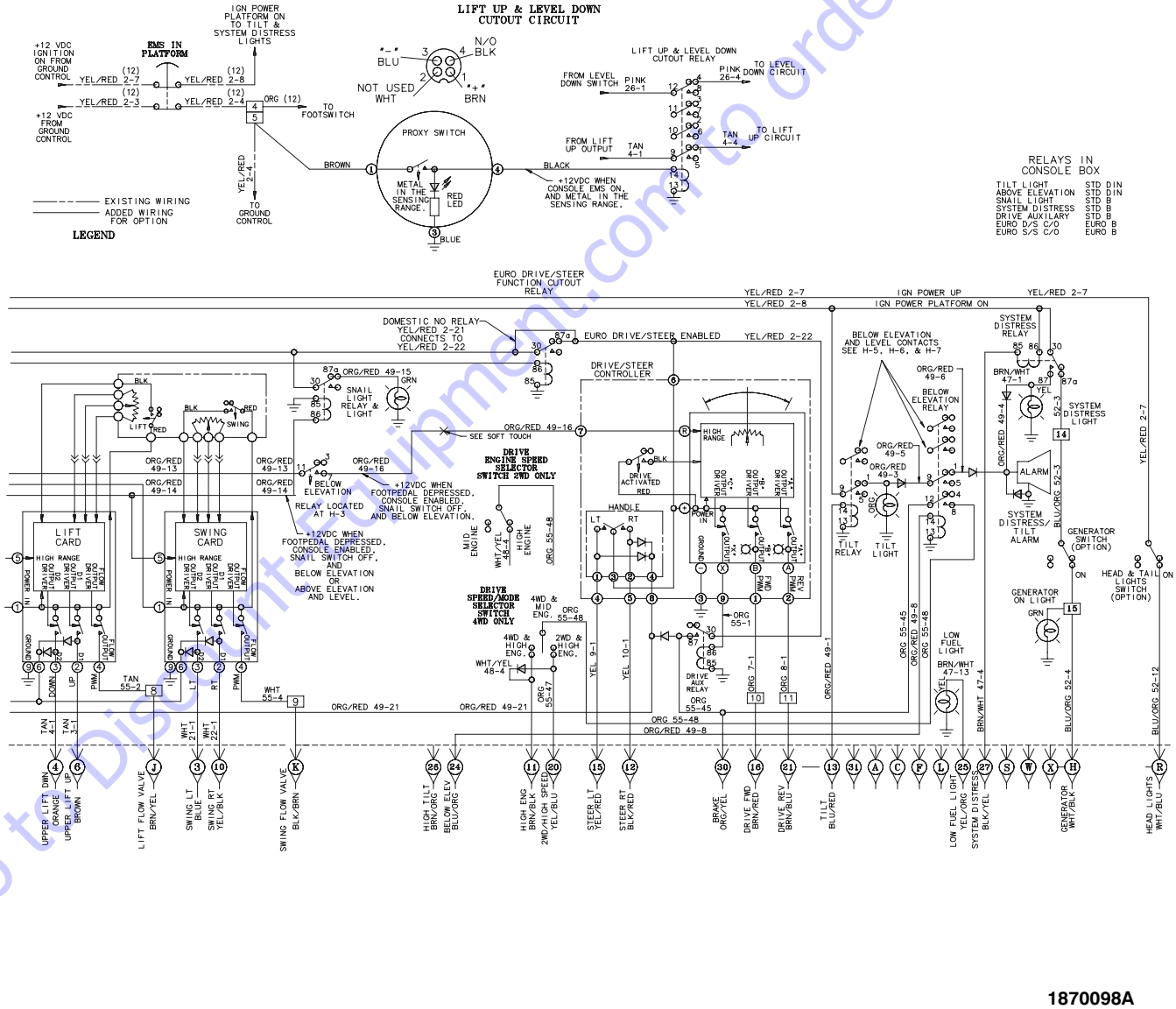

Figure 3-16. Electrical Schematic - Platform - Isuzu - Sheet 2

