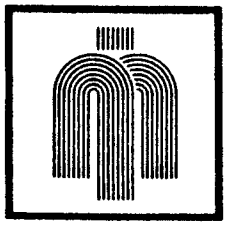
Marklift®

SELF-PROPELLED BOOM

OPERATING AND MAINTENANCE INSTRUCTIONS



MARK INDUSTRIES

VI EDITION

17101-988

Mark Industries

OMI-002

OPERATION

AND

MAINTENANCE

INSTRUCTIONS

SELF-PROPELLED BOOM

MODELS

21RT
21S
30H
30L
30RT
40
40RT

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P/N 17101-988

INTRODUCTION

Mark Industries provides this manual as a guide for the operation and maintenance of your Marklift Boom Unit.

This manual has been especially developed to allow for quick reference information in the event of operational problems or maintenance requirements. We are using a new method for trouble shooting any operational problem. You will find this in the Trouble Shooting Guide, and we believe it will help you to quickly isolate the problem.

We realize that special operating conditions will exist with various users of the Marklift, and Mark Industries' Factory Assistance is always available.

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I	21S & 21RT MARKLIFT	FIGURE 1

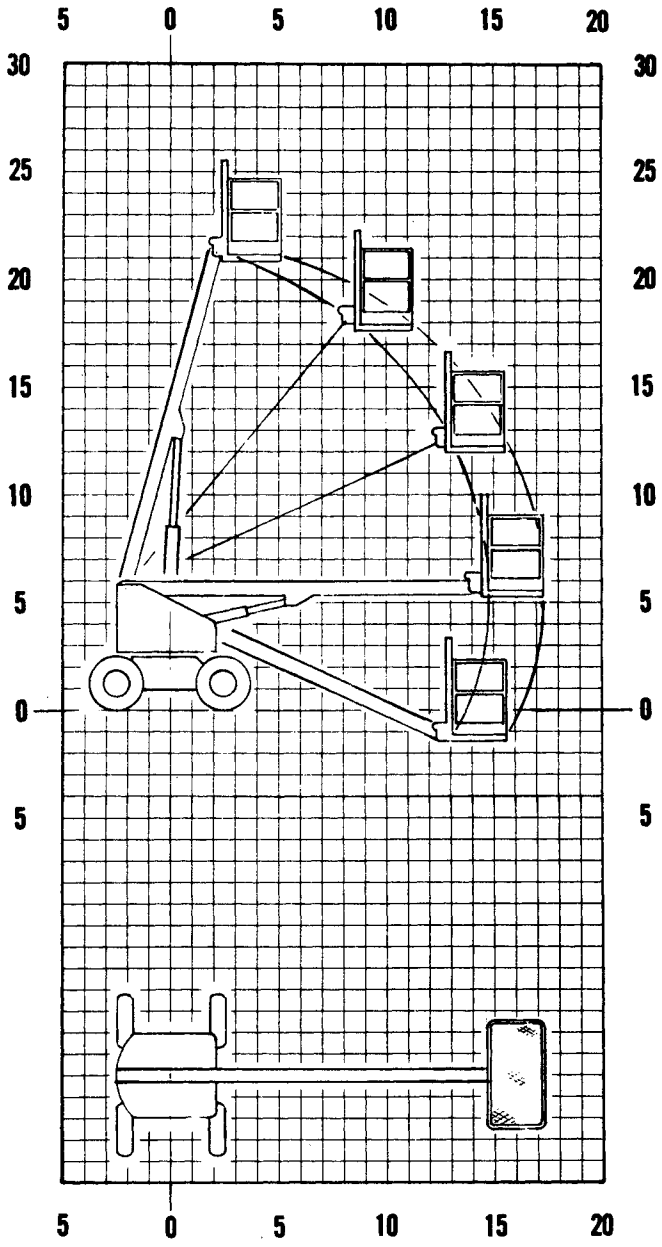


FIGURE 1	21S & 21RT SPECIFICATIONS	2

MODEL 21S & 21RT

DESCRIPTION	ENGLISH	METRIC
Lift Capacity	500#	227 kg
Platform Max Height	21'-0	6.40 m
Machine Height with Platform Lowered	6'-3	1.90 m
Machine Width, 21S	5'-0	1.56 m
21RT	5'-8	1.75 m
Length, Minimum	19'-11	6.07 m
Wheel Base	60"	152.4 cm
Wheel Track	48.3"	122.68 cm
Turning Radius	15'-6	4.72 m
Turret Rotation	360°	
Tall Swing	Within Frame Width	
Engine, 21S, Dual Fuel	20 H.P. Air-Cooled	
21RT, Gasoline Only	20 H.P. Air-Cooled	
Travel Speed	1.3 mph	2.1 kph
Standard Controls:		
Drive	Proportional	
Swing	Solenoid	
Raise	Solenoid	
Steer	Solenoid	
Hydraulic System Pressure	1600 psi	107 atmos
Fuel Tank Capacity	11 Gallons	41.5 Liter
Hydraulic Tank Capacity	24 Gallons	90.5 Liter
Weight	7700 lb	3495 kg
Shipping Cube, 21S	622.4cu. ft.	17.63cu. m.
21RT	719.0cu. ft.	20.30cu. m.
Basket Dimensions	59" Wide	149.9 cm
	30" Deep	76.2 cm
	42" High	106.7 cm
Tires, 21S	7:00 x 15 Lt, 8 ply (75psi)	
21RT, Drive Wheels	29 x 12:00 -15, 6 ply "Super Tera Grip" Air-Filled (35psi)	
Steering Wheels	11L - 15 SL, 6 Ply "Maxi-Trac" Air-Filled (35psi)	

3	30L MARKLIFT	FIGURE 2

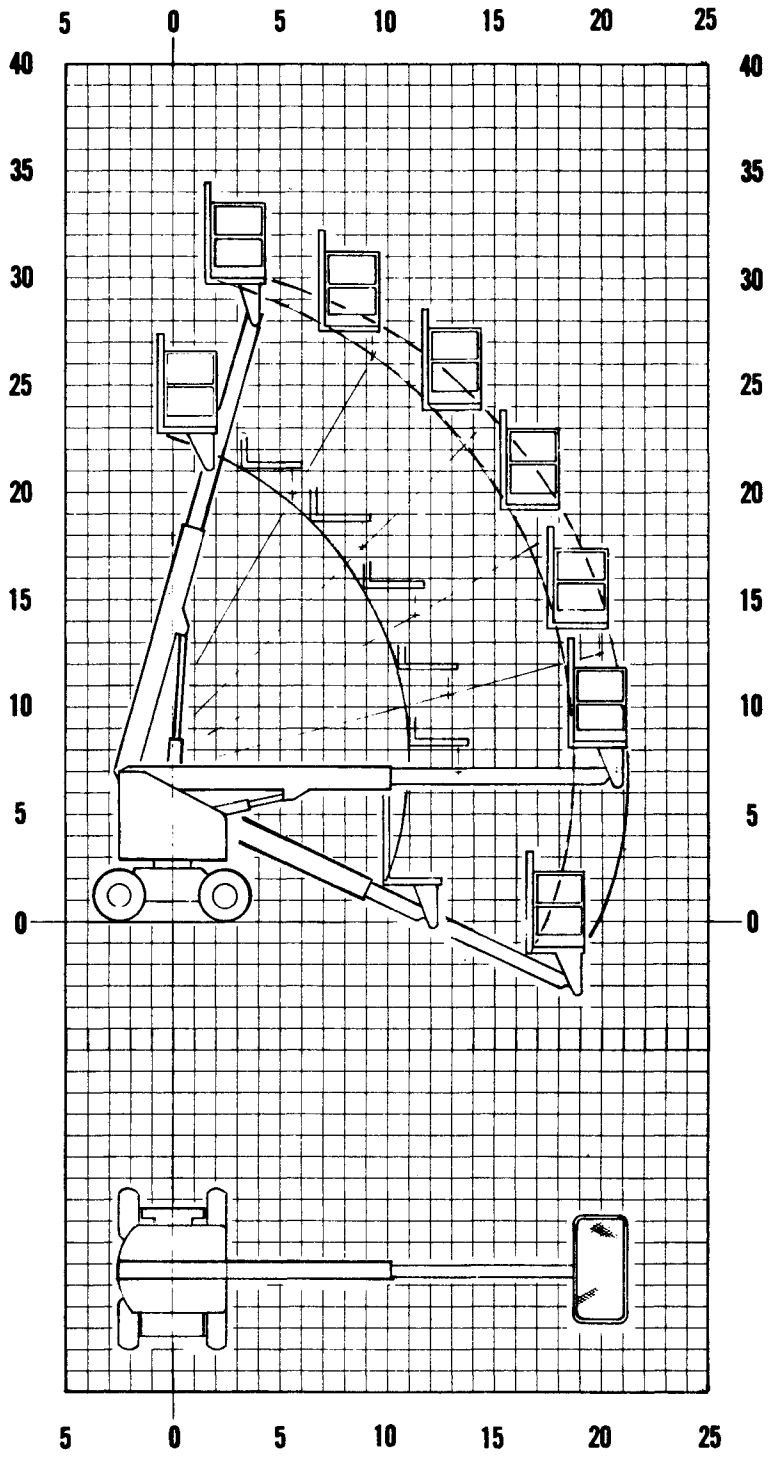


FIGURE 2	30L SPECIFICATIONS	4

MODEL 30L

DESCRIPTION	ENGLISH	METRIC
Lift Capacity	400#	259 kg
Platform Maximum Floor Height	30'-0"	9.14 m
Machine Height with Platform Lowered	6'-11"	2.11 m
Machine Width	5'-0"	1.56 m
Length, Minimum	16'-2"	4.92 m
Wheel Base	60"	152.4 cm
Wheel Track	51.2"	130.4 cm
Turning Radius	15'-6"	4.72 m
Turret Rotation	Continuous	
Tail Swing	Within Frame Width	
Engine, Dual Fuel, Standard	20/HP Air Cooled	
Travel Speed	1.3 mph	2.1 kph
Standard Controls: Drive	Proportional	
Swing	Proportional	
Raise	Proportional	
Extend	Proportional	
Steer	Solenoid	
Platform Leveling	Master/Slave w/Solenoid Override	
Hydraulic System Pressure	1650 psi	107 atmos
Fuel Tank Capacity	13 gal	49 liter
Hydraulic Tank	28 gal	106 liter
Weight	11000#	4954 kg
Shipping Cube	584.38 cu. ft.	16.55 cu.m
Basket Dimensions	59" Wide	149.9 cm
	30" Deep	76.2 cm
	42" High	106.7 cm
Tires, 8 Ply	10:00 x 16.5 LT Mono-filled	

5	30H & 30RT MARKLIFT	FIGURE 3

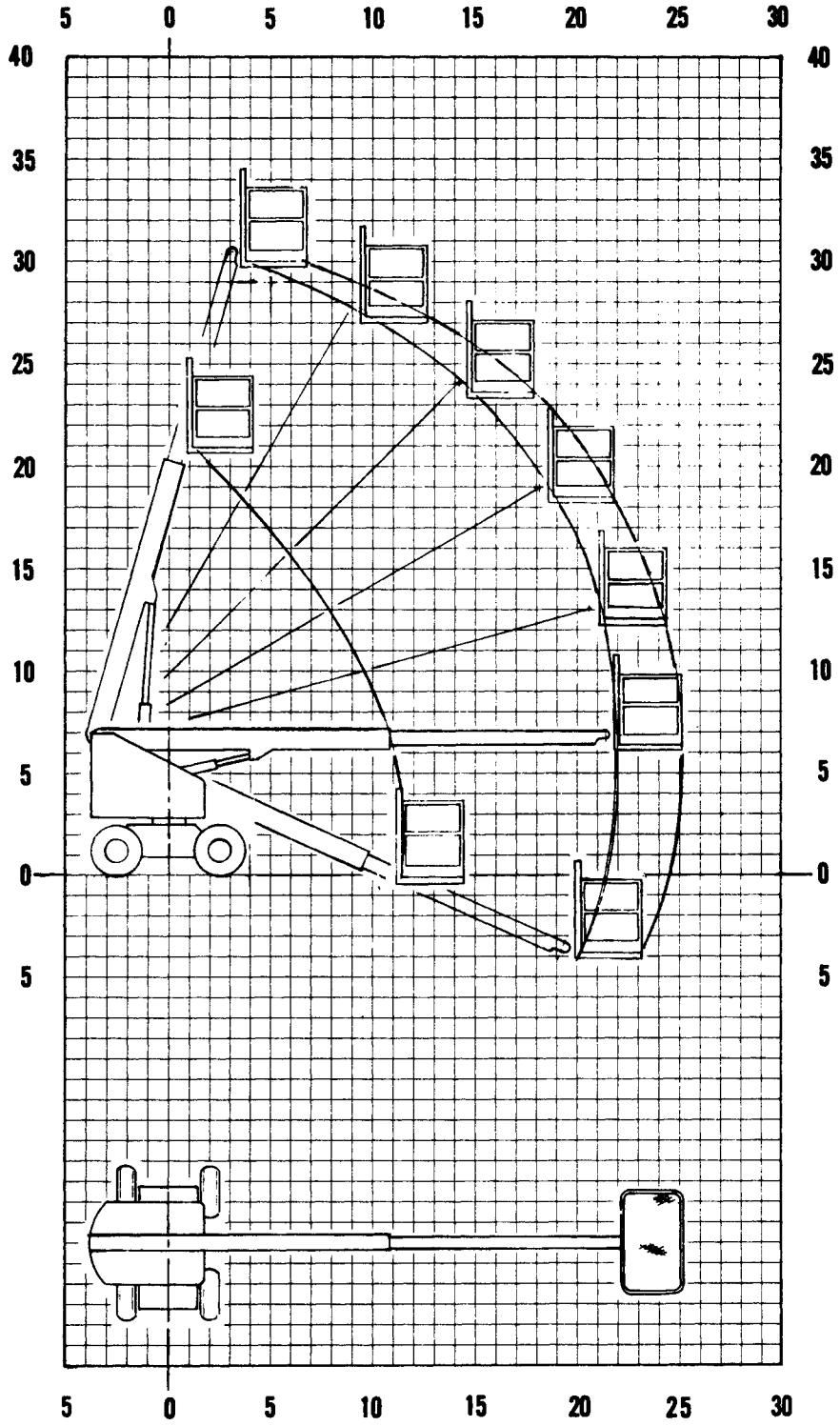


FIGURE 3	30H & 30RT Specifications	6

MODEL 30H & 30RT

DESCRIPTION		ENGLISH	METRIC
Lift Capacity		500#	227 kg
Platform Macimum Floor Height		30'-0"	9.14 m
Machine Height with Platform Lowered		6'- 11"	2.11 m
Machine Width,	30H	5'-0"	1.56 m
	30RT	5'-8"	1.75 m
Length, Minimum		17'-10"	5.43 m
Wheel Base		60"	152.4 cm
Wheel Track		51.2"	130.04 cm
Turning Radius		15'-6"	4.72 m
Turret Rotation		Continuous	
Tail Swing		15" Beyond Frame	38.1 cm
Engine, Dual Fuel, Standard	30H	20 H.P. Air Cooled	
Gasoline or Diesel	30RT	20 H.P. Air Cooled	
Travel Speed		1.3 mph	2.41
Standard Controls:	Drive	Proportional	
	Swing	Proportional	
	Raise	Proportional	
	Extend	Proportional	
	Steer	Solenoid	
Platform Leveling		Master/Slave w/Solenoid Override	
Hydraulic System Pressure		1650 psi	107 atmos
Fuel Tank Capacity		13 gal	49 liter
Hydraulic Tank		28 gal	106 liter
Weight		11300#	5130 kg
Shipping Cube,	30H	620.14 cu ft	17.56 cu m
	30RT	725.0 cu ft	20.5 cu m
Basket Dimensions		59" Wide	149.9 cm
		30" Deep	76.2 cm
		42" High	106.7 cm
Tires, 30H		10:00 x 16.5 LT, 8 Ply Mono Filled	
30RT, Drive Wheels		29 x 12:00-15, 6 Ply "Super Tera Grip" Air Filled (35psi)	
Steering Wheels		11L-15SL, 6 Ply "Maxi Trac" Air Filled (35psi)	

7	40 MARKLIFT	3.1

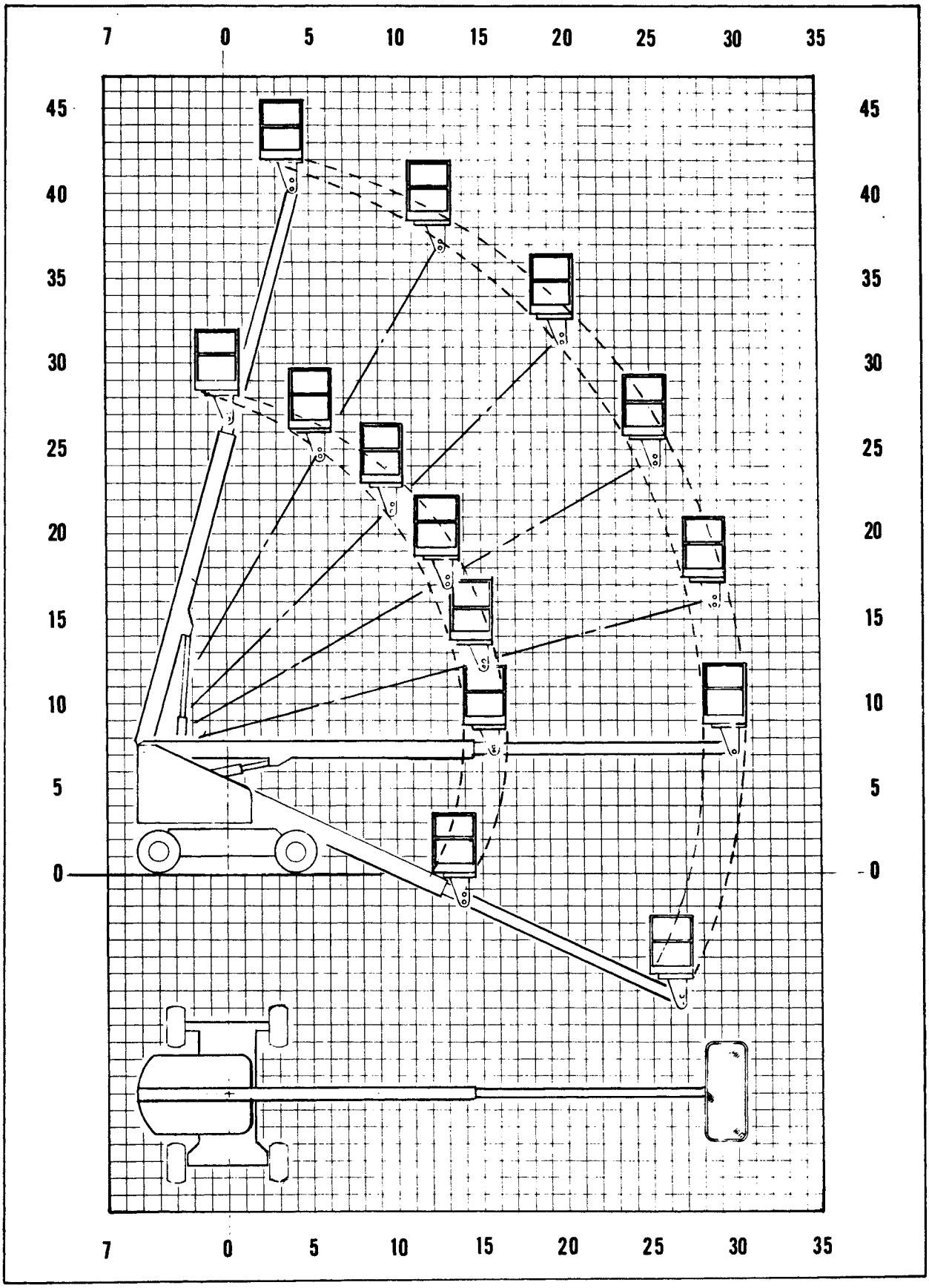


FIGURE 3.1	40 SPECIFICATIONS	7.1

MODEL 40

DESCRIPTION	ENGLISH	METRIC
Lift Capacity	800#	365 kg
Platform Maximum	42'-0"	12.76 m
Machine Height with Platform Lowered	7'-6"	2.28 m
Machine Width	7'-0"	2.12 m
Length, Minimum	19'-0"	5.78 m
Wheel Base	96"	244 cm
Wheel Track	70"	178 cm
Turning Radius	16'-0"	4.86 m
Turret Rotation	Continuous	
Tail Swing	19" Past Wheels	48.26 cm
Engine, Gasoline, Standard	30 HP Air Cooled	
Travel Speed	1.6 mph	2.57 kph
Standard Controls: Drive	Proportional	
Swing	Proportional	
Raise	Proportional	
Extend	Proportional	
Steer	Solenoid	
Platform Leveling	Master/Slave	w/Solenoid override
Hydraulic System Pressure	2300 psi	156 atmos
Fuel Tank Capacity	20 gal	76 liter
Hydraulic Tank	40 gal	152 liter
Weight	13500#	6124 kg
Shipping Cube	998.0 cu.ft.	28.25 cu. m.
Basket Dimensions	72" Wide	183.9 cm
	30" Deep	76.2 cm
	42" High	106.7 cm
Tires, Drive Wheels	29 x 12:00-15, 6 Ply "Super Tera Grip" Monofilled	
Steering Wheels	11L-15SL, 6 Ply "Maxi Trac," Monofilled	

7.2	40RT MARKLIFT	FIGURE 3.2

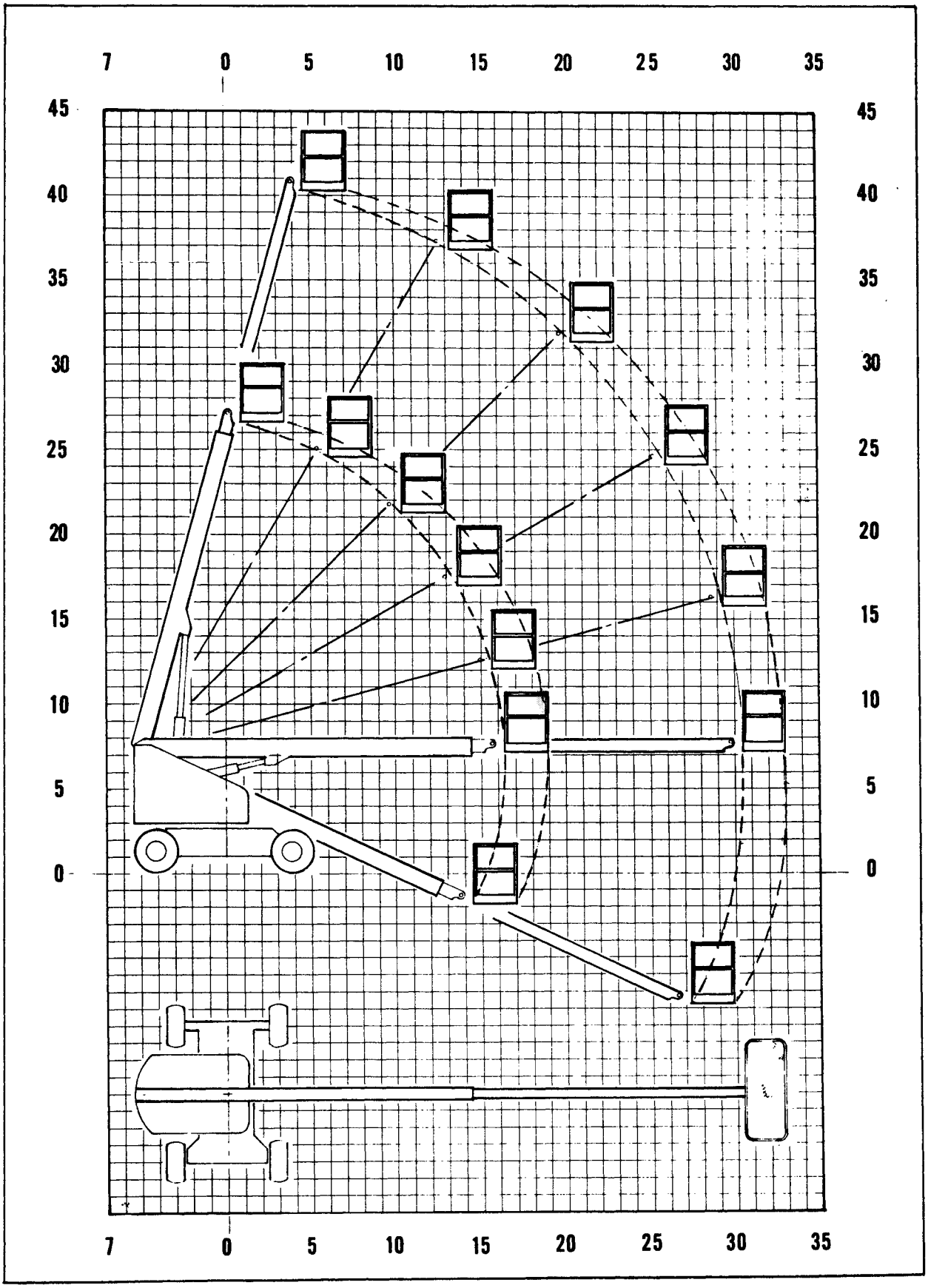


FIGURE 3.2	40RT SPECIFICATIONS	7.3

MODEL 40RT

DESCRIPTION		ENGLISH	METRIC
Lift Capacity		600#	272 kg
Platform Maximum Floor Height		40'-0	12.19 m
Machine Height with Platform Lowered		7'-6"	2.28 m
Machine Width		7'-0	2.13 m
Length, Minimum		22'-0"	6.71 m
Wheel Base		96"	244 cm
Wheel Track		70"	178 cm
Turning Radius		16'-0	4.86 m
Turret Rotation		Continuous	
Tail Swing		19" Past Wheels	48.26 cm
Engine, Diesel, Standard		30 H.P. Air Cooled	
Travel Speed	Low	1.3 mph	2.10 kph
	High	3.2 mph	5.15 kph
Standard Controls:	Drive	Proportional	
	Swing	Proportional	
	Raise	Proportional	
	Extend	Proportional	
	Steer	Solenoid	
Platform Leveling		Master/Slave w/Solenoid Override	
Hydraulic System Pressure		2300 psi	156 atmos
Fuel Tank Capacity		20 gal	76 liter
Hydraulic Tank		40 gal	152 liter
Weight		13500#	6124 kg
Shipping Cube		1155 cu. ft.	32.68 cu. m
Basket Dimensions		72" Wide	183 cm
		30" Deep	76.2 cm
		42" High	106.7 cm
Tires, Drive Wheels		29 x 12:00-15, 6 Ply "Super Tera Grip" Monofilled	
Steering Wheels		11L-15SL, 6 Ply "Maxi Trac" Monofilled	

GENERAL INFORMATION

HYDRAULIC SYSTEM

A working knowledge of the hydraulic system facilitates trouble shooting or adjustments by a mechanic. Therefore, the information below, although general, will provide the mechanic with such knowledge.

Each MARKLIFT contains a variable displacement hydraulic piston pump capable of delivering 15 GPM at 3000 RPM. The pump is both pressure and flow compensated. This combination results in a highly effective, extremely controllable system. The pump control has a load sensing port connected directly to the control valve cylinder ports through a shuttle valve system. The maximum pressure signal, therefore, is shuttled directly to the sensing port, and the pump displacement is automatically adjusted to the valve spool opening.

The load sensing system is automatically removed from the hydraulic circuit during the engine start operations so as not to create excessive starter drag.

The throttle is activated hydraulically directly from the pump high pressure discharge, through a solenoid valve. The ground control function switches actuate this solenoid valve as well as direct oil to the proper function in the proper direction. The throttle solenoid valve is energized, also, by the foot switch in the work platform. The high and low

HYDRAULIC SYSTEM (continued)

throttle selector switch at the platform is wired in series with the foot switch.

The proportional control valves require a small flow and pressure signal constantly while the engine is running. This supply is also tapped off the high pressure pump discharge through a fixed orifice. This low pressure and flow system is connected directly to the proportional control valve after being filtered, and acts on the first stage pilot of the control valve.

A satisfactory pilot line pressure is maintained constantly at 325 psi $\pm$ 25 psi. A capped test port has been provided for a gauge. The gauge thread size is 7/16-20 straight thread.

A small needle valve is installed on the load sensing line from the shuttle valve assembly to the sensing port on the pump. This valve controls the horsepower required to operate the functions of the MARKLIFT. With this valve closed and a function actuated, nothing will move. Slightly open or crack the needle valve, and the function will start to become operative.

It should be noted, at this point, that pressure (psi) and flow (gpm) are directly proportional to horsepower.

Since the pump is preset at 1650 psi, a relatively small engine can deliver enough horsepower to drive the pump,

HYDRAULIC SYSTEM (Continued)

assuming the pump output flow is low enough. If the flow is increased and the pressure maintained at 1650 psi, the engine will burden under the load. If flow is increased further, (by introducing another function) the pump could eventually stall the engine. Therefore, when driving the MARKLIFT over uneven terrain, metering back on flow is helpful in keeping horsepower requirements to a minimum. When the unit is traversing flat, level ground, the pressure in the drive system is minimal and flow may be increased to obtain a faster rate of speed, without exceeding the engine horsepower output. It is important on MARKLIFTS equipped with all solenoid valve controls that the horsepower limiter valve be carefully set and locked to prevent further tampering. Solenoid valves are two position valves, either fully closed or opened. The operator has no metering capabilities with the use of such valves. Therefore, the horsepower limiter valve must be carefully set so as not to stall the engine during any single function in either direction.

The hydraulic oil is filtered on the return line from the control valves to the tank. The element can be easily replaced. Allow the engine to run 2 minutes after changing any filter elements. This enables filter cans to completely fill automatically.

The MARKLIFT is designed to be towed in plant, only, and NOT to exceed 10mph. The towing kit is available from the

HYDRAULIC SYSTEM (continued)

factory as an option. Towing the MARKLIFT can be accomplished by locking out the plantary drive hubs, and hydraulic steering. When hubs are disengaged, there are no wheel brakes. Care should be taken to disengage on flat. level ground and all precautions taken to prevent accidents.

ELECTRICAL SYSTEM

The MARKLIFT electrical system is very straight forward and easy to trouble shoot due to it's simplicity. There are two major junction boxes which also serve as the ground and aerial control consoles. The source for the electrical system is a 12 volt battery with a negative ground. All electrical components operate directly from the source through either switches or proportional controllers.

The ground control console houses the necessary switches for starting and stopping the engine - a selector switch for isolating either the ground or aerial control console, and the required toggle switches for moving the boom. The ground console also contains a keyed ignition/start switch, as well as an engine stop switch, ammeter and hour gauge.

When the selector switch is placed in the aerial position, the electrical source is routed to the aerial control junction box. The intent of the footswitch is to provide an additional safety interlock in the control circuit to insure multiple physical movement by the operator, thereby requiring maximum operator attention. The function of the footswitch only completes the electrical cicuit to the aerial control console and engine throttle. The footswitch, in no way, is directly connected to the drive braking system. The footswitch has the additional safety feature that, in the event of loss of control by the operator, if he moves his foot from the switch,

ELECTRICAL SYSTEM (continued)

the brakes will be normally applied (see Page 19, Paragraph 14) if the brake adjustment needle valve has not been readjusted. Engine start and stop are independently wired around both the selector switch and footswitch, making them operable any time the master switch or ignition switch is on.

The aerial control console is equipped with all controllers and switches necessary to operate the boom functions, as well as drive and steer. It also contains a start/stop switch. If your MARKLIFT is equipped with proportional control valves for all boom functions, the aerial control console will contain electrical controllers complete with manual lockouts. The controllers are spring-centered and are designed to produce a variable output signal to the control valve. The output signal is directly proportional to the handle movement on the controller. The valve is electrically coupled to the controller and responds only to the signal level transmitted to it by the operator.

The operator must learn how to move the controller slowly to obtain a smooth, erratic-free transition from start up to wide open and back to neutral.

ELECTRICAL SYSTEM (continued)

The MARKLIFT 40 series Boom units have additional safety systems for driving. When the unit is driven with the boom extended or raised above horizontal, the unit speed is automatically reduced by one half. A level sensor is also automatically engaged and will activate a warning buzzer and light if the unit is 5^{o} or more out of level. The level sensor also prevents any operation of the boom controls at 5^{o} or more out of level. When the unit is driven to a slope of less than 5^{o}, the buzzer & light go off and the boom controls become operable.

DUAL FUEL SYSTEM

MARKLIFT Boom units equipped with a dual fuel system allow the operator to remotely select gasoline or propane operation, with a 3-position selector switch located on the aerial control console. The selector switch energizes solenoid valves, which close one fuel line and open the other.

ENGINE STARTING

The engine should be started with propane. The propane system bypasses the fuel pump and carburetor bowl and supplies fuel directly into the carburetor for quick starting. If the engine has been run on propane and starting is done with gasoline, more than normal cranking and battery drainage is required for the fuel pump to fill the lines and carburetor bowl with gasoline.

ENGINE STOPPING

The engine is stopped by pushing the red "STOP" button on the ground or aerial console. The fuel selector switch does not need to be moved to the "OFF" position; the engine may be restarted with the ignition switch or aerial start button. Prior to starting from ground console, check fuel selector switch on aerial console for proper fuel source.

SWITCHING FROM PROPANE TO GASOLINE

With the engine running, step on the deadman footswitch and position the throttle switch to "HI" speed. Switch fuel selector to gasoline. The engine will begin to stall as the

SWITCHING FROM PROPANE TO GASOLINE (continued)

carburetor bowl starts filling with gasoline. Switch back to propane until the engine resumes high speed. Switch back and forth from LPG to gasoline until the engine is running smoothly on gasoline.

SWITCHING FROM GASOLINE TO PROPANE

With the engine running, step on the deadman footswitch and position the throttle switch to "HI" speed. Switch fuel selector to "OFF". The engine will continue to run as it uses fuel from the carburetor bowl. When the engine begins to run roughly, allow it to run several seconds and switch to propane. Switch throttle to "LOW" and release footswitch. Let the engine idle for 20-30 seconds to completely burn up any remaining gasoline in the bowl.

INSPECTION

and

CHECK OUT

INSPECTION AND CHECK OUT

1) Visually inspect all exposed parts of the MARKLIFT. Secure any loose bolts and nuts. Replace any damaged hydraulic lines or broken wires. Check for any structural damage, including cut or damaged tires. Check tire pressure. See specification sheets for each model.

2) Check oil level in the engine.

3) Check hydraulic oil level - sight gauge shows full with unit in stowed position.

4) Fill fuel tank - use regular gasoline only or diesel fuel. Open fuel valve on tank of L.P. equipped engines.

5) Check battery for 1200 $\pm$ 50 reading on hydrometer. Charge battery if reading is below 1100.

6) Check hydraulic valve panel for loose hardware and broken fittings or tubing.

7) The ground control panel is accessible by opening the turret cover opposite the engine side of the machine.

8) Start engine. Allow engine to warm up.

9) After initial warm-up of gasoline engine, press engine stop button making sure stop circuit is operational. The engine switch may be left in the ON position indefinitely if engine stop button has been pressed, without fear of burning the engine points. However, should the engine stall, the operator must either push the stop button or turn off ignition switch to prevent current path to coil.

10) Position selector switch to ground and operate switches, moving as follows: Boom UP/DOWN, rotation RIGHT/LEFT, and extend OUT/IN. Check for hose leaks.

11) After check-out of ground control functions, position selector switch to AERIAL for operation at work platform. Depress foot switch prior to moving any control function switches. This increases engine RPM (if throttle HI/LO selector is positioned in HI), and electically completes circuit to controls.

If your MARKLIFT is equipped with proportional controls like the drive function, press foot switch, raise controller locking device and gradually move controller in direction selected. The controller handle is spring-centered and self-locking to prevent inadvertent operation. Familiarize yourself with the operation of the

controller until you are able to start and stop each function, forward and reverse, obtaining a gradual, smooth movement.

12) THE TRAVEL OR DRIVE CONFIGURATION IS WITH THE STEERING WHEELS UNDER THE BOOM. THIS PROVIDES THE BEST WEIGHT DISTRIBUTION FOR MAXIMUM TRACTION. IF THE BOOM IS ROTATED 180°, THE DRIVE AND STEER DECALS READ IN REVERSE. THE FORWARD DECALS ATTACHED TO EACH END OF THE CARRIAGE ASSEMBLY WILL HELP ORIENTATE THE OPERATOR TO THE CONTROL CONSOLE.

13) A manually operated needle valve is installed under the cover between the drive wheels to provide a positraction feature when closed. By opening the valve, the MARKLIFT will perform with 100% differential action for in-plant level ground.

14) Brake adjustments may be made by turning a small needle valve (Page 44, Item 2). The valve is merely a time delay for applying the brakes. With the valve completely open, the time delay for applying the brakes is at a minimum. The delay has been set between minimum and that time required to stop the machine in approximately three feet on level ground.

UNLOADING

INSTRUCTIONS

It shall be the responsibility of all users of the MARKLIFT to read and comply with the following operating instructions. They are designed to promote safety and a better understanding of the operation of the self-propelled aerial platform.

These instructions do not propose to be all inclusive, nor to supplement or replace other additional safety and/or precautionary measures covering usual or unusual conditions. If these instructions conflict in any way with the state, local or federal statute or regulations, said statute or regulations shall supercede these instructions, and it shall be the responsibility of each user to comply therewith, and inform MARK INDUSTRIES of the variances.

1) With selector switch in ground position, move boom across transporter bed to attach platform, if required. Position selector switch to aerial position and operate MARKLIFT from platform. Familiarize yourself with the control panel; raise boom slightly and rotate turret. If your MARKLIFT is equipped with proportional controllers for all boom functions, the locking lever must be lifted prior to moving the lever forward and reverse. The footswitch completes circuit to controls and must be pressed before attempting to move any boom functions. It is desirable to place the throttle toggle switch to the high speed position when operating unit on grades or inclines.

2) Before unloading the MARKLIFT, the operator may check the wheel braking system by slowly driving forward and reverse. If done correctly and controller moved slowly enough, the operator can feel when the brakes release and the driving mode takes effect.

3) The drive brakes are automatically applied except when drive controller handle is positioned in a driving mode, forward or reverse. The deadman footswitch must be depressed to activate control function handles or switches.

4) It is recommended that the MARKLIFT be moved into an area free of any overhead obstructions on a flat, level surface with no hazardous irregularities or accumulation of debris.

5) It is suggested that the operator familiarize himself with the drive by raising the boom approximately 5 feet off the ground prior to driving the unit. He will soon find that gradual starts and stops are relatively easy to perform. Gradually raise the boom higher, and drive unit again until maximum height is established. Remember, at all times, that the proportional signal from the controller to the valve is controlled by the operator. There is approximtely 3 degrees of "dead" motion each side of the controller NEUTRAL position.

6) The best operation position can be achieved by placing the thumb over the knob of the controller and wrapping the fingers loosely around the locking stem. Now, rest the heel of the hand on the controller housing and apply a downward motion with the thumb, making the index finger lift the locking stem. Once the controller is disengaged and moved foreward or reverse, the pressure on the thumb may be omitted because the locking stem has engaged the cam and cannot drop into the locking position until the lever or handle is returned to the center position.

7) When moving the boom using two proportional functions, remember that pressure times flow equal horsepower. If the engine attempts to stall during multiple functions, then the operator must learn to "feather" back on one or both controllers to diminish pump output flow. An immediate change in engine characteristics will occur and engine will adequately continue to drive the pump and boom functions will continue to move, although at a lesser rate.

8) After the operator has spent less than 30 minutes practicing, he should be capable of smoothly starting and stopping the machine on all proportional functions.

MARKLIFT

SAFETY

Article 86. Provisions for Preventing Accidents Due to Proximity to Overhead Lines

2946. Provisions for Preventing Accidents Due to Proximity to Overhead Lines. (a) **General.** No person, firm, or corporation, or agent of same, shall require or permit any employee to perform any function in proximity to energized high-voltage lines; to enter upon any land, building, or other premises and thereto engage in any excavation, demolition, construction, repair, or other operation; or to erect, install, operate, or store in or upon such premises any tools, machinery, equipment, materials, or structures (including scaffolding, house moving, well drilling, pile driving, or hoisting equipment) unless and until danger from accidental contact with said high-voltage lines has been effectively guarded against.

(b) **Clearances or Safeguards Required.** Except where electrical distribution and transmission lines have been de-energized and visibly grounded or effective barriers have been erected to prevent physical and arcing contacts with the high-voltage lines, the following provisions shall be met:

(1) **Over Lines.** The operation, erection, or handling of tools, machinery, apparatus, supplies, or materials, or any part thereof, over energized high-voltage lines shall be prohibited.

(2) **Equipment and Materials in Use.** The operation, erection, or handling of tools, machinery, equipment, apparatus, materials, or supplies, or any part thereof within the minimum clearances from energized lines set forth in Table X shall be prohibited.

Table X
Required Clearances from Overhead High-Voltage Lines

Nominal voltage (Phase to Phase)	*Minimum Required Clearance (Feet)*
750 - 50,000	10
over 50,000 - 75,000	11
over 75,000 - 125,000	13
over 125,000 - 175,000	15
over 175,000 - 250,000	17
over 250,000 - 370,000	21
over 370,000 - 550,000	27
over 550,000 - 1,000,000	42

(3) **Transportation or Transit.** The transportation or transit of any tool, machinery, equipment, or apparatus, or the moving of any house or other building in proximity to overhead high-voltage lines shall be expressly prohibited if at any time during such transportation or transit such tool, machinery, equipment, apparatus, or building, or any part thereof, can come closer to high-voltage lines than the minimum clearances set forth in Table Y.

40—76640
12—76643

Article 86. Provisions for Preventing Accidents

Except where the boom of boom-type equipment is lowered and no load is imposed thereon, the equipment in transit shall conform to the minimum required clearances set forth in Table X.

Table Y
Required Clearances from Energized High-Voltage Conductors
(While in Transit)

Nominal Voltage (Phase to Phase)		*Minimum Required Clearance (Feet)*
750–	50,000	6
over 50,000–	345,000	10
over 345,000–	750,000	16
over 750,000–	1,000,000	20

(4) **Storage.** The storage of tools, machinery, equipment, supplies, materials, or apparatus under, by, or near energized high-voltage lines is hereby expressly prohibited if at any time during such handling or other manipulation it is possible to bring such tools, machinery, equipment, supplies, materials, or apparatus, or any part thereof, within the minimum required clearances from high-voltage lines as set forth in Table X.

(c) The specified clearance shall not be reduced by movement due to any strains impressed (by attachments or otherwise) upon the structures supporting the high-voltage line or upon any equipment, fixtures, or attachments thereon.

(d) Insulated cage-type boom guards, boom stops, insulating links, or proximity warning devices may be used on cranes, but the use of such devices shall not alter the required clearances set forth in Table X.

(e) Any overhead conductor shall be considered to be energized unless and until the person owning or operating such line verifies that the line is not energized, and the line is visibly grounded at the work site.

2947. Warning Signs Required. The owner, agent, or employer responsible for the operations of equipment shall post and maintain in plain view of the operator and driver on each crane, derrick, power shovel, drilling rig, hay loader, hay stacker, pile driver, or similar apparatus, a durable warning sign legible at 12 feet reading: **"Unlawful To Operate This Equipment Within 10 Feet Of High-Voltage Lines of 50,000 Volts Or Less."**

In addition to the above wording, the following statement in small lettering shall be provided on the warning sign: **"For Minimum Clearances of High-Voltage Lines In Excess of 50,000 Volts, See Article 86, Title 8, High-Voltage Electrical Safety Orders."**

Every operator of the MARKLIFT must know, understand and follow the safety rules set forth herein.

1) The MARKLIFT self-propelled aerial work platform is a personnel lifting device, and it is essential that it be properly maintained and operated to perform all functions with maximum safety and efficiency.

2) The operation of any new and unfamiliar equipment can be hazardous in the hands of untrained operators. Only trained operators must be assigned to operate the MARKLIFT.

3) It is the responsibility of the operator to be familiar with the manufacturer's manual and to follow all recommendations made. Never exceed manufacturer's recommended platform load capacity.

4) It is the responsibility of the owner to instruct the operators with the safety requirements made not only by MARK INDUSTRIES, but by the various safety boards in your area, as well as requirements set forth by ANSI and OSHA.

5) The MARKLIFT is a non-insulated personnel carrier and

must not be operated within 10 feet of a 50,000 volt line. (See Page 26.1 for complete chart)

6) Remember, the load capacity of the MARKLIFT is <u>total</u> combined weight of personnel and tools, fixtures, accessories, etc.

7) Always distribute load evenly over platform floor area.

8) The MARKLIFT platform is equipped with safety belt rings. A body belt for each person must be worn with the safety strap attached.

9) It is recommended that head gear (hard hats) be worn by all personnel in the work platform.

10) Under no circumstances should horseplay be tolerated. Report any misuse of equipment to the proper personnel.

11) The MARKLIFT structure must not be used as a welding ground. Disconnect both battery leads prior to performing any welding operations.

12) <u>DO NOT</u> lean over platform guard railings to perform work.

13) <u>DO NOT</u> use ladders or scaffolding on the platform to obtain greater height.

14) DO NOT raise or lower boom into protruding objects.

15) DO NOT drive carriage or platform into stationary objects.

16) DO NOT store loose material in the work platform such as pipe, rope, extension cords, wire and/or miscellaneous boxes. If required to store such items, they must be situated in such a way as to prevent walking and tripping over such items.

17) DO NOT alter equipment in any fashion.

18) DO NOT override any hydraulic, mechanical, or electrical safety devices.

19) DO NOT drive on uneven, sloping or soft terrain, as this is hazardous and must be avoided. The MARKLIFT must not be operated on more than a 5 degree out-of-plumb condition.

20) DO NOT work on platform if your physical condition is such that you feel dizzy or unsteady in any way.

21) DO NOT jump start other vehicles using MARKLIFT battery.

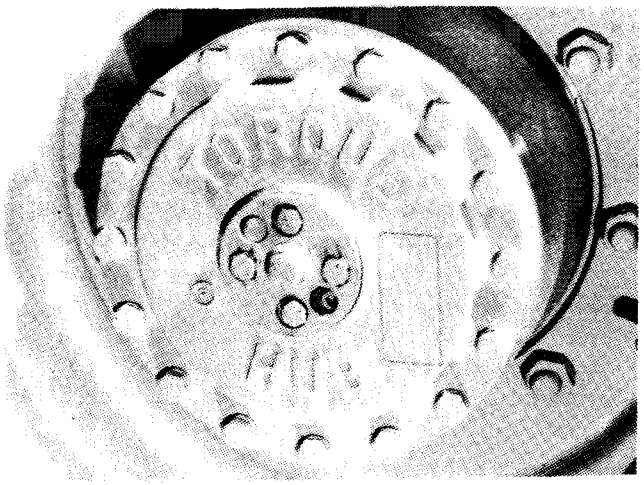
TORQUE HUB MUST BE DISENGAGED FOR TOWING.

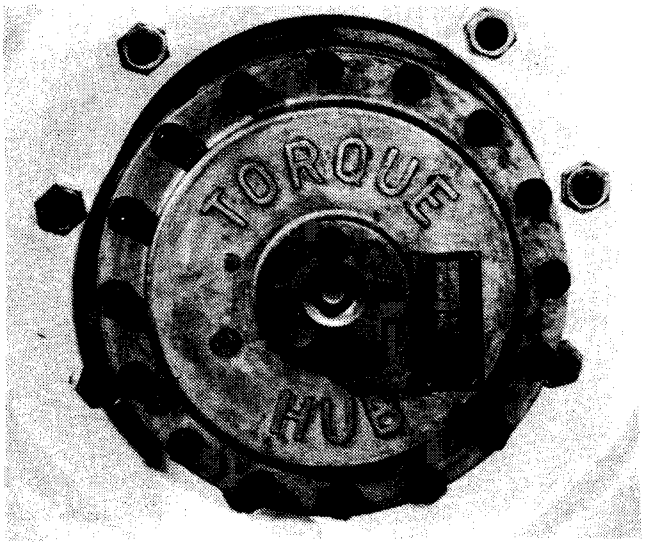
MAXIMUM TOWING SPEED IS 8 M.P.H.

TO DISENGAGE TORQUE HUB, REVERSE THE DISCONNECT CAP. THE KNOB ON THE CAP DISENGAGES THE DRIVE HUB INPUT SHAFT.

CAUTION: BRAKES ARE ALSO DISENGAGED!

HUB ENGAGED





HUB DISENGAGED

31	TORQUE HUB LUBRICATION	FIGURE 5

1. TYPE - EP 90

   On normal application EP 90 should be used. On applications where the lubricant must meet special requirements, the manufacturer of the lubricant should be able to recommend a suitable substitute.

2. OIL TEMPERATURE

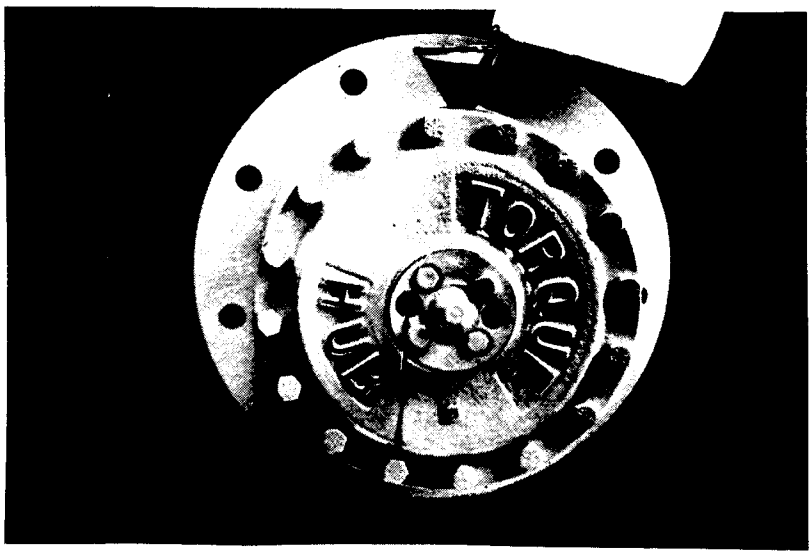
   Continuous - 160°F
   Intermittent - 200°F

3. OIL CHANGE

   Initial - After 50 hours or 50,000 revolutions of operation. Preferably in a loaded condition.
   Subsequent - 1000 hours or (1) year whichever comes first. Higher temperatures make it necessary to change oil more frequently.

4. OIL FILL LEVEL

   Unit mounted horizontal - half-full

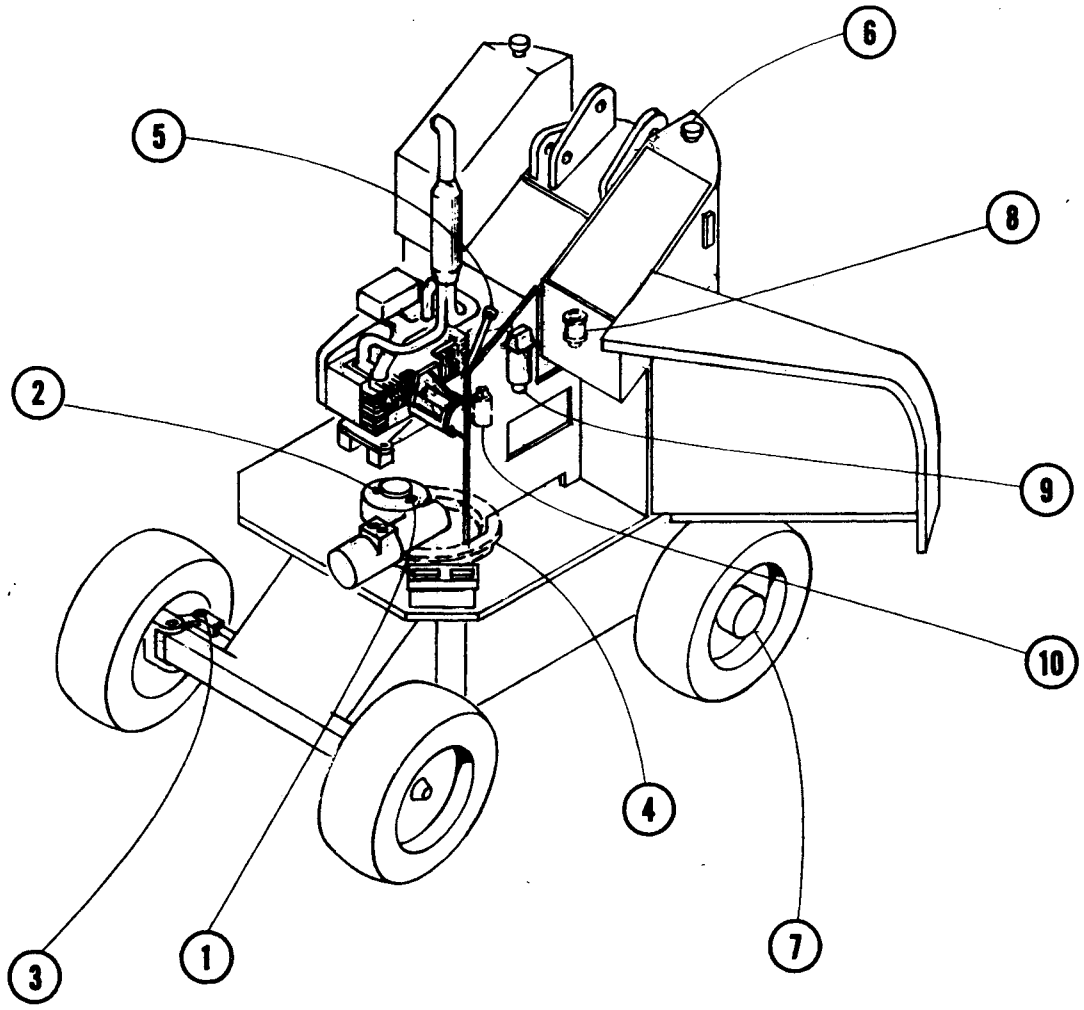


LUBRICATION

INSTRUCTIONS

LUBRICATION GUIDE

FIGURE 6



ITEM	DESCRIPTION	LUBRICANT	FREQUENCY
1	Swing Drive Gear Box Gearing	Gear Oil, SAE 90	Monthly
2	Swing Drive Gear Box Bearings	Grease-Mobil VA6L36AG or equivalent	Monthly
3	Tie Rod Pin	Grease-Mobil VA6L36AG	Monthly
4	Ring Gear	Grease-Mobil VA6L36AG- 4 zerks, rotate gear while greasing	Monthly
5	Engine	SAE 30	See ONAN Maint. Manual
6	Hydraulic Fluid	Page 35	Yearly
7	Torque-Hub	See Fig.5 Page 31 &	
8	Strainer	-	Yearly
9	Filter Element	-	Repl. every 100 hrs.
10	Filter Element	-	Repl. every 100 hrs.

