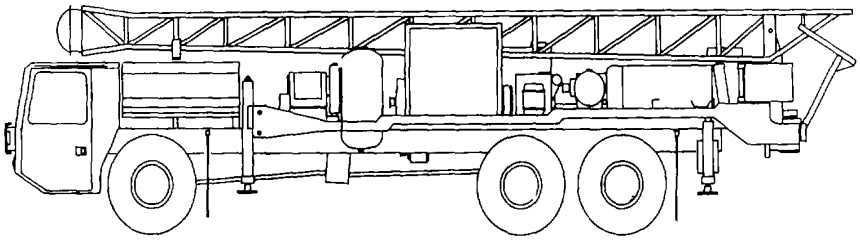
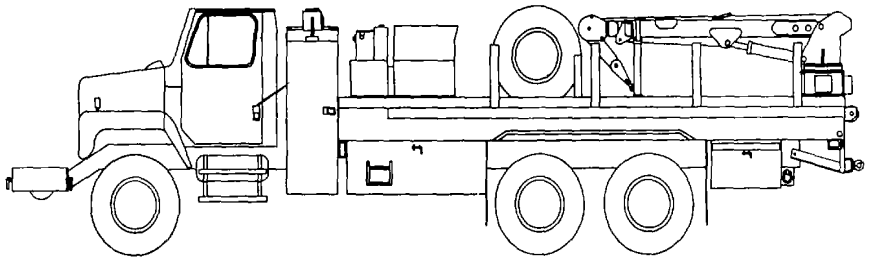
OPERATOR'S MANUAL





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

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NO. 6

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Operator's Manual

**DRILLING SYSTEM, WELL, ROTARY,
TRUCK MOUNTED, AIR TRANSPORTABLE,
600 FEET CAPACITY
Model Number 165F299
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600 FEET CAPACITY
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600 FEET CAPACITY
MODEL NUMBER 165F299
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TRUCK MOUNTED, AIR TRANSPORTABLE,
600 FEET CAPACITY
MODEL NUMBER 165F299
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Operators Manual

**DRILLING SYSTEM, WELL, ROTARY,
TRUCK MOUNTED, AIR TRANSPORTABLE,
600 FEET CAPACITY
Model Number 165F299
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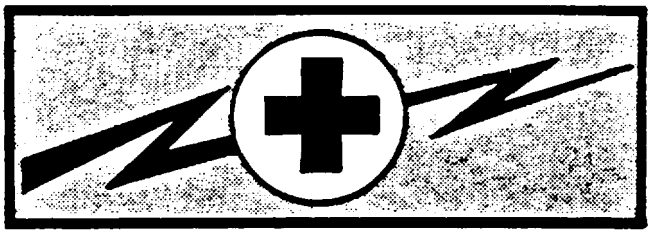

MI 131637

ELECTRIC POWER LINES CAN KILL

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

WARNING

Improper use can result in serious bodily injury or death.

Never leave the operator's station while any part of the unit is operating.

Never raise mast or operate machine when working clearance to electrical power lines is less than 25 feet.

Check for buried utility lines before drilling.

Keep away from moving parts.

Do not allow mast to stay in any position except full up with mast locks closed or completely lowered.

Noise hazard exists 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.

BEFORE STARTING

Make sure you know the manual completely before you operate this machine.

Make sure all controls are in neutral, all people are away from moving parts, all guards are in place and secured, and all hose safety chains are fastened.

WHEN OPERATING

Keep clothing and body parts away from moving parts

Do not perform any maintenance, adjustments or lubrication with engine running.

Make sure mud, air and hydraulic pressures stated in manual are not exceeded.

LOWERING MAST

Do not use controls as hand grip or steps.

Check that mast locks are open and kelly is out of rotary table.

Bleed air from mast raising cylinder before lowering mast.

For Artificial Respiration Refer to FM 21-11.

WARNING

The orifice of a fabricated nozzle may not be smaller than 3/4 in and the truck engine may not be operated above 1000 rpm while performing cleaning operations.

TECHNICAL MANUAL

NO. 5-3820-256-10

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 15 March 1989

Operator's Manual
DRILLING SYSTEM, WELL, ROTARY, TRUCK MOUNTED, AIR TRANSPORTABLE, 600 FEET CAPACITY MODEL NUMBER 165F299 NSN 3820-01-246-4276

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes, or if you know of a way to improve these procedures, please let us know. Mail your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual directly to: Commander, US Army Aviation and Troop Command, ATTN: AMSAT-I-MP, 4300 Goodfellow Blvd., St. Louis, MO 63120-1798. You may also submit your recommended changes by E-mail directly to <mpmt%avma28@st-louis-emh7.army.mil>. A reply will be furnished directly to you. Instructions for sending an electronic 2028 may be found at the back of this manual immediately preceding the hard copy 2028.

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CHAPTER 1
INTRODUCTION

Section I. GENERAL INFORMATION

1-1. Scope. This manual contains instructions for operating and servicing the Drilling System, Well, Rotary, Truck-Mounted, Air-Transportable, 600-Feet Capacity (drilling system). The drilling system includes two primary units: a drilling rig, and a support vehicle commonly referred to as a rig tender.

1-2. Maintenance Forms and Records. Department of the Army forms and procedures used for equipment maintenance will be those prescribed by DA PAM 738-750, The Army Maintenance Management System (TAMMS).

1-3. Hand Receipt (-HR) Manuals. This manual has no hand receipt manual.

1-4. Reporting Equipment Improvement Recommendations (EIR's). If your drilling system needs improvement, let us know by sending us an EIR. You, the user can give us valuable information about the equipment's deficiencies. Let us know why you dislike the design or performance. Fill out an SF 368 (Quality Deficiency Report) and mail it to us at AMSAT-I-MP, 4300 Goodfellow Blvd., St. Louis, MO 63120-1798. We'll send you a reply.

1-5. Warranty Information. The Drilling rig is warranted by Geo. E. Failing Co., and the rig tender is warranted by Flatwater Fleet, Inc., for 2 years from the date found in block 23, DA Form 2408-9, in the log book. Report all defects in material or workmanship to your supervisor, who will take appropriate action through your organizational maintenance shop.

1-6. Destruction of Army Material to Prevent Enemy Use. Refer to TM 750-244-3, Procedures for Destruction of Equipment to Prevent Enemy Use, for information about destruction.

Section II. EQUIPMENT DESCRIPTION

1-7. Drilling Rig Equipment Characteristics, Capabilities, and Features. The drilling rig is an air-transportable vehicle. It is capable of drilling a water well to 600 feet depth; it supports both air and mud drilling methods. The drilling rig requires a three-man crew. It is designed for use in all types of environmental conditions. Figure 1-1 shows the rig's lifting and tie-down points.

a. Major Components Features and Capabilities.
   (1) Mast.
      (a) Mud and air discharge piping.
      (b) Hydraulic mast raising cylinders.
      (c) Mast lighting.
      (d) Chain pulldown assembly.
      (e) Chain feed sprocket assembly.
      (f) Crown block assembly.
   (2) Mud Pump System.
      (a) Mud pump drive.
      (b) Air clutch.
      (c) Powerend.
      (d) Fluid end.
   (3) Air Compressor System.
      (a) Air compressor.
      (b) Air/oil separator.
      (c) Oil cooler.
      (d) Air cleaner.
      (e) Air clutch.
   (4) Sub-Drive Assembly.
      (a) Mud pump driveshaft.
      (b) Power take-off.
      (c) Drawworks driveshaft.
      (d) Hydraulic pumps.
   (5) Drawworks.
      (a) Hoist drum.
      (b) Auxiliary drum.
      (c) Third drum.
      (d) Bevel gear box.
      (e) Band-type brakes.
      (f) Air clutch.
   (6) Hydraulic System.
      (a) 3-micron oil filter.
      (b) 40-gal oil reservoir.
      (c) Control valves.
   (7) Water/Foam Injection System.
      (a) Hydraulic motor.
      (b) Water pump.