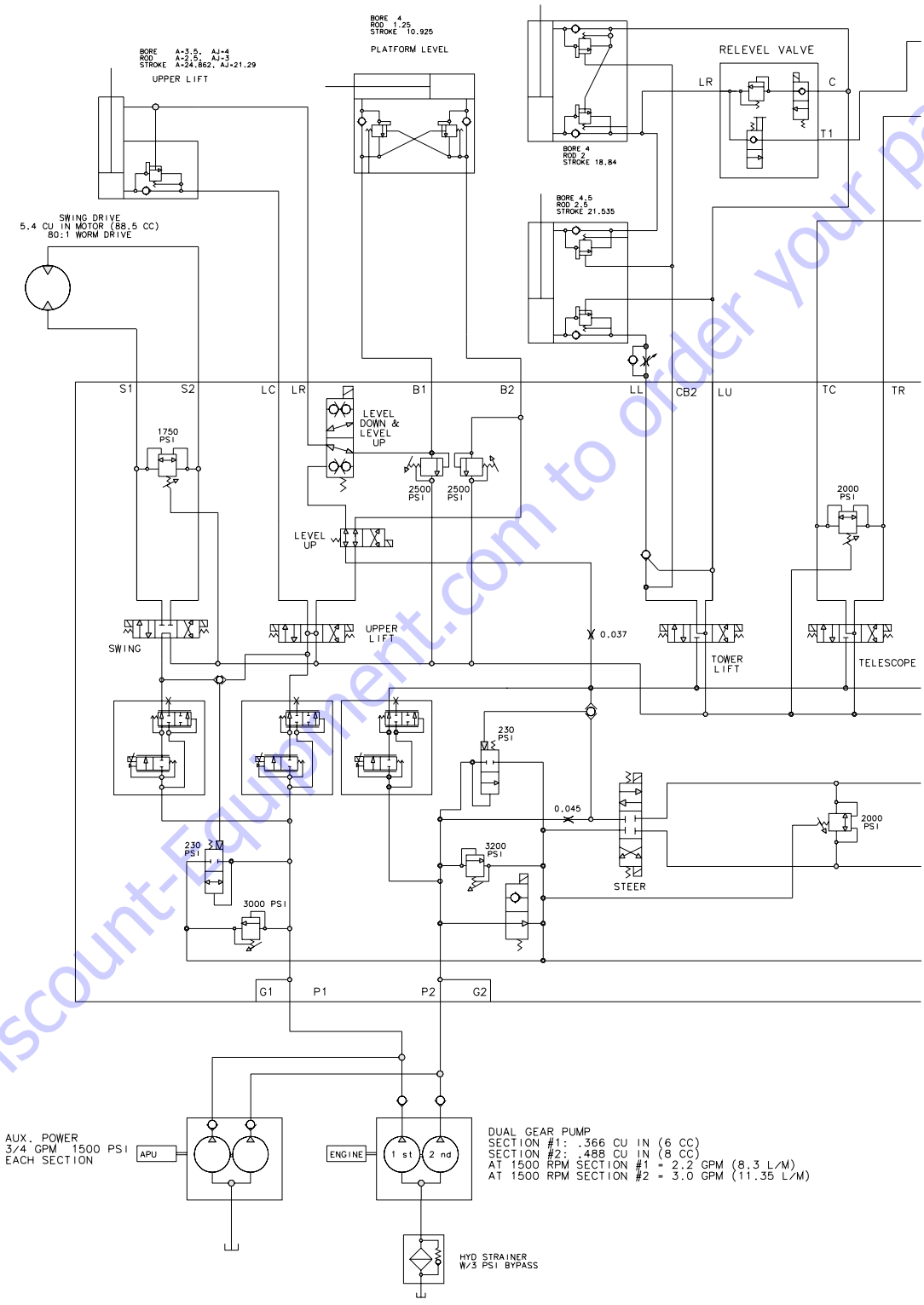

Figure 3-17. Hydraulic Schematic - Proportional Controls (Sheet 1 of 6)