HYDRAULIC SYSTEM FLUID

FIGURE 7

OIL COMPANY	Chevron	Gulf	Shell	Union
Brand Name	ATF Dexron 11	ATF Dexron 11	Donax-T6	ATF Dexron
Viscosity - SUS @ 100°F	187.4	195	200	200
SUS @ 210°F	49.2	50.4	50	52.3
Viscosity Index Typical	153°	155°	160°	172°
Flash Point °F	400°	405°	390°	395°
Pour Point °F	-40°	-50°	-50°	-45°

ILLUSTRATED

PARTS

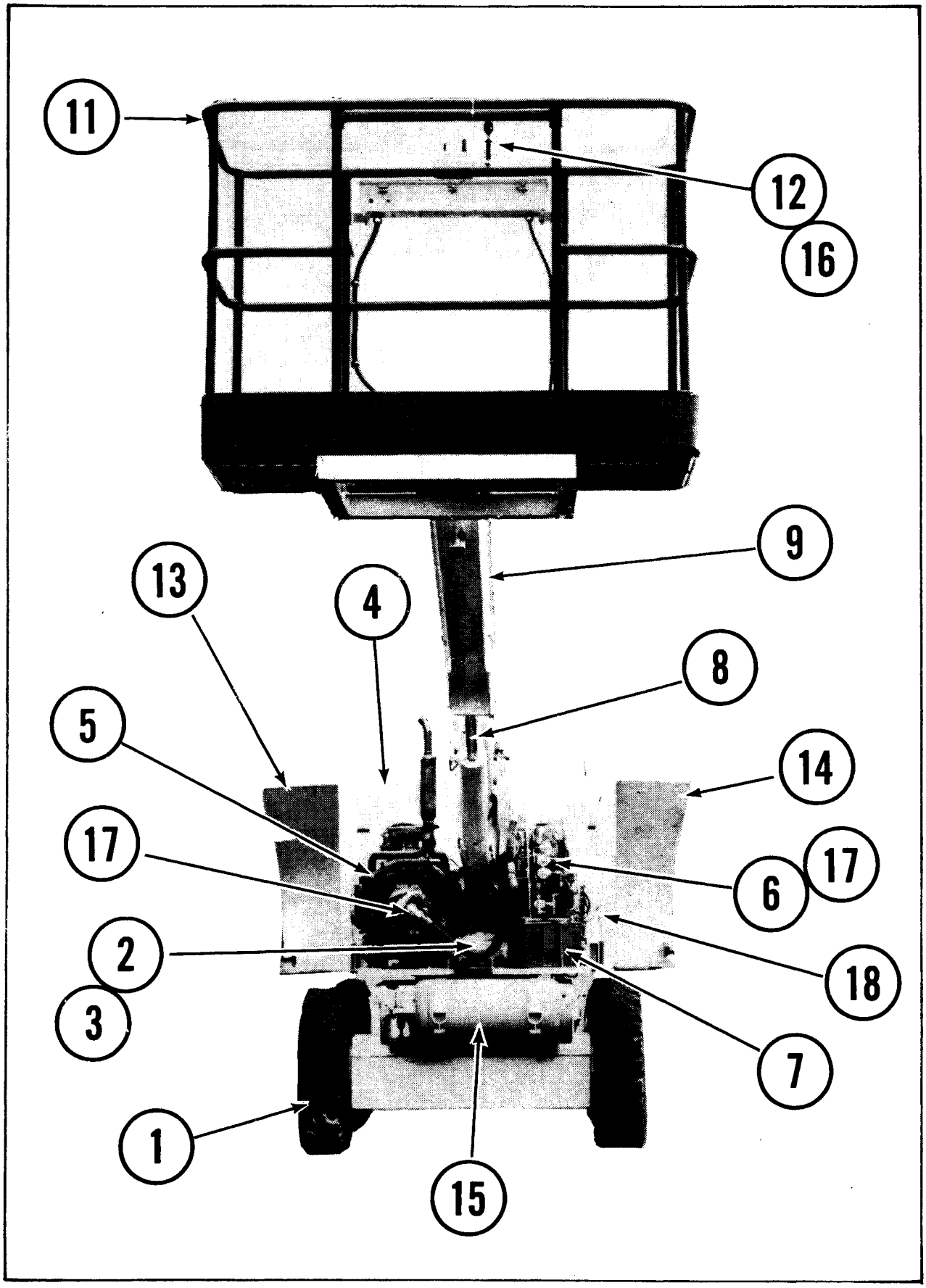

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FIGURE 8	MODEL 21S & 21 RT GENERAL ASSEMBLY	38

ITEM	DESCRIPTION	PAGE	FIGURE
1.	Base Assembly	41	
2.	Gear Box & Motor	45	
3.	Manifold	45	
4.	Turret	Part No.	20230
5.	Engine Group	47	
6.	Valve Plate Assembly	51	
7.	Battery (12V, 75 AMP-HR)		
8.	Lift Cylinder	59	
9.	Boom	71	
10.	Fork	Part No.	20215
11.	Platform	Part No.	20235
12.	Aerial Controls	75	
13.	Turret Cover (Right)	Part No.	20303-1
14.	Turret Cover (Left)	Part No.	20303-2
15.	L.P.G. System (Optional)		
16.	Electric Schematic	105	
17.	Hydraulic Schematic	101	
18.	Ground Controls	51	

30H, 30L & 30RT
GENERAL ASSEMBLY

FIGURE 9

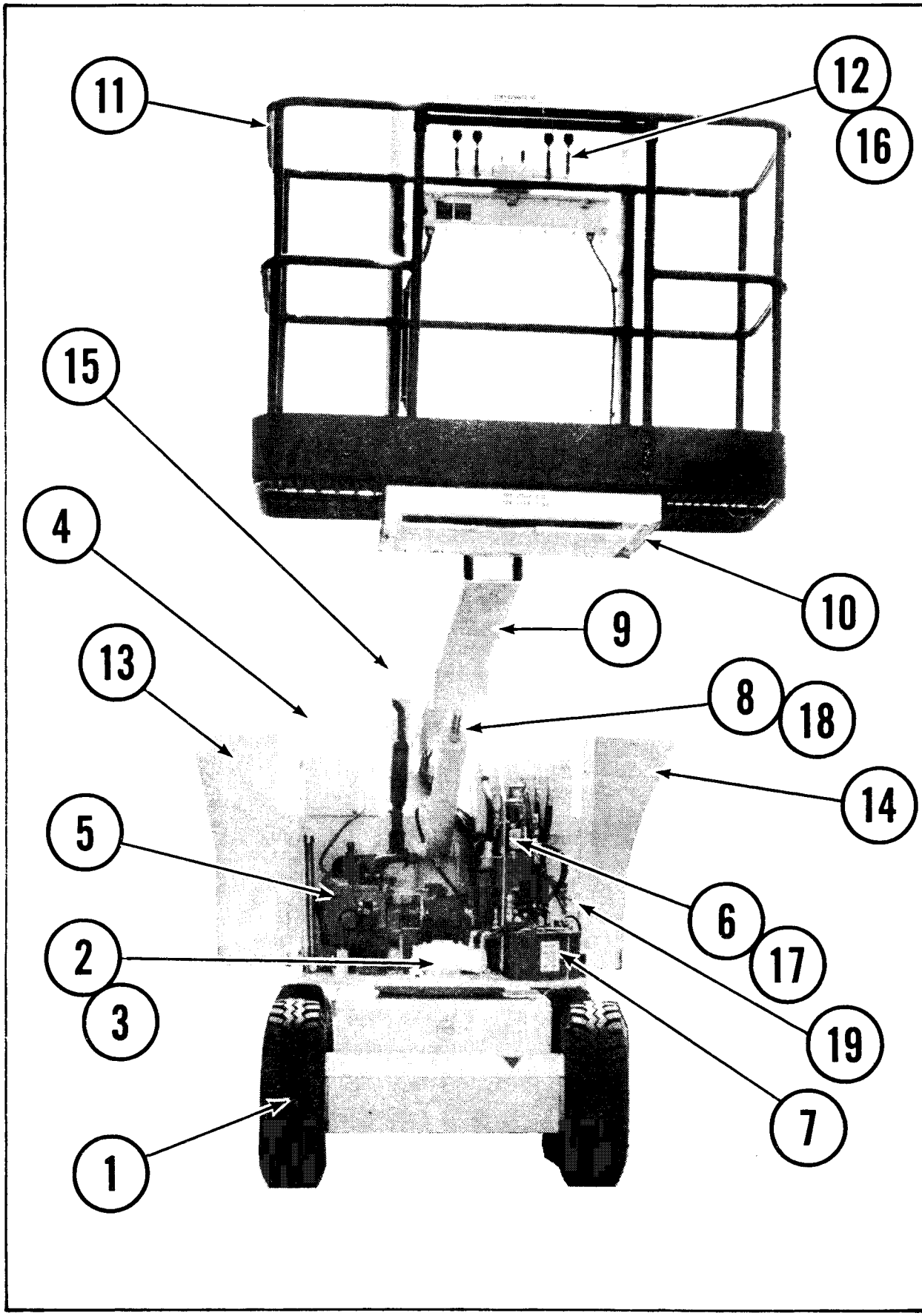
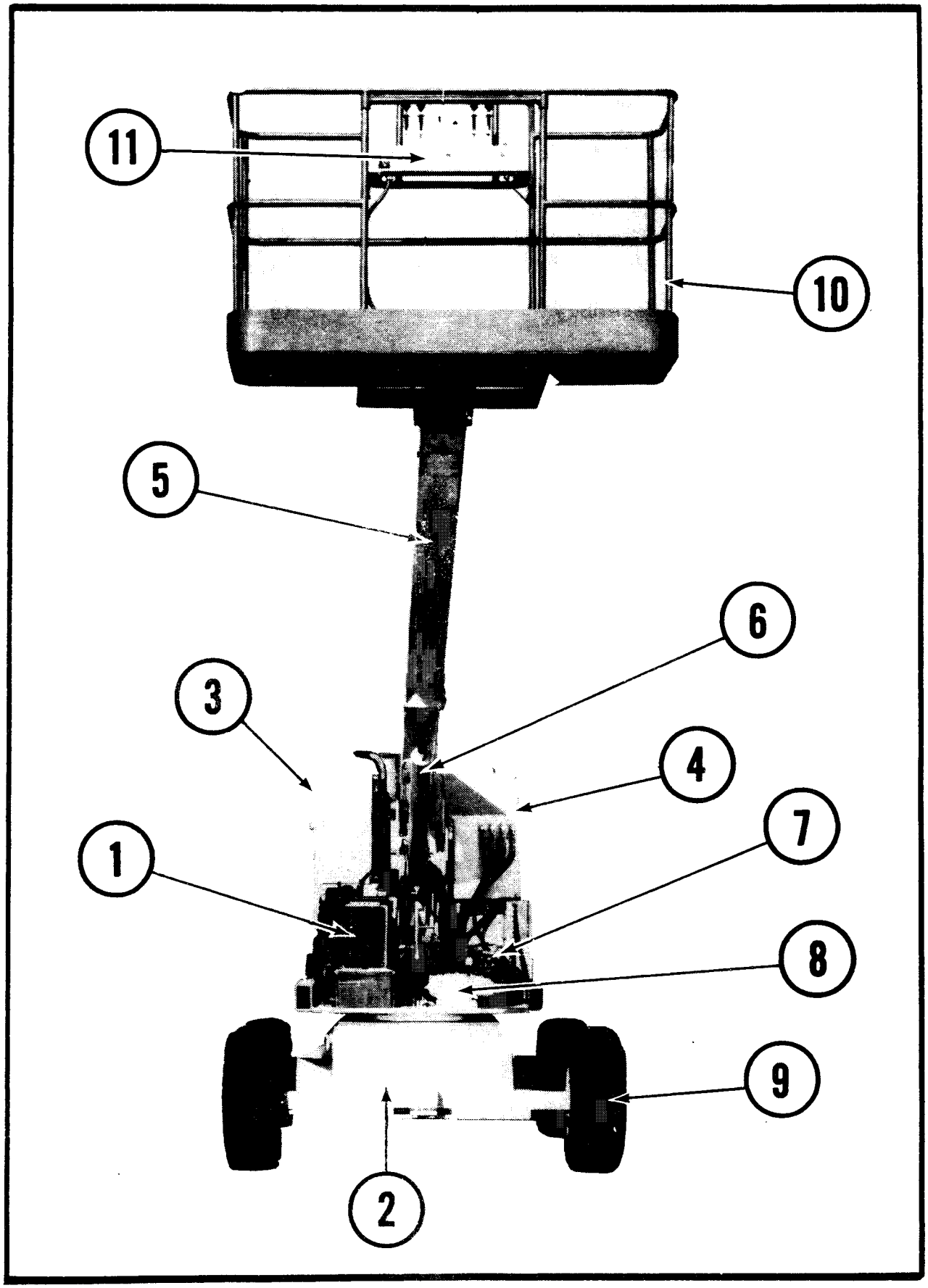


FIGURE 9	MODEL 30H, 30L & 30RT GENERAL ASSEMBLY	40

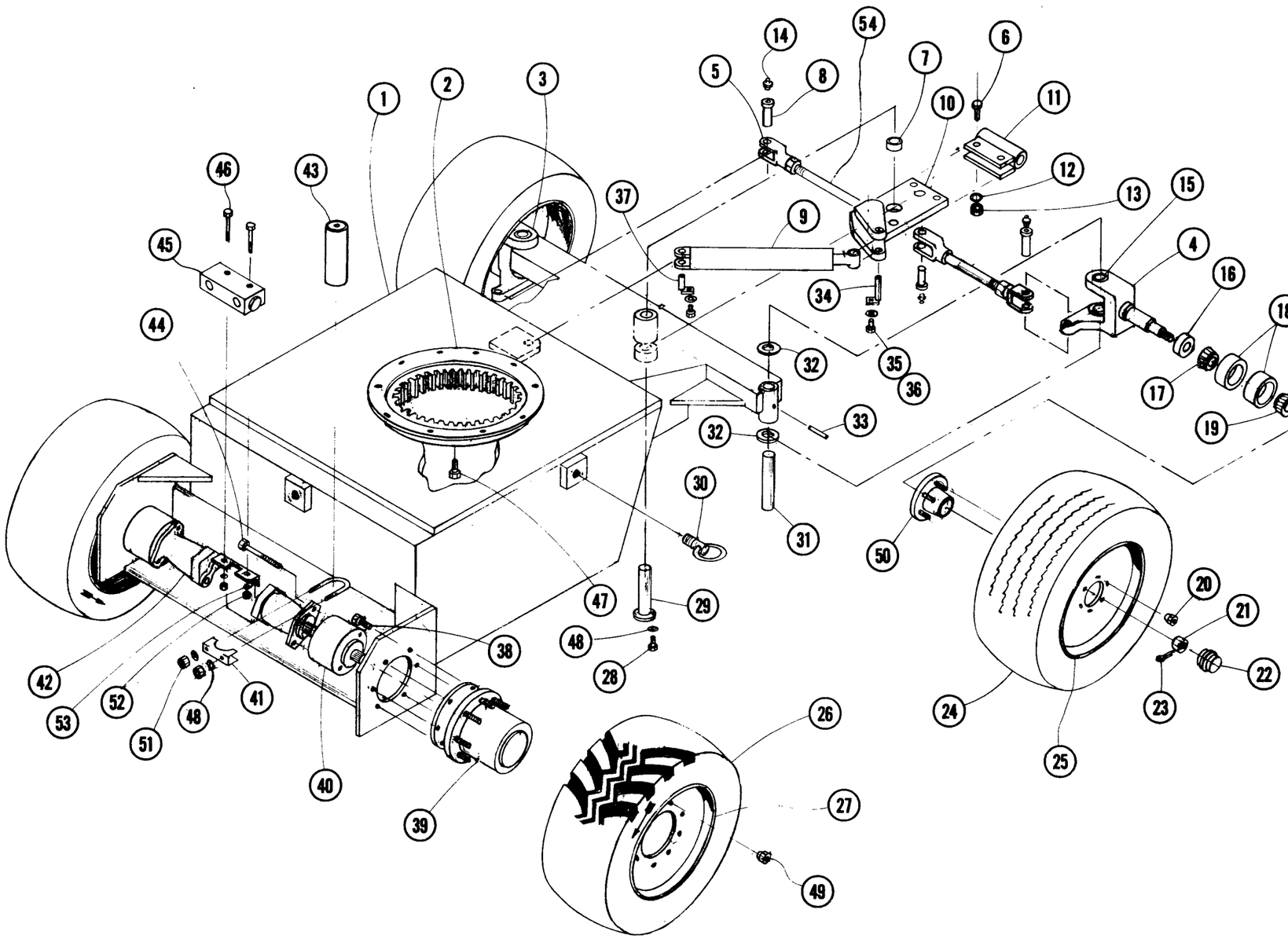
ITEM	DESCRIPTION	PAGE	FIGURE
1.	Base Assembly	41	
2.	Gear Box & Motor	45	
3.	Manifold	45	
4.	Turret (Model 30L)	Part No.	20232
4.	Turret (Model 30H & 30RT)	Part No.	20231
5.	Engine Assembly	49	
6.	Valve Plate	53	
7.	Battery (12V, 75 AMP-HRS)		
8.	Lift Cylinder	59	
9.	Boom	73	
10.	Fork (Model 30L)	Part No.	20306
10.	Fork (Model 30H)	Part No.	20216
11.	Platform	Part No.	20235
12.	Aerial Controls	77	
13.	Turret Cover, Right (Model 30L)	Part No.	20330-1
13.	Turret Cover, Right (Model 30H & 30RT)	Part No.	20331-1
14.	Turret Cover, Left (Model 30L)	Part No.	20330-2
14.	Turret Cover, Left (Model 30H & 30RT)	Part No.	20331-2
15.	Master Leveling Cylinder	61	
16.	Electric Schematic	105	
17.	Hydraulic Schematic	103	
18.	Emergency Descent Motor & Pump	58	
19.	Ground Control Console	53	

40.1	40 & 40RT GENERAL ASSEMBLY	FIGURE 9.1



CARRIAGE ASSEMBLY MODELS 21 & 30

FIGURE 10



ITEM	PART NUMBER	DESCRIPTION	QTY
1.	20250	Base Weld Assy	1
2.	20353	Ring Gear	1
3.	20320-1	Yoke Assy (RH) (21-30RT)	1
3A.	20709	Yoke Assy (RH) (40S Before 7/80)	1
4.	20320-2	Yoke Assy (LH) (21-30RT)	1
4A.	20716	Yoke Assy (LH) (40S Before 7/80)	1
5.	20578	Yoke	2
6.	3/4-10NC & 3" Long	Cap Screw	2
7.	20576	Bushing	1
8.	20577	Pin	4
9.	20206	Hydraulic Cylinder (Page 67)	1
10.	20222	Steering Arm	1
11.	20312	Towing Eye	1
12.	3/4"	Lock Washer	4
13.	3/4-10NC	Hex Nut	4
14.	1/8NPT	Grease Zerk	4
15.	20322	Bushing	4
16.	65102-10272	Seal	2
17.	65051	Bearing Cone (Timken)	1
18.		Bearing Cup (Timken)	2
19.		Bearing Cone (Timken)	1
20.	7/16-20NC	Lug Nut	12
21.	20514	Castle Nut	2
22.	20513	Dust Cap	2
23.		Cotter Pin	2
24.	See Page 43	Tire	2
25.	See Page 43	Rim	2
26.	See Page 43	Tire	2
27.	See Page 43	Rim	2

ITEM	PART NUMBER	DESCRIPTION	QTY
28.	60511	Capscrew	1
29.	20254	Steering Pin	1
30.	20483	Tie Down Ring	4
31.	20321	King Pin	2
32.	20323	Thrust Washer	4
33.	1/4 DIA x 2 1/2" Long	Roll Pin	
34.	20270	Pin	1
35.	63359	Capscrew	2
36.	63301	Lock Washer	2
37.	20252	Pin	1
38.	60604	Bomalok	12
39.	20350	Drive Hub	2
40.	20354	Brake	2
41.		Clamp	1
42.	20352	Motor Model 21S & 30L	2
42A.	20381	Motor Model 30H	2
43.	20355	Accumulator	1
44.	60348	Bomalok	4
45.	20359	Flo Divider	1
46.	60515	Capscrew	2
47	60604	Bomalok Capscrew	10
48.	63302	Lock Washer	1
49.	61156	Lug Nut	18
50.	20510	Hub	2
51.	60702	Hex Nut	2
52.	60703	Hex Nut	2
53.	63319	Lock Washer	2
54.	20579	Tie Rod	2

MODEL 21S

ITEM	PART NUMBER	DESCRIPTION	QTY
24.	7:00 x 15LT (75 PSI AIR)	Steering Tire Super Hi Miler Load Range D	
25.	20400	Tire & Rim	2
26.	7:00 x 15LT	Drive Tire Custom Extra Grip, Load Range D	
27.	20398	Tire & Rim	2

MODEL 30H

24.	10:00 x 16.5LT (Mono-filled)	Steering Tire Super Hi Miler Load Range D	
25.	20399	Tire & Rim	2
26.	10:00 x 16.5LT (Mono-filled)	Drive Tire Super Traction Tread, Load Range D	
27.	20397	Tire & Rim	2

MODEL 30L

24.	10:00 x 16.5LT (Mono-filled)	Steering Tire Super Hi Miler Load Range D	
25.	20399	Tire & Rim	2
26.	10:00 x 16.5LT (Mono-filled)	Drive Tire Super Hi Miler Load Range D	
27.	20421	Tire & Rim	2

MODEL 21RT & 30 RT

ITEM	PART NUMBER	DESCRIPTION	QTY
24.	11L-15SL, 6 Ply (35 PSI AIR)	Steering Tire "Maxi-Trac"	
25.	20714	Tire & Rim	2
26.	29 x 12:00-15, 6 ply (35 PSI AIR)	Drive Tire "Super Tera Grip"	
27.	20715	Tire & Rim	2

MODEL 40

24.	11L-15SL, 6 ply (mono-filled	Steering Tire "Maxi-Trac"	
25.	20713	Tire & Rim	2
26.	29 x 12:00-15, 6 ply (mono-filled)	Drive Tire "Super Tera Grip"	
27.	20712	Tire & Rim	2

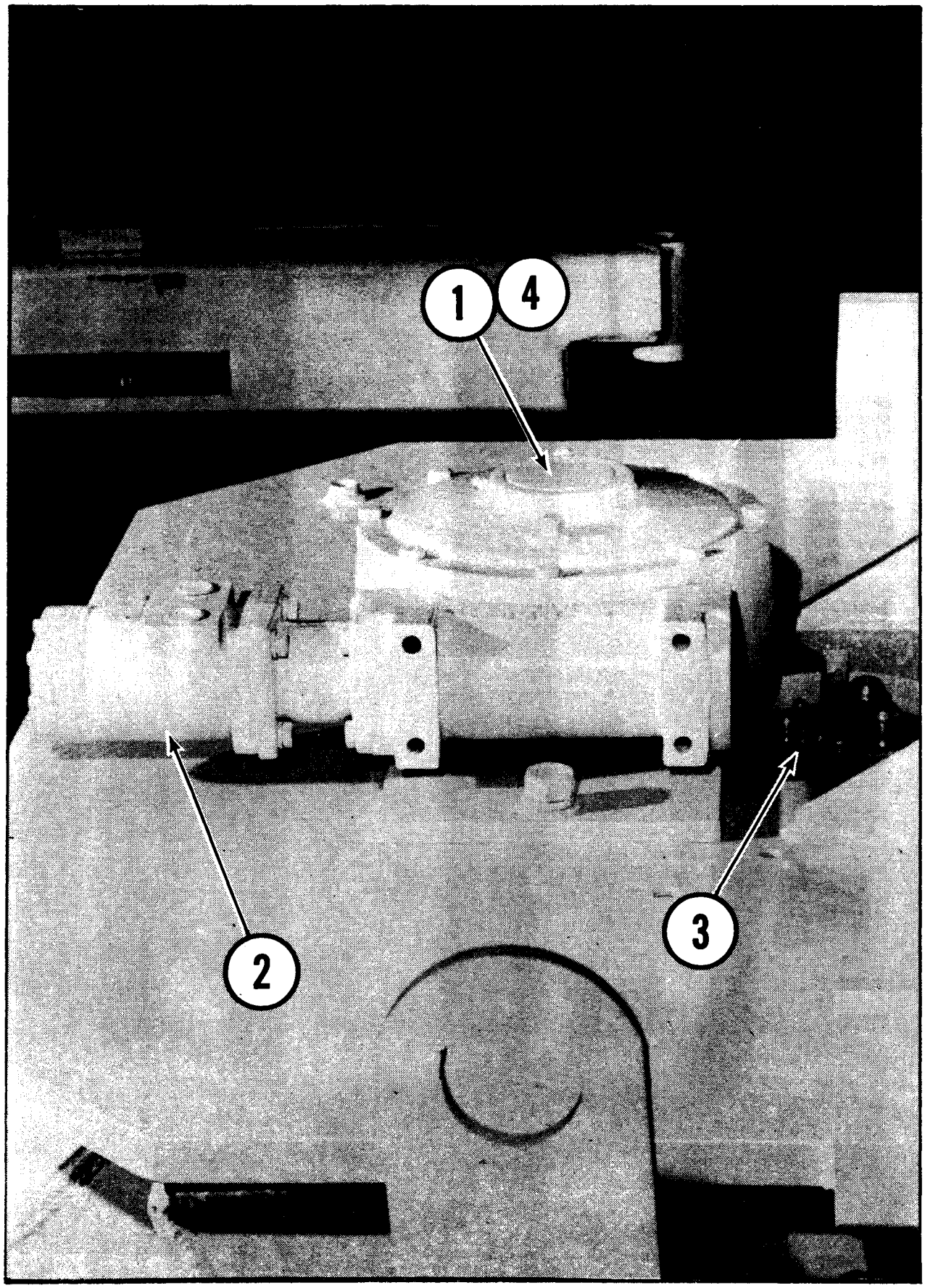
MODEL 40RT

24.	11L-15SL, 6 ply (mono-filled)	Steering Tire "Maxi-Trac"	
25.	20713	Tire & Rim	2
26.	29 x 12:00-15 6 ply (mono-filled)	Drive Tire "Super Tera Grip"	
27.	20711	Tire & Rim	2


MARKLIFT®
A PRODUCT OF MARK INDUSTRIES
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GEAR BOX & MANIFOLD

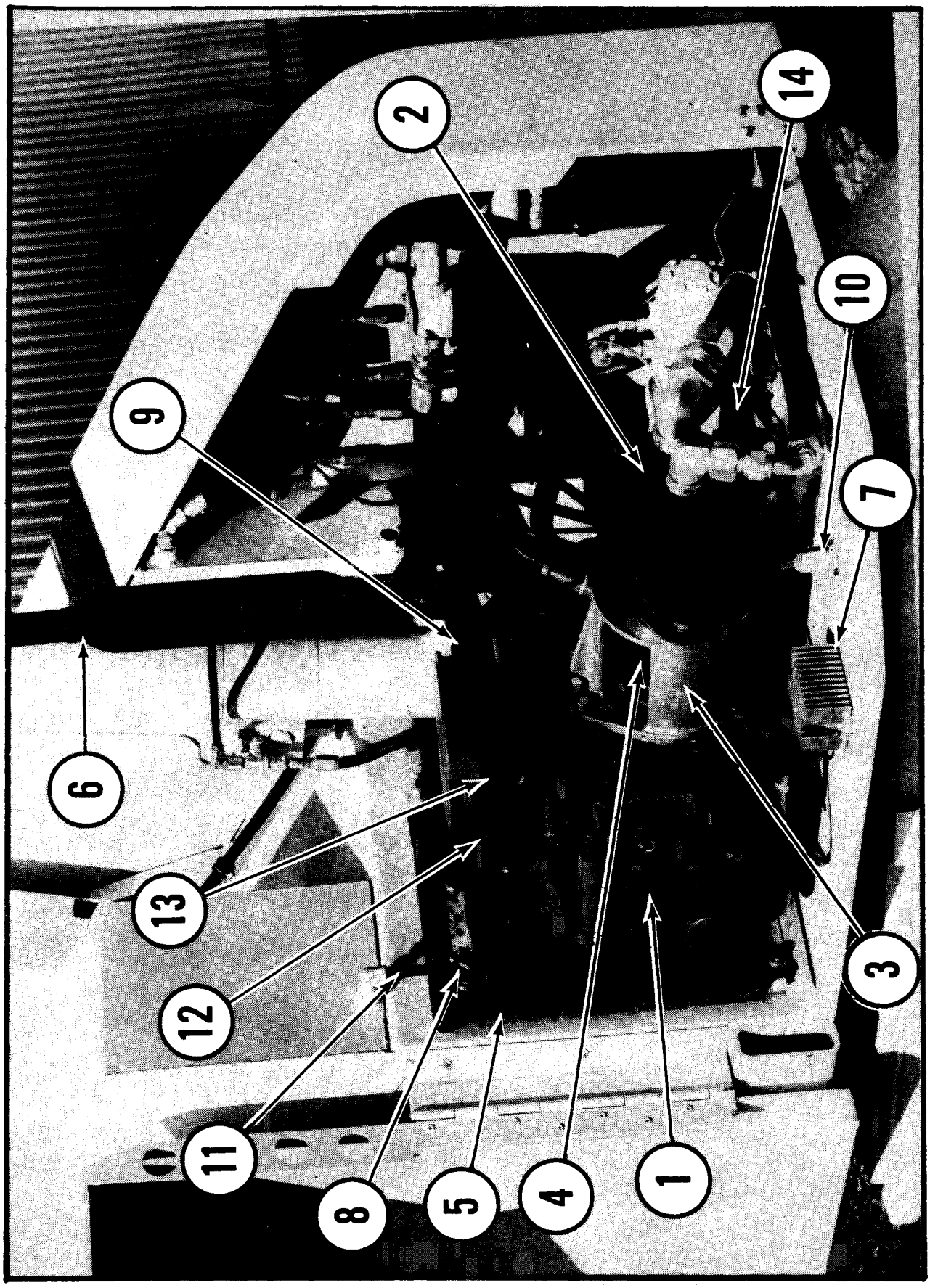
FIGURE 12



ITEM	PART NUMBER	DESCRIPTION
1.	20362	Gear Box
2.	20488	Hydraulic Motor
3.	20339	Manifold (Model 30L & 30H)
3A	20301	Manifold (Model 21S & 21RT)
4.	20249	Pinion
5.	16838	Output Shaft
6.	16159	Cover Gasket
7.	66160	Output Seal
8.	66175	Cover
9.	66440	Bearing
10.	66534	Bearing
11.	66535	Bearing
12.	15245	Bearing
13.	66505	Input Cap
14.	66752	Housing

21RT &
21S ENGINE GROUP

FIGURE 13



ITEM	DESCRIPTION	PAGE
1.	Diesel Engine (40RT)	50.1
2.	Drive Details	50.1
3.	Cover Assembly	Part N^{O}. 20775
4.	Cover Assembly	Part N^{O}. 20827
5.	Boom Assembly	73
6.	Raising Cylinder	59
7.	Hydraulic System	54.1
8.	Gear Box Assembly	54.1
9.	Tires & Rims	43
10.	Basket	Part N^{O}. 20538
11.	Controls	77 & 79

ITEM	PART NUMBER	DESCRIPTION
1.	20506	Engine (20 H.P.)
2.	20361	Pump
3.	20328	Pump Adaptor
4.	20198	Coupling
5.	20385	Oil Cooler
6.	20300	Muffler
7.		Voltage Regulator
8.		Fuel Filter
9.	20478	Automatic Choke
10.	Reference	Crankcase Drain
11.		Fuel Cut-Off Valve
12.	20364	Throttle Actuator
13.	20424	Exhaust Manifold
14.	Reference	Pump Compensator

30L & 30H ENGINE GROUP

FIGURE 14

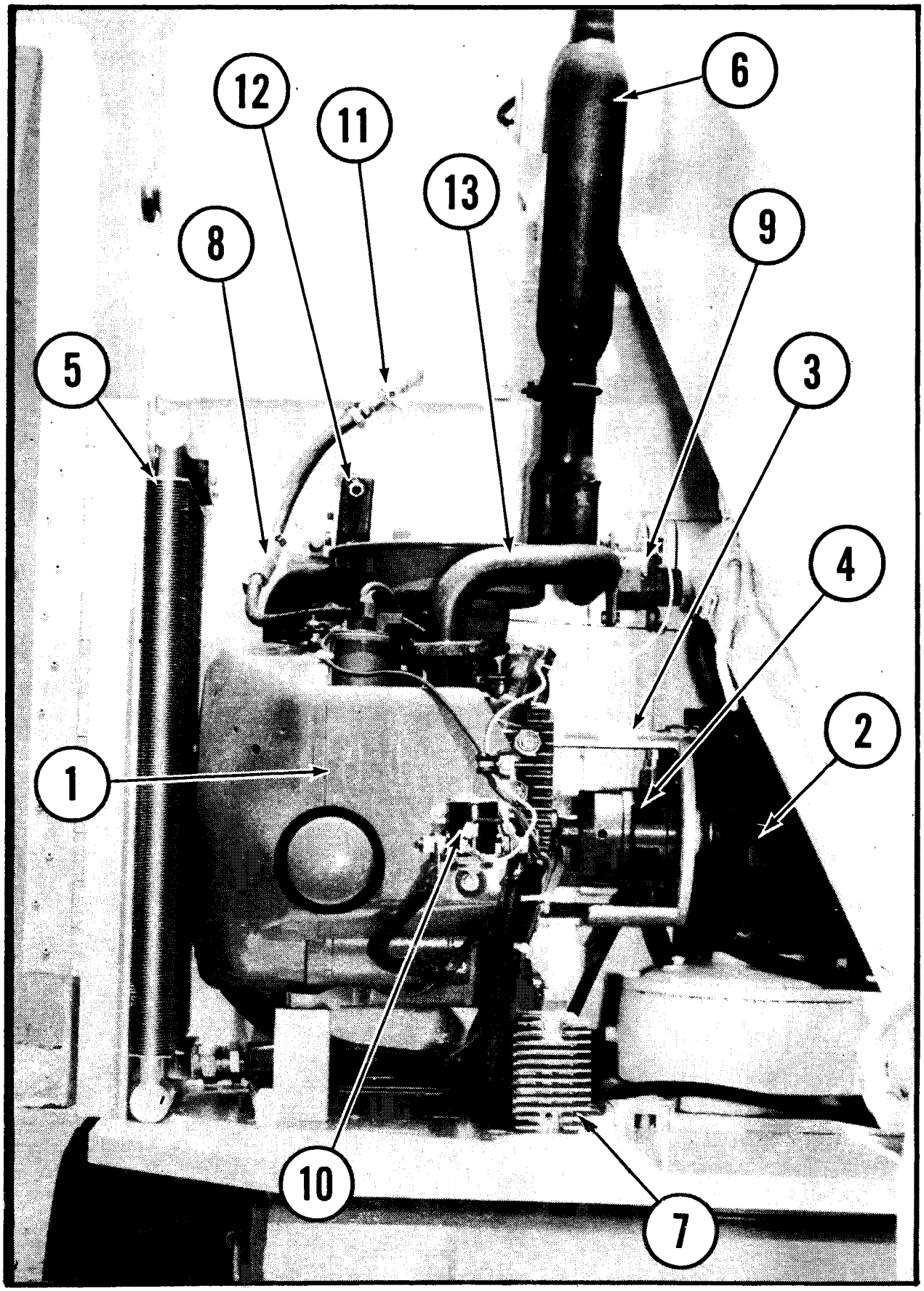
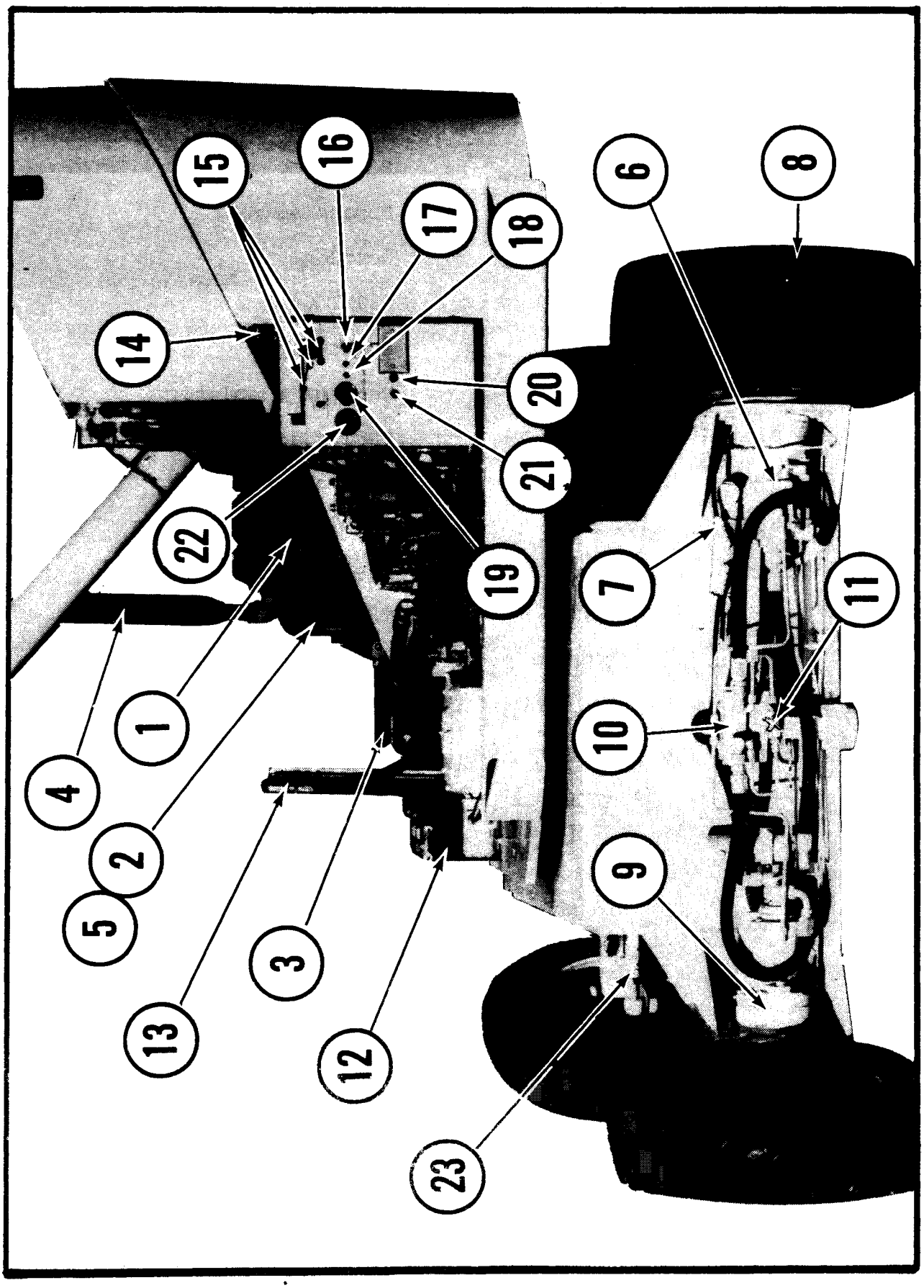


FIGURE 14	30L AND 30H ENGINE GROUP	50

ITEM	PART NUMBER	DESCRIPTION
1.	20506	Engine (20 H.P.)
2.	20361	Pump
3.	20328	Pump Adaptor
4.	20198	Coupling (See Item 14, 15, 16)
5.	20377	Oil Cooler
6.	20300	Muffler
7.	20585	Voltage Regulator
8.	160	Fuel Filter
9.	66411	Automatic Choke
10.	20587	Starter Relay
11.	12000	Fuel Cut-Off Valve
12.	20364	Throttle Actuator
13.	20487	Exhaust Manifold
14.	20927	Half Jaw Coupling Engine
15.	20930	Cushion Block
16.	20925	Half Jaw Coupling Pump

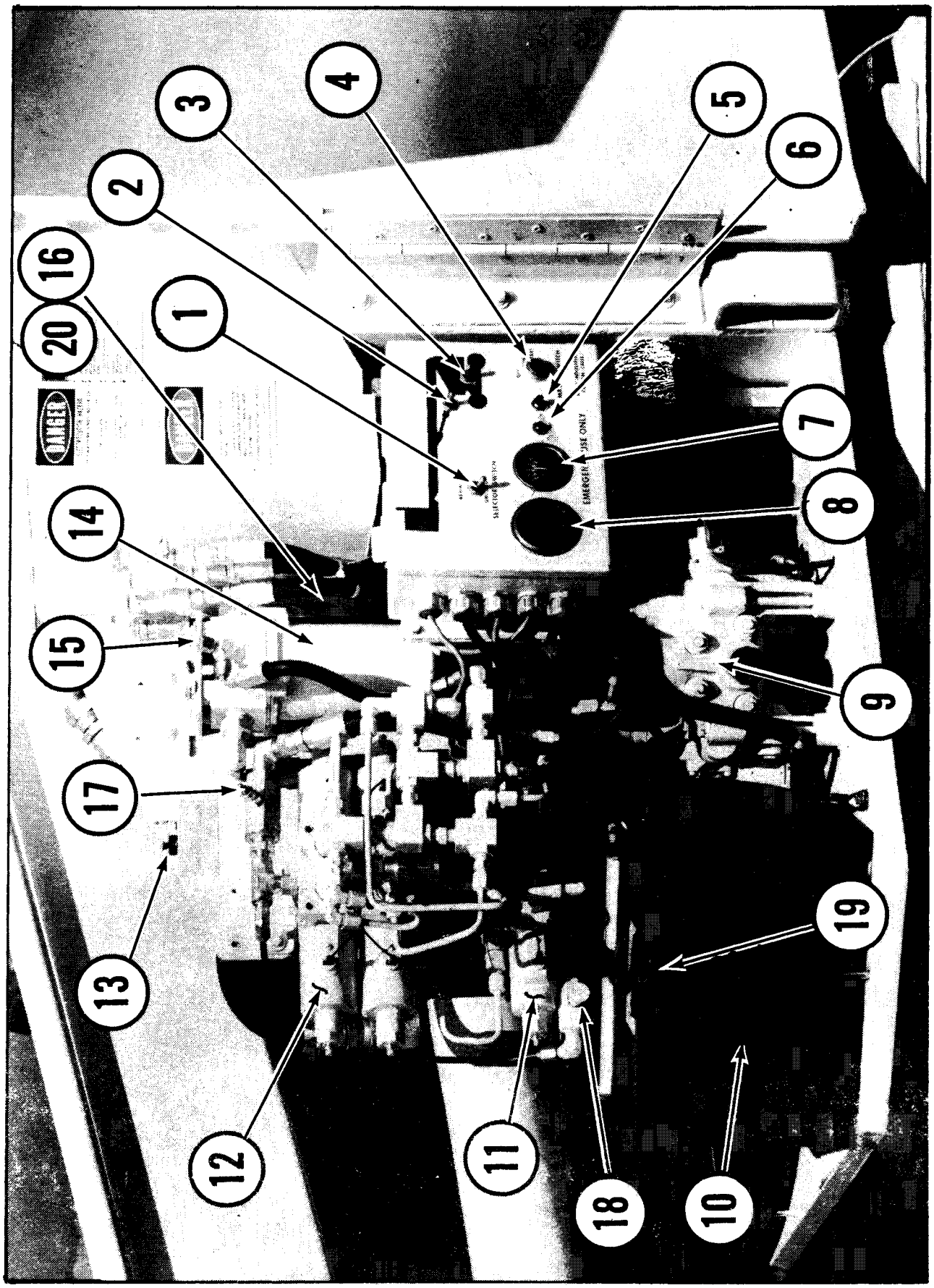
50.1	40 RT DIESEL	FIGURE 14.1



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1.	20790	30 H.P. Engine	1
2.		Pump Adaptor	1
3.	20801	Pump	1
4.	20743	Muffler	1
5.		Coupling	1
6.	20381	Motor (Model 40)	2
	20800	Motor (Model 40RT)	2
7.	20719	Shifting Cylinder	1
8.	20507	Drive Hub (Model 40)	2
	20524	Drive Hub (Model 40RT)	2
9.	20354	Brake	2
10.	20359	Flow Divider	1
11.	20436	Positraction Valve	1
12.	12V, 75Amp-HR	Battery	1
13.	20377	Oil Cooler	1
14.	20376	Emergency Descent Valve	1
15.	20481	Raise,Extend,Swing & Select	4
16.	405	Ignition	1
17.	20480	Circuit Breaker	1
18.	4011	Stop Switch	1
19.	20572	Ammeter	1
20.	4031	Red Light	1
21.	20563	Yellow Light	1
22.	20571	Hour Meter	1
23.	20728	Steering Cylinder	1

21RT & 21S VALVE PLATE ASSEMBLY

FIGURE 15



ITEM	PART NUMBER	DESCRIPTION
1.	2 TL1-7	Selector Switch
2.	2 TL1-7	Boom Raising Switch
3.	2 TL1-7	Boom Swing Switch
4.	405	Ignition Switch
5.	20480	Circuit Breaker
6.	4011	Stop Switch
7.	82200	Ammeter
8.	15002-3	Hour Meter
9.	20395	Proportional Valve (Drive Motors)
10.	12V, 75 AMP - HR	Battery
11.	20371	Solenoid Valve (Steering)
12.	20372	Solenoid Valve (Swing & Raise)
13.	20376	Emergency Descent Valve
14.	20368	Filter
15.	7/16-20	Pilot Pressure Check
16.	20366	Flow Control
17.	20358	Needle Valve
18.	20357	Needle Valve
19.	20375	Battery Clamp
20.	7/16-20 Thread	Pump Pressure Check

*See Page 55 For Back Of Valve Plate
*See Page101, Hydraulic Schematic
*See Page105, Electric Schematic

30RT,
30L & 30H VALVE PLATE

FIGURE 16

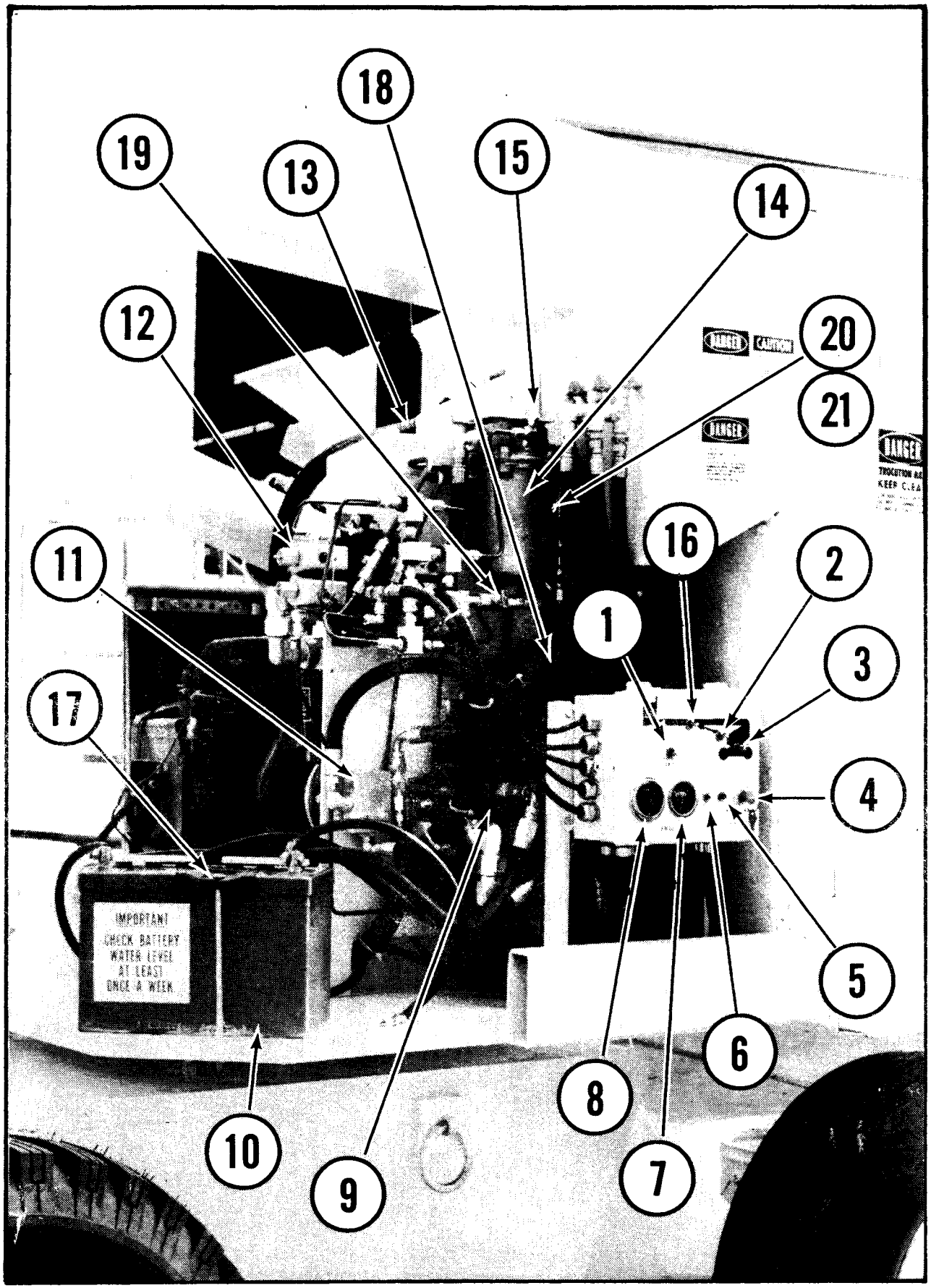


FIGURE 16	30RT, 30L & 30H VALVE PLATE	54

ITEM	PART NUMBER	DESCRIPTION
1.	20482	Selector Switch
2.	20481	Boom Raising Switch
3.	20481	Boom Swing Switch
4.	405	Ignition Switch
5.	20480	Circuit Breaker
6.	4011	Stop Switch
7.	20572	Ammeter
8.	20571	Hour Meter
9.	20394	Proportional Valve
10.	12V, 75 AMP - HR	Battery,
11.	20365	Holding Valve
12.	20372	Solenoid Valve
13.	20376	Emergency Descent Valve
14.	20368	Filter
15.	7/16-20	Pilot Pressure Check
16.	20481	Boom Extend Switch
17.	20375	Battery Clamp
18.	20357	Needle Valve
19.	20357	Needle Valve
20.	7/16-20 Thread	Pump Pressure Check
21.	20366	Flow Control Valve

*See Page 55 For Back of Valve Plate
*See Page 103 For Hydraulic Schematic
*See Page 105 For Electric Schematic

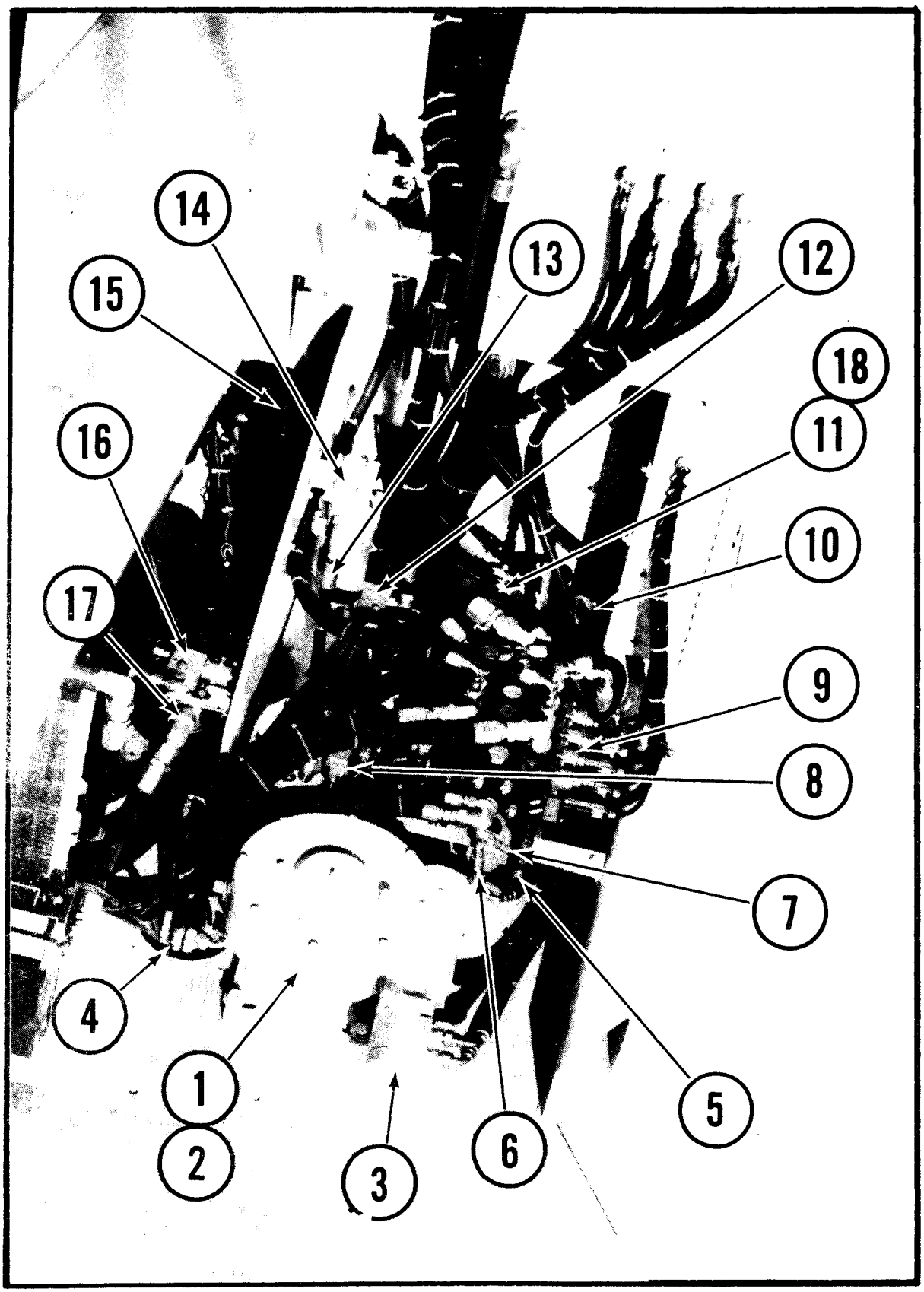

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5

FIGURE 16.1	40RT HYDRAULICS	54.2

ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1.	20519	Gear Box (Durst)	1
	20726	Gear Box (Braden)	1
2.	20739	Pinion (Durst)	1
	20725	Pinion (Braden)	1
3.	20517	Motor (Durst)	1
	20520	Motor (Braden)	1
4.	20339	Rotary Union	1
5.	7/16-20thread	Low Pressure Check	1
6.	20357	Needle Valve	1
7.	7/16-20Thread	High Pressure Check	1
8.	20372	Solenoid Valve	1
9.	20394	Proportional Valve	1
10.	20767	2 Speed Valve	1
11.	20391	Pilot Check Valve	1
12.	20516	Relief Valve	1
13.	20366	Flow Control	1
14.	20368	Filter (20472 element)	1
15.	20384	Emergency pump	1
16.	20378	Unloading Valve	1
17.	20367	Filter (20477 element)	1
18.	20365	Holding Valve	1

