**TECHNICAL MANUAL**

# UNIT, INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT MAINTENANCE MANUAL

**DRILLING SYSTEM, WELL, ROTARY,**
**TRUCK MOUNTED, AIR TRANSPORTABLE,**
**600 FEET CAPACITY**
**MODEL LP-12**
**NSN 3820-01-246-4276**

**This technical manual is an authentication of the manufacturer's commercial literature and does not conform with the format and content requirements normally associated with Army technical manuals. This technical manual does, however, contain all essential information required to operate and maintain the equipment.**

**Approved for public release; distribution is unlimited.**

**HEADQUARTERS, DEPARTMENT OF THE ARMY**
**8 MAY 1989**

CHANGE
No. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C. 4 October 1989

**UNIT, INTERMEDIATE DIRECT SUPPORT AND
INTERMEDIATE GENERAL SUPPORT MAINTENANCE MANUAL**

**DRILLING SYSTEM, WELL, ROTARY
TRUCK MOUNTED, AIR TRANSPORTABLE,
600 FEET CAPACITY
MODEL LP-165F299
NSN 3820-01-246-4276**

**Approved for public release; distribution is unlimited.**

TM 5-3820-256-24-2, 8 May 1989 is changed as follows.

1. Title is changed as shown above.

2. Retain this sheet in front of manual for reference purposes.

By Order of the Secretary of the Army:

**CARL E. VUONO**
*General, United States Army*
*Chief of Staff*

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*Brigadier General, United States Army*
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DISTRIBUTION:
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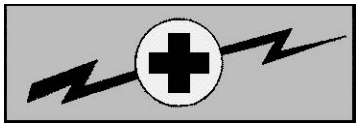
**WARNING**



MI 131637

**ELECTRIC POWER LINES CAN KILL**

**Never raise mast or crane, or operate drill unit with less than 25 feet working clearance to any electrical power line.**

**Do not touch live electrical parts.**

**Check for buried utility lines before drilling.**

**WARNING**

**Crane and drilling operations have inherent hazards that cannot be mechanically safe guarded. Operator and maintenance personnel are required to wear hard hats and safety shoes.**

**Compressed air used for cleaning can create airborne particles that may enter the eyes. Pressure will not exceed 30 psig. Eye protection required.**

**Never operate engine in enclosed areas. Exhaust gases, particularly carbon monoxide, may build up. These gases are harmful and potentially lethal.**

**Cleaning solvent (PD-680, Type 11) is toxic to skin, eyes and respiratory tract. Skin and eye protection required. Avoid repeated or prolonged contact. Good general ventilation is normally adequate.**

**Welding operations produce heat, highly toxic fumes, injurious radiation, metal slag and airborne particles. Protection equipment consisting of welding goggles with proper tinted lenses, apron or jacket, and welder's boots required. Good general ventilation is normally adequate.**

**Exercise care when using sharp or pointed tools to prevent injury to personnel.**

**Personnel will be trained in safe climbing practices. Climbing devices will be used on mast at all times. Safety climbing devices will be inspected prior to each use to insure good working order.**

**For Artificial Respiration, refer to FM 21-1 1.**

**WARNING**

**NOISE HAZARD**

**exist for all personnel within 15 Feet of an operating drilling unit. Personnel must wear approved ear protection equipment. Failure to do so may result in impairment or loss of hearing.**

# INTRODUCTION

## 1. SCOPE

This manual covers the 600 Feet Capacity Well Drilling System, Model LP-12, NSN 3820-01-246-4276. This manual consists of six volumes.

## 2. DRILLING SYSTEM

The Drilling System consists of three main components; a well drilling machine; a support vehicle (rig tender); and a well completion kit. Government furnished (GFE) incorporated as part of the system include a trailer mounted power unit and 3,000 gallon, collapsible, fabric water tank.

## 3. DRILLING MACHINE - VOLUME 1

The drilling machine is a truck mounted rotary well drilling machine consisting of a 32 foot mast, three drum drawworks assembly, rotary table, mud pump and air compressor. The components of the drilling machine are powered by the truck engine.

## 4. SUPPORT VEHICLE - VOLUME 2

The support vehicle is a truck mounted vehicle consisting of a 1,000 gallon water tank, hydraulically driven water pump, an electric fuel pump and fuel dispensing nozzle, a welder-generator assembly, and an electro-hydraulic crane. The support vehicle also provides a storage area for transport of drill pipe, collars, hand tools, operating and accessory equipment for the drilling machine, and the well completion equipment.

## 5. TRUCKS - VOLUMES 3, 4 and 5

The drilling machine and support vehicle are mounted on truck chassis of the same model. The drilling machine truck has a special design low profile cab. The truck is a diesel engine powered, 6x6 vehicle with a transfer case to transfer engine power to truck mounted components.

## 6. WELL COMPLETION - VOLUME 6

The well completion kit consists of equipment necessary for completion of a 600-ft. water well.

## 7. OPERATION INSTRUCTIONS

Refer to TM5-3820-256-10 for Operation, Preventive Maintenance and Lubrication of the Well Drilling System.

## 8. REPAIR PARTS

For repair parts refer to TM5-3820-256-24P, Repair Parts and Special Tools List.

## 9. APPENDIXES - VOLUME 6

Maintenance Allocation Chart is contained in Appendix A; Torque Requirements are contained in Appendix B.

**TABLE OF CONTENTS**
**VOLUME 1**


**CHAPTER 1. GENERAL DESCRIPTION**

| | | |
|---|---|---|
| 1-1 | Description | 1-1 |
| 1-2 | Capabilities | 1-1 |
| 1-3 | Repair Parts | 1-1 |
| 1-4 | Tabulated Data | 1-2 |

**CHAPTER 2.** 2-1

**CHAPTER 3. SERVICE AND LUBRICATION**

| | | |
|---|---|---|
| 3-1 | Periodic Service | 3-1 |
| 3-2 | Lubrication | 3-4 |

**CHAPTER 4. MAINTENANCE**

| | | |
|---|---|---|
| 4-1 | Introduction | 4-1 |
| 4-2 | Troubleshooting | 4-1 |
| 4-3 | Maintenance of Air System | 4-21 |
| 4-4 | Maintenance of the Mud Pump Drive | 4-32 |
| 4-5 | Maintenance of the Mud Pump | 4-38 |
| 4-6 | Maintenance of the Subdrive Assembly | 4-46 |
| 4-7 | Maintenance of Air Compressor Drive | 4-81 |
| 4-8 | Maintenance of Water Injection System | 4-101 |
| 4-9 | Maintenance of Drawworks | 4-112 |
| 4-10 | Maintenance of Rotary Table Drive | 4-130 |
| 4-11 | Maintenance of Rotary Table Transfer Cylinder | 4-141 |
| 4-12 | Maintenance of Leveling Jacks | 4-144 |
| 4-13 | Maintenance of the Mast | 4-146 |
| 4-14 | Maintenance of Chain Feed Drive | 4-151 |
| 4-15 | Maintenance of Discharge Piping Assembly | 4-159 |
| 4-16 | Mast Raising Cylinder Assembly | 4-164 |
| 4-17 | Hydraulic Breakout Assembly | 4-166 |
| 4-18 | Maintenance of Hydraulic System | 4-169 |
| 4-19 | Maintenance of Winch Assembly | 4-171 |
| 4-20 | Maintenance of Frame Components | 4-185 |

**TABLE OF CONTENTS - Continued**

**VOLUME 2**


**CHAPTER 1. GENERAL INFORMATION**

1-1 Introduction ..... 1-1
1-2 Tabulated Data ..... 1-1

**CHAPTER 2.** 2-1

**CHAPTER 3. WATER TANK AND PUMPING SYSTEM**

Maintenance

3-3 Water Pump ..... 3-4
3-4 Hydraulic Motor ..... 3-6

**CHAPTER 4. WELDER GENERATOR**

Section 1. Safety Rules for Operation of Arc Welding Power Source

4-1 Introduction ..... 4-1
4-2 General Precautions ..... 4-1
4-3 Arc Welding ..... 4-7
4-4 Standards Booklet Index ..... 4-10

Section 2. Introduction

4-5 General Information and Safety ..... 4-11

Sections 3 thru 5 refer to TM 5-3820-256-10

Section 6. Maintenance

4-9 Maintenance ..... 4-22
4-10 Engine Maintenance ..... 4-26

Section 7. Troubleshooting

4-11 Troubleshooting Chart ..... 4-30
4-12 Booster Battery Jump Starting ..... 4-33
4-13 Engine Specification Data ..... 4-35

**CHAPTER 5. CRANE**

Maintenance

5-4 Lubrication and Service ..... 5-9
5-5 Field Testing ..... 5-11
5-6 Troubleshooting ..... 5-12
5-7 Crane Assembly ..... 5-13

**TABLE OF CONTENTS - Continued**

**VOLUME 2 - Continued**


**CHAPTER 6. WINCH**

| | | |
|---|---|---|
| 6-2 | Lubrication | 6-3 |
| 6-3 | Adjusting the Oil Cooled Worm Brake | 6-3 |
| 6-4 | Attaching Wire Rope to the Drum | 6-4 |
| 6-5 | Preventive Maintenance | 6-5 |
| 6-6 | Troubleshooting | 6-5 |
| 6-7 | Maintenance of Worm Brake | 6-6 |
| 6-8 | Winch Overhaul | 6-9 |

**CHAPTER 7. HYDRAULIC PUMP/PTO ASSEMBLY**

| | | |
|---|---|---|
| 7-1 | Hydraulic Pump | 7-1 |
| 7-2 | Power Take-Off | 7-9 |

**CHAPTER 8. FUEL TRANSFER**

| | | |
|---|---|---|
| 8-1 | Fuel Pump | 8-1 |
| 8-2 | Fuel Transfer Motor | 8-2 |

**TABLE OF CONTENTS - Continued**
**VOLUME 3**


**CHAPTER 1. GENERAL INFORMATION**

| | | |
|---|---|---|
| 1-1 | Introduction | 1-1 |
| 1-2 | Component Code Numbers | 1-1 |

**CHAPTER 2. OPERATION** 2-1

**CHAPTER 3. MAINTENANCE**

| | | |
|---|---|---|
| 3-1 | Preface | 3-1 |
| 3-2 | Axle - Front | 3-2 |
| 3-3 | Axle - Rear | 3-2 |
| 3-4 | Brakes | 3-2 |
| 3-5 | Cab | 3-4 |
| 3-6 | Care of Vehicle | 3-4 |
| 3-7 | Clutch | 3-4 |
| 3-8 | Electrical | 3-5 |
| 3-9 | Engine | 3-5 |
| 3-10 | Frame and Tow Hooks | 3-10 |
| 3-11 | Fuel and Lubricant Additives | 3-10 |
| 3-12 | Fuel System | 3-10 |
| 3-13 | Supporting Vehicle for Service | 3-11 |
| 3-14 | Propeller Shaft | 3-11 |
| 3-15 | Springs | 3-11 |
| 3-16 | Steering | 3-12 |
| 3-17 | Tires | 3-13 |
| 3-18 | Transmission | 3-16 |
| 3-19 | Wheels | 3-16 |

**CHAPTER 4. LUBRICATION**

| | | |
|---|---|---|
| 4-1 | Lubrication Instructions | 4-1 |
| 4-2 | Specifications and Capacities | 4-11 |

**TABLE OF CONTENTS - Continued**
**VOLUME 4**


| Subject | CTS No. |
|---|---|
| **GENERAL INFORMATION** | Pages 4-10 |
| **GROUP 01 FRAME** | 4004 |
| **GROUP 02 FRONT AXLE** | |
| Model FA-83 Fabco (SDA-12) | |
| **GROUP 03 SPRINGS** | |
| SUSPENSION ALIGNMENT | 4016 |
| SPRINGS, SHOCK ABSORBERS | 4168 |
| EQUALIZING BEAM SUSPENSION (HENDRICKSON) | 4169 |
| **GROUP 04 BRAKES** | |
| AIR BRAKES | |
| Air System, General Information | 4154 |
| Air Compressor | |
| Midland Ross EL-1300-1600 | 4077 |
| Components | 4079 |
| Foundation Brake Group | |
| Cam Actuated Type (Includes Air Chambers and Manual Slack Adjusters) | 4080 |
| Reconditioning Brake Drums and Shoes | 4082 |
| PARKING BRAKES | |
| MGM Stopguard | 4101 |
| **GROUP 05 STEERING** | |
| PUMPS | |
| Eaton | 4027 |
| COLUMNS | 4150 |
| **GROUP 06 PROPELLER SHAFT** | 401 7 |
| **GROUP 07 EXHAUST** | —— |
| **GROUP 08 ELECTRICAL** | |
| ALTERNATOR: IH 08142 | 4043 |
| BATTERY: | |
| "Fleetrite' International Low Maintenance and Maintenance-Free | 4111 |
| CIRCUIT DIAGRAMS: Regular Cab | 4341 |
| GENERAL: Lights | 4088 |
| INSTRUMENTS | 4140 |
| STARTING MOTOR: | |
| Delco-Remy Heavy Duty | CGES-230 |
| **GROUP 09 FRONT END SHEET METAL (See Group 16)** | —— |
| **GROUP 10 LUBRICATION** | 4033 |

**GROUP 11 CLUTCH**
CLUTCH ASSEMBLY
Code 11369 ..... 4195
CLUTCH LINKAGE
S-Series ..... 4050

**TABLE OF CONTENTS - Continued**
**VOLUME 5**


| Subject | CTS No. |
|---|---|
| **GROUP 12 ENGINE** | |
| DIESEL ENGINE | |
| Diagnostic Manual DT/DTI 466 | CGES-240-4 |
| DT/DTI Engine | |
| Service Manual | CGES-185-3 |
| Injection Pump (Robert Bosch Model MW) and Nozzles | CGES-375 |
| Turbocharger | 4104 |
| COOLING SYSTEM | 4181 |
| **GROUP 13 TRANSMISSION** | |
| **CM5952D SPICER 5-SPEED** | |
| **GROUP 14 REAR AXLES** | |
| TANDEM RA-355 | 4044 |
| **GROUP 15 FUEL TANKS** | —— |
| **GROUP 16 BODY CAB/COWL** | |
| CAB 4065 | |
| Repair Instructions Using Fiber Glass Material | 4049 |
| Air Conditioning/Heating Systems Basic Theory and General Application | 4194 |
| WINDSHIELD WIPER/WASHERS | |
| Windshield Wiper (Electric) | 4056 |
| Windshield Wiper/Washer | 4061 |
| **GROUP 17 WHEELS, RIMS AND TIRES** | 4148 |

**TABLE OF CONTENTS - Continued**

**VOLUME 6**


**CHAPTER 1. GENERAL INFORMATION**

1-1 Introduction ..... 1-1
1-2 Definitions ..... 1-1

**CHAPTER 2. LOGGING WELLS**

2-4 Troubleshooting ..... 2-7
2-5 Maintenance ..... 2-9
2-6 Interpretation of Electrical Logs ..... 2-9

**CHAPTER 3. WELL CASING** ..... 3-1

**CHAPTER 4. WATER PRODUCTION**

4-1 Submersible Pump ..... 4-1
4-2 Water Production ..... 4-7
4-4 Troubleshooting ..... 4-13

Appendix A Maintenance Allocation Chart ..... A-1
Appendix B Torque Requirements ..... B-1

## LIST OF ILLUSTRATIONS - Volume 1


| Figure | | Page |
|---|---|---|
| 3-1 | Lubrication Chart | 3-5 |
| 4-1 | Air Compressor Diagrams | 4-19 |
| 4-2 | Controlair Valve | 4-22 |
| 4-3 | Adjustment Set-Up | 4-24 |
| 4-4 | Pilotair Valve | 4-26 |
| 4-4 A | Air Line Conditioner Unit | 4-29 |
| 4-5 | Mud Pump Drive Assembly | 4-33 |
| 4-6 | Clutch Plate Wear Limits | 4-36 |
| 4-7 | Mud Pump Drive Clutch | 4-36 |
| 4-8 | Mud Pump | 4-39 |
| 4-9 | Subdrive Assembly, Major Components | 4-47 |
| 4-10 | Subdrive Assembly, Exploded View | 4-50 |
| 4-11 | Power Take-Off | 4-54 |
| 4-12 | Hydraulic Pump | 4-61 |
| 4-13 | Hydraulic Pump Control | 4-64 |
| 4-14 | Cylinder Block Kit | 4-66 |
| 4-15 | Pump Flow Adjustment | 4-67 |
| 4-16 | Hydraulic Gear Pump | 4-68 |
| 4-17 | Body Pore Measurement | 4-69 |
| 4-18 | Pump Gears | 4-70 |
| 4-19 | Displacement Pump | 4-72 |
| 4-19A | Driveshaft | 4-82 |
| 4-20 | Shaft Seal Assembly | 4-83 |
| 4-21 | Air Compressor Drive Clutch | 4-86 |
| 4-21A | Oil Filter | 4-88 |
| 4-21B | Hydraulic Cooling Fan Motor | 4-89 |
| 4-21C | Thermostatic Bypass Valve | 4-90 |
| 4-21D | Air Compressor Air Filter | 4-92 |
| 4-21E | Inlet Throttle Assembly | 4-93 |
| 4-21F | Air/Oil Separator | 4-95 |
| 4-21G | Force Feed Lubricator | 4-99 |
| 4-21H | Lubricator Assembly | 4-100 |
| 4-22 | Water Injection Pump | 4-103 |
| 4-22A | Foam Pulse Pump | 4-106 |
| 4-22B | Water Injection Drive Motor | 4-107 |
| 4-23 | Bevel Gear Box Assembly | 4-113 |
| 4-24 | Third Drum | 4-116 |
| 4-25 | Third Drum Clutch | 4-118 |
| 4-26 | Hoisting and Auxiliary Drum | 4-121 |
| 4-27 | Hoisting and Auxiliary Drum Clutch | 4-123 |
| 4-28 | Rotorseal | 4-126 |
| 4-28A | Drum Brakes | 4-127 |
| 4-28B | Third Drum Clutch Control | 4-129 |

## LIST OF ILLUSTRATIONS - Volume 1 (Contd)


| Figure | | Page |
|---|---|---|
| 4-29 | Fixed Displacement Motor | 4-131 |
| 4-30 | Motor Manifold Valve Assembly | 4-136 |
| 4-30A | Rotary Table Transmission | 4-139 |
| 4-30B | Rotary Table Sliding Base | 4-142 |
| 4-31 | Rotary Table Transfer Cylinder | 4-143 |
| 4-32 | Hydraulic Leveling Jack | 4-145 |
| 4-33 | Crown Block Assembly | 4-147 |
| 4-34 | Chain Feed Sprocket | 4-149 |
| 4-34A | Chain Pulldown Assembly | 4-150 |
| 4-35 | Service Tools | 4-151 |
| 4-36 | Chain Feed Drive Motor | 4-153 |
| 4-37 | Pulldown Transmission | 4-156 |
| 4-37A | Pulldown Transmission Control | 4-160 |
| 4-38 | Shear Relief Valve | 4-161 |
| 4-39 | Discharge Ball Valve | 4-163 |
| 4-40 | Mast Raising Cylinder | 4-165 |
| 4-40A | Breakout Tong Assembly | 4-167 |
| 4-41 | Breakout Cylinder | 4-168 |
| 4-42 | Hydraulic Piping | 4-168.1 |
| 4-43 | Hydraulic Oil Filter | 4-170 |
| 4-44 | Winch Assembly | 4-172 |
| 4-45 | W inch Motor | 4-176 |
| 4-45A | Timing the Winch Motor | 4-177 |
| 4-46 | Power Take-Off, Winch | 4-179 |
| 4-47 | Winch Pump | 4-181 |
| 4-48 | Drill Platform Assembly | 4-186 |


## LIST OF TABLES - Volume 1


| Table | | Page |
|---|---|---|
| 1-1 | Tabulated Data | 1-2 |
| 3-1 | Periodic Services | 3-1 |
| 4-1 | Troubleshooting | 4-1 |
| 4-2 | Air Compressor Troubleshooting | 4-17 |
| 4-3 | Clearance Limits | 4-45 |

## LIST OF ILLUSTRATIONS - Volume 2


| Figure | Title | Page |
|---|---|---|
| 3-4 | Water Pump, Exploded View | 3-5 |
| 3-5 | Water System Hydraulic Motor | 3-7 |
| 4-7 | Brush Replacement | 4-24 |
| 4-8 | Engine Speed Adjustments | 4-25 |
| 4-9 | Air Cleaner | 4-27 |
| 4-10 | Checking Valve Clearance | 4-28 |
| 4-11 | Cylinder Head Tightening Sequence | 4-29 |
| 4-12 | Circuit Diagram For Automatic Idle Control Circuit Board PC1 | 4-36 |
| 4-13 | Circuit Diagram For Voltage Regulator Circuit Board PC2 | 4-37 |
| 5-4 | Crane and Hydraulics Lubrication | 5-10 |
| 5-5 | Troubleshooting Chart | 5-12 |
| 5-6 | Crane Winch Motor | 5-13 |
| 5-7 | Crane Winch, Exploded View | 5-15 |
| 5-8 | Crane Winch Motor | 5-19 |
| 5-9 | Extension Boom Assembly | 5-22 |
| 5-10 | Main Boom Assembly | 5-24 |
| 5-11 | Main and Extension Cylinders | 5-27 |
| 5-12 | Rod Seal Installation | 5-28 |
| 5-13 | Control Valve | 5-29 |
| 5-14 | Turret and Crane Base | 5-33 |
| 5-15 | Hydraulic Diagram, Crane | 5-35 |
| 5-16 | Electrical Schematic, Crane | 5-36 |
| 6-1 | Attaching Wire Rope | 6-4 |
| 6-2 | Worm Brake | 6-7 |
| 6-3 | Adjustment Adapter | 6-8 |
| 6-4 | Winch, Exploded View | 6-10 |
| 7-1 | Check Valve Tool | 7-2 |
| 7-2 | Seal Removal Tool | 7-3 |
| 7-3 | Special Steel Sleeve | 7-3 |
| 7-4 | Hydraulic Pump | 7-5 |
| 8-1 | Fuel Transfer Pump and Motor | 8-3 |

## LIST OF TABLES - Volume 2


| Figure | Title | Page |
|---|---|---|
| 4-1 | Engine Maintenance Chart | 4-26 |
| 4-2 | Engine Torque Values | 4-30 |
| 4-3 | Troubleshooting | 4-31 |
| 6-1 | Specifications | 6-2 |
| 6-2 | Troubleshooting | 6-5 |

## LIST OF ILLUSTRATIONS - Volume 3


| Figure | Title | Page |
|---|---|---|
| 3-1 | Deleted | |
| 3-2 | Steering Column Clamp or Yoke Bolt | 3-13 |
| 3-3 | Circumferential Tread Channeling | 3-15 |
| 3-4 | Disc Wheel Tightening Sequence | 3-17 |


## LIST OF TABLES - Volume 3


| Figure | Title | Page |
|---|---|---|
| 2-1 | Air Restriction Gauge Troubleshooting | 2-14 |
| 2-2 | Starting Aid Chart | 2-17 |
| 3-1 | Engine Maintenance Schedule Chart | 3-7 |
| 3-2 | Belt Tension Chart | 3-10 |
| 3-3 | U-Bolt Nut Chart | 3-12 |
| 3-4 | Steering Bolts Chart | 3-13 |

## CHAPTER 1

## GENERAL INFORMATION

**1-1 INTRODUCTION**. This manual contains operation, service, and maintenance instructions for the Rig Tender Truck, a component of the 600-Foot Well Drilling System manufactured by George E. Failing Co. of Enid, Oklahoma.

**1-2 TABULATED DATA**. Table 1-1 contains specification and identification data pertinent to the truck and its major components.

**Table 1-1. Tabulated Data**

| | |
|---|---|
| Overall Dimensions: | |
| Length | 405 in. |
| Width | 96 in. |
| Height | 101 in. |
| Max GVW | 40,000 lb. |
| Capacities: | |
| Waterbed | 1,000 Gallons |
| Fuel Tank (Service) | 230 Gallons |
| Fuel Tanks (Truck) | 200 Gallons |
| Hydraulic Reservoir | 7.5 Gallons |
| Truck Chassis: | |
| Make | Navistar International |
| Model | F-1 954 6X6 Modified |
| Engine: | |
| Make | Navistar International |
| Model | DT-466C |
| Fuel | Diesel |
| Horsepower | 210 |
| Displacement | 466.1 Cu. In. |
| Transmission: | |
| Make | Spicer |
| Model | CM5952D |
| Speeds | 5 Forward/I Reverse |
| Oil Capacity | 17 Pints |
| Water Pump: | |
| Make | Bowie |
| Model | 2300/STD/F |
| Delivery | 140 GPM @ 400 RPM |
| Crane: | |
| Make | Flatwater Fleet |
| Model | 8 K 20 |
| Reach (Max.from Centerline of Rot.) | 15'-8" |
| Extension | 60" |

Welder/Generator:

| | |
|---|---|
| Make | Miller Electric Mfg. |
| Model | DEL-200 |
| Engine Make | Deutz |
| Engine Model | FIL 210 D |
| Horsepower | 13.9 |
| Output Rating (@ 100% duty cycle) | 225 Amps @ 25V AC<br>200 Amps @ 25V AC |
| Welding Range | 45-225 Amps (AC)<br>35-200 Amps (DC) |
| Open Circuit Voltage | 80V AC<br>72V DC |
| Power | 1 kva, 11 5V, 8.7 Amps AC (welding);<br>4.5 kva, 120/240V, 38/19 Amps 60Hz AC<br>as power plant |

## CHAPTER 2

All information in chapter 2 is contained in TM 5-3820-256-10.

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Pages 3-1 thru 3-3 are deleted. All information regarding operation is contained in TM 5-3820-256-10.

## Maintenance

### 3-3 WATER PUMP.

3-3.1 Lubrication. The water pump requires lubrication only where grease fittings are provided. Use a good grade of gun grease. Lubrication should be done every four (4) hours of continuous operation.

3-3.2 Troubleshooting.

When the pump is requiring an excessive amount of power, the causes may be due to one of the following:

1. Pump has been run dry and gears have swelled due to heat caused by friction.
2. Liquid more viscous than anticipated.
3. Pumping against excess pressure.
4. Discharge line too small causing excess pressure.
5. Discharge line obstructed causing excess pressure.
6. Foreign matter lodged in pump.
7. Shaft bent due to dropping, etc.
8. Too great a lift causing excess pressure.
9. Removal of too many gaskets, causing drag on gears.

3-3.3 Adjustment. (Refer to figure 3-4)

3-3.3.1 Should it be necessary to adjust the pump due to excessive clearance of the impellers (4 & 5) between the front and back of housing (3) due to normal wear, remove the back (7) plate and remove one, two, or three, etc. pump gaskets (6) as may be required to take up the slack. Replace back plate, being extremely careful that the remaining gaskets do not crimp or wrinkle, and tighten bolts (14) diametrically opposed to each other, pulling each bolt up evenly.

3-3.4 Maintenance. (Refer to figure 3-4)

3-3.4.1 The pump is furnished with a high grade, braided type of asbestos packing (1 3), lubricated with graphite and impregnated with lubricant. No further lubrication is needed for normal operation of this packing. When tightening the packing nut (1) do not compress the packing too greatly and cause excessive binding on the shaft. When installing bronze or alloy bushings (9) in the pump, care must be taken to not "scar" the bushings. It is preferable to press the bushings in place rather than tap or hammer them. Bushings should be reamed for shaft clearance of .010 after they are press fit into the end plates (2 & 7).

When replacing pump gears (4 & 5), the gears come with shafts installed.