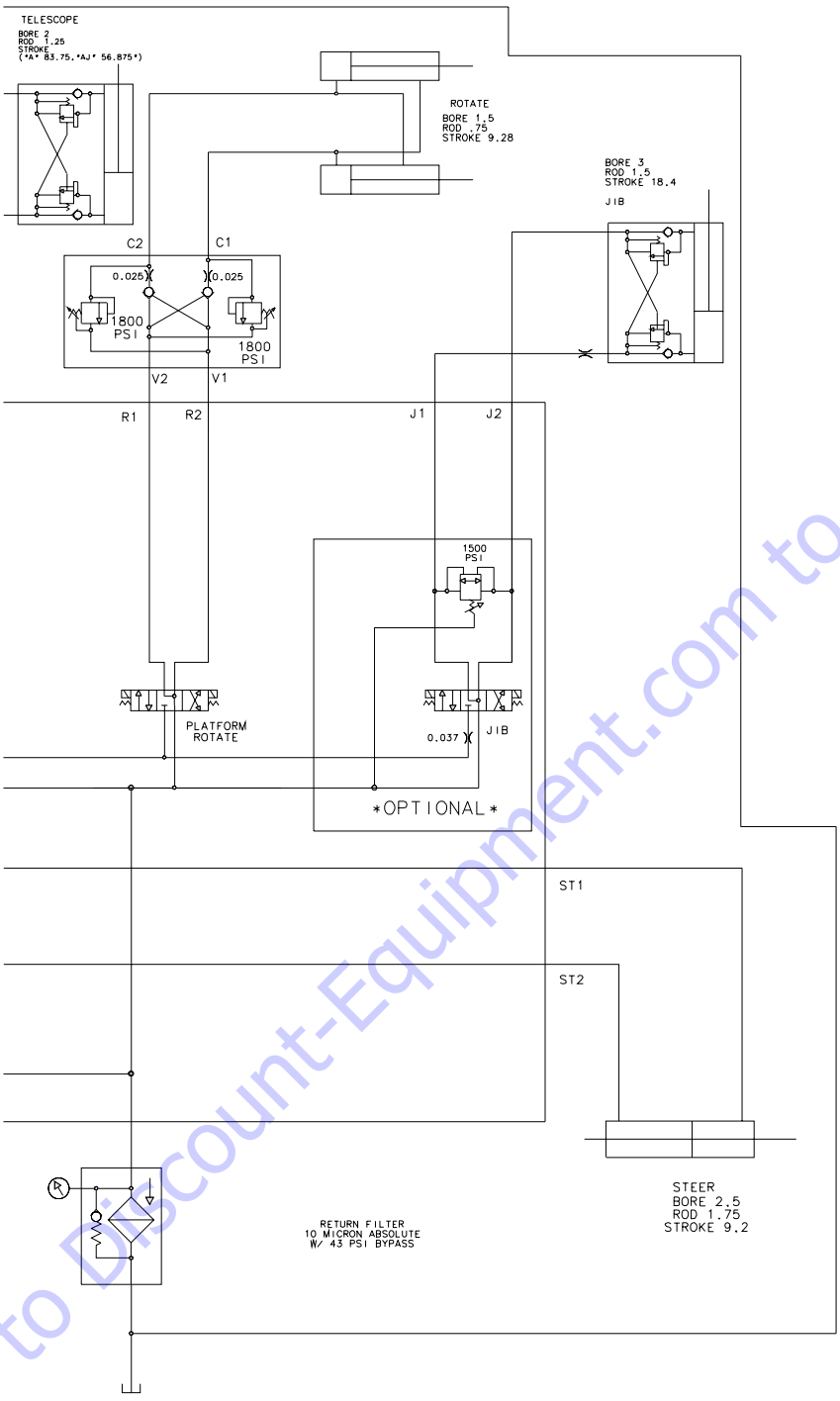

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Figure 3-14. Hydraulic Shematic - Proportional Controls (Sheet 2 of 6)