55	VALVE PLATE BACK	FIGURE 17

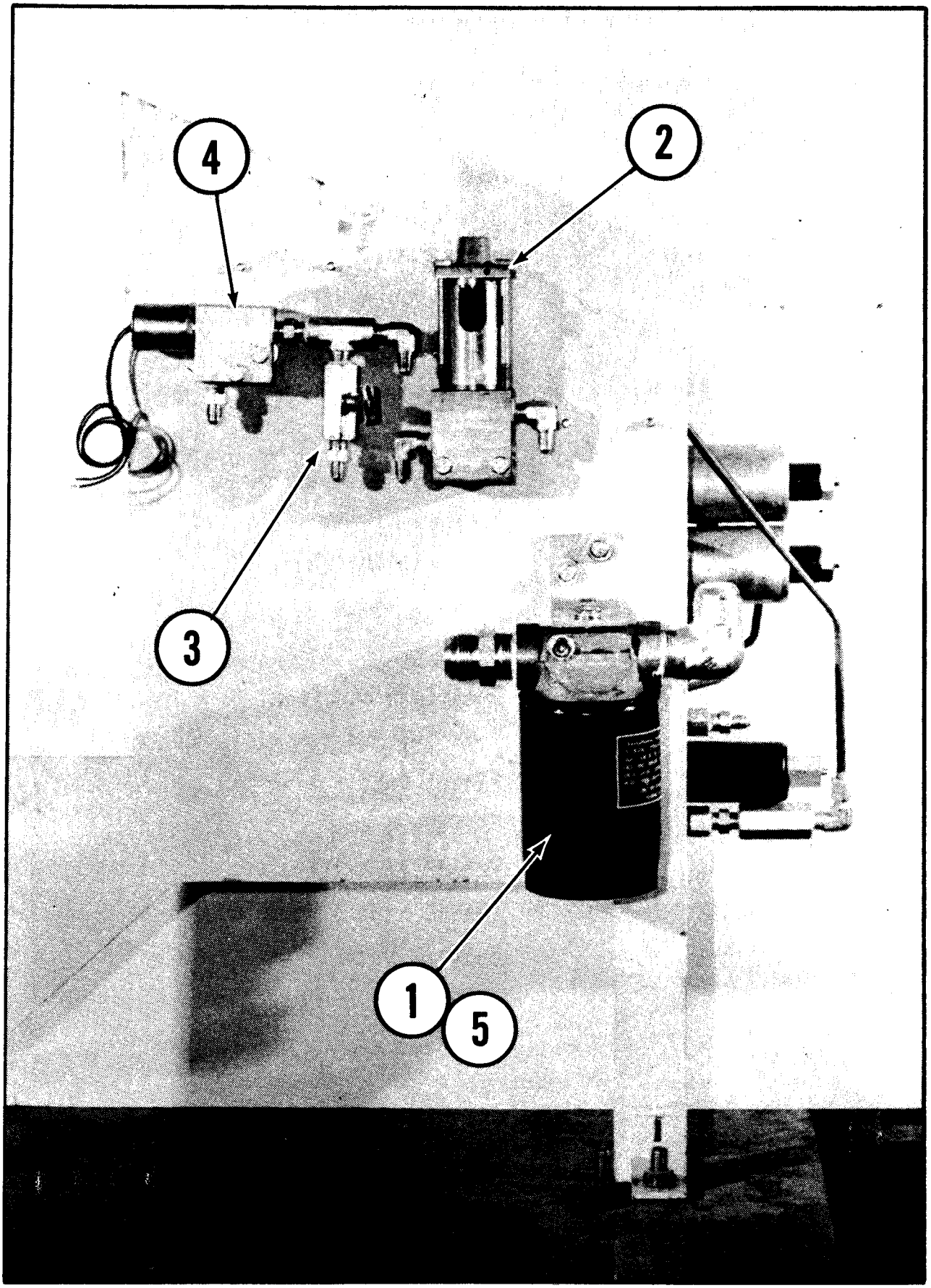
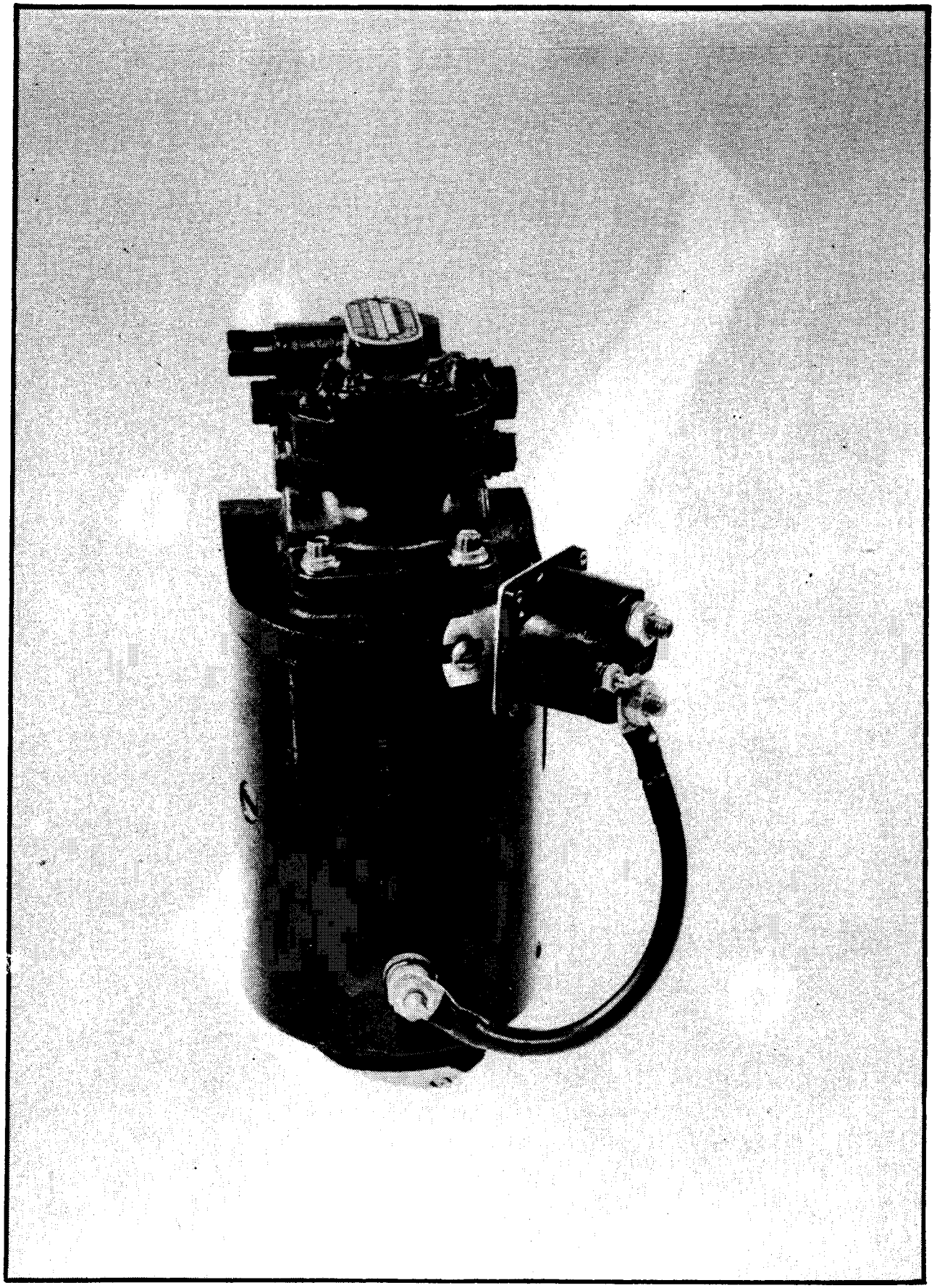


FIGURE 17

VALVE PLATE BACK

ITEM	PART NUMBER	DESCRIPTION
1.	20367	Filter
2.	20376	Emergency Descent
3.	20357	Needle Valve
4.	20378	Valve
5.	20477	Element

FIGURE 18	20384 EMERGENCY DESCENT MOTOR & PUMP	58



BOOM LIFT CYLINDER

FIGURE 19

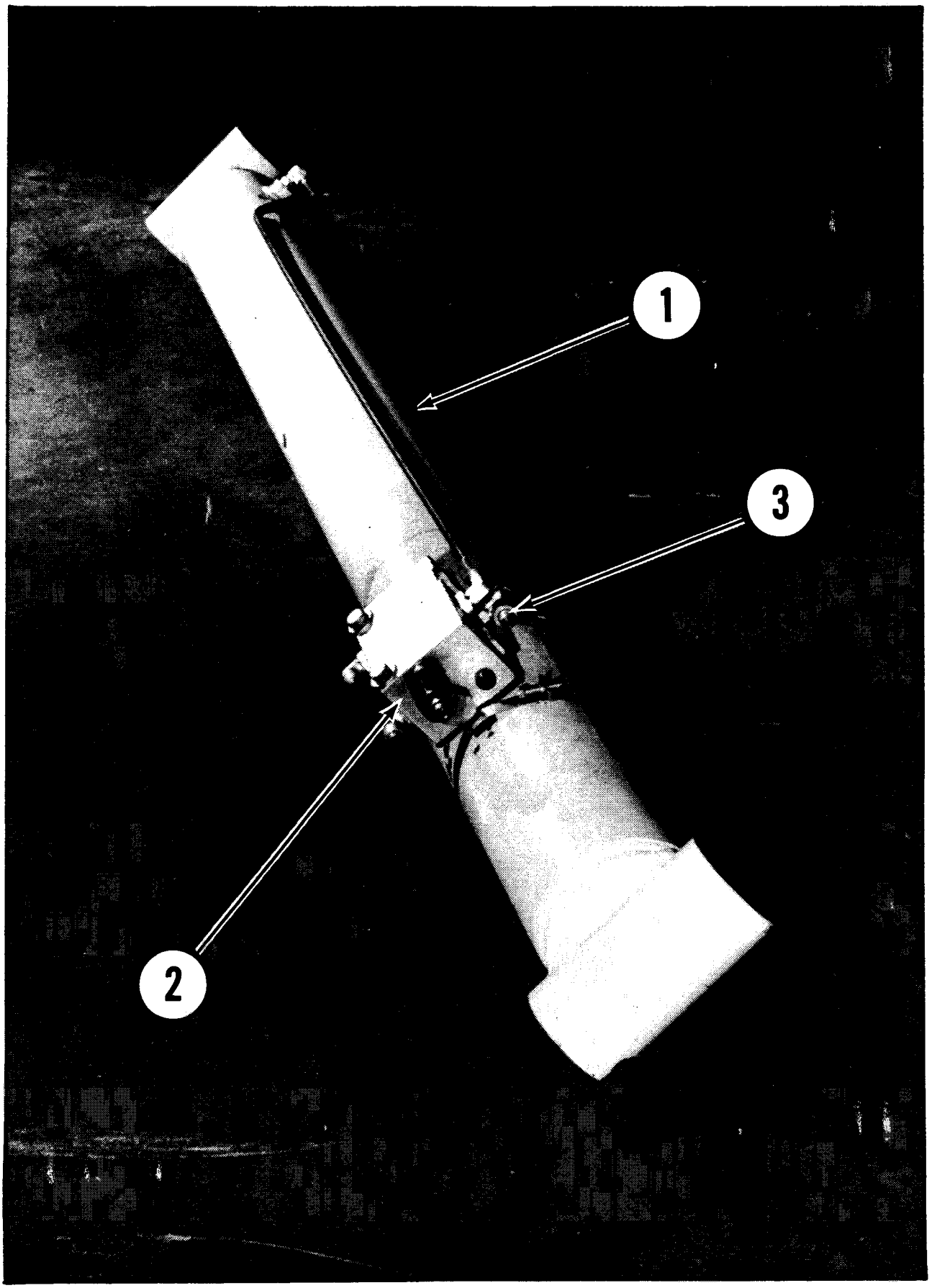


FIGURE 19	BOOM LIFT CYLINDER	60

ITEM	PART NUMBER	DESCRIPTION
1.	20205	Cylinder
2.	20365	Load Holding Valve
3.	20348	Bleed Down Orifice

*SEE PAGE 66 FOR CYLINDER SEAL KIT

20303 HYDRAULIC BASKET
LEVELING CYLINDER (MASTER)

FIGURE 20

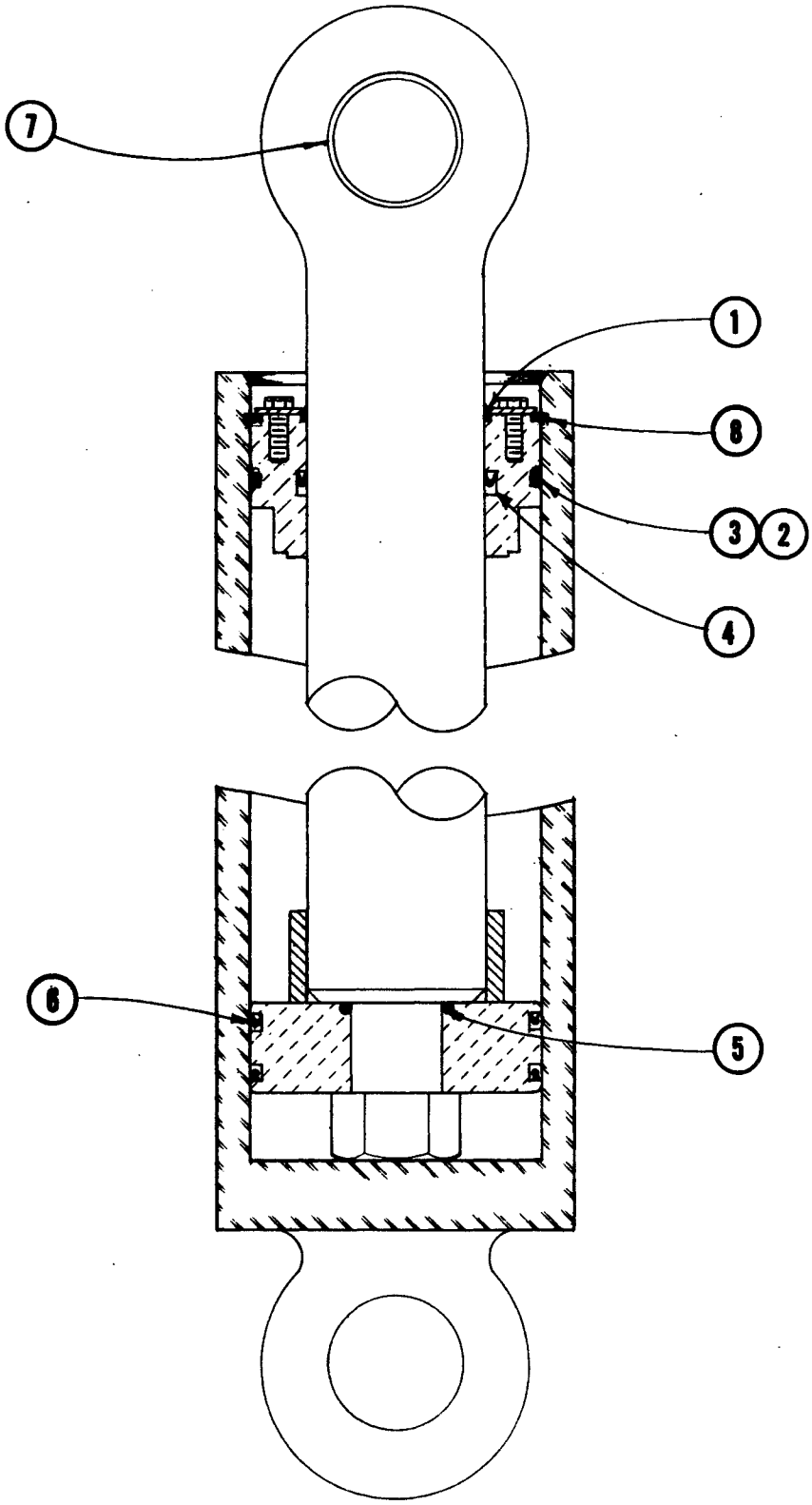
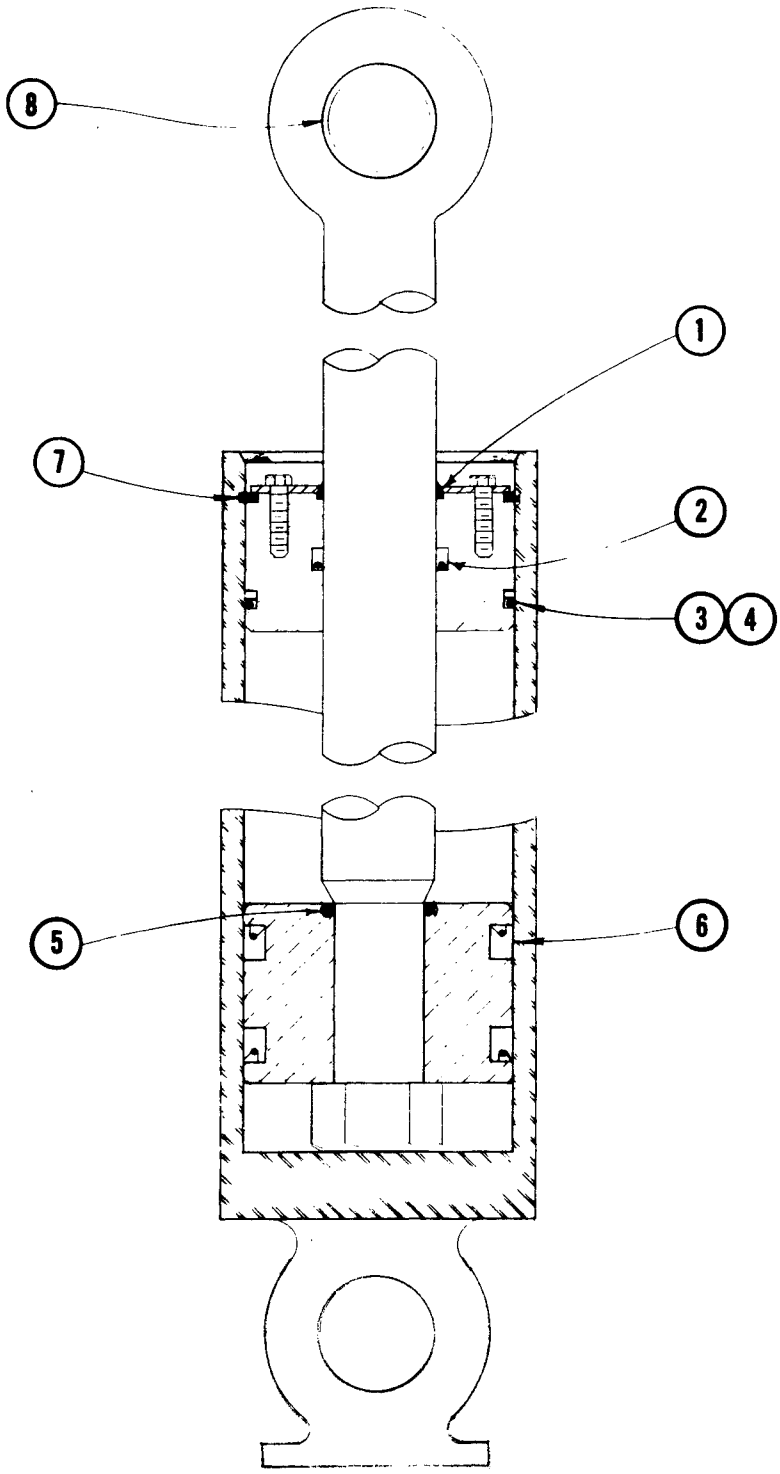


FIGURE 20	20303 HYDRAULIC BASKET LEVELING CYLINDER (MASTER)	62

ITEM		DESCRIPTION	QUANTITY
1.		Rod Wiper	1
2.		Rod Seal	1
3.		"O" Ring	1
4.		Back Up Ring	1
5.		"O" Ring	1
6.		Piston Seal	2
7.		Snap Ring	1
8.		Bushing	2
9.	66476	Rod Assy	1

Items 1 thru 6 available as Seal Kit number 20128

63	20204 HYDRAULIC BASKET LEVELING CYLINDER (SLAVE)	FIGURE 21



ITEM		DESCRIPTION	QUANTITY
1.		Rod Wiper	1
2.		Rod Seal	1
3.		"O" Ring	1
4.		Back Up Ring	1
5.		"O" Ring	1
6.		Piston Seal	2
7.		Snap Ring	1
8.	66465	Bushing	2
9.	66789	Rod Assy	1

Items 1 thru 6 available as Seal Kit number 20128

20205 HYDRAULIC RAISING CYLINDER

FIGURE 22

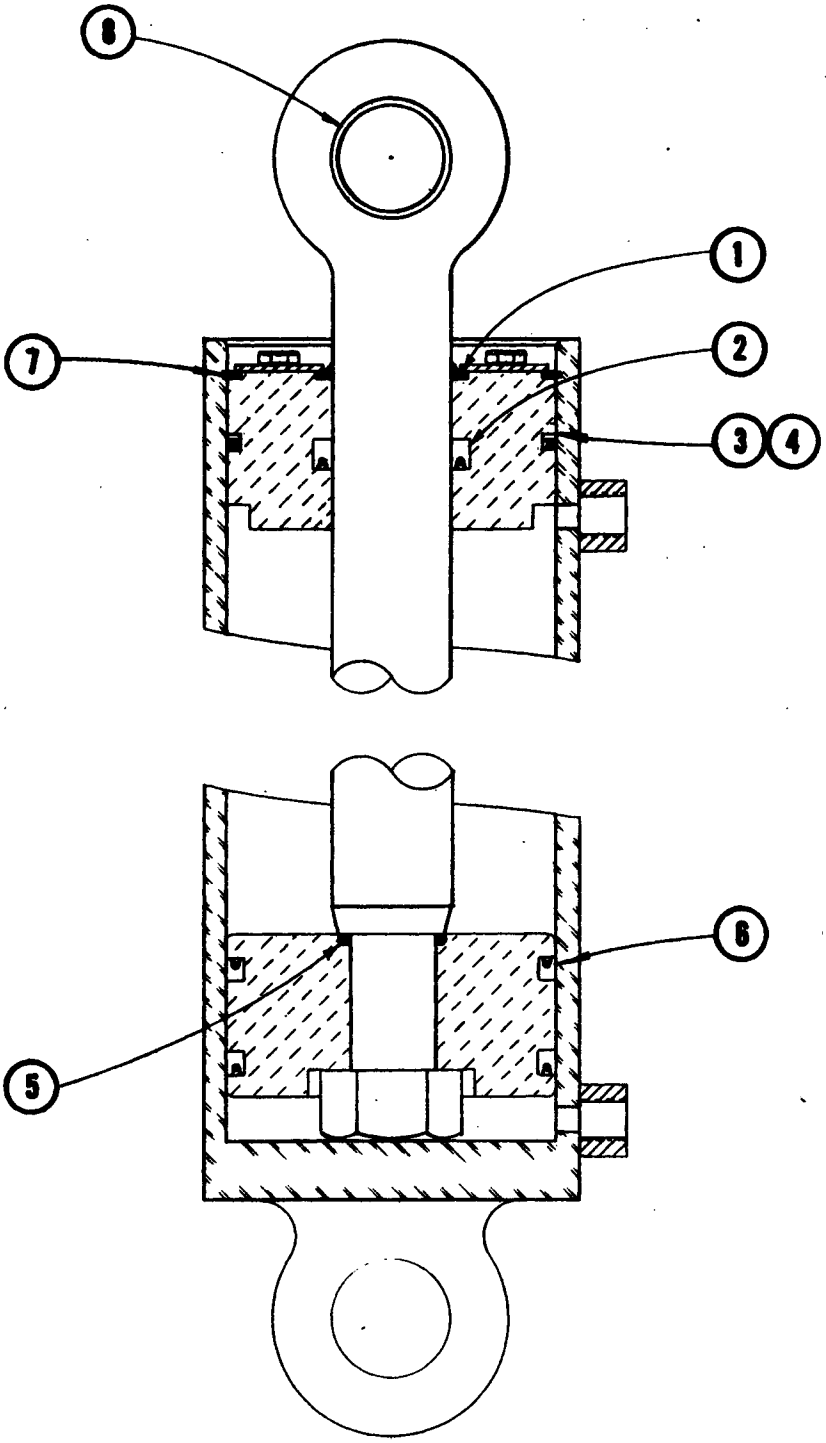


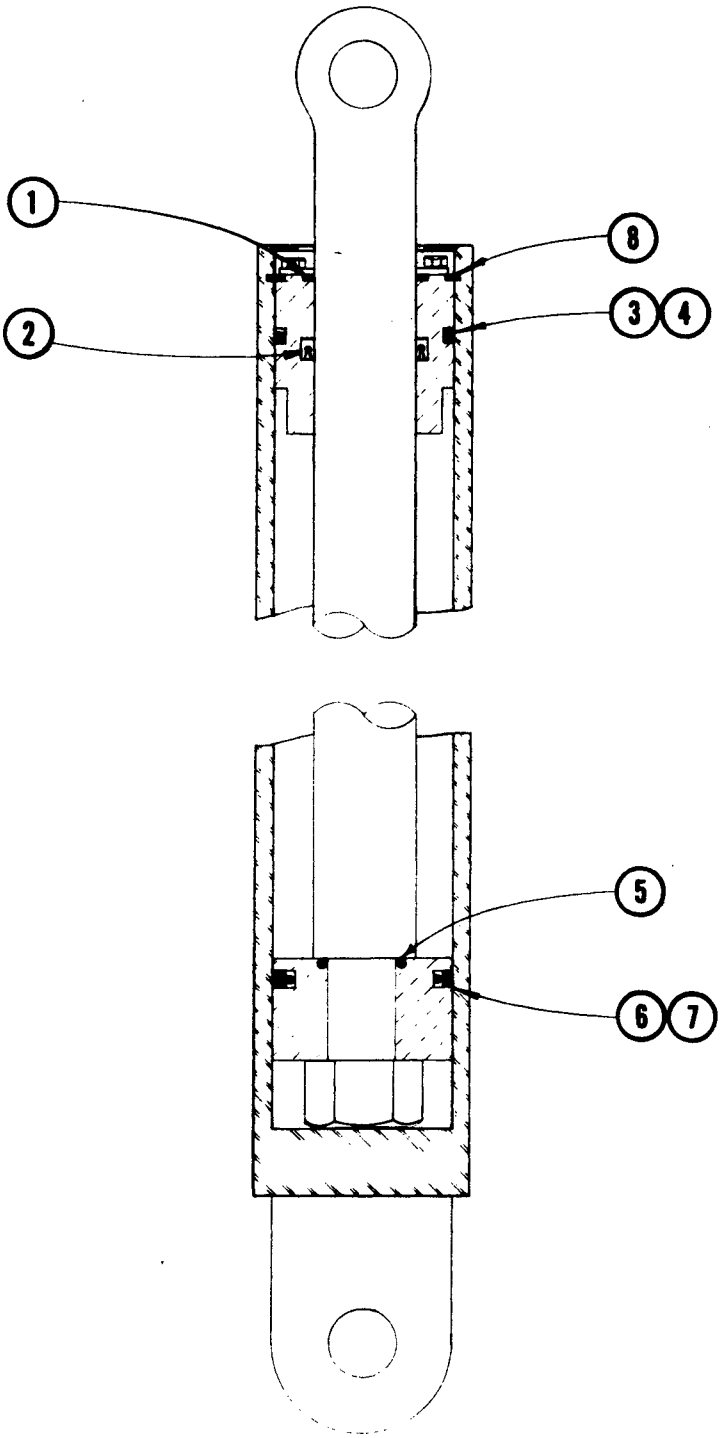
FIGURE 22	20205 HYDRAULIC LIFT CYLINDER	66

ITEM		DESCRIPTION	QUANTITY
1.		Rod Wiper	1
2.		"O"-Ring	1
3.		Back up Ring	1
4.		Rod Seal	1
5.		"O"-Ring	1
6.		Seal	2
7.		Snap Ring	1
8.		Bushing	2
9.	66467	Rod Assy	1
10.	66474	Head	1

Items 1 thru 6 available as Seal Kit number 20126

20206 STEERING CYLINDER
20728 STEERING CYLINDER

FIGURE 23



ITEM		DESCRIPTION		QUANTITY
1.		Rod Wiper		1
2.		Rod Seal		1
3.		"O"-Ring		1
4.		Back Up Ring		1
5.		"O"-Ring		1
6.		Piston Seal		1
7.		Back Up		1
8.		Snap Ring		1
9.	66464	Rod Assy	(20728)	1
10.	66541	Head	(20728)	1
11.	16279	Bushing	(20728)	4

MODELS 21 RT, 21S, 30H, 30L & 30RT

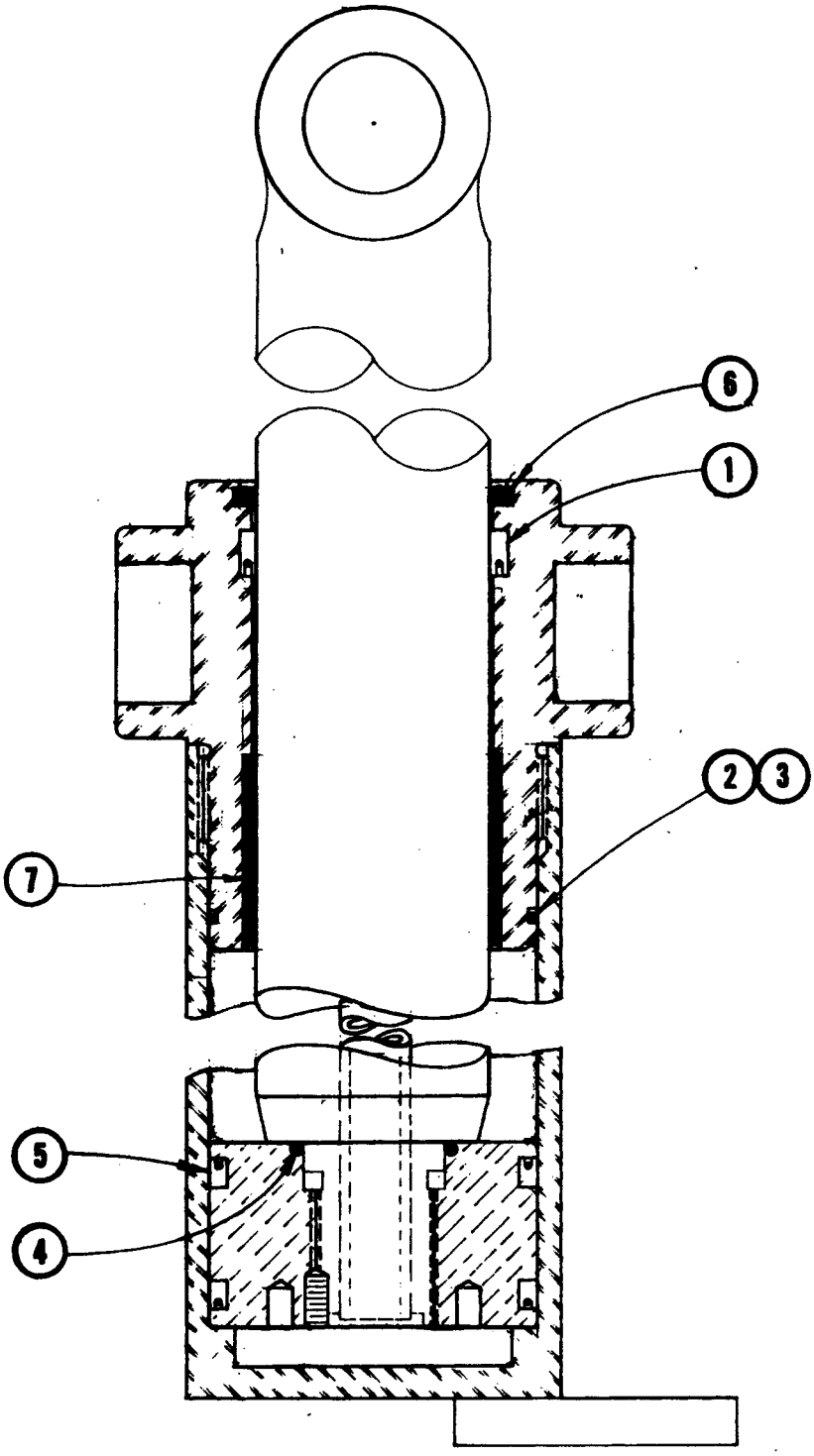
Items 1 thru 6 available as Seal Kit number 20125

MODELS 40 & 40RT

Items 1 thru 6 available as Seal Kit number 20588

20207, 20404 & 20727
EXTENDING CYLINDER

FIGURE 24

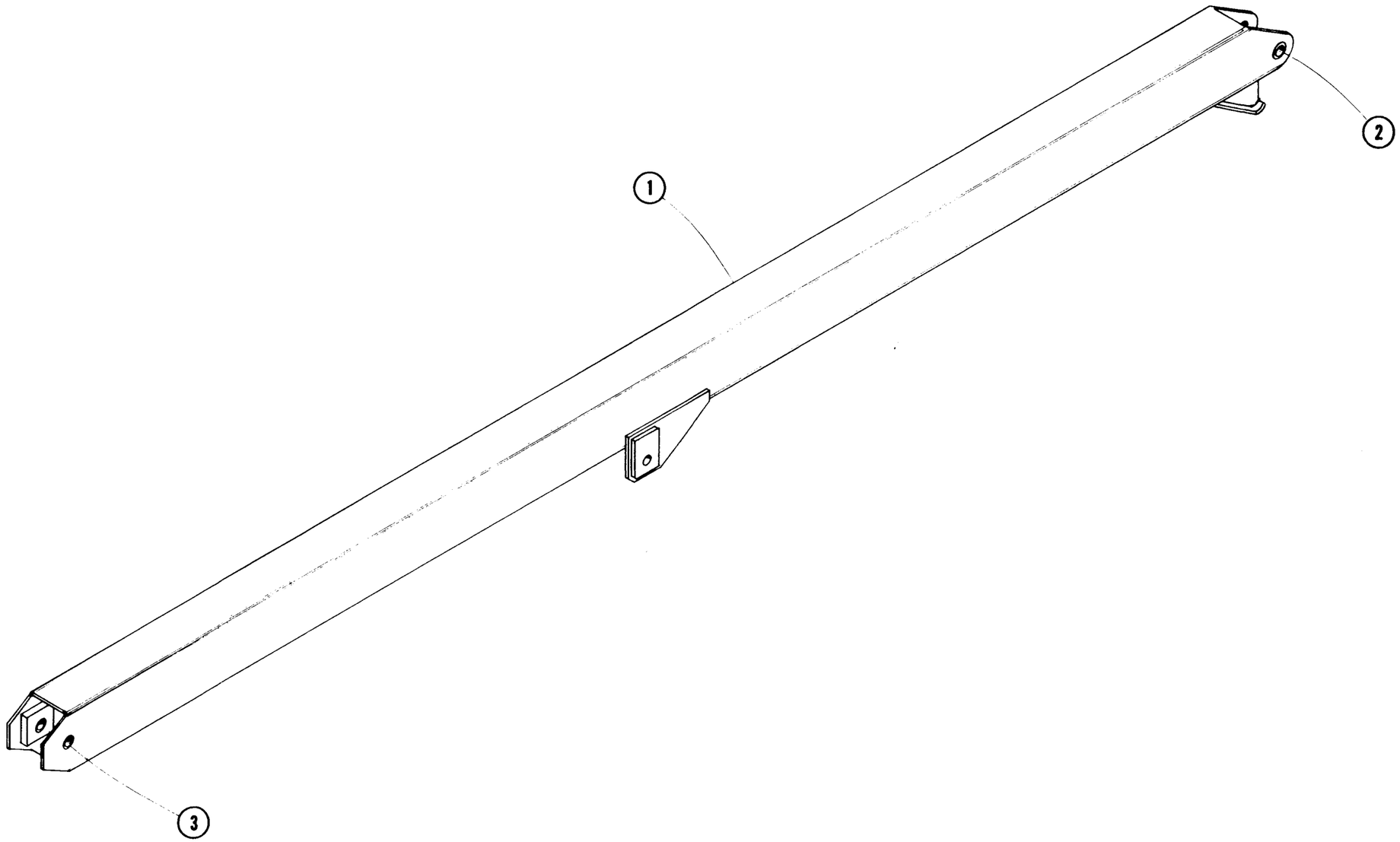


ITEM		DESCRIPTION		QUANTITY
1.		Rod Seal		1
2.		"O"-Ring		1
3.		Back Up Ring		1
4.		"O"-Ring		1
5.		Seal		2
6.		Rod Wiper		1
7.		Rod Bearing		1
8.	66459	Head	(20207)	1
9.	66460	Rod	(20207)	1
10.	66461	3 1/2" Piston	(20727)	1
11.	66475	Piston	(20707)	1
12.	66549	Rod Assy	(20707)	1
13.	66882	Bushing	(20727 - 24DV16)	2

Items 1 thru 6 available as Seal Kit number 20127

21RT & 21S BOOM ASSEMBLY

FIGURE 25



ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1.	20220	Boom	1
2.	20582	Bushing	2
3.	20574	Bushing	2

30H, 30L, 40 & 40RT
BOOM ASSEMBLY

FIGURE 26

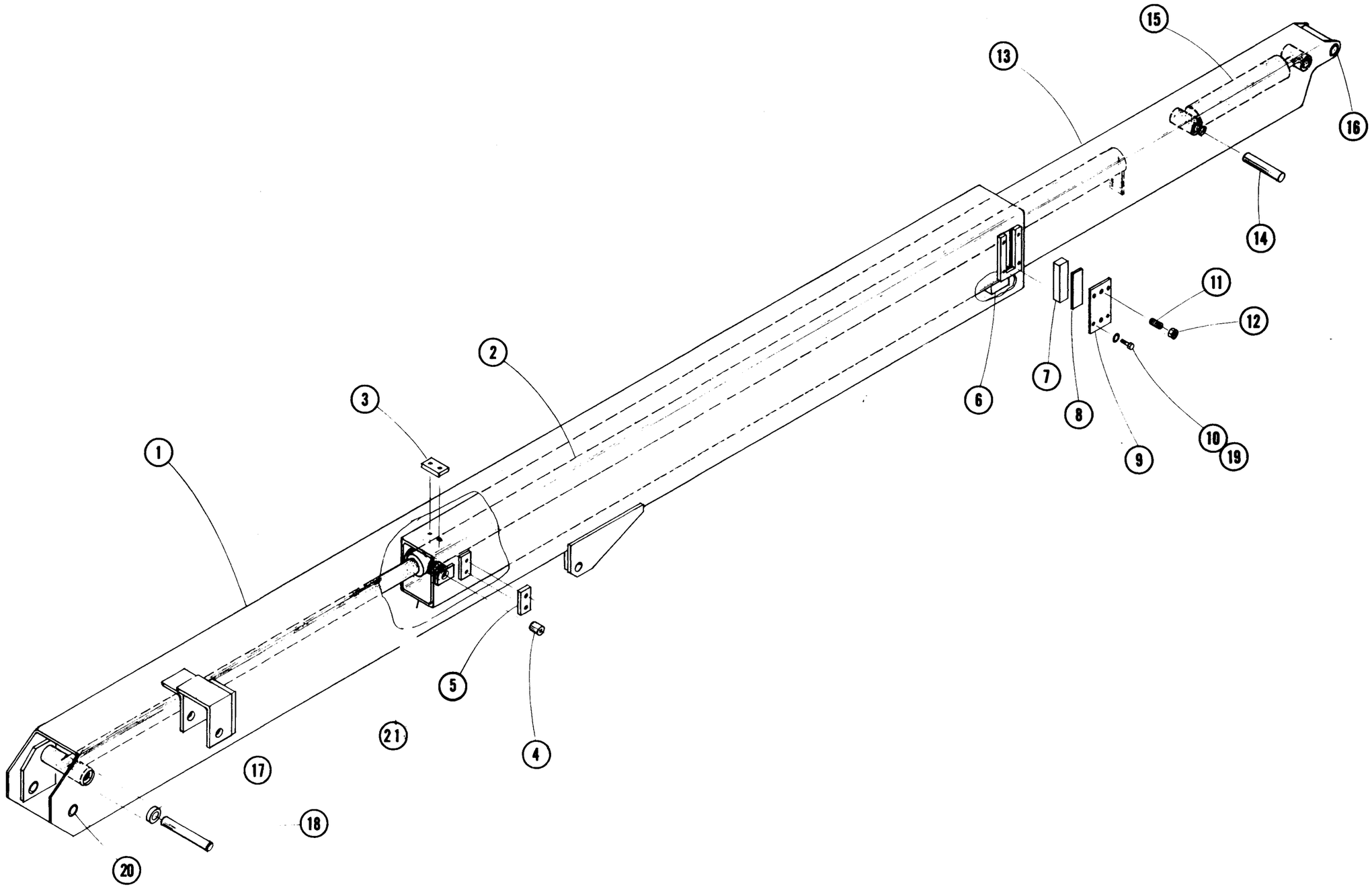
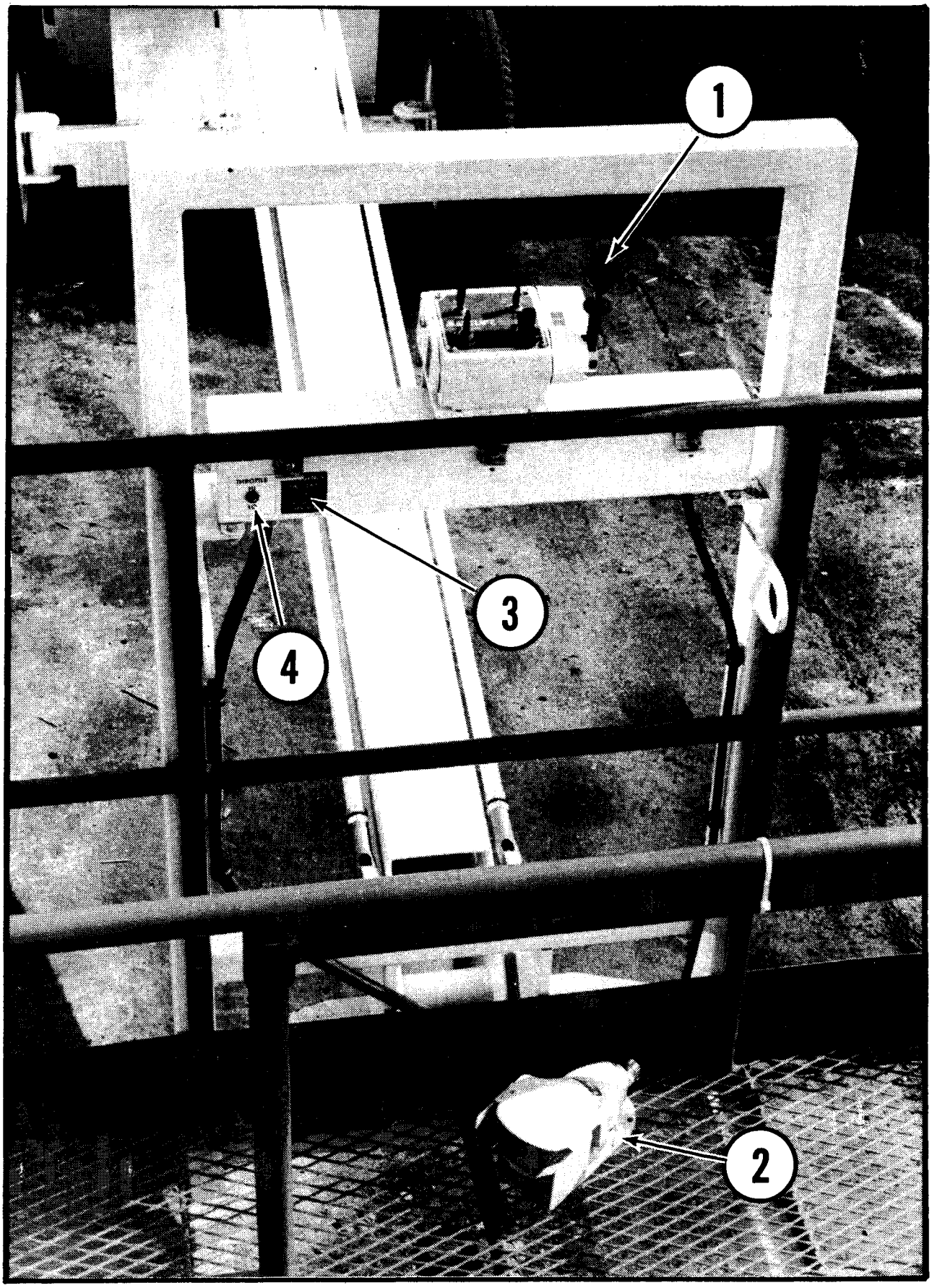


FIGURE 26	30H, 30L, 40 & 40RT BOOM ASSEMBLY	74

ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1.	20432	Outer Boom (30L)	1
	20219	Outer Boom (30H)	1
	20733	Outer Boom (40 & 40RT)	1
2.	20404	Extending Cylinder (page 69, 30L)	1
	20207	Extending Cylinder (page 69, 30H)	1
	20728	Extending Cylinder (page 69, 40 & 40RT)	1
3.	20280	Wear Pad (top)	1
4.	20266	Trunnion Pin	2
5.	20282	Wear Pad (side)	2
6.	20284	Wear Pad (bottom)	1
7.	20454	Wear Pad (side)	2
8.	20453	Pressure Plate	2
9.	20452	Pressure Plate	2
10.	5/16NCx3/4"LG	HEX Head Cap Screw	8
11.	1/2NCx1" LG	Socket Head Set Screw	4
12.	1/2NC	HEX Nut	4
13.	20218	Inner Boom Assembly (30L)	1
	20181	Inner Boom Assembly (30H)	1
	20734	Inner Boom Assembly (40 & 40RT)	1
14.	20262	Pin	1
15.	20204	Leveling Cylinder(p.64)	1
16.	20582	Bushing	2
17.	20268	Eccentric Bushing	2
18.	20267	Pin	1
19.	5/16"	Lock Washer	8
20.	20583	Bushing	2
21.	20281	Wear Pad (bottom)	1
22.	21784	Boom to Turret	1

21RT & 21S AERIAL CONTROLS

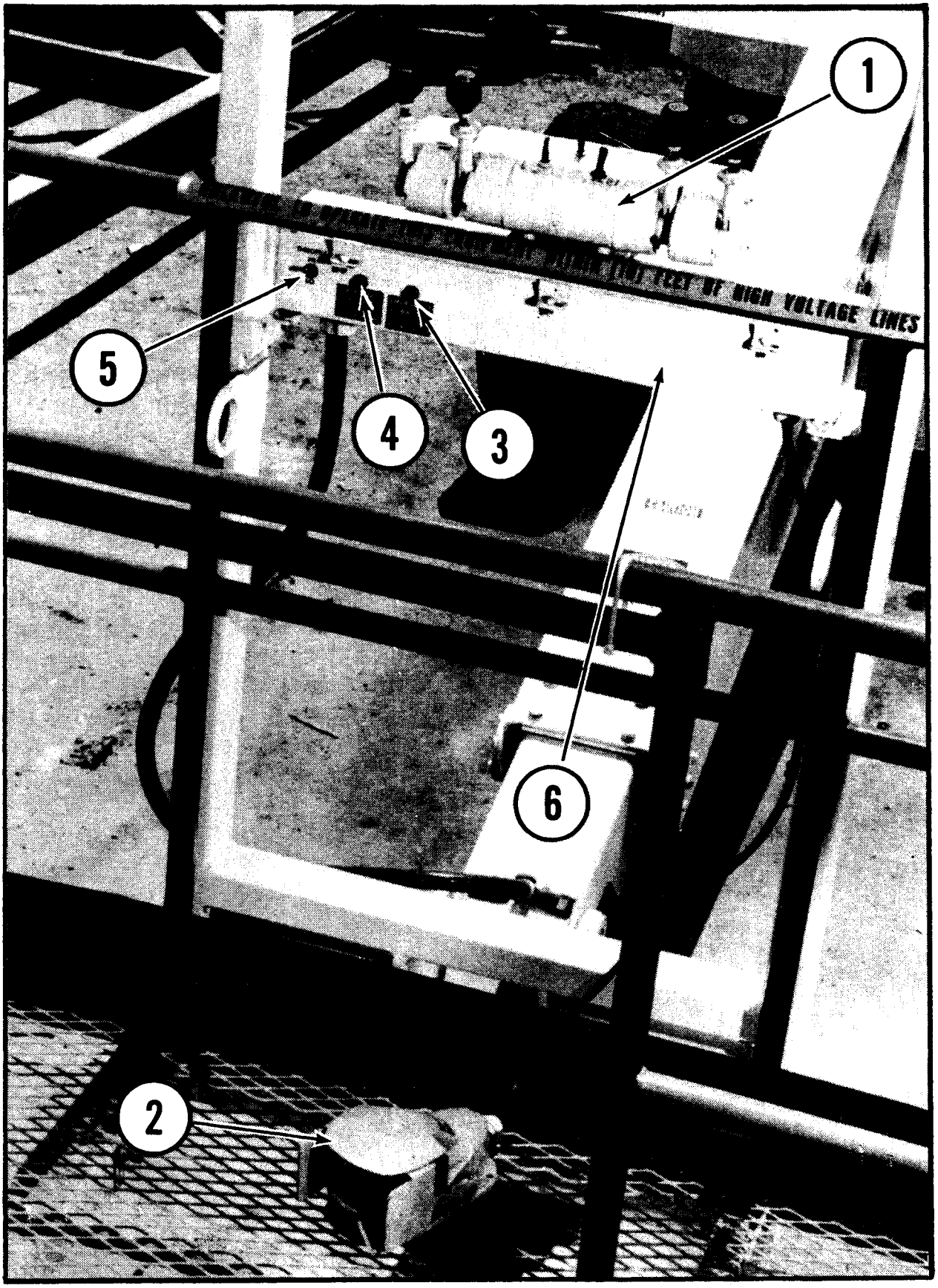
FIGURE 27



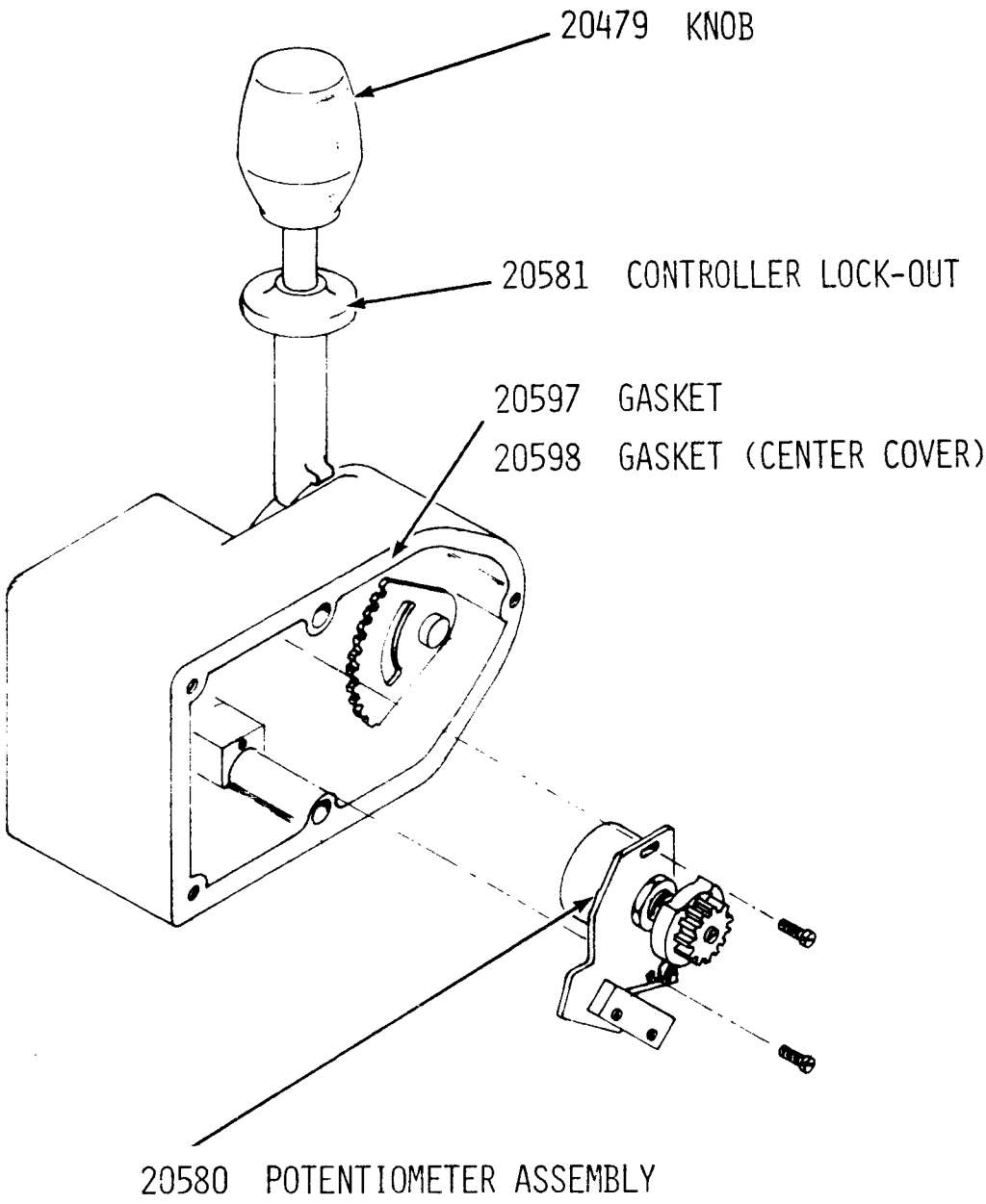
ITEM	PART NUMBER	DESCRIPTION
1.	20380	Control Station
2.	20379	Foot Switch
3.	4011	Emergency Descent
4.	20584	Throttle, Hi-Lo

30H, 30L, 40 & 40RT
AERIAL CONTROLS

FIGURE 28



ITEM	PART NUMBER	DESCRIPTION
1.	20392	Control Station
2.	20379	Foot Switch
3.	4011	Emergency Descent
4.	4011	Emergency Retract
5.	20584	Throttle, Hi-Lo
6.		Aerial Junction Box


20479 KNOB
20581 CONTROLLER LOCK-OUT
20597 GASKET
20598 GASKET (CENTER COVER)
20580 POTENTIOMETER ASSEMBLY

PREVENTIVE MAINTENANCE

This preventive maintenance information is intended as a general guide line which may be expanded by the owners normal maintenance program.