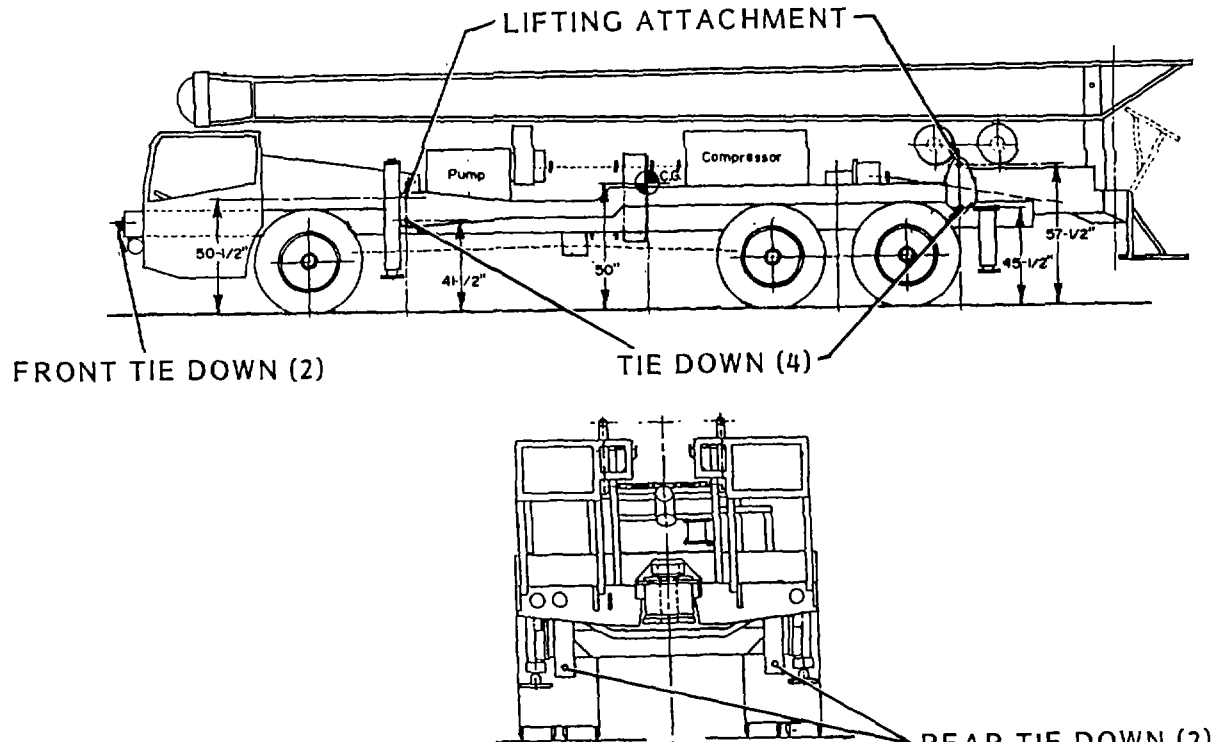


Figure 1-1. Drilling Rig Lifting and Tie-Down Point

(8) Force-Feed Lubricator.
  (a) Electric motor driven pump.
  (b) Reservoir.
(9) Break-Out Assembly.
  (a) Break-out wrench.
  (b) Break-out tongs.
  (c) Hydraulic break-out cylinder.
(10) Rotary Table and Drive.
  (a) Transfer cylinders.
  (b) Hydrostatic transmission.
  (c) Hydraulic motor.
  (d) Rotary table.
(11) Pulldown Drive System.
  (a) Chain feed drive.
  (b) Hydraulic motor.
  (c) Pulldown transmission.
(12) Operator's Instrument Cluster.
  (a) Air control valves.
  (b) Air line conditioner.
  (c) Gages and meters.

(13) Frame Components.
  (a) Frame lighting.
  (b) Operator's and helper's platform.
  (c) Front and rear hydraulic leveling jacks.
(14) Truck.
  (a) Rear axle or front and rear axle drive.
  (b) Air brakes.
  (c) 6-cylinder diesel engine.
  (d) Turbocharger.
  (e) Five-speed transmission.
  (f) Two-speed transfer case.
  (g) Power steering.

b. Location and Description of Major Components.

(1) Mast (1, Figure 1-2). The mast is mounted to mast pivot brackets at the rear of the drilling rig. Hydraulic cylinders raise and lower the mast to upright or transport positions. The mast's height (32') permits the use of 20' drill pipe or'20' lengths of casing. The mast is equipped with a chain feed, hydraulic-motor powered pulldown system for applying drilling pressure on the bit. A lighting system allows use of the drilling system at night.

(2) Mud Pump (2, Figure 1-2). The mud pump provides circulation of drilling fluid during drilling operations. It is a duplex, double-acting, piston-type pump with removable, hardened-steel cylinder liners. The pump is driveshaft driven from the sub-drive, by way of an air-clutch operated mud pump drive unit.

(3) Air Compressor (3, Figure 1-2). The air compressor provides air for air rotary drilling; it can also be used to supply air for drilling large diameter holes using the foam method. The compressor is powered from the sub-drive through an air clutch.

(4) Sub-Drive (4, Figure 1-2). The sub-drive assembly is a power transfer unit that receives power from the truck's power take-off. One side of the subdrive delivers power to drive the drawworks and the air compressor; the other side delivers power to drive the mud pump and the four hydraulic pumps used to deliver hydrostatic power to other rig systems.

(5) Drawworks (5, Figure 1-2). The drawworks consists of three cable drums used for lifting drilling components at the drilling site. The hoist drum supports the swivel, kelly, drill pipe, drill collars, and bits-elements that make up the "drill string." The auxiliary drum is used to handle drill pipe when adding joints of drill pipe to the drill string. These two drums have a relatively short length of cable, typically long enough for raising and lowering items the height of the mast. The third drum has much more cable, of smaller diameter, and is used to lower tools and instruments to the bottom of the hole. The drawworks is drive-shaft driven from the sub-drive, through a bevel gear box. Each drum is independently operated by an air clutch.

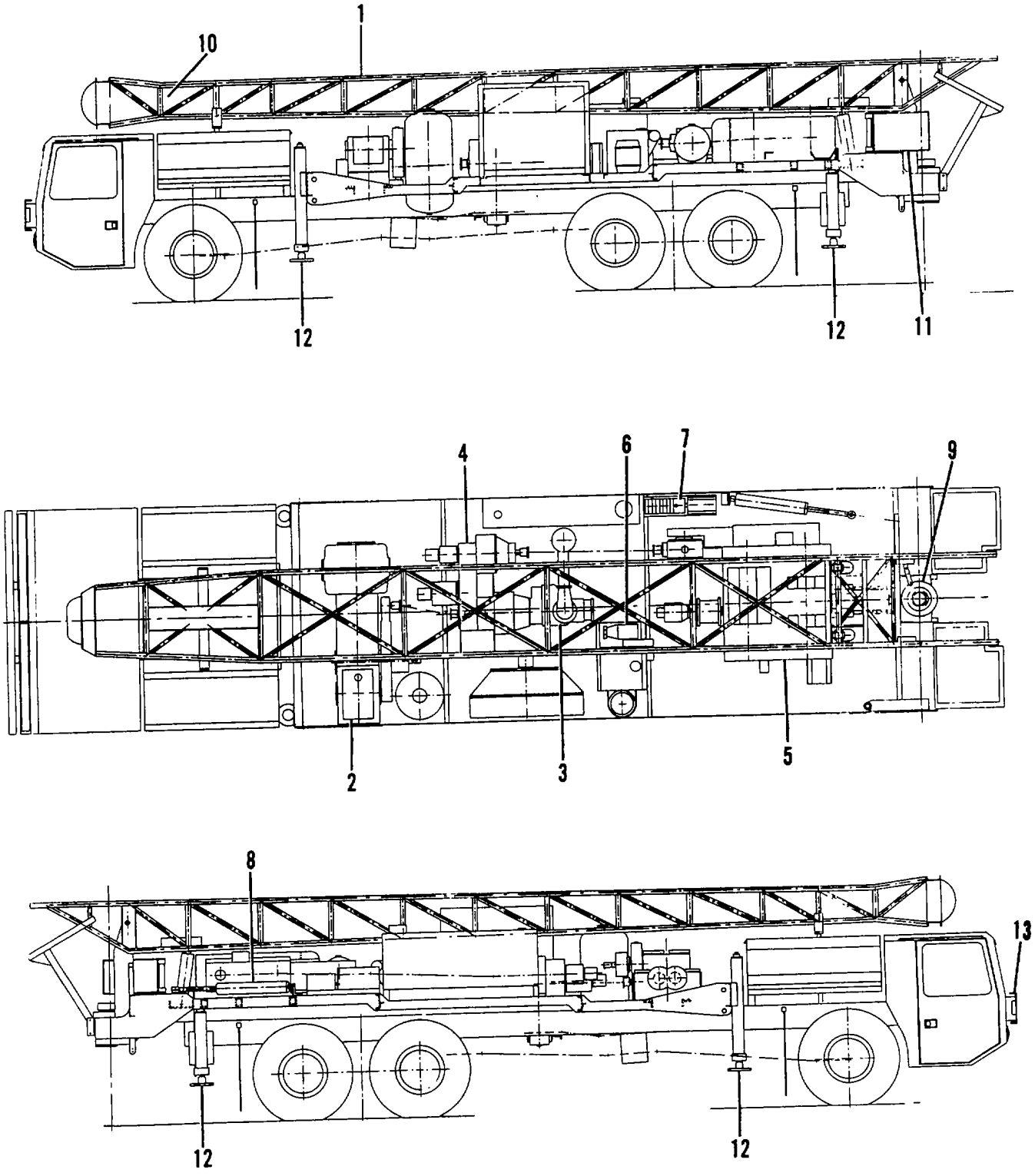


Figure 1-2. Drilling Rig Major Components

(6) Water/Foam Injection Pump (6, Figure 1-2). This pump system injects water and foam into the drilling system discharge line during certain drilling operations. It includes a high-pressure piston pump powered by a variable-speed hydraulic motor. Foam concentrates are injected into the water discharge line by a pulse pump, at a controlled rate.

(7) Force Feed Lubrication System (7, Figure 1-2). This system provides lubrication into the air discharge line to lubricate down-the-hole drilling tools. It includes a force feed pumping mechanism; it has two feeds and one check valve.

(8) Break-out Tool Assembly (8, Figure 1-2). This device consists of a wrench and a hydraulic cylinder. It provides a mechanical leverage to separate the drill pipe connections when the drill string is being removed from the hole.

(9) Rotary Drive and Rotary Table (9, Figure 1-2). The rotary table is driven by a hydraulic motor, through a 4-speed transmission and a drive shaft. These components work together to provide the rotating motion that is then transferred to the drill pipe, and therefore, to the drill bit.