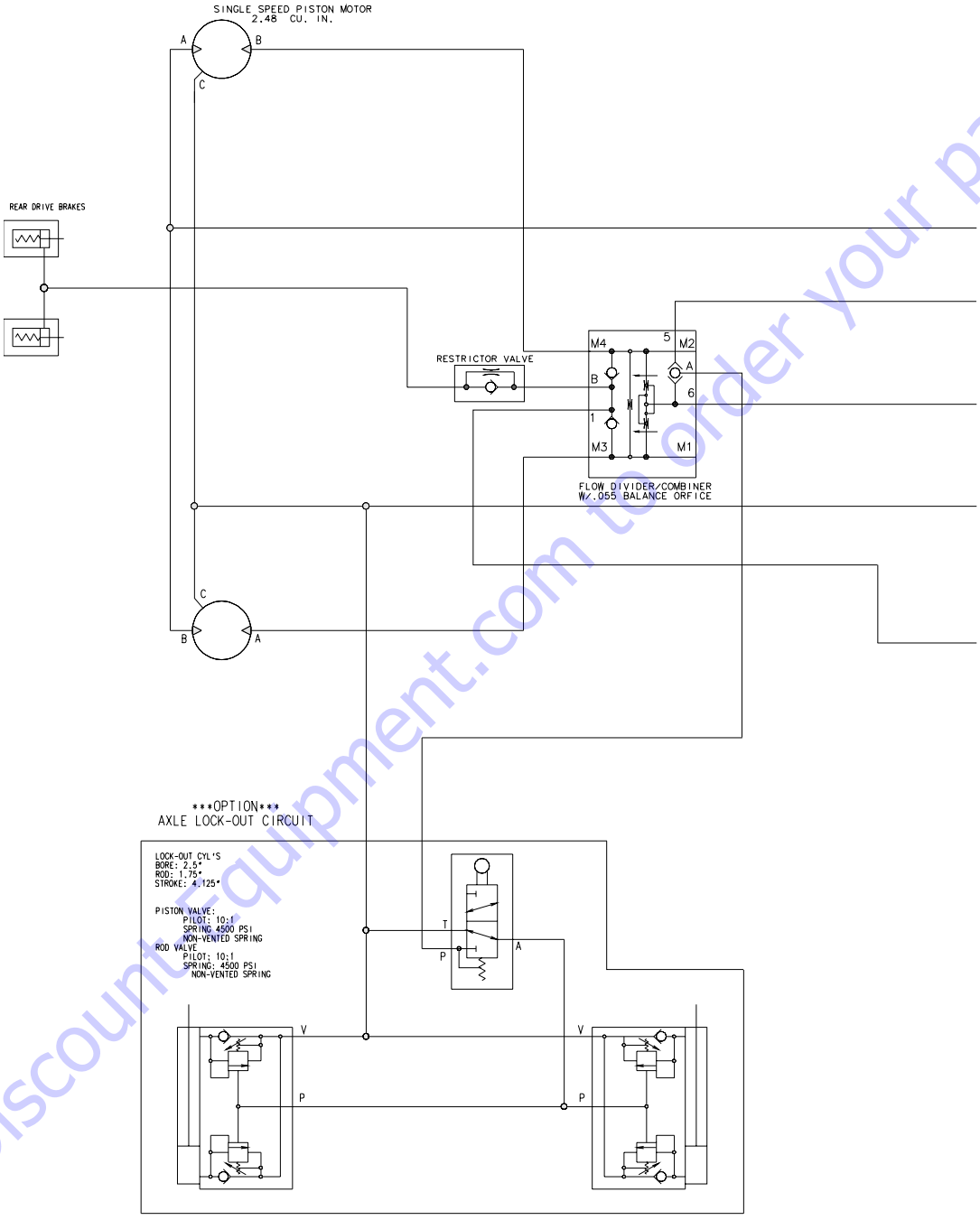

Figure 3-14. Hydraulic Shematic - Proportional Controls (Sheet 3 of 6)