Mark Industries recommends the following items be checked:

WEEKLY

1. Clean unit by removing oil and grease with thinner. Machine may be washed with soap and water.
2. Operation and safety decals in place and legible
3. Tire pressure at 75 P.S.I. (except filled tires)
4. Tire condition (free of serious cuts or defects)
5. Proper engine oil level
6. Proper hydraulic oil level
7. Air cleaner (ONAN Maintenance Instructions)
8. Battery electrolyte level
9. Battery fully charged
10. Fuel level, daily
11. Check and lube, if necessary. See page 33.
12. Engine RPM should be 3000.
13. Proper brake operation
14. Record hour meter reading.

MONTHLY, OR FIRST 50 HOURS

1. Check and lube, if necessary
2. Check condition of battery
3. Change engine oil filter
4. Change hydraulic return oil filter
5. Check ring gear bolt for torque - 175 LBS/FT Turret, 87 LBS/FT Base. Torque values are with lubrication.
6. Check torque-hub oil level (See Page 31)
7. Check air cleaner
8. Check on level, rotation gear box.

SIX MONTHS, OR 100 HOURS

1. Check and lube, if necessary
2. Change control pressure oil filter (Item 14, Page 51 and 53)
3. Change engine oil filter
4. Change hydraulic return oil filter (Item 1, Page 55)

ANNUALLY

1. Repack all wheel bearings
2. Change hydraulic oil
3. Check torque-hub oil level
4. Check ring gear bolts for torque.

TROUBLE SHOOTING GUIDE
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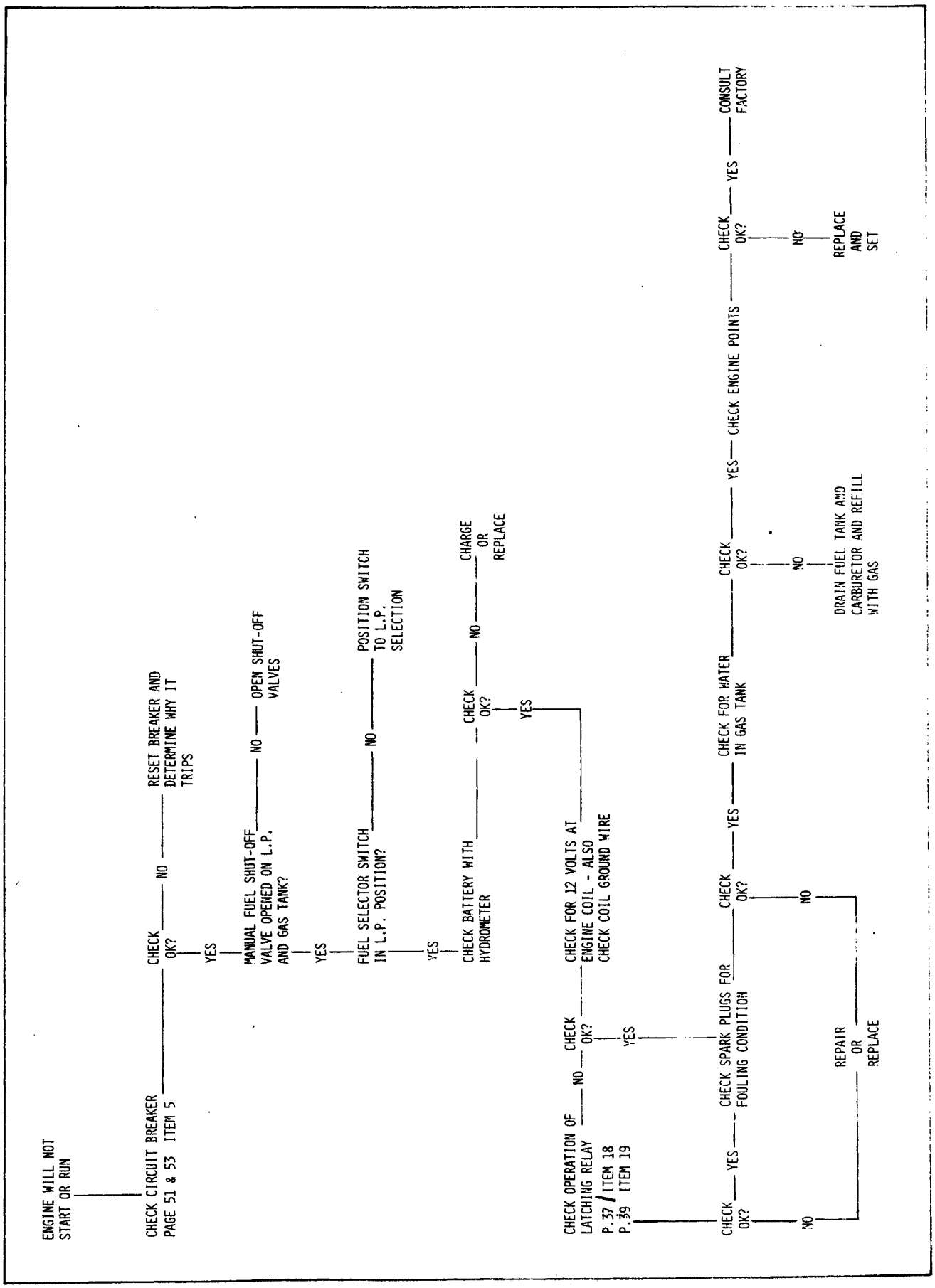
ONAN ENGINE.....115

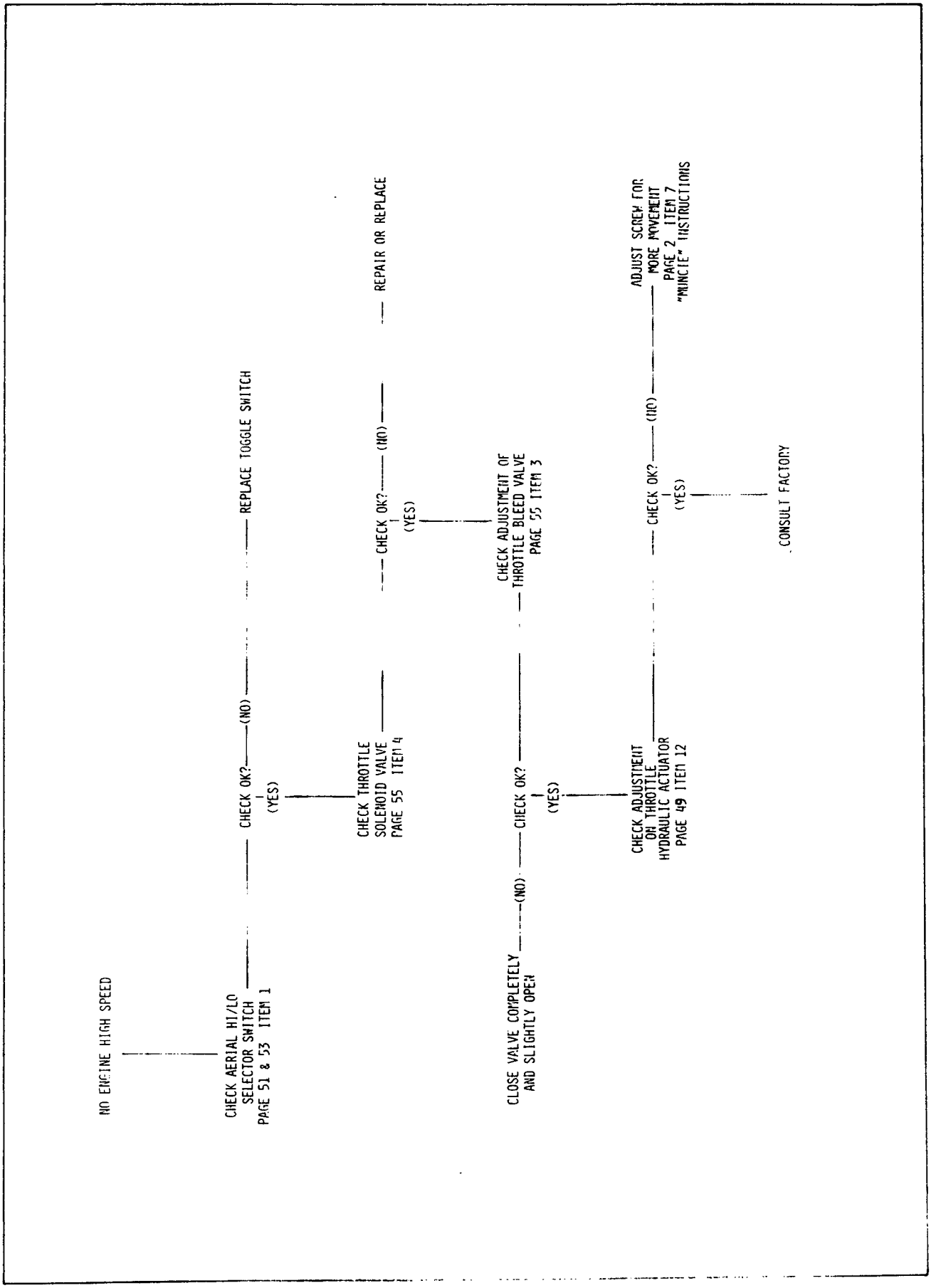
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TROUBLE SHOOTING

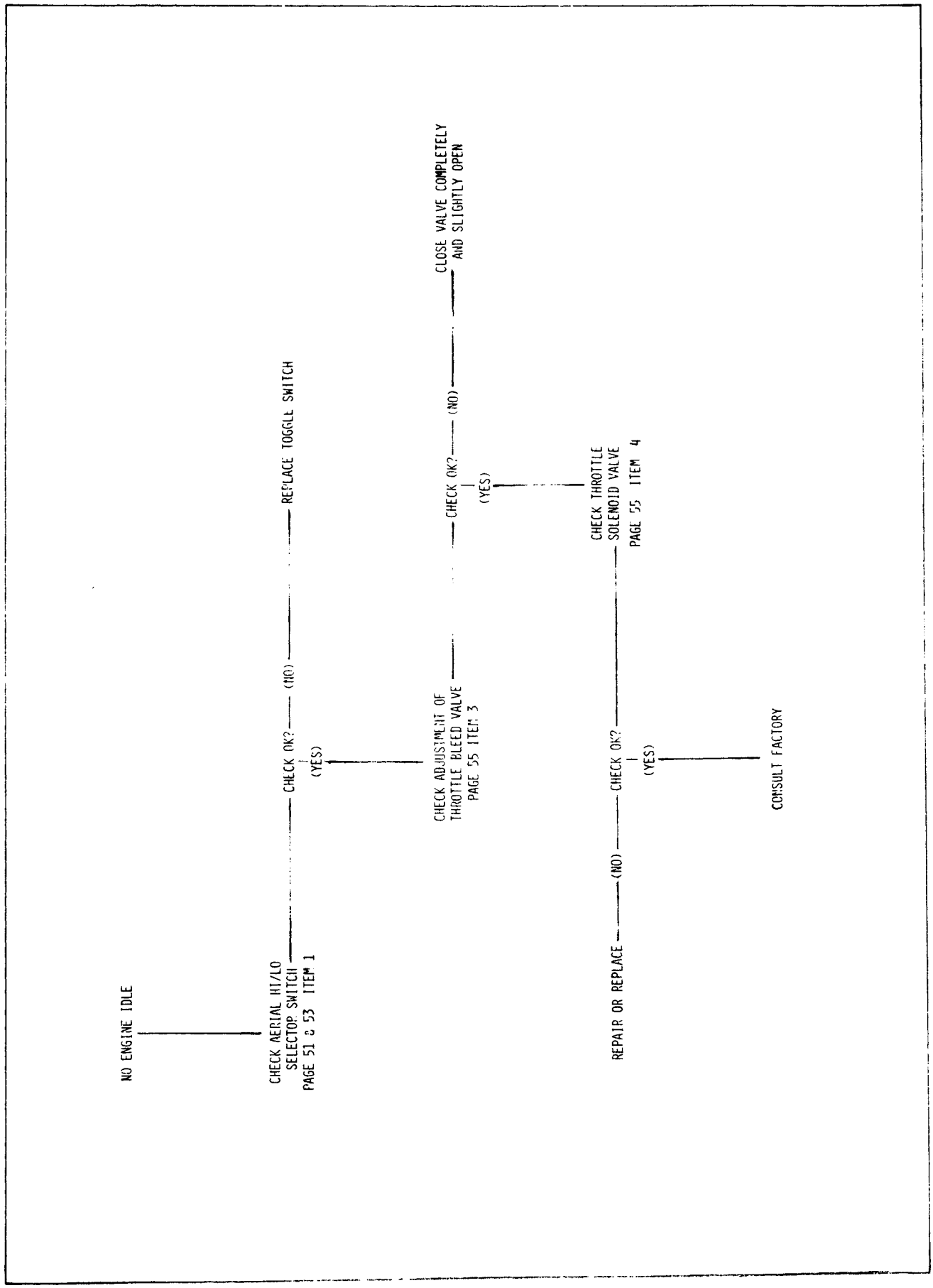
FIGURE 29

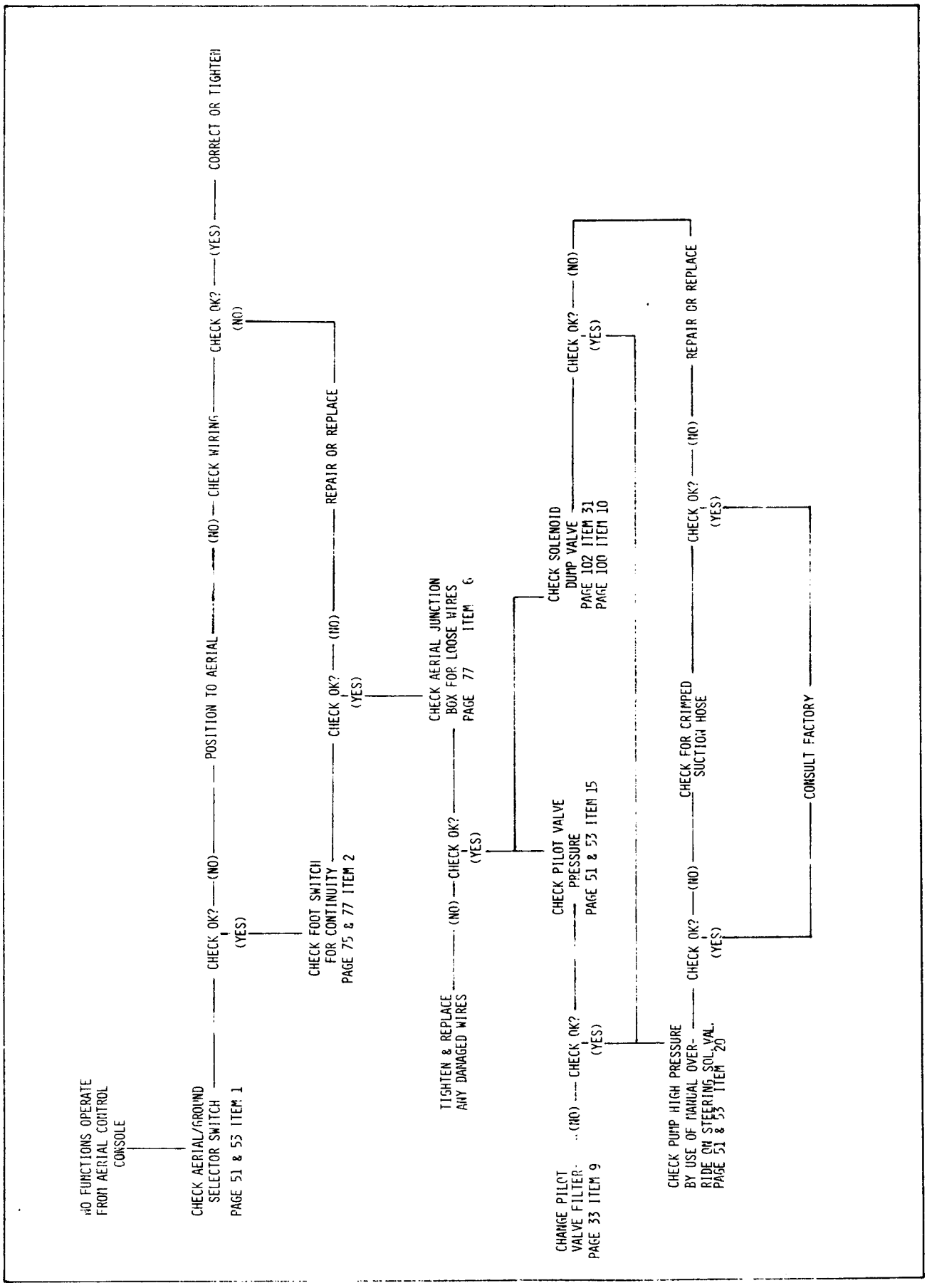


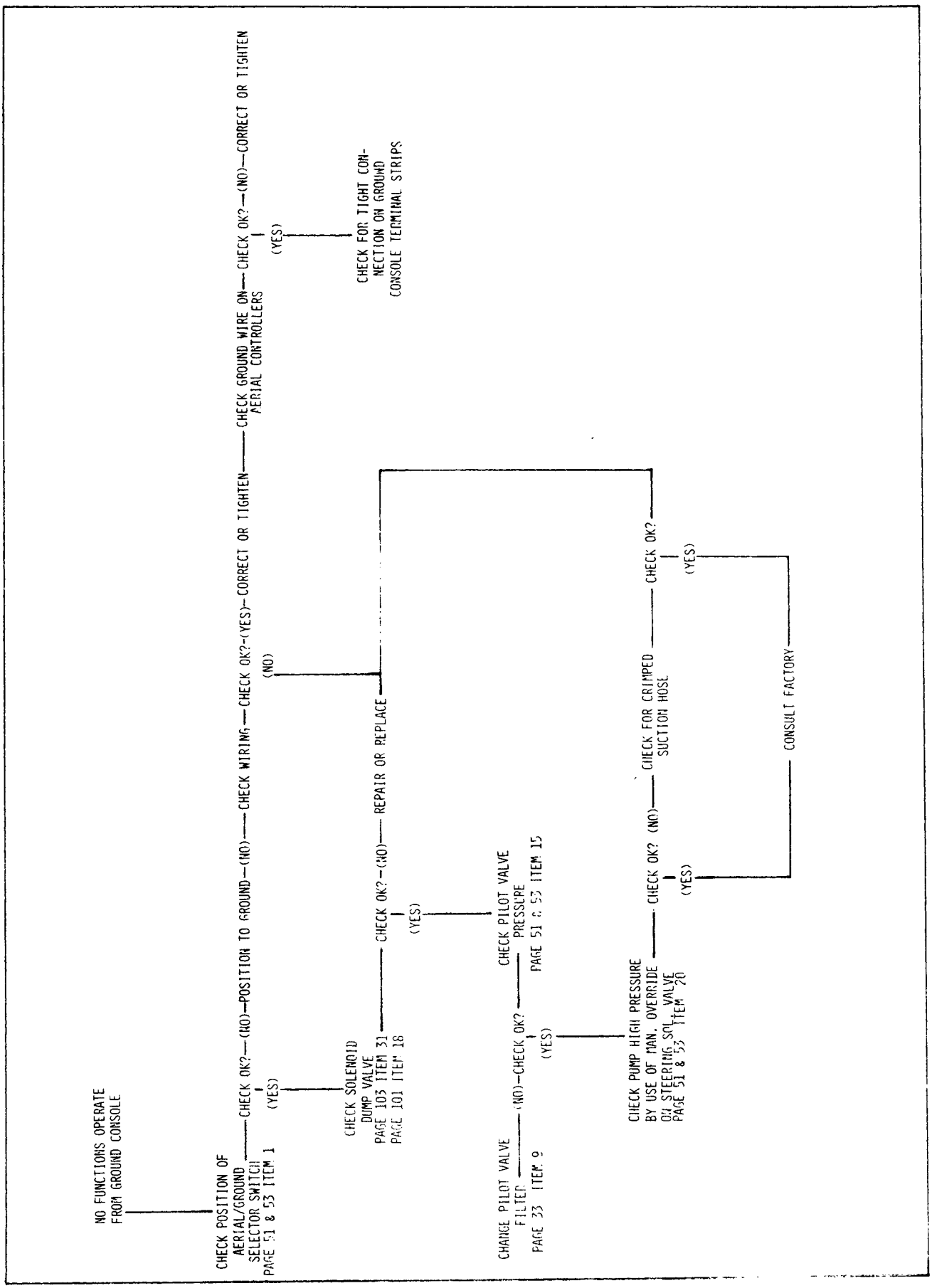

NO ENGINE HIGH SPEED
CHECK AERIAL HI/LO SELECTOR SWITCH PAGE 51 & 53 ITEM 1
CHECK OK?
(NO)
REPLACE TOGGLE SWITCH
(YES)
CHECK THROTTLE SOLENOID VALVE PAGE 55 ITEM 4
CHECK OK?
(NO)
REPAIR OR REPLACE
(YES)
CHECK ADJUSTMENT OF THROTTLE BLEED VALVE PAGE 55 ITEM 3
CLOSE VALVE COMPLETELY AND SLIGHTLY OPEN
(NO)
CHECK OK?
(YES)
CHECK ADJUSTMENT ON THROTTLE HYDRAULIC ACTUATOR PAGE 49 ITEM 12
CHECK OK?
(NO)
ADJUST SCREW FOR MORE MOVEMENT PAGE 2 ITEM 7 "MINCIE" INSTRUCTIONS
(YES)
CONSULT FACTORY

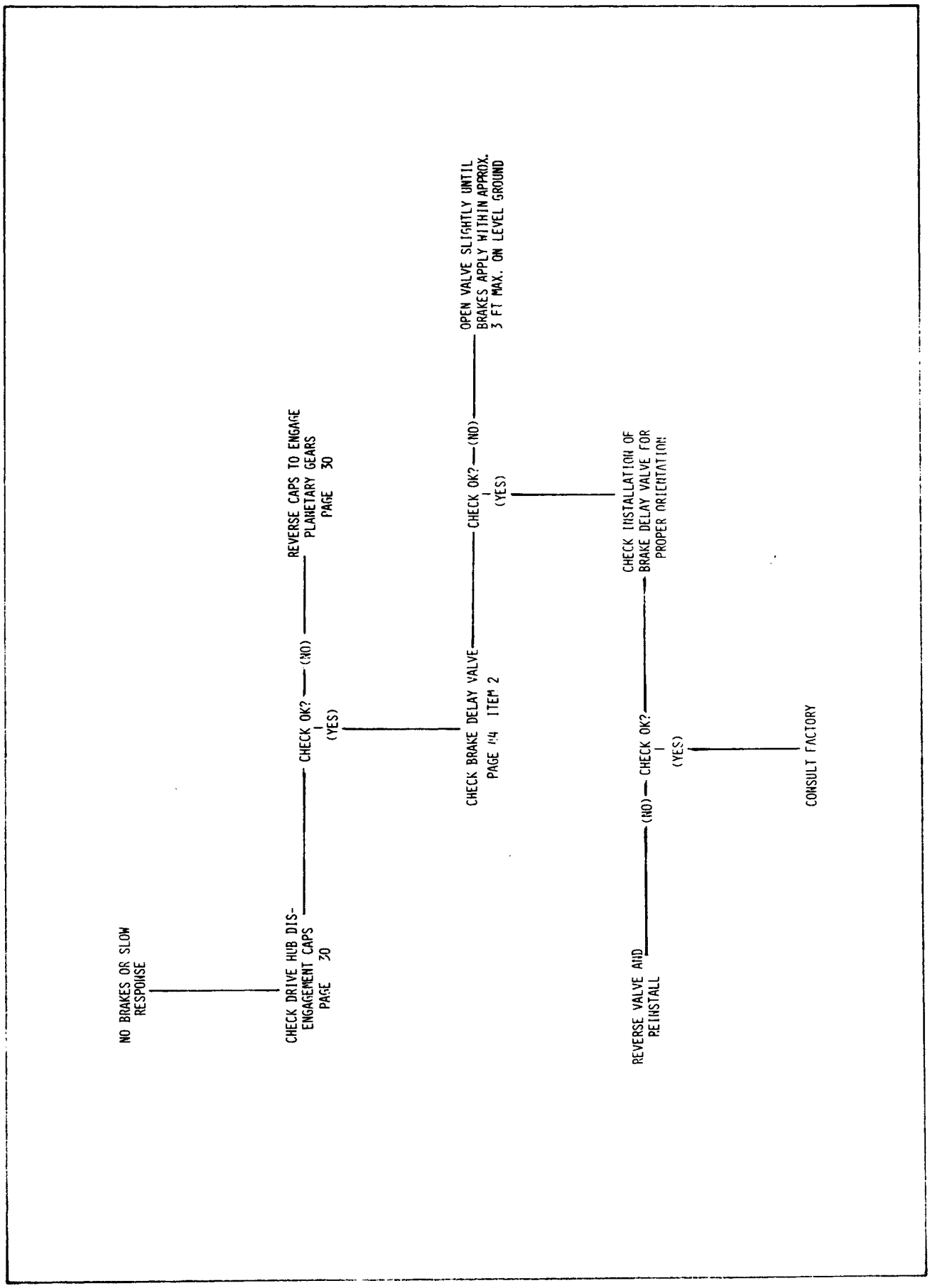
TROUBLE SHOOTING

FIGURE 31



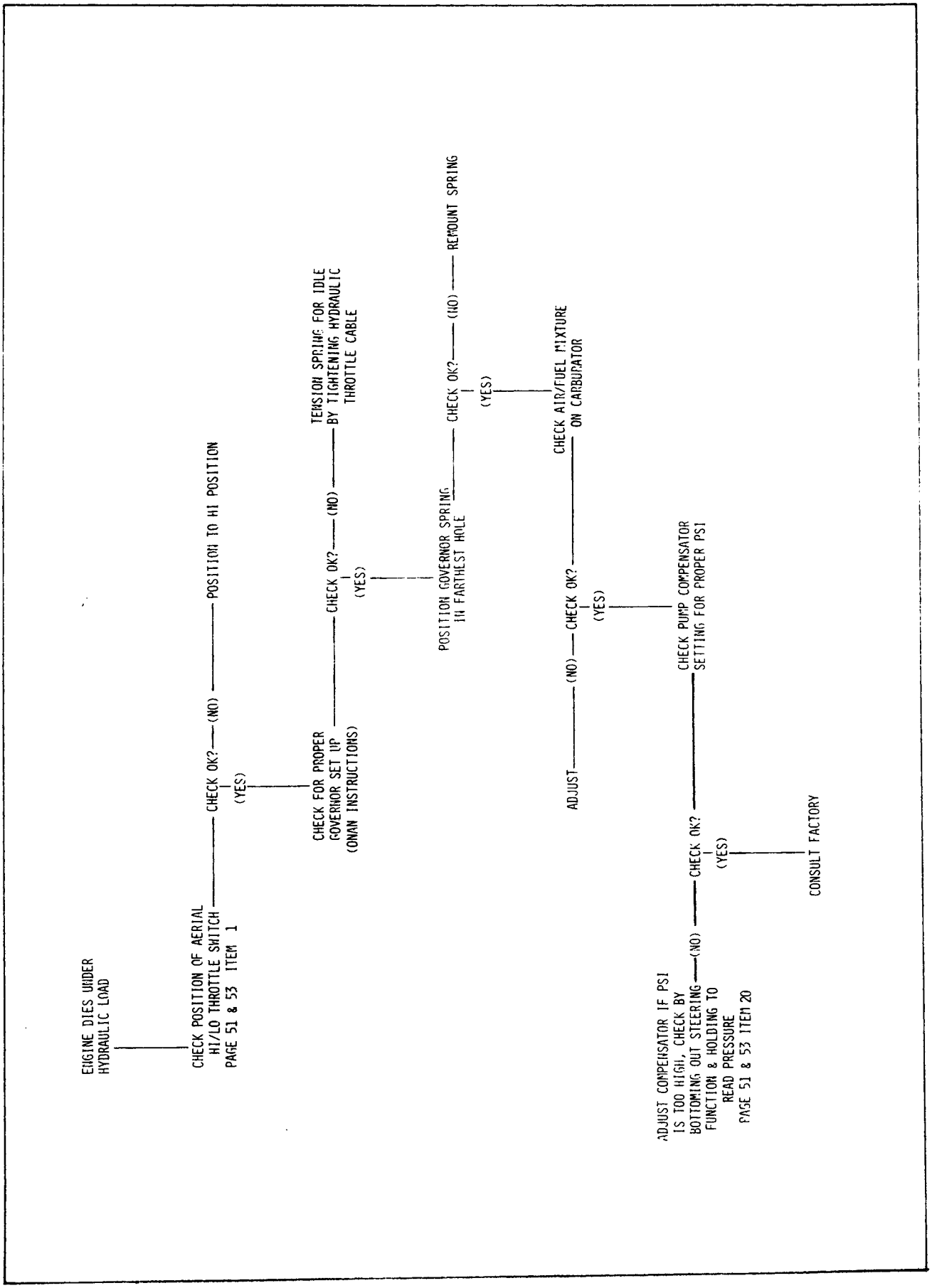

NO FUNCTIONS OPERATE FROM AERIAL CONTROL CONSOLE
CHECK AERIAL/GROUND SELECTOR SWITCH
PAGE 51 & 55 ITEM 1
CHECK OK?
(NO)
(YES)
POSITION TO AERIAL
(NO)
CHECK WIRING
CHECK OK?
(YES)
CORRECT OR TIGHTEN
(NO)
CHECK FOOT SWITCH FOR CONTINUITY
PAGE 75 & 77 ITEM 2
CHECK OK?
(NO)
(YES)
REPAIR OR REPLACE
CHECK AERIAL JUNCTION BOX FOR LOOSE WIRES
PAGE 77 ITEM 6
TIGHTEN & REPLACE ANY DAMAGED WIRES
(NO)
CHECK OK?
(YES)
CHECK SOLENOID DUMP VALVE
PAGE 102 ITEM 31
PAGE 100 ITEM 10
CHECK OK?
(NO)
(YES)
CHECK PILOT VALVE PRESSURE
PAGE 51 & 53 ITEM 15
CHANGE PILOT VALVE FILTER
PAGE 33 ITEM 9
(NO)
CHECK OK?
(YES)
CHECK PUMP HIGH PRESSURE BY USE OF MANUAL OVER-RIDE ON STEERING SOL.VAL.
PAGE 51 & 53 ITEM 20
CHECK OK?
(NO)
(YES)
CHECK FOR CRIMPED SUCTION HOSE
CHECK OK?
(NO)
(YES)
REPAIR OR REPLACE
CONSULT FACTORY

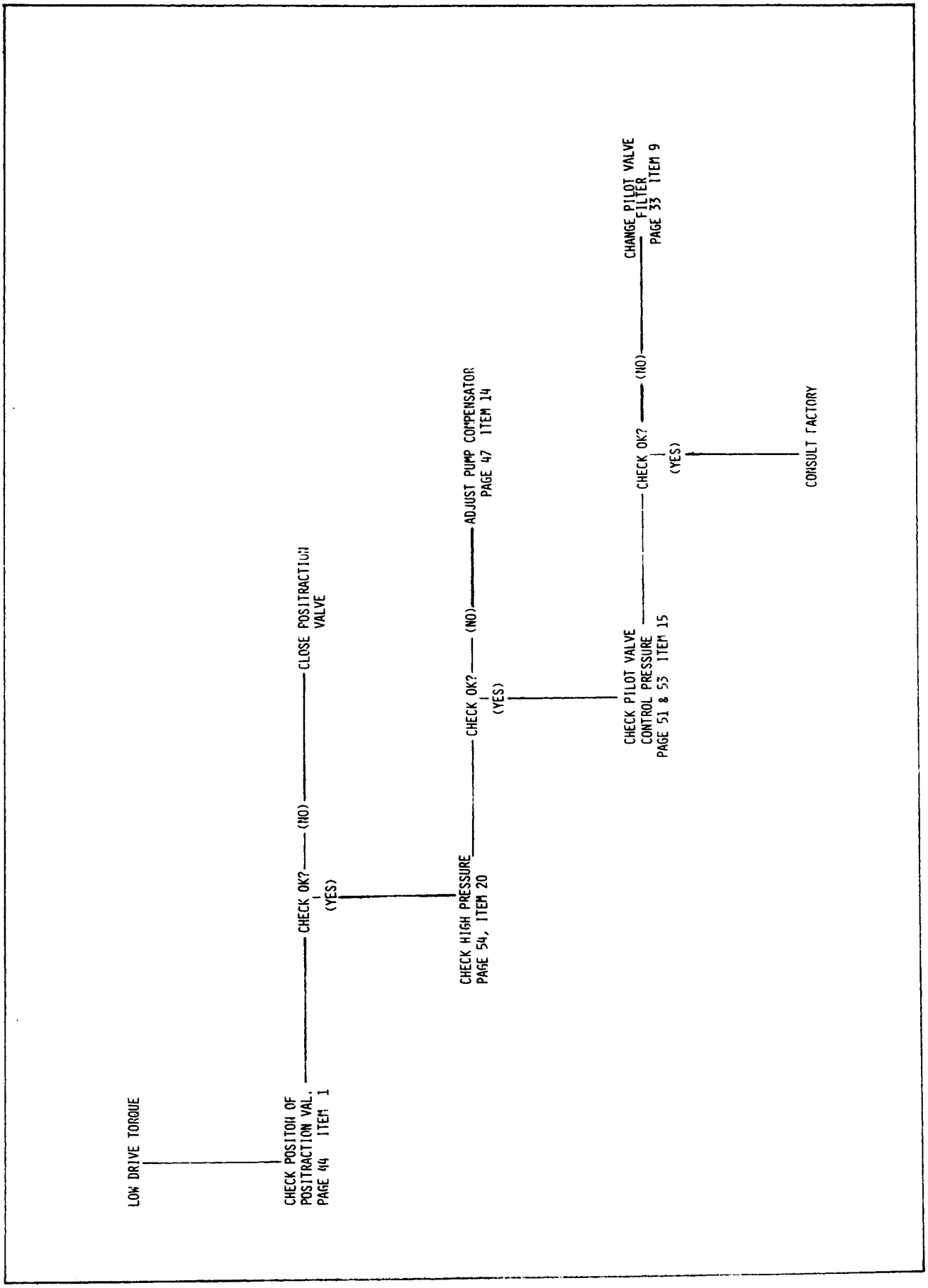

NO FUNCTIONS OPERATE FROM GROUND CONSOLE
CHECK POSITION OF AERIAL/GROUND SELECTOR SWITCH
PAGE 51 & 53 ITEM 1
CHECK OK?
(NO)
POSITION TO GROUND
(NO)
CHECK WIRING
CHECK OK?
(YES)
CORRECT OR TIGHTEN
CHECK GROUND WIRE ON AERIAL CONTROLLERS
CHECK OK?
(NO)
CORRECT OR TIGHTEN
(YES)
CHECK FOR TIGHT CONNECTION ON GROUND CONSOLE TERMINAL STRIPS
(YES)
CHECK SOLENOID DUMP VALVE
PAGE 103 ITEM 31
PAGE 101 ITEM 18
CHECK OK?
(NO)
REPAIR OR REPLACE
(YES)
CHANGE PILOT VALVE FILTER
PAGE 33 ITEM 9
(NO)
CHECK OK?
(YES)
CHECK PILOT VALVE PRESSURE
PAGE 51 & 53 ITEM 15
CHECK PUMP HIGH PRESSURE BY USE OF MAN. OVERRIDE OIL STEERING SOL. VALVE
PAGE 51 & 53 ITEM 20
CHECK OK?
(NO)
CHECK FOR CRIMPED SUCTION HOSE
CHECK OK?
(YES)
(YES)
CONSULT FACTORY


NO BRAKES OR SLOW RESPONSE
CHECK DRIVE HUB DISENGAGEMENT CAPS PAGE 30
CHECK OK?
(NO)
REVERSE CAPS TO ENGAGE PLANETARY GEARS PAGE 30
(YES)
CHECK BRAKE DELAY VALVE PAGE 14 ITEM 2
CHECK OK?
(NO)
OPEN VALVE SLIGHTLY UNTIL BRAKES APPLY WITHIN APPROX. 3 FT MAX. ON LEVEL GROUND
(YES)
CHECK INSTALLATION OF BRAKE DELAY VALVE FOR PROPER ORIENTATION
REVERSE VALVE AND REINSTALL
(NO)
CHECK OK?
(YES)
CONSULT FACTORY

TROUBLE SHOOTING

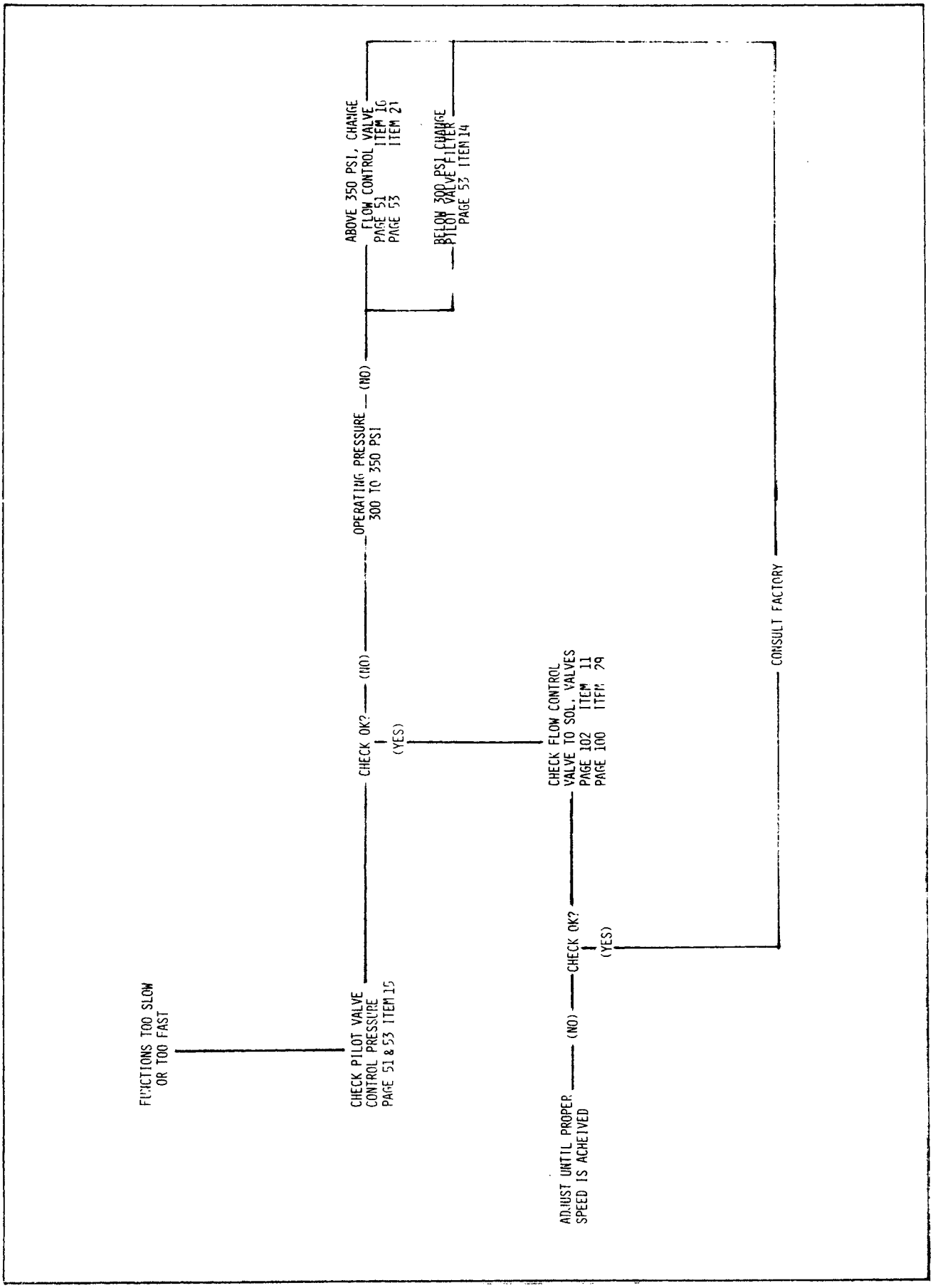
FIGURE 35

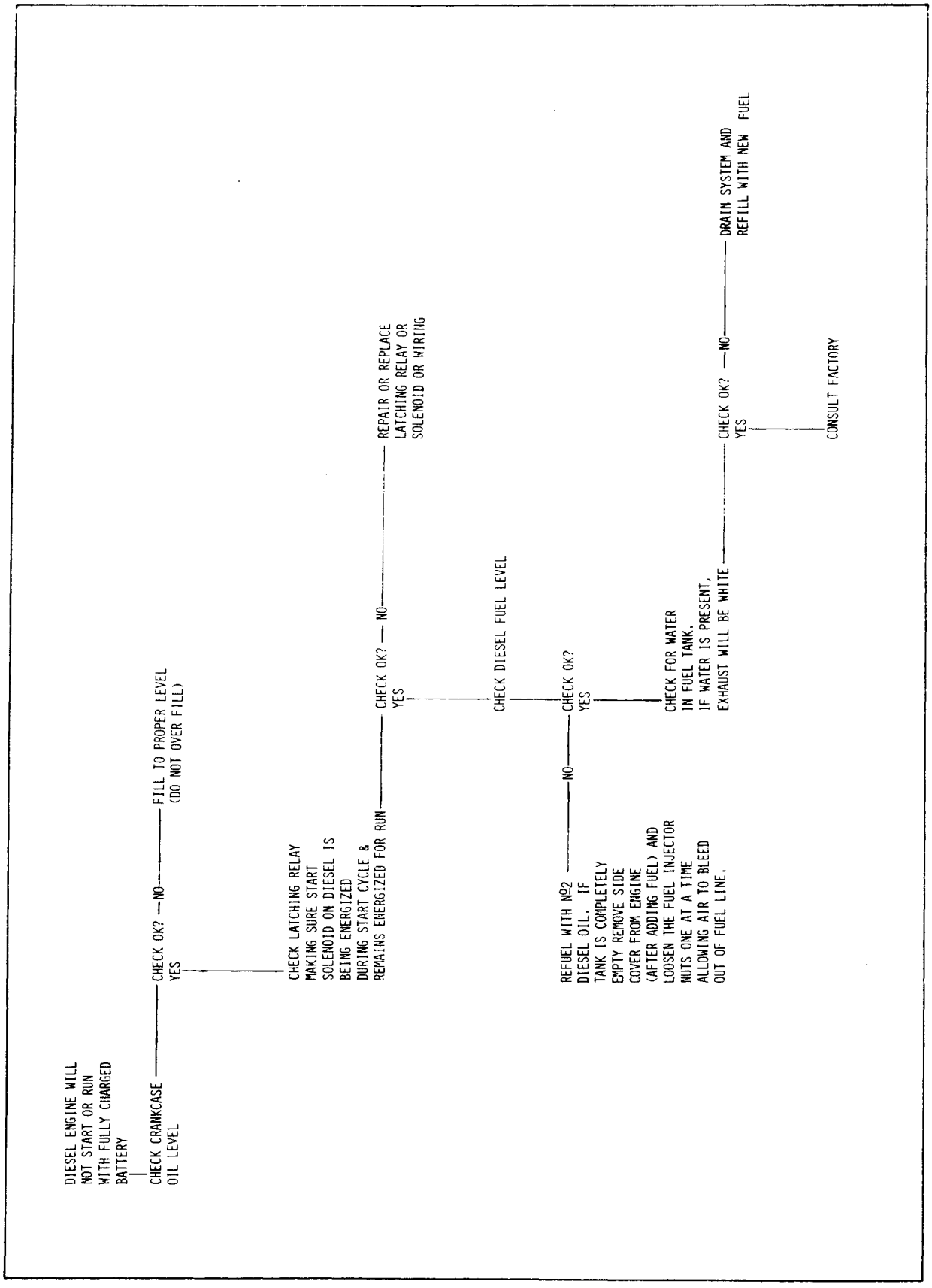



LOW DRIVE TORQUE
CHECK POSITON OF POSITRACTION VAL. PAGE 44 ITEM 1
CHECK OK?
(NO)
CLOSE POSITRACTION VALVE
(YES)
CHECK HIGH PRESSURE PAGE 54, ITEM 20
CHECK OK?
(NO)
ADJUST PUMP COMPENSATOR PAGE 47 ITEM 14
(YES)
CHECK PILOT VALVE CONTROL PRESSURE PAGE 51 & 53 ITEM 15
CHECK OK?
(NO)
CHANGE PILOT VALVE FILTER PAGE 33 ITEM 9
(YES)
CONSULT FACTORY

TROUBLE SHOOTING

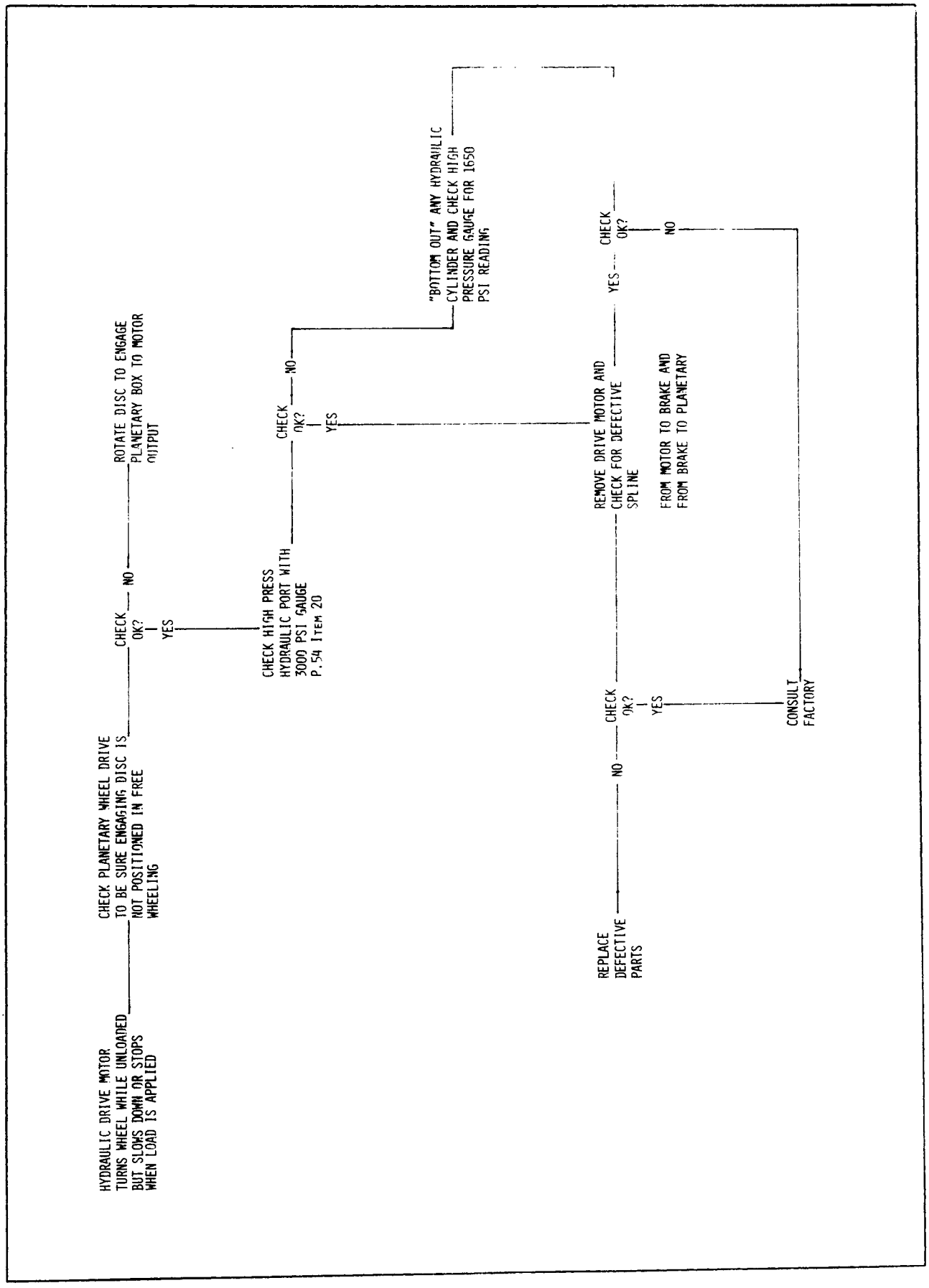
FIGURE 37

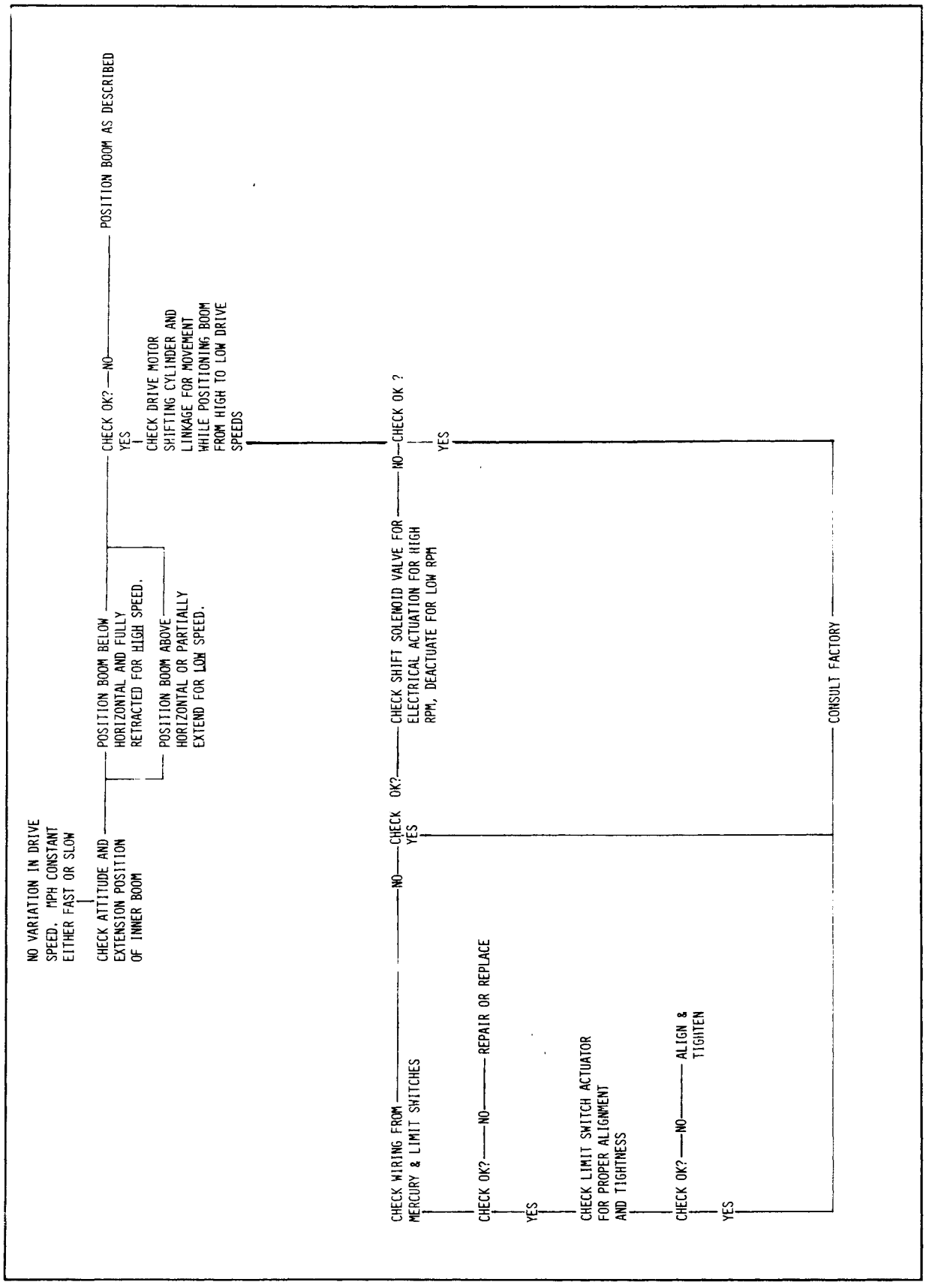


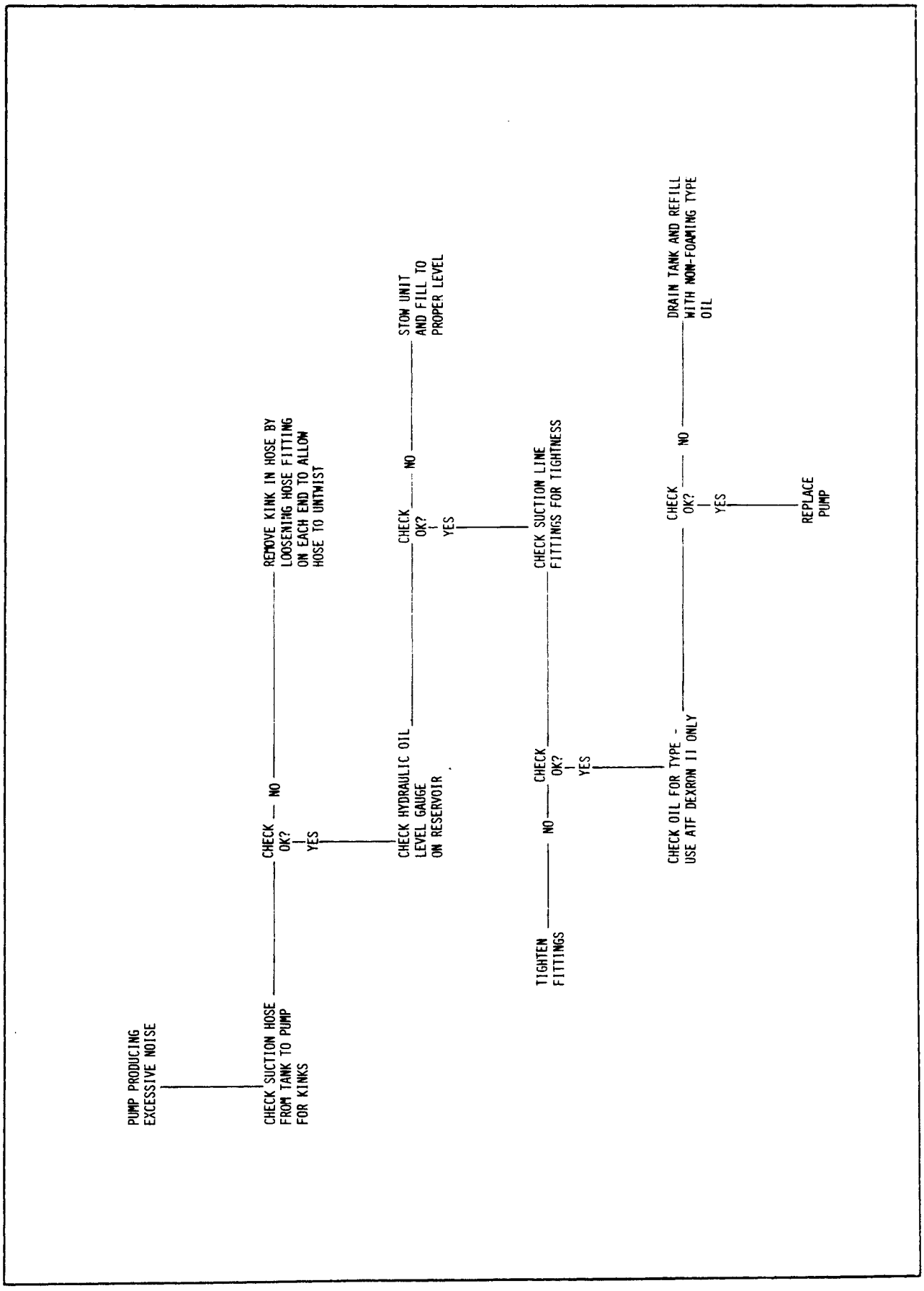

DIESEL ENGINE WILL NOT START OR RUN WITH FULLY CHARGED BATTERY
CHECK CRANKCASE OIL LEVEL
CHECK OK?
NO
FILL TO PROPER LEVEL (DO NOT OVER FILL)
YES
CHECK LATCHING RELAY MAKING SURE START SOLENOID ON DIESEL IS BEING ENERGIZED DURING START CYCLE & REMAINS ENERGIZED FOR RUN
CHECK OK?
NO
REPAIR OR REPLACE LATCHING RELAY OR SOLENOID OR WIRING
YES
CHECK DIESEL FUEL LEVEL
REFUEL WITH #2 DIESEL OIL. IF TANK IS COMPLETELY EMPTY REMOVE SIDE COVER FROM ENGINE (AFTER ADDING FUEL) AND LOOSEN THE FUEL INJECTOR NUTS ONE AT A TIME ALLOWING AIR TO BLEED OUT OF FUEL LINE.
CHECK OK?
NO
YES
CHECK FOR WATER IN FUEL TANK. IF WATER IS PRESENT, EXHAUST WILL BE WHITE
CHECK OK?
NO
DRAIN SYSTEM AND REFILL WITH NEW FUEL
YES
CONSULT FACTORY

TROUBLE SHOOTING

FIGURE 39




NO VARIATION IN DRIVE SPEED. MPH CONSTANT EITHER FAST OR SLOW
CHECK ATTITUDE AND EXTENSION POSITION OF INNER BOOM
POSITION BOOM BELOW HORIZONTAL AND FULLY RETRACTED FOR HIGH SPEED.
POSITION BOOM ABOVE HORIZONTAL OR PARTIALLY EXTEND FOR LOW SPEED.
CHECK OK? NO
POSITION BOOM AS DESCRIBED
YES
CHECK DRIVE MOTOR SHIFTING CYLINDER AND LINKAGE FOR MOVEMENT WHILE POSITIONING BOOM FROM HIGH TO LOW DRIVE SPEEDS
CHECK OK ?
NO
YES
CHECK SHIFT SOLENOID VALVE FOR ELECTRICAL ACTUATION FOR HIGH RPM, DEACTUATE FOR LOW RPM
CHECK OK?
NO
YES
CHECK WIRING FROM MERCURY & LIMIT SWITCHES
CHECK OK?
NO
REPAIR OR REPLACE
YES
CHECK LIMIT SWITCH ACTUATOR FOR PROPER ALIGNMENT AND TIGHTNESS
CHECK OK?
NO
ALIGN & TIGHTEN
YES
CONSULT FACTORY


PUMP PRODUCING EXCESSIVE NOISE
CHECK SUCTION HOSE FROM TANK TO PUMP FOR KINKS
CHECK OK?
NO
REMOVE KINK IN HOSE BY LOOSENING HOSE FITTING ON EACH END TO ALLOW HOSE TO UNTWIST
YES
CHECK HYDRAULIC OIL LEVEL GAUGE ON RESERVOIR
CHECK OK?
NO
STOW UNIT AND FILL TO PROPER LEVEL
YES
TIGHTEN FITTINGS
NO
CHECK OK?
YES
CHECK SUCTION LINE FITTINGS FOR TIGHTNESS
CHECK OIL FOR TYPE - USE ATF DEXRON II ONLY
CHECK OK?
NO
DRAIN TANK AND REFILL WITH NON-FOAMING TYPE OIL
YES
REPLACE PUMP

1. Fill the pump half full of system oil and complete installation. Check all fittings to be sure they are tight.

2. Fill oil reservoir with ATF Dexron II.

3. Start engine and run at low idle.

4. The pump should immediately pick up oil and fill system, if there is no indication of fill in 60 seconds, stop engine and determine cause.