(10) Pulldown and Chain Feed (10, Figure 1-2). This system, most of which is mounted on the mast, includes a hydraulic motor and a 2-speed transmission. Power from the motor/transmission is transferred to shaft sprockets, and then to the chain which spans the length of the mast. The chains connect to a yoke that is attached to the rotary swivel. When power is applied to the chains, pressure is transferred to the yoke, swivel, drill pipe, and subsequently, to the drill bit.

(11) Instruments (11, Figure 1-2). The controls needed to perform most of the drilling operations are located at the left rear corner of the drilling rig. Gages and indicators provide sight readings of the various conditions of components of the drilling rig. Some indicators and controls are located at other remote points around the drilling rig.

(12) Hydraulic Jacks (12, Figure 1-2). Four hydraulic cylinders and jack baseplates are mounted to the drill frame at each of the rig's four corners. Each cylinder is controlled, independent of the others, by hydraulic actuators on the operator's control panel. The removable baseplates include security chains. Ample blocking is provided to ensure rig stability in sandy locations.

(13) Winch Assembly (13, Figure 1-2). A hydraulically driven, 20, 000 pound capacity winch is mounted on the front bumper of the drilling rig truck. It is operated from inside the truck cab by an air-shift control. Normally, the winch is used for non-drilling related operations, such as pulling the drilling rig, or other vehicles, from difficult-terrain situations.

c. Equipment Data.

(1) Mast.

DIMENSIONS:	
Working height above drill frame	32 ft (9.75 m)
CAPACITY:	
Maximum static hook load for 2 lines to traveling block deadlined at crown	30, 000 lb. (13, 608 kg)
Gross capacity	45, 000 lb. (20, 412 kg)

(2) Mud Pump.

DESIGN	Reciprocating Piston
NUMBER OF PISTONS	Two
DIMENSIONS	
Nominal suction pipe size	4 in (102 mm)
Nominal discharge pipe size	2 in (51 mm)
PERFORMANCE	
Displacement (nominal)	156 gpm (590 1/min)
Maximum discharge pressure	310 psi (21 bar)
INPUT POWER	
Mud pump drive	Driveshaft from sub-drive
Mud pump	Jackshaft from mud pump drive
LUBRICANT CAPACITIES	
Pump drive case	12 gal (45 1)
Pump drive end	12 qt (11.3 1)

(3) Air Compressor.

DESIGN	Rotary Screw
NUMBER OF STAGES	One
PERFORMANCE	
Rated capacity	350 cfm (10 cu m/min)
Normal operating pressure	200 psig (14 bar)
Maximum discharge pressure	215 psig (15 bar)
Operating speed	2100 rpm
INPUT POWER	
Compressor	Clutch driven from sub-drive
Oil cooler fan	Hydraulic motor via hydraulic pump on sub-drive

(Air Compressor continued)

LUBRICANT CAPACITIES

Air/oil separator	4 gal (15 1)
Total	5 gal (19 1)

OPERATING TEMPERATURES

Maximum ambient temp.	125 deg F (52 deg C)
Air/oil discharge temp.	200 deg F (93 deg C)
Oil injection temp.	160 deg F (71 deg C)

(4) Sub-Drive Assembly.

PERFORMANCE

Input shaft speed from truck power take-off	2100 rpm
Output speed to air compressor clutch	2100 rpm
Output shaft speed to drawworks bevel gear box	2100 rpm
Output shaft speed to mud pump drive	2100 rpm
Hydraulic pump output:	
Pump (165F103) to rotary table motor piping:	
Displacement per revolution	3.15 cu in (51.6 cc)
Maximum pressure	5000 psi (345 bar)
Pump (165F104) to mast cylinder/pulldown piping:	
Nominal flow per 1000 rpm	5 gpm (19.2 1/min)
Maximum pressure	3025 psi (210 bar)
Pump (165F105) to oil cooler motor piping:	
Displacement per revolution	2.30 cu in (38 cc)
Maximum pressure	2100 psi (145 bar)
Pump (165F105) to rotary table cylinders, breakout wrench, water and foam injection pump motor and hydraulic jacks:	
Displacement per revolution	2.30 cu in (38 cc)
Maximum pressure	2100 psi (145 bar)

INPUT POWER

Roller chain drive sprocket	Drive shaft from truck PTO

CAPACITY

Lubricant in sub-drive case	14 qt (13 1)

(5) Drawworks.

PERFORMANCE

Hoisting drum line pull	15, 000 lb. (6804 kg)
Auxiliary drum line pull	15, 000 lb. (6804 kg)

INPUT POWER

Bevel gear case	Driveshaft from sub-drive
Third drum assembly	Sprocket and roller chain from gear case assembly.
Hoist and auxiliary drum assembly	Sprocket and roller chain from third drum assembly.

CAPACITY

Lubricant in bevel gear box	3 qt (2.8 1)

(6) Water and Foam Injection.

TYPE

Water pump design	Reciprocating Piston
Number of water pump pistons	Three
Foam injection pulse pump	Water pressure actuated internal diaphragm

DIMENSIONS

Water pump inlet ports	1-in npt
Water pump outlet ports	3/4-in npt
Foam injection pulse pump:	
Chemical inlet port	1/4-in npt
Discharge port	1/4-in npt
Water manifold port	1/2-in npt
Motor pulley O. D.	5-1/4 in (133.3 mm)
Water pump pulley O. D.	5-1/4 in (133.3 mm)
Drive belt O. D.	42 in (1066.8 mm)

PERFORMANCE

Water pump:	
Discharge volume 12 gpm (45 1/min)	
Discharge pressure (max.)	700 psi (48 bar)
Rated speed 750 rpm	
Foam injection pulse pump	
Normal discharge volume	1 qt/m (1 1/min)
Operating pressure 1000 psi (70 bar)	
Water pump hydraulic motor	
Normal hydraulic pressure	2500 psi (173 bar)
Operating speed (rated) 750 rpm	

INPUT POWER

Water pump hydraulic motor	Hydraulic pump on sub-drive
Water pump V-belt from hydraulic motor	
Foam injection pulse pump	Pressure from water pump

(Water and Foam Injection continued)

CAPACITY

Water tank	25 gal (94.6 1)
Foam chemical container	5 gal (19 1)
Lubricant in water pump crankcase	1.25 qt (1.18 1)

(7) Force Feed Lubricator.

TYPE

Design	Cam-operated pistons
Number of pistons	Two
Drive type	Electric motor

DIMENSIONS

Piston diameter 3/8-in (9.5 mm)

PERFORMANCE

Min strokes per minute	3
Max strokes per minute	50
Min output volume per stroke	0.008 cu in (0.131 cu cm)
Max output volume per stroke	0.055 cu in (0.901 cu cm)
Maximum pressure	2500 psi (173 bar)

INPUT POWER

Electric motor 12 vdc

CAPACITY

Lubricant in reservoir	6 qt (5.7 1)

(8) Break-out Assembly.

DIMENSIONS

Hydraulic cylinder stroke	20 in (508 mm)
Wire rope size	1/2-in (12.7 mm)
Nominal pipe wrench size	36 in (914 mm)
Maximum wrench jaw opening	4.5 in (114.3 mm)

PERFORMANCE

Maximum hydraulic cylinder working pressure	2500 psi (173 bar)
Maximum pipe wrench torque	16 ft lb.

INPUT POWER

Break-out Cylinder	Hydraulic pump on sub-drive

(9) Rotary Table.

DIMENSIONS

Quill inside diameter	5.3125 in (134.93 mm)
Transfer cylinder stroke	15.25 in (387.35 mm)

PERFORMANCE

Hyd. motor operating pressure	5000 psi (345 bar)
Hyd. motor operating speed	2900 rpm
Transmission output speed	
1st gear	462 rpm
2nd gear	929 rpm
3rd gear	1657 rpm
4th gear	2900 rpm
Quill speed with xmsn in:	
1st gear	70 rpm
2nd gear	140 rpm
3rd gear	250 rpm
4th gear	435 rpm

INPUT POWER

Rotary table hydraulic motor	Hydraulic pump on sub-drive
Rotary table transmission	Hydraulic motor shaft
Rotary table Drive shaft from transmission	

LUBRICANT CAPACITY

Rotary table transmission	3 qt (2.84 1)
Rotary table housing	5-1/2 lb. (2500 g)

(10) Chain Feed Pulldown.

PERFORMANCE

Hydraulic motor	
operating torque	185 in lb. at 100 psi
Transmission output ratio:	
Low gear 5:1	
High gear 3.09:1	

INPUT POWER

Pulldown hydraulic motor	Hydraulic pump on sub-drive
Pulldown transmission	Sprocket and roller chain from hydraulic motor
Feed Chains	Sprocket and roller chain from transmission

CAPACITY

Lubricant in pulldown transmission	3 qt (2.84 1)

(11) Air Controls Assembly.

PERFORMANCE	
Minimum operating pressure	110 psi (7.6 bar)
Normal operating pressure	125 psi (8.6 bar)
Maximum operating pressure	135 psi (9.3 bar)
INPUT POWER	
Air receiver	Compressed air from truck air tank
CAPACITY	
Lubricant in lubricator bowl	10 ounces (283 g)

(12) Hydraulic System and Jacks.