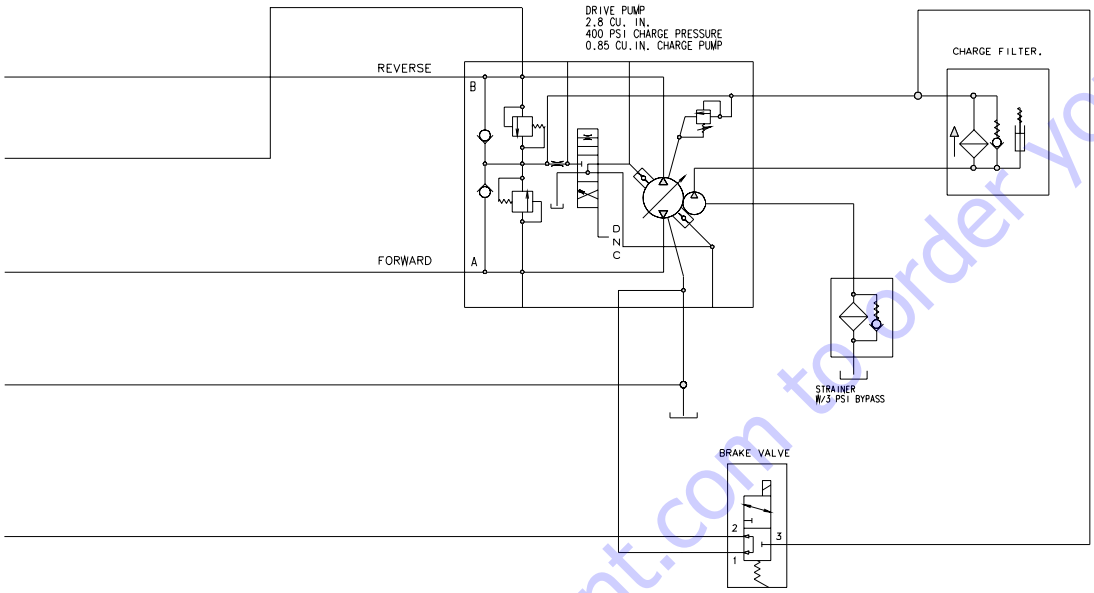

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Figure 3-14. Hydraulic Shematic - Proportional Controls (Sheet 4 of 6)