5. After system starts to show signs of fill, operate control valve to purge system. Continue to operate system slowly with no load until system responds fully.

6. Check fluid lines for leaks. Tighten if necessary.

7. Check reservoir fluid level and add if necessary.

8. Machine is now ready to operate.

SUGGESTED SPARE PARTS

ITEM	PART NUMBER	DESCRIPTION
1.	20477	Filter Element, return line
2.	20472	Filter Element, low pressure
3.	20369	Filter, Sump
4.	20125	Seal Kit, Steering Cylinder
5.	20126	Seal Kit, Raising Cylinder
6.	20127	Seal Kit, Extension Cylinder
7.	20128	Seal Kit, Master & Slave Leveling Cylinders
8.	20480	Circuit Breaker
9.	20481	Toggle Switch
10.	20482	Toggle Switch
11.	20356	Shuttle Valve
12.	20580	Potentiometer Assembly
13.	20597	Gasket
14.	20598	Gasket
15.	20581	Lock-out

HYDRAULIC

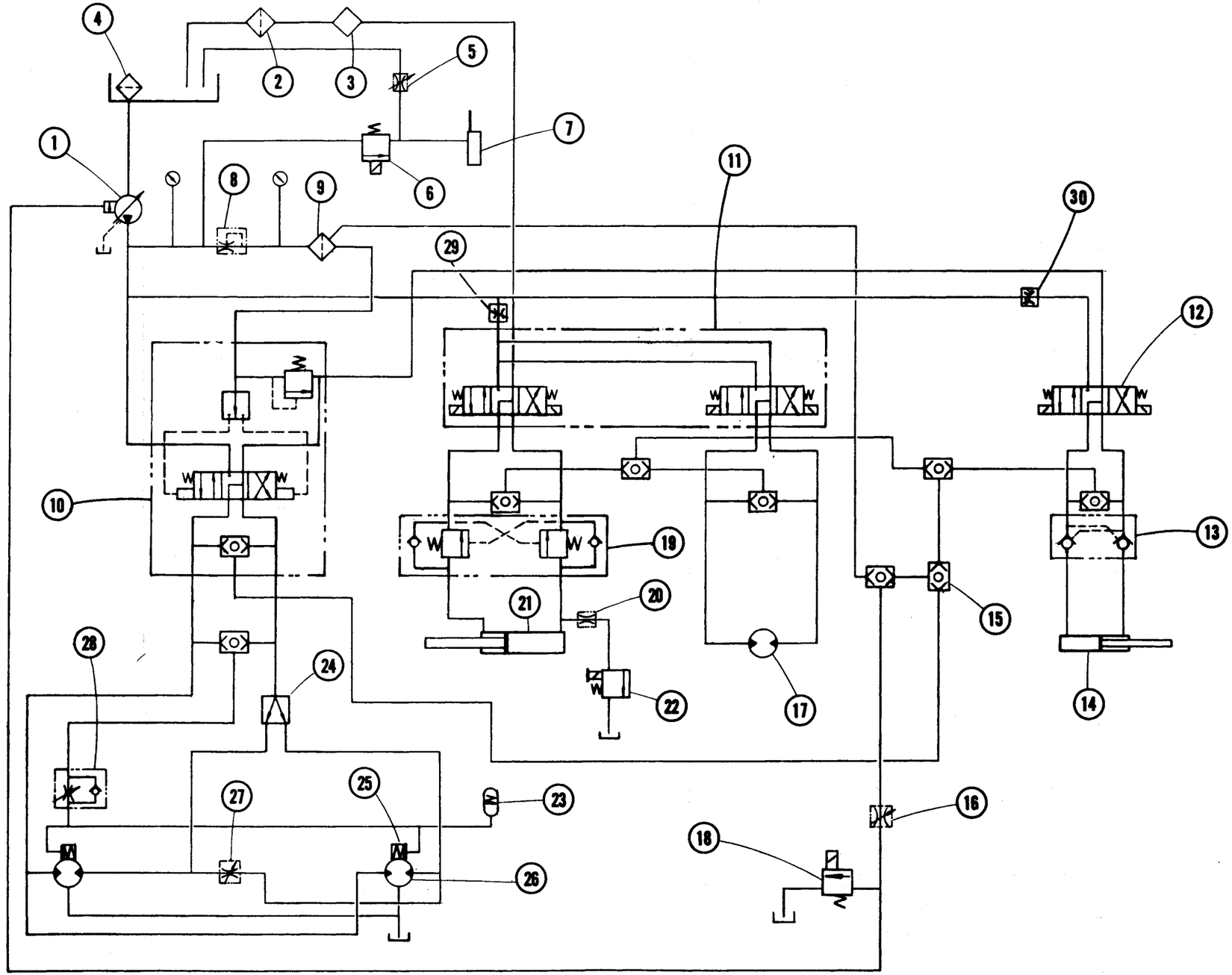
AND

ELECTRIC

SCHEMATICS

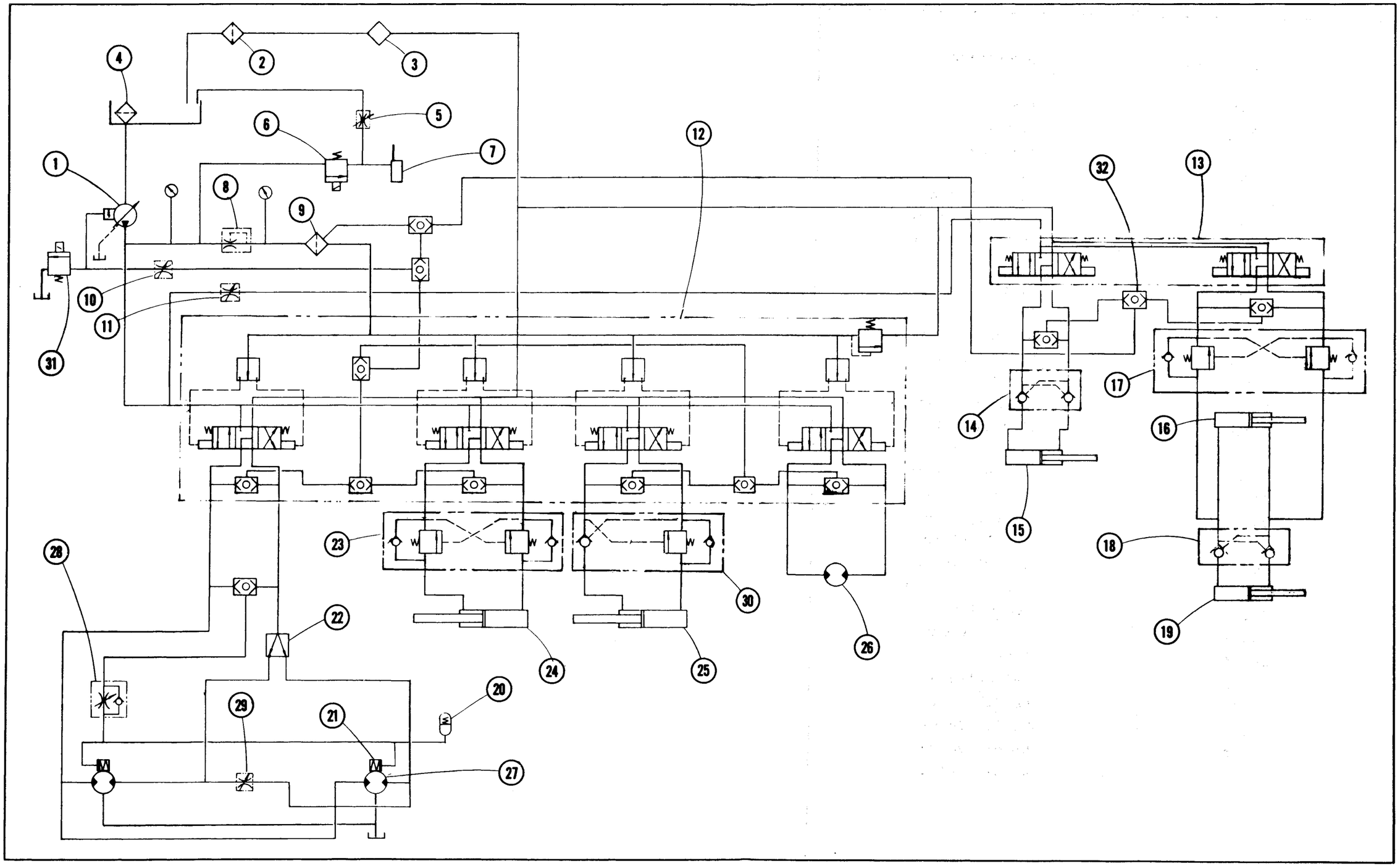
21S & 21RT HYDRAULIC CIRCUIT

FIGURE 38



ITEM	PART NUMBER	DESCRIPTION
1.	20361	Pump
2.	20367	Filter
3.	20385	Radiator
4.	20369	Filter
5.	20357	Needle Valve
6.	20378	Solenoid Valve
7.	20364	Throttle Control
8.	20366	Flow Control
9.	20368	Filter
10.	20395	Proportional Valve
11.	20372	Solenoid Valve
12.	20371	Solenoid Valve
13.	20351	Double Pilot Check
14.	20206	Steering Cylinder
15.	20356	Shuttle Valve
16.	20357	Needle Valve
17.	20488	Hydraulic Motor
18.	20378	Solenoid Valve
19.	20365	Holding Valve
20.	20348	Fixed Orifice
21.	20205	Lift Cylinder
22.	20376	Solenoid Valve
23.	20355	Accumulator
24.	20359	Flow Divider
25.	20354	Brake
26.	20352	Hydraulic Motor
27.	20436	Needle Valve
28.	20370	Needle Valve
29.	20358	Needle Valve
30.	20357	Needle Valve

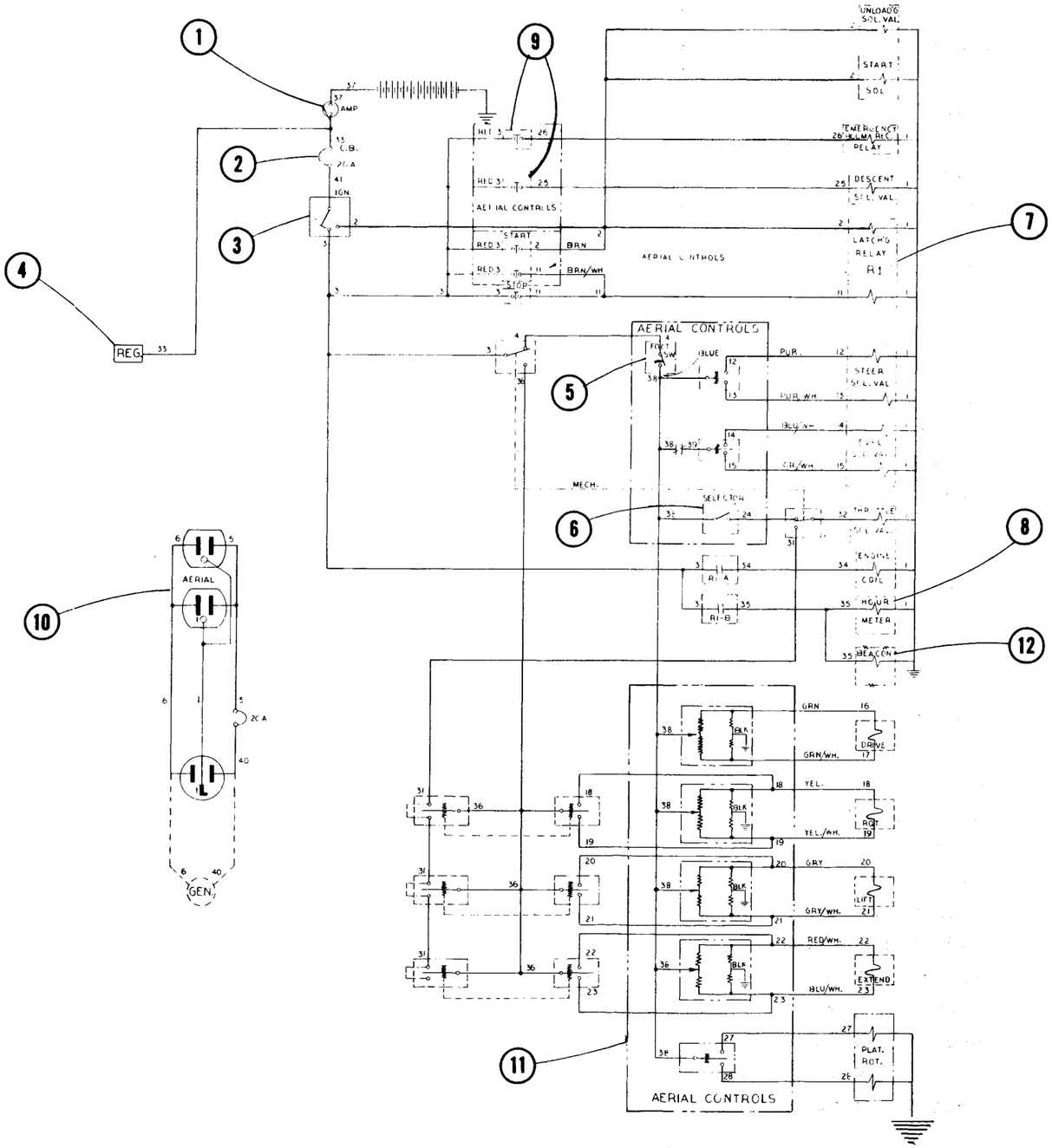
30L & 30H HYDRAULIC CIRCUIT



30L & 30H HYDRAULIC CIRCUIT

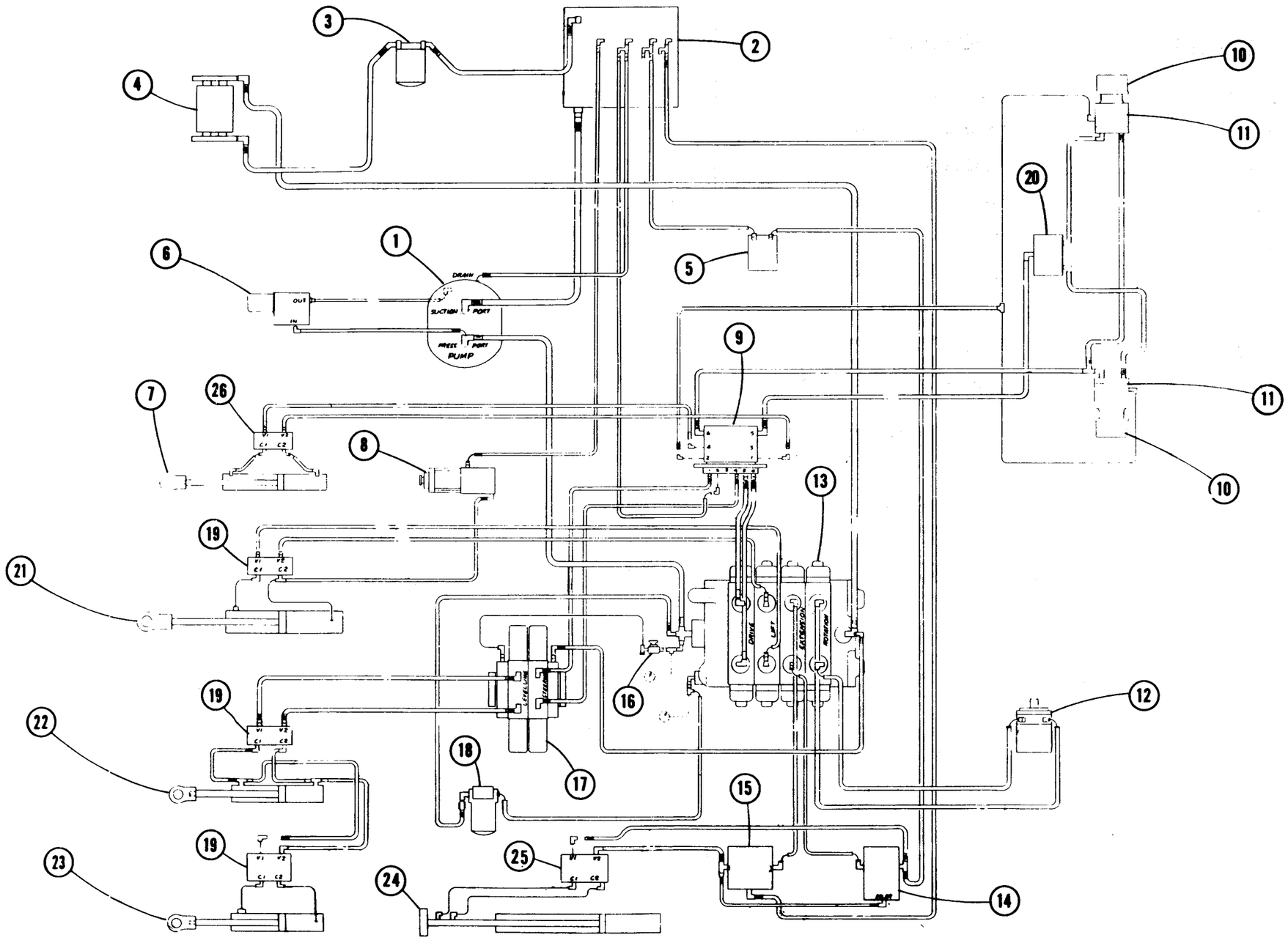
ITEM	PART NUMBER	DESCRIPTION
1.	20361	Pump
2.	20367	Filter
3.	20385	Radiator
4.	20369	Filter
5.	20357	Needle Valve
6.	20378	Solenoid Valve
7.	20357	Throttle Control
8.	20366	Flow Control
9.	20368	Filter
10.	20357	Needle Valve
11.	20358	Needle Valve
12.	20394	Proportional Valve
13.	20372	Solenoid Valve
14.	20351	Check Valve
15.	20206	Steering Cylinder
16.	20303	Master Cylinder
17.	20365	Holding Valve
18.	20351	Check Valve
19.	20304	Slave Cylinder
20.	20355	Accumulator
21.	20354	Brake
22.	20359	Flow Divider
23.	20365	Holding Valve
24.	20205	Raising Cylinder
25.	20207	Extension Cylinder
26.	20488	Hydraulic Motor
27.	20381	Hydraulic Motor
28.	20370	Needle Valve
29.	20436	Needle Valve
30.	20402	Holding Valve
31.	20378	Solenoid Valve
32.	20356	Shuttle Valve

MODELS 21 & 30 ELECTRICAL SCHEMATIC



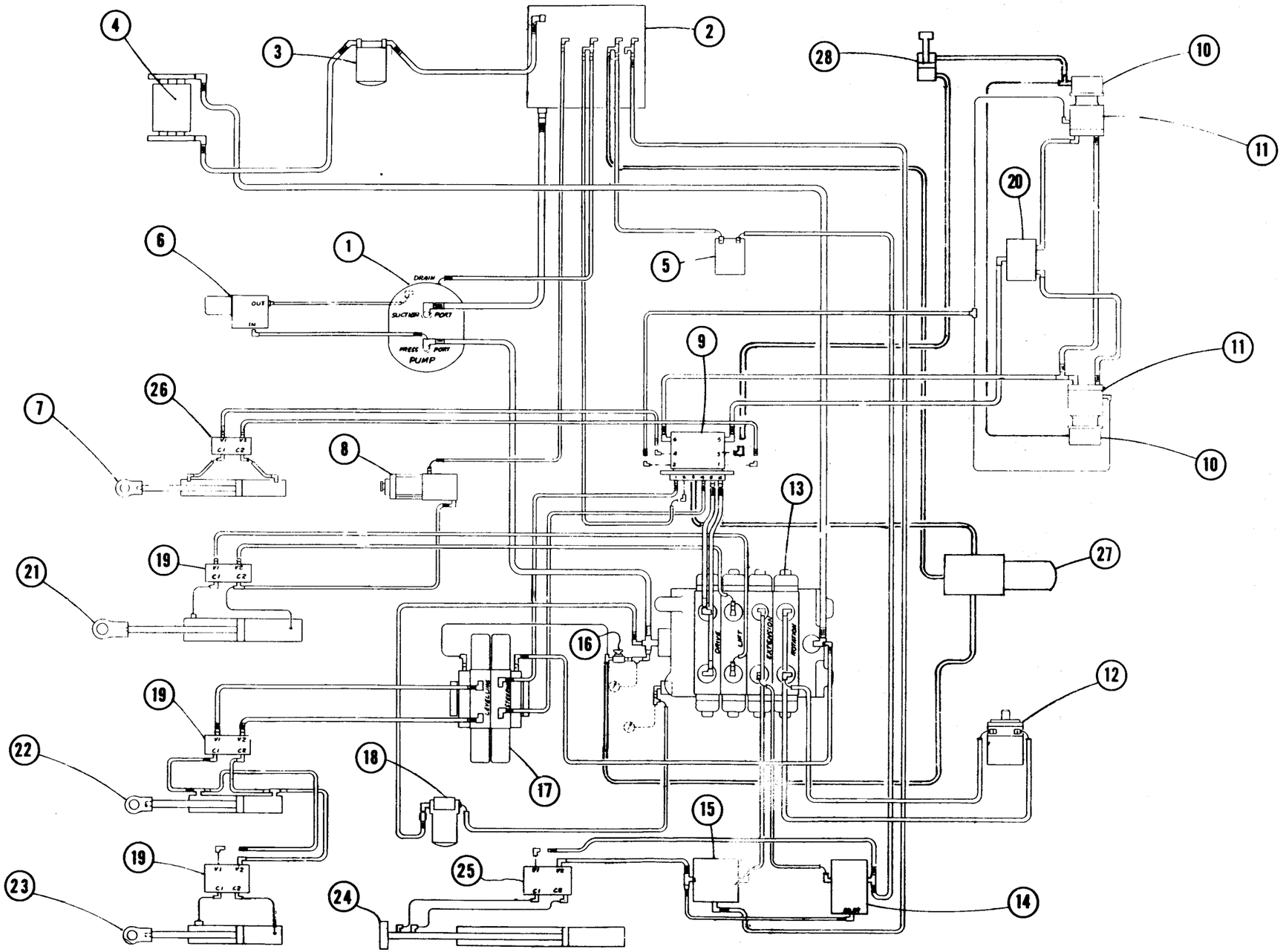
ITEM	PART NUMBER	DESCRIPTION
1.	20572	Ammeter
2.	20480	Circuit Breaker
3.	405	Ignition Switch
4.	20585	Voltage Regulator
5.	20379	Foot Switch
6.	20584	Hi-Lo Selector
7.	20573	Latching Relay
8.	20571	Hour Meter
9.	4011	Emergency Retract & Descent
10.	20104	Power Outlet Option
11.		Controller
12.	4078	Beacon Light

MODEL 40 HYDRAULIC CIRCUIT

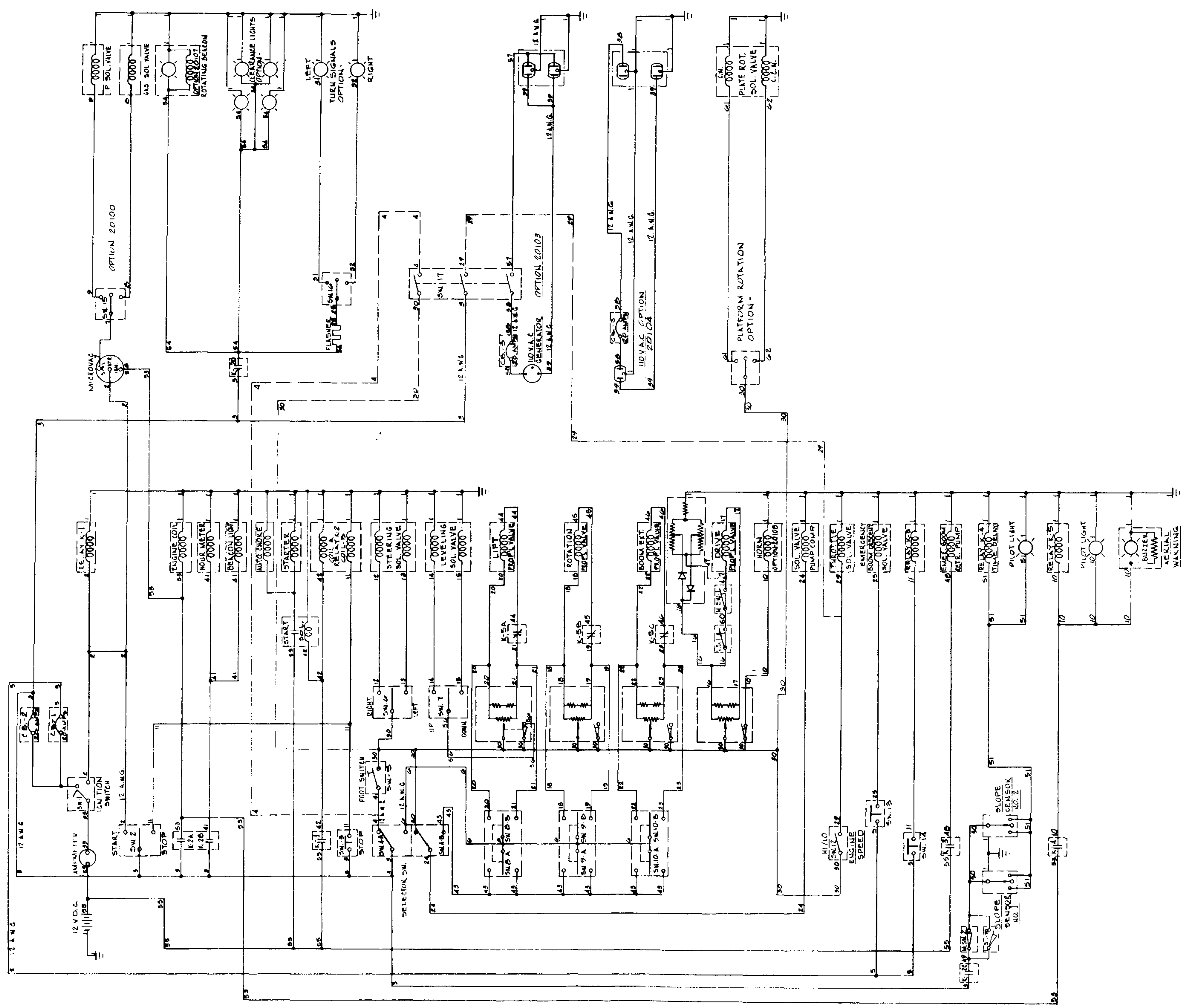


ITEM	PART NUMBER	DESCRIPTION
1.	20801	Pump
2.	20757	Hydraulic Tank
3.	20367	Filter (20477 element)
4.	20377	Oil Cooler
5.	20384	Emergency Pump
6.	20378	Unloading Valve
7.	20728	Steering Cylinder
8.	20376	Emergency Descent
9.	20339	Rotary Union
10.	20354	Brake
11.	20381	Motor (Drive)
12.	20520	Motor (Braden) (Rotation)
	20517	Motor (Durst)
13.	20762	Proportional Valve
14.	20391	Pilot Check
15.	20516	Relief Valve
16.	20357	Needle Valve
17.	20372	Solenoid Valve
18.	20368	Filter (20472 element)
19.	20365	Holding Valve
20.	20359	Flow Divider
21.	20205	Lift Cylinder
22.	20303	Master Leveling Cylinder
23.	20304	Slave Leveling Cylinder
24.	20727	Extending Cylinder
25.	20402	Holding Valve
26.	20351	Holding Valve

MODEL 40RT HYDRAULIC CIRCUIT



ITEM	PART NUMBER	DESCRIPTION
1.	20801	Pump
2.	20757	Hydraulic Tank
3.	20367	Filter (20477 element)
4.	20377	Oil Cooler
5.	20384	Emergency Pump
6.	20378	Unloading Valve
7.	20728	Steering Cylinder
8.	20376	Emergency Descent
9.	20339	Rotary Union
10.	20354	Brake
11.	20800	Motor
12.	20520	Motor (Braden)
	20517	Motor (Durst)
13.	20762	Proportional Valve
14.	20391	Pilot Check
15.	20516	Relief Valve
16.	20357	Needle Valve
17.	20372	Solenoid Valve
18.	20368	Filter (20472 element)
19.	20365	Holding Valve
20.	20359	Flow Divider
21.	20205	Lift Cylinder
22.	20303	Master Leveling Cylinder
23.	20304	Slave Leveling Cylinder
24.	20727	Extending Cylinder
25.	20402	Holding Valve
26.	20351	Holding Valve
27.	20767	2 Speed Valve
28.	20719	Shift Cylinder



ONAN ENGINE

WISCONSIN ENGINE

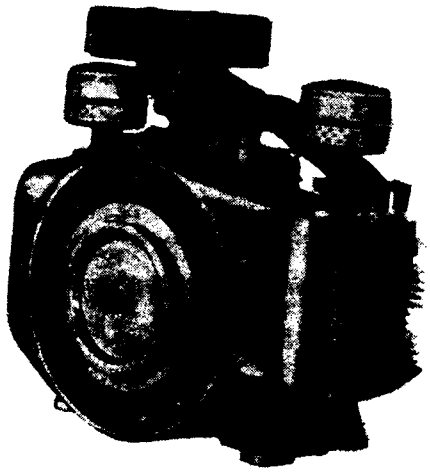
BERTEA VALVES

MARK INDUSTRIES

2662 East Del Amo Boulevard, Carson, CA 90746
Post Office Box 720, Long Beach, CA 90801

Onan

OPERATING AND MAINTENANCE INSTRUCTIONS



CCKB
ENGINE

ONAN 1400 73RD AVENUE N.E. • MINNEAPOLIS, MINNESOTA 55432
A DIVISION OF ONAN CORPORATION

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ENGINE SAFETY PRECAUTIONS

It is recommended that you read your engine manual and become thoroughly acquainted with your equipment before you start the engine.

WARNING **This symbol is used throughout this manual to warn of possible serious personal injury.**

CAUTION **This symbol refers to possible equipment damage.**

Fuels, electrical equipment, batteries, exhaust gases and moving parts present potential hazards that could result in serious, personal injury. Take care in following these recommended procedures.

Safety Codes

- All local, state and federal codes should be consulted and complied with.

General

- Provide appropriate fire extinguishers and install them in convenient locations. Use an extinguisher rated ABC by NFPA.
- Make sure that all fasteners on the engine are secure. Tighten supports and clamps, keep guards in position over fans, driving belts, etc.
- If it is necessary to make adjustments while the engine is running, use extreme caution when close to hot exhausts, moving parts, etc.

Protect Against Moving Parts

- Do not wear loose clothing in the vicinity of moving parts, such as PTO shafts, flywheels, blowers, couplings, fans, belts, etc.
- Keep your hands away from moving parts.

Batteries

- Before starting work on the engine, disconnect batteries to prevent inadvertent starting of the engine.
- DO NOT SMOKE while servicing batteries. Lead acid batteries give off a highly explosive hydrogen gas which can be ignited by flame, electrical arcing or by smoking.
- Verify battery polarity before connecting battery cables. Connect negative cable last.

Fuel System

- DO NOT fill fuel tanks while engine is running, unless tanks are outside engine compartment.
- DO NOT smoke or use an open flame in the vicinity of the engine or fuel tank. Internal combustion engine fuels are highly flammable.
- Fuel lines must be of steel piping, adequately secured, and free from leaks. Piping at the engine should be approved flexible line. Do not use copper piping on flexible lines as copper will work harden and become brittle enough to break.
- Be sure all fuel supplies have a positive shutoff valve.

Exhaust System

- Exhaust products of any internal combustion engine are toxic and can cause injury, or death if inhaled. All engine installations, especially those within a confine, should be equipped with an exhaust system to discharge gases to the atmosphere.
- Do not use exhaust gases to heat a compartment.
- Make sure that your exhaust system is free of leaks. Ensure that exhaust manifolds are secure and are not warped by bolts unevenly torqued.

Engine Exhaust Gas (Carbon Monoxide) Is Deadly!

Carbon monoxide is an odorless, colorless gas formed by incomplete combustion of hydrocarbon fuels. Carbon monoxide is a dangerous gas that can cause unconsciousness and is potentially lethal. Some of the symptoms or signs of carbon monoxide inhalation are:

- Dizziness
- Intense Headache
- Weakness and Sleepiness
- Vomiting
- Muscular Twitching
- Throbbing in Temples

If you experience any of the above symptoms, get out into fresh air immediately.

The best protection against carbon monoxide inhalation is a regular inspection of the complete exhaust system. If you notice a change in the sound or appearance of exhaust system, shut the unit down immediately and have it inspected and repaired at once by a competent mechanic.

Cooling System

- Coolants under pressure have a higher boiling point than water. DO NOT open a radiator pressure cap while the engine is running. Bleed the system pressure first.

Keep the Unit and Surrounding Area Clean

- Make sure that oily rags are not left on or near the engine.
- Remove all oil deposits. Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and subsequent engine damage and may present a potential fire hazard.

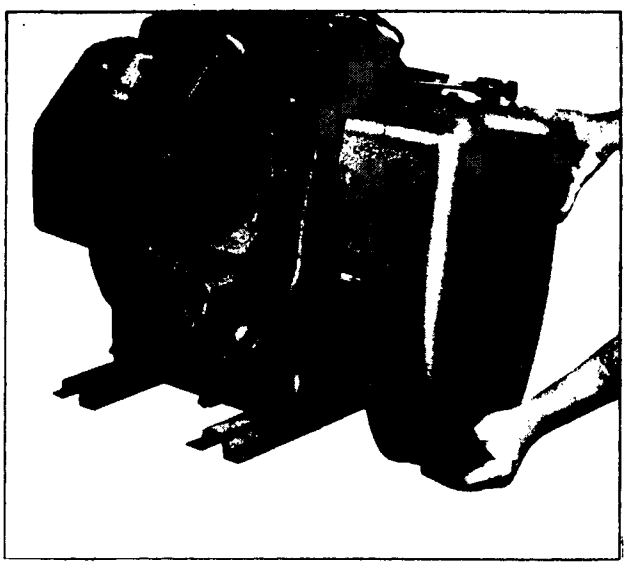


Fig. 19 104811C

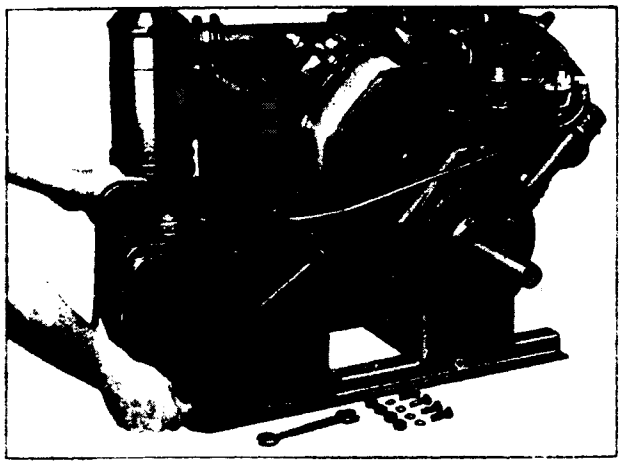


Fig. 20 83608C

ing the flywheel shroud to the lower cylinder shrouds and cylinder heat deflectors, then remove the screws holding the flywheel shroud to gear cover.

On power units, remove the front end panel together with flywheel shroud. Remove the rear end panel complete with fuel tank. Balance of shrouding can now be readily removed.

In Reassembly; use the *thin head* capscrews, for mounting the flywheel shroud, in the two holes close to the horizontal centerline. This is for *stator* clearance on engines with flywheel alternator.

FUEL TANK

If a side mount fuel tank is used, disconnect fuel line and remove tank assembly as illustrated in *Fig. 20.*

CARBURETOR AND MANIFOLD

The carburetor and manifold can be removed as a complete unit. *In reassembly;* tighten the manifold nuts to *18 ft. lbs. torque.* Tightening beyond specifications may cause the flanges to break.

CYLINDER HEAD

The cylinder head must be removed if it is necessary to regrind valves, or to work on the piston, rings or connecting rods. All of the cylinder head screws are plainly in view and can be easily removed. Screws of different lengths are used but these can be properly reassembled according to the various lengths of cylinder head bosses.

In reassembly; remove all carbon and lead deposits from combustion chamber. It is recommended that new cylinder head gaskets be used as the old gaskets will be compressed and hard and may not seal properly. Use a mixture of graphite and oil on the cylinder head screws to prevent them from rusting tight against the cylinder block. Tighten cylinder head screws to *24 ft. lbs. torque* in the sequence shown in *Fig. 21.* After complete assembly and engine is run in, retorque head screws.

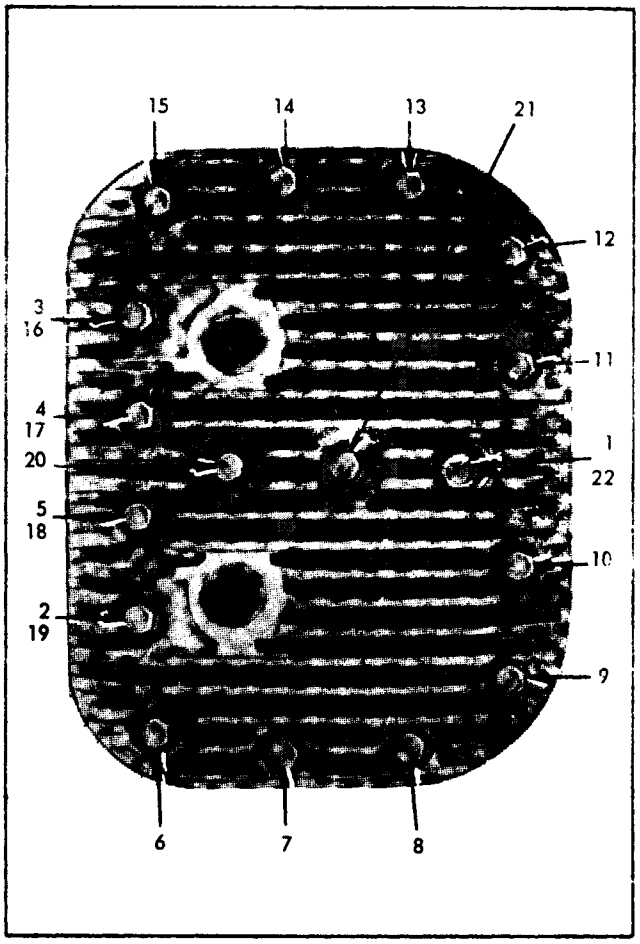


Fig. 21

GEAR COVER

Disconnect the governor linkage and remove governor housing and gear-flyweight assembly from shaft in gear cover. Take out the ten gear cover capscrews and drive out the two dowel pins as shown in *Fig. 23.* The cover can then be taken off – exposing the gear train as illustrated in *Fig. 24.*

In reassembly; inspect crankshaft oil seal and replace if necessary. Be sure that oil sling is in place on crankshaft, then mount gear cover using a new flange gasket. Tap the two dowel pins in place and mount capscrews. Tighten screws ***14*** to ***18 ft. lbs. torque.***

CAMSHAFT GEAR

If it is necessary that the camshaft gear be removed, first pry oil sling off crankshaft, and remove thrust plunger and spring from end of camshaft. Take out the three capscrews and lockwashers, and remove gear from camshaft using a screw driver or similar wedge tool.

The ***camshaft gear*** has offset mounting holes to provide accurate assembly for valve timing. The gear can only be put on the correct way for matching up the timing mark with that of the crankshaft gear. *See Fig. 24.*

IDLER GEAR AND SHAFT

A tapped hole in the side of the crankcase contains a setscrew for locking idler shaft in place. *See Fig. 25.* Remove screw with a 5/32" Allen wrench. Disassemble shaft and gear from case by means of the 3/8"-16 tapped puller hole in end of idler shaft.

In reassembly; be sure oil groove in shaft is facing up. Drive shaft into crankcase with soft metal hammer and maintain a ***.003*** to ***.004 inch*** clearance between idler gear and shoulder of shaft. Lock shaft in place with the Allen set screw.

OIL PAN

The engine can now be inverted so that the supports and oil pan can be removed, *see Fig. 26.*

In reassembly; tighten oil pan mounting screws, ***6*** to ***9 foot pounds torque.***



Fig. 23 71056C

OIL PUMP (Fig. 27)

Remove locknut and driver gear from shaft. If gear is too tight to remove by hand, use a puller, ***hammering*** on end of shaft to loosen gear will ***damage pump.***

Take out slotted pipe plug from bottom of crankcase. By means of a 5/32 inch Allen wrench, remove lockscrew from pipe plug hole. Withdraw oil pump from inside crankcase. If pump fits too tight to remove by hand, tap front of pump housing (not shaft), with hammer and brass rod.

PISTONS and CONNECTING RODS (Figs. 28, 29, 32)

By means of a 1/2" socket wrench, loosen and remove the hex locknuts from connecting rod bolts. Then, by tapping the ends of the bolts lightly, the connecting rod cap will break free from the bolts.

Scrape off all carbon deposits that might interfere with removal of pistons from upper end of cylinder. Turn

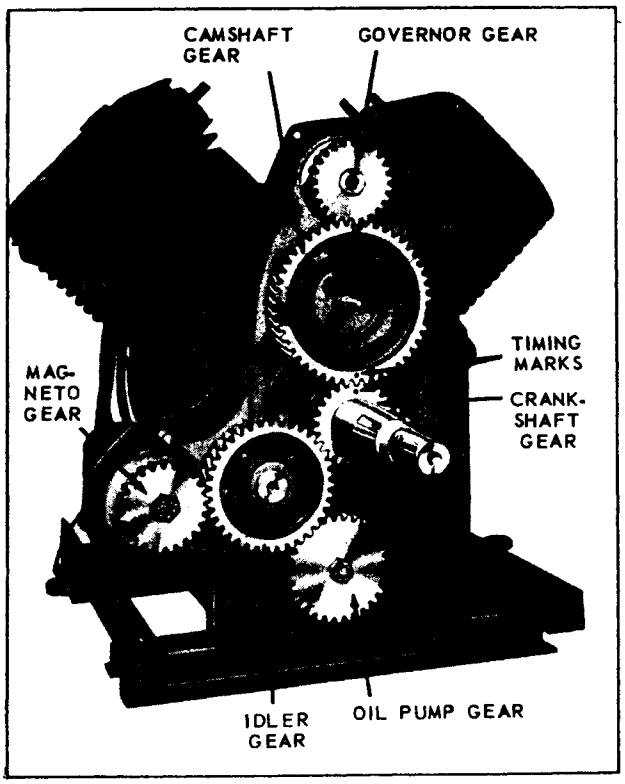


Fig. 24 104716C-1

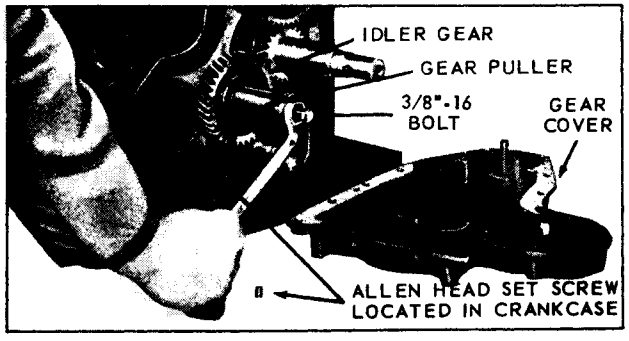


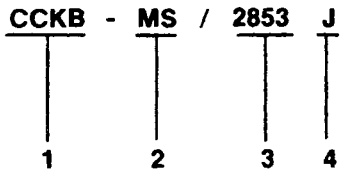
Fig. 25 71066C

GENERAL INFORMATION

ENGINE MODEL REFERENCE

Identify your model by referring to the MODEL and SPEC (specification) NO. as shown on the unit nameplate. Always use this number and the engine serial number when making reference to your engine.

How to interpret MODEL and SPEC NO.



1. Factory code for general identification purposes.
2. Specific Type:
   S - MANUAL STARTING
   MS - ELECTRIC STARTING
3. Factory code for optional equipment supplied.
4. Specification (Spec Letter) advances with factory production modification.

If your engine needs service or repair, contact an Onan Service Center. Trained mechanics will assure expert repair service on your Onan engine.

SPECIFICATIONS

Engine Design ..... Opposed two cylinder, four cycle, L head and air cooled
Bore ..... 3-¼ inch (82.55 mm)
Stroke ..... 3 inch (76.20 mm)
Displacement ..... 49.8 cu inch (816.22 cm³)
H.P. - Garden Tractor Service ..... 19-½ hp @ 3600 rpm; 20 hp max. @ 3900 rpm
Oil Capacity with Filter Change ... 4 qts. (3.78 lit)
Oil Capacity without Filter Change ..... 3-½ qts. (3.31 lit)

TUNE-UP SPECIFICATIONS

Spark Plug Gap ..... .025 (0.64 mm)
Breaker Point Gap (Gasoline) ..... .020 (0.51 mm)
Breaker Point Gap (LPG) ..... .018 (0.46 mm)
Valve Lash
  Intake ..... .006 to .008 (0.152 to 0.203 mm)
  Exhaust ..... .015 to .017 (0.381 to 0.432 mm)
Ignition Timing:
  Standard Electric Start (Stopped or Running) ..... 20° BTC
  Manual Start with Spark Advance ..... 1° ATDC (Stopped)
    24° BTC (Running)
  Electric Start with Magneto and Spark Advance ..... 5° (Stopped)
    24° BTC (Running)

OUT-OF-SERVICE PROTECTION

Protect an engine that will be out-of-service for more than 30 days as follows:

1. Run engine until thoroughly warm (5 to 10 minutes).
2. Turn off fuel supply and run until engine stops.
3. Drain oil from oil base while still warm. Refill and attach a warning tag stating oil viscosity used.
4. Remove spark plugs. Pour one ounce (two tablespoons) of rust inhibitor (or SAE #50 oil) into the cylinders. Crank engine over a few times. Install spark plugs.
5. Service air cleaner.
6. Clean governor linkage and protect by wrapping with a clean cloth.
7. Plug exhaust outlet to prevent entrance of moisture, dirt, bugs, etc.
8. Wipe entire unit. Coat rustable parts with a light film of grease or oil.
9. Provide a suitable cover for the entire unit.
10. If battery is used, disconnect and follow standard battery storage procedure.

RUNNING REPLACEMENT PARTS

Oil Filter	122-0323
Air Filter	140-0636
Spark Plugs—Non-Resistor	167-0241
Spark Plugs—Resistor	167-0237
Breaker Points	160-0002
Condenser (Breaker Box)	312-0069
Coil	166-0535

WARNING

ENGINE EXHAUST GAS (CARBON MONOXIDE) IS DEADLY!

Carbon monoxide is an odorless, colorless gas formed by incomplete combustion of hydrocarbon fuels. Carbon monoxide is a dangerous gas that can cause unconsciousness and is potentially lethal. Some of the symptoms or signs of carbon monoxide inhalation are:

- **Dizziness**
- **Intense Headache**
- **Weakness and Sleepiness**
- **Vomiting**
- **Muscular Twitching**
- **Throbbing in Temples**

If you experience any of the above symptoms, get out into fresh air immediately.

The best protection against carbon monoxide inhalation is a regular inspection of the complete exhaust system. If you notice a change in the sound or appearance of exhaust system, shut the unit down immediately and have it inspected and repaired at once by a competent mechanic.

PRE-START

BEFORE STARTING

Check the engine to make sure it has been filled with oil and fuel. The chart below lists oil and fuel recommendations.

Crankcase Oil: Fill the crankcase with a good quality oil that meets the API (American Petroleum Institute) service designation SE or SE/CC. Recommended oil numbers for expected ambient temperatures are as follows:

TEMPERATURE	GRADE
Below 0° F (18° C)	SAE 5W30
Below 32° F (0° C)	SAE 5W30 or 10W40
Above 32° F (0° C)	SAE 30

Fill to "Full" mark on dipstick.

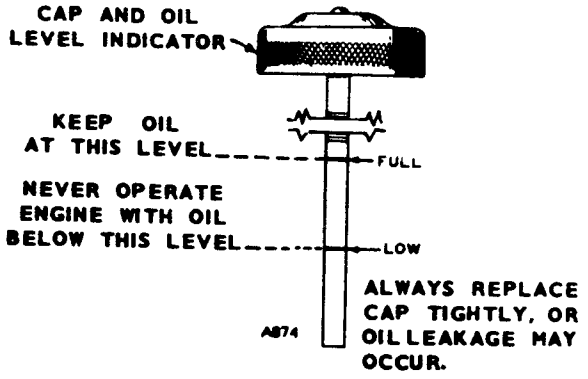
CAUTION **Do not overfill crankcase. Do not use service DS oil. Do not mix brands nor grades of motor oil.**

Refer to *Periodic Service* section for recommended oil change intervals.

Recommended Fuel: Use clean, fresh, non-leaded or regular grade, automotive gasoline. Do not use highly leaded premium types.

For new engines, the most satisfactory results are obtained by using nonleaded gasoline. For older engines that have previously used leaded gasoline, heads must be taken off and all lead deposits removed from engine before switching to nonleaded gasoline.

WARNING **Never check oil level while engine is running. Hot oil discharged from the engine could cause personal injury.**



CRANKCASE OIL FILL

CAUTION **If lead deposits are not removed from engine before switching from leaded to nonleaded gasoline, preignition could occur, causing severe damage to the engine.**

WARNING **Never fill the fuel tank when the engine is running. Gasoline could ignite, causing a serious injury.**

Inspection: Inspect the engine visually before starting. Check for loose or rnissing parts and any damage which may have occurred in shipment.

STARTING

If your engine has a START-RUN-STOP switch, press switch toggle to START, then release to RUN when engine starts. Press toggle to STOP, to stop engine.

1. Turn on ignition switch, pull the choke lever way out (for a cold engine) and push the start switch. When the engine starts, gradually push the choke lever in until the engine runs smoothly.
2. Black smoke from the exhaust and a rough running engine usually indicate over-choking.
3. To stop engine, turn ignition switch to off position.

OPERATION

BREAK-IN PROCEDURE

Controlled break-in with proper oil and a conscientiously applied maintenance program will help assure satisfactory service for many hours from your Onan engine.

Break-in or ideal fitting of all internal moving metal parts can best be achieved by maintaining proper cooling and correct lubrication during the running-in period. Run the engine at about half load for the first three hours with intermittent periods of full load to control engine break-in. Engine damage can be caused by using the wrong grade and weight of oil and high engine operating temperatures during break-in.

Check the oil level at least every five operating hours. Add oil to keep it at the proper level, but never overfill as overfilling may cause the oil to foam and enter the breather system.

HOT WEATHER OPERATION

When operating the engine in temperatures above 75° F (24° C) pay particular attention to the following items to prevent damage:

1. Keep the engine cooling fins clean and free of obstruction which would decrease air flow to and from the engine.
2. See that nothing obstructs air flow to and from the engine.
3. Ensure that you are using the proper grade and weight of oil for the temperature the engine is being used in. Check the oil level each time you fill the fuel tank.
4. Check the battery water level more frequently than every 50 hours which is recommended under normal conditions. High temperatures cause faster evaporation.