PERFORMANCE	
Hydraulic system:	
Normal operating pressure	1900 psig (131 bar)
Maximum operating pressure	2000 psig (138 bar)
Hydraulic jacks:	
Maximum hydraulic pressure	2000 psig (138 bar)
OPERATING TEMPERATURE	
Hydraulic oil cooler outlet maximum temperature	200 deg F (93 deg C)
INPUT POWER	
Motors, cylinders, jacks	Hydraulic pumps on sub-drive
CAPACITY	
Hydraulic oil tank	79 gal (299 1)
DIMENSIONS (JACKS)	
Ground contact surface area (each jack)	324 sq. in (5309 sq. cm)
Maximum ram stroke:	
Front jacks	38 in (965 mm)
Rear jacks	21 in (533 mm)

(13) Winch Assembly.

WEIGHT	345 lb. (156 kg)
GEAR REDUCTION	40:1
MAXIMUM INPUT RPM	
For loads between 10, 000 and 20, 000 (4, 536 to 9, 072 kg) on the first layer	570 rpm
For loads less than 10, 000 lb. (4, 536 kg) on first layer	1, 140 rpm
Input torque to drive rated load	2, 960 in lb.
OPERATING TEMPERATURES	
Maximum gear box oil temp	250 deg F (121 deg C)

RATED LINE PULL

Layer of cable	1	2	3	4	5
*Rated line pull					
Pounds	20, 000	16, 700	14, 300	12, 500	11, 100
(Kilograms)	(9, 072)	(7, 575)	(6, 486)	(5, 670)	(5, 035)
*Cumulative cable capacity					
Feet	35	78	128	185	249
(Meters)	(10.7)	(23.8)	(39.0)	(56.4)	(75.9)
*Line speed					
Feet per min.	23.6	28.2	32.9	37.5	42.2
(Meters/min.)	(7.2)	(8.6)	(10.0)	(11.4)	(12.9)

*Based on a recommended wire rope of 5/8-in (15.88 mm) diameter, extra improved plow steel.

(14) Truck.

MAKE/MODEL	Navistar International Series 'S', Model F1954 (1987)
CAPACITIES	
Cooling system	42 qt (39.7 1)
Fuel (per tank)	51 gal (193 1)
Fuel (total)	102 gal (386 1)
Engine oil (including filters and oil cooler)	20 qt (18.9 1)
Transmission oil	17 pt (8 1)
Transfer case oil	19 pt (9 1)
Front axle housing oil	18 pt (8.5 1)
Forward rear axle housing oil	31.8 pt (15 1)
Rear rear axle housing oil	24 pt (11.4 1)
DIMENSIONS	
Length (ready for travel)	35 ft (10.67 m)
Width	8 ft (2.44 m)
Height	8 ft (2.44 m)
PERFORMANCE	
Maximum forward speed:	

Gear:	Reverse	1	2	3	4	5
High range:						
Mph	8.1	8.1	14.9	27.5	45.0	58.0
(Km/hr)	13.0	13.0	24.0	44.2	72.4	93.3
Low range:						
Mph	3.6	3.6	6.7	12.3	20.2	26.0
(Km/hr)	5.8	5.8	10.8	19.8	32.5	41.8

Maximum towing speed	20 mph (32 km/hr)
Fuel Consumption (approximate):	
Highway:	5.98 mpg (39 1/100 km)
Drilling:	2.38 gph (9 1/hr)
Turning radius; approach, departure, and breakover angle; center of gravity	(see figure 1-3)
Maximum grade	51.7%
OPERATING TEMPERATURES	
Maximum ambient	190 deg F (88 deg C)
Minimum ambient	160 deg F (71 deg C)
TIRE PRESSURE	
Front	90 psi (6.2 bar)
Rear	100 psi (6.9 bar)
SUSPENSION	
Front Springs	8-leaf, constant rate
Rear springs and suspension	Equalizing beam tandem suspension with leaf spring

(Truck continued)

POWER STEERING GEAR	Single rack piston and sector type
ELECTRICAL SYSTEM	
Alternator	12 vdc, 90 amp
Batteries	12 vdc, 104 amp, maintenance free, top terminals
Starting motor	12 vdc, solenoid operated, enclosed shift lever
ENGINE	
Make and model	Navistar International, Model DTI-466C
Characteristics	
Cylinders and arrangement	6, in-line
Bore	4.30 in (109.2 mm)
Stroke	5.35 in (135.9 mm)
Displacement	466.1 cu in (7.6 cu m)
Compression ratio	16.3:1
Firing order	1-5-3-6-2-4
Dry weight, no accessories	1441 lb. (654 kg)
Rating	210 bhp at 2600 rpm
Fuel	Diesel, No 2
Oil filter type	Full flow, dual spin-on with by-pass valve
Oil cooler type	Shell and tube, multiple coolant tubes
Fuel injection pump type	Multiple plunger
Fuel filter type	Spin-on primary and final
Air cleaner type	Dual element, replaceable
Intercooler type	Water-to-air, tube and enclosed fin
Radiator type	Down-flow
CLUTCH TYPE	14-inch (355.6 mm), 2-plate
BRAKES	
Type	Drum, split air system
Air compressor:	
Type	2-cylinder, single stage, reciprocating piston, air cooled, belt driven
Rated displacement	13.0 cfm
Discharge pressure	120 psi (8.3 bar)

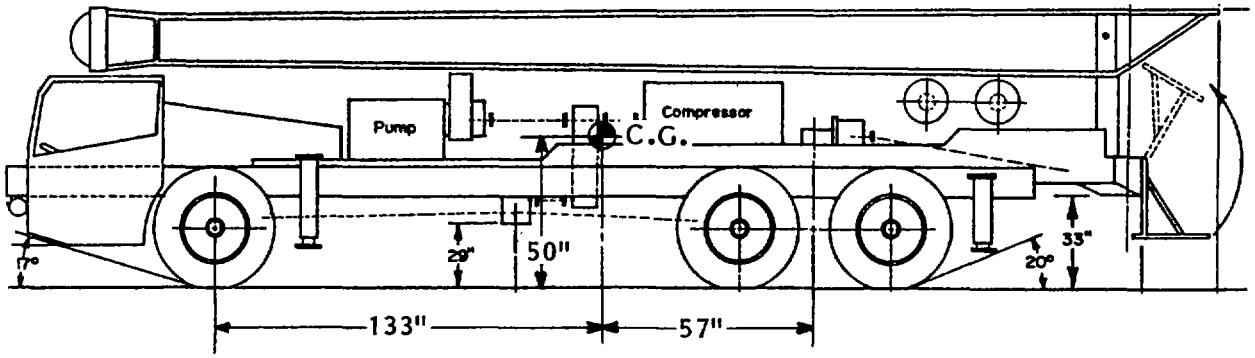


Figure 1-3. Drilling Rig Clearance Angles, Center of Gravity

1-8. Rig Tender Equipment Characteristics, Capabilities, and Features. The rig tender is an air-transportable support vehicle and is designed to haul water, fuel, and water well drilling support equipment to the drill site. The rig tender is designed for one-man operation; it is also designed for use in all types of environmental conditions. Figure 1-4 shows the rig tender's lifting and tie-down points.

a. Major Components Features and Capabilities.

(1) Crane.
- (a) Manual pullout boom.
- (b) Hydraulic extension boom.
- (c) Extension cylinder.
- (d) Mainboom.
- (e) Boom cylinder.
- (f) Turret assembly.
- (g) Base assembly.
- (h) Winch.
- (i) Cable.
- (j) Snatch block.
- (k) Remote control unit.

(2) Welder and generator.
- (a) Engine.
- (b) Battery.
- (c) Generator
- (d) Control panel.

(3) Fuel transfer system.
- (a) Fuel transfer pump.
- (b) Fuel tank.
- (c) Storage cabinet (2).
- (d) Flood lights.

(4) Waterbed and Water Pump.
- (a) Water storage chamber.
- (b) Water pump.
- (c) Drill pipe storage area.

(5) Hydraulic System.
- (a) Hydraulic reservoir.
- (b) Hydraulic pump.
- (c) Sight gauge.

(6) Winch.
- (a) Drum.
- (b) Cable.

(7) Truck.
- (a) Rear axle or front and rear axle drive.
- (b) Air brakes.
- (c) 6-cylinder diesel engine.
- (d) Turbocharger.
- (e) Five-speed transmission.
- (f) Two-speed transfer case.
- (g) Power steering.