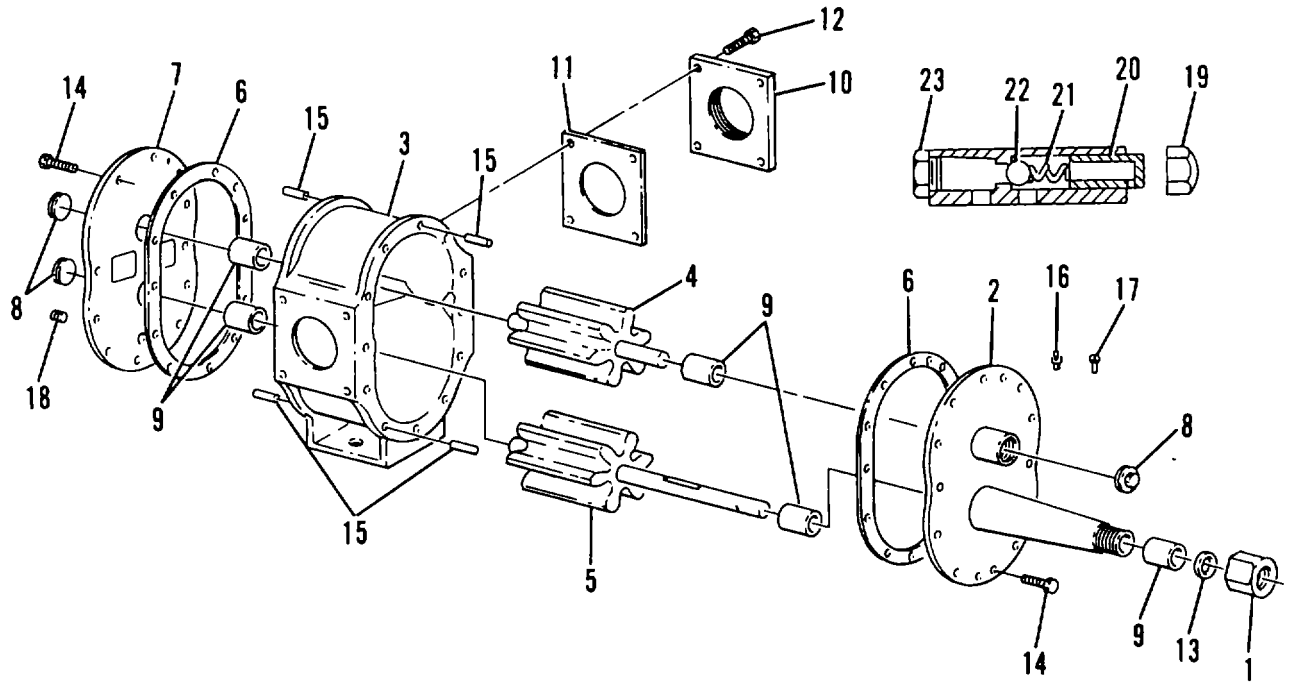



**Figure 3-4. Water Pump, Exploded View**

**3-4 HYDRAULIC MOTOR Figure 3-5)**

3-4.1 Disassembly. Prior to removing roller strator motor from unit, clean off all dirt, disconnect hydraulic connections and plug ports. Remove motor from unit. After removal, clean the motor with solvent to remove all excess dirt from outside of the motor. Remove the key from shaft (11). Place the motor in a vise, shaft down, taking care to clamp at port area of housing. Place newspaper or a sheet of cardboard on top of work bench to obtain a clean work area.

a. Remove seven bolts (19) (9/16 socket or boxed end).

b. Lift end cover (18), pressure plate (17), rotor assembly (10), manifold boot (22), and manifold plate (14), from housing assembly. Take care to note top and bottom of pressure plate, rotor assembly, manifold boot, and manifold plate.

c. Remove pins (16), drivelink (12) and thrust bearing (10).

d. Remove shaft (11) from housing (5) by pushing coupling end of shaft into and through housing with palm of one hand while lifting shaft with the other hand. At no time should shaft be struck directly with a hammer.

e. Remove dust seal (1) from housing by prying with a screw driver.

f. Push down the seal carrier (6) and thrust bearing (10) with thumbs past the housing bore seal to facilitate seal and retainer removal. With a small screw driver, dislodge and remove retaining ring (2).

g. Remove steel shim back up (3) and seal (4) with a small screw driver.

h. Lift out seal carrier (6) and thrust bearing (10).

3-4.2 Assembly. Before assembling, wash all parts off in clean solvent. It is advisable to obtain a new seal kit containing items 1, 2, 3, 4, 7, 8, 9, 13 (4 seals) and 21. All seals should be lightly lubricated prior to assembly.

a. Place housing in vise with mounting flange end up.

b. Assemble spacer ring (7) into seal carrier (6) making sure tang is engaged in slot provided in seal carrier. Next install steel shim backing ring (8), then shaft seal (9) with lip side away from steel backup (8). Again, check tang engagement. Work spring (21) into carrier (6) and around seal lip.

c. Place thrust bearing (10) on shaft (11) followed by the seal carrier assembly (6, 7, 8, 9, and 21) with large diameter of seal carrier toward thrust bearing.

d. Slide shaft assembly (6, 7, 8, 9, 21, 10, 11) into housing assembly. (Inserting large diameter of shaft into mounting flange end of housing and pushing through.) Push shaft assembly into housing so that seal carrier is beyond housing bore seal groove in order to facilitate seal and retainer installation.

e. Install seal (4) into housing groove.

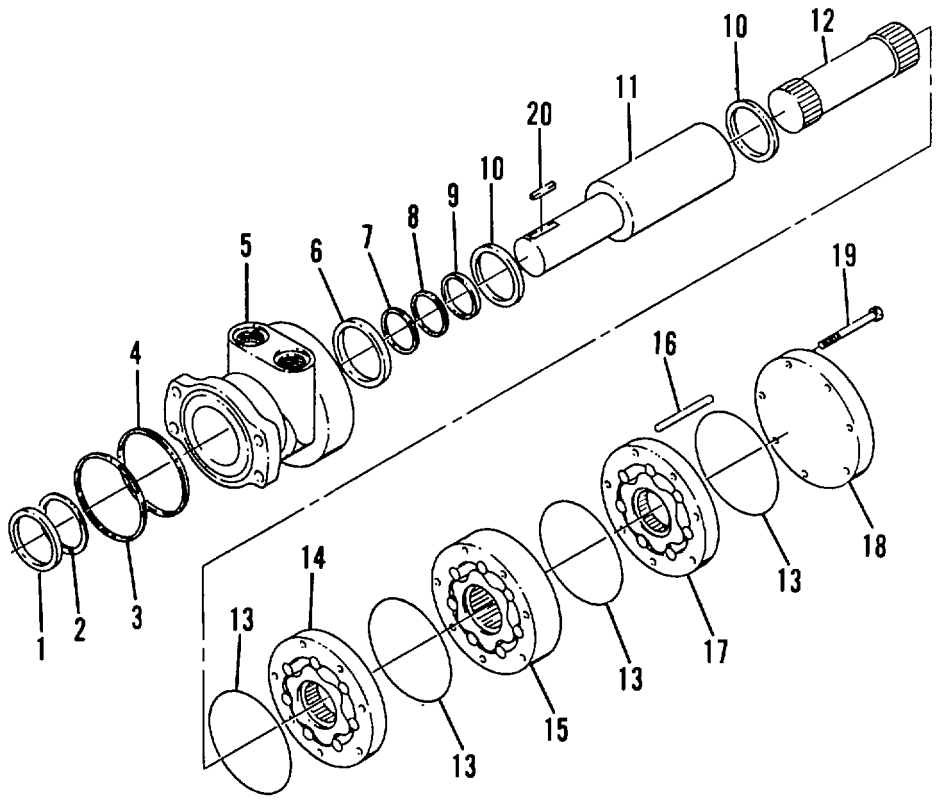



**Figure 3-5. Water System Hydraulic Motor**

f. Install steel backup shim (3) into groove next to seal.

g. Push retaining ring (2) into position by prying against shaft and end (2) with a small screw driver.

h. Place complete housing and shaft assembly in vise with large end of housing up.

i. Place thrust bearing (10) on shaft end.

j. Install drive link (12) into shaft spline.

k. Push down on drive link to seat shaft assembly against retaining ring. (If necessary, lightly tap on drive link with a hammer to seal shaft assembly.) Make sure thrust bearing seats on shaft end and inside housing bore.

l. Install seal (13) in groove provided in housing (5).

m. Place manifold plate (14) on housing with the side with only seven valving holes down. Align bolt cut outs with bolt holes in housing.

n. Place manifold boot (22) around manifold plate (14). Boot must be placed with flat side up and the tab in boot I.D. must match up with one of the two brazing recesses on the O.D. of the manifold plate (14).

o. Install 2 seals (1 3) in grooves provided on either side of rotor assembly (15). Place rotor assembly onto manifold plate while at the same time engaging spline in rotor with drive link (12). Make certain that the deep groove in the rotor goes down toward the manifold plate and the shallow groove faces up. Align bolt holes.

p. Drop pin (16) into the drive link (12).

q. Place pressure plate (17) onto rotor assembly (15) taking extreme care to insure that pin (16) engages with the 1/8" center hole in pressure plate (17). (It is very important that pin engages in hole as improper assembly here will cause rapid motor failure.) Turn pressure plate to align bolt holes.

r. Install seal (13) into groove provided in end cover (18).

s. Place end cover (18) onto pressure plate (17) and align bolt holes.

t. Insert seven bolts (19) and torque to 50 foot-pounds. Remove motor from vise and place on work bench, shaft up.

u. Install dust seal (1) top flush with housing pilot face.

# CHAPTER 4

# WELDER/GENERATOR

## Section 1 - Safety Rules for Operation of Arc Welding Power Source

### 4-1 INTRODUCTION

4-1.1 We learn by experience. Learning safety through personal experience, like a child touching a hot stove is harmful, wasteful, and unwise. Let the experience of others teach you.

4-1.2 Safe practices developed from experience in the use of welding and cutting are described in this manual. Research, development, and field experience have evolved reliable equipment and safe installation, operation, and servicing practices. Accidents occur when equipment is improperly used or maintained. The reason for the safe practices may not always be given. Some are based on common sense, others may require technical volumes to explain. It is wiser to follow the rules.

4-1.3 Read and understand these safe practices before attempting to install, operate, or service the equipment. Comply with these procedures as applicable to the particular equipment used and their instruction manuals, for personal safety and for the safety of others.

4-1.4 Failure to observe these safe practices may cause serious injury or death. When safety becomes a habit, the equipment can be used with confidence.

4-1.5 Reference standards: Published Standards on safety are also available for additional and more complete procedures than those given in this manual. They are listed in paragraph 4-4. ANSI Z49.1 is the most complete.

4-1.6 The National Electrical Code, Occupational Safety and Health Administration, local industrial codes, and local inspection requirements also provide a basis for equipment installation, use, and service.

### 4-2 GENERAL PRECAUTIONS

**NOTE**

**Different arc welding processes, electrode alloys, and fluxes can produce different fumes, gases, and radiation levels. In addition to the information in this manual, be sure to consult flux and electrode manufacturers for specific technical data and precautionary measures concerning their material.**

4-2.1 Burn Prevention

a. Wear protective clothing - gauntlet gloves designed for use in welding, hat, and high safety-toe shoes. Button shirt collar and pocket flaps, and wear cuffless trousers to avoid entry of sparks and slag.

b. Wear helmet with safety goggles or glasses with side shields underneath, appropriate filter lenses or plates (protected by clear cover glass). This is a MUST

for welding or cutting, (and chipping) to protect the eyes from radiant energy and flying metal. Replace cover glass when broken, pitted, or spattered.

c. Avoid oily or greasy clothing. A spark may ignite them.

d. Hot metal such as electrode stubs and workpieces should never be handled without gloves.

e. Medical first aid and eye treatment. First aid facilities and a qualified first aid person should be available for each shift unless medical facilities are close by for immediate treatment of flash burns of the eyes and skin burns.

f. Ear plugs should be worn when working on overhead or in a confined space. A hard hat should be worn when others work overhead.

g. Flammable hair preparations should not be used by persons intending to weld or cut.

4-2.2 Toxic Fume Prevention

a. Severe discomfort, illness or death can result from fumes, vapors, heat, or oxygen enrichment or depletion that welding (or cutting) may produce. Prevent them with adequate ventilation as described in ANSI Standard Z49.1. NEVER ventilate with oxygen.

b. Lead -, cadmium -, zinc -, mercury -, and beryllium - bearing and similar materials, when welded (or cut) may produce harmful concentrations of toxic fumes. Adequate local exhaust ventilation must be used, or each person in the area as well as the operator must wear an air-supplied respirator. For beryllium, both must be used.

c. Metals coated with or containing materials that emit toxic fumes should not be heated unless coating is removed from the work surface, the area is well ventilated, or the operator wears an air-supplied respirator.

d. Work in a confined space only while it is being ventilated and, if necessary, while wearing an air-supplied respirator.

e. Gas leaks in a confined space should be avoided. Leaked gas in large quantities can change oxygen concentration dangerously. Do not bring gas cylinders into a confined space.

f. Leaving confined space, shut OFF gas supply at source to prevent possible accumulation of gases in the space if downstream valves have been accidentally opened or left open. Check to be sure that the space is safe before re-entering it.

g. Vapors from chlorinated solvents can be decomposed by the heat of the arc (or flame) to form PHOSGENE, a highly toxic gas, and other lung and eye irritating products. The ultraviolet (radiant) energy of the arc can also decompose trichloroethylene and perchloroethylene vapors to form phosgene. DO NOT WELD or cut where solvent vapors can be drawn into the welding or cutting atmosphere or where the radiant energy can penetrate to atmospheres containing even minute amounts of trichloroethylene or perchloroethylene.

4-2.3 Fire and Explosion Prevention.

a. Causes of fire and explosion are: combustibles reached by the arc, flame, flying sparks, hot slag or heated material; misuse of compressed gases and cylinders; and short circuits.

b. BE AWARE THAT flying sparks or falling slag can pass through cracks, along pipes, through windows or doors, and through wall or floor openings, out of sight of the goggled operator. Sparks and slag can fly 35 feet.

c. Keep equipment clean and operable, free of oil, grease, and (in electrical parts) of metallic particles that can cause short circuits.

d. If combustibles are in area, do NOT weld or cut. Move the work if practicable, to an area free of combustibles. Avoid paint spray rooms, dip tanks, storage areas, ventilators. If the work cannot be moved, move combustibles at least 35 feet away out of reach of sparks and heat; or protect against ignition with suitable and snug-fitting, fire-resistant covers or shields.

e. Walls touching combustibles on opposite sides should not be welded on (or cut). Walls, ceilings, and floor near work should be protected by heat-resistant covers or shields.

f. Fire watcher must be standing by with suitable fire extinguishing equipment during and for some time after welding or cutting if:

(1) Appreciable combustibles (including building construction) are within 35 feet.

(2) Appreciable combustibles are further than 35 feet but can be ignited by sparks.

(3) Openings (concealed or visible) in floors or walls within 35 feet may expose combustibles to sparks.

(4) Combustibles adjacent to walls, ceilings, roofs, or metal partitions can be ignited by radiant or conducted heat.

g. Hot work permit should be obtained before operation to ensure supervisor's approval that adequate precautions have been taken.

h. After work is done, check that area is free of sparks, glowing embers, and flames.

i. An empty container that held combustibles, or that can produce flammable or toxic vapors when heated, must never be welded on or cut, unless container has first been cleaned as described in AWS Standard A6.0, listed 3 in Standards index (para. 4-4).

j. This includes: a thorough steam or caustic cleaning (or a solvent or water washing, depending on the combustible's solubility) followed by purging and inerting with nitrogen or carbon dioxide, and using protective equipment as recommended in A6.0. Waterfilling just below working level may substitute for inerting.

k. A container with unknown contents should be cleaned (see paragraph above). Do NOT depend on sense of smell or sight to determine if it is safe to weld or cut.

l. Hollow castings or containers must be vented before welding or cutting. They can explode.

m. Explosive atmospheres. Never weld or cut where the air may contain flammable dust, gas, or liquid vapors (such as gasoline).

4-2.4 Compressed Gas Equipment. Standard precautions. Comply with precautions in this manual, and those detailed in CGA Standard P-1, PRECAUTIONS FOR SAFE HANDLING OF COMPRESSED GASES IN CYLINDERS, listed 6 in Standards index (para. 4-4).

4-2.4.1. Pressure Regulators

a. Regulator relief valve is designed to protect only the regulator from overpressure; it is not intended to protect any downstream equipment. Provide such protection with one or more relief devices.

b. Never connect a regulator to a cylinder containing gas other than that for which the regulator was designed.

c. Remove faulty regulator from service immediately for repair (first close cylinder valve). The following symptoms indicate a faulty regulator:

(1) Leaks - if gas leaks externally.

(2) Excessive Creep - if delivery pressure continues to rise with downstream valve closed.

(3) Faulty Gauge - if gauge pointer does not move off stop pin when pressurized, nor returns to stop pin after pressure release.

d. Repair. Do NOT attempt repair. Send faulty regulators for repair to manufacturer's designated repair center, where special techniques and tools are used by trained personnel.

4-2.4.2 Cylinders. Cylinders must be handled carefully to prevent leaks and damage to their walls, valves, or safety devices.

a. Avoid electrical circuit contact with cylinders including third rails, electrical wires, or welding circuits They can produce short circuit arcs that may lead to a serious accident. (See para. 4-3.3.)

b. ICC or DOT marking must be on each cylinder. It is an assurance of safety when the cylinder is properly handled.

c. Identifying gas content. Use only cylinders with name of gas marked on them; do not rely on color to identify gas content. Notify supplier if unmarked. NEVER DEFACE or alter name, number, or other markings on a cylinder. It is illegal and hazardous.

d. Empties: Keep valves closed, replace caps securely; mark MT; keep them separate from FULLS and return promptly.

e. Prohibited use. Never use a cylinder or its contents for other than its intended use, NEVER as a support or roller.

f. Locate or secure cylinders so they cannot be knocked over.

g. Passageways and work areas. Keep cylinders clear of areas where they may be struck.

h. Transporting cylinders. With a crane, use a secure support such as a platform or cradle. Do NOT lift cylinders off the ground by their valves or caps, or by chains, slings, or magnets.

i. Do NOT expose cylinders to excessive heat, sparks, slag, and flame, etc. That may cause rupture. Do not allow contents to exceed 130°F. Cool with water spray where such exposure exists.

j. Protect cylinders particularly valves from bumps, falls, falling objects, and weather. Replace caps securely when moving cylinders.

k. Stuck valve. Do NOT use a hammer or wrench to open a cylinder valve that can not be opened by hand. Notify your supplier.

l. Mixing gases. Never try to mix any gasses in a cylinder.

m. Never refill any cylinder.

n. Cylinder fittings should never be modified or exchanged.

4-2.4.3. Hose

a. Prohibited use. Never use hose other than that designed for the specified gas. A general hose identification rule is: red for fuel gas, green for oxygen, and black for inert gases.

b. Use ferrules or clamps designed for the hose (not ordinary wire or other substitute) as a binding to connect hoses to fittings.

c. No copper tubing splices. Use only standard brass fittings to splice hose.

d. Avoid long runs to prevent kinks and abuse. Suspend hose off ground to keep it from being run over, stepped on, or otherwise damaged.

e. Coil excess hose to prevent kinks and tangles.

f. Protect hose from damage by sharp edges, and by sparks, slag, and open flame.

g. Examine hose regularly for leaks, wear, and loose connections. Immerse pressured hose in water; bubbles indicate leaks.

h. Repair leaky or worn hose by cutting area out and splicing (1-2D3). Do NOT use tape.

4-2.4.4. Proper Connections.

a. Clean cylinder valve outlet of impurities that may clog orifices and damage seats before connecting regulator. Except for hydrogen, crack valve momentarily, pointing outlet away from people and sources of ignition. Wipe with a clean lintless cloth.

b. Match regulator to cylinder. Before connecting, check that the regulator label and cylinder marking agree, and that the regulator inlet and cylinder outlet match. NEVER CONNECT a regulator designed for a particular gas or gases to a cylinder containing any other gas.

c. Tighten connections. When assembling threaded connections, clean and smooth seats where necessary. Tighten. If connection leaks, disassemble, clean, and retighten using properly fitting wrench.

d. Adapters. Use a CGA adapter (available from your supplier) between cylinder and regulator, if one is required. Use two wrenches to tighten adapter marked RIGHT and LEFT HAND threads.

e. Regulator outlet (or hose) connections may be identified by right hand threads for oxygen and left hand threads (with grooved hex on nut or shank) for fuel gas.

4-2.4.5. Pressurizing Steps.

a. Drain regulator of residual gas through suitable vent before opening cylinder (or manifold valve) by turning adjusting screw in (clockwise). Draining prevents excessive compression heat at high pressure seat by allowing seat to open on pressurization. Leave adjusting screw engaged slightly on single-stage regulators.

b. Stand to side of regulator while opening cylinder valve.

c. Open cylinder valve slowly so that regulator pressure increases slowly. When gauge is pressurized (gauge reaches regulator maximum) leave cylinder valve in following position: For oxygen, and inert gases, open fully to seal stem against possible leak. For fuel gas, open to less than one turn to permit quick emergency shutoff.

d. Use pressure charts (available from your supplier) for safe and efficient, recommended pressure settings on regulators.

e. Check for leaks on first pressurization and regularly there-after. Brush with soap solution (capful of dish detergent per gallon of water). Bubbles indicate leak. Clean off soapy water after test; dried soap is combustible.

4-2.5 User Responsibilities. Remove leaky or defective equipment from service immediately for repair.

4-2.6 Leaving Equipment Unattended. Close gas supply at source and drain gas.

4-2.7 Rope Staging-Support. Rope staging-support should not be used for welding or cutting operation; rope may burn.

**4-3. ARC WELDING**

4-3.1 Introduction. Comply with precautions in 4-1, 4-2 and this paragraph. Arc Welding, properly done, is a safe process, but a careless operator invites trouble. The equipment carries high currents at significant voltages. The arc is very bright and hot. Sparks fly, fumes rise, ultraviolet and infrared energy radiates, weldments are hot, and compressed gases may be used. The wise operator avoids unnecessary risks and protects himself and others from accidents. Precautions are described here and in standards referenced in index.

4-3.2 Burn Protection. The welding arc is intense and visibly bright. Its radiation can damage eyes, penetrate lightweight clothing, reflect from light-colored surfaces, and burn the skin and eyes. Skin burns resemble acute sunburn, those from gas-shielded arcs are more severe and painful. DON'T GET BURNED; COMPLY WITH PRECAUTIONS. (Refer to paragraph 4-2.)

4-3.2.1. Protective Clothing.

a. Wear long-sleeve clothing (particularly for gas-shielded arc) in addition to gloves, hat, shoes (1-2A). As necessary, use additional protective clothing such as leather jacket or sleeves, flame-proof apron, and fire-resistant leggings. Avoid outer-garments of untreated cotton.

b. Bare skin protection. Wear dark, substantial clothing. Button collar to protect chest and neck and button pockets to prevent entry of sparks.

4-3.2.2. Eye and Head Protection.

a. Protect eyes from exposure to arc. NEVER look at an electric arc without protection.

b. Welding helmet or shield containing a filter plate shade no. 12 or denser must be used when welding. Place over face before striking arc.

c. Protect filter plate with a clear cover plate.

d. Cracked or broken helmet or shield should NOT be worn; radiation can pass through to cause burns.

e. Cracked, broken, or loose filter plates must be replaced IMMEDIATELY. Replace clear cover plate when broken, pitted, or spattered.

f. Flash goggles with side shields MUST be worn under the helmet to give some protection to the eyes should the helmet not be lowered over the face before an arc is struck. Looking at an arc momentarily with unprotected eyes (particularly a high intensity gas-shielded arc) can cause a retinal burn that may leave a permanent dark area in the field of vision.

4-3.2.3 Protection of Nearby Personnel.

a. Enclosed welding area. For production welding, a separate room or enclosed bay is best. In open areas, surround the operation with low-reflective, non-combustible screens or panels. Allow for free air circulation, particularly at floor level.

b. Viewing the weld. Provide face shields for all persons who will be looking directly at the weld.

c. Others working in area. See that all persons are wearing flash goggles.

d. Before starting to weld, make sure that screen flaps or bay doors are closed.

4-3.3 Toxic Fume Prevention.

a. Comply with precautions in 4-2.2.

b. Generator engine exhaust must be vented to the outside air. Carbon monoxide can kill.

4-3.4 Fire and Explosion Prevention.

a. Comply with precautions in 4-2.3.

b. Equipment's rated capacity. Do not overload arc welding equipment. It may overheat cables and cause a fire.

c. Loose cable connections may overheat or flash and cause a fire.

d. Never strike an arc on a cylinder or other pressure vessel. It creates a brittle area than can cause a violent rupture or lead to such a rupture later under rough handling.

4-3.5 Compressed Gas Equipment. Comply with precautions in 4-2.4.

4-3.6 Shock Prevention.

a. Exposed hot conductors or other bare metal in the welding circuit, or in ungrounded, electrically-HOT equipment can fatally shock a person whose body becomes a conductor. DO NOT STAND, SIT, LIE, LEAN ON, OR TOUCH a wet surface when welding, without suitable protection.

b. To protect against shock: Keep body and clothing dry. Never work in damp area without adequate insulation against electrical shock. Stay on a dry duckboard, or rubber mat when dampness or sweat can not be avoided. Sweat, sea water, or moisture between body and an electrically HOT part - or grounded metal reduces the body surface electrical resistance, enabling dangerous and possibly lethal currents to flow through the body.

c. When arc welding equipment is grounded according to the National Electrical Code, and the work is grounded according to ANSI Z49.1 "Safety in Welding And Cutting," a voltage may exist between the electrode and any conducting object. Examples of conducting objects include, but are not limited to, buildings, electrical tools, work benches, welding power source cases, workpieces, etc. **Never touch the electrode and any metal object unless the welding power source is off.**

d. When installing, connect the frames of each unit such as welding power source, control, work table, and water circulator to the building ground. Conductors must be adequate to carry ground currents safely. Equipment made electrically HOT by stray current may shock, possibly fatally. Do NOT GROUND to electrical conduit, or to a pipe carrying ANY gas or a flammable liquid such as oil or fuel.

e. Three-phase connection. Check phase requirements of equipment before installing. If only 3-phase power is available, connect single-phase equipment to only two wires of the 3-phase line. Do NOT connect the equipment ground lead to the third (live) wire, or the equipment will become electrically HOT - a dangerous condition that can shock, possibly fatally.

f. Before welding, check ground for continuity. Be sure conductors are touching bare metal of equipment frames at connections.

g. If a line cord with a ground lead is provided with the equipment for connection to a switchbox, connect the ground lead to the grounded switchbox. If a three-prong plug is added for connection to a grounded mating receptacle, the ground lead must be connected to the ground prong only. If the line cord comes with a three-prong plug, connect to a grounded mating receptacle. Never remove the ground prong from a plug, or use a plug with a broken off ground prong.

h. Fully insulated electrode holders should be used. Do NOT use holders with protruding screws.

i. Fully insulated lock-type connectors should be used to join welding cable lengths.

j. Frequently inspect cables for wear, cracks and damage. IMMEDIATELY REPLACE those with excessively worn or damaged insulation to avoid possibly - lethal shock from bared cable. Cables with damaged areas may be taped to give resistance equivalent to original cable.

k. Keep cable dry, free of oil and grease, and protected from hot metal and sparks.

l. Terminals and other exposed parts of electrical units should have insulating covers secured before operation.

m. Welding power sources for use with the gas metal arc welding (GMAW), gas tungsten arc welding (GTAW) and similar processes normally are equipped with devices that permit on-off control of the welding power output. When so equipped the electrode wire becomes electrically HOT when the power source switch is ON and the welding gun switch is closed. Never touch the electrode wire or any conducting object in contact with the electrode circuit unless the welding power source is off.

n. Safety devices such as interlocks and circuit breakers should not be disconnected or shunted out.

o. Before installation, inspection, or service, of equipment, shut OFF all power and remove line fuses (or lock or red-tag switches) to prevent accidental turning ON of power. Disconnect all cables from welding power source, and pull all 115 volts line-cord plugs.

p. Do not open power circuit or change polarity while welding. If, in an emergency, it must be disconnected, guard against shock burns, or flash from switch arcing.

q. Leaving equipment unattended. Always shut OFF and disconnect all power to equipment.

r. Power disconnect switch must be available near the welding power source.

4-3.7 Protection for Wearers of Electronic Life Support Devices (Pacemakers). Magnetic fields from high currents can affect pacemaker operation. Persons wearing electronic life support equipment (pacemaker) should consult with their doctor before going near arc welding, gouging, or spot welding operations.

## 4-4 STANDARDS BOOKLET INDEX

4-4.1 For more information, refer to the following standards or their latest revisions and comply as applicable:

1. ANSI Standard Z49.1, SAFETY IN WELDING AND CUTTING obtainable from the American Welding Society, 550 Le Jeune Rd., P. O. Box 351040, Miami, FL 33135.

2. NIOSH, SAFETY AND HEALTH IN ARC WELDING AND GAS WELDING AND CUTTING obtainable from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.

3. OSHA, SAFETY AND HEALTH STANDARDS, 29CFR 1910, obtainable from the U. S. Government Printing Office, Washington, D. C. 20402.

4. ANSI Standard Z87.1, SAFE PRACTICES FOR OCCUPATION AND EDUCATIONAL EYE AND FACE PROTECTION obtainable from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

5. ANSI Standard Z41.1, STANDARD FOR MEN'S SAFETY-TOE FOOTWEAR obtainable from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

6. ANSI Standard Z49.2, FIRE PREVENTION IN THE USE OF CUTTING AND WELDING PROCESSES obtainable from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

7. AWS Standard A6.0, WELDING AND CUTTING CONTAINERS WHICH HAVE HELD COMBUSTIBLES obtainable from the American Welding Society, 550 Le Jeune Rd. P. O. Box 351040, Miami, FL 33135.

8. NFPA Standard 51, OXYGEN - FUEL GAS SYSTEMS FOR WELDING AND CUTTING obtainable from the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

9. NFPA Standard 70-1978, NATIONAL ELECTRICAL CODE obtainable from the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

10. NFPA Standard 51B, CUTTING AND WELDING PROCESSES obtainable from the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

11. CGA Pamphlet P-1, SAFE HANDLING OF COMPRESSED GASES IN CYLINDERS obtainable from the Compressed Gas Association, 500 Fifth Avenue, New York, NY 10036.

12. CSA Standard WI 17.2, CODE FOR SAFETY IN WELDING AND CUTTING obtainable from the Canadian Standards Association, Standards Sales, 178 Rexdale Boulevard, Rexdale, Ontario, Canada M9W 1 R3.

13. NWSA booklet, WELDING SAFETY BIBLIOGRAPHY obtainable from the National Welding Supply Association, 1900 Arch Street, Philadelphia, PA 19103.

14. American Welding Society Standard AWSF4.1 "Recommended Safe Practices for the Preparation for Welding and Cutting of Containers and Piping That Have Held Hazardous Substances", obtainable from the American Welding Society, 550 Le Jeune Rd., P. O. Box 351040, Miami, FL 33135.

15. ANSI Standard Z88.2 "Practice for Respiratory Protection" obtainable from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

**Section 2 - Introduction**

## 4-5 GENERAL INFORMATION AND SAFETY

4-5.1 General.

a. Information presented in this manual and on various labels, tags, and plates on the unit pertains to equipment design, installation, operation, maintenance, and troubleshooting which should be read, understood, and followed for safe and effective use of this equipment.

b. The nameplate of this unit uses international symbols for labeling the front panel controls. The symbols also appear at the appropriate section in the text.

Pages 4-12 thru 4-21 including Sections 3 thru 5 are deleted. All information regarding Operation is contained in TM 5-3820-256-10.

## Section 6 - Maintenance

### 4-9 MAINTENANCE

**WARNING: ELECTRIC SHOCK can kill.**
Do not touch live electrical parts. Shut down the engine and disconnect negative (-) battery cable from battery, if applicable, before internally inspecting or servicing.
**MOVING PARTS can cause serious injury.**
Keep clear of moving parts, i. e., fans, belts, rotors, etc.
**HOT SURFACES can cause burns.**
Allow equipment and work to cool before touching.

4-9.1 General. The service life of this welding generator can be prolonged and operating efficiency maintained under normal conditions by following the routine service and workshop maintenance procedures outlined in this section. Where operating conditions are severe, more frequent attention must be given to all routine service categories; however a special effort must be made to maintain clean internal and external engine surfaces.

4-9.2 Periodic Cleaning and Inspection. - A schedule for cleaning and inspection should be set up, based on the type and conditions of service, to include the following:

a. Keep the inside of the unit clean by blowing out the unit with clean, dry compressed air.

b. Wipe oil and fuel spills from engine immediately to avoid accumulation of dust.

c. Check for fluid leaks indicating loose oil or fuel connections. Tighten loose connections and clean oil or fuel spills or leaks off engine surfaces.

**IMPORTANT**

**Periodically inspect the labels on this unit for legibility. All precautionary labels must be maintained in a clearly readable state and replaced when necessary. See the Parts List for part number of precautionary labels.**

4-9.3 Air Venting the Fuel System.

a. Loosen thumb screw and slide retaining spring off hand primer on fuel pump mounted to base on left side of engine.

b. Loosen bleed screw in banjo connector at injection pump.

c. Hand prime the injection pump until fuel free of bubbles emerges.

d. Lock primer pump and tighten bleed screw.

e. Start the engine. If the engine does not run properly, loosen the bleed screw until air is completely vented from fuel line. Tighten bleed screw.

**IMPORTANT**

**If the engine still does not run properly, loosen injection line at injector, crank engine until fuel free of bubbles emerges at injector; tighten injection line.**

4-9.4 Air Cleaner Service. - The air cleaner is one of the most important parts of the engine from the standpoint of engine life. An engine consumes several thousand cubic feet of air per hour when operating. If dirty air gets into the engine, it can wear out a set of piston rings within a few operating hours.

**CAUTION**

**DIRTY AIR can damage engine.**
Do not operate engine with dirty air cleaner.
Do not operate engine without air cleaner in plate.

4-9.5 Electrical System.

4-9.5.1 Cables and Wiring. Check interconnecting wiring and connections for tightness and flaws. Ensure that the weld output cable connections are clean and tight. Check the insulation for breaks or other signs of damage. Repair or replace cables or wiring as necessary.

4-9.5.2 Battery.

**WARNING**

BATTERY ACID can burn eyes and skin and destroy clothing and other materials. Wear correct eye and body protection.

a. Periodically inspect the battery for loose connections, defective cables, corrosion, cracked case or cover, loose holddowns, and loose or deformed terminal posts.

b. On units equipped with conventional wet or dry charged batteries with removable vent caps, check the electrolyte level frequently. Add clean, mineral-free or distilled water to bring the electrolyte in each cell up to the level indicator.

4-9.6 Idle Control Circuit Protection.

4-9.6.1 The idle control printed circuit board and the throttle solenoid are protected by an automatic reset circuit breaker CB1 located behind the right side panel.

4-9.6.2 Normally, this circuit breaker should not trip. However, if an arc is struck or the AUTO IDLE switch is placed in the OFF position after the throttle solenoid has deenergized and the engine is slowing down, CB1 may trip. If this occurs, wait approximately one minute before resuming operation.

4-9.7 Brushes and Slip Rings. (Figure 4-7) - Brush life is very good under normal operating conditions. The brushes and slip rings should be inspected every six months or whenever excitation voltage is lost. Check for cleanliness of the slip rings and freedom of motion of the brushes. If the welding generator has been operating under extremely dusty or dirty conditions, increase the frequence of inspection.

a. Under normal use the slip rings will discolor to a dark brown. If a buildup of brush material is noted, it may be necessary to clean the slip rings. Use a 3/0 or finer sandpaper followed by a crocus cloth. Never use emery cloth as part of the emery will embed itself into the rings and in turn destroy the carbon brushes.

b. Replace the brushes if they become chipped or broken or if less than 1/4 in. (6.4mm) of fresh material is left.

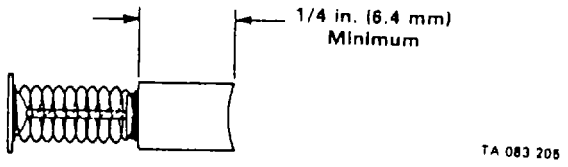



**Figure 4-7. Brush Replacement**

4-9.8 Engine Speed Adjustments (Figure 4-8). The engine speeds have been factory adjusted and will not require frequent readjustment. After tuning the engine, check the speeds with a tachometer. With no load applied, the power speed should be 1860 rpm for 60 Hz. Models and the weld speed 3000 rpm. If necessary adjust the speeds as described following.

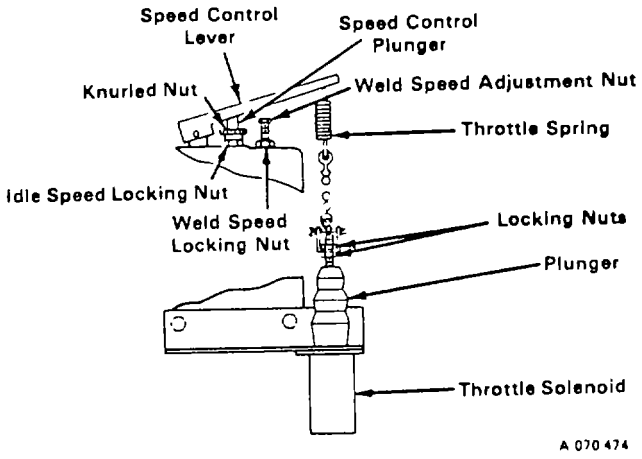



**Figure 4-8. Engine Speed Adjustments**

4-9.8.1 Idle Speed Adjustment

a. Start the engine as outlined in paragraph 4-8.3.

b. Place the Weld/Power switch in the POWER position.

c. Rotate the FINE AMPERAGE control to 100.

d. Ensure that the speed control lever does not contact the speed control plunger during the following adjustment:

Loosen the idle speed locking nut. Rotate the knurled adjustment nut until 1860 rpm is obtained. Tighten the locking nut.

4-9.8.2 Weld Speed Adjustment

a. Shut down the engine.

b. Remove the lead seal from the weld speed adjustment nut.

c. Press the plunger to the bottom of the throttle solenoid and check for 1/8 ± 1/16 inch (3.2 ± 1.6 mm) stretch in throttle spring. If adjustment is necessary, loosen the appropriate locking nut on the plunger and rotate the remaining locking nut to obtain the proper distance.

d. Start the engine as outlined in paragraph 4-8.3.

e. Place the Weld/Power switch in the WELD position.

f. Place the Automatic Idle Control switch in the AUTO IDLE OFF position.

g. Loosen the weld speed locking nut and rotate the weld speed adjustment nut until 3000 rpm is obtained. Check for proper throttle spring stretch. Readjust spring stretch if necessary and recheck weld speed. Tighten locking nut.

**IMPORTANT**

**If the throttle spring works loose or is disconnected, reattach the spring as shown in Figure 4-8.**

h. Shut down the engine.

i. Reseal the weld speed adjustment nut.

## 4-10 ENGINE MAINTENANCE

4-10.1 Scheduled Maintenance. Refer to table 4-1.

**Table 4-1. Engine Maintenance Chart**

| | Daily | After First 50 Working Hours | After every 125 Working Hours | After Every 250 Working Hours | After Every 500 Working Hours |
|---|---|---|---|---|---|
| Check the engine oil level | X | | | | |
| Fill the fuel tank | X | | | | |
| Clean the oil bath air filter* | | X | X | | |
| Change the engine oil | | X | X | | |
| Replace the micro engine oil filter | | X | | X | |
| Check the tongue wrench settings | | X | | | X |
| Check the valve clearances | | X | | X | |
| Clean the cooling air inlet screen and the cooling fins* | | X | X | | |
| Check the idle running speed and maximum governed speed | | X | | | X |
| Replace the fule filter | | | | X | |
| Check the injector nozzle | | | | | X |
| Check the compression pressure | | | | | X |

*Depending on the operating conditions, these components may need more frequent attention.

4-10.2 Oil bath air cleaner. (Figure 4-9)

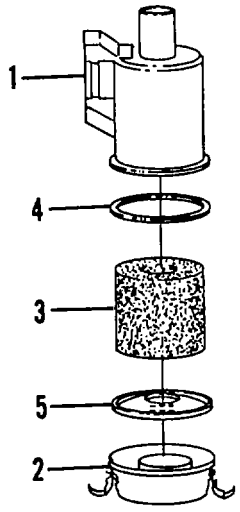



**Figure 4-9. Air Cleaner**

a. Check must be made after the engine has been stopped for at least one hour so that the oil has had time to drip from filter (1) into bowl (2).

b. Take down bowl (2) of the oil bath air cleaner. Remove sludge and clean bowl. Fill fresh motor oil into the bowl up to the oil level mark.

c. If the oil has already been changed several times or is heavily contaminated, unscrew filter (1) and wash it thoroughly in diesel fuel after having removed bowl. Wait about 15 minutes before reassembling the filter parts to give the fuel time to drip out.

d. Replace filter element (3) if it is soiled or if it sits no longer close to the filter wall or to the central tube.

e. Take care that the connection between air cleaner and intake pipe is perfectly tight. Check that the rubber washer seal (4) is not defective.

4-10.3 Engine Oil. Always change oil when the engine is still warm, as warm oil runs off more easily. To do this, screw off drain plug in the oil sump. After the old oil has drained off, screw in plug again and fill with fresh oil through filler neck in the cylinder head up to the upper dipstick mark.

4-10.4 Cleaning cooling air strainer and cooling fins.

a. Cleaning the cooling fins by dry means, e. g. a wire and, if possible, compressed air. It is advisable to start blowing through the cooling fins from the exhaust side. If diesel fuel or a cold detergent is used for cleaning, it is important, after allowing for an adequate soaking-in period, to wash the engine parts with a powerful water jet.

b. Following this, the engine should be run until warm so that any water left behind will be evaporated before rust can form.

c. If a steam jet is available, this method of cleaning is preferable to any other.

d. When doing a major cleaning operation of the fins in a workshop, the whole air cowling can of course be removed for better access.

4-10.5 Checking V-belt tension.

a. Apply thumb pressure to check that deflection on the belt between the pulleys is not more than approx. 10 mm. If the belt has to be retighten, slacken nuts and push alternator outward. Retighten nuts after having obtained correct tension.

b. New belts should be retensioned firmly a short time after having been taken into use, after 40 running hours at the latest.

c. To avoid damage to the V-belt, remove or refit the V-belt **without** using a screwdriver or other tools, only after slackening nuts and **with the alternator completely pushed** towards the engine.

4-10.6 Replacing lube oil filter. Before fitting the new filter element, wet rubber seal slightly with oil. Screw in filter by hand until seal is squarely seated. Tighten filter by a further half turn. After mounting, check for tightness during a short test run.

4-10.7 Checking valve clearances. (Figure 4-10)

In case of unfavorable operating conditions, such as constantly changing loads, frequent daily starting or ambient dusty conditions, shorter checking intervals are required where valve clearance must be set to the maximum gap.

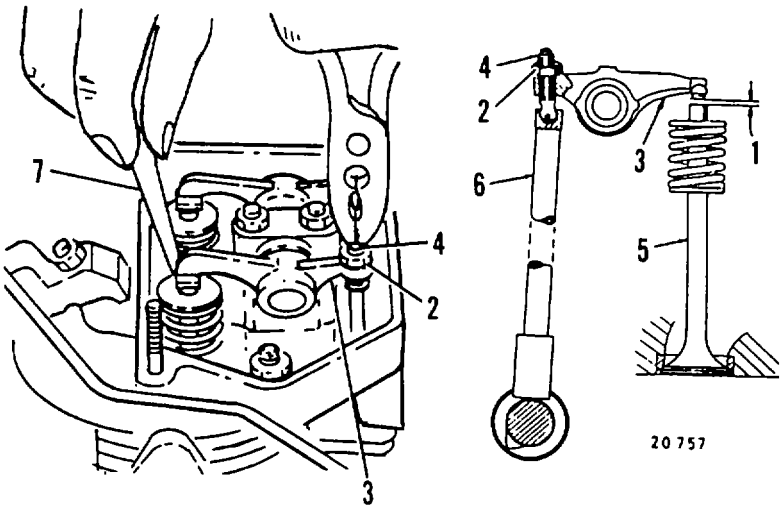



**Figure 4-10. Checking Valve Clearance**

a. Check valve clearance with cold engine by means of a 0.20 mm (0.008 in) feeler gauge (7). To do this, turn crankshaft until the piston reaches the compression dead center, i. e. after overlapping of both valves (exhaust valve about to close, inlet valve about to open) go on turning the crank-shaft through 3600C, corresponding to a complete rotation.

b. The resulting gap (1) between rocker arm (3) and valve (5) should now admit with a slight drag the 0.20 mm feeler gauge (7) at the inlet and exhaust valves. If the gap is found to be too small or too big, slacken lock nut (2) by giving it one or two turns and adjust screw (4) with a flatnose plier so that, when lock nut (2) has been retightened, the feeler gauge (7) can be withdrawn easily.

4-10.8 Replacing fuel filter.

a. Screw off filter carefully as fuel from higher level will run out.

b. Before refitting the new filter, wet the rubber seal with a drop of oil. Then screw in filter by hand until the seal is squarely seated and tighten filter by a further half turn.

c. After mounting, check for leaks during a short test run.

4-10.9 Intake and exhaust manifolds. After every 600 running hours check the intake and exhaust manifolds for tightness at the cylinder heads, retighten fastening bolts if necessary.

4-10.10 Tightening cylinder head nuts. After removal of the cylinder head cover, cylinder head nuts and nuts of the rocker arm bracket are accessible. Retighten cylinder head nuts crosswise with cold engine, i. e. 1, 2, 3, 4 (refer to figure 4-11).

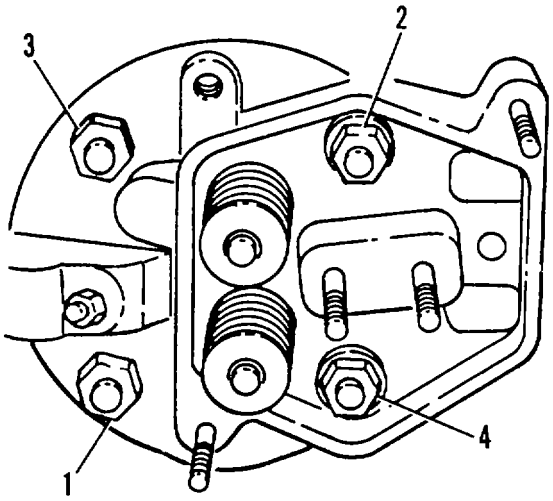



**Figure 4-11. Cylinder Head Tightening Sequence.**

**Table 4-2. Engine Torque Values**

| Location | Size | Torque |
|---|---|---|
| Cylinder head nuts | M12 x 1,5* | 5,5mkp |
| Rocker arm bracket nut | M 8* | 3 mkp |
| Injection nozzle holder nut | M 8* | 3,5mkp |
| Timing gear cover bolts | M 8 | 2, 3mkp |
| Bearing plate nuts (flywheel end) | M 8* | 3,5mkp |
| Connecting rod bolts | M 10 | 4,5mkp |
| Flywheel fastening nut | M33 x 1,5 | 18mkp |
| Oil sump bolts | M 8 | 2,3mkp |
| Injection pump nuts | M 8 | 2,3mkp |
| Cylinder head cover nuts | M 8 | 2, 3mkp |

* DIN 934 - 10 phosphated

## Section 7 -Troubleshooting

### 4-11 TROUBLESHOOTING CHART

**WARNING**

**ELECTRIC SHOCK can kill.**

**Do not touch live electrical parts. Shut down the engine and disconnect negative (-) battery cable from battery before internally inspecting or servicing.**

**MOVING PARTS can cause severe injury.**

**Keep clear of moving parts, i.e., fans, belts, rotors, etc.**

**HOT ENGINE PARTS can cause severe burns.**

**Wear protective gloves and clothing when working on a hot engine.**

4-11.1 Use the chart in conjunction with the circuit diagram while performing troubleshooting procedures. (figures 4-12 and 4-13).

**Table 4-3. Troubleshooting**

| Trouble | Possible cause | Remedy |
|---|---|---|
| Engine fails to start. | 1. Fuel tank empty. | Fill up tank and vent fuel system. |
| | 2. Fuel filter choked in winter by paraffin clouding. | Renew fuel filter element, Use winter-grade fuel. |
| | 3. Fuel lines leaky. | Check all fuel lines for tightness. |
| | 4. Battery. | Inspect the electrical system. If the battery requires recharg ing follow all applicable safety precautions and the battery charger manufacturer's inst-ructions. Never use a battery charger without these instruc-tions. If the battery does not recharge, replace the battery.<br><br>Units With Maintenance-Free Batteries: Inspect the elect-rical system. If the trouble is isolated to the battery, replace the battery.<br><br>Jump start the engine employ-ing approved safety practices and booster jump starting in-structions provided in para-graph 4-12. |
| Engine difficult to start. | 1. Battery output low, battery terminals loose or oxidized causing starting motor to run slowly; in win-ter, oil too viscous. | Have battery tested, clean terminals, tighten and coat with acid-free grease; crank engine smartly by hand. |
| | 2. In winter especially, grade of motor oil used is too viscous. | Use a grade of motor oil to suit the temperature condi-tions. |
| | 3. Inadequate fuel supply Blocking of fuel sys-tern by paraffin cloud-ing in winter. | Renew fuel filter, evacuate air, check fuel line connec-tions for tightness. Use winter grade fuel. |

**Table 4-3. Troubleshooting — continued.**

| Trouble | Possible cause | Remedy |
|---|---|---|
| Engine runs unsteadily | 1. Inadequate fuel supply. and power output is low. connections. | Renew fuel filter and evacuate air. Tighten fuel line |
| | 2. Valve clearance out of adjustment, valve spring broken. | Readjust valve clearances. Have valve spring renewed. |
| | 3. Nozzle needles stick. | Have them checked by a specialist. |
| Dense exhaust. | 1. Level of motor oil too high. | Drain to upper mark on dipstick. |
| | 2. Level of oil in oil bath air cleaner too high. | Pour off oil to reduce level to the mark. |
| | 3. Inefficient compression due to seized or broken compression rings, or incorrect valve clearances. | Have compression rings and pistons checked by a specialist. Readjust valve clearances. |
| Engine overheats. | 1. Cooling fins on cylinders and cylinder heads very dirty. | Clean cooling fins, on cylinder head in particular. |
| | 2. Injectors defective. | Have them checked by a specialist. |
| | 3. Injection pump delivery out of adjustment. | Have it readjusted by a specialist. |
| | 4. Insufficient air inducted to cooling air blower. | Clear air intake. |
| Engine oil pressure too low. | Leaks in lubrication system. | Stop engine immediately. Check unions on lubricating pump and oil pressure gauge for tightness and retighten screws. Otherwise call in a specialist. |
| Battery discharges between uses. | 1. Build-up of acid on top of battery (white-grayish substance) . | Clean battery with soda solution; rinse with clear water. |
| | 2. Infrequent use (units with conventional | Periodically recharge battery (approximately every 3 |

**Table 4-3. Troubleshooting — continued.**

| Trouble | Possible cause | Remedy |
|---|---|---|
| Battery discharges between uses (cont'd.) | batteries only). | months). |
| | 3. Battery. | Replace battery. |
| | 4. Oil pressure switch S2. | Replace S2. |
| No power output at power receptacles. | Weld/Power switch S1 in WELD position. | Place S1 in POWER position. |
| Low power output at power receptacles. | 1. Low setting on FINE AMPERAGE control R1. | Rotate R1 to 100. |
| | 2. Engine running below required speed (1860 rpm). | Check air filter; clean if necessary. Adjust engine speed. |
| | 3. Voltage Regulator board PC 2. | Replace PC2. |
| | 4. Transformer T1. | Replace T1. |
| Low weld output. | Engine running below required speed (3000 rpm). | Check air filter; clean if necessary. Fill fuel tank. Adjust engine speed. |
| Erratic weld output. | 1. Damp or wrong type electrodes. | Try different electrodes. |
| | 2. Improper connection to workpiece. | Check and tighten loose connections. |
| Erratic weld and power output. | Dirty slip rings and/or worn brushes. | Clean slip rings and/or replace worn brushes. |
| High power voltage. | Voltage Regulator board PC 2. | Replace PC2. |
| High weld voltage. | Voltage Regulator board PC2. | Disconnect lead No. 48 from Voltage Regulator board PC2. If voltage drops to 80 volts ac, replace Voltage Regulator board PC2. |

**4-12 BOOSTER BATTERY JUMP STARTING.**

4-12.1 If jump starting is attempted, employ the safety precautions below and the following step by step procedures in order of appearance.

**WARNING**

**BATTERY GASES OR A DAMAGED BATTERY can explode thereby shattering the battery; BATTERY ACID can burn eyes, skin, destroy clothing, and damage other material; MOVING PARTS and IMPROPER CONNECTIONS can cause serious personal injury and damage equipment.**

**Keep sparks, flames, cigarettes, and other ignition sources away from batteries.**

**Ensure that all personnel are a safe distance from batteries and clear of moving parts while starting.**

**Do not jump start a frozen or completely discharged battery.**

**Do not jump start a battery which has loose terminals or one having evidence of damage such as a cracked case or cover.**

**Be sure that vent caps are tight and level on both batteries and cover both batteries with a damp cloth.**

**Wear correct eye and body protection and remove all metal jewelry.**

**Keep jumper cables clear of moving parts.**

**Ensure that both batteries are the same voltage.**

**Do not jump start a vehicle mounted welding generator from the vehicle battery.**

**Do not jump start by applying power to weld output receptacles or terminals.**

**Do not allow jumper cable clamps to contact any metal while attaching or removing cables.**

a. Use properly insulated jumper cables of adequate size.

b. Connect ends of one cable to positive (+) terminals of each battery.

c. Connect one end of other cable to negative (-) terminal of booster battery.

d. Connect remaining end of cable to welding generator engine block at least 18 inches (457 mm) from battery (do not connect to welding generator case, frame, or equipment grounding terminal as damage to equipment can result).

e. Wait at least one minute after connecting cables before starting engine.

f. Start engine following procedures outlined in Section 6 (Sequence Of Operation) of this manual and allow engine to return to idle speed. If the unit does not start after cranking for thirty seconds, stop the jump starting procedure. More than thirty seconds seldom starts the engine unless some mechanical adjustment is made.

g. Remove jumper cable from engine block.

h. Remove other end of same cable from booster battery negative (-) terminal.

i. Remove other jumper cable from welding generator battery positive (+) terminal.

j. Remove remaining end of cable from booster battery positive (+) terminal.

k. Discard damp cloths.

## 4-13 ENGINE SPECIFICATION DATA

| | |
|---|---|
| Noof Cylinders | 1 |
| Bore | 95mm |
| Stroke | 95mm |
| Displacement | 673cm$^3$ |
| Direction of Rotation | CCW |
| Working Principle | 4-Stroke Diesel with Direct Injection |
| Lubrication System | Forced Circulation |
| Oil Capacity | 2.4L |
| Valve Clearance (cold engine) | 0.20mm |
| Piston Crown Clearance | 1.0-1.2mm |

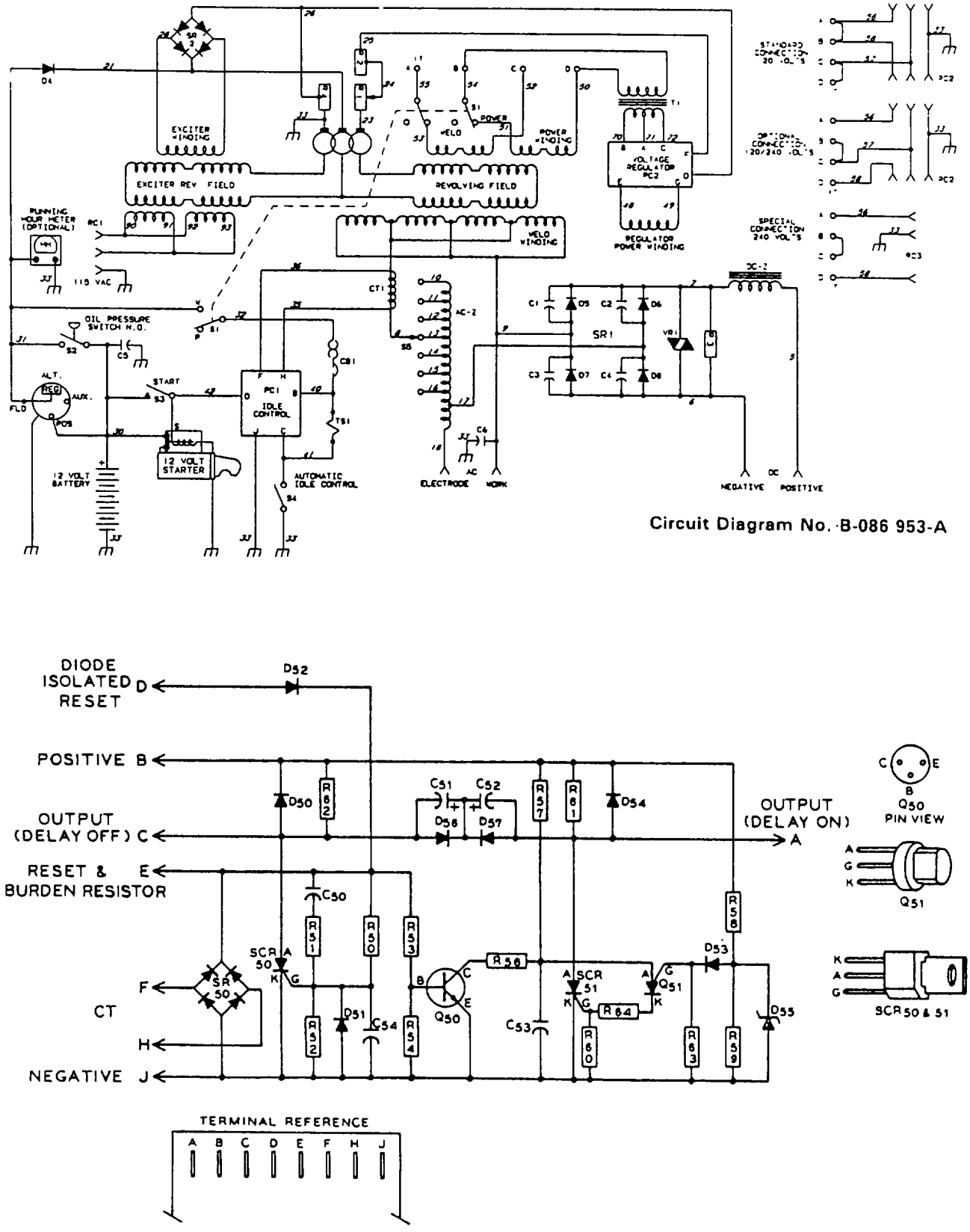
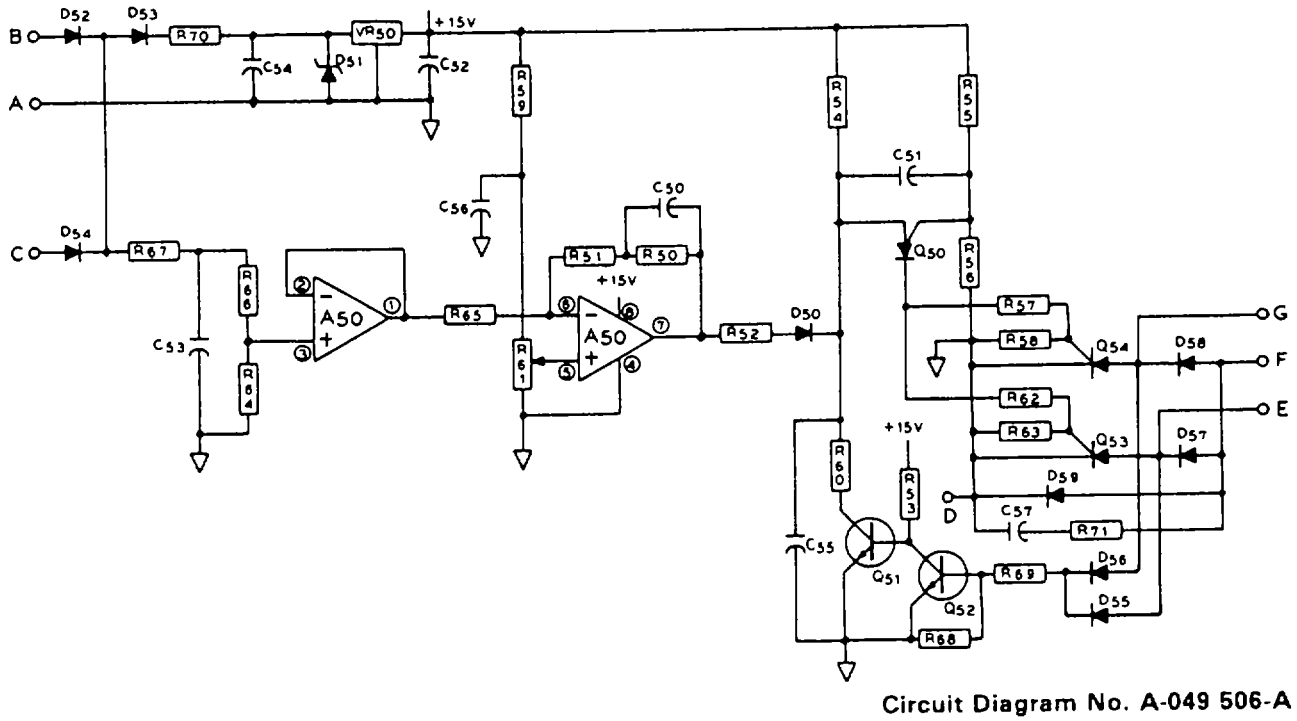



**Figure 4-12. Circuit Diagram For Automatic Idle Control Circuit Board PC1**




Circuit Diagram No. A-049 506-A

**Figure 4-13. Circuit Diagram For Voltage Regulator Circuit Board PC2**

Pages 5-1 thru 5-8 are deleted. Information regarding Operation is contained in TM 5-3820-256-10.

**Maintenance**

## 5-4 LUBRICATION AND SERVICE

5-4.1 Preventive Maintenance. The best possible preventive maintenance program is protection of the hydraulic system from dirt and moisture. Change the filters frequently. Drain the system annually and replace the fluid. Take care to prevent dirt from entering the system at any point.

5-4.2 Scheduled Maintenance.

a. Weekly:

(1) Lubricate all points indicated on a weekly lube interval.

(2) Check the hydraulic fluid level in the reservoir.

b. Monthly:

(1) Lubricate all points indicated on a monthly lube interval.

(2) Check all accessible hose fittings for tightness.

(3) Check winch gearcase oil level.

(4) Check rotation gearbox oil level.

(5) Check control handles for freedom of movement.

c. Semi-annual:

(1) Replace the 10 micron return line filter element.

(2) Check the crane mounting bolts for tightness.

d. Annual:

(1) With unit in stowed position, drain the hydraulic system.

(2) Remove and clean the suction line 100 mesh strainer.

(3) Refill the reservoir with fresh hydraulic fluid.

(4) Run the unit, extending the cylinders. With cylinders in the extended position, recheck the fluid level in the reservoir and add fluid if necessary to make sure there is some reserve in the tank.

(5) Drain winch and rotation gearboxes and fill to plug level.

5-4.3 Lubrication. Refer to figure 5-4 for lubrication of the crane and hydraulics.

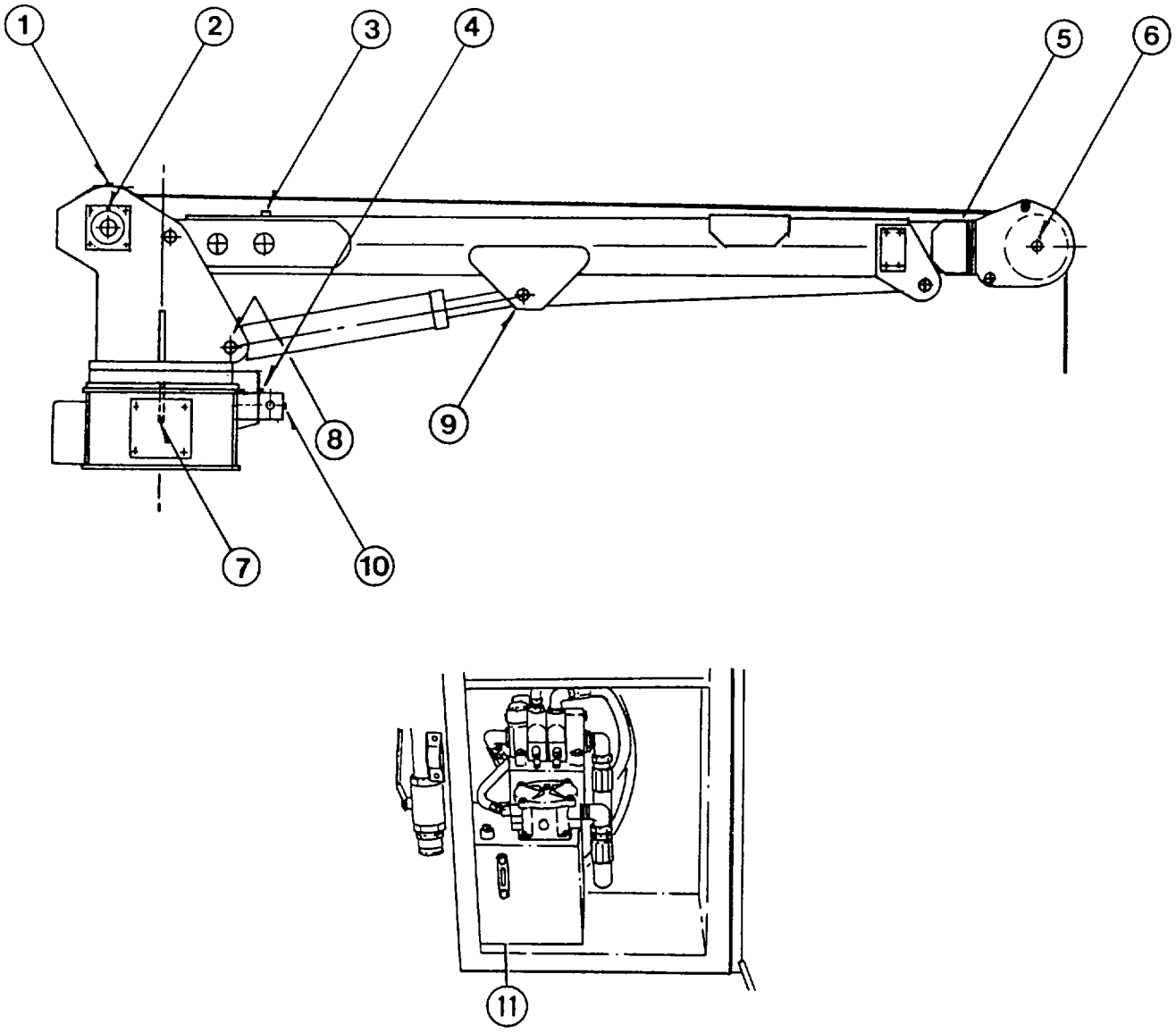



**Figure 5-4. Crane and Hydraulics Lubrication**

**Legend For Figure 5-4**

| No. | Item | Lubricant | Interval | Remarks |
|---|---|---|---|---|
| 1 | Winch Gear Box | A | Annually | Drain and refill gearcase 1/2 to 2/3 full. |
| 2 | Winch Shaft Bearing | B | Monthly | Apply one pump to fitting. |
| 3 | Extension Boom Top Surface | B | Monthly | Apply one pump to fitting. |
| 4 | Rotation Gearbox Output Shaft | B | Monthly | Apply one pump to fitting. |
| 5 | Exten. Cylinder Rod End Pin | B | Monthly | Pump until excess lube appears around pin. Wipe off excess. |
| 6 | Boom Tip Sheave | B | Monthly | Pump until excess lube appears around pin. Wipe off excess. |
| 7 | Rotation Bearing (Access inside crane base) | B | Monthly | Apply 1-2 pumps, rotate unit 1800 and repeat. |
| 8, 9 | Boom Cylinder Pivot Pins | B | Monthly | Pump until excess lube appears around pin. Wipe off excess. |
| 10 | Rotation Gear Box | A | Annually | Drain and refill gearbox 1/2 to 2/3 full. |
| 11 | Hydraulic Tank | C | Annually | Drain reservoir, clean suction line strainer, refill with fresh oil. |

A= SAE 140EP Gearlube B= Medium Pressure Gun Lubricant
C= Hydraulic Oil, Winter inhibited and anti-wear type "MS" Industrial Ident. No. S-150 Summer SAE 10W40 API Service Class "NS"

## 5-5 FIELD TESTING

5-5.1 In the event operation of the crane becomes slow or sluggish it is advisable to check the condition of the hydraulic system. Follow the procedure below:

a. Disconnect the inlet (pressure) line at the control valve bank. Tee a 0-3000 psi gauge in at this point and reconnect the pressure line.

b. Operate the boom control to "up." When the boom reaches its maximum travel, continue to hold the control lever to "up." The gauge should quickly rise to the setting of the main relief valve.

c. If pressure does not rise to the specified psi, there are two possible causes, a worn pump or a defective relief valve.

d. Have someone raise the vehicle engine speed about 800 to 1000 rpm while you watch the gauge. If the pressure rises somewhat as the engine is speeded up, the cause is most likely the pump.

e. If there is no rise in the pressure when engine speed is increased, the main relief valve should be suspected.

## 5-6 TROUBLESHOOTING

5-6.1 Troubleshooting Guide. Refer to Figure 5-5 for troubleshooting.

5. Troubleshooting Guide

| POSSIBLE CAUSE ↓ / SYMPTOM → | Controls sticking | Controls don't respond | Unit will not operate | Pump won't run | Pump runs hot | Pump runs noisy | Main relief valve noisy | Winch won't pick up load | Unit can't handle rated load | Outrigger won't hold position | Rotation movement erratic | Boom movement slow | Boom drifts down | Boom movement erratic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fluid contaminated | | | | | ● | | | | | | | | | |
| Restricted fluid line | | | | | ● | ● | | | | | | | | ● |
| Valve spool return spring weak | ● | | | | | | | | | | | | | |
| Main relief valve defective | | | | | | | ● | | ● | | | | | |
| No voltage to pump (if electrical) | | | ● | ● | | | | | | | | | | |
| Load too heavy for the crane | | | | | | | ● | ● | ● | | | | | |
| Defective holding valve | | | | | | | | | | ● | | | ● | |
| Worn cylinder seals | | | | | | | | | | ● | ● | ● | ● | ● |
| Control switch defect (if electrical) | | ● | | | | | | | | | | | | |
| Boom pivot points not lubed | | | | | | | | | | | | | | ● |
| Winch motor defective | | | | | | | | ● | | | | | | |
| Control valve spool seals worn | | ● | | | | | | | | | | ● | | |
| Pump not running at right speed | | | | | | | | ● | ● | | | ● | | |
| PTO not engaged | | ● | ● | ● | | | | | | | | | | |
| Rotation rack shoe maladjusted | | | | | | | | | | | ● | | | |
| Control valve spool worn | | ● | | | | | | ● | | | | | | |
| Filter clogged | | | | | ● | ● | | | | | | ● | | |
| Pump switch defect (if electrical) | | | ● | | | | | | | | | | | |
| Broken rotation gear teeth | | | | | | | | | | | ● | | | |
| Valve handle linkage binding | ● | | | | | | | | | | | | | |
| Low fluid supply | | | ● | | ● | ● | | ● | ● | | | ● | | ● |

**Figure 5-5. Troubleshooting Chart**

## 5-7 CRANE ASSEMBLY

5-7.1 Winch Assembly.

5-7.1.1 Replacing Wire Line. (Figure 5-6)

a. Refer to operating instructions, TM5-3820-256-10 and operate crane to spool line off of winch drum (1).

b. When all of line (2) is unrolled, stop rotation. Hold line so that there is no pull on it, then loosen setscrew (3) to remove end of line from drum (1).

c. Route new line through end of boom and over sheave. Insert the new line into the hole in drum (1) and secure with setscrew (3).

d. Operate winch to spool new line onto drum.

5-7.1.2 Removal. (Figure 5-6)

a. Disconnect and cap hydraulic lines to winch motor (5).

b. Remove screws (4) and motor (5) from winch. Refer to paragraph 5-7.2 for repair of motor.

c. Refer to 5-7.1.1 and remove wire line from drum. Attach a supporting sling around the drum.

d. Loosen, or remove, setscrew (6). Remove the screws (7) and pull the winch assembly (8) straight out until its shaft is out of drum (1). Lift out drum.

1. Drum
2. Wire line
3. Setscrew
4. Screw
5. Motor
6. Setscrew
7. Screw
8. Winch Assembly
9. Key

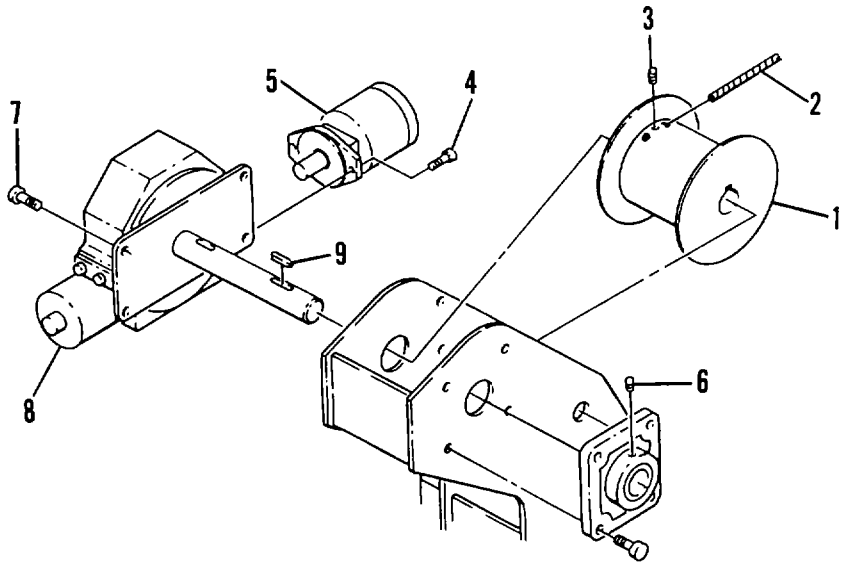



**Figure 5-6. Crane Winch**

e. Remove keys (9) from winch shaft.

5-7.1.3 Disassembly. (Figure 5-7)

a. Remove plug (1) and drain gear oil.

b. Remove the screws (2), washers (3), brake housing (4) and gasket (5). The o-ring (6), gasket (7), nut (8), spring assembly (9), pressure plate (16) and disc (17) will come off with housing (4).

c. Remove parts from housing (4). Do not disassemble the spring assembly (9) unless parts are to be replaced.

d. Slide the rotor assembly (18) off the shaft.

**NOTE**

**The rotor assembly (18) is difficult to assemble and should not be disassembled unless necessary. Follow steps e. and f. to disassemble the rotor assembly.**

e. Remove snap rings (19) and rings (20).

**NOTE**

**The rollers (22) are spring loaded and will fly in all directions unless precautions are taken. Hold the rotor in a box when disassembling.**

f. Slowly slide the driver (25) out of the race (21). Rollers (22), plungers (23) and springs (24) will fall from driver (25) as it is removed.

g. Remove the bearing container (26) and gaskets (27). The friction disc (28) is glued to the container and should not be removed unless replacement is required.

h. Remove keys (29) from drum shaft (30) and slide the spacer (31) off the shaft.

**NOTE**

**If keys (29) are tight, clamp a vise grip on the key and pry against the vise grip with a screwdriver.**

i. Remove screws (32), washers (33) and screws (34). Slide cover (35), gaskets (36) and 0-rings (37) off the shaft (30). Remove thrust ring (38).

**NOTE**

**The gaskets (36) may be stuck together and prevent the cover (35) from being easily removed. Wrap the shaft in a rag to protect hands and give it a sharp tug. The cover should break free.**

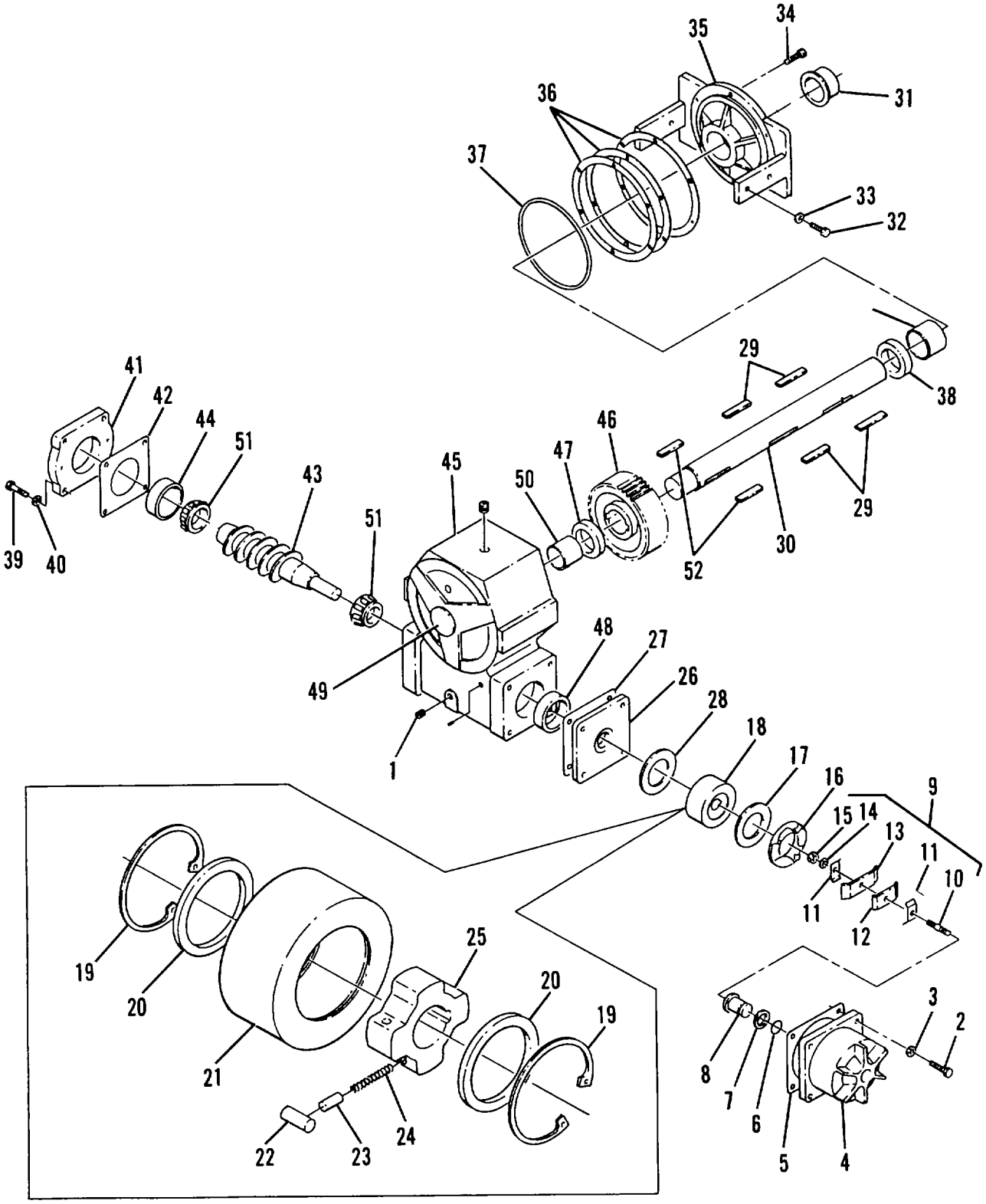



**Figure 5-7. Crane Winch, Exploded View**

**Legend for Figure 5-7.**

1. Plug
2. Screw
3. Washer
4. Brake Housing
5. Gasket
6. O-Ring
7. Gasket
8. Nut
9. Spring Assembly
10. Stud
11. Clip
12. Secondary Spring
13. Main Spring
14. Washer
15. Nut
16. Pressure Plate
17. Disc
18. Rotor Assembly
19. Snap Ring
20. Ring
21. Race
22. Roller
23. Plunger
24. Spring
25. Driver
26. Container
27. Gasket
28. Disc
29. Key
30. Shaft
31. Spacer
32. Screw
33. Washer
34. Screw
35. Cover
36. Gasket
37. O-Ring
38. Thrust Ring
39. Screw
40. Washer
41. Retainer
42. Gasket
43. Worm
44. Bearing Cup
45. Housing
46. Worm Gear
47. Thrust Ring
48. Bearing Cup
49. Expansion Plug
50. Bushing
51. Bearing
52. Key

j. Remove screws (39), washers (40), retainer (41) and gasket (42).

k. Apply pressure on the splined end of worm (43) shaft and press until bearing cup (44) is pressed out of housing (45).

l. Pull the worm (43) partially out of the housing (45). Do not pull it far enough that the bearing interferes with the worm gear (46). Slide the worm to one side and remove the shaft (30) and worm gear (46). Slide off thrust ring (47).

m. Press the worm (43) shaft from the other end to remove the other bearing cup (48). Remove worm from housing.

n. Drive the expansion plug (49) out of the housing (45) from the inside with a hammer and drive pin.

**NOTE**

**The following parts should only be removed as necessary for replacement.**

o. If required, press bushings (50) from housing (45) and cover (35).

p. If required, use a gear puller to pull gear (46) from shaft (30) and bearings (51) from worm (43).

q. Thoroughly wash all metal parts with a cleaning solvent and dry with low pressure compressed air.

5-7.1.4 Assembly. (Figure 5-7)

a. At assembly replace all seals and gaskets. Replace any part suspected of being damaged.

b. Dress any nicks and scratches that may have occurred during disassembly. Use a wire brush or #400 emery paper.

c. Press bushings (50) into housing (45) and cover (35).

d. Press new bearings (51) onto worm (43) shaft. Slide the worm into the housing (45) making certain the splined end is on the motor side.

e. Install keys (52) in shaft (30) and press on new gear (46).

f. With the housing (45) lying flat, position the thrust ring (47) over the bushing (50). Slide the shaft (30) through the thrust ring and into the bushing. The worm will have to be moved to one side to provide adequate clearance for the worm gear (46). Aline the teeth of the gear with the worm.

g. Start both bearing cups (44 and 48) into position with a plastic hammer.

h. Position the bearing retainer (41) and gasket (42) on the housing (45). Install screws (39) and washers (40) and tighten them to press the bearing cup (44) into position. Tighten each screw about two turns then tighten another screw until all are tight.

i. Position bearing container (26) and gaskets (27) on housing. If the friction disc (28) was removed, glue a new disc to container using a good quality high-temperature glue.

j. If the rotor assembly (18) was disassembled, assemble the rotor assembly as follows:

   (1) Place the race (21) on a flat surface.

   (2) Install a screw type ring compressor loosely around the driver (25). Install the springs (24), plungers (23) and rollers (22) in the driver. The plunger must be inserted in the hole of the driver before the ring compressor is tightened. Tighten ring compressor.

   (3) Position the assembled driver over the race (21) and push the driver into the race. Work slowly and keep the rollers (22) in position with respect to the driver (25).

k. Slide the rotor assembly (18) over the shaft of worm (43).

l. Tighten adjustment nut (8) on the spring assembly (9). Install gasket (7) and o-ring (6) on the adjustment nut (8) and install spring assembly in the brake housing (4).

m. Slide the pressure plate (16) into the brake housing (4). The "ears" on the pressure plate fit in the detent inside the brake housing. The ends of the spring assembly

fit in the recessed area of the pressure plate. Insert the friction disc (1 7) into _ the housing.

n. Position the gasket (5) on the bearing container (26) and slide the housing (4) with spring assembly (9), pressure plate (16) and friction disc (17) over the shaft and into position.

o. Install the screws (2) and washers (3) and tighten each one alternately to press the bearing cup (48) into position.

p. Slide thrust ring (38) over the drum shaft (30) and install cover (35) with new gaskets (36) and o-ring (37).

q. Install screws (34) to draw the cover up tight against housing (45). Install and tighten screws (32) and washers (33) through the cover side brackets.

r. Slide the spacer (31) over the shaft and install keys (29). Start the end of the key closest to the cover and then rap the other end sharply with a plastic mallet.

5-7.1.5 Installation. (Figure 5-6)

a. Support winch drum (1) in position. Be sure that keyway in drum alines with keys (9) in winch shaft.

b. Slide the winch assembly (8) into position on turret and install screws (7). Tighten setscrew (6).

c. Assemble motor (5) to winch assembly (8) and install screws (4). Apply thread sealer on threads of hydraulic hoses and connect them to motor (5).

d. Fill winch with gear oil then operate winch in and out several times to purge air.

5-7. 2 Winch Motor. (Figure 5-8)

5-7.2.1 Disassembly. Prior to removing roller stator motor from unit, clean off all dirt. Disconnect hydraulic connections and plug ports. Remove the motor from unit. After removal, wash the motor with solvent to remove all excess dirt from outside of the motor. Remove the woodruff key from shaft (11), place the motor in a vise taking care to clamp at port area of housing. Place newspapers or a sheet of cardboard on top of bench to obtain a clean work area.

a. Remove four bolts (18) (9/16 socket or boxed end).

b. Shift wear plate to clear end of drive link and lift group [end cover (17), rotor assembly (15) and wear plate (13)J from housing assembly (5).

c. Remove shaft (11) and drive link (12) from housing by pushing up on shaft end ½Y with palm of one hand and lifting shaft with the other hand. Items 6, 7, 8, 9, 10, 11, 12 and 16 usually will come out from assembly.

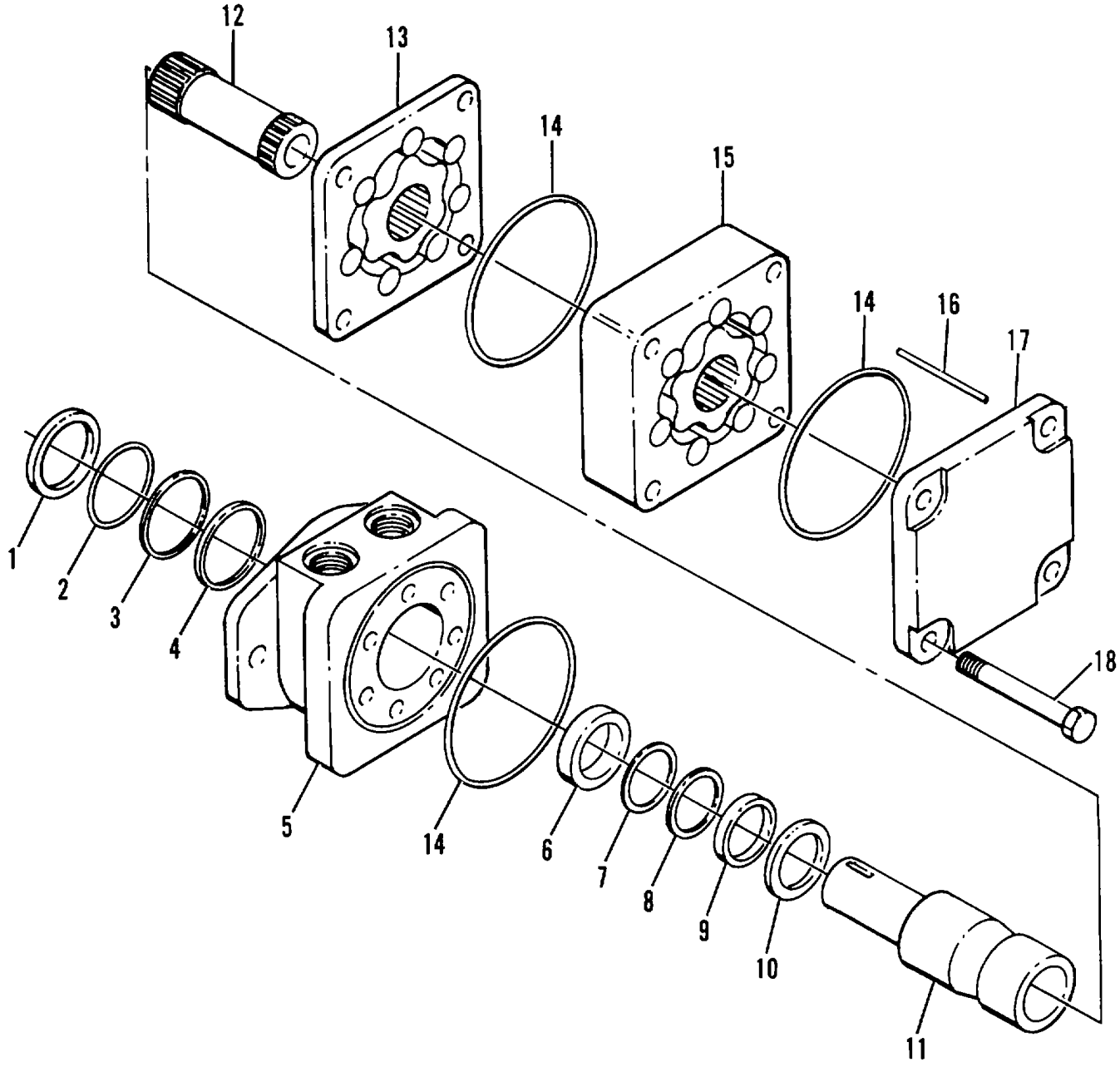



**Figure 5-8. Crane Winch Motor**

d. Remove housing (5) from vise and place upside down on work bench. This allows thrust bearing (10) to fall free. Next place fingers through dust seal (1) of housing and push seal carrier (6) out the opposite end from the dust seal. Care should be taken to keep the seal carrier from maring the housing bore. This procedure will remove items 6, 7, 8, 9, and 10 from housing.

e. Mount housing assembly (5) in vise, using the grip end of a large screw driver, tap dust seal (1) until it falls free.

f. With small screw driver remove retaining ring (2), seal (4) and shim (3).

5-7.2.2 Assembly.

**NOTE**

**Before assembling, wash all parts off in clean solvent. It is advisable to use a new seal kit containing items 1, 3, 4, 7, 8, 9 and 14 (3 seals).**

a. Place housing with mounting flange end up on newspaper, install seal (4) in groove.

b. Install shim (3) into groove next to seal.

c. Push retaining ring (2) into position.

d. Place housing (5) in vise with groove side up clamping at ports.

e. Assemble shim (7) in seal carrier (6) next push leather backup (8) into place followed by shaft seal (9) with lip side away from leather backup.

f. Place thrust bearing (10) on shaft (11) followed by the seal carrier assembly (6, 7, 8 and 9) with large diameter of seal carrier towards thrust bearing.

g. Assemble the drive link (12) into shaft (11). Care must be taken to align mark at root of drive line tooth with mark on cupped end of shaft. If spline is tight, assembly can be made by rapping the end of the drive link with a hammer. Fill drive link end with grease. Note, if markings are indistinguishable the root of the drive link tooth should be placed with the angle drill slot of the output shaft to the right and 1/4" thru hole to the left. (Mark alignment as described on drive link end with soft pencil if no marks appear. )

h. Slide output shaft assembly (6, 7, 8, 9, 10, 11 and 12) into housing. (Shaft must be flush or slightly below housing. )

i. Place lightly oiled seal (14) in groove of housing.

j. Place wear plate '1 3) on top of drilled end of housing, insuring alignment of seven feed holes. Note alignment groove of wear plate to be in direction of ports.

k. Install lightly oiled seal (14) into groove of roller stator (15). With seal side down place roller stator (15) over the drive link with mark on drive link root in line with rotor valley (min. diameter). Mark on stator must be in line with slot in wear plate. Note alignment of seven feed holes with wear plate and housing. Align four bolt holes with housing. Care must be taken to insure that seal stays in place. Note: Counterbore on rotor is away from housing.

l. Place lightly oiled seal (14) into end cover (17).

m. Place grease in recessed center of end cover face. Install pin (16) into greased recess if recess is filled with oil, wipe clean before loading with grease.

n. Carefully invert end cover assembly (17, 16 and 14) and place into position on top of roller stator assembly. Take care not to dislodge seal or pin from end cover.

0. Check sides for seals that may be out of place.

p. Insert four bolts (18) and torque to 50 foot pounds.

q. Place assembly on side (ports up) in vise and rotate shaft with key in place and check to insure the suction port is in the same direction of rotation.

5-7.3 Extension Boom Assembly. (Figure 5-9)

5-7.3.1 Removal and Disassembly.

a. Remove clinch pin (1) and extension pin (2).

b. Withdraw the manual extension boom (3) from the extension boom (4).

c. Remove the nut (5), screw (6) and spacer (7).

d. Remove the nut (8), screw (9) and spacer (10).

e Remove the nut (I1), pin (12), with grease fitting (13), and remove the sheave (14), bearings (15) and cups (16) from the boom (3).

f. Remove cotter cotter pins (17) and cylinder pin (18) to disconnect extension boom (4) from cylinder.

g. Refer to figure 5-10 and remove screws (1), retainer (2), nut (3), pin (4) and trunnion (5) from main boom.

h. Pull extension boom (4, figure 5-9) out of main boom and, as necessary, remove screws (19) and wear pads (20, 21 and 22).

i. Replace worn parts as required.

5-7.32 Assembly and Installation.

a. Attach the wear pads (20, 21 and 22) to the extension boom (4) with screws (19). Be sure that screw heads are recessed below surface of wear pads and tightened securely.

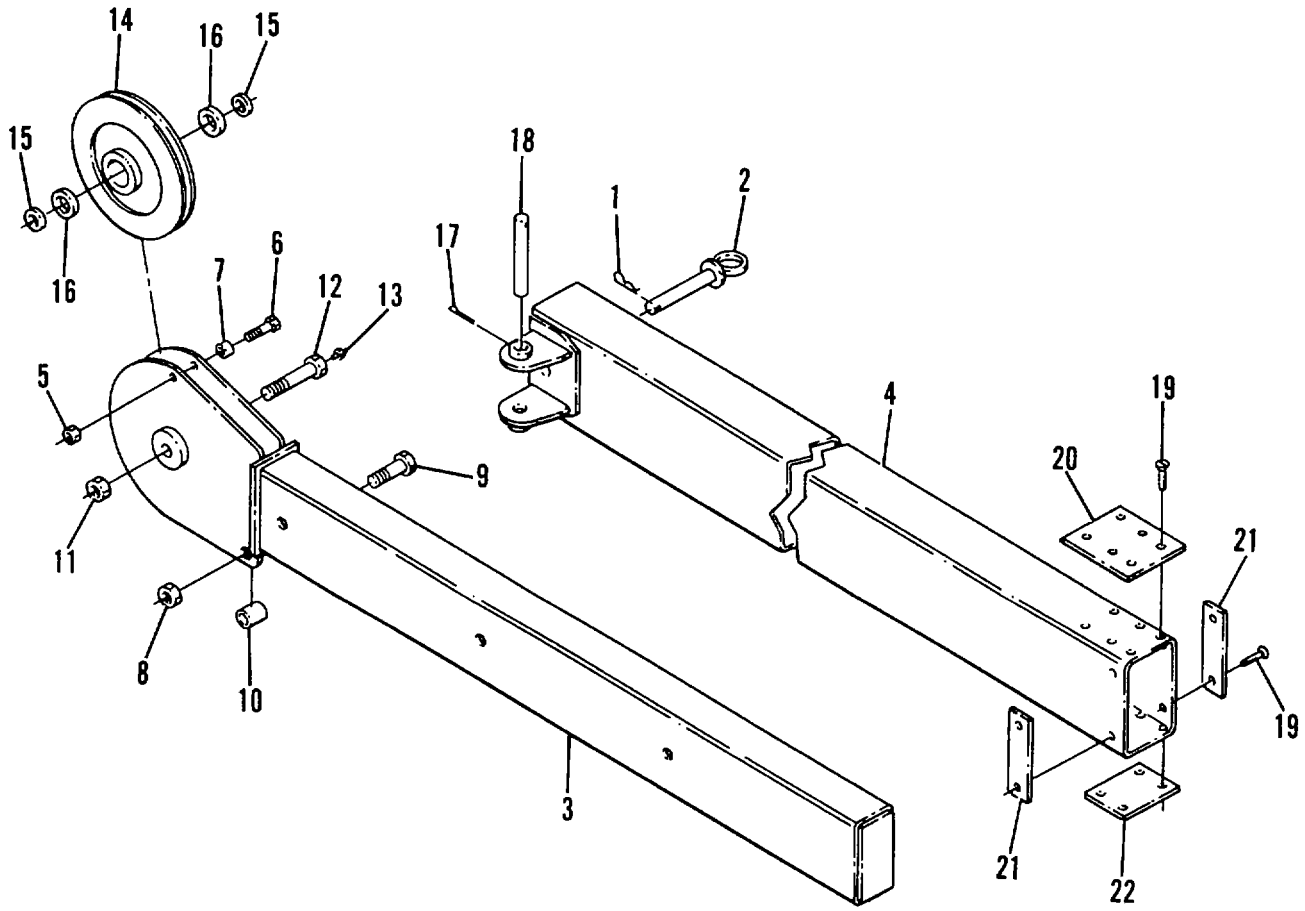



**Figure 5-9. Extension Boom Assembly**

b. Position the extension boom into the end of main boom squarely and slide extension boom in.

c. Line cylinder bracket on extension boom (4) with cylinder rod end and install cylinder pin (18) and cotter pins (17).

d. Assemble cups (16) in sheave (14) and install bearings (15).

e. While holding the bearings (15) in place, insert the sheave (14) into the end of manual extension boom (3). Aline holes and install pin (12) and nut (11). Make sure grease fitting (13) is installed in pin.

f. Install screw (9), spacer (10), nut (8), screw (6), spacer (7) and nut (5) in manual extension boom (3).

g. Slide manual extension boom (3) into extension boom (4), aline holes and install extension pin (2) and clinch pin (1).

5-7.4 Main Boom Assembly. (Figure 5-10)

5-7.4.1 Removal and Disassembly.

a. Refer to paragraph 5-7.3 and remove the extension boom assembly.

b. Remove screws (6), and wear pads (7) from retainers (2), and screws (8) and wear pad (9) from trunnion (5).

c. Disconnect and cap the hydraulic lines to the extension cylinder (12), then remove cotter pins (10), pin (11) and cylinder (12) from main boom (13). Refer to paragraph 5-7.5 for repair of cylinder.

d. Attach a supporting sling to the main boom (1 3).

e. Support the main cylinder (16) and remove nut (14) and pin (15). Carefully lower the rod end of cylinder.

f. Disconnect and cap hydraulic lines to main cylinder (16). Remove nut (17), pin (18) and cylinder (16). Remove bushings (19 and 20) and, if replacement is required, grease fittings (21). Refer to paragraph 5-7.6 for repair of cylinder.

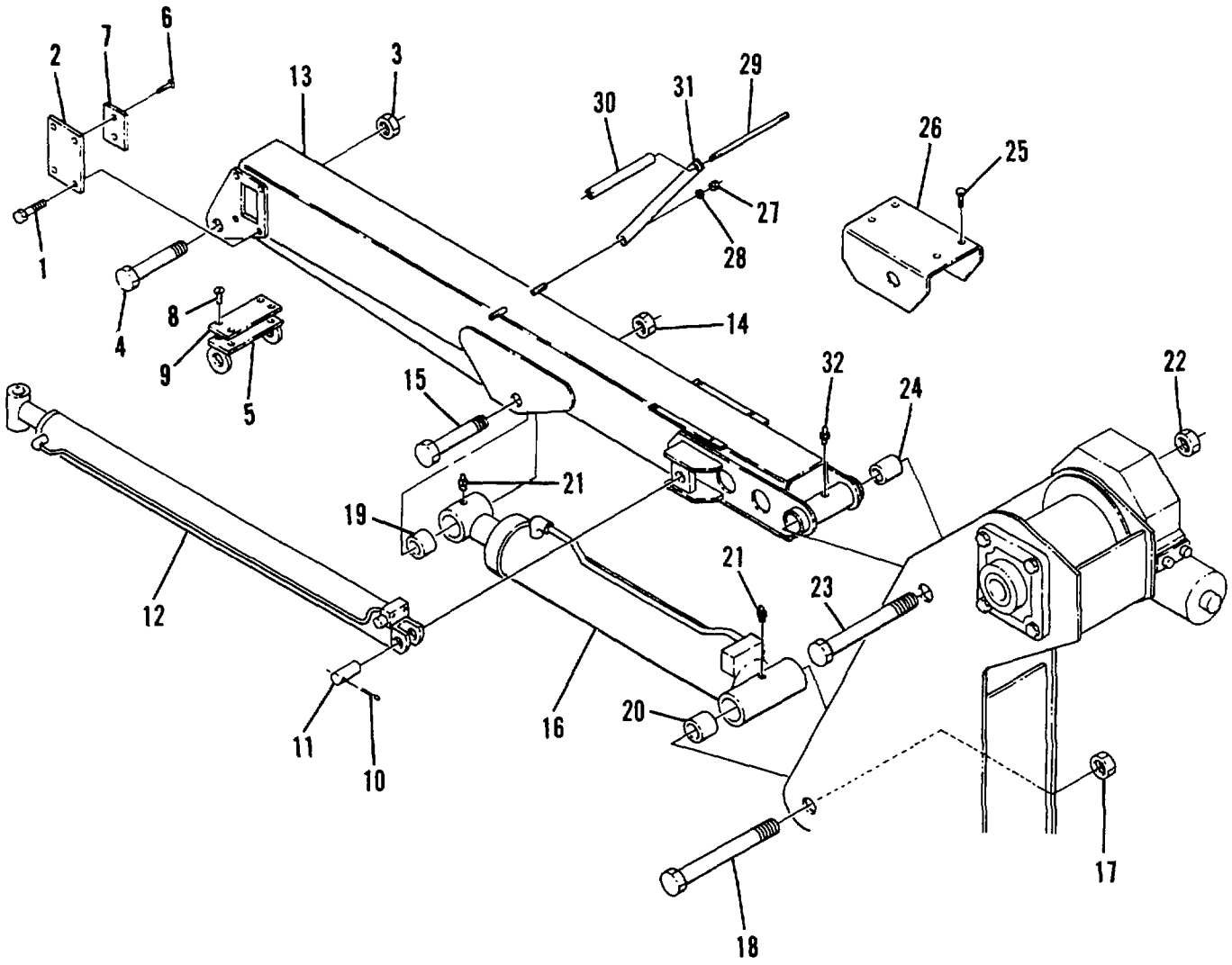
g. Remove nut (22) and drive out pin (23). Lift the main boom (1 3) out of the turret. Remove bushings (24).

h. As needed, remove screws (25), indicator (26), nuts (27), washers (28), rod (29), roller (30), bars (31) and grease fittings (32).

i. Replace parts as required.

5-7.3.2 Assembly and Installation.

a. Attach a lifting sling to main boom (13). Install bushings (24) and grease fittings (32).




1. Screw
2. Retainer
3. Nut
4. Pin
5. Trunnion
6. Screw
7. Wear Pad
8. Screw
9. Wear Pad
10. Cotter Pin
11. Pin
12. Extension Cylinder
13. Main Boom
14. Nut
15. Pin
16. Main Cylinder
17. Nut
18. Pin
19. Bushing
20. Bushing
21. Grease Fitting
22. Nut
23. Pin
24. Bushing
25. Screw
26. Indicator
27. Nut
28. Washer
29. Rod
30. Roller
31. Bar
32. Grease Fitting

**Figure 5-10. Main Boom Assembly**

b. Lift boom and maneuver into position in the frame of turret and install pin (23) and nut (22).

c. Install bushings (19 and 20) and grease fittings (21) in main cylinder (16).

d. Position the base of cylinder (16) in turret and install pin (18) and nut (17). Uncap and connect hydraulic lines to cylinder.

e Lift rod end of cylinder (16) and place in position on main boom (1 3). Install pin (15) and nut (14). Remove sling from boom.

f. Install bars (31), roller (30), rod (29), washers (28) and nuts (27). Install indicator (26) and screws (25).

g. Refer to paragraph 5-7. 3 and install the extension boom.

h. Attach wear pad (9)to trunnion (5) with screws (8). Attach wear pads (7) to retainers (2) with screws (6). Be sure that screw heads are recessed below the surface of wear pads.

i. Install retainers (2) and screws (1). Install trunnion (5), pin (4) and nut (3).

j. Put the extension cylinder (12) in place and install pin (11) and cotter pins (10). Connect rod end to extension boom with pin (18, figure 5-7) and cotter pins (17).

k. Uncap and connect hydraulic lines to extension cylinder.

5-7.5 Main and Extension Cylinders. (Figure 5-11)

5-7.5.1 Disassembly. Before proceeding with disassembly, thoroughly wash the exterior of the cylinder case.

a. Remove tube (1), elbow (2), screws (3) and holding valve (4).

**CAUTION**

**Do not clamp the cylinder in a vise. It may damage the cylinder.**

b. Place the cylinder on a flat surface near a vise. Slip a pin through the pin boss on the end of tube (6) and clamp the pin in a vise.

c. Using a spanner wrench, unscrew the end gland (5), or retaining nut (6), from tube (7).

**WARNING**

**Do not use compressed air to assist in withdrawing the piston/rod assembly. The use of compressed air may result in propelling the piston/rod assembly out of the cylinder and may cause injury or death.**

d. Withdraw the rod (8), with attached parts, from the cylinder tube (7).

**CAUTION**

**Do not clamp the machined surface of the rod in a vise. Damage to the rod will result.**

e. Slip a pin through the pin boss on end of rod (8) and clamp the pin in a vise.

f. Remove nut (9), piston (10) and end gland (5) from rod (8). Remove o-ring (12). (For main cylinder remove retaining nut 16].)

g. Spread and remove piston rings (11). Remove each ring from the end of piston (10) nearest ring.

h. Work a slack section in o-ring (13) and pick it up out of the groove to remove it from end gland (5).

i. Pinch the lip of the wiper (14) with needle nose pliers and pull it out of end gland (5).

j. Position the end gland (5) with the top up and puncture the seal (15) with an awl. Pry it out of the groove and push it through the end gland.

k. Inspect the cylinder tube (7) interior and rod (8) for dents, nicks, scratches, etc. and replace if necessary.

I. Clean the piston (10), end gland (5), rod (8) and tube (7). Dress any nicks and gouges that may have occurred during disassembly.

5-7.5.2 Assembly. When assembling cylinder, use all new seals, rings and o-rings.

a. Install o-ring (12) on rod (8).

b. Slide the piston rings (11) over end of piston (10) and allow them to snap into grooves.

c. Position the end gland (5) with the wiper (14) side up. Grasp the seal (15) with needle nose pliers (refer to figure 5-12).

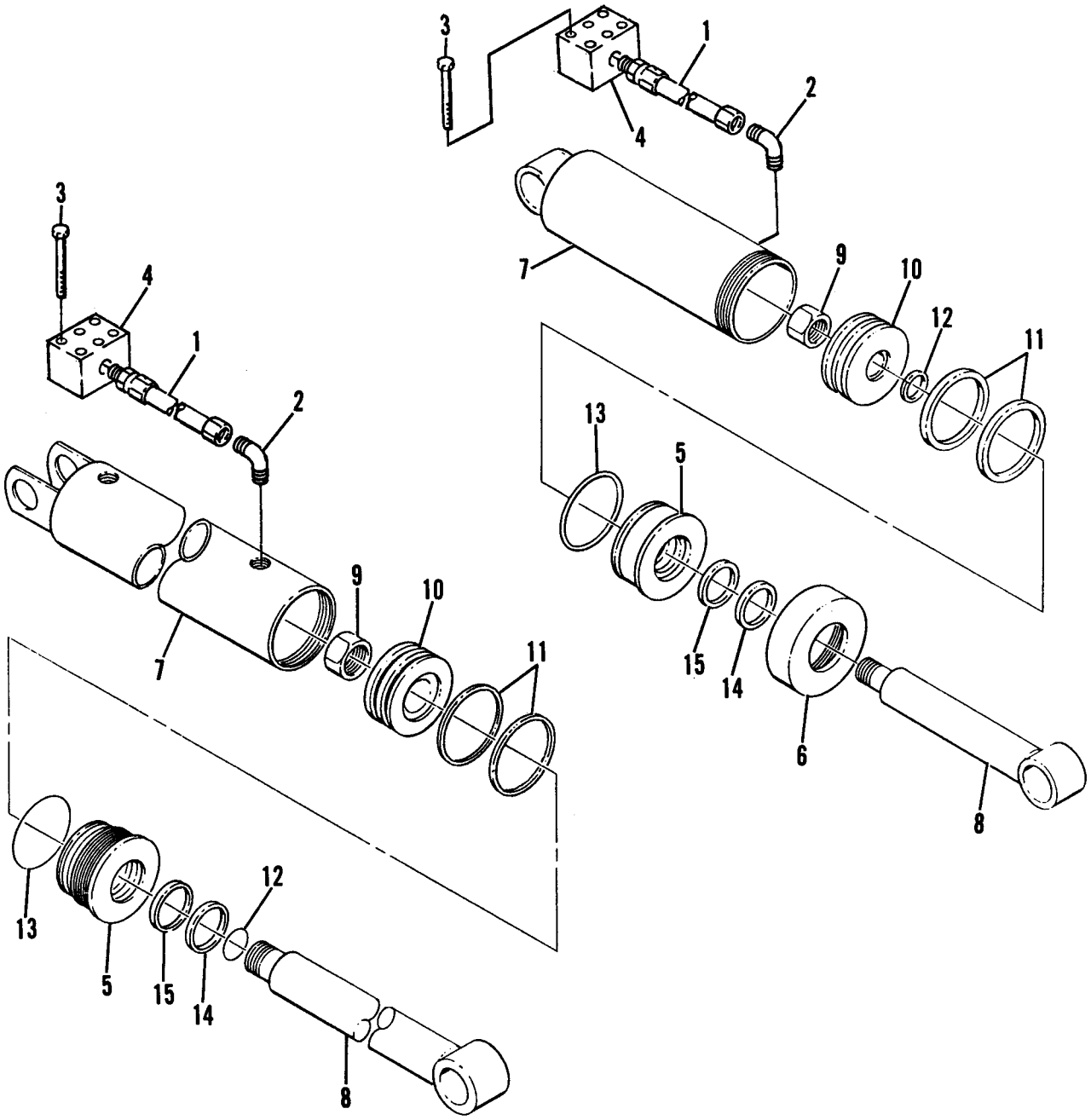
**CAUTION**

**Do not apply too much pressure to the rod seal (15) or you may cut it with the needle nose pliers.**

d. Insert the seal (15) into end gland (5) and allow it to snap into position. Use your fingers to help it if necessary.

e. Install rod wiper (14) and o-ring (13).

f. Using a pin in rod (8), clamp in a vise as in disassembly.




1. Tube
2. Elbow
3. Screw
4. Holding Valve
5. End Gland
6. Retaining Nut
7. Cylinder Tube
8. Rod
9. Nut
10. Piston
11. Piston Ring
12. O-Ring
13. O-Ring
14. Wiper
15. Rod Seal

**Figure 5-11. Main and Extension Cylinders**

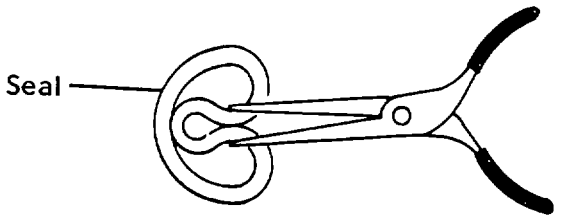



**Figure 5-12. Rod Seal Installation**

g. Install retaining nut (6) on rod (8). (Main cylinder only.)

h. Generously lubricate the inside diameter of the end gland (5) with a non-fibrous U bearing grease, then carefully slide the end gland onto the rod (8). Make certain the rod wiper (14) does not catch on the rod when it is first started. Slide the end gland all the way onto the rod.

i. Install the piston (10) on the rod (8) and install nut (9). Tighten nut.

j. Generously lubricate the outside diameter of the piston (10) and end gland (5) with a non-fibrous bearing grease. Also lubricate the threads and beveled area of the top of cylinder tube (7).

k. With a side-to-side or up-and-down motion, work the piston (10) into the tube (7). Slide the piston into the tube.

l. With a rotating motion, work the o-ring (13) into the tube (7).

m. Hand tighten the end gland (5) on extension cylinder; or retaining nut (6) on main cylinder.

n. Clamp the cylinder in a vise as in disassembly, then tighten the end gland (5) or retaining nut (6) to 250 ft-lbs.

o. Install holding valve (4), screws (3), elbow (2) and tube (1).

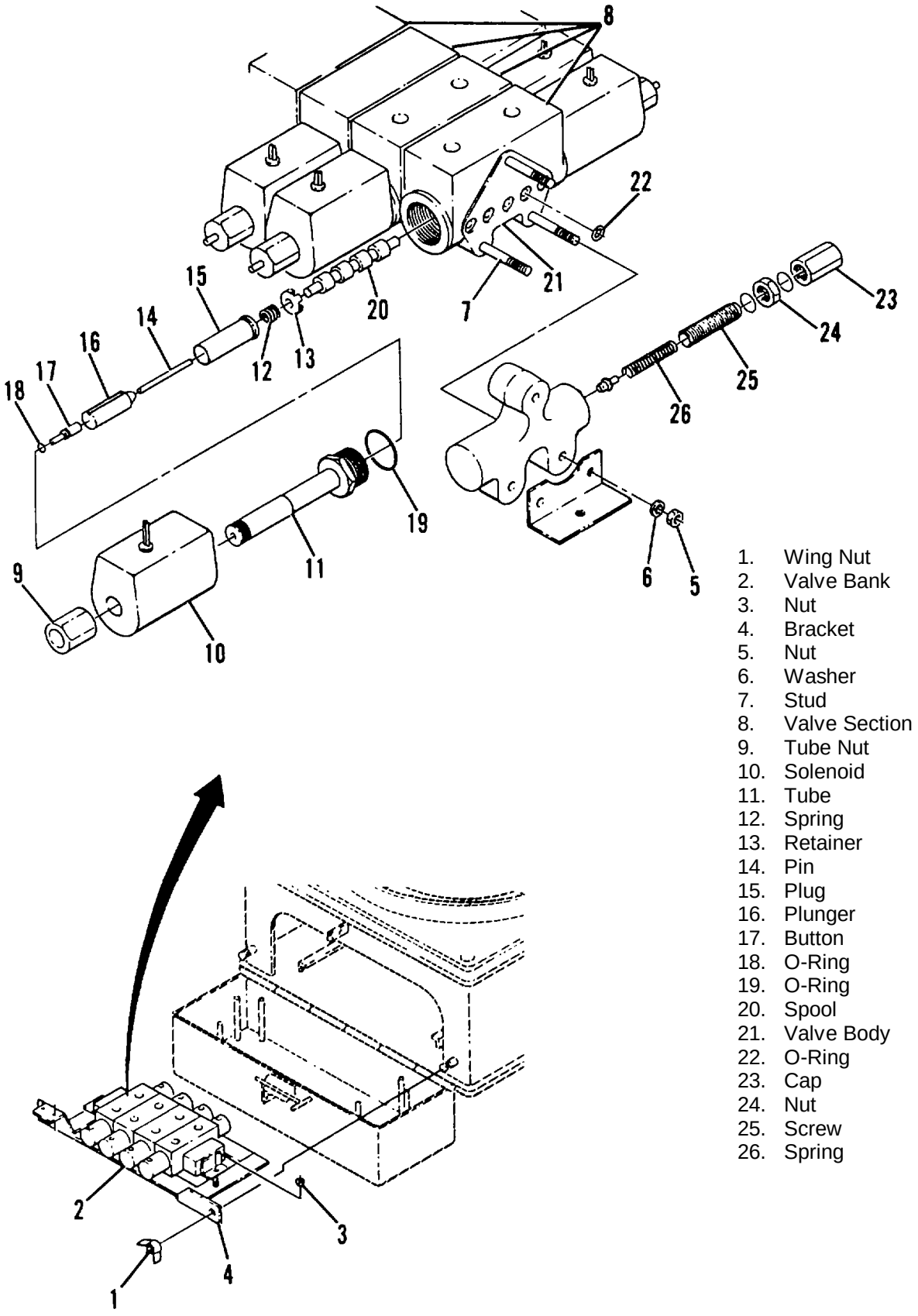
5-7.6 Control Valve. (Figure 5-13)

**NOTE**

**The control valve consists of four electrically activated valve sections and two end sections. It is recommended that repair of the valve be limited to replacement of a malfunctioning valve section. However, if a new section is not available, the valve section may be disassembled and seals and springs replaced.**

5-7.5.1 Removal.

a. Open the valve bank cover in the base of crane. Move control pendant and cable out of way.




1. Wing Nut
2. Valve Bank
3. Nut
4. Bracket
5. Nut
6. Washer
7. Stud
8. Valve Section
9. Tube Nut
10. Solenoid
11. Tube
12. Spring
13. Retainer
14. Pin
15. Plug
16. Plunger
17. Button
18. O-Ring
19. O-Ring
20. Spool
21. Valve Body
22. O-Ring
23. Cap
24. Nut
25. Screw
26. Spring

**Figure 5-13. Control Valve**

b. Unscrew wing nuts (1) and move valve bank assembly (2) out of base far enough to gain access to connections.

c. Disconnect the hoses from the affected section of the valve bank. Disconnect the electrical connections.

d. Remove the nuts (3) to release the valve bank from the mount bracket (4).

e. Remove the nuts (5) and washers (6) from one end of the studs (7). Work from the end nearest the affected section (8). Slide the studs (7) far enough out of the valve bank to permit removal of the affected section.

f. Slide the valve section (8) out of the valve bank and loosely install the studs (7) back in the valve bank.

**NOTE**

**If the complete section is being replaced, position the new section in place of the old one, slide studs (7) back in and install washers (6) and nuts (5).**

5-7.6.2 Disassembly. Before disassembly, prepare an oil bath of clean SAE 10 oil to receive the parts as described in the following procedures.

a. Remove the tube nut (9) and slide the solenoid coil (10) off the tube (11).

**CAUTION**

**Use the proper tool to avoid damaging the tube. Do not use an adjustable wrench or vise grip pliers.**

b. Use a 1-1/4" spanner wrench to loosen the tube (11).

**NOTE**

**The spring (12) and spring retainer (13) may fall out when the tube (11) is removed.**

c. Remove the tube (11) by hand.

d. Remove the spring (12) and spring retainer (13) from the valve body. Place spring and retainer in oil bath.

e. Slide the pin (14), plug (15) and plunger (16) out the open end of the tube (11). Place pin, plug and plunger in oil bath.

f. Using a small screwdriver or punch, gently push the button (17) into the tube (11) until it is free and falls out. Remove and discard o-ring (18) and place button in oil bath.

g. Remove and discard o-ring (19) from tube (11) and place tube in oil bath.

h. Repeat steps a. through g. to remove the second tube.

**CAUTION**

**Handle spool (20) with extreme care. Damage to surface of spool will prevent it from functioning properly.**

i. Carefully slide the spool (20) from the valve body (21). Discard 0-rings (22).

j. Inspect all parts for damage. Replace all 0-rings and any part suspected of being damaged. The spool (20) and valve body (21) are a matched pair and if either is damaged, both must be replaced. Place all replacement parts in oil bath.

5-7. 6. 3 Assembly.

**CAUTION**

**Before assembly, check that both valve body and spool are thoroughly dry. Any residual cleaning agent may damage the o-rings.**

a. Wash all parts with an approved cleaning solvent and dry with low pressure compressed air.

**CAUTION**

**Handle the spool (20) with extreme care. Contamination or damage to surface of spool will prevent it from functioning properly.**

b. Dip the spool (20) and valve body (21) in clean SAE 10 oil and slide spool carefully into the body. If the spool does not slide freely into the valve body, inspect for burrs. Remove burrs with a stiff wire brush or no. 400 emery paper and repeat steps a. an-d b.

c. Place a new o-ring (19) on tube (11).

d. Place a new o-ring (18) on button (17) and drop button into the tube (11). Use a screwdriver to push it into place.

e. Insert plunger (16), plug (15) and pin (14) in tube (11).

f. Place spring retainer (1 3) and spring (1 2) over end of spool (20).

g. Install the tube (11) and hand tighten.

h. Repeat steps c. through g. for second tube assembly.

i. Using a 1-1/4" spanner wrench, tighten the tubes (11).

j. Install solenoid coils (10) and tube nuts (9).

5-7.6.4 Installation.

a. Slide the studs (7) far enough out of the valve bank to permit insertion of new or repaired section (8).

b. Install 0-rings (22) on both sides of section.

c. Carefully slide the valve section (8) into the valve bank, being careful not to dislodge the o-rings (22).

d. Slide the studs (7) through the valve bank and install the nuts (5) and washers (6). Torque to 125 in-lbs.

e. Position valve bank assembly (2) on bracket (4) and install nuts (3).

f. Reconnect electrical connections and hydraulic hoses to valve. Refer to 5-7.6.5 and adjust relief valve.

g. Slide the valve bank assembly (2) into position in the crane base and install wing nuts (1).

5-7.6.5 Relief Valve Adjustment. Normally the relief valve will not require adjustment. However, if the valve was disassembled for cleaning, or otherwise tampered with, or if the spring (26) is weakening, it must be adjusted. The correct relief setting is 2500 PSI.

a. Start the engine and engage the PTO. Operate the crane to bring any function to full open. After the cylinder is fully extended or retracted, check pressure on pressure gauge while keeping the control full open. If the pressure reading is not 2500 PSI, perform the following steps for adjustment.

b. Remove the cap (23) and loosen jam nut (24).

c. Turn the adjusting screw (25) clockwise to increase pressure and counterclockwise to decrease pressure. Adjust to 2500 PSI.

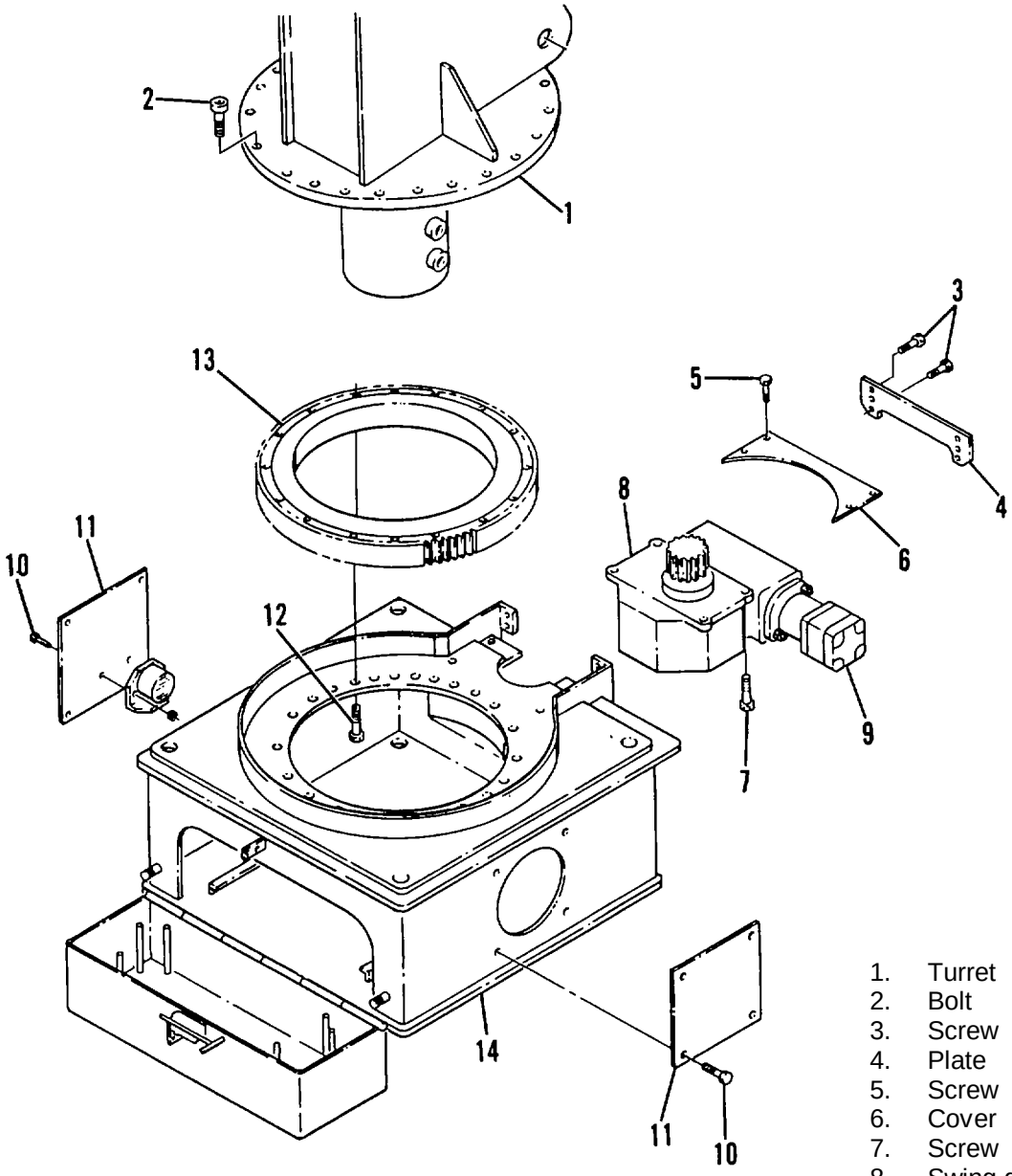
d. When valve is adjusted, tighten jam nut (24) and install cap (23).

5-7.7 Turret and Crane Base. (Figure 5-14)

5-7.7.1 Replacing Turntable Gear-Bearing.

a. Position the main boom parallel with the ground. Kill the vehicle engine.

b. Disconnect the pressure and return hoses from the valve bank. Push the hoses through the base and out of the way.




1. Turret
2. Bolt
3. Screw
4. Plate
5. Screw
6. Cover
7. Screw
8. Swing drive
9. Motor
10. Screw
11. Plate
12. Screw
13. Gear bearing
14. Base

**Figure 5-14. Turret and Crane Base**

c. Disconnect the rotation hoses from the valve bank. Disconnect the remote control handle.

d. Support the crane with an overhead crane, forklift or other lifting device. Take up the slack in lifting device.

e. With crane fully supported, remove all turret (1) mounting bolts (2). Lift off the crane and set it to one side.

f. Remove screws (3), plate (4), screws (5) and cover (6).

g. Remove screws (7) and lift out swing drive (8) and motor (9).

h. Remove screws (10) and access plates (11).

i. Remove screws (12) and lift out gear-bearing (13).

j. Position new gear-bearing (13) on base (14). Install screws (12) and tighten in a criss-cross pattern to 180 ft-lbs.

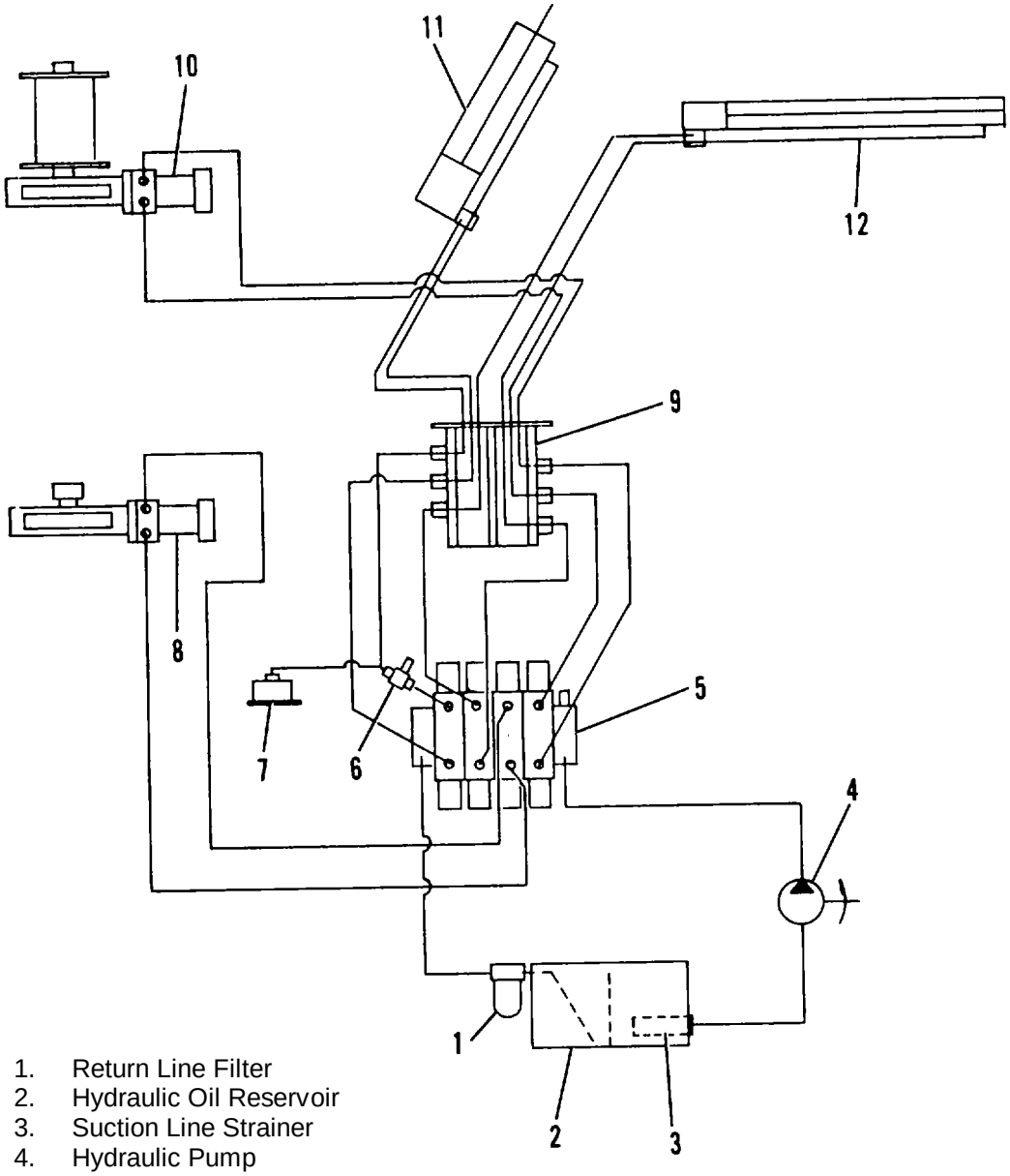
k. Position the swing driver (8) and motor (9), and install screws (7), cover (6), screws (5), plate (4) and screws (3).

l. Grease the gear-bearing and coat the entire outside diameter of the gear with a thick layer of grease.

m. Lift the crane and position turret (1) on the base (14). Install mounting bolts (2) and tighten in a criss-cross pattern to a torque of 180 ft-lbs.

n. Reconnect all hydraulic connections, using thread sealer on all connections. Install access plates (11) and screws (10).

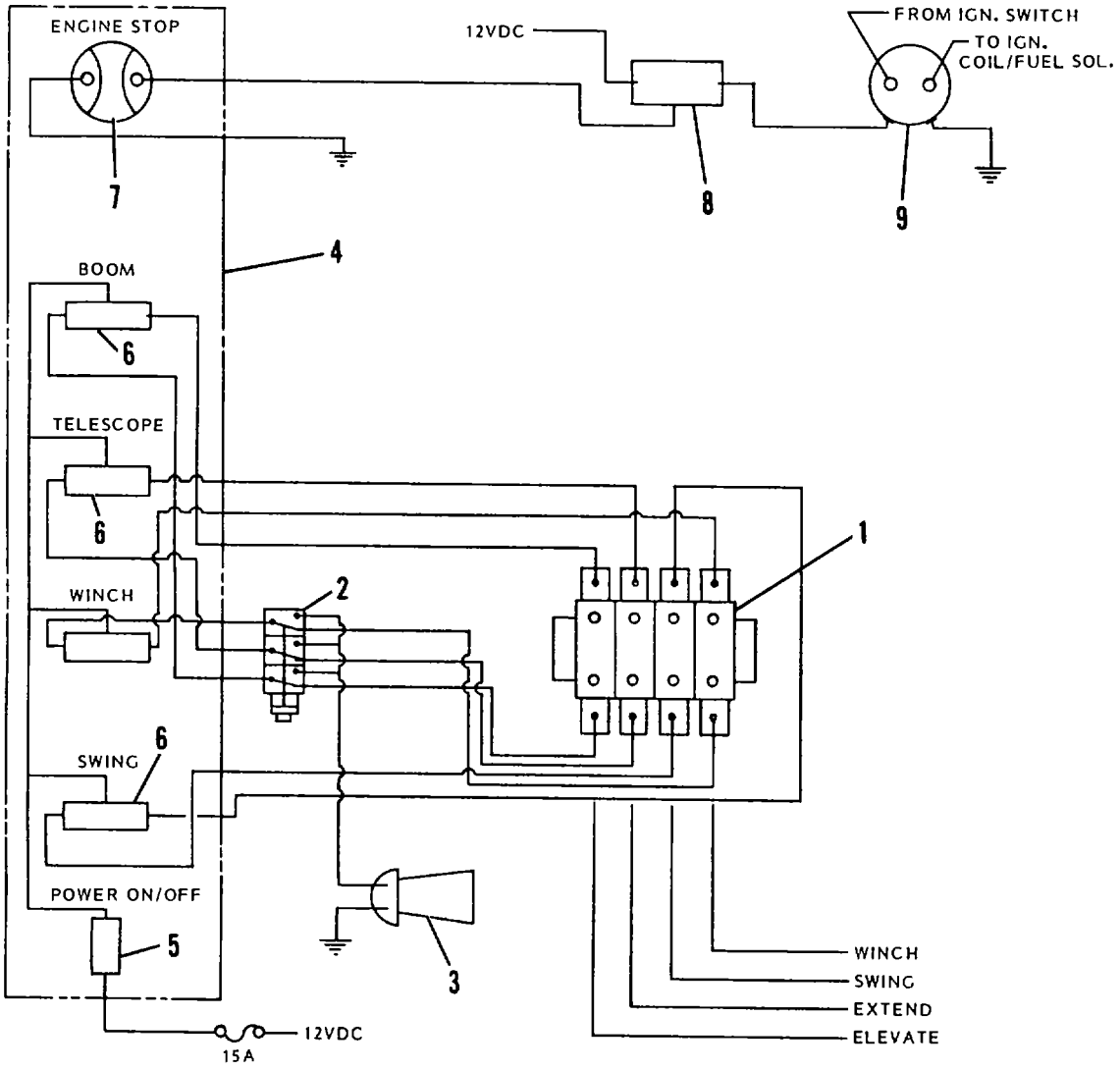
o. Operate the crane and test actuate all functions. Each function should be operated until the motion is smooth and air is purged from system.




1. Return Line Filter
2. Hydraulic Oil Reservoir
3. Suction Line Strainer
4. Hydraulic Pump
5. Control Valve
6. Flow Control
7. Pressure Switch
8. Swing Drive Motor
9. Swivel Manifold
10. Winch Drive Motor
11. Boom Elevation Cylinder
12. Boom Extend Cylinder

SYSTEM RELIEF PRESSURE SET AT 2500 PSI.

Figure 5-15. Hydraulic Diagram, Carne




1. Control Valve
2. Pressure Switch
3. Audible Warning Horn
4. Remote Control
5. Power On/Off Switch
6. Crane Function Switch
7. Engine Stop Switch
8. Relay - Engine Stop
9. Solenoid - Engine Stop

**Figure 5-16. Electrical Schematic, Crane**

Pages 6-1 and 6-2 are deleted. All information regarding Operation is contained in TM 5-3820-256-10.

## 6-2 LUBRICATION

6-2. 1 The clutch is lubricated at the time of assembly and will normally require cleaning and lubrication every six months by carefully following the disassembly/assembly procedure. If under adverse conditions, such as being submerged, the clutch becomes stiff and will not spring freely into engagement, it will be necessary to clean and lubricate the clutch parts at that time.

6-2. 2 Maintain correct oil level in the gear housing in order to dissipate heat. Too high or too low oil levels will result in damage to the winch.

6-2. 3 Be sure to use S. A. E. 140 on the worm and gear set. The oil capacity of the winch is 3-3/4 pints. Fill oil to level plug located on gear housing cover.

6-2. 4 Grease fittings on the winch should be lubricated occasionally with any heavy duty graphite-bearing grease.

## 6-3 ADJUSTING THE OIL COOLED WORM BRAKE

6-3. 1 The oil-cooled, fully adjustable, automatic safety brake operates in the worm gear housing lubricant, all parts being submerged in oil. When the brake wears to the point that the load begins to drift, the brake can be adjusted as follows:

a. Loosen the lock nut on the adjusting screw.

b. Tighten the brake by turning the adjusting screw clockwise. CAUTION: Only 1/4 turn is usually required to adjust the brake. Over-tightening can cause over-heating, and damage to the brake parts. If the brake requires more tightening than 1/4 turn, a torque wrench should be used to check the proper torque, at the worm each time the adjusting screw is turned. Refer to paragraph 6-7. 3 ADJUSTMENT OF THE BRAKE. Tighten the lock nut after adjustment is completed.

6-3. 2 If the brake does not respond to adjustment, a new leaf spring and brake disc are needed. After installing new part, see paragraph 6-7. 3 ADJUSTMENT OF THE BRAKE.

**6-4 ATTACHING WIRE ROPE TO THE DRUM**

6-4. 1 General. The winch has two tapered pockets cast into the drum. One pocket is for installations with the wire rope wound over the drum. The other pocket is for an under-wound wire rope. When properly used, the wedge pocket design is one of the most secure anchoring methods available.

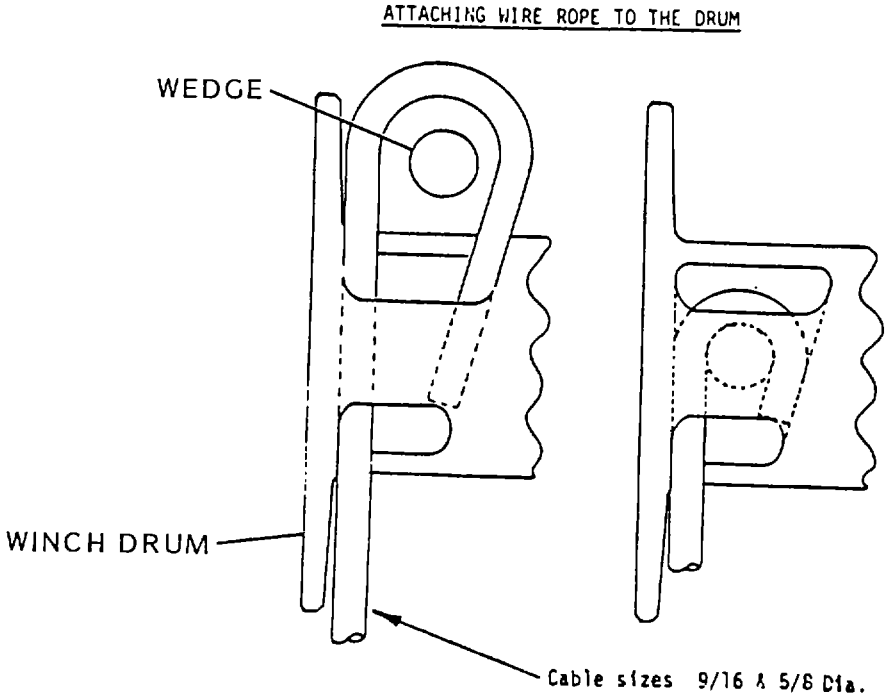



**Figure 6-1. Attaching Wire Rope**

6-4.2 To Attach Wire Rope To the Drum:

a. Slide the wire rope into the narrow end of the pocket against the drum flange.

b. Wrap the wire rope around the anchor "puck" and pull the wire rope and anchor back into the wide end of the pocket.

c. Use a soft hammer to drive the back side of the wire rope, firmly seating the wire rope and anchor into the pocket.

6-4.3 The wire rope can easily be removed from the drum by driving the anchor out the wide end of the pocket.

**6-5 PREVENTIVE MAINTENANCE**

6-5.1 Suggestions for Maintenance of your Winch:

a. Spool the cable properly on the drum when storing between each usage.

b. Check the oil level in the gear box every six months. At the same time, check mounting bolts, tighten if necessary.

c. Replace oil annually or more often if winch is used frequently. If there is an accumulation of bronze shavings in the oil, the bronze ring gear should be removed and inspected for signs of galling, caused by running the winch too fast. Remove the gear housing cover, if any signs of bronze is found on the worm, replace the worm immediately. Also inspect the bronze ring gear for wear. If gear teeth show signs of extensive wear, then it should be replaced.

d. Keep the breather plug, located at the top of the gear housing, free of dirt. The plug's purpose is to release the gasses which form from oil heating when the winch is in operation. If the plug is clogged, pressure will build up within the housing and cause excessive heating and oil leakage.

**6-6 TROUBLESHOOTING**

**Table 6-2. Trouble Shooting**

| CONDITIONS | POSSIBLE CAUSE | CORRECTION |
|---|---|---|
| Clutch inoperative or binds up. | 1. Dry or rusted clutch.<br>2. Bent yoke or linkage. | 1. Clean and lubricate.<br>2. Replace yoke or shifter assembly. |
| Clutch handle won't latch into slots. | 1. Loose shift pattern plate.<br>2. Debris in clutch. | 1. Adjust shift pattern plate.<br>2. Clean and lubricate. |
| Oil leaks from housing. | 1. New Seal.<br>2. Seal damaged or worn. | 1. New seals sometimes leak until seated to shaft.<br>2. Replace seal. |

**Table 6-2. Trouble Shooting Continued**

| CONDITIONS | POSSIBLE CAUSE | CORRECTION |
|---|---|---|
| Oil leaks from housing continued. | 3. Too much oil.<br>4. Damaged gasket. | 3. Drain excess oil.<br>4. Replace gasket. |
| Load drifts down. | 1. Brake set for rotation opposite that required for application.<br>2. Safety brake out of adjustment.<br>3. Safety brake has become worn. | 1. Test for proper brake assembly (assume adjustment is proper).<br>2. Turn adjusting bolt clockwise 1/4 turn or until load does not drift.<br>3. Replace brake disc. |

## 6-7 MAINTENANCE OF WORM BRAKE

6-7.1 Disassembly of the Worm Brake. (Figure 6-2.) Remove the drain plug located in lower side of gear housing and drain the oil from the gear housing.

a. Back off the lock nut, then the adjusting screw, both two turns or more by turning them counter-clockwise.

b. Remove the cover mounting screws.

c. Remove the cover along with coil spring and leaf spring.

d. NOTE: Which slots balls are in. Remove the retainer plate, composition brake disc, cam plate, and balls.

e. Inspect parts as follows:

(1) Composition brake disc are 1/4" thick when new. Replace if thinner than 3/16 or if surfaces are glazed or burned.

(2) Inspect the flat, ground surface of the cam plate for glazing, warpage or other damage. Glazing can be removed by scraping carefully.

(3) Inspect the flat, ground surface of the retainer plate, same as described in step 2.

(4) Inspect the leaf spring. It should be bowed 1/8".

6-7.2 Reassembling And Checking the Brake. (Figure 6-2).

a. Press brake hub into place over worm shaft and key.

b. Assemble balls into appropriate slots of cam. Use stiff grease to hold balls into place and slide cam over end of worm. Be sure that balls are secure, between cam slots and hub slots.

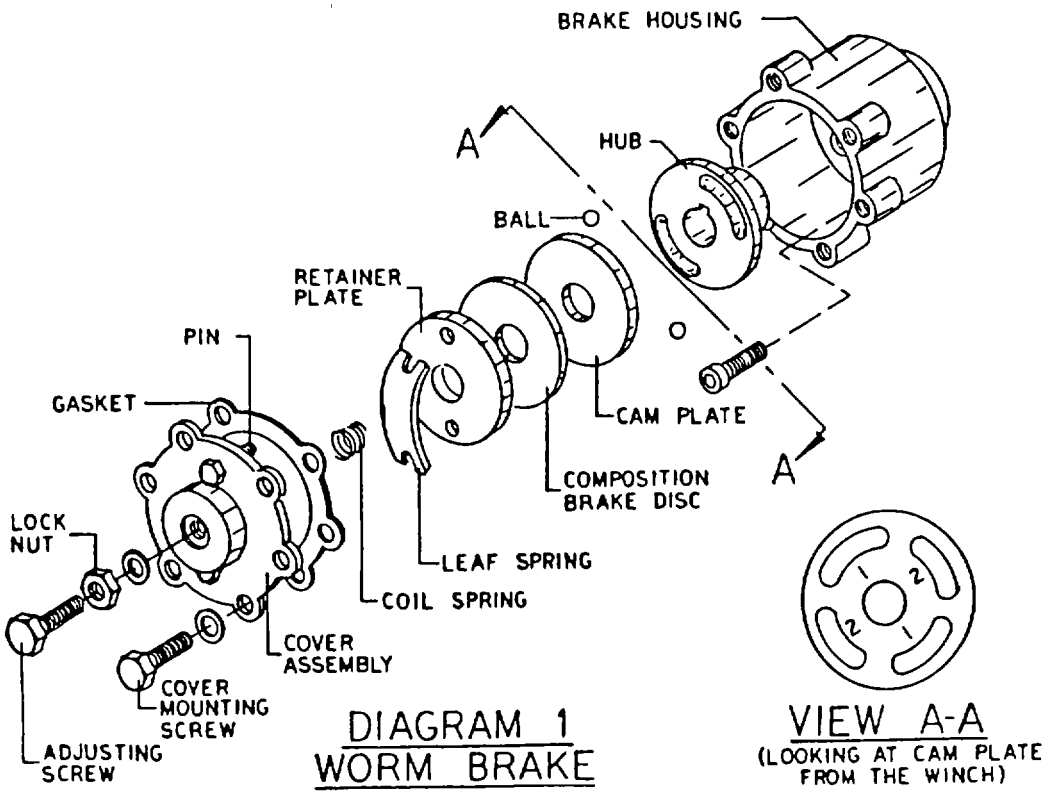



**Figure 6-2. Worm Brake**

c. Install brake disc.

d. Install retainer plate, smooth side toward brake disc.

e. Install the gasket on the cover with a small amount of grease or sealer.

f. The coil spring goes over the adjusting screw on the inside of the cover.

g. Install the notches of the leaf spring on the pins protruding through the cover. The hollow side of the leaf spring goes toward the brake.

h. Install brake housing cover, making sure the protruding pins go through the leaf spring and into the holes in the retainer plate.

i. Bolt cover into place with the mounting screws.

j. Turn winch in the hoisting direction at least one turn of the input shaft.

k. Turn the adjusting screw in until it is finger tight.

l. Replace oil in gear housing. (3-3/4 pints of S. A. E. 140. )

6-7.3 Adjustment of the Brake:

a. The torque required to turn the winch input shaft, in the lowering direction against the worm brake, should be 40 to 45 foot lbs. If a torque wrench does not show the proper value as it turns, then the worm brake adjusting bolt should be turned clockwise 1/4 turn. Each time the adjusting bolt is turned, check the torque reading on the input shaft. Continue this procedure until the proper torque reading is achieved. Then tighten the lock nut.

b. A torque wrench can be equipped with a special adapter to fit the input shaft (worm) of the winch. The adapter can be made by welding a nut to the end of a piece of tubing as shown in figure 6-3.

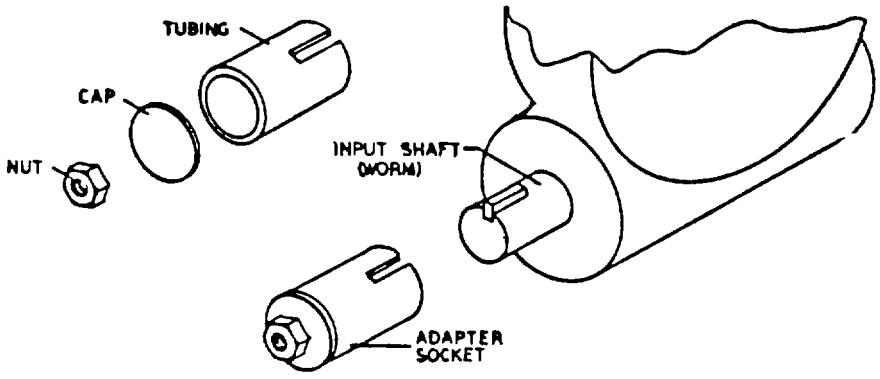



**Figure 6-3. Adjustment Adapter**

c. After welding the cap and nut to the tubing, slot the tubing as shown. This will allow the special adapter to slide over the keyway and will then act as a large socket. A torque wrench can then be used to apply the proper torque. Turn the torque wrench so that the drum turns in the spoolout direction or lowering direction.

6-7. 4 Test for Proper Brake Assembly:

a. After the brake has been adjusted to the proper torque setting, disengage the clutch, operate the winch in the spool-in direction (hoisting direction).

b. Allow the winch to run in this direction for one minute. Place your hand on the safety brake housing and, if it is not heating, change the power take-off lever to the reverse position. Run the winch for another minute and hold your hand on the safety brake. It should begin to heat.

c. When these conditions exist, proper installation has been made. If heating becomes noticeable when running the winch in forward rotation (reeling in), the brake should be again disassembled. When disassembled, place the brake balls in the correct slots in the cam plate, then carefully follow the instructions for reassembling and checking the brake.

**6-8 WINCH OVERHAUL** (Figure 6-4)

6-8.1 Disassembly.

a. Drain oil from gear housing by removing pipe plug (56) from gear housing.

b. Shift clutch into the engaged "IN" position. Remove frame angles (2) from Winch Assembly.

c. Remove two capscrews (40) from clutch housing (14) and unlatch shifter assembly.

d. Remove clutch housing from end of drum shaft. Press in on retainer plate (60), to relieve the spring tension and remove the retainer ring (62).

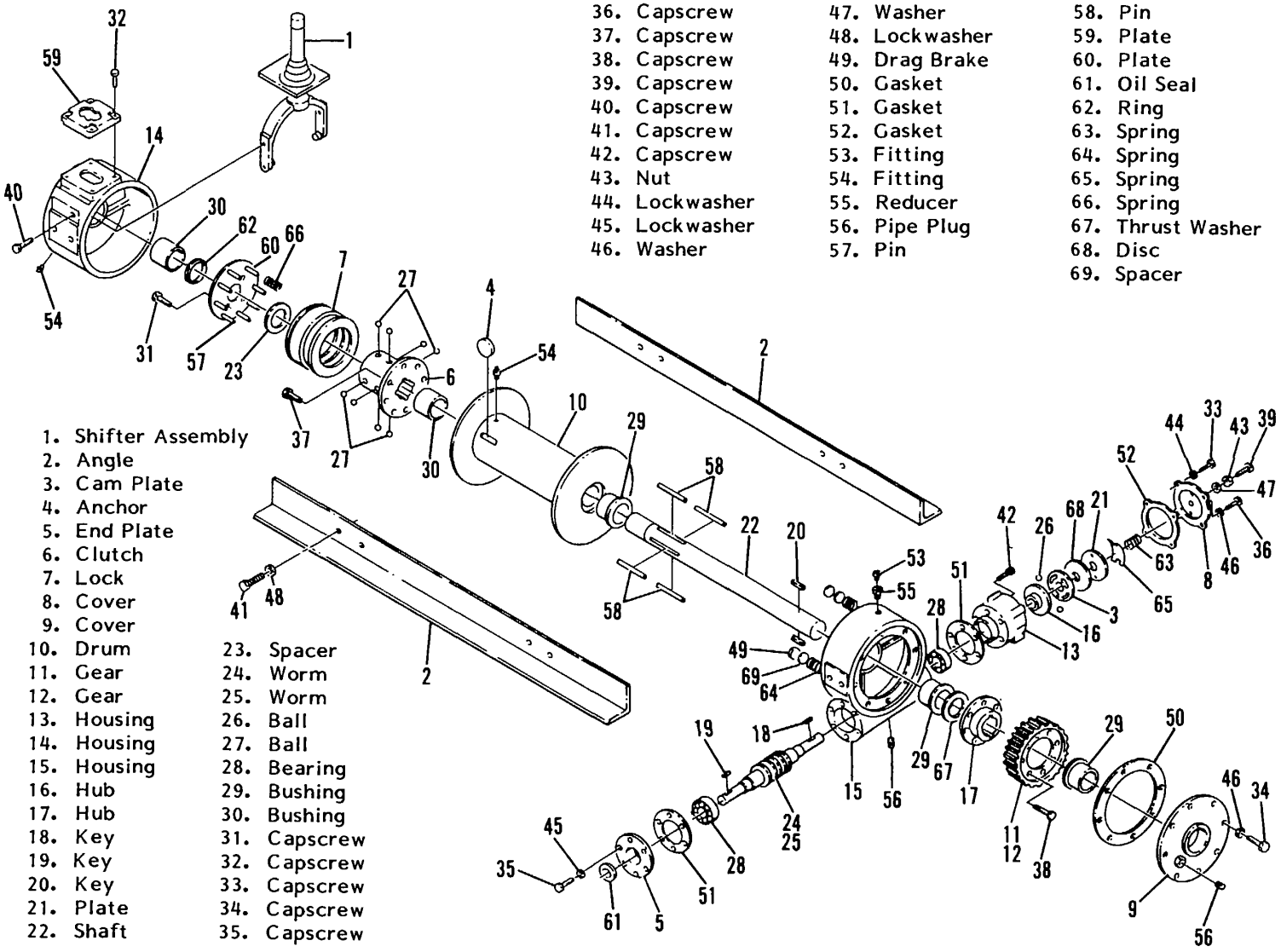
e. Remove four capscrews (31), retainer plate (60) and springs (66).

f. Remove clutch spacer (23) and slide the locking ring (7) from the clutch. NOTE: The locking ring cannot be removed unless the clutch is engaged, with dowel pins (58) seated in the shaft keyways.

g. Rotate the drum so the eight balls (27) and four dowel pins (58) can be removed.

h. If necessary, the clutch (6) may be disassembled from the drum by removing eight capscrews (37).

i. Lift drum (10) from end of drum shaft. Remove disc brake (49), spacer (69) and spring (64), from gear housing.



1. Shifter Assembly
2. Angle
3. Cam Plate
4. Anchor
5. End Plate
6. Clutch
7. Lock
8. Cover
9. Cover
10. Drum
11. Gear
12. Gear
13. Housing
14. Housing
15. Housing
16. Hub
17. Hub
18. Key
19. Key
20. Key
21. Plate
22. Shaft
23. Spacer
24. Worm
25. Worm
26. Ball
27. Ball
28. Bearing
29. Bushing
30. Bushing
31. Capscrew
32. Capscrew
33. Capscrew
34. Capscrew
35. Capscrew
36. Capscrew
37. Capscrew
38. Capscrew
39. Capscrew
40. Capscrew
41. Capscrew
42. Capscrew
43. Nut
44. Lockwasher
45. Lockwasher
46. Washer
47. Washer
48. Lockwasher
49. Drag Brake
50. Gasket
51. Gasket
52. Gasket
53. Fitting
54. Fitting
55. Reducer
56. Pipe Plug
57. Pin
58. Pin
59. Plate
60. Plate
61. Oil Seal
62. Ring
63. Spring
64. Spring
65. Spring
66. Spring
67. Thrust Washer
68. Disc
69. Spacer

**Figure 6-4. Winch Exploded View**

j. Remove brake parts from winch assembly. Refer to paragraph 6-7. 1, Disassembly of the Worm Brake.

k. Remove the brake housing (13) by removing six capscrews (42). Remove keys (18 & 19) from worm shaft.

l. Remove worm (25) and bearing (28) from gear housing. Use a soft hammer to tap input end of worm and drive worm from housing. Once worm has been removed from housing, bearing (28) can be pressed from end of worm.

m. Check for signs of wear or damage to worm (25) and bearing (28).

n. Remove bearing cap (5) by unscrewing six capscrews (35). Check seal (61) for signs of wear. Replace if necessary by pressing new one back, in the same position.

o. Remove gear housing cover (9) from gear housing by unscrewing eight capscrews (34). Place capscrews in the two tapped holes in the cover and tighten. This will pull the cover loose from the gear housing.

p. Remove gasket (50).

q. Pull gear and drum shaft (1 2) from gear housing.

r. Check for signs of wear on gear teeth. If necessary replace gear by removing eight capscrews (38).

6-8.2 Reassembly:

a. Place new gear (12) onto gear hub. Align holes in gear with holes in hub. Press gear onto hub. Be sure gear is seated all the way on the hub. Use eight bolts (38) to secure gear to hub. Torque to 75 ft. lbs. each.

b. If shaft and/or hub is damaged, replace as follows:

(1) Tap keys (20) into short keyways of drum shaft (22).

(2) Press shaft (22) and keys through gear hub (17) until end of keys on long end of shaft are flush with hub.

(3) Secure gear to hub using eight (38) capscrews. Torque to 133 ft. lbs. each.

c. Check gear housing (29) for signs of wear. Replace bushing, if necessary, by pressing the old bushing out of gear housing (15) and pressing new bushing into place.

d. Check drum bushings (29 & 30) for wear. Replace bushings, if necessary, by removing the old bushings and pressing new ones into place.

e. Check end bearing bushing (30) for signs of wear. If necessary, remove old bushing and press new bushing into place.

f. Check cover bushing (29) for signs of wear. Replace if necessary by removing old bushing and pressing new bushing into place.

g. Slide thrust washer (67) over long end of shaft until washer rests against gear (12). h. Apply grease to end of drum shaft, opposite gear. Apply grease to bushing in gear housing (15). Place greased end of shaft through gear housing bushing. Push shaft through gear housing until gear hub and thrust washer rests against bushing. Put gasket (50) onto gear housing cover (9). Apply grease to gear end of shaft and bushing in cover. Slide cover onto shaft and align mounting holes so that oil level hole is at lowest position. Use eight capscrews (34) and lockwashers (46) to secure cover.

i. Press bearing (28) onto worm (25). Be sure that thick shoulder of bearings outer race (side with manufacturer's name and part number) is out, away from worm threads. Press bearing and worm into gear housing. Slip gasket (51) and bearing cap (5) into place around worm gear shaft. Use six capscrews (35) and lockwashers (45) to secure cap to gear housing. Insert key (19) into shaft keyway.

j. Press bearings (28) onto worm, and into gear housing. Insert key (18) into keyway. Place gasket (51) onto brake housing (13) and attach brake housing to gear housing. Use six capscrews (42) to secure.

k. Reassemble brake parts into brake housing. (Refer to paragraph 6-7. 2, Reassembly and Checking The Brake. )

l. Place springs (64), spacer (69), and brake disc (49) into place, in gear housing. Grease drum shaft and drum bushing. Slide drum (10) onto shaft.

m. Slide clutch (6) over end of drum shaft. Align the clutch over the pilot bushing in drum. Install the eight capscrews (37) and torque the capscrews to 75 ft. lbs. to securely seat the clutch to the drum.

n. Rotate the drum to align the clutch slots with the shaft keyways. Lightly grease four dowel pins, eight balls. Use molybdenum disulfide or graphite bearing grease. Insert the four dowel pins (58) and eight balls (27). In the engaged position the balls are nearly flush with the clutch.

o. Lightly grease the internal and external groove and bore in locking ring (7) and clutch (6).

p. Slide locking ring onto the clutch. When fully engaged, the locking ring touches the clutch flange and there is . 71 to . 73 inches between the end of the locking ring and the end of the clutch. Install the clutch spacer ring (23).

q. Place eight springs (66) over eight roll pins on retainer plate (60). Install retainer plate and secure to clutch using four capscrews (31). Firmly seat the retainer ring (62) into drum shaft groove.

r. Set the shifter assembly (1) so that the screw heads engage the external groove in the locking ring (7). Push the clutch housing (14) onto the drum shaft and latch the shifter assembly in the engaged "IN" position. Insert the two capscrews (40).

s. Attach mounting angles (2) to winch assembly. Use hardware shown in parts list. Remove plug (55 & 53) from top to gear housing. Pour 3-3/4 pints of S. A. E. 140 oil into hole and replace plugs. Plug (56) can be removed to check oil level.

t. Check the action of the clutch by shifting and freespooling the winch drum several times.

u. The shift pattern plate on top of the clutch housing is adjusted at the factory to provide reliable shifting of the clutch. If the plate should loosen or be removed, you must readjust the plate. Shift the handle to disengage the clutch and hold against the internal stop. With the latching pin in the "OUT" slots, push the shift pattern plate toward the cable drum. Unsnap plastic lever cover from pattern plate. Tighten the four capscrews which hold the plate to housing. Snap lever cover back into place around the pattern plate.

**6-9 WINCH DRIVE MOTOR**

6-9.1 Maintenance. The winch drive motor is the same type as water system hydraulic motor. Refer to paragraph 3-4 for maintenance procedures.

## CHAPTER 7

## HYDRAULIC PUMP/PTO ASSEMBLY

### 7-1 HYDRAULIC PUMP.

7-1.1 Recommended Test Procedure.

a. Be sure there is an adequate supply of oil for the pump, at least one gallon of oil for each gpm of pump capacity.

b. If one section of a tandem pump is being tested, make sure that all other sections not being tested are adequately supplied with oil. If any of the other sections run dry, or if plugs are left in ports, serious and permanent damage will result.

c. The oil should be a good quality hydraulic oil rated at 150 SSU at 100°F. , with the oil temperature held at 120°F. plus or minus 5°F. (Test procedures are described in detail in SAE handbooks; see Hydraulic Power Pump Test Procedure, SAE J745c. )

d. The feed line must be of adequate size with no more than 5" mercury vacuum adjacent to the pump inlet. As a rule, the feed line must provide a feed flow velocity not in excess of 8 feet per second.

e. Hot oil must not be fed into a cold pump. It may seize. Jogging may prevent seizure.

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

g. If pump becomes hot to touch, it is binding and may seize. This doesn't happen very often, but if it does, pump will have to be disassembled and rebuilt, with extra care taken to remove burrs and to assure freedom from binding.

h. Gradually increase pressure on pump, intermittently, until the desired test pressure has been reached. This should take about five minutes.

i. Delivery should run close to rated catalog performance figures which are averaged from testing several pumps. Something like a 5% lower reading may be used as a rated minimum if new or relatively new parts have been used. When rebuilding the pump with parts from the original pump, which, while worn, appear satisfactory for re-use, a 10% or 15% lower reading may be permitted, depending on the performance expected from the equipment. One's own experience will prove the best guide here.

j. Measure the output at normal operating speed and at zero pressure, then again at 1000 psi (or the operating pressure of the equipment) and allow a volume decrease approximating the listing below. It is suggested reference only which makes allowance for re-used parts.

**NOTE**

**Pumps are generally tested to 2000 psi maximum.**

| GPM DELIVERY at 1800 rpm 100 psi | GPM DROP OFF AT... | | | |
|---|---|---|---|---|
| | 1000 psi/70 bar | 1500 psi/105 bar | 2000 psi/140 bar | 2500 psi/175 bar |
| 5 -- 14 | 2 to 3 | 2½ to 3½ | 3 to 4 | 3½ to 4½ |
| 15 -- 25 | 2½ to 3½ | 3 to 4 | 3½ to 5 | 4 to 5½ |
| 26 -- 50 | 3 to 4 | 4 to 5 | 4 to 6 | 4½ to 6½ |

**NOTE**

**At test speeds other than 1800 rpm, gpm delivery will vary almost proportionately, but the same (drop-off) figures should be used.**

k. Be sure to run the pump in the direction for which it was designed and built. Driving pump in the wrong direction will build up pressure behind shaft seal, damaging it and necessitating replacement.

l. After completing testing procedures, pump is ready for installation and immediate duty operation on equipment. Again, it must be remembered that to prevent seizure, hot oil must not be fed into a cold pump.

7-1.2 Fabricated Tools.

a. Check Valve Tool. The check valve tool is made from a 4 inch length of 3/8 inch drill rod. Refer to figure 7-1 to fabricate this tool.

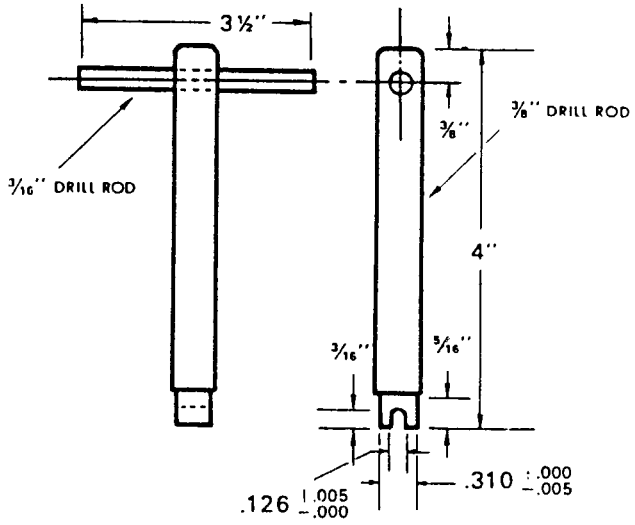



**Figure 7-1. Check Valve Tool**

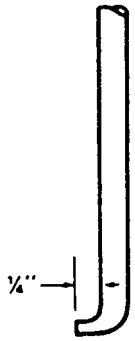



**Figure 7-2. Seal Removal Tool**

b. Seal Removal Tool. The seal removal tool can be easily made from an old screwdriver. Heat the tip and bend as shown in figure 7-2. Grind off the tip to fit the notch behind the shaft seal.

c. Special Steel Sleeve. The special steel sleeve is used to insert the driveshaft through the lip seal without damage and can be made from bar stock. Use a 1 1/4 inch diameter by 5-3/d inch bar. Refer to figure 7-3 for details to fabricate this tool.

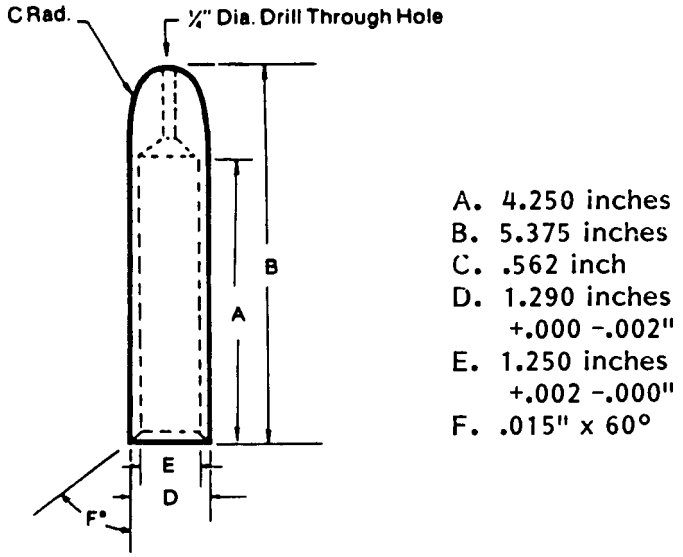



**Figure 7-3. Special Steel Sleeve**

**7-1.3 Disassembly. (Figure 7-4)**

**CAUTION**

**If prying off sections becomes necessary, take extreme care not to mar or damage machined surfaces. Excessive force while prying can result in misalignment and seriously damage parts.**

**If parts are stubborn during assembly, do not force them and never employ an iron hammer.**

**Gears are closely matched, therefore they must be kept together as sets when removed from a unit. Handle with care to avoid damage to the journals or teeth.**

**Never hammer roller bearings into bores. Use only an arbor press or other suitable tool.**

a. Mount the pump in a vise with the shaft end pointing down. Index mark all sections with a punch. Be sure to align these marks when reassembling.

b. Remove the 4 hex nuts (1), studs (2) and washers (3) with a socket wrench.

c. Lift off the port end cover (4). If necessary to pry loose, refer to caution.

d. If the thrust plate (5) remains in the gear housing (6), it can be tapped out later with a wooden hammer handle. Be careful not to distort the thrust plate.

e. Lift the gear housing (6) from the gears (7). Take care not to damage machined surfaces.

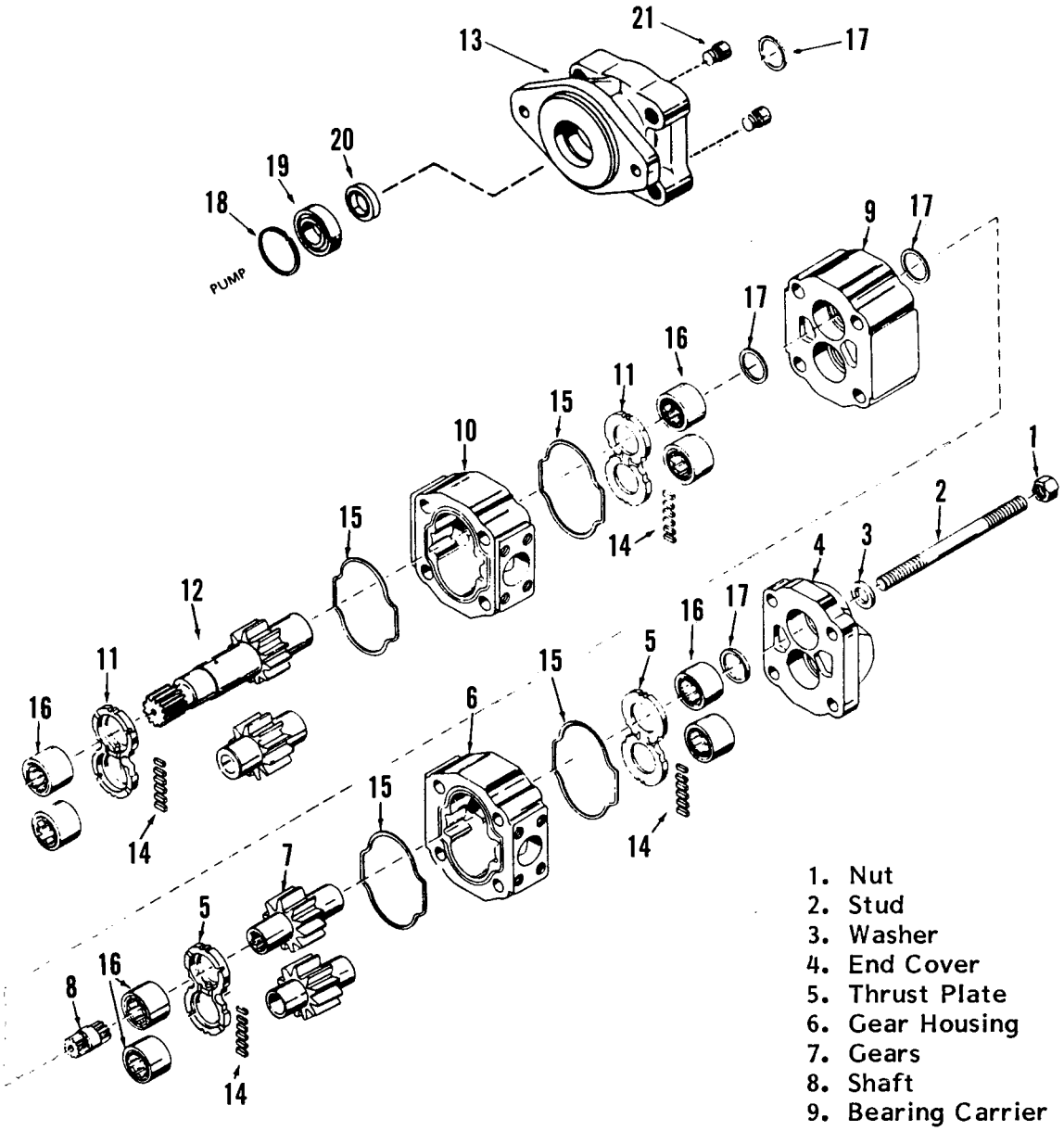
f. Carefully remove the drive and driven gears (7), not letting the teeth come into rough handling contact. Keep these gears together because they are a matched set. Examine and replace if necessary.

g. Remove the drive gear connecting shaft (8).

h. Lift or pry off the bearing carrier (9) carefully to prevent damage to contact face and edges.

i. Lift or pry off the first section gear housing (10). Be careful not to damage machined surfaces. If the thrust plate (11) remains in the gear housing, remove as described in step d.

j. Remove the integral gear and drive shaft set (12). Keep these together as they are a matched set. Examine and replace if necessary. Be careful not to damage the machined surfaces of the gears.




1. Nut
2. Stud
3. Washer
4. End Cover
5. Thrust Plate
6. Gear Housing
7. Gears
8. Shaft
9. Bearing Carrier
10. Gear Housing
11. Thrust Plate
12. Drive Shaft Set
13. End Cover
14. Seal
15. Seal
16. Bearing
17. Seal
18. Snap Ring
19. Bearing
20. Seal
21. Check Valve

**Figure 7-4. Hydraulic Pump**

k. Pry the thrust plates (5 or 11) from the shaft end cover (1 3), port end cover (4), or bearing carrier (9) with a screwdriver or similar tool. Avoid distorting the thrust plates. Visually inspect thrust plates for wear or damage. Replace if necessary. Remove and discard all rubber pocket seals (14) and gasket seals (15).

l. Examine all roller bearings (16) for scoring, spalling, or pitting. If replacement is necessary, remove the bearings with a bearing puller.

m. It is generally advisable to replace ring seals (17) when rebuilding unit. To replace, remove the drive gear bearing with a bearing puller and remove ring seal from the bottom of bearing bore.

n. Place the shaft end cover (13) in a vise with the mounting face up. Remove the bearing snap ring (18) with a small screwdriver or awl.

o. Use a bearing puller to remove the outboard bearing (19).

p. Grip the shaft end cover (13) in a vise with the mounting face down. Remove double lip seal (20) by inserting the special seal removal tool (see figure 7-2) into the notch between the double lip seal and the shaft end cover. Tap the seal out and discard.

**7-1.4 Inspection**

**7-1.4.1 Gear Housings (6 and 10).**

a. Wear in excess of .005" cut-out necessitates replacement of the gear housing.

b. Place a straight-edge across bore. If you can slip a .005" feeler gage under the straight-edge in the cut-out area, replace the gear housing.

c. Pressure pushes the gears against the housing on the low pressure side. As the hubs and bearings wear, the cut-out becomes more pronounced. Excessive cut-out in a short period of time indicates excessive pressure or oil contamination. If the relief valve settings are within prescribed limits, check for shock pressures or tampering. Withdraw oil sample and check it and tank for dirt.

d. Where cut-out is moderate, .005" or less, gear housing is in good condition, and both ports are of the same size, housing may be flopped over and reused.

**7-1.4.2 Gears (7 and 12).** Any wear on gear hubs detectable by touch, or in excess of .002" necessitates replacement. Scoring, grooving, or burring of outside diameter of teeth requires replacement. Nicking, grooving, or fretting of teeth surfaces also necessitates replacement.

**7-1.4.3 Drive Shafts (8 and 12).**

a. Replace if there is any wear detectable by touch in the seal areas or at the drive coupling. .002" wear is the maximum allowable.

b. Wear in the shaft seal areas indicates oil contamination. Wear or damage to splines, keys, or keyways necessitates replacement.

**7-1.4.4 Thrust Plates (5 and 11).**

a. The thrust plates seal the gear section at the sides of the gears. Wear here will allow internal slippage, that is, oil will bypass within the pump. .002" maximum wear is allowable. Replace thrust plates if they are scored, eroded, or pitted.

b. Check center of thrust plates where the gears mesh. Erosion here indicates oil contamination.

c. Pitted thrust plates indicate cavitation or oil aeration.

d. Discolored thrust plates indicate overheating, probably insufficient oi.

**7-1.4.5 Bearings (16).** If gears are replaced, bearings must be replaced. Bearings should fit into bore with a light press fit. A neat hand fit is allowable. If bearings can fall out, bore may be oversize.

**7-1.4.6 Seals and Gaskets**. Replace all rubber and polymer seals whenever disassembling pump. Include all "O" rings (17), pocket seals (14) behind thrust plates, shaft seal (20), and gasket seals (15).

**7-1.5 Assembly.**

a. Stone off all machined surfaces with a medium grit carborundum stone.

b. If bearings (16) have been removed, deburr bearing bores. Rinse parts in a solvent. Air blast all parts and wipe with a clean lintless cloth before starting assembly.

c. Grip shaft end cover (13) in vise with mounting face down. Examine plug or 2 check valves (21) to be sure they're tightly in place. Replacement is necessary only if parts are damaged. Remove with screwdriver or special check valve tool (see figure 7-1).

d. If plug or check valves (21) are being replaced, screw in new parts tightly. Stake plug with prick punch at both ends of screwdriver slot and around edges. Screw check valves in tightly with tool. Peen edge of hole 1/32" to 1/16" with 14" diameter steel ball.

e. If ring seals (17) are being replaced insert into bottom of drive gear bearing bore. The notch in the ring seal MUST BE VISIBLE. This is a check to be certain the notched side is next to the bearing.

f. If any bearings (16) have been removed from the shaft end cover (13), port end cover (4), or bearing carrier (9), replace the bearings by pressing them into the bearing bore with an arbor press.

g. Before inserting a new lip seal (20) in the shaft end cover (13), coat the outer edge of the lip seal and its recess with Permatex Aviation Form-A-Gasket No. 3 Non-hardening Sealant or equivalent. With the metal side of the lip seal up, press it into the mounting flange side of the shaft end cover with an arbor press

and bar (see figure 7-3). Do not attempt to bottom-out seal, press in only until it is flush with the face of the recess. Wipe off surplus sealant.

h. Grip the shaft end cover (13) in a vise with the mounting face down. Cut 2 pocket seals (14) 7/32" long from the pocket seal strip. Grease these pocket seals well and insert them into the middle slots on the reverse side of the thrust plate (11).

i. With the pocket seals (14) facing down, place the thrust plate (11) over the bearings (16) in the shaft end cover (13). Tap thrust plate with a soft hammer to about 1/32" from the machined surface.

j. Cut 4 pocket seals (14) approximately 1/4" long from the pocket seal strip. Insert one pocket seal into each of the slots in the thrust plate (11). Push each pocket seal all the way in so that it touches the roller bearings. Tap the thrust plate down firmly against the machined surface with a soft hammer. Use a sharp razor blade to trim exposed end of the pocket seal square and flush with the thrust plate.

k. Insert the splined end of the drive shaft (12) into the special steel sleeve (see figure 7-3). Lightly grease the drive shaft and sleeve. Insert the integral gear and drive shaft (12) with sleeve into the shaft end cover (13) with a twisting motion. Be careful not to damage the double lip seal (20). Push down carefully until the gear rests against the thrust plate. Remove the steel sleeve. Insert the driven gear.

l. Grease the new gasket seals (15) and insert them into the grooves in both sides of all gear housings (6 and 10).

m. Slide the first section gear housing (10) over the gears and tap it with a soft hammer until it rests lightly against the shaft end cover (13). Be careful not to pinch the gasket seal (15). Squirt oil over the gears to provide initial lubrication when pump is started.

n. With the thrust plates (5 and 11) mounted on the bearing carrier (9) (as in steps h, i, and j), position it on the gear housing (10) so that the roller bearings receive the journals of the drive and driven gears (12). Make sure that the drain port in the bearing carrier is on the suction or inlet side. Make sure that the index marks are properly aligned.

o. Insert the connecting shaft (8) in the spline of the drive gear (7).

p. Insert the drive and driven gears (7) of the second section in their respective bearings. Make certain gears are in contact with thrust plate face.

q. Slide the second section gear housing (6) over the gears and tap it tight against the bearing carrier (9) with a soft hammer. Be careful not to pinch the gasket seal (15). Squirt oil over the gears to provide initial lubrication when pump is started.

r. Place the port end cover (4) over the gear journals and tap lightly against the gear housing (6). Be careful not to pinch the gasket seal (15).

s. Thread the studs (2), washers (3) and nuts (4) into the shaft end cover (13) and tighten alternately or cross-corner. Rotate the drive shaft with a 6" wrench to make certain there is not binding in the pump.

t. Guide the outboard bearing (19) into its recess in the shaft end cover (13). This is not a press fit. Insert the snap ring (18) into its groove to retain the outboard bearing.

u. After the fasteners are tight and you are sure there is no internal binding, torque the diagonally opposite nuts (1) to 200 ft. lbs. (2400 in. lbs.).

**7-2 POWER TAKE-OFF.**

7-2.1 Refer to Volume 1, Chapter 4, paragraph 4-19.3 for maintenance of the power take-off.

## CHAPTER 8

## FUEL TRANSFER

**8-1 FUEL PUMP**. (Figure 8-1)

**NOTE**

**These instructions cover service of the pump while installed. For easier handling, we recommend removing the pump from the tank and using a vise to hold it whenever it is possible.**

8-1.1 Replacement of Rotor, Vanes or Shaft Seal.

a. To prevent vanes from dropping thru inlet port, loosen pump cover screws (14). Hand hold pump cover (15) firmly against pump housing (4) and remove loosened screws.

b. Slide pump cover aside partially exposing rotor (18) and transfer holding action from pump cover to rotor.

c. Keep vanes (19) and rotor pressed fully in pump cavity while turning rotor to remove vanes. Remove vanes one at a time at 2 O'clock position.

d. Remove key (17) and rotor.

e. Replace in reverse order. Make sure outer edge of vanes slope away from direction of rotor rotation (counterclockwise).

f. With rotor removed, the 6 piece shaft seal (20-25) can be picked out with needlenose pliers. Replace in sequence shown in exploded view, figure 8-1.

8-1.2 Check Valve, Bypass, Strainer Service or Replacement.

a. For easier handling, remove hose (64) and nozzle (63).

b. Remove four screws (14) beneath housing (4) and lift pump housing (4) off; freeing bypass (12) and spring (13). Check valve assembly (11) and strainer (9) can be withdrawn from inlet cavity of base adapter (8) for cleaning or replacement.

c. To reassemble, insert screen into inlet cavity followed by "O" ring (10) and check valve assembly (11).

d. Lay gasket (3) on base (8) oriented so shape of gasket matches pump housing and aligned to match screw holes. Place bypass spring (13) in recess in base and stack bypass (12) on top of spring (13) with closed end up.

e. Thread bypass and spring into bypass cavity of pump housing during assembly of housing to base.

f. If base (8) has been removed from tank, assemble by holding pump in vise upside down; insert bypass (closed end first) into cavity in pump housing; stack spring on bypass; use a small quantity of grease on check valve to hold it in position during assembly of base to housing.

g. Hold base down against pump housing, align gasket with screw holes and replace screws (14).

**8-2 FUEL TRANSFER MOTOR** (Figure 8-1)

8-2.1 Motor Protector and Line Switch.

a. To check continuity or replace motor protector (41) or line switch (44), disconnect power at battery and junction box. Remove cover assembly (51) exposing both parts.

b. If continuity is not present across both terminals of motor protector, the motor has overheated in which case it will feel hot, or the contacts are not in their normally-closed position, and the motor protector should be replaced.

c. To replace protector, loosen screw (43), move retaining clip (42) out of the way, withdraw protector and pull wires from terminals. When reconnecting wires to new protector, connect black wire from upper brush assembly (28) to top protector terminal and while wire from line switch terminal B to bottom protector terminal. (See wiring diagram). Insert protector in housing (38) and tighten in place with clip (42).

d. To check continuity or replace line switch (44), remove keps nuts (47) and pull out switch; wires attached to terminals are of sufficient length to permit withdrawal far enough to expose back of switch. Check switch for continuity in "on" and "off" position; with switch "on", continuity should be established between terminals A & B, C & D. If continuity exists with switch "off" or does not with switch "on", the switch should be replaced.

e. To replace switch, pull wires from terminals, note orientation of switch to switch plate, remove locknut (46) and install new switch on plate. Reconnect wires to terminals. Reattach switch and plate assembly to protector housing (38).

f. Reinstall switch cover assembly, making sure slot in yoke (53) fits over toggle switch stem.

8-2.2 Brush Replacement.

a. To replace bushes, remove pump cover (15), rotor (18), vanes (19) and seal (20-25). Remove switch cover (51) and pull black wires from top terminal of motor protector (41) and terminal D of motor switch. Remove tie rods (35), motor end cover (34) and magnet barrel (32). Armature (31) should come off with magnet barrel. Remove brush holder (26) and replace brushes. Not position of springs (27) before removing to insure proper reassembly.

b. Reassemble in reverse order; make sure locating slot in magnet barrel is aligned with locating pin (36) before pressing magnet barrel into pump housing (4); connect

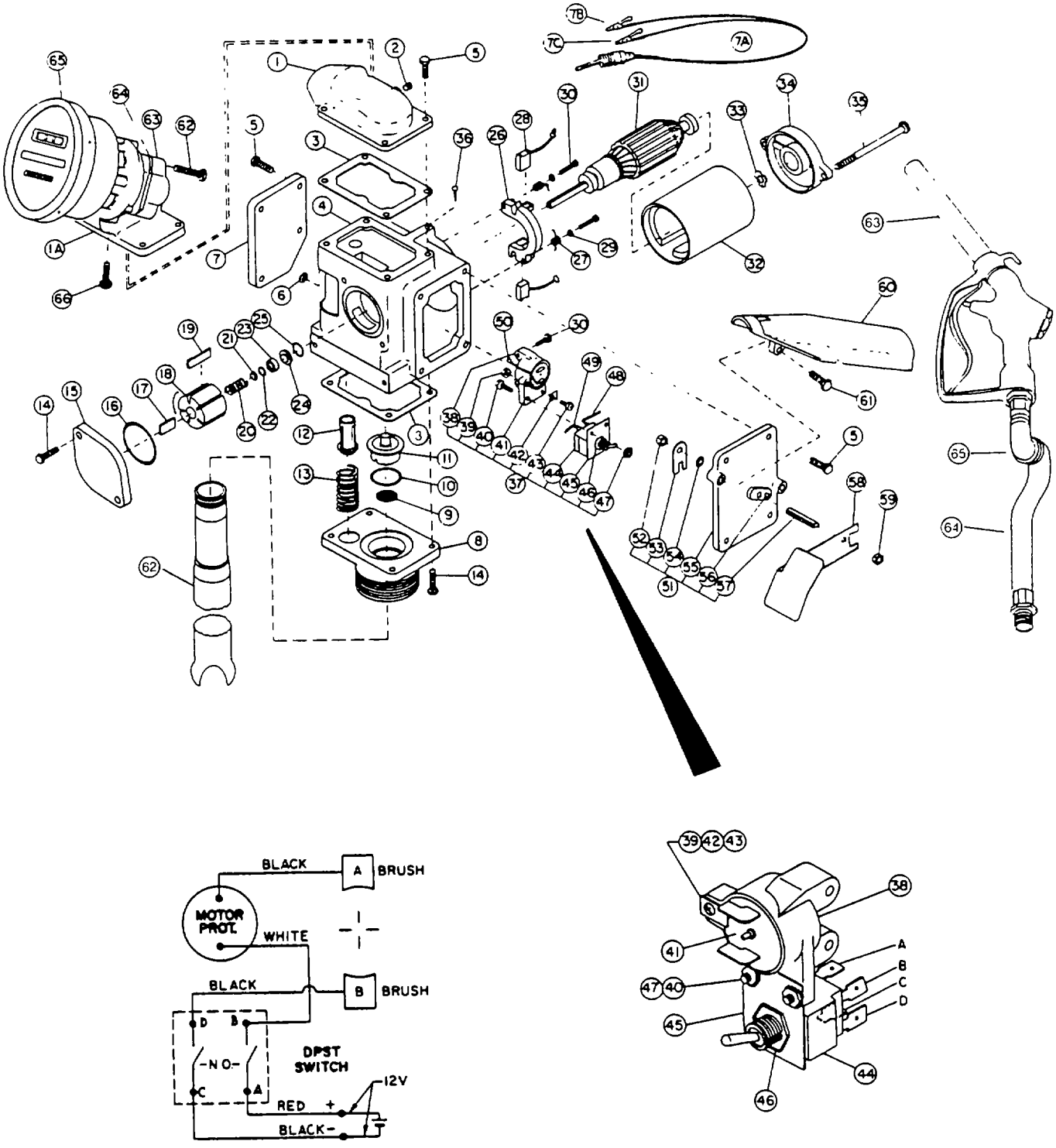



**Figure 8-1. Fuel Transfer Pump and Motor**

top brush to top terminal of motor protector and bottom brush to terminal D of switch.

c. Removal of armature and magnet barrel is covered in paragraph above. To remove armature from magnet barrel, apply a firm steady pressure against shaft while holding magnet barrel to overcome the magnetic attraction of these two parts to remain assembled.

Legend for Figure 8-1

1. Top Cover
1A. Adapter
2. Pipe Plug
3. Gasket
4. Pump Housing
5. Machine Screw
6. Wire Stop
7. Junction Box Cover
7A. Power Cord Assembly
7B. Alligator Clip-Red
7C. Alligator Clip-Black
8. Base Adapter
9. Strainer
10. O-Ring
11. Check Valve Assembly
12. Bypass Valve
13. Bypass Spring
14. Machine Screw
15. Pump Cover
16. O-Ring
17. Key
18. Rotor
19. Vane
Seal Group (incl. items 20-25).
20. Spring
21. Washer
22. O-Ring
23. Rotating Seal Ring
24. Seal Ring
25. O-Ring
26. Brush Holder
27. Brush Spring
28. Brush Assembly
29. Fiber Washer
30. Machine Screw
31. Armature Assembly
32. Magnet Barrel Assembly
33. Bearing Spring
34. End Cover
35. Tie Rod
36. Locating Pin
37. Motor Protector & Switch Assembly
(inc. Items 38-50)
38. Housing -- Motor Protector
39. Nut
40. Machine Screw
41. Motor Protector
42. Retaining Clip
43. Screw
44. Switch (DPST)
45. Switch Plate
46. Lock Nut
47. Keps Nut
48. Wire Assembly
49. Wire Assembly
50. Wire Assembly
51. Switch Cover Assembly
(Incl. items 52-57)
52. Nylok Nut
53. Yoke
54. Spring Washer
55. Switch Cover
56. Switch Actuator Stop
57. Switch Shaft
58. Actuator
59. Nylok Nut
60. Nozzle Boot
61. Machine Screw
62. Telescopic Suction
63. Nozzle w/Hook
64. Hose
65. Swivel

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# The Metric System and Equivalents

### *Linear Measure*

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

### *Weights*

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 dekagram = 10 grams = .35 ounce
1 hectogram = 10 dekagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

### *Liquid Measure*

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons

### *Square Measure*

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

### *Cubic Measure*

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

# Approximate Conversion Factors

| *To change* | *To* | *Multiply by* | *To change* | *To* | *Multiply by* |
|---|---|---|---|---|---|
| inches | centimeters | 2.540 | ounce-inches | newton-meters | .007062 |
| feet | meters | .305 | centimeters | inches | .394 |
| yards | meters | .914 | meters | feet | 3.280 |
| miles | kilometers | 1.609 | meters | yards | 1.094 |
| square inches | square centimeters | 6.451 | kilometers | miles | .621 |
| square feet | square meters | .093 | square centimeters | square inches | .155 |
| square yards | square meters | .836 | square meters | square feet | 10.764 |
| square miles | square kilometers | 2.590 | square meters | square yards | 1.196 |
| acres | square hectometers | .405 | square kilometers | square miles | .386 |
| cubic feet | cubic meters | .028 | square hectometers | acres | 2.471 |
| cubic yards | cubic meters | .765 | cubic meters | cubic feet | 35.315 |
| fluid ounces | milliliters | 29,573 | cubic meters | cubic yards | 1.308 |
| pints | liters | .473 | milliliters | fluid ounces | .034 |
| quarts | liters | .946 | liters | pints | 2.113 |
| gallons | liters | 3.785 | liters | quarts | 1.057 |
| ounces | grams | 28.349 | liters | gallons | .264 |
| pounds | kilograms | .454 | grams | ounces | .035 |
| short tons | metric tons | .907 | kilograms | pounds | 2.205 |
| pound-feet | newton-meters | 1.356 | metric tons | short tons | 1.102 |
| pound-inches | newton-meters | .11296 | | | |

# Temperature (Exact)

| | | | | |
|---|---|---|---|---|
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |

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