COLD WEATHER OPERATION

When the engine is being used in temperatures below 32° F (0° C), check the following items closely:

1. Use the correct grade and weight of oil for the temperature conditions. Change the oil only when the engine is warm. If an unexpected temperature drop occurs when the engine is filled with summer oil, move to a warm location until the oil will flow freely before starting the engine.
2. Use fresh fuel. Fill the fuel tank after each days use to protect against moisture condensation.
3. Keep battery in a well-charged condition.

MAINTENANCE

Oil Level: Check oil level at least every eight hours of operation. Check more frequently on a new or overhauled engine as oil consumption is higher until piston rings seat properly.

Oil Change: Change crankcase oil after the first 25 hours of operation; change every 50 hours after that. If operating in extremely dusty conditions, change oil more frequently.

Oil Filter (If Used): Replace oil filter every 100 hours; replace more often in dusty conditions. Tighten the filter finger-tight plus one quarter to one half turn. Be sure to replace rubber ring around filter.

Crankcase Breather: This engine uses a crankcase breather valve for maintaining crankcase vacuum. No maintenance is generally required. If the crankcase becomes pressurized as evidenced by oil leaks at the seals, clean the crankcase breather cap and valve assembly, and the breather tube baffle in suitable solvent. To remove breather cap and valve assembly, remove the breather hose clamp and breather tube clamp.

Moistened Foam Air Cleaner: This air cleaner consists of a synthetic sponge over a metal retainer. The base and cover are similar to those of the dry paper kind. Wash the sponge periodically, moisten in oil and squeeze dry.

Cooling System: Check and clean cooling fins at least every 50 hours. Remove any dust, dirt or oil which may have accumulated.

CAUTION **Plugged or clogged cooling fins can cause overheating and engine damage.**

Spark Plugs: Check, clean and reset spark plugs every 100 operating hours. Replace spark plugs that show signs of fouling or electrode erosion. Replace plugs every 250 operating hours.

Breaker Points: Check, clean and reset breaker points every 200 operating hours. Replace points if they are pitted or burned. See *ADJUSTMENT* section.

ADJUSTMENTS

CARBURETOR

The carburetor has an idle jet and a main jet. The idle jet which is adjustable, affects engine operation at low speed. The main jet usually affects operation under load (high speed). Under normal circumstances, factory carburetor adjustments should not be disturbed. If the idle adjustment has been disturbed, turn the needle (counterclockwise) off its seat 1 to 1-1/2 turns to permit starting the engine, then readjust as follows:

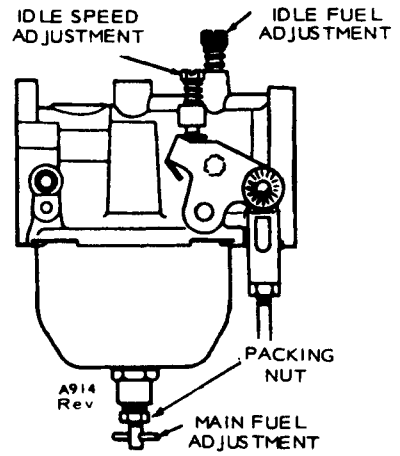
Carburetor Idle Adjustment

1. Allow the engine to run at least 10 minutes to warm it up.
2. Move engine speed control to SLOW position. The engine should run at about 1300 rpm.
3. Turn the idle needle out (counterclockwise) until engine begins to slow down or run unevenly. Remember this position.
4. Turn needle in (clockwise) past the position where the engine runs smoothly until it begins to slow down or run unevenly.

CAUTION **Do not force the needle against its seat; doing so will damage it.**

5. Back the needle out to a position approximately halfway between the two positions. This should provide a smooth running idle.

CAUTION **Loosen the packing nut before making main fuel adjustment and then tighten the nut to a snug fit after the adjustment has been made. This procedure makes it easier to use the carburetor adjusting tool and prevents fuel leaks around the packing nut. Fuel leaks cause hard starting because the float level becomes lower than normal.**



CARBURETOR ADJUSTMENTS

Carburetor Main (Load) Adjustment

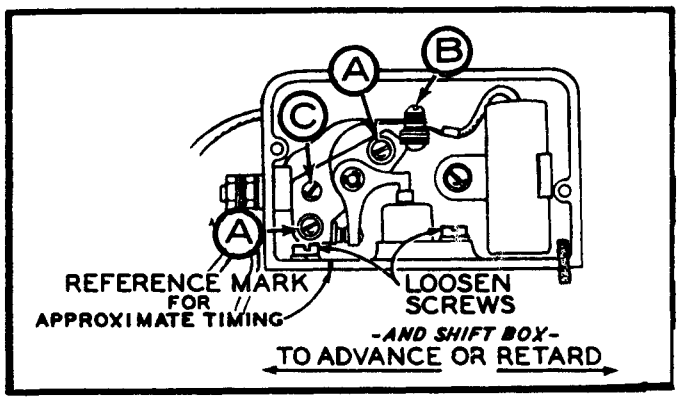
If engine runs unevenly at half or full load due to faulty carburetion, the main adjusting needle needs readjustment. For initial start-up, turn main adjustment 1 to 1-1/2 turns (counterclockwise) off its seat.

1. Start engine and allow it to warm up.
2. Push in on the governor mechanism to slow the unit down to about 400-500 rpm.
3. Set idle adjustment so engine runs smoothly.
4. Release governor mechanism to allow engine to accelerate. If engine accelerates evenly and without hesitation, main adjustment is correct. If not, turn needle outward about 1/2 turn and again slow the engine down and release the mechanism. Continue until the engine accelerates evenly and without hesitation after releasing the governor.
5. If engine tends to hunt (alternate increase and decrease of speed), open the main adjusting needle a little more. Do not open more than 1/2 turn beyond the maximum power point.

BREAKER POINTS

To maintain maximum efficiency from the engine, check condition of the breaker points every 200 hours of operation. Proceed as follows:

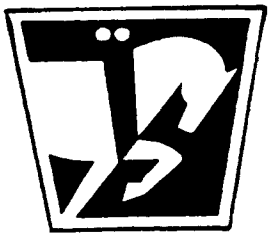
1. Remove the two screws and the cover on the breaker box.
2. Remove both spark plugs so engine can be easily rotated by hand. If plugs have not been changed within the last 100 hours, clean and regap or replace them with new ones after setting the breaker points.
3. Remove the two mounting screws (A) and pull the points out of the box just far enough so screw (B) can be removed. Replace points with a new set (if needed) but do not completely tighten mounting screws (A).
4. Rotate the engine clockwise (facing flywheel) by hand until TC mark on gear cover aligns with TC mark on flywheel. Turn screw (C) until point gap measures .020" (0.508 mm) with a flat thickness gauge.
5. Tighten mounting screws and recheck gap.



BREAKER POINT ADJUSTMENT

WISCONSIN *Air-Cooled*

Four Cylinder Engine





MARK INDUSTRIES
2662 East Del Amo Boulevard, Carson, CA 90746
Post Office Box 720, Long Beach, CA 90801

MO-630-11

STARTING AND OPERATING OF NEW ENGINES

Careful breaking in of a new engine will greatly increase its life and result in trouble-free operation. A factory test is not sufficient to establish the polished bearing surfaces, which are so necessary to the proper performance and long life of an engine. Neither is there a quick way to force the establishment of good bearing surfaces. These can only be obtained by running a new engine carefully and under reduced speeds and loads for a short time, as follows:

First, be sure the engine is filled to the proper level with a good quality of engine oil, see "Grade of Oil" chart.

Before a new engine is put to its regular work, the engine should be operated at low idle speed (1000 to 1200 R.P.M.) for one half hour, without load. The R.P.M. should then be increased to engine operating speed, still without load, for an additional two hours.

If at all possible, operate the engine at light loads, for a period totaling about eight hours, before maximum load is applied. This will greatly increase engine life.

The various bearing surfaces in a new engine have not been glazed, as they will be with continued operation, and it is in this period of "running in," that special care must be exercised, otherwise the highly desired glaze will never be obtained. A new bearing surface that has once been damaged by carelessness will be ruined forever.

Models
VH4 • VH4D

ISSUE MM-274-E

3-1/4" Bore – 3-1/4" Stroke
107.7 cu. in. Displacement

INTRODUCTION

This manual has been compiled to suit the service requirements of the basic engine and accessories most commonly supplied with the engine.

Teledyne Wisconsin adapts its engines to suit individual customer requirements whenever practical. However, it would become too involved to include all variations in one manual; therefore, should any problems arise concerning engine servicing, we advise that a Teledyne Wisconsin Distributor or authorized Service Center be contacted, as they are capable of identifying all parts by the specification number stamped on the name plate of engine.

A listing of approved Service Centers appears in the rear section of this manual.

WISCONSIN heavy duty air cooled engines are of the most advanced design and are built in a modern factory, equipped with the latest machinery available. Only the best materials, most suitable for the particular part, are used. During production, every part is subjected to the most rigid inspection, as are also the completely assembled engines. After assembly, every engine is operated on its own power and all adjustments are carefully made so that each engine will be in perfect operating condition when it leaves the factory.

Teledyne Wisconsin Motor is backed by over sixty years of engineering experience in the design of internal-combustion engines for every conceivable type of service. The performance of these engines is proof of the long satisfactory service you too can expect from your engine.

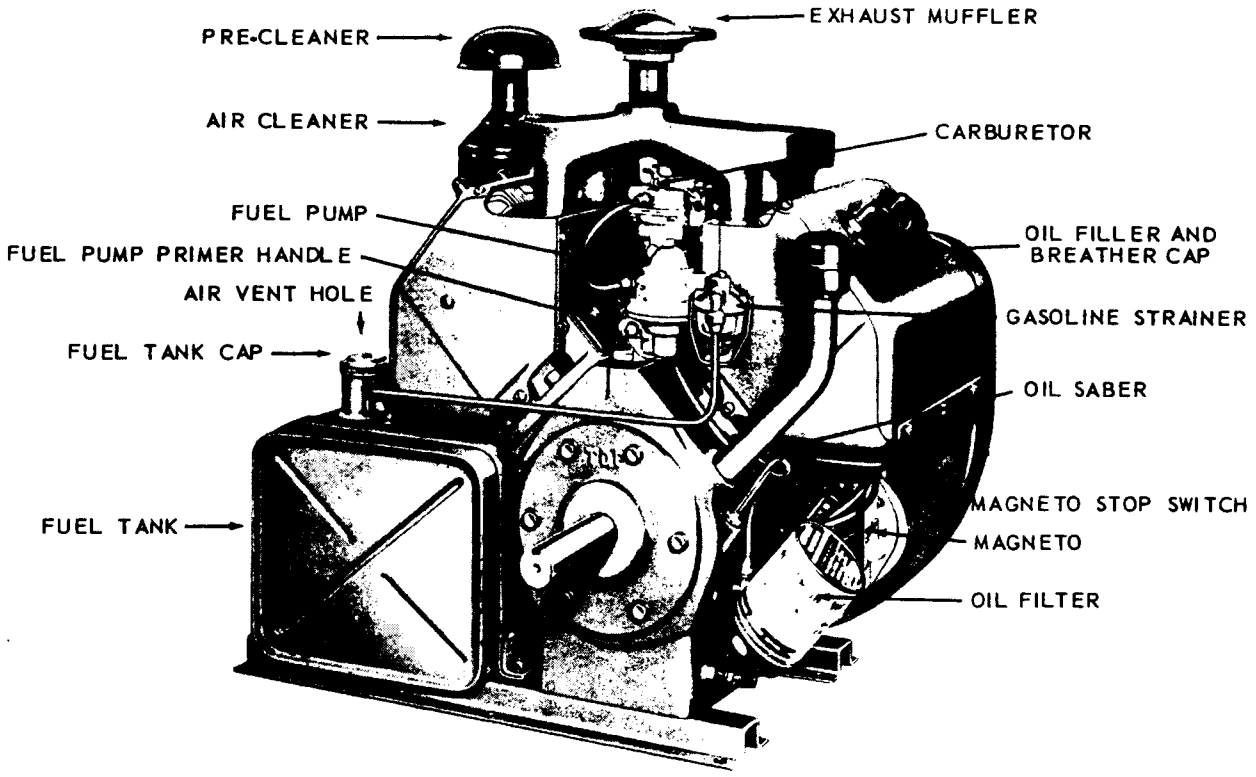
Like all fine machinery, the engine must be given regular care and be operated in accordance with the instructions.

SAFETY PRECAUTIONS

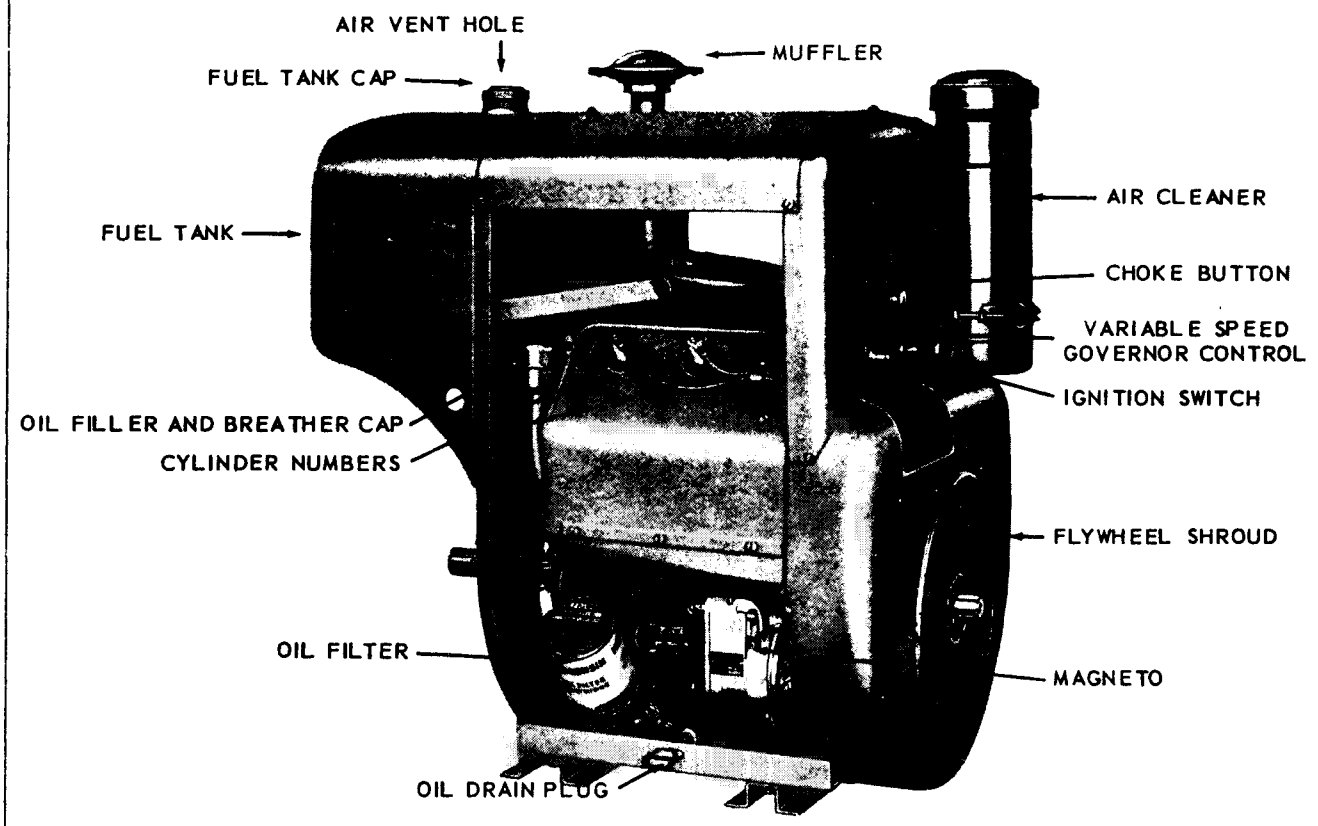
- Never fill fuel tank while engine is running or hot; avoid the possibility of spilled fuel causing a fire.
- Always refuel slowly to avoid spillage.
- When starting engine, maintain a safe distance from moving parts of equipment.
- Do not start engine with clutch engaged.
- Do not spin hand crank when starting. Keep cranking components clean and free from conditions which might cause the crank jaw to bind and not release properly. Oil periodically to prevent rust.
- Never run engine with governor disconnected, or operate at speeds in excess of 2800 R.P.M. load.
- Do not operate engine in a closed building unless the exhaust is piped outside. This exhaust contains carbon monoxide, a poisonous, odorless and invisible gas, which if breathed causes serious illness and possible death.
- Never make adjustments on machinery while it is connected to the engine, without first removing the ignition cable from the spark plug. Turning the machinery over by hand during adjusting or cleaning might start the engine and machinery with it, causing serious injury to the operator.
- Precaution is the best insurance against accidents.

Keep this book handy at all times, familiarize yourself with the operating instructions.

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TAKE-OFF (Side Mount Tank) VIEW OF ENGINE



POWER UNIT FAN END VIEW OF ENGINE

218641C-1
218642C-1

Fig. 1

MODEL VH4 OPEN ENGINE AND POWER UNIT

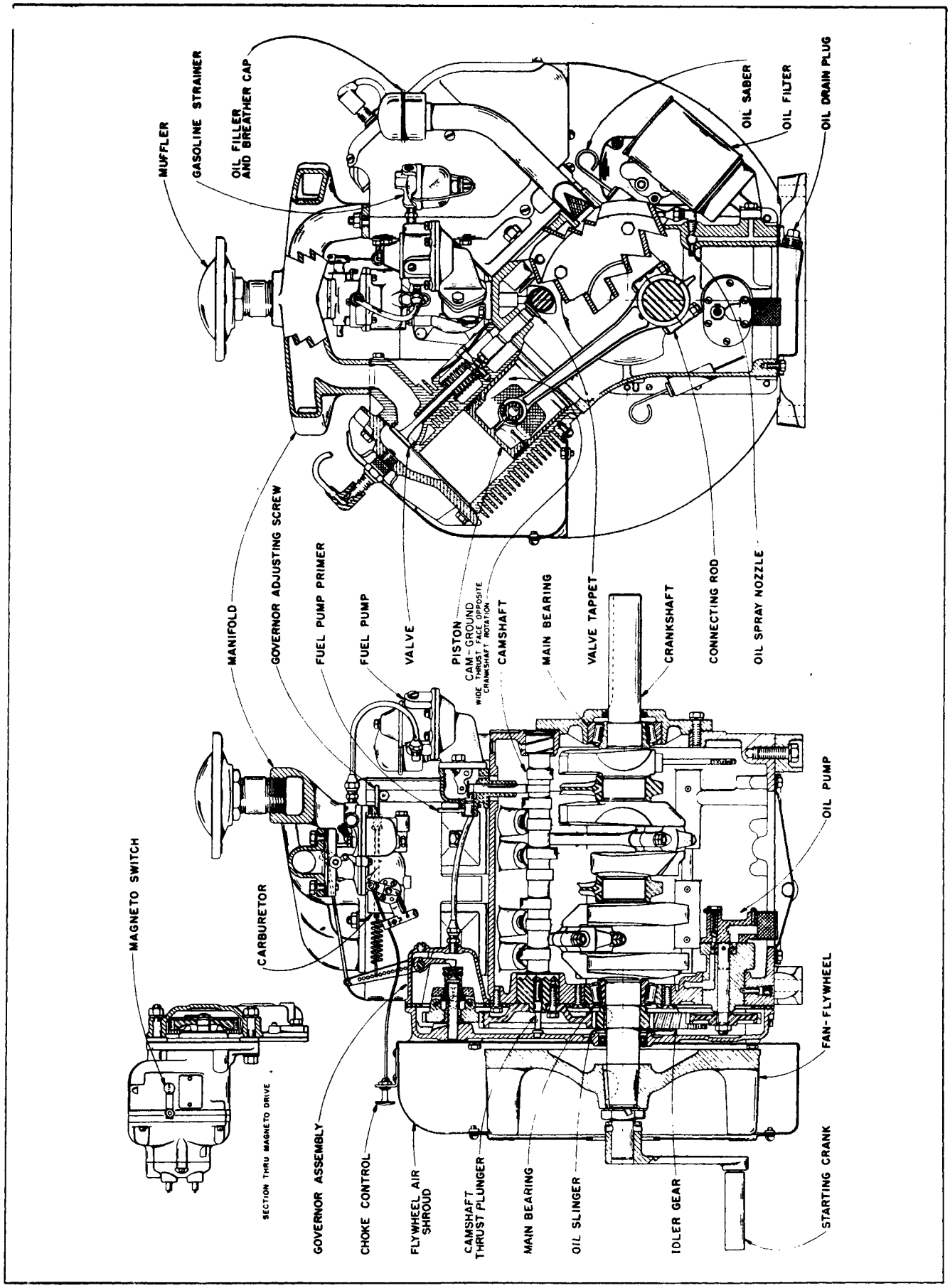
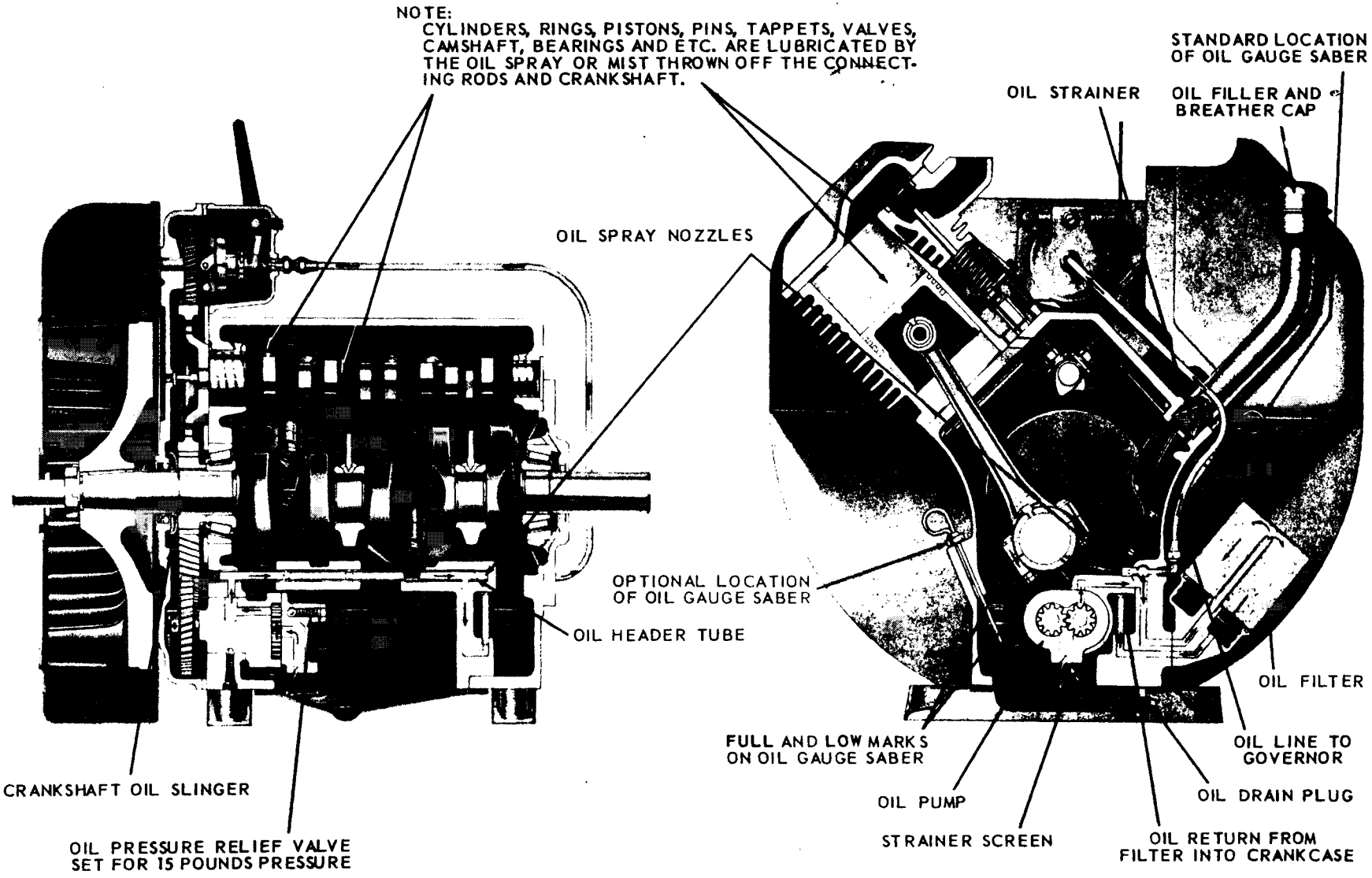


Fig. 2
CROSS SECTION OF ENGINE MODEL VH4

Fig. 3



WITH ENGINE AT OPERATING TEMPERATURE, OIL PRESSURE IN HEADER WILL BE APPROXIMATELY 5 POUNDS. AN OIL PRESSURE GAUGE IS NOT REQUIRED.

166738CA

166737CA

GENERAL INFORMATION and DESIGN

Wisconsin engines are of the *four cycle* type, in which each of the four operations of *suction, compression, expansion* and *exhaust* requires a complete stroke. This gives one power stroke per cylinder for each two revolutions of the crankshaft.

COOLING

Cooling is accomplished by a flow of air, circulated over the cylinders and heads of the engine, by a combination fan-flywheel encased in a sheet metal shroud. The air is divided and directed by ducts and baffle plates to insure uniform cooling of all parts.

Never operate an engine with any part of the shrouding removed – this will retard air cooling.

Keep the cylinder and head fins free from dirt and chaff. Improper circulation of cooling air will cause engine to overheat.

CARBURETOR

The proper combustible mixture of gasoline and air is furnished by a balanced carburetor, giving correct fuel to air ratios for all speeds and loads.

IGNITION SYSTEM

The spark for ignition of the fuel mixture is furnished by a high tension magneto driven off the timing gears at crankshaft speed. The magneto distributor rotor turns at half-engine speed. The magneto is fitted with an impulse coupling, which makes possible a powerful spark for easy starting. Also, the impulse coupling automatically retards the spark for starting, thus eliminating possible kick back from engine while cranking.

Battery ignition (12 volt); distributor is furnished in place of magneto on engines equipped with flywheel alternator or belt driven generator. *See Page 12.*

LUBRICATION SYSTEM (Fig. 3)

A gear type pump supplies oil to four nozzles which direct oil streams against fins on the connecting rod caps. Part of the oil enters the rod bearing through holes in the rods, and the balance of the oil forms a spray or mist which lubricates the cylinder walls and other internal parts of the engine. An external oil line from the oil header tube in the crankcase lubricates the governor and gear train.

GOVERNOR

A governor of the centrifugal flyweight type maintains the engine speed by varying the throttle opening to suit the load imposed upon the engine. These engines are equipped with either a ***fixed speed*** governor, a ***variable speed control*** to regulate the governed speed of the engine, or an ***idle control.***

ROTATION

The rotation of the crankshaft is clockwise when viewing the flywheel or cranking end of the engine. This gives ***counter-clockwise rotation*** when viewing the power take-off end of the crankshaft. The flywheel end of the engine is designated the ***front end,*** and the power take-off end, the ***rear end*** of the engine.

R.P.M.	HORSEPOWER
1400	17.2
1600	20.0
1800	22.5
2000	24.7
2200	26.5
2400	28.0
2600	29.2
2800	30.0

HORSEPOWER

Horsepower specified in the accompanying chart is for an atmospheric temperature of 60° Fahrenheit at sea level and at a Barometric pressure of 29.92 inches of mercury.

For each inch lower the Barometric pressure drops, there will be a loss in horsepower of 3½%.

For each 10° temperature rise there will be a reduction in horsepower of 1%.

For each 1000 ft. altitude above sea level there will be a reduction in horsepower of 3½%.

The friction in new engines cannot be reduced to the ultimate minimum during the regular block test, but engines are guaranteed to develop at least 85 per cent of maximum power when shipped from the factory. The power will increase as friction is reduced during the first few days of operation. The engine will develop at least 95% of maximum horsepower when friction is reduced to a minimum.

For continuous operation, allow 20% of horsepower shown as a safety factor.

STARTING and OPERATING INSTRUCTIONS

Engines that are enclosed in a sheet metal house, as shown in bottom view of *Fig. 1,* are called ***power units.*** Others are furnished without a house, as shown in top view of *Fig. 1,* and are called ***open engines.***

On engines with a house, the side doors must always be removed when operating.

This is necessary for circulating sufficient air for cooling the engine.

LUBRICATION

Before starting a new engine, fill the oil base with good "gasoline engine" oil, as specified in the "Grade of Oil" chart. Fill through the breather tube shown in *Fig. 3,* with 4 quarts of oil.

For ***run-in of new engines,*** use same oil as recommended in *Grade of Oil Chart.*

After the engine has been run for a short time, the oil lines and oil filter will have been filled with oil. Shut

GRADE OF OIL

SEASON OR TEMPERATURE	GRADE OF OIL
Spring, Summer or Fall + 120°F to + 40°F	SAE 30
Winter + 40°F to + 15°F + 15°F to 0°F Below Zero	SAE 20-20W SAE 10W SAE 5W-20
Use oils classified as Service MS, SD or SE	

Crankcase Capacity	New engine	4 Qts.
	Oil and filter change	4 Qts.
	Less – filter or filter change	3½ Qts.

off the engine and check the oil level by means of ***dip stick*** (oil gauge saber). If necessary, add enough oil to bring level up to the ***full mark.*** The standard dip stick location is below the oil filler-breather tube, but can be located on starting motor side upon request.

Use only high-grade highly refined oils, corresponding in body to the S. A. E. (Society of Automotive Engineers) Viscosity Numbers listed in *Grade of Oil Chart.*

SERVICE CLASSIFICATION OF OIL

In addition to the S.A.E. Viscosity grades, oils are also classified according to severity of engine service. Use oils classified by the American Petroleum Institute as ***Service MS, SD*** or ***SE.*** These types of oil are for engines performing under unfavorable or severe operating conditions such as: high speeds, constant starting and stopping, operating in extreme high or low temperatures and excessive idling.

Follow summer recommendations in winter if engine is housed in warm building.

Check oil level every 8 hours of operation.

The old oil should be drained and fresh oil added after every 50 hours of operation.

To drain oil, remove drain plug illustrated in *Fig. 3.* Oil should be drained while engine is hot, as it will then flow more freely.

OIL PRESSURE

At engine operating temperature, the oil pressure will be about 4 to 5 pounds per square inch, and due to this low pressure system, an oil pressure gauge is not required. When the engine is cold the pressure will be higher, and a relief valve is fitted to the oil pump so that under these conditions the maximum pressure will be limited to 15 pounds.

FUEL

These engines can be furnished with either a gravity feed tank mounted above the carburetor fuel level, a side mount tank, or tank mounted below the engine. In the latter two cases, a fuel pump is furnished.

The fuel tank should be filled with a ***good quality*** gasoline free from dirt and water. The capacity of the tank is approximately 6 gallons. Some of the poorer grades of gasoline contain gum which will deposit on valve stems, piston rings, and in the various small passages in the carburetor, causing serious trouble in operating and in fact might prevent the engine from operating at all.

Use only reputable, well known brands of REGULAR GRADE gasoline.

The gasoline should have an octane rating of at least 90. Low octane gasoline will cause the engine to detonate, or *knock*, and if operation is continued under this condition, cylinders will score, valves will burn, pistons and bearings will be damaged, etc.

Be sure that air vent in tank cap is not plugged with dirt, as this would prevent fuel from flowing to the carburetor.

FUEL PUMP and PRIMING (Fig. 4)

The diaghragm type fuel pump, furnished on engines with side mount or underslung fuel tanks, is actuated by an eccentric on the camshaft, as illustrated in cross section of engine, *Fig. 2.*

Hand Primer for ***hand crank engine*** is an accessory furnished only upon request, and is a necessary function when starting a new engine for the first time, or when engine has been out of operation for a period of time. Gravity feed and electric start engines do not require hand priming.

When priming, a distinct resistance of the fuel pump diaghragm should be felt when moving the hand lever up and down. If this does not occur, the engine should be turned over one revolution so that the fuel pump drive cam will be rotated from its upper position which prevents movement of the pump rocker arm.

Assuming the gasoline strainer is empty, approximately 25 strokes of the primer lever are required to fill the bowl. *See Fig. 4.* After strainer bowl is full, an additional 5 to 10 strokes are required to fill the carburetor bowl. When carburetor is full the hand primer lever will move more easily.

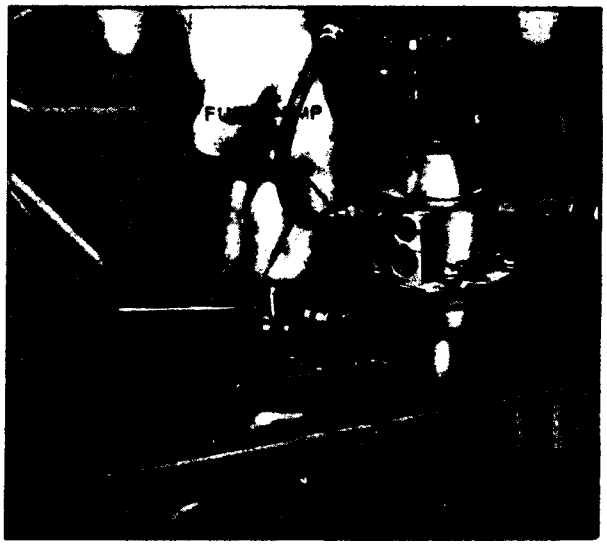


Fig. 4 83622C

IGNITION SWITCH

Magneto ignition is standard on these engines, with a lever type switch on the side of the magneto, which is always in the **on** or running position, except when depressed for stopping the engine. *See top view of Fig. 1.*

On power unit engines, a push button ignition switch is mounted on the outside of the house panel at the flywheel end. *See bottom view of Fig. 1.* When starting engine, the ignition switch button is ***pulled out.*** To stop, ***push in.*** This will apply to both ***magneto*** and ***battery ignition*** systems.

STARTING

STARTING PROCEDURE

1. Check crankcase oil level and gasoline supply. Open shut-off valve in fuel strainer.
2. Disengage clutch, if furnished.
3. New engines may require priming; refer to "Fuel Pump" paragraph for instructions.
4. Set throttle about 1/2 open if a variable speed control is furnished; with a two-speed control, start in full load position – idle after engine starts.
5. Pull out ignition switch button, if applicable (switch tag reads "To Stop Push In"). Refer to *Ignition Switch* paragraph.
6. Close carburetor choke by pulling choke button to extreme out position.
7. Turn engine over slowly one or two revolutions. *Caution:* Be sure that crank does not bind. Push choke button in about half-way and then pull up briskly on the starting crank. ***Do not*** attempt to ***spin*** the engine with the starting crank. If the engine does not start on the first pull up of crank, re-engage the crank and repeat the operation.
   With electric starting motor; depress starter button in place of hand cranking.
8. After engine starts, push choke button in gradually as required for smooth running. Choke must be completely open (button in) when engine is warmed up.

If flooding should occur, open choke fully by pushing choke button in and continue cranking. Less choking is necessary in warm weather or when engine is warm, than when cold.

If all conditions are right, engine will start promptly after one or two attempts. Allow engine to warm up a few minutes before applying load, as prescribed in '***Warm-Up Period***' paragraphs.

New engines should be "run-in" gradually to insure trouble-free service. Refer to "*Starting and Operation of New Engine*", on the inside front cover of this manual, for correct "running-in" procedure.

WARM-UP PERIOD

The engine should be allowed to warm up to operating temperature before load is applied. This requires only a few minutes of running at moderate speed. ***Racing an engine*** or ***gunning it,*** to hurry the warm-up period, ***is very destructive*** to the polished wearing surfaces on pistons, rings, cylinders, bearings, etc., as the proper oil film on these various surfaces cannot be established until the oil has warmed up and become sufficiently fluid. This is especially important on new engines and in cool weather.

Racing an engine by disconnecting the governor, or by doing anything to interfere with the governor controlled engine speed, ***is extremely dangerous.*** The governor is provided as a means for controlling the engine speed to suit the load applied, and also as a safety measure to guard against excessive speeds, which not only overstrain all working parts, but which might cause wrecking of the engine and possible injury to bystanders.

All parts of the engine are designed to safely withstand any speeds which might normally be required, but it must be remembered that the stresses set up in rotating parts, increase with the square of the speed. That means that if the speed is doubled the stresses will be quadrupled; and if the speeds are trebled, the stresses will be nine times as great.

Strict adherence to the above instructions cannot be too strongly urged, and greatly increased engine life will result as a reward for these easily applied recommendations.

STOPPING ENGINE

Magneto ignition engines, less house, have a lever type stop switch on the side of the magneto. On these, ***to stop engine,*** depress lever and ***hold down until engine stops.***

Power units and battery ignition engines, are furnished with an ignition switch, "*To Stop Push In*".

If the engine has been running hard and is hot, do not stop it abruptly from full load, but remove the load and allow engine to run idle at 1000 to 1200 R.P.M. for three to five minutes. This will reduce the internal temperature of the engine much faster, minimize valve warping, and of course the external temperature, including the manifold and carburetor will also reduce faster, due to air circulation from the flywheel.

Two main troubles resulting from abruptly shutting off a hot engine are ***vapor lock*** and ***dieseling.*** Vapor lock will prevent the flow of fuel in the fuel lines and carburetor passages, which will result in hard starting. This can be overcome by choking the engine when cranking or waiting until the engine has cooled off sufficiently to overcome the vapor lock.

Dieseling, is caused by the carbon and lead deposits in the cylinder head being heated up to such an extent that they continue to fire the engine and keep it running after the ignition has been shut off. By idling the engine, as previously mentioned, the carbon and lead deposits cool off, break up and will blow out thru the exhaust. If engine has a tendency to diesel, by suddenly setting the throttle wide open and at the same time shutting off the ignition, the engine will stop.

MAINTENANCE

OIL FILTER

A ***by-pass*** type oil filter is furnished on these engines, as shown in *Fig. 3*, except in a few cases where the use of other accessories prevents the mounting of an oil filter. The oil ***filtering cartridge should be replaced after every other oil change.*** If operating conditions are ***extremely dusty,*** replace cartridge after ***every oil change.***

AIR CLEANERS

The air cleaner is an essential accessory, filtering the air entering the carburetor and preventing abrasive dirt from entering the engine and wearing out valves and piston rings in a very short time.

The air cleaner must be serviced frequently, depending on the dust conditions where engine is operated. Check hose connections for leaks or breaks; replace all broken or damaged hose clamps.

Excessive smoke or loss of power are good indications the air cleaner requires attention.

The ***oil bath*** type air cleaner, illustrated in *Fig. 5* is standard equipment on power units. On open engines, the oil bath air filter furnished is illustrated in *Fig. 6.* A ***dry element air cleaner*** is optionally available for both power unit and open engine.

OIL BATH AIR CLEANER (Fig. 5)

Service daily or twice a day; if engine is operating in very dusty conditions. ***Once each week;*** in comparatively clean conditions.

Remove oil cup from bottom of air cleaner and clean thoroughly. Add fresh oil to the ***level line*** indicated on cup, using the same grade oil as used in engine crankcase.

Operating the engine under dusty conditions without oil in the air cleaner or with dirty oil, may wear out cylinders, pistons, rings and bearings in a few days time, and result in costly repairs.

Once a year; or oftener in very dusty conditions, the air cleaner should be removed from the engine and the element, which is not removable, should be washed in a solvent to clean out accumulated dust and dirt.

DRY ELEMENT AIR CLEANER

Service daily; squeeze rubber dust unloader once or twice a day to check for possible obstruction. If engine is operating in very dusty conditions, remove cartridge and shake out accumulated dirt.

Once each week; the filtering cartridge should be taken out and either dry-cleaned with compressed air or washed by repeated dipping for several minutes in a solution of lukewarm water and a mild ***non-sudsing*** detergent. Rinse in cold water from the inside out and allow to dry overnight before installing.

Do not use gasoline, kerosene or solvent for cleaning. – Do not oil element.



Fig. 5 104577C

After ten washings or one year of service, whichever comes first, replace cartridge.

PRE-CLEANER (Fig. 6)

The collector type pre-cleaner, mounted to the top of the air cleaner, removes the larger dirt and dust particles before the air reaches the main air cleaner.

Daily; clean bowl of accumulated dust and dirt. ***Do not use oil or water in pre-cleaner. This must be kept dry.***

FUEL STRAINER (Fig. 7)

A fuel strainer is very necessary to prevent sediment, dirt and water from entering the carburetor and causing trouble or even complete stoppage of the engine. The strainer has a glass bowl and should be inspected frequently and cleaned if dirt or water are present. To remove bowl, first shut off fuel valve, then loosen the knurled nut below bowl and swing the wire bail to one side. After cleaning bowl and screen, reassemble the parts, being sure the gasket

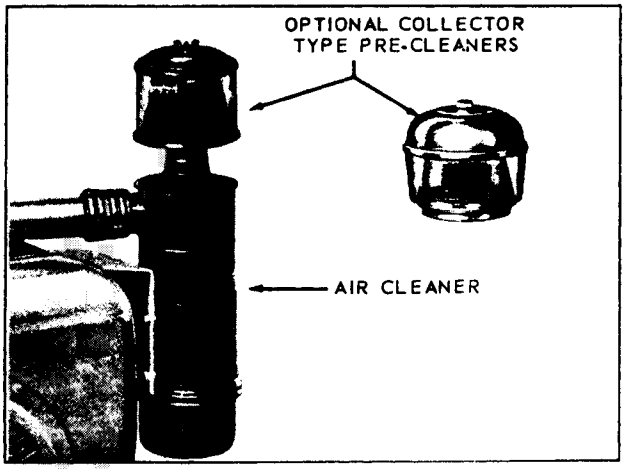


Fig. 6 217102C



Fig. 7 71051C

is in good condition; otherwise use a new gasket. *See Fig. 7*, which shows the strainer mounted to the fuel tank of a power unit. On open engines, the strainer is mounted to the inlet of the fuel pump.

CARBURETOR ADJUSTMENT

The main metering jet in the carburetor is of the fixed type, that is, it requires no adjustment. The idle needle should be adjusted for best low speed operation, while carburetor throttle is closed by hand. For illustrations and more information, see Carburetor Manufacturer's Instruction Bulletin in the back of this manual.

MAGNETO BREAKER POINT ADJUSTMENT

Magnetos are properly adjusted before leaving factory. The ***breaker points*** on the Fairbanks-Morse magneto and on the Wico magneto should be .015" at full separation. If the spark becomes weak after continued operation, it may be necessary to readjust these points. To do this first remove the end cover on the magneto. The crankshaft should then be rotated with the starting crank, (this also rotates the magneto), until the breaker points are wide open. The opening or gap should then be measured with a feeler gauge as shown in *Fig. 8* and if necessary reset. To readjust points, first loosen the ***locking screws*** on the ***contact plate*** enough so that the plate can be moved. Insert the end of a small screw driver into the ***adjusting slot*** at the bottom of the ***contact plate*** and open or close the contacts by moving the plate until the proper opening is obtained. *See Fig. 9*. After tightening the locking screws, recheck breaker point gap to make sure it has not changed. If it is found that the breaker points have become rough, they should be smoothed with a breaker point file before the preceding adjustments are made. Replace magneto end cover carefully

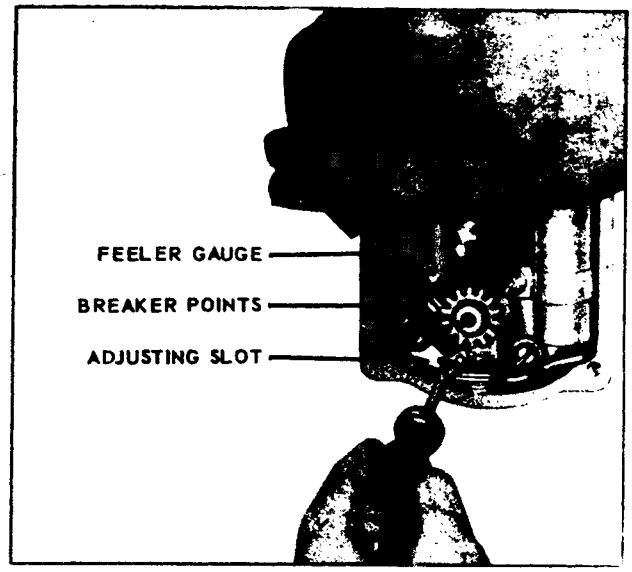
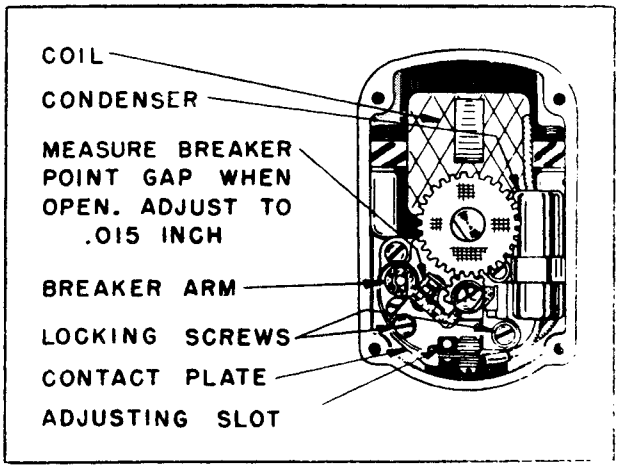


Fig. 8 208070C



OPEN END VIEW OF FAIRBANKS-MORSE MAGNETO
Fig. 9

so that it will seal properly. Do not force cover screws too tightly otherwise cover may crack. For further information, see Fairbanks-Morse or Wico Magneto Maintenance Manual in the back of this manual.

MAGNETO IGNITION SPARK

If difficulty is experienced in starting the engine or if engine misses firing, the strength of the ignition spark may be tested by disconnecting the No. 1 ignition cable from the spark plug and holding the terminal about 1/8 inch away from the air shroud or any other conveniently located metal part of the engine. If the ignition cables have a molded rubber insulated spark plug terminal at the end, as illustrated in *Fig. 10*, wedge a piece of bare wire up into the terminal and let one end of the wire extend out. Turn the engine over slowly by the starting crank two complete revolutions and watch for a strong spark discharge, which should occur during the cycle at the instant the impulse coupling on the magneto snaps. Repeat this check with each of the other ignition cables. If there is a weak spark, or none at all, check breaker point opening as mentioned in preceding paragraph under

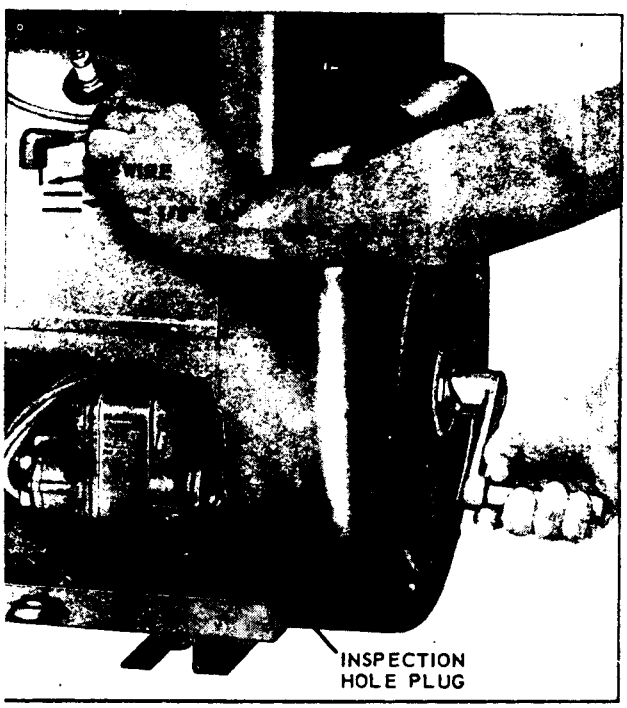


Fig. 10 104816C-1

"Magneto Breaker Point Adjustment". If this does not remedy the trouble, it may be necessary to install a new condenser. See Magneto Manufacturer's Maintenance Instructions in back of this manual.

FIRING ORDER

The ***firing order*** of the cylinders is ***1-3-4-2***, and the magneto and battery type distributor rotate at one-half engine speed, as is the case with conventional *"in line"* engines. The intervals between the firing of the cylinders is 180°. No. 1 cylinder is the one nearest to the flywheel in the left bank of cylinders, when viewed from the flywheel end of the engine. No. 3 cylinder is the other cylinder in this bank. No. 2 cylinder is the one nearest to the flywheel in the right bank of cylinders and No. 4 is the other cylinder in this bank. The cylinders are numbered from 1 to 4 on the air shroud near the spark plugs. The flywheel end of the engine is designated the ***front*** and the power take-off end, the ***rear*** of the engine.

MAGNETO TIMING

The proper spark advance is ***23°***. To check timing with a ***neon light***, the running spark advance is indicated by a 3/8 inch slotted hole in the rim of the air intake screen, 68° left of the flywheel shroud vertical centerline, ***marked VH***, or if screen is removed, time to the ***lower half*** of the 1/4 inch elongated hole on the face of flywheel shroud 23° below the centerline of No. 1 and No. 3 cylinders as illustrated in *Fig. 11.* The end of the ***'X'*** marked vane should be whitened with chalk or paint for this operation.

To Time Magneto to Engine: Remove air intake screen to expose ***timing marks*** on both flywheel and shroud. *See Magneto Timing Diagram, Fig. 11.*

Next, remove the spark plug from No. 1 cylinder and slowly turn the flywheel clockwise, at the same time holding a finger over the spark plug hole, so that the compression stroke can be determined from the air blowing out of the hole.

The flywheel is marked with the letters ***'DC'*** near one of the air circulating vanes. This vane is further identified by an ***'X'*** mark cast on the end. *See Fig. 11.* When the air blows out of the No. 1 spark plug hole, continue turning the crank until the edge of the ***marked vane*** on flywheel is on line with the ***mark*** on the ***vertical centerline*** of the ***shroud*** as shown on *Fig. 11.* Leave flywheel in this position. At this point the ***keyway*** for mounting the flywheel is also on top. Reassemble spark plug.

Next, remove the inspection hole plug from the magneto timing opening, located in the gear cover as shown in *Fig. 10.*

Assuming that the magneto has been removed from the engine, the following procedure should be followed before remounting.

The Number 1 cylinder firing position of the magneto must be determined. Insert the ignition cable into the No. 1 tower terminal of the magneto end cap and hold the spark plug terminal at the other end, about 1/8" away from the magneto body. Turn the magneto gear in a clockwise rotation, tripping the impulse coupling, until the No. 1 terminal sparks, then hold the gear in this position. Mount the magneto to the engine, meshing the gears so that when the magneto is in place, the gear tooth marked with an ***'X'*** will be visible through the ***lower half*** of the ***inspection hole*** in the gear cover, as shown in *Timing Diagram, Fig. 11.* Tighten the nut and capscrew for mounting the magneto to the gear cover, making sure the magneto flange gasket is in place.

The ***No. 1*** terminal is identified on the magneto cap. The terminals follow the proper firing order of 1-3-4-2 in a clockwise direction viewing the cap end. The leads from the magneto should be connected to spark plugs of corresponding numbers.

No. 1 cylinder is the cylinder nearest the fan-flywheel of the engine in the left bank and No. 3 cylinder is the other cylinder in that bank. No. 2 cylinder is across the engine from No. 1 and No. 4 is across from No. 3.

When the magneto is properly timed the impulse coupling will snap when the ***'DC'*** and ***'X'*** marked vane of the flywheel, line up with the ***mark*** on the flywheel shroud which indicate the ***centerline*** of the No. 1 and 3 cylinders. This can be checked by turning crankshaft over slowly by means of a hand crank. The impulse will also snap every 180° of flywheel rotation thereafter.

DISTRIBUTOR – BATTERY IGNITION

On engines equipped with Flywheel Alternator or direct mounted Generator, battery ignition is used in place of magneto ignition. The distributor is of the automatic advance type, and rotor turns at ***one-half engine speed*** in a counter-clockwise direction. As

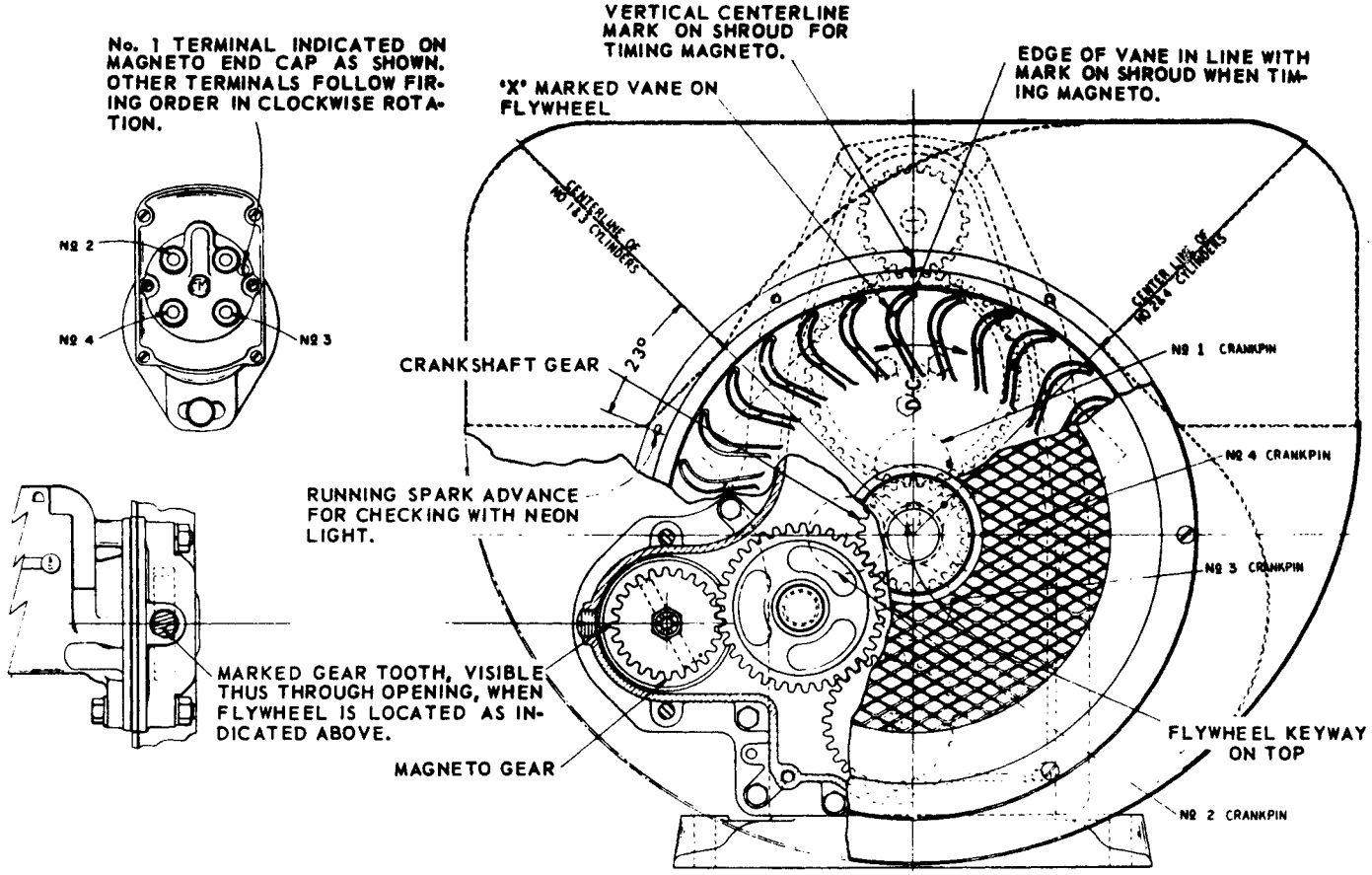


Fig. 11, MAGNETO TIMING DIAGRAM

illustrated in *Fig. 15*, the distributor is mounted to the end of the generator – with Flywheel Alternator it is mounted to an adapter attached to the gear cover, or Top Mounted – attached to the governor housing.