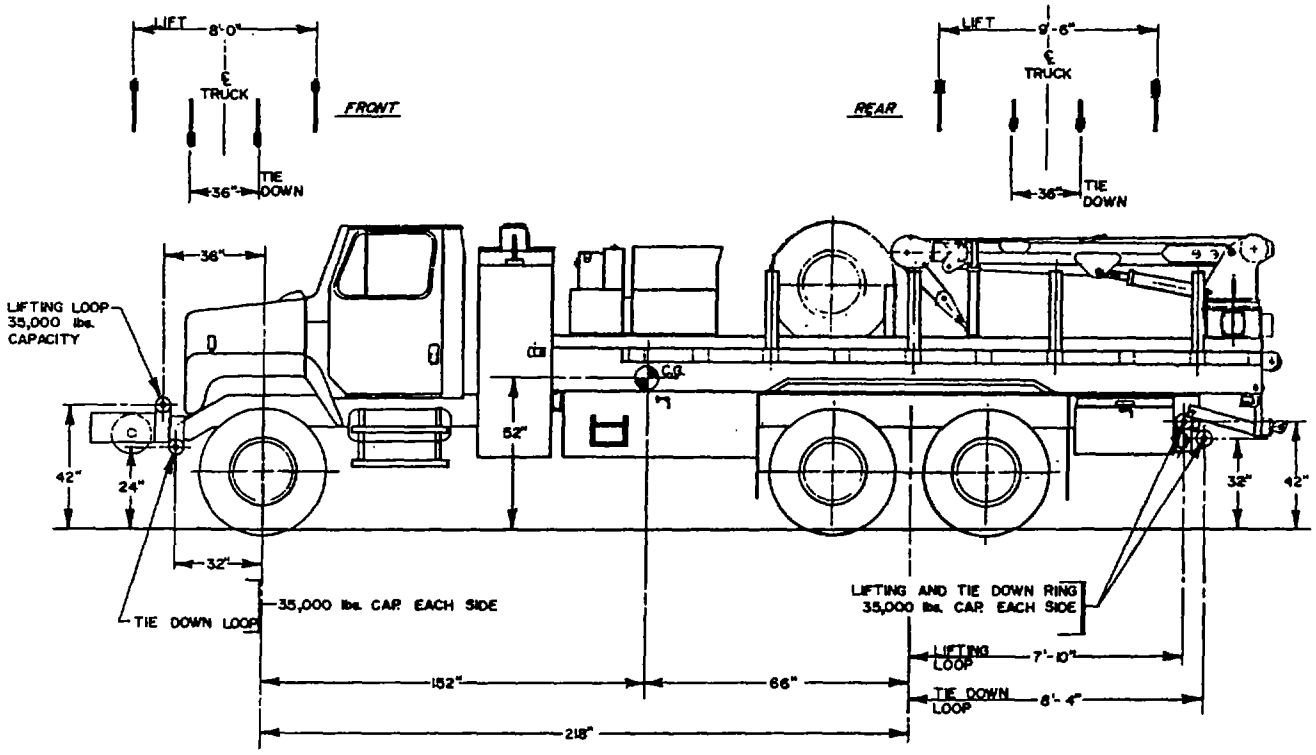


Figure 1-4. Rig Tender Lifting and Tie-Down Points

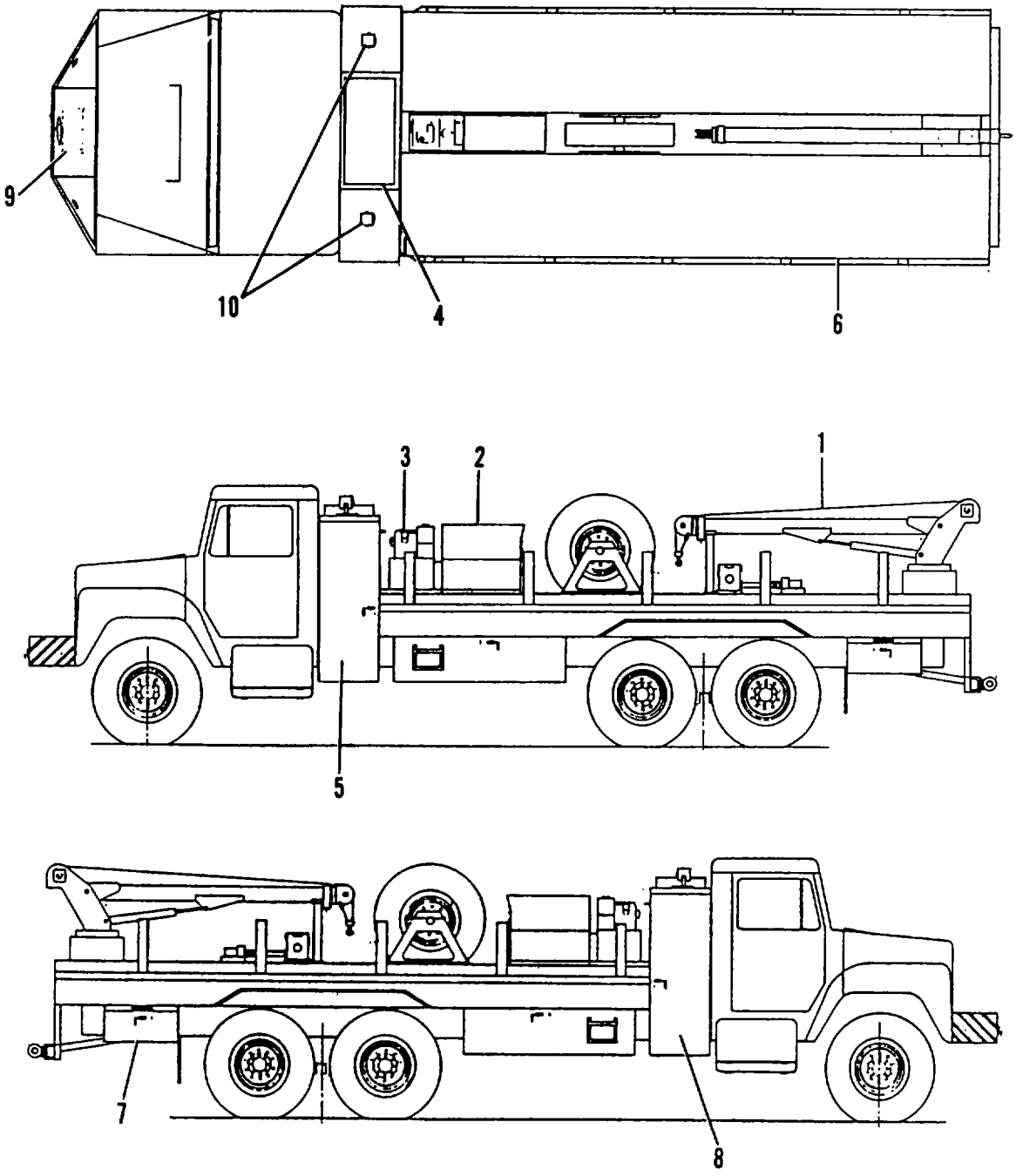


Figure 1-5. Rig Tender Major Components

b. Location and Description of Major Components.

(1) Crane (1, Figure 1-5). Provides backup well servicing capability, as well as tool and casing handling support. Located at the rear center of the waterbed, the crane turret and boom assembly rotate continuously in any direction. Crane operation is by remote pendant control stored in the base of the crane. Hydraulic and electrical power is controlled from a panel inside the truck cab.

(2) Welder and Generator (2, Figure 1-5). Self-contained unit mounted at the top, front center of the waterbed. The unit is used as an alternating current (ac) or direct current (dc) welder and as a power plant for supplying auxiliary power.

(3) Welder Engine (3, Figure 1-5). Provides power for welder/generator unit. It is an air-cooled, single cylinder, electrically started 14-horsepower diesel engine.

(4) Fuel Transfer System (4, Figure 1-5). Consists of an auxiliary fuel tank, fuel transfer pump, hose, and fuel nozzle. Electrical power to operate the pump is controlled from inside the truck cab. Fuel flow is controlled at the nozzle.

(5) Water Heater (5, Figure 1-5). Consists of integrated open-loop water heating manifold. Contains liquid propane (LP) gas heating torch, hose, pre-set regulator, manifold mounting bracket, and LP tank. Manifold also provides in-transit storage for water pump hoses.

(6) Waterbed (6, Figure 1-5). Provides water storage for rotary well drilling operations. Water level is indicated by magnetically operated water level gauge. Filling and discharging operations are by rotary reversible water pump.

(7) Water Pump (7, Figure 1-5). Provides ability to move water into or out of the waterbed, or from one external water source to another without going through the waterbed. The pump is a hydraulically driven unit, mounted in the rear curbside tool box. Hydraulic power is controlled from inside the truck cab. Pump is engaged and disengaged by an air-shift control located at the pump.

(8) Hydraulic Reservoir (8, Figure 1-5). Holds fluid that hydraulically drives either the water pump or the front winch. Air-shifted controls operate the tank-mounted valves that direct the flow of fluid.

(9) Winch (9, Figure 1-5). Hydraulically driven, 20, 000-pound capacity unit mounted on front of truck. Operated from inside the truck cab by an airshift control. Used for pulling drilling rig or rig tender.

(10) Night Lighting (10, Figure 1-5). Consists of two floodlights mounted on vertical cabinets behind the truck cab. Electrical power ON/OFF switches are inside the truck cab.

c. Equipment Data.

(1) Crane.

DIMENSIONS AND WEIGHT	
Length (extended)	240 in (610 cm)
Length (retracted)	108 in (274 cm)
Height Above Deck (Maximum)	264 in (670 cm)
Height Above Deck (Minimum)	40 in (102 cm)
Weight	1, 500 lb. (680 kg)
CAPACITY	
Fluid in Rotation Mechanism	3 pints (1.65 liters)
Fluid in Winch Mechanism	3 pints (1.65 liters)

(2) Welder and Generator.