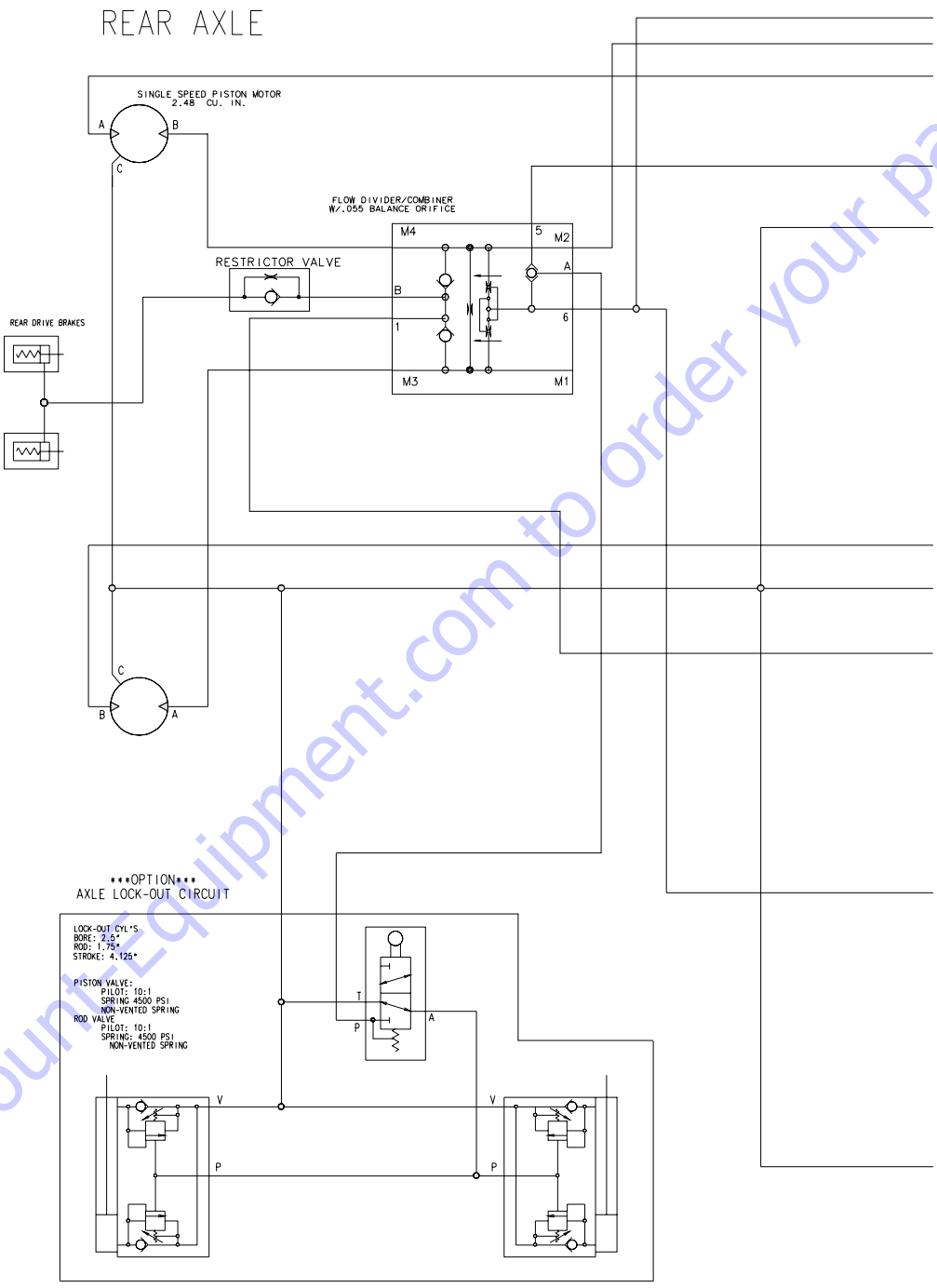

Figure 3-14. Hydraulic Shematic - Proportional Controls (Sheet 5 of 6)

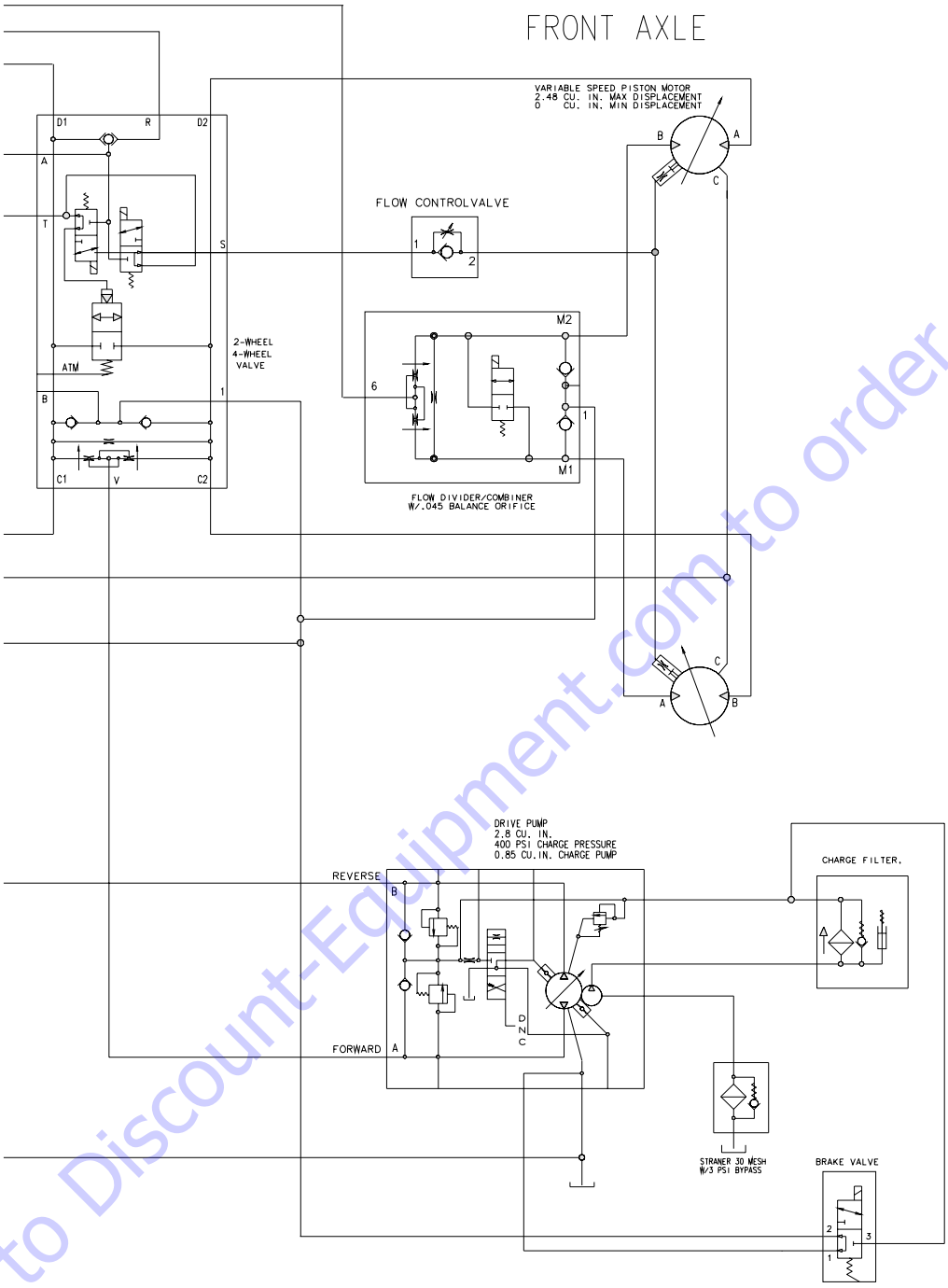

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Figure 3-14. Hydraulic Shematic - Proportional Controls (Sheet 6 of 6)

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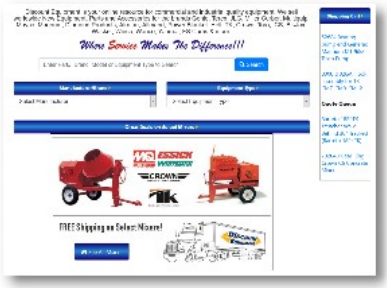

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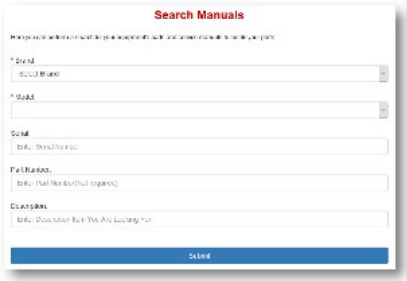

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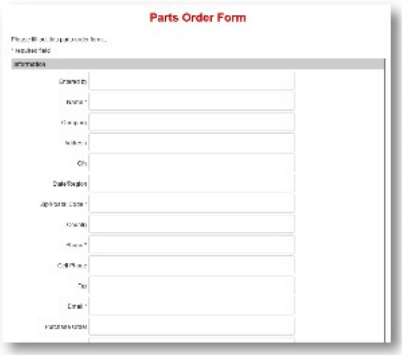

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