The ***spark advance*** for normal speeds is 23°, the same as for magneto ignition. ***Engine must be running at 2000 R.P.M. or over when adjusting spark advance.***

ELECTRICAL WIRING CIRCUITS

NOTE: Beginning with engine serial No. 3987113, the standard wiring circuits for all ***12 volt*** electrical equipment is ***negative ground polarity,*** in place of the previously furnished positive ground. All ***6 volt*** systems remain positive ground.

The Flywheel Alternator circuit illustrated in *Fig. 12* always was and is a negative ground system. It replaces the previously furnished gear driven generator which was available both negative and positive ground.

Wiring diagram and service parts information for ***obsolete*** gear driven type generator can be obtained by writing to Teledyne Wisconsin Motor, Product Support Center, Milwaukee, Wisconsin 53219.

DISTRIBUTOR TIMING

A slotted opening has been added to the rim of the flywheel screen to check ***running spark advance*** without removing screen. To make a ***stationary check*** of the timing–remove the screen over the flywheel air intake opening by taking out the screws holding the screen in

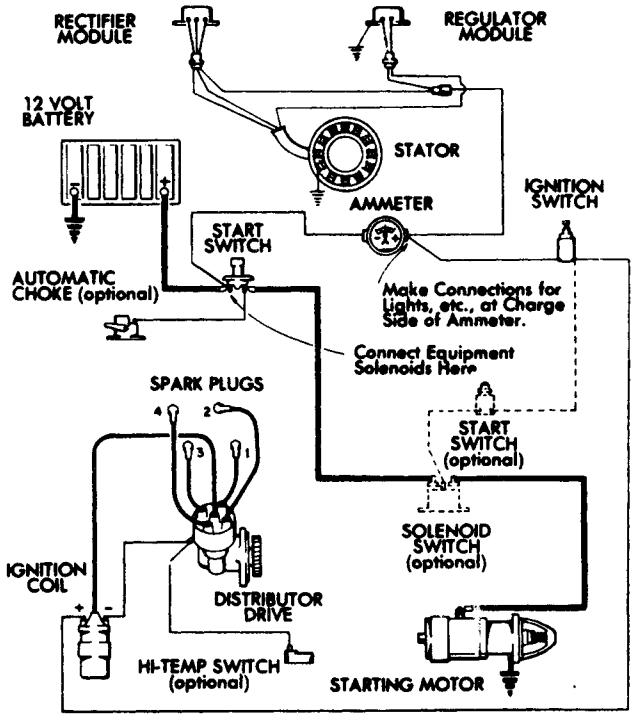


Fig. 12, WIRING DIAGRAM, Flywheel Alternator and Battery Ignition

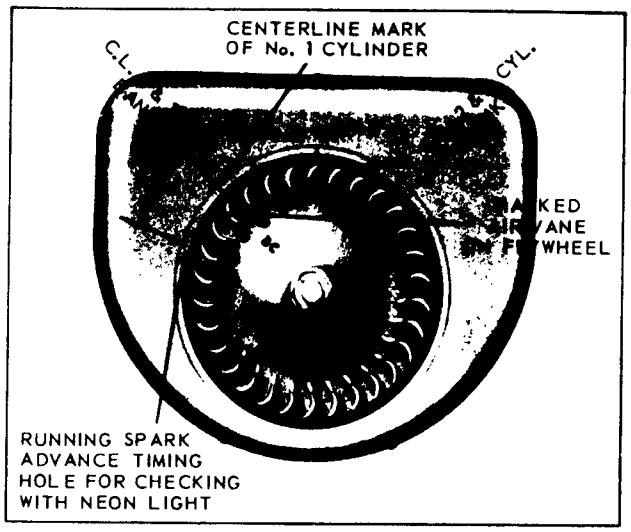


Fig. 13 78399C-1B

place. This will expose the timing marks on the fly wheel shroud, also the ***vane*** on flywheel, marked by an ***'X'*** and the letters ***'DC'***. *See Fig. 13.* Next, remove the spark plug from No. 1 cylinder and turn the engine over slowly by the starting crank, at the same time holding a finger over the spark plug hole, so that the compression stroke can be determined from the air blowing out of the hole.

Upon reaching the compression stroke, continue turning the starting crank until the leading edge of the ***marked vane*** on the flywheel is in line with the ***centerline mark*** on the flywheel shroud of the ***No. 1*** cylinder. The No. 1 piston is on top dead center in the position shown in *Fig. 13.* Reassemble spark plug.

Remove the upper half of the distributor body by disengaging snap springs. The ***centerline*** of the ***distributor rotor*** should be in line with the ***center*** of the ***notch*** in the distributor housing. No. 1 cylinder is ready to fire in the retarded timing position, when the distributor rotor is in this position, as shown in *Figs. 14* and *15.* If the distributor rotor is not in the above mentioned position, withdraw the entire distributor from the generator. Remove the distributor rotor in order to take off the dust cover from the distributor body, which will expose the breaker points. Mount rotor back on distributor shaft. Assemble distributor with the ***distributor rotor*** in line with the ***notch*** in the distributor housing as shown in *Fig. 14,* and the ***primary terminal*** pointing toward the generator ***circuit breaker.*** *See Fig. 15.* Be sure that the ***advance arm lockscrew,*** *Fig. 14,* which is mounted to the ***distributor clamp*** is tight, as a manual spark advance is not used with these engines.

With the ***advance arm clamp screw*** loose, turn the distributor body slightly in a counter-clockwise rotation so that the breaker points are firmly closed. Then turn the distributor body in a ***clockwise*** rotation until the ***breaker points*** are just ***beginning to open,*** *see Fig. 14.* At this point, a slight resistance can be felt as the breaker point cam strikes the breaker point arm. Tighten ***advance arm clamp screw.*** The No. 1 cylinder is now ready to fire in the retarded position,

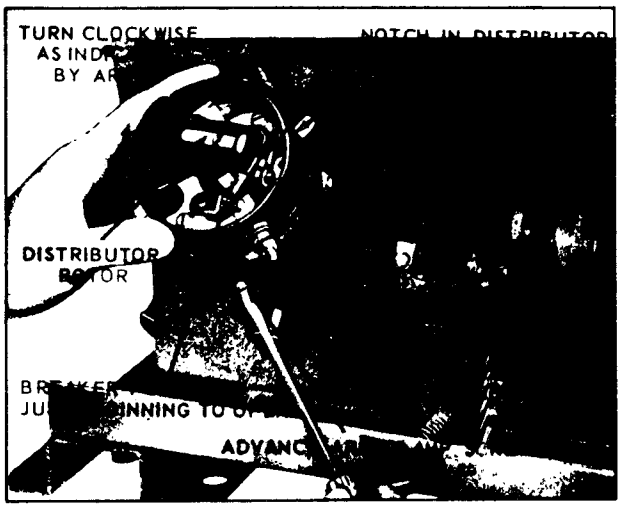


Fig. 14 180183C

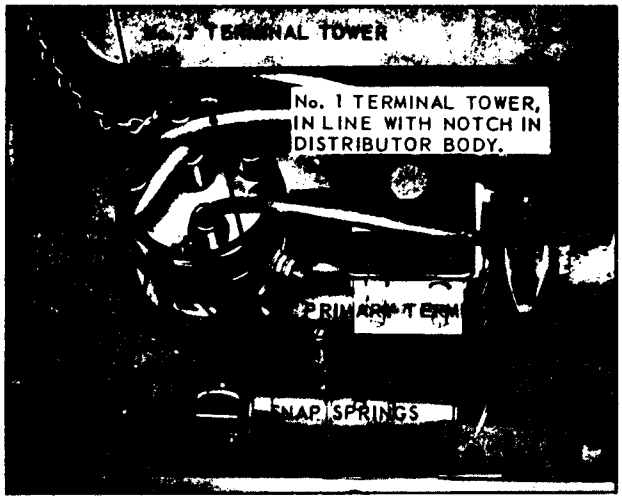


Fig. 15 180187C

with the centerline of the ***distributor rotor*** in line with the ***center*** of the ***notch*** in the distributor body as shown in *Fig. 14.*

The breaker point gap should be ***.018*** to ***.022*** inches. This opening should be checked before the distributor body is set, otherwise any adjustment made to the breaker point opening will change the ignition advance. Replace distributor dust cover. If care is exercised in the above operations, the spark timing should be accurate enough for satisfactory starting, however, ***checking spark advance*** with a ***neon lamp,*** as described in *'Neon Lamp Timing',* ***is necessary.***

The four ignition cables from the distributor should be connected to the proper spark plugs. The cylinder shroud covers are marked for identification. The No. 1 terminal tower on the distributor is in line with the notch in the distributor body. The terminal sequence is ***1-3-4-2*** in a counter-clockwise rotation. *See Fig. 15.*

NEON LAMP TIMING

The engine should be timed to the 23° advanced position at not less than 2000 R.P.M.

The timing should be checked with a neon lamp connected in series with No. 1 spark plug. Chalk or paint

the end of the 'X' marked vane on the flywheel, white. Then with the engine operating at **2000 R.P.M.** or over, allow the flash from the neon lamp to illuminate the whitened vane. At the time of the flash, the leading edge of the vane should line up with the lower half of the ***running spark advance timing hole*** on the flywheel shroud, *see Fig. 13.* If it does not, the ***advance arm clamp screw*** should be loosened as shown in *Fig. 14*, and the distributor body turned slightly clockwise or counter-clockwise, as required, until the ***white flywheel vane*** matches up with the lower half of the ***advance timing hole.*** Be sure ***advance arm clamp screw*** is then carefully tightened. If the engine is running below ***2000 R.P.M.*** when timing, the automatic advance in the distributor will not be fully advanced and the inaccurate timing may cause serious damage to the engine when operating at high speeds. Mount flywheel screen if removed – use ***slotted opening*** without removing screen for running spark advance check only.

DISTRIBUTOR AND GENERATOR MAINTENANCE

The distributor breaker point gap should be ***.018*** to ***.022*** inches. To readjust breaker point gap, turn engine over by means of the starting crank until the distributor breaker arm ***rubbing block*** is on a high point of the cam. Loosen the ***stationary contact lock-nut*** and screw ***fixed contact,*** in or out, until correct gap is obtained. Tighten locknut and recheck gap.

The generator and distributor should be periodically lubricated and inspected for external conditions which would affect their operation.

It is recommended that the generator oiler, located below the primary terminal of the distributor, be given 3 to 5 drops of medium engine oil every 50 hours.

Every 50 hours of operation, the oiler on the side of the distributor base should have 3 to 5 drops of medium engine oil added, and the grease cup given one complete turn. Use a high melting point grease. Every 100 hours, apply 3 to 5 drops of medium engine oil to the felt in the top of the cam sleeve. ***Do not over-lubricate.***

FLYWHEEL ALTERNATOR

12 volt – 10 or 25 amp flywheel alternator furnished in place of gear driven generator. Instructions and parts bulletin is located in the rear of this manual.

RESTORING COMPRESSION

In a new engine or one which has been out of operation for some time, oil may have drained off the cylinders so that compression will be weak, causing difficulty in starting. To remedy this condition, remove the spark plugs and pour about a fluid ounce of crankcase oil through the spark plug hole into each cylinder. Turn engine over several times with the hand crank to distribute oil over the cylinder walls. Assemble spark plugs and compression should be satisfactory.

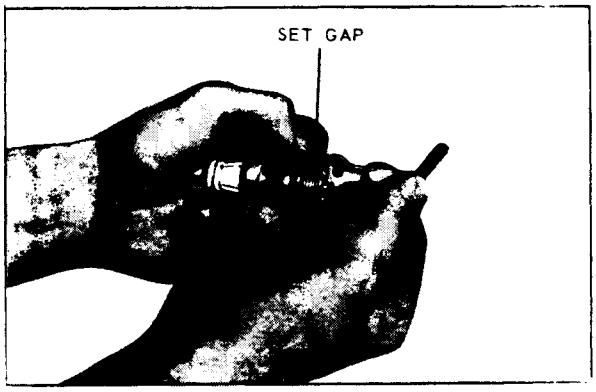


Fig. 16 104713C

SPARK PLUGS, Fig. 16

Incorrect gap, fouled or worn spark plug electrodes, will have an adverse affect on engine operation. Remove spark plugs periodically, clean, regap or replace if necessary. Thread size is 18 mm.

Spark plug gap – 0.030 of an inch.

Replacement plugs must be of the correct heat range, like Champion No. D-16J, AC No. C86 commercial. Tighten spark plugs, ***25*** to ***30 foot pounds torque.***

HIGH TEMPERATURE SAFETY SWITCH

As a safety precaution against overheating, engines can be equipped with a high temperature switch mounted to the cylinder head at the ***No. 4*** spark plug.

When cylinder head temperature becomes critically high, the safety switch will automatically stop the engine by shorting out the ignition system. A waiting period of about ***10 minutes*** will be required before the switch has cooled off sufficiently to re-start the engine. An overheated engine will score the cylinder walls, burn out connecting rod and crankshaft bearings, also warp pistons and valves. The cause of the overheating condition will have to be remedied before the engine is re-started. *See* ***Engine Overheats*** *paragraph in Troubles, Causes and Remedies section.* ***Service Kit*** is available – see parts list section.

KEEP ENGINE CLEAN - PREVENT OVERHEATING
(Agricultural and Industrial Engines)

This engine is cooled by blasts of air which must be allowed to circulate all around the cylinders and cylinder heads to properly cool the engine and thereby keep it in good running condition. If ***dust, dirt or chaff is allowed to collect in the cylinder shrouding or in the V between the cylinders,*** it will retard the flow of air and cause the engine to overheat. Keep ***flywheel screen*** and ***rotating screen*** clean, so as not to restrict the intake of cooling air.

With reference to *Fig. 17*; follow the cleaning and maintenance instructions pointed out, to obtain trouble free and satisfactory engine performance.

1. Remove these covers frequently and clean out all dust, dirt and chaff. Be sure to replace covers.

Loose or burnt out connecting rod bearing.

Engine overheated due to causes under previous heading.

Worn or loose piston pin.

ENGINE BACKFIRES THROUGH CARBURETOR

Water or dirt in gasoline.

Engine cold.

Poor grade of gasoline.

Sticky inlet valves. *See 'Valves', Page 22.*

Overheated valves.

Spark plugs too hot. *See 'Spark Plug', Page 15.*

Hot carbon particles in engine.

DISASSEMBLY AND REASSEMBLY OF VH4 ENGINE

Engine repairs should be made only by a mechanic who has had experience in such work. When disassembling the engine, it is advisable to have several boxes available so that parts belonging to certain groups can be kept together, such as, for instance, the cylinder head screws, etc. Capscrews of various lengths are used in the engine, therefore great care must be exercised in reassembly so the right screw will be used in the various places, otherwise damage may result.

Tighten the capscrews and nuts of the manifolds, cylinder heads, gear cover, oil pan, connecting rods, cylinder blocks, main bearing plate and the spark plugs to the specified torque readings indicated in the following paragraphs of reassembly.

While the engine is partly or fully dismantled, all of the parts should be thoroughly cleaned. Remove all accumulated dirt between the fins.

If it is desired to disassemble the engine, the following order should be substantially adhered to. As disassembly progresses, the order may be altered somewhat if desired, as will be self-evident to the mechanic. Reassembly of the engine should be made in the reverse order.

TESTING REBUILT ENGINE

An engine that has been completely overhauled, such as having the cylinders rebored and fitted with new pistons, rings and valves, should go through a thorough "run-in" period, before any amount of load is applied to the engine.

The engine should be started and allowed to run for about one-half hour, at about 1200 to 1400 R.P.M. without load. The R.P.M. should then be increased to engine operating speed, still without load, for an additional three and one-half to four hours.

The proper "running-in" of the engine will help to establish polished bearing surfaces and proper clearances between the various operating parts and thus add years of trouble free service to the life of your engine.

ACCESSORIES

The air cleaner, oil filter, magneto, and if an electric starter and generator are used, these should be removed first.

Remove clutch or clutch reduction unit if engine is equipped with either of these accessories.

SHEET METAL HOUSE

On power units, remove the muffler and canopy first. Disconnect air cleaner, choke, governor control and instrument wires at the front house panel. The front panel can be removed as part of the flywheel shroud, as explained in the following paragraphs of disassembly.

FLYWHEEL

After the flywheel screen has been removed, drive out the starting crank pin in the crankshaft and remove the flywheel nut and washer.

The flywheel is mounted to a taper on the crankshaft. Take a firm hold on the flywheel fins, pull outward and at the same time strike the end of the crankshaft with a babbitt hammer, *see Fig. 18.* The flywheel will slide off the taper of the crankshaft. Do not use a hard hammer as it may ruin the crankshaft and bearings. When reassembling the flywheel, be sure the Woodruff key is in position on the shaft and that the keyway in the flywheel is lined up accurately with the key.

AIR SHROUDING

To disassemble air shrouding, refer to *Fig. 19.* First remove cylinder head covers and the screws mount-

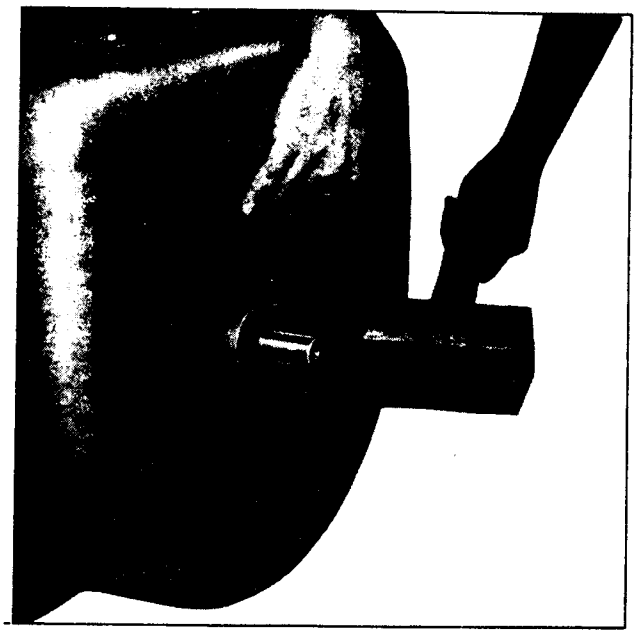


Fig. 18 76696C

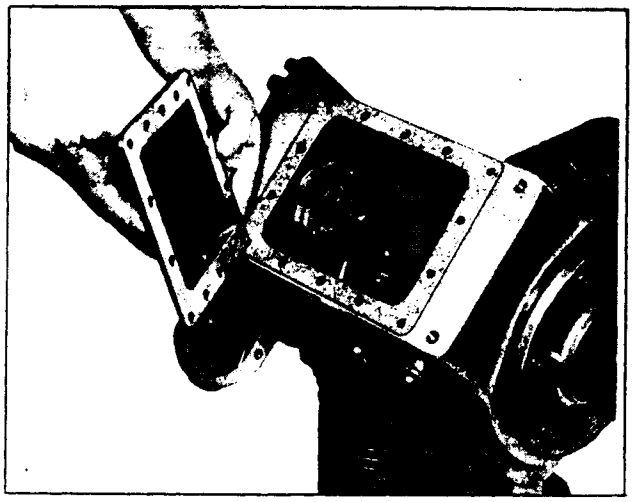


Fig. 26 104721C

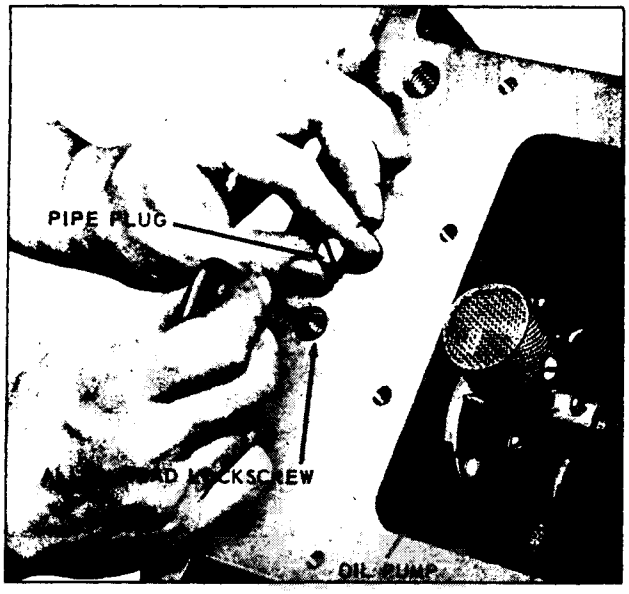


Fig. 27 180178C

crankshaft until piston is at top, then push connecting rod and piston assembly upward and out thru top of cylinder. Be careful not to mar the crank pin by allowing the rod bolts to strike or scrape across it. Place caps on rods immediately so that they will not be mismatched in reassembly. Be sure that shims (used in babbitt bearing rods), are in place before cap is put on.

NOTE: These models of engines were originally furnished with ***babbitt cast*** connecting rod bearings. ***Shell bearing*** rods are now being used for current production engines, and are interchangeable with babbitt bearing rods for service replacement. Care should be taken ***in reassembly*** to mount bearings properly. The cap should be assembled to the rod so that the ***locating lug*** of both bearing halves are on the same side as illustrated in *Fig. 28.* Refer to chart, *Fig. 32,* for clearance between bearing and crank pin.

The piston skirt is ***cam-ground*** to an elliptical contour. Clearance between the piston and cylinder must be measured at the center of the thrust face at the bottom of the piston skirt. Refer to Chart, *Fig. 32,* for proper clearance. The thrust faces on the piston skirt

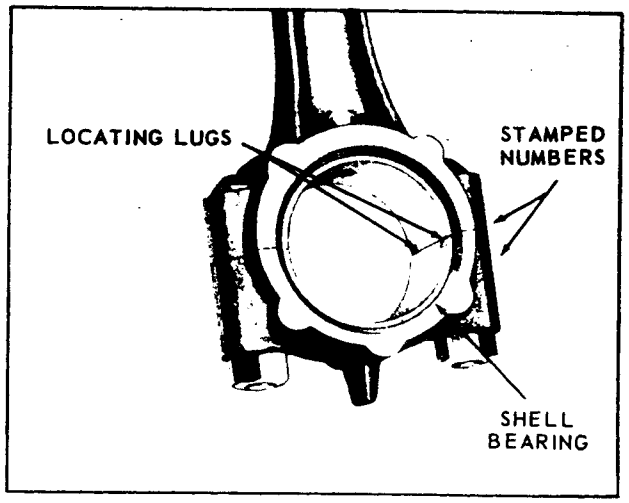


Fig. 28 316307C

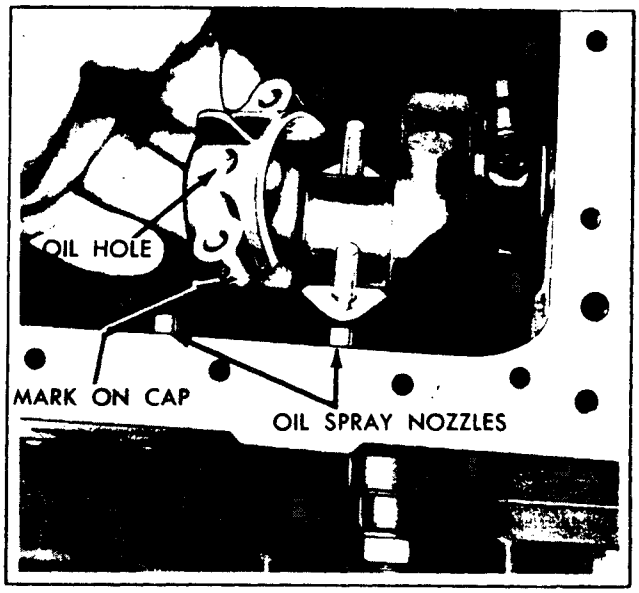


Fig. 29 104819C

are 90° from the axis of the piston pin hole, with the wide section of the piston skirt toward the maximum thrust side, or opposite the crankshaft rotation. *See Engine Sectional, Fig. 2.*

In reassembly; be sure piston and connecting rod assemblies are put back into the same bore from which they were removed. Use a suitable ring compressor and stagger the piston ring gaps 90° apart around the piston. Oil the pistons, rings, wrist pins, rod bearings and cylinder walls before assembly.

CAUTION: Identical numbers are stamped on the side of the rod with its corresponding cap. These numbers must be on the same side of the connecting rod when mounted in engine. Be sure that ***oil hole*** in connecting rod cap is facing toward the oil spray nozzle, as illustrated in *Fig. 29.* ***Install new nuts*** on connecting rod bolts and ***torque 22*** to ***28 foot pounds.***

PISTON RINGS (Fig's. 30, 31, 32)

If a ring expander tool is not available, install rings by placing the open end of ring on piston first, as shown in *Fig. 30.* Spread ring only far enough to slip



Fig. 30 71152C

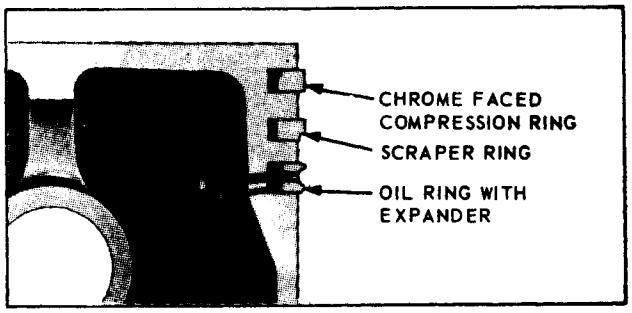


Fig. 31 285335C

over piston and into correct groove, being careful not to distort ring. Install bottom ring first and work toward the head of the piston, installing top ring last. The word ***'TOP'*** on compression and scraper rings indicates direction of ring placement on piston.

Beginning with serial #5538322, ***three ring*** pistons (chrome faced ***compression ring, scraper ring, oil ring*** and expander), with improved oil control characteristics, replaces four ring pistons furnished with two compression rings.

CAUTION: When replacing four ring pistons with three ring pistons, a complete set of ***four pistons*** must be used. ***Do not*** mix three and four ring pistons in the same engine.

The outer diameter of the compression ring is ***chrome plated.*** Mount scraper ring with scraper edge down, otherwise oil pumping and excessive oil consumption will result. Refer to *Fig. 31* for the correct placement of piston rings.

CYLINDER BLOCKS

Clean all dirt and foreign deposits from between the cylinder fins and manifold ports.

The cylinder blocks do not have to be removed unless the cylinder bore is scored, out-of-round, or worn oversize more than 0.005 inch. In this event, the block will have to be removed, rebored and fitted with oversize pistons and rings. This work should be done by an authorized Wisconsin Service Center.

In Reassembly; tighten the cylinder block mounting nuts, ***40*** to ***50 foot pounds torque.***

PISTON TO CYLINDER AT PISTON SKIRT THRUST FACE		.003 to .004"
PISTON RING GAP		.010 to .020"
PISTON RING SIDE CLEARANCE IN GROOVES	TOP RING	.002 to .004"
	SCRAPER RING	.002 to .004"
	OIL RING	.001 to .003"
PISTON PIN TO CONNECTING ROD BUSHING		.0004 to .0012"
PISTON PIN TO PISTON		.0000 to .0008" tight
CONNECTING ROD TO CRANK PIN – SIDE CLEARANCE		.009 to .016"
CONNECTING ROD SHELL BEARING TO CRANK PIN DIA. (VERTICAL)		.0012 to .0033"
CONNECTING ROD BABBITT BEARING TO CRANK PIN		.0007 to .0020"

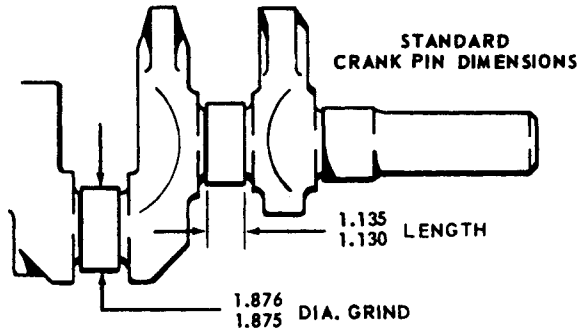


Fig. 32, PISTON, RING AND ROD CLEARANCES CHART

VALVES and SEAT INSERTS (Fig. 33)

Remove valve tappet inspection plate and compress valve springs with a standard automotive type valve lifter as illustrated. Insert a rag in the opening at the bottom of valve chamber so the retaining locks do not fall into engine crankcase. Remove retaining locks, seats, springs, valves and clean these, as well as the ports and guides, of all carbon and gum deposits. Tag each valve so that in reassembly they will be mounted in the same guide they were removed from. Replace valves that are burned or pitted.

The inlet and exhaust valve ***seat inserts*** can be removed, when replacement becomes necessary, by means of Wisconsin Motor ***DF-66-A*** insert puller.

Before grinding valves, inspect valve guides for possible replacement. Refer to *Valve Guide* paragraph. The valve face is ground at 45° to the vertical center line of the valve stem and the valve seat insert should also be ground at a 45° angle. ***After grinding,*** lap valves in place until a uniform ring will show entirely around the face of the valve. Clean valves and wash block thoroughly with a hot solution of soap and water. Wipe cylinder walls with clean lint free rags and light engine oil, especially if cylinders were rebored and honed.

Valve guides in the cylinder block are easily replaceable by use of Wisconsin ***DF-72 driver tool.*** ***In reassembly;*** mount guides with inside chamfer down. The valve stem has a clearance of ***.003*** to ***.005"*** in the guide. When the clearance becomes

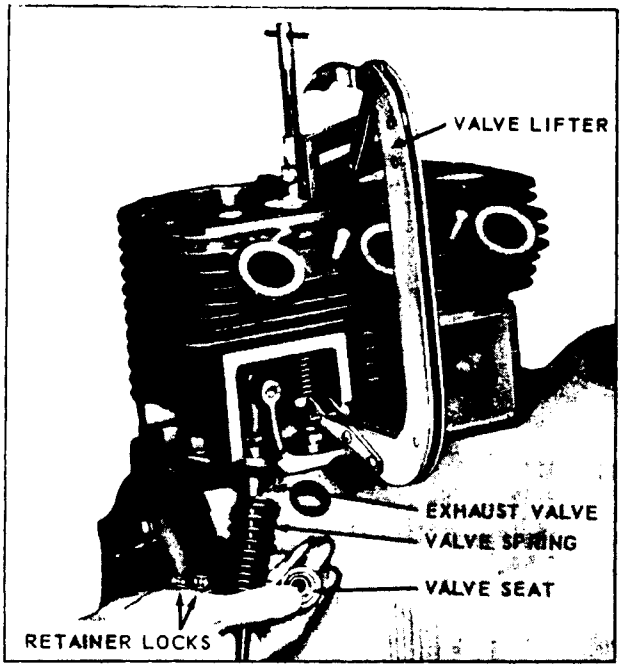


Fig. 33 180188C

.007", the guides should be driven out and replaced with new guides.

These engines that have ***Stellite*** exhaust valves and inserts are designated as Model ***VH4D*** and are equipped with ***positive*** type ***exhaust valve rotators.*** The action of the rotocap, which rotates the valve slightly each time the valve opens, helps prevent sticky valve and will impart a wiping action between the valve face and valve seat, thereby preventing the build-up of foreign deposits. Valve rotation will also avoid prolonged exposure of any one sector of the valve face to a local hot spot on the seat which will result in lower and more uniform valve face-seat temperatures.

CRANKSHAFT

To remove the crankshaft, first remove the six capscrews in the main bearing plate at the take-off end of the engine. This plate can then be pried off, and crankshaft removed from that end of crankcase. *See Fig. 34.* Be sure to keep shims and gaskets in place as these are necessary to give the proper end play to the tapered roller main bearings on the crankshaft. This ***end play*** should be ***.002*** to ***.004*** inch when engine is cold. There is practically no wear in these bearings so that no readjustment is necessary after proper assembly.

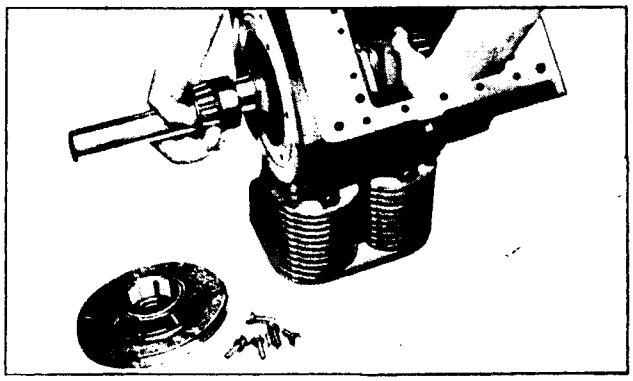


Fig. 34 71075C

When reassembling crankshaft, the timing marks on the crankshaft gear and the camshaft gear must be matched as shown in *Fig. 24*, otherwise engine will not operate properly, or if timing is off considerably, engine will not run at all.

The mounting holes for the main bearing plate are off-set in such a manner that it can only be mounted in the correct position. Tighten main bearing plate capscrews, 25 to 30 foot pounds torque.

CAMSHAFT

The camshaft must be withdrawn from the flywheel end of the engine as shown in *Fig. 35.* When reassembling, be sure the spring and plunger are in place in the end of the camshaft, as they hold the camshaft in position endwise. These parts are shown in the sectional view of the engine, *Fig. 2.*

VALVE TAPPETS

The valve tappets are taken out after the camshaft is removed. In reassembly, the tappets must of course be inserted in proper position in crankcase, before the camshaft is assembled.

After the cylinder blocks have been assembled to the crankcase, adjust the valve tappets as shown in *Fig. 36.* With the tappets in their lowest positions, engine cold, the clearance should be ***.008 inch*** for the ***inlet*** and ***.016 inch*** for the ***exhaust***, with or without Stellite valves.

GOVERNOR – OPERATION

The centrifugal flyball governor rotates on a stationary pin driven into the upper part of the timing gear

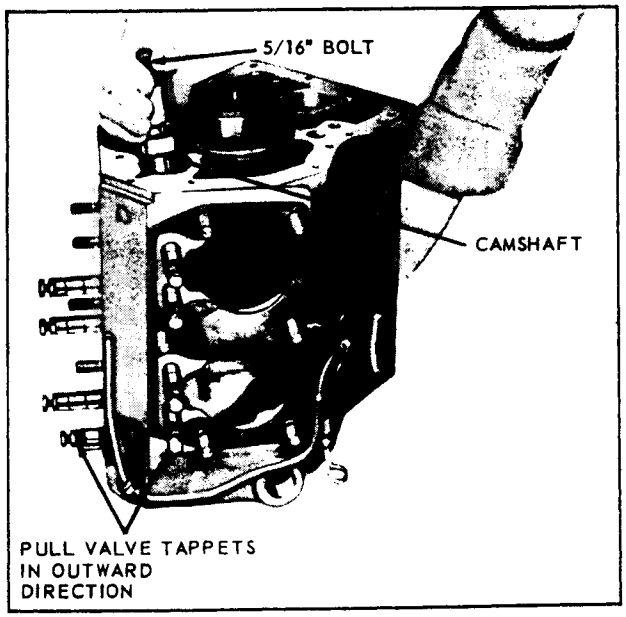


Fig. 35 104726C-A



Fig. 36 180186C

cover, and the governor is driven off the camshaft gear at crankshaft speed.

Flyweights are hinged to lugs on the drive gear. Hardened pins on the flyweights bear against the flanged sliding sleeve, moving it back and forth as the flyweights move in or out. The motion of the sleeve is transmitted through a ball thrust bearing to the governor lever, which in turn is connected to the carburetor throttle lever. A spring connected to the governor lever tends to hold the governor flyweights to their *inner* position, also to hold the carburetor throttle open. As the engine speed increases, the centrifugal force in the flyweights acts against the spring and closes the throttle to a point where the engine speed will be maintained practically constant under varying load conditions. This speed can be varied to suit conditions by adjusting the governor spring tension to suit.

GOVERNOR ADJUSTMENT

The governor rod connection to the carburetor must be very carefully adjusted for length, otherwise the governor will not function properly and cause the engine to surge badly. With the engine at rest, the governor spring will keep the flyweights *in*, and the control rod must be of such length as to hold the carburetor throttle wide open at that point. The accuracy of this adjustment can be tested by disconnecting the control rod from the governor lever, and then pushing the rod toward the carburetor as far as it will go. This will open the throttle wide. The governor lever should then be moved as far as possible in the same direction, all of this being done with the rod disconnected from the lever. Holding both parts in the above position, the rod should be screwed into the swivel block on the carburetor, until the bent end of the rod will register with the hole in the lever, then, screw the rod in two more turns. Insert the rod into the hole in the governor lever and assemble cotter pin. With the governor lever pushed toward the carburetor as far as it will go, there should be about a 1/16 inch clearance between the throttle lever and the stop pin on the carburetor. The clearance will cause the lever to bounce back from the stop pin, rather than jam against the pin, when a load is suddenly applied to an idling engine. This will eliminate excessive wear on the threads in the carburetor throttle swivel block.

	STANDARD Vertical Mounted Carburetor		SPECIAL Horizontal Mtd. Carburetor-Top Mtd. Distributor	
LOAD R.P.M.	NO LOAD R.P.M.	HOLE NO.	NO LOAD R.P.M.	HOLE NO.
1400	1525	4	1600	4
1500	1650	5	1735	5
1600	1725	5	1775	5
1700	1850	6	1905	6
1800	1950	7	2050	7
1900	2025	7	2115	7
2000	2150	8	2230	8
2100	2225	8	2300	8
2200	2350	9	2430	9
2300	2425	9	2480	9
2400	2550	10	2625	10
2500	2625	10	2685	10
2600	2750	11	2795	11
2700	2850	12	2930	12
2800	2925	12	3005	12

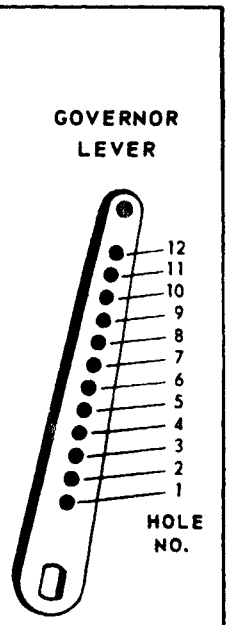


Fig. 37

The governor lever is furnished with 12 holes, as shown in *Fig. 37*, for attaching the governor spring. It is very important that the spring is hooked into the proper hole to suit the speed at which the engine is to be operated. The Governor Lever Chart, *Fig. 37*, shows the ***full load*** and ***no load*** speeds of the engine and the hole corresponding thereto. Note that the ***full load*** speed is less than the ***no load*** speed and this must be taken into consideration when readjusting the governor. As an example; if the engine is to be operated at 2000 revolutions per minute under load, the spring should be hooked into the *8th* hole in the governor lever, and the spring tension adjusted by means of the adjusting screw, to run 2150 R.P.M. at no load. When load is applied, the engine will run at approximately 2000 R.P.M.

A tachometer or revolution counter should be used against the crankshaft to check speed while adjusting the governor spring tension. Tightening the adjusting screw locknut will give higher speeds, while loosening the locknut will lower the spring tension and reduce the R.P.M.

NOTE: The settings, in the column of *Fig. 37* marked ***special***, are for engines that have an Ignition Distributor attached to and driven off the governor. These engines have a horizontal mounted carburetor, resulting in governor settings different than standard.

CLUTCH AND REDUCTION GEARS

CLUTCH

The clutch furnished with this model of engine is of the disc type running in oil. Use the same grade of oil in the clutch as is used in the engine crankcase. The oil should be filled through the inspection plate opening, to the height of the oil level plug. Approximately a pint of oil is required. *See Fig. 38.*

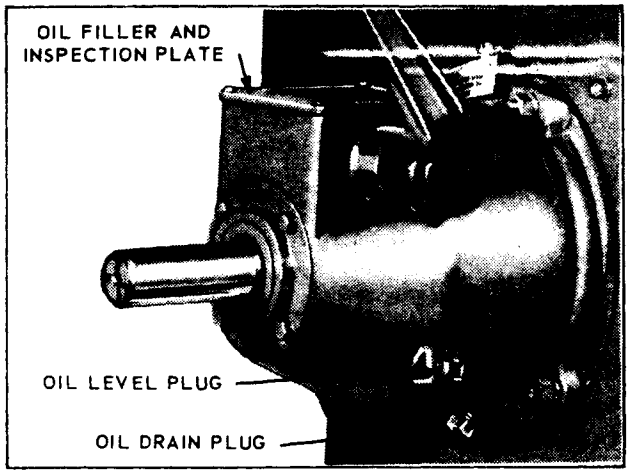


Fig. 38 84066C

CLUTCH ADJUSTMENT

If the clutch begins to slip, it should be readjusted, otherwise it will become overheated and damaged. First remove the inspection plate which will expose the notched ***adjusting ring.*** Release the ***clutch,*** by pushing the ***engaging lever*** forward. Turn engine over until the clutch ***adjustment lock*** is visible thru the inspection opening. Loosen ***adjustment lockscrew,*** one full turn. Keep the engine crankshaft from turning, then, by means of a screw driver as shown in *Fig. 39,* turn the ***adjusting ring,*** one notch at a time in a clockwise direction, until a very firm pressure is required to engage the clutch with the lever. Be sure that the clutch cams snap over-center on final adjustment. Securely tighten adjustment lockscrew. Assemble inspection plate, being sure that the gasket fits properly and is not broken.

CLUTCH REDUCTION UNIT

ADJUSTMENT

The clutch in the clutch reduction unit is the same as used in the clutch take-off assembly. The clutch adjustment is made thru two pipe tap openings; one for the ***adjustment lockscrew*** and the other for turning the ***adjusting ring,*** as illustrated in *Fig. 40.* There are four ½ inch square head pipe plugs in the housing, to provide a means of adjusting the clutch regardless of what position the unit is mounted in.

Remove the two pipe plugs on the side of the housing (if not accessible, use the two optional taps). Disengage the clutch and turn engine over slowly with a hand crank until the ***adjustment lockscrew*** is visible thru the pipe plug opening nearest to the engine. Loosen ***lockscrew*** one full turn, or enough to relieve the tension of the lock against the notches on the ***adjusting ring.*** Then, turn engine over slightly to expose the ***notches*** on ***adjusting ring.*** Keep engine crankshaft from turning, while thru the adjacent pipe plug opening, turn the ***adjusting ring*** with a screw driver, one notch at a time in a clockwise direction (viewing from take-off end), until a very firm pressure is required to engage the clutch with the lever. Tighten adjustment lockscrew and mount pipe plugs, when adjustment is completed.

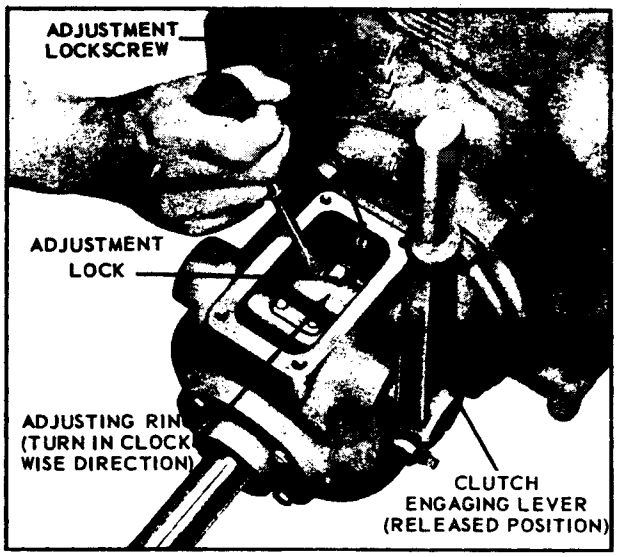


Fig. 39 244949C-A

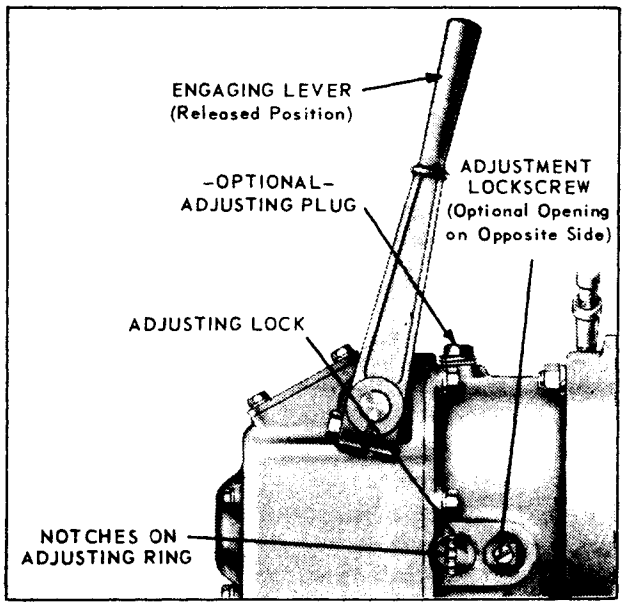


Fig. 40 275568C

REDUCTION GEARS

Reduction gears are furnished with several different ratios, some with spur gears, others with chains. All are of the same general design, except that some are furnished with clutches, others without, and for various installations can be mounted with the take-off shaft in either a 3, 6, 9 or 12 o'clock position. Use the same grade of oil in the reduction unit as is used in the engine crankcase.

Several plugs are furnished so that lubrication may be properly taken care of regardless of the position of the installation. There will always be one plug on top to be used for filling oil, a plug below for draining oil, and there will be one plug on the side slightly above the bottom, to be used as an oil level plug. *See Fig. 41.*

The oil should always be filled when the engine is at rest. When the oil becomes dirty, it should be drained, while the engine is hot, and fresh oil added. The fre-

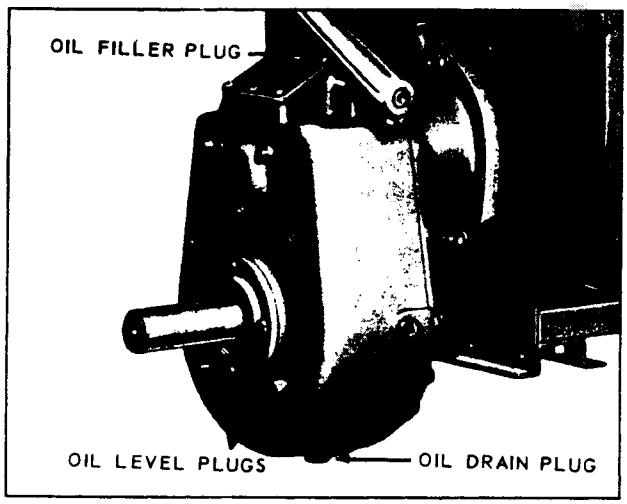


Fig. 41 76090C

quency at which these oil changes should be made depends entirely on the kind of service in which these gears are used, but even with light service the change should be made at least once every five hundred hours of operation, adding sufficient oil between changes to keep the oil up to the oil level plug.

STORAGE OF ENGINE FOR WINTER

When the season's work is completed, the following instructions should be carried out very carefully to protect the engine over winter.

The outside of the engine, including the cooling fins on the cylinders and heads, should be thoroughly cleaned of all dirt and other deposits.

The air cleaner, at the carburetor intake, should be thoroughly cleaned of all oil and accumulated dust, and the sediment removed from the oil cup at the bottom of the cleaner.

To protect the cylinders, pistons, rings and valves and keep them from rusting and sticking, a half and half mixture of kerosene and good "gasoline engine" oil (the same kind of oil as used in the crankcase of the engine), should be injected into the ***pipe tap*** opening on the ***intake manifold*** while the engine is warm and running at moderate speed. About a quarter of a pint is necessary, or enough so that a heavy bluish smoke will appear at the exhaust. The ignition switch should then be shut off and the engine stopped. This fogging operation will leave a coating of oil on the above mentioned parts, protecting them from the atmosphere.

On engines where the pipe tap opening on the intake manifold is inaccessible, the rust preventative may be injected into the air intake on the carburetor while the engine is running, so the mixture will be drawn into the engine. The air cleaner connection will of course have to be disconnected from the carburetor to do this.

All the oil should be drained from the crankcase while the engine is warm, as the oil will then flow more freely than when cold.

Drain fuel system, including gasoline lines, carburetor, fuel pump and tank of all gasoline, to prevent lead and gum sediment interfering with future operation.

The air cleaner or carburetor intake, as well as the exhaust manifold and breather openings, should be taped or otherwise sealed off, for the duration of the storage period.

All exposed unpainted metal parts should be coated with grease or heavy oil.

Before starting the engine again the next season, the crankcase drain plug should again be removed, so that any condensation, which may have collected during the winter, may be drained before new crankcase oil is added.

A good plan, and one that is recommended, is to remove the crankcase oil base in the spring before starting the engine for the new season, and scrubbing off all sediment which may have collected there.

When replacing the engine base, a new gasket should be used.

Be sure to fill the crankcase with a good quality of crankcase oil to the high level point, before starting the engine. Do not use any oil heavier than SAE No. 30. Also be sure to put oil to the proper level in the air cleaner.

It is also recommended to use new spark plugs at the beginning of the next season, especially if the engine has given considerable service.

Refuel engine and follow the starting instructions as shown on preceding pages of this manual.

It is highly recommended that machines be stored inside a building through the winter. If this is not possible, the engine should be protected from snow and ice by a proper covering.

BERTEA / INDUSTRIAL PRODUCTS

SERVICE MANUAL

REMOTE CONTROL PROPORTIONAL DIRECTIONAL VALVE

LOAD SENSING CIRCUITS

Model 264300

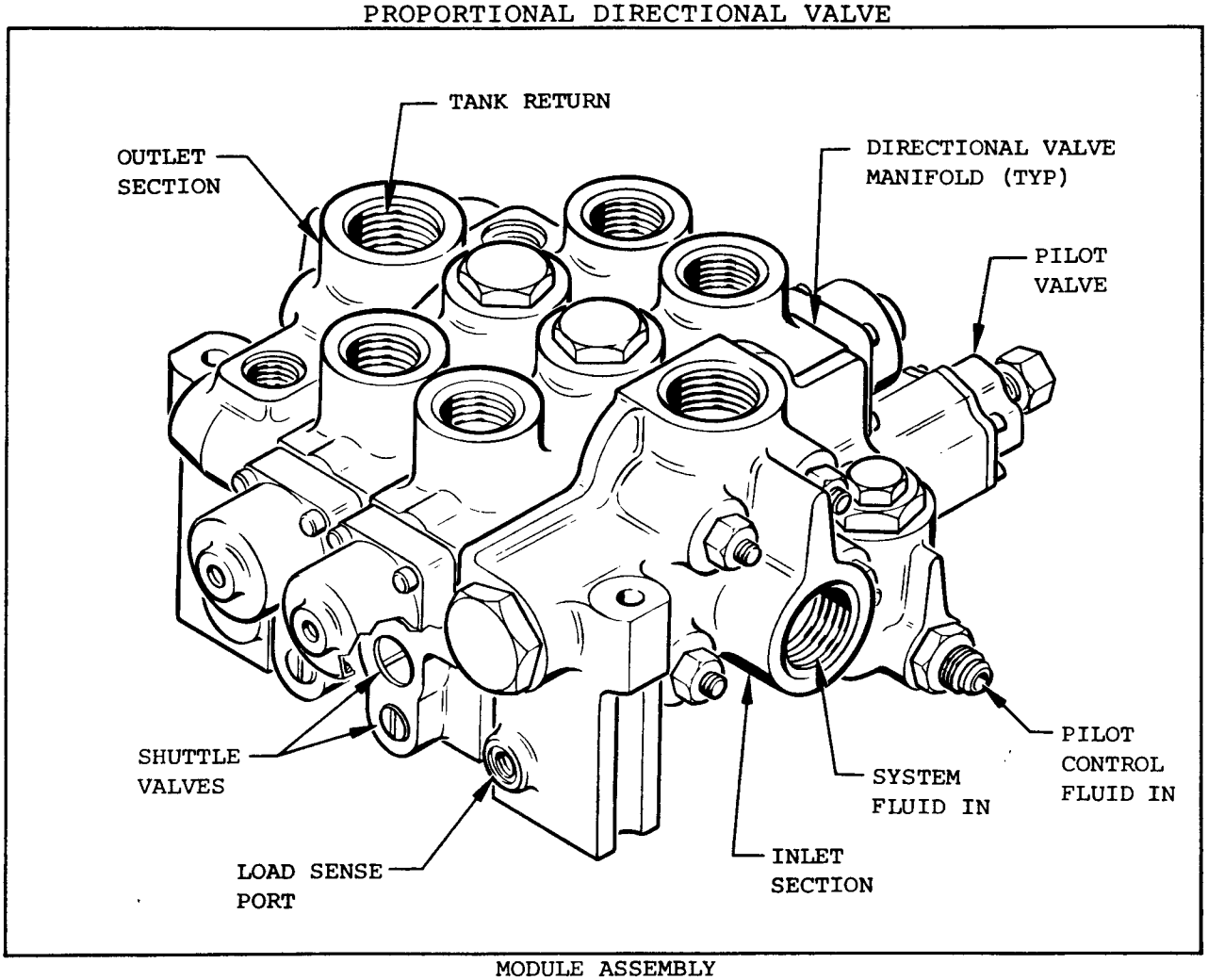
DEC. 1977

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BERTEA LOAD SENSING - PRESSURE COMPENSATING
PROPORTIONAL DIRECTIONAL VALVE



MODULE ASSEMBLY
FIGURE 1

I. INTRODUCTION

The Bertea "Load Sensing" directional valve module, Figure #1, provides a means of sensing the highest "work cylinder port" pressure, and then transmit this load sensing signal to a variable displacement pump with flow and pressure compensating controls.

These pumps will normally provide flow upon demand at a pressure of 100 psi to 300 psi above the load sensing pressure from the module. When the load sensing port is connected to tank, the pump will provide minimum flow at 100 to 300 psi output pressure.

Since the pump pressure is always held at only 100 to 300 psi above the highest load pressure, this system reduces the energy requirements and heat generation. Also, control

I. INTRODUCTION (Continued)

is optimum since the pressure drop across the directional valve spool is held constant at 100 to 300 psi by the load sensing line signal to the pump compensator.