DIMENSIONS AND WEIGHT (with Engine Mounted)	
Base Length	49.25 in (125.1 cm)
Base Width	15 in (38.1 cm)
Overall Length	49.25 in (125.1 cm)
Overall width	23.5 in (59.7 cm)
Overall Height	28.75 in (28.7 cm)
Weight (Net)	670 lb. (304 kg)
OPERATING MODES	
Welding - Alternating Current Range	45-225 amp ac
Welding - Direct Current Range	35-200 amp ac
POWER	
Welding	
Rating	1 kva
Volts	115 vac
Current	8.7 amp ac
Power Plant (Generator)	
Rating	4.5 kva
Volts	120/240 vac
Current	38/19 amp ac
Frequency	60 Hz
VOLTAGE	
Welding - Alternating Current	
Open Circuit	80 vac
Closed Circuit	25 vac
Welding - Direct Current	
Open Circuit	72 vdc
Closed Circuit	25 vdc
ENGINE CHARACTERISTICS	
Model	FIL 210 D
Number of Cylinders	1

(Welder and Generator ENGINE CHARACTERISTICS continued)

Bore	3.74 (95 mm)
Stroke	3.74 (95 mm)
Displacement	41.07 cu in (673 cc)
Maximum rpm	3000 rpm
Horsepower	15 hp
Rotation (facing flywheel)	counterclockwise direction
Working Principle	4-stroke diesel with direct injection
Lubrication System Type	forced circulation
Weight (standard equipment)	210.9 lb (95.7 kg)
Capacities:	
Oil capacity	2.54 qt (2.4 liters)
Fuel capacity	3.5 gal (13.2 liters)

(3) Fuel Transfer.

DIMENSIONS AND WEIGHT	
Length	8-3/4 in (22.2 cm)
Width	8-3/4 in (22.2 cm)
Height	8-3/4 in (22.2 cm)
Shipping Weight	40 lb (18.1 kg)
CAPACITY	
Pump	13-1/2 gpm (51 liters/min)

(4) Fuel Reservoir.

DIMENSIONS	
Hose	
Size (Inside Diameter)	3/4 in (19.1 mm)
Length	50 ft (15.2 m)
CAPACITY	
Fuel	200 gal (757 liters)

(5) Water Heater.

DIMENSIONS AND WEIGHT	
Length	Varies
Weight	80 lb (36.3 kg)
CAPACITY,	
Heating Torch	400,000 btu/hr
ACCESSORIES	
LP Gas Hose w/Preset Regulator	25 ft (7.62 m)
Propane Tank or Cylinder	20 lb (9.07 kg)
Torch to Manifold Adapter	2 lb (.91 kg)

(6) Waterbed and Water Pump.

DIMENSIONS AND WEIGHT	
Pump:	
Length	33 in (84 cm)
Width	12 in (30 cm)
Height	15.75 in (40 cm)
Weight	200 lb (91 kg)
Hoses:	
Length	20 ft (6.1 m)
Width	2 in 1. D. (51 mm)
Weight	25 lb (11 kg)
Tank:	
Length	20 ft (6.1 m)
Width	8 ft (2.4 m)
CAPACITY	
Water tank	1,000 gal (3785 liters)
Load (any 4X4 area)	30,000 lb (1 3,590 kg)
Water pump rpm	420 rpm
Displacement:	
@200 psi (13.8 bar)	147 gpm (556 1/min)
@ 100 psi (6.9 bar)	133 gpm (503 1/min)
OPERATING TEMPERATURES	
Low water extreme	32 deg F (0 deg C)
High water extreme	180 deg F (82 deg C)
Low ambient extreme	-40 deg F

(7) Hydraulic Reservoir.

CAPACITY	
Reservoir	7.0 gal (26.5 liters)
OPERATING TEMPERATURE	
Maximum	200 deg F (93 deg C)
Range	150 - 200 deg F (65 - 93 deg C)
ACCESSORIES	
Return Line Filter	25 micron
Suction Line Strainer	100 mesh

(8) Hydraulic Valve.

DIMENSIONS AND WEIGHT

Length	16 in (40.6 cm)
Width	10 in (25.4 cm)
Height	6 in (15.2 cm)
Shipping Weight	30 lb (13.6 kg)

TYPE

Linear spool, open center

OPERATION

Air Cylinder Spool	Remote Air Shift
Back Up	Manual Push/Pull

(9) Winch.

WEIGHT	345 lb (156 kg)
GEAR REDUCTION	40:1

MAXIMUM INPUT RPM

For loads equivalent to 10,000 to 20,000 lb (4,536 to 9,072 kg) on the first layer	570 rpm
For loads equivalent to less than 10,000 lb (4,536 kg) on the first layer 1,140 rpm	
Input torque to drive rated load	2,960 in lb

OPERATING TEMPERATURES

Maximum Gear Box Oil Temperature	250 deg F (121 deg C)

RATED LINE PULL

Layer of Cable	1	2	3	4	5
*Rated Line Pull					
Pounds	20,000		16,700	14,300	12,500	11,100
(Kilograms)	(9,072)		(7,575)	(6,486)	(5,670)	(5,035)
*Cumulative Cable Capacity					
Feet	35		78	128	185	249
(Meters)	(10.7)		(23.8)	(39.0)	(56.4)	(75.9)
*Line Speed					
Feet per Minute	23.6		28.2	32.9	37.5	42.2
(Meters per Minute)	(7.2)		(8.6)	(10.0)	(11.4)	(12.9)

*Based on a recommended wire rope of 5/8-in diameter, extra improved plow steel.

(10) Hydraulic Pump/PTO.

WEIGHT	
Net Weight	65 lb (29.5 kg)
CAPACITY	
Pump, Tandem	30 & 5 gpm (113 & 19 liter/min)
OPERATING MODES	
Control - ON/OFF	Air Shift
Operating Speed	600-1000 Engine RPM

(11) Power Take-Off.

DIMENSIONS AND WEIGHT	
Length	10 in (25.4 cm)
Diameter	8 in (20.3 cm)
Weight	45 lb (20.4 kg)
OPERATING MODE	
Control - ON/OFF	Air Shift
Operating Speed	600-800 Engine RPM

(12) Night Lighting.

DIMENSIONS AND WEIGHT	
Length	9 in (22.9 cm)
Diameter	10 in (25.4 cm)
Weight	10 lb (4.54 kg)
CAPACITY	
Output	12 volts, 60 amps = 30,000 candlepower
Lighting Range Beam Spread	30 deg wide x 6 deg elevation

(13) Truck.

MAKE/MODEL	Navistar International Series 'S', Model F1954 (1987)
CAPACITIES	
Cooling system	42 qt (39.7 1)
Fuel (per tank)	51 gal (193 1)
Fuel (total) 102 gal (386 1)	
Engine oil (including filters and oil cooler)	20 qt (18.9 1)
Transmission oil	17 pt (8 1)
Transfer case oil	19 pt (9 1)
Front axle housing oil	18 pt (8.5 1)
Forward rear axle housing oil	31.8 pt (15 1)
Rear axle housing oil	24 pt (11.4 1)
DIMENSIONS	
Length (ready for travel)	33.75 ft (10.29 m)
Width	8 ft (2.44 m)
Height	8.42 ft (2.57 m)

PERFORMANCE

Maximum forward speed:

Gear:	Reverse	1	2	3	4	5
High Range:						
Mph	8.1	8.1	14.9	27.5	45.0	58.0
(Km/hr)	13.0	13.0	24.0	44.2	72.4	93.3
Low Range:						
Mph	3.6	3.6	6.7	12.3	20.2	26.0
(Km/hr)	5.8	5.8	10.8	19.8	32.5	41.8

Maximum towing speed	20 mph (32 km/hr)
Fuel Consumption (approximate):	
Highway:	5.98 mpg (39 1/100 km)
Drilling:	2.38 gph (9 1/hr)
Turning radius; approach, departure, and breakover angle; center of gravity	(See figure 1-6)
Maximum grade	51.7%
OPERATING TEMPERATURES	
Maximum ambient	190 deg F (88 deg C)
Minimum ambient	160 deg F (71 deg C)
TIRE PRESSURE	
Front 90 psi (6.2 bar)	
Rear 100 psi (6.9 bar)	
SUSPENSION	
Front Springs	8-leaf, constant rate
Rear springs and suspension leaf spring	Equalizing beam tandem suspension with

(Truck continued)

POWER STEERING GEAR	Single rack piston and sector type
ELECTRICAL SYSTEM	
Alternator	12 vdc, 90 amp
Batteries	12 vdc, 104 amp, maintenance free, top terminals
Starting motor	12 vdc, solenoid operated, enclosed shift lever
ENGINE	
Make and model	Navistar International, Model DTI-466C
Characteristics	
Cylinders and arrangement	6, in-line
Bore	4.30 in (109.2 mm)
Stroke	5.35 in (135.9 mm)
Displacement	466.1 cu in (7.6 cu m)
Compression ratio	16.3:1
Firing order	1-5-3-6-2-4
Dry weight, no accessories	1441 lb (654 kg)
Rating	210 bhp at 2600 rpm
Fuel	Diesel, No. 2
Oil filter type	Full flow, dual spin-on with by-pass valve
Oil cooler type	Shell and tube, multiple coolant tubes
Fuel injection pump type	Multiple plunger
Fuel filter type	Spin-on primary and final
Air cleaner type	Dual element, replaceable
Intercooler type	Water-to-air, tube and enclosed fin
Radiator type	Down-flow
CLUTCH TYPE 14-inch (355.6 mm),	2-plate
BRAKES	
Type	Drum, split air system
Air compressor:	
Type	2-cylinder, single stage, reciprocating piston, air cooled, belt driven
Rated displacement	13.0 cfm
Discharge pressure	120 psi (8.3 bar)

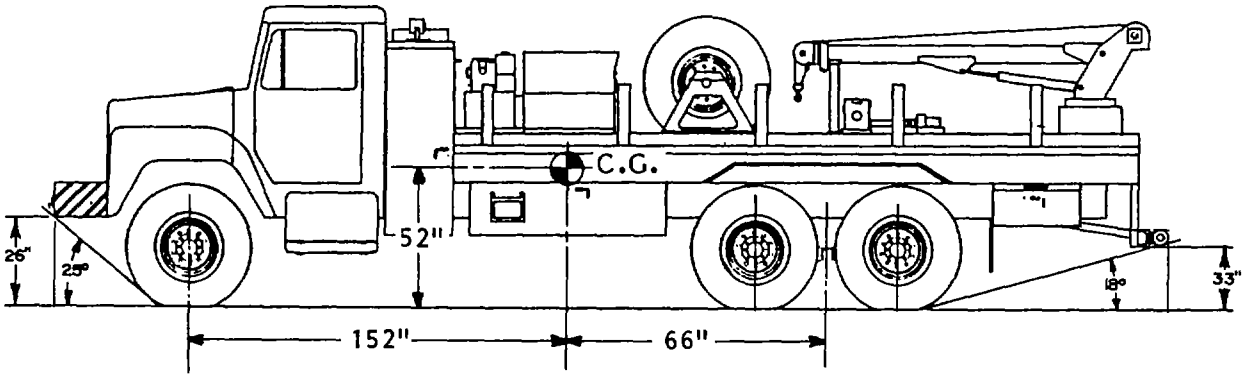


Figure 1-6 . Rig Tender Clearance Angles, Center of Gravity

1-27/1-28 Blank

CHAPTER 2
OPERATING INSTRUCTIONS

Section I. DESCRIPTION AND USE OF OPERATOR'S CONTROLS AND INDICATORS

2-1. Drilling Rig.

a. Mast.

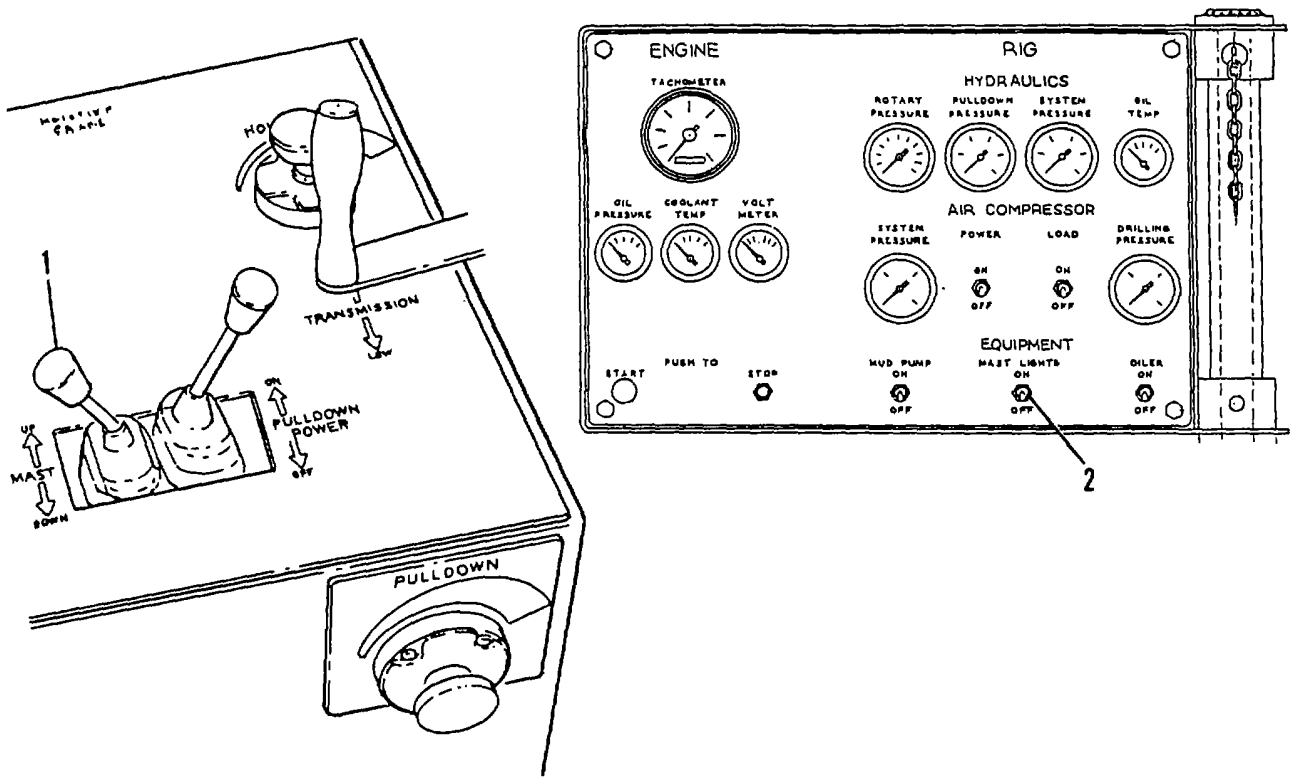


Figure 2-1 . Mast Controls

KEY	CONTROL or INDICATOR	FUNCTION
1	Mast Raise Control	Operates cylinders to raise and lower the mast.
2	Mast Lights Switch	Turns the mast lights on and off.

b. Mud Pump.

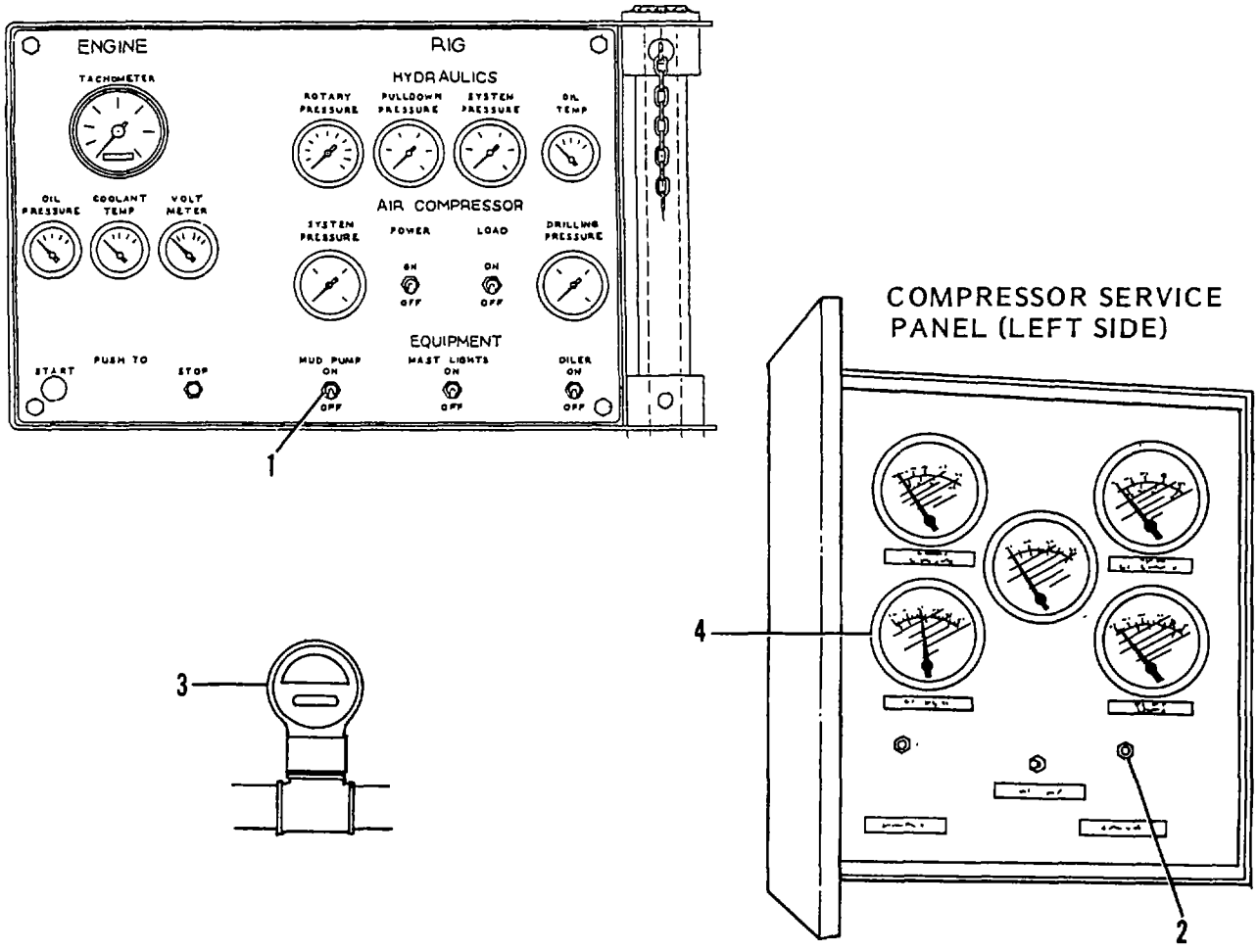


Figure 2-2 . Mud Pump Controls and Indicators .

KEY	CONTROL or INDICATOR	FUNCTION
1	Mud Pump Switch	Starts and stops mud pump operation.
2	Mud pump reset	Resets mud pump after a malfunction shuts down mud pump operations.
3	Mud pump pressure gage	Indicates fluid pressure in mud circulating system.
4	Air pressure switchgage	Indicates pressure in clutch air supply system. When pressure falls to 40 psi it shuts down compressor or mud pump.

c. Air Compressor System.

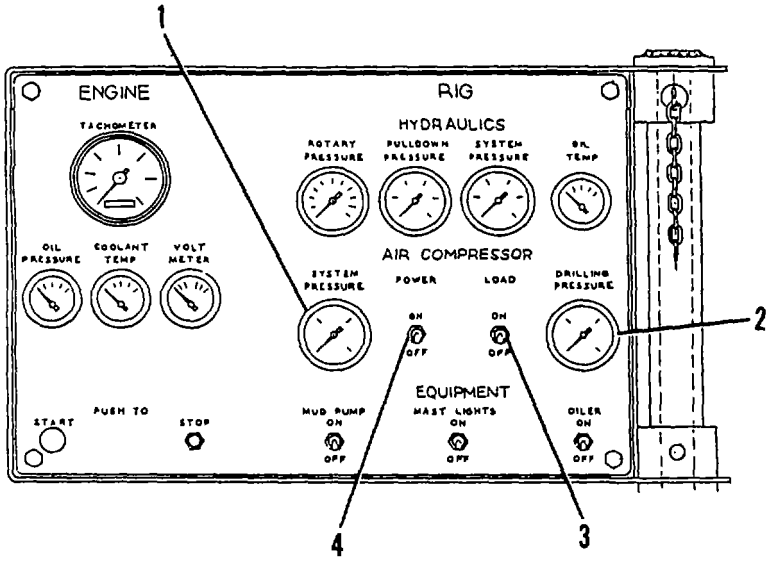


Figure 2-3 . Air Compressor Controls and Indicators (Sheet 1 of 2)

KEY	CONTROL or INDICATOR	FUNCTION
1	System pressure gage	Indicates system air pressure. Operating ranqe:110 to 135 psi.
2	Drilling pressure gage	Indicates pressure being used when drilling with air.
3	Air load switch	Selects ON to load air to air drilling system.
4	Air compressor power switch	Starts and stops air compressor operation.

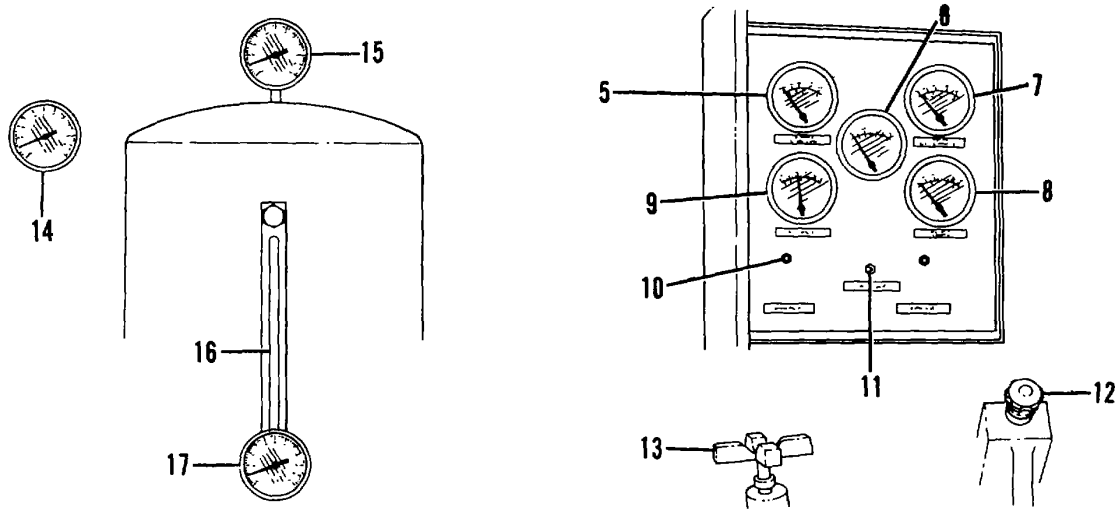


Figure 2-3 . Air Compressor Controls and Indicators (Sheet 2 of 2)

KEY	CONTROL or INDICATOR	FUNCTION
5	Air/oil temperature switchgage	Indicates compressor air/oil mixture temperature. Stops compressor operation if temperature exceeds 230 deq. F.
6	Air compressor intake air switchgage	Indicates compressor suction air vacuum. If vacuum reaches 15" W.C., stops compressor operation.
7	Injection oil temperature switchgage	Indicates oil temperature being injected into compressor. Stops compressor when temperature reaches 180 deq F.
8	Low oil pressure switchgage	Indicates oil pressure injected into compressor. Stops compressor when oil pressure falls to 5 psi.
9	Air pressure switchgage	Indicates pressure in clutch air supply system. When pressure falls to 40 psi, it shuts down compressor or mud pump.
10	Compressor reset button	When low air pressure shuts down compressor, button pops out to indicate problem. Must be pushed in after problem is corrected.
11	ON-OFF power switch	Turns power to compressor panel on and off.
12	Cooling fan adjust valve	Regulates oil flow to cooling fan motor. CCW increases motor speed; CW reduces speed.
13	Compressor oil inject throttle valve	Regulates amount of cooling oil injected into compressor during operation. CCW increases the amount of flow; CW decreases flow.
14 & 15	Air pressure gages	Shows pressure differential before and after coalescent filter. 10 psi difference indicates filter needs change.
16	Oil level indicator	Sight glass indicates the level of injection oil in the compressor system.
17	Oil Temperature gage	Indicates temperature of oil in air/oil separator.

d. Drawworks Assembly.

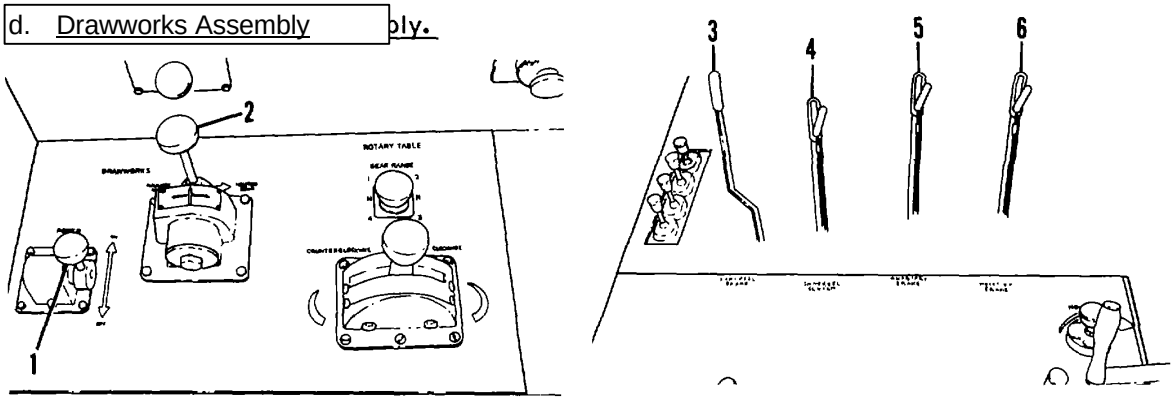


Figure 2-4 . Drawworks Controls

KEY	CONTROL or INDICATOR	FUNCTION
1	Drawworks power switch	Operates air cylinder to engage subdrive.
2	Auxiliary and hoist drum clutch control	Engages auxiliary drum when shifted to the right, engages hoist drum when shifted to the left.
3	Third drum clutch control	Engages third drum clutch when pulled back. When released clutch disengages.
4	Third drum brake lever	Engages third drum brakes.
5	Hoist drum brake lever	Engages hoist drum brakes.
6	Auxiliary drum brake lever	Engages auxiliary drum brakes.

e. Water/Foam Injection.

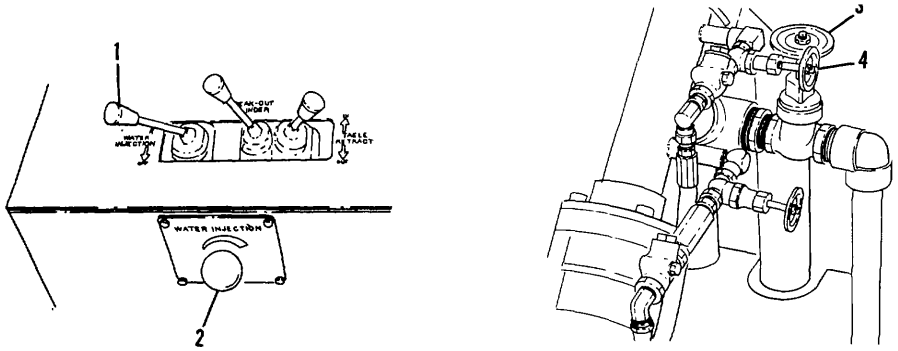


Figure 2-5 . Water/Foam Injection Controls

KEY	CONTROL or INDICATOR	FUNCTION
1	Water injection control	Turns water injection system on and off.
2	Water injection volume control	Controls speed of water pump to increase and decrease injected water volume.
3	Blow down valve	Relieves pressure in discharge piping.
4	Water/foam injection valve	Regulates water or foam injected into discharge piping.

f. Force Feed Lubricator.