In order to provide control of the directional valve spools under various system configurations and operating modes, the module is designed to contain two separate hydraulic circuits. The main power pump circuit is configured in the normal manner to provide power oil to the working cylinder ports. The control circuit used to position the directional valve spool is independent of the power oil circuit and operates at approximately 300 to 400 psi. This circuit separation, also, provides the capability to control the module from a remote location with electrohydraulic controls or by a remote pilot oil system with variable pressure capability.

The method used to port the Load Sensing Control Circuit to tank when not in use requires all directional valve spools to be open cylinder port configuration. Therefore, external controls will be required for load holding capability.

II SYSTEM DESCRIPTION

The Bertea load sensing valve module consists of (3) basic sub-systems as noted: (Reference: Figure 1 and Figure 2)

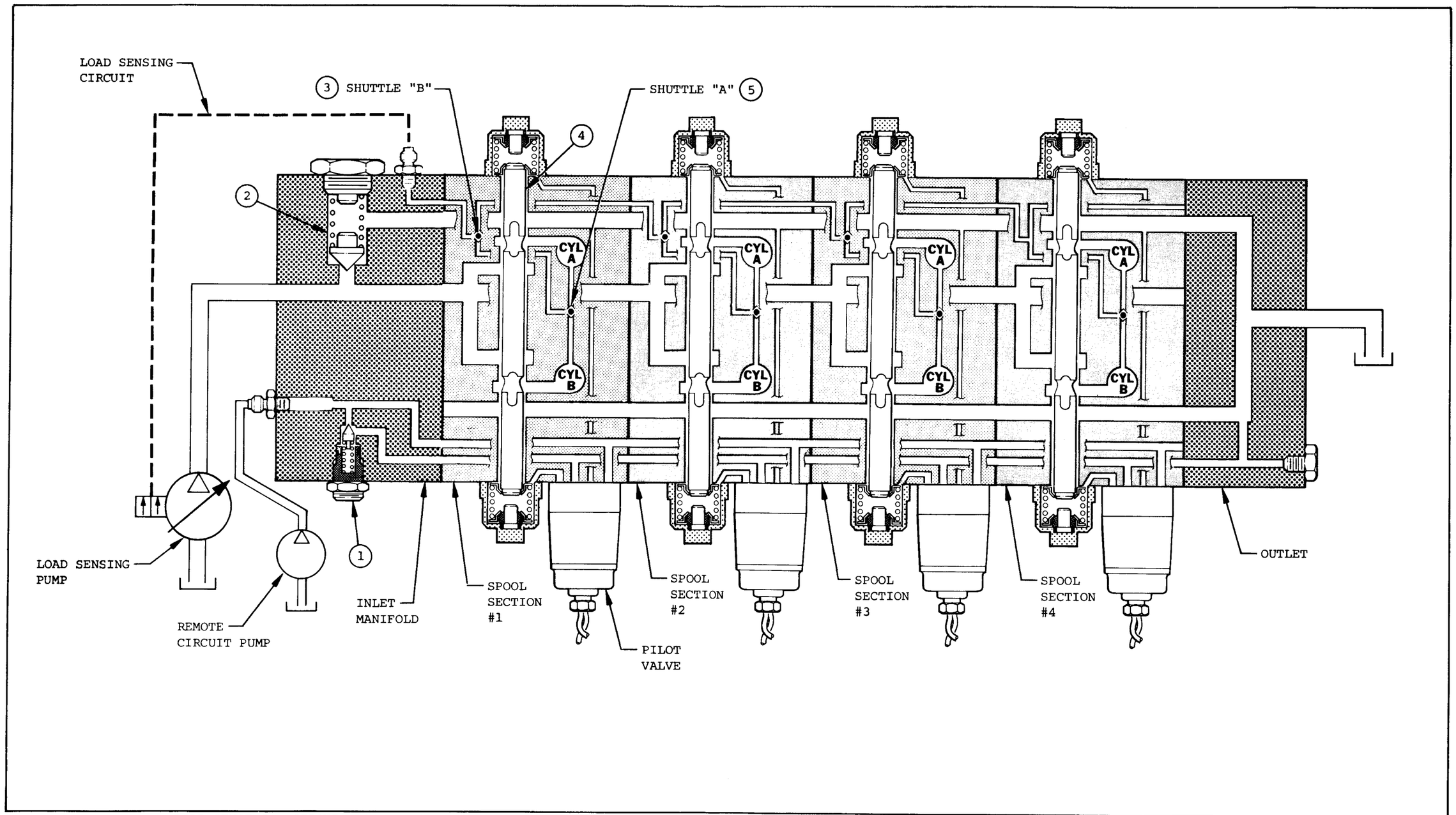
A. The shuttle valves, within the spool sections, sense the highest cylinder port pressure within each spool section manifold assembly and, also, select the highest load pressure among all of the spool sections in the complete module, and port this signal to the load sensing port of the pump.

B. The directional valve spool directs and meters the fluid to the function as specified by the amount of spool travel from its neutral or shut off position. This travel is determined by the difference in pressure established in the two spool end caps by the external control source.

C. The remote control system determines the directional valve spool position by varying the pressure in each spool end cap. The two commonly used control systems are:

(1) Remote pilot control oil ported to each end cap thru external tubing from a remote pressure reducing valve.

(2) Electrohydraulic pilot valves, manifolded to the spool section, and controlled electrically from a remote location. This pilot valve obtains its pilot supply oil from the module and ports it to the spool end cap at various pressure levels proportional to the electrical command.



LOAD SENSING - CIRCUIT SCHEMATIC
FIGURE 2

III OPERATION (Figure #2)

A. Load Sensing

When the system is not in use and the directional valve spools are in the center position, the load sensing circuit is connected to tank thru the shuttles and the open cylinder port spools. In this configuration, the load sensing, variable displacement pump will be at minimum output flow and providing only 100 to 300 psi pressure depending on the compensator differential setting.

The directional valve spool (Item 4) is spring caged to the center position with a 19# preload. As the remote control system builds up a differential pressure across the spool - ie-increases the pressure in one end cap and lowers the pressure in the other end cap - the spool will move out of center detent at about 40 psi differential pressure. Increasing the differential pressure will move the spool thru its 0.100 inch over lap length to the initial metering area and, also, with this movement, close off the open path across the spool from the cylinder port to the tank port. (Additional increase in differential pressure, up to 200 psi, will move the spool thru the metering notch area to full stroke of .350 travel and maximum flow).

As the directional valve spool of spool section #1 moves into the initial metering area, the shuttle system is now connected to the cylinder load instead of the tank port. Shuttle "A" (Item 5) senses this load pressure and passes it thru shuttle "B" (Item 3) into the load sensing circuit. This pressure signal is transmitted thru the inlet manifold to the pump where it controls the compensator setting to always provide an output pump pressure of 100 to 300 psi above the cylinder load pressure as picked up by shuttle "A".

If only one spool is operated, this system will provide constant rate of operation for any spool position since the load sensing circuit is holding a constant pressure drop of 100 to 300 psi across the metering notch of the spool.

Assume that spool #3 is now operated at the same time as spool #1 but at a higher pressure. Shuttle "A" of spool section #3 senses this load pressure and passes it thru shuttle "B" and into the load sensing circuit. This higher pressure will cause the shuttle "B" of spool #1 and #2 to pass the pressure on while they block their respective sensing lines to the "A" shuttles. This higher pressure signal to the pump increases its output pressure to 100 to 300 psi above this new load.

IV. ASSEMBLY AND SERVICE

The Bertea proportional electrohydraulic control valve is a stack configuration with all components field exchangeable as cartridges or sub-assemblies. The basic module consists of an inlet manifold assembly, a number of directional valve section assemblies with pilot valves, plus an outlet manifold assembly as shown in Figure #1.

A. Inlet Manifold Assembly (Figure 4)

The inlet manifold provides the inlet porting for the main power fluid circuit and the pilot valve fluid circuit. An optional 30 gpm system relief valve cartridge (Item 5) is available to replace the standard plug assembly (Item 6) for the power fluid circuit.

Each vehicle installation requires only one control pressure relief valve (Item 10), to maintain the 300 psi control pressure, regardless of the number of modules used. This valve should be installed in the module that is the greatest distance from the pump in order to assure a minimum of 300 psi pilot valve supply pressure to all units. The other inlet sections would use the standard plug assembly (Item 7). This pressure relief valve will provide 300 psi differential pressure for the pilot valve supply regardless of tank pressure. Therefore, if the vehicle return line has 100 psi back pressure the inlet to the pilot valves will be 400 psi.

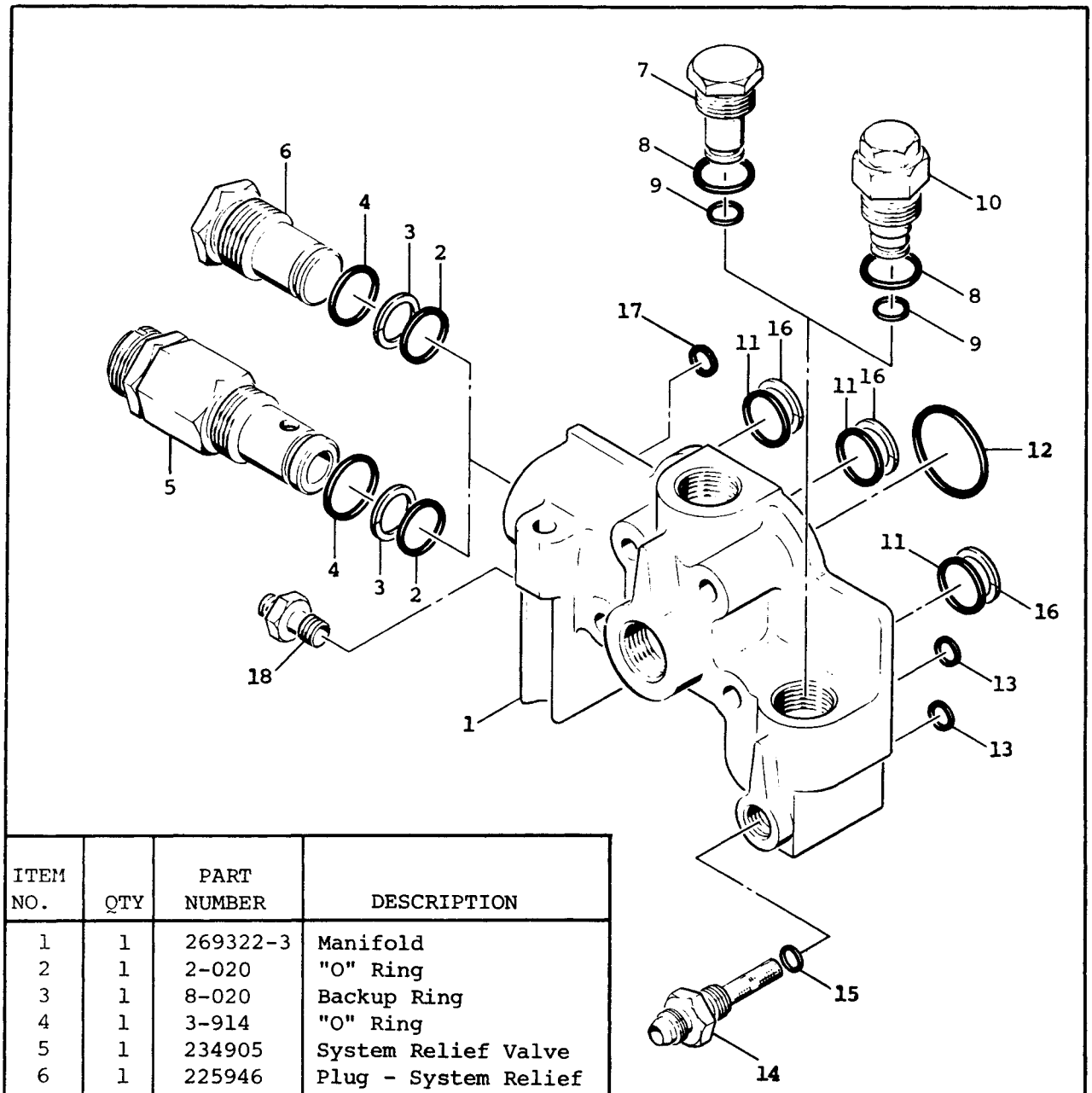
All inlet sections contain the pilot valve filter assembly (Item 14) regardless of the location of the pressure relief valve. The replacement schedule of this filter will be determined by the system usage and the quality of filtration of the power circuits.

The "O" ring face seals are the same as the ones used in the directional valve section (Figure 6). Care should be taken to assure that each ring is in its respective groove when clamping a module together.

B. Directional Valve Manifold Assembly (Figure #6)

Each directional valve assembly consists of the directional valve spool (Item 23); a means to position the spool by either the electrohydraulic pilot valve (Item 11) or a remote pilot oil system (Item 2 or 4); a shuttle to sense highest working cylinder port pressure (Item 31 or 35); and a shuttle (Item 36) to transmit the highest pressure within the total module to the load sensing pump.

The spool section body is a 30 gpm configuration with optional spools for lower flow rates to a 2 gpm size. All



	ITEM NO.	QTY	PART NUMBER	DESCRIPTION
	1	1	269322-3	Manifold
	2	1	2-020	"O" Ring
	3	1	8-020	Backup Ring
	4	1	3-914	"O" Ring
	5	1	234905	System Relief Valve
	6	1	225946	Plug - System Relief
	7	1	231856	Plug - Pilot Pressure
	8	1	3-912	"O" Ring
	9	1	2-014	"O" Ring
	10	1	231852	Pilot Pressure Relief
Δ	11	3	2-117	"O" Ring
Δ	12	1	2-128	"O" Ring
Δ	13	2	2-112	"O" Ring
	14	1	234950	Filter Assembly
	15	1	3-908	"O" Ring
Δ	16	3	248584-3	Backup Ring
Δ	17	1	2-108	"O" Ring
	18	1		1/4 Tube - Connector

Δ 269344-3 "O" Ring Kit

MANIFOLD ASSEMBLY, PART NO. 269381
FIGURE 4

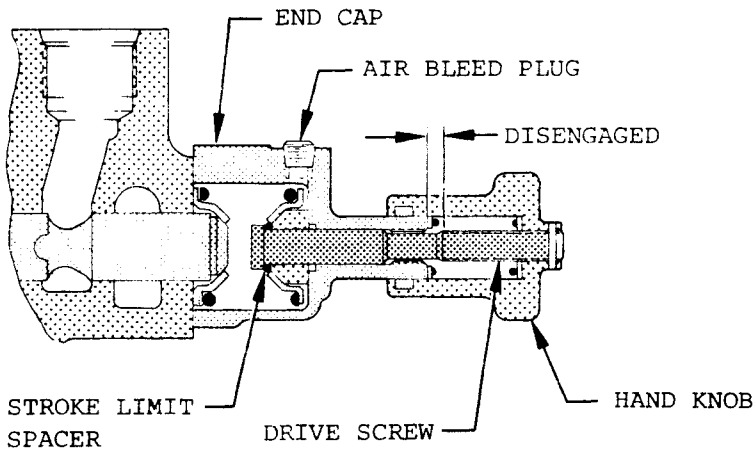
IV ASSEMBLY AND SERVICE (Continued)

B. Directional Valve Manifold Assembly (Continued)

spools are field interchangeable in order to select the optimum flow rate control desired.

The standard end cap (Item 20) with various length pins (Item 18) determine the maximum spool travel and hence the maximum flow rate for any specific spool. This selection of spool and pins provide field adjustment of desired function speeds.

The optional manual override assembly for a remote controlled spool is shown in Figure #5. This assembly will provide direct manual control of the spool in the event of a failure in the remote controller, the electrical power supply, or a malfunction of the pilot valve.



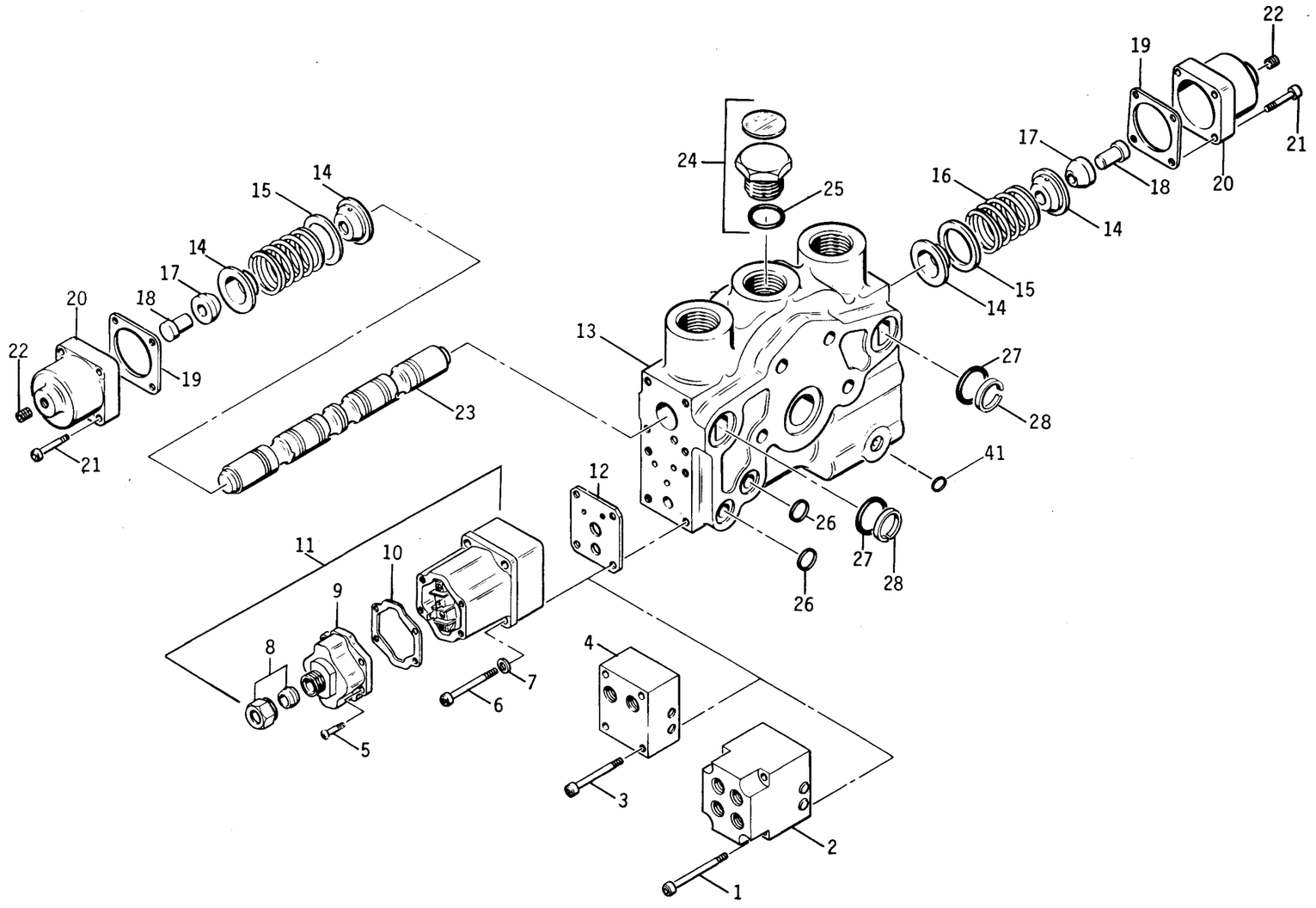
MANUAL OVERRIDE END CAP ASSEMBLY NO. 234955
FIGURE 5

The hand knob is held in the thread disengaged position by a light spring to prevent inadvertent operation. Press the knob inward while rotating to engage the threads in the cap and the drive screw. Continued rotation clockwise will move the spool from center and will provide flow from the cylinder port adjacent to this end cap. The knob must be rotated outward and disengaged prior to operating the manual override on the opposite end cap.

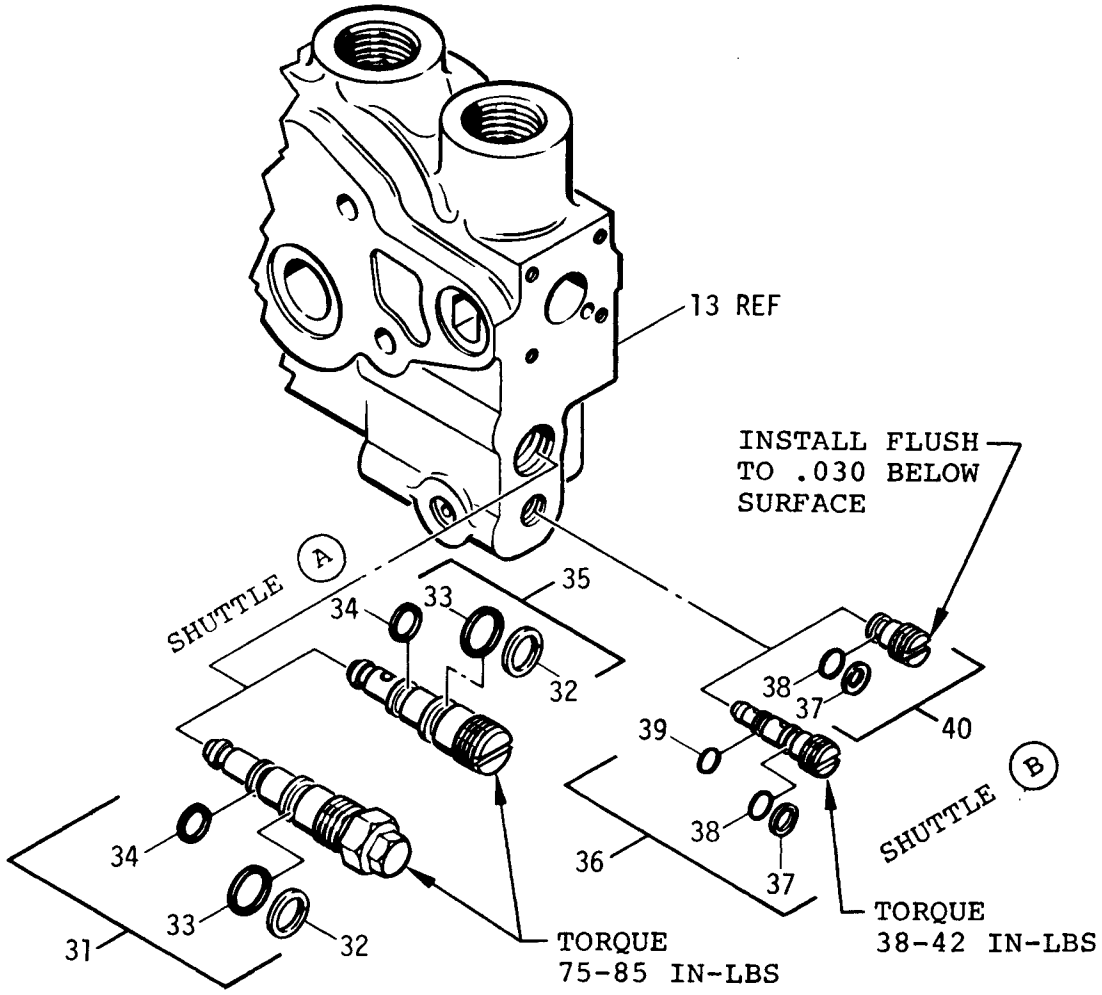
A plug is provided, as shown, to bleed the air from each end cap after initial assembly and operation. Air trapped in the spool end cap will reduce the response of the valve assembly.

ITEM NO.	QTY	PART NUMBER	DESCRIPTION
1	4	10-24x1 3/4	SCREW-SOC. HEAD
2	1	269357-1	MANIFOLD ASSY.-PURGE & SHUTTLE VALVE
3	4	10-24x1 1/2	SCREW-SOC. HEAD
4	1	269327-1	MANIFOLD ASSY.-PURGE CIRCUIT
5	4	#6-32x1/2	SCREW-PHILLIPS HD.
6	4	234980	SCREW-SOC. HEAD
7	4	234959	WASHER
8	1	249896	SEAL KIT
9	1	242933	COVER
10	1	242907	GASKET
11	1	234912	PILOT VALVE
12	1	225931-1	GASKET
13	1	269319-3	BODY
14	4	234927-1	SPRING GUIDE
15	2	234953-1	SHIM
16	2	231830-1	SPRING
17	2	234932-1	PIVOT
18	2	234931-1	PIN .350 SPOOL TRVL
		-3	PIN .300 SPOOL TRVL
		-9	PIN .250 SPOOL TRVL
19	2	225989-1	GASKET
20	2	269315-1	END CAP
21	8	#10-24x3/4	SCREW-SOC. HEAD
22	2	1/8-27 NPT	PLUG SOC. HEAD
23	1	AS REQ'D	SPOOL
24	1	261850-5	PLUG ASSY.
25	1	3-912N300-90	"O" RING
△ 26	2	2-112N674-70	"O" RING
△ 27	2	2-114N674-70	"O" RING
△ 28	2	248584-3	BACKUP RING
△ 29	1	2-122N674-70	"O" RING
△ 30	1	2-107N674-70	"O" RING
41	1	2-108N674-70	"O" RING

△ 269344-3 "O" RING KIT

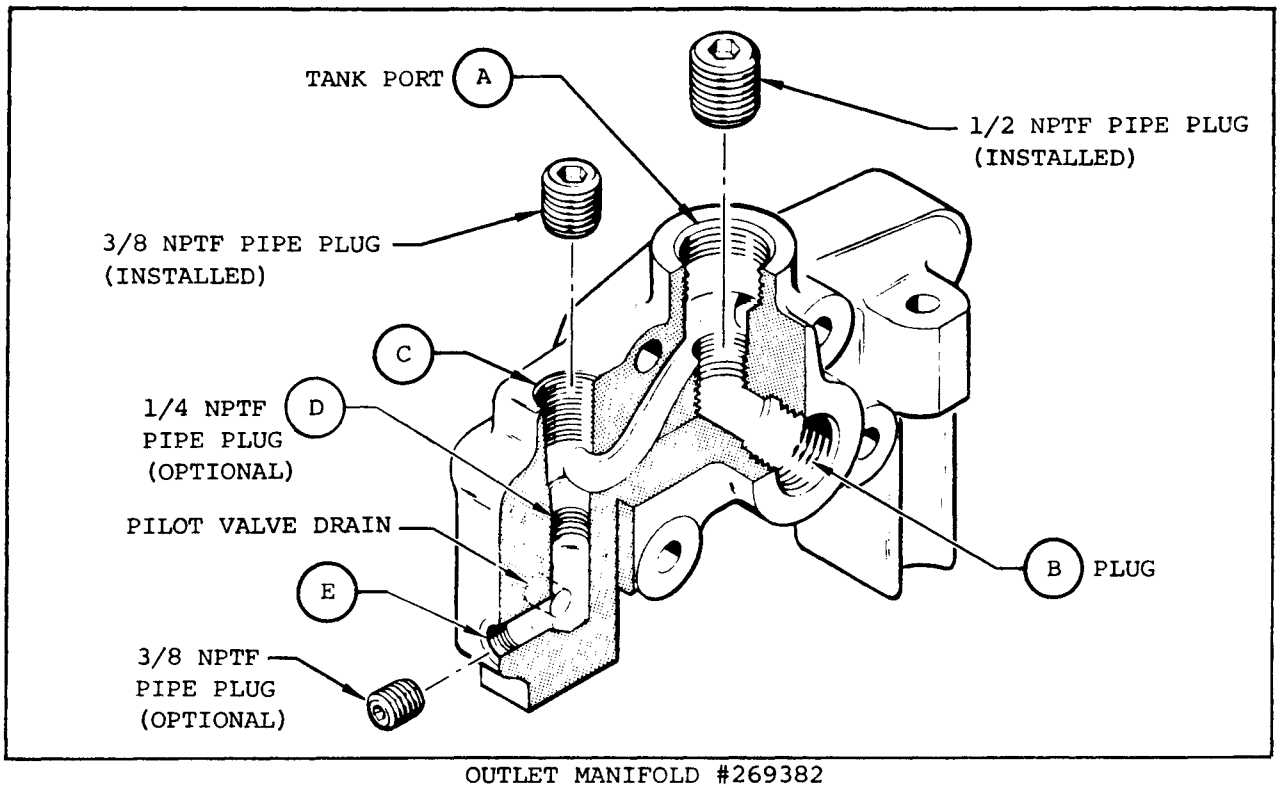


DIRECTIONAL VALVE MANIFOLD (SHEET 1 OF 2)
FIGURE 6



ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
31	1	269360-1	SHUTTLE BY-PASS VALVE ASSY.
32	1	8-014	BACKUP RING
33	1	2-014 N64-70	"O" RING
34	1	269370-012	"O" RING
35	1	269364-1	SHUTTLE VALVE ASSY (1/4 BALL)
36	1	269330-1	SHUTTLE VALVE ASSY. (5/32 BALL)
37	1	8-010	BACKUP RING
38	1	2-010N64-70	"O" RING
39	1	269379-009	"O" RING
40	1	269359-1	PLUG ASSY. (SHUTTLE VALVE)

DIRECTIONAL VALVE MANIFOLD (SHEET 2 OF 2)
FIGURE 6



OUTLET MANIFOLD #269382
FIGURE 7

C. Outlet Manifold Assembly (Figure #7)

The outlet manifold provides the porting to tank for the module. The plugs will be installed as shown for the power system fluid to return to tank from port "A".

Optional porting is available for the pilot circuit drain so that it may be returned to tank separately from port "E" or joined with the power system fluid thru port "A".

If the main system return line pressure will exceed 100 psi the pilot drain should be connected to tank thru port "E" by inserting the 1/4" pipe plug into port "D". If the main system return line pressure is less than 100 psi, the pilot drain can be ported to this circuit within the manifold by inserting the 3/8" plug into port "E" and omitting the 1/4" plug at "D".

CAUTION: DO NOT PLUG BOTH PORTS "D" AND "E" AT SAME TIME since this will block the pilot valve drain.

Port "C" is only for access to Port "D"

IV ASSEMBLY AND SERVICE (Continued)

D. Pilot Valve Assembly

The electrohydraulic pilot valve is a separate replaceable assembly as shown on Figure #6. The correct mounting orientation of the pilot valve is determined by the locating pin in the valve body mounting face. A 150 micron filter is installed beneath this roll pin.

There are no external adjustments for the pilot valve nor mechanical connections to the spool. If a problem related to the pilot valve develops, the unit should be replaced and returned to the factory.

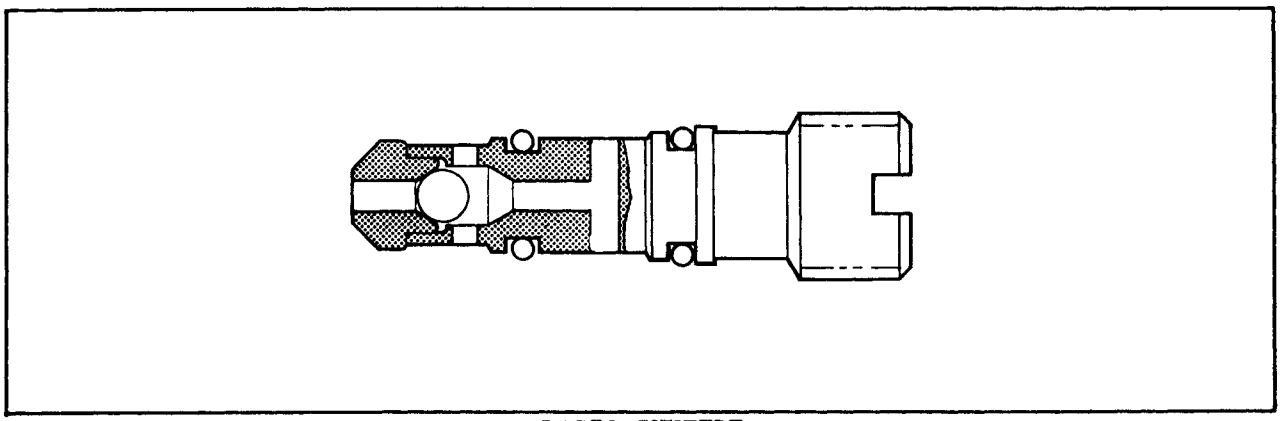
The pilot valve ratings include the following:

Coil	60 ohm resistance
Operating Current	0 to 60 ma
Operating Voltage	0 to 3.6 volts
Maximum Current	100 ma rated
Required Flow	.5 to .6 gpm at 300 psi differential

A positive polarity of the red wire of the pilot valve will provide flow from the cylinder port adjacent to the pilot valve.

E. Shuttle Assemblies

Two types of shuttle assemblies are used in the load sensing control circuit. The basic shuttle shown in Figure #8, is a single ball unit that seals in either position. This type is the standard configuration for shuttle "B" (Reference Figure #2), and is optional for shuttle "A" usage. There are no adjustments in this shuttle.

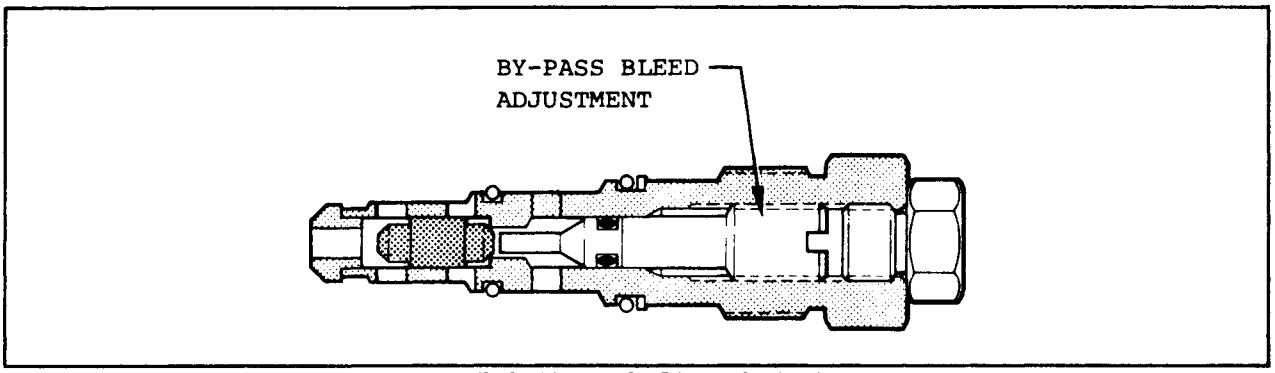


BASIC SHUTTLE
FIGURE 8

IV ASSEMBLY AND SERVICE (Continued)

E. Shuttle Assemblies (Continued)

Figure #9 shows the second shuttle configuration used as shuttle "A", and it provides an adjustable by-pass bleed from cylinder port "B" to cylinder port "A", as shown on Figure #2. This is used to smooth the operation of a holding valve in a topping cylinder application. Therefore, cylinder port "B", which is adjacent to the pilot valve or purge manifold mounting face must be connected to lower the function.



ADJUSTABLE BY-PASS SHUTTLE
FIGURE 9

V. TROUBLE SHOOTING

The modular design of the valve provides simple field trouble shooting and service. The first step should be to isolate the problem to a specific component if possible. For example, change the remote controller leads from one pilot valve to another to check if the problem follows the remote controller.

The same procedure can then be used to check the pilot valves by interchanging two units. Care should be taken to avoid introducing dirt into the system when removing pilot valves.

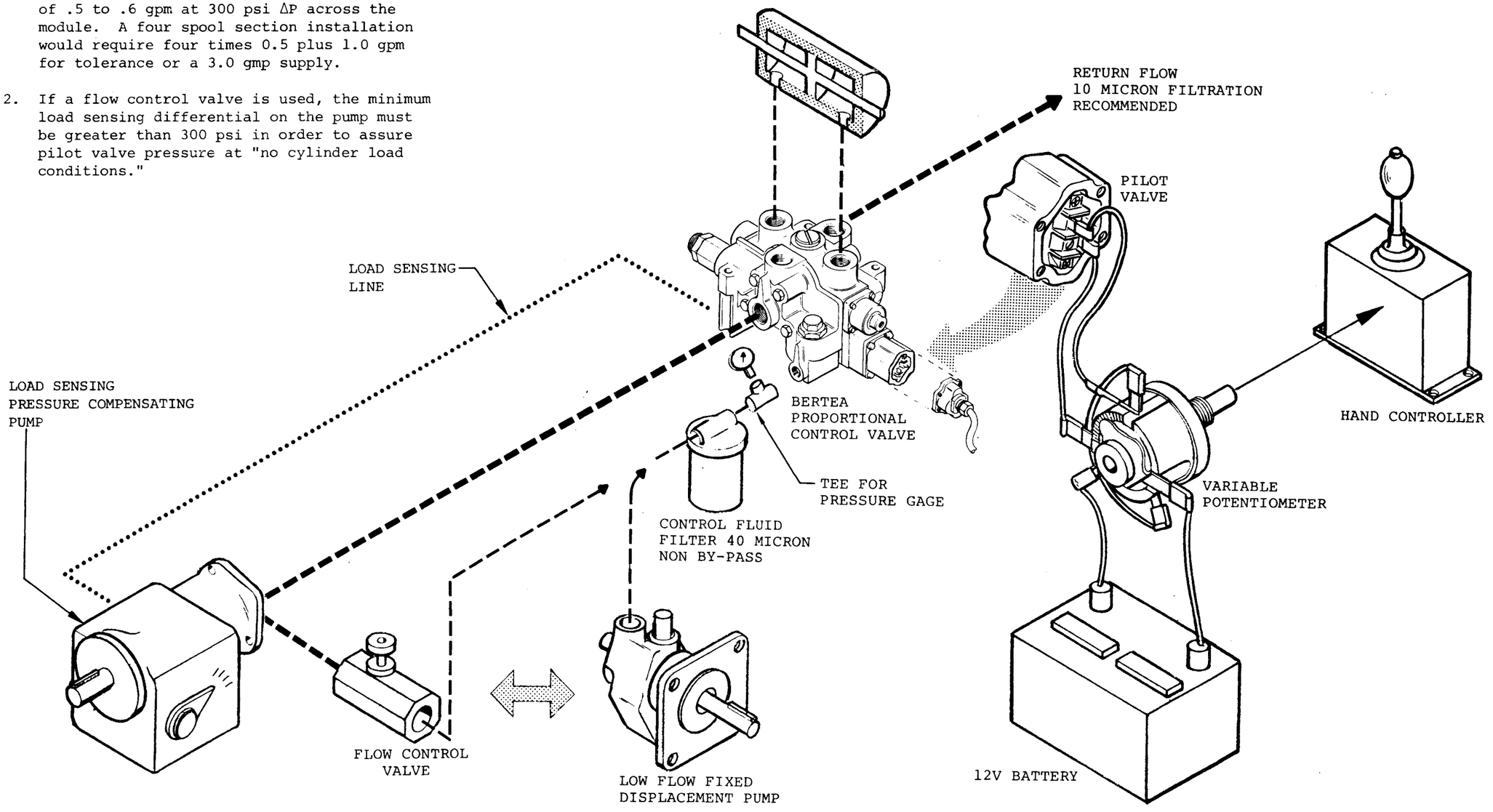
The pilot valve converts an electrical input signal of 0 to 3.6 volts into a pressure unbalance across the directional valve spool. At the factory setting of 300 psi differential pressure across the the pilot valve, the directional valve spool deadband will be a minimum of 20%. Increasing the differential pressure across the pilot valve will reduce the deadband signficantly.

Control problems are usually either electrical, hydraulic or mechanical.

Electrical problems are isolated by disconnecting the wires from the pilot valve to determine if the problem is caused by the remote electrical controller or the pilot valve.

1. Each pilot valve requires a continuous flow of .5 to .6 gpm at 300 psi ΔP across the module. A four spool section installation would require four times 0.5 plus 1.0 gpm for tolerance or a 3.0 gmp supply.

2. If a flow control valve is used, the minimum load sensing differential on the pump must be greater than 300 psi in order to assure pilot valve pressure at "no cylinder load conditions."



BERTEA VALVE INSTALLATION
FIGURE 10

V. TROUBLE SHOOTING (Continued)

Hydraulic control problems, such as poor feathering, can be caused by very high or very low differential pressure across the pilot valve. Hydraulic mal-function problems, such as unwanted motion or non operation, can be caused by contamination failures Check the control system filter and the inlet manifold filter (Item 14, Figure 4) for plugging or failure. Replace the pilot valve with a spare unit or one from another function to check for a plugged valve.

A plugged shuttle valve will prevent the load sensing signal from being transmitted to the pump and therefore, the system will not build up pressure.

VI INSTALLATION

A. Module Assembly

Insert the "O" rings into the respective groves of the inlet manifold and spool sections. Assemble the required number of spool sections between the inlet and outlet manifolds with the pilot valve porting on the right hand side as shown in Figure 11. Use a flat surface for support in order to align the inlet and outlet manifolds. Torque the clamping bolts as noted on below.

The valves are not sensitive to attitude and therefore may be installed in any reasonable manner on the vehicle. Caution should be exercised to avoid placing steel tubing or magnetic material within 1.5 inches of the pilot valve as shown in Figure 11. Magnetic material will affect the flux field of the pilot valve permanent magnet and will cause a major shift in the valve null position.

The optional configurations of the inlet manifold assembly are shown in Figure 4. If the 234905 system relief valve is not required, the 225946 plug must be used in the port in order to provide the correct seals for the internal lands.

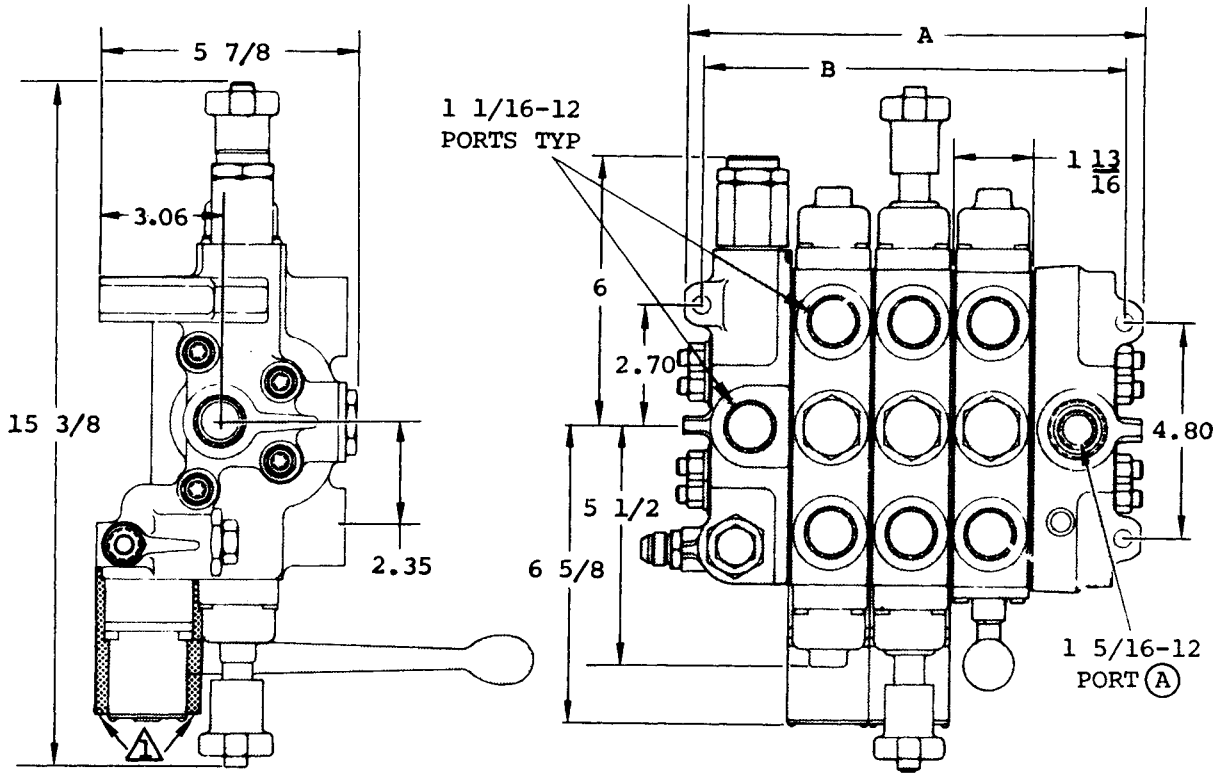
PORT SIZES

Cylinders	1-1/16 - 12 (3/4 tube)
Inlet	1-1/16 - 12 (3/4 tube)
Outlet(Port "A"). .	1-5/16 - 12 (1" tube)
Control Pressure .	3/8 Flared tube - male

BOLT TORQUES

3/8 - 16 Clamping Studs	23 lb-ft	Lube
. . . . .	30 lb-ft	Dry
10 - 24 Screws	30 in-lb	Dry
. . . . .	40 in-lb	Dry

VI. INSTALLATION (Continued)



⚠1 CAUTION: NO MAGNETIC METAL WITHIN 1.5" OF PILOT VALVE AS SHOWN.

⚠2 LOAD SENSING PORT SAE 7/16-20 HNF (1/4" TUBE)

NUMBER OF SPOOL SECTIONS	1	2	3	4	5	6
DIMENSION "A"	6.83	8.72	10.61	12.50	14.39	16.28
DIMENSION "B"	5.96	7.85	9.74	11.63	13.52	13.41
STACKING KIT P/N 242902 DASH NO.	-1	-2	-3	-4	-5	-6

MODULE INSTALLATION
FIGURE 11

A. Module Assembly (Continued)

The 231852 pilot pressure relief valve establishes the 300 psi differential pressure for the pilot valve circuit. Only one pilot pressure relief valve is required per vehicle and therefore when two or more modules are used, this port must be closed with a 231856 plug in the extra modules. Each pilot valve requires a continuous flow of .5 to .6 GMP at 300 psi

A. Module Assembly (Continued)

Δ P. A four spool section installation would require four times .5 GPM plus 1.0 GPM for assurance or a 3.0 GPM supply. Figure 10 shows typical installations of a separate pump for pilot fluid supply and a circuit using a divider. A 40μ filter is required as shown for this pilot fluid circuit.

B. Filtration and Hydraulic System Preparation

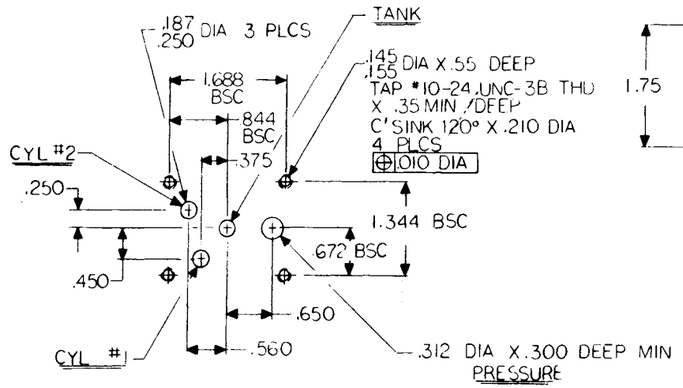
The life of any hydraulic system is sensitive to the cleanliness of the fluid stream. It is recommended that good cleaning and flushing procedures be followed in the assembly and test of the system.

The purpose of separating the control pressure fluid from the main power circuit fluid as shown on Figure 10 is to assure continuous filtration of the fluid supply to the pilot valves. A 40 micron full flow, non bypass filter is required for the control pressure circuit. The minimum flow rate will be based on the number of pilot valves used, it is recommended that a unit as large as possible be used to insure long filter life.

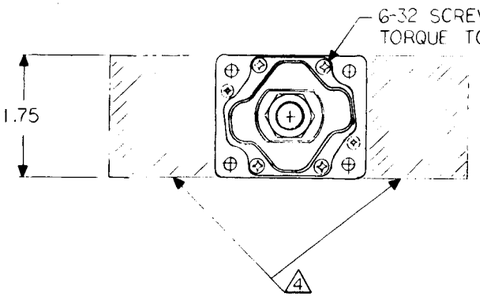
The main power fluid circuit filtration should be 10 micron as shown on Figure 10. A suction strainer on the pump and magnetic tank unit are benefical to filter life.

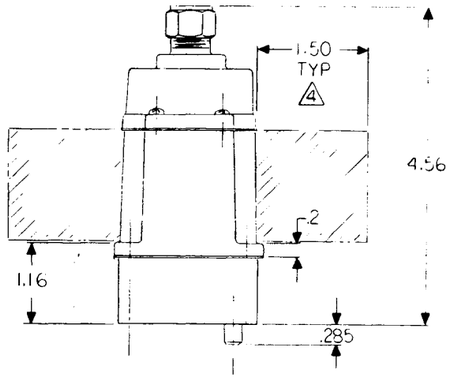
A secondary filter is installed in each inlet section (see Figure 4) to provide pilot valve protection from contamination generated between the main control fluid filter and the valve.

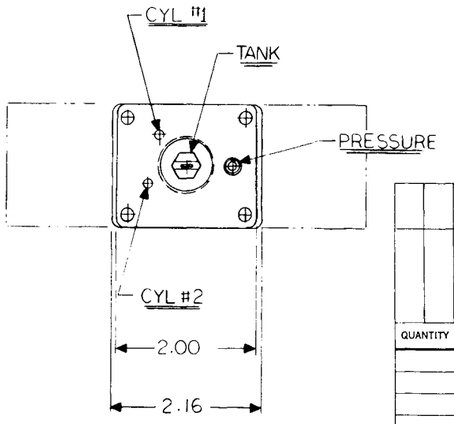
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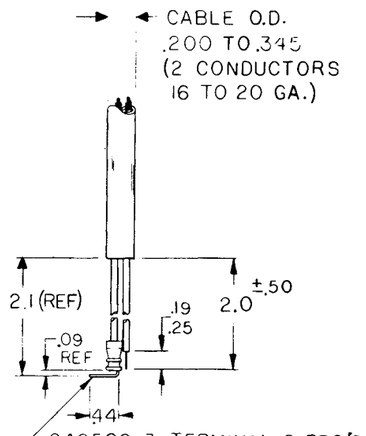


MOUNTING FACE
(REQ'D FOR MOUNTING MANIFOLD)



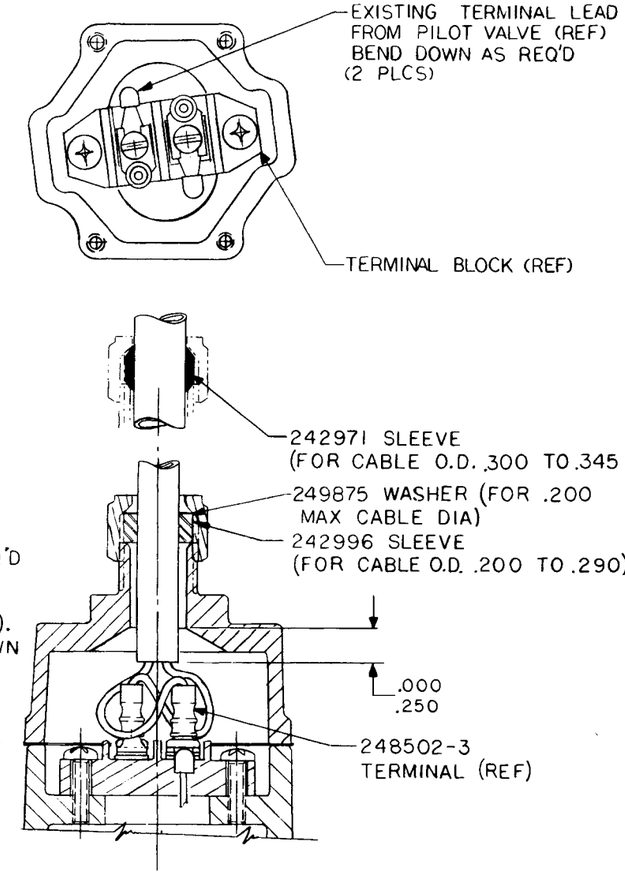






248502-3 TERMINAL 2 REQ'D
(BERTEA FURNISHED)
(AMP SPECIAL IND.
P/N 327043 BEFORE BEND).
STRIP INSULATION AS SHOWN
AND CRIMP WITH ONE OF
THE FOLLOWING CRIMPING
TOOL:
AMP SPEC. IND. NO. 29564
VACO CORP. NO. 1902
THOMAS & BETTS
NO. WT1000
HOLLINGSWORTH
SOLDERLESS TERMINAL CO.
NO. H2A
OR EQUIV. TOOL

CUSTOMER'S CABLE



TERMINAL CONNECTIONS
2X SIZE

NOTES:

1. TECHNICAL DATA

DIFFERENTIAL PRESSURE	300 PSI
QUIESCENT FLOW	.5 TO .6 GPM
COIL RESISTANCE	60 OHMS
RATED CURRENT	60 MA
FILTRATION	25 MICRON
RATED VOLTAGE @ 60 MA	3.6 VOLTS DC
FLUID	PETROLEUM OIL
WEIGHT	.85 LB/385 GM

2. WHEN RED WIRE IS POSITIVE, PRESSURE AT CYL #2 IS GREATER THAN CYL #1.
3. FOR MOUNTING, USE BERTEA SCREW P/N 234909 (10-24 X 1-1/2 SOC HEAD CAP SCREW - NON MAGNETIC CRES), AND BERTEA GASKET P/N 225931 TORQUE TO 38-42 IN-LBS DRY 4 PLC. USE BERTEA WASHER P/N 234959 UNDER HEAD OF SCREW.
4. CAUTION: NO MAGNETIC MATERIAL ALLOWED WITHIN AREA SHOWN.

TABLE OF ELECTRICAL CABLES REF.

TYPE	NO. OF COND.	WIRE SIZE	O.D. (REF)
SJO	2	18 AWG	.300
SJO	2	16 AWG	.330
SDN	2	18 AWG	.278
SDN	2	16 AWG	.292

QUANTITY REQUIRED FOR NOTED ASSEMBLY			
NEXT ASSY.	QTY. REQ.	COMPLETE ASSY.	QTY. REQ.

PART NO. & NAME	MATERIAL	MATERIAL SPEC.	HEAT TREATMENT	FINISH	SHT

UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN INCHES
TOLERANCE ON:

LINEAR DIMENSIONS		ANGLES	
.XXX	= ± .010	XX.XX	= ± 0.50°
.XX	= ± .040	XX.X	= ± 1.0°
.X	= ± .100	XX	= ± 5.0°

DRAWING SYMBOLS & TOLERANCE PER USASI Y14.5
125 MAX. SURFACE ROUGHNESS PER USASI B46.1
STRAIGHT THREADS PER MIL-S-8879
MFG. PRACTICES PER BMF 5103

DRAWN: L. LAMBERT	7-2-74	BERTEA / CORPORATION IRVINE • CALIFORNIA
CHECKED: VAD	8-15-74	INSTALLATION DRAWING - FOR 234912 PILOT VALVE
APPROVED: ACW	8-16-74	SIZE D · CODE IDENT NO. 82106 · 242980
		SCALE: 1/1 & NOTED · SHEET 1 OF 1

PILOT VALVE INSTALLATION
FIGURE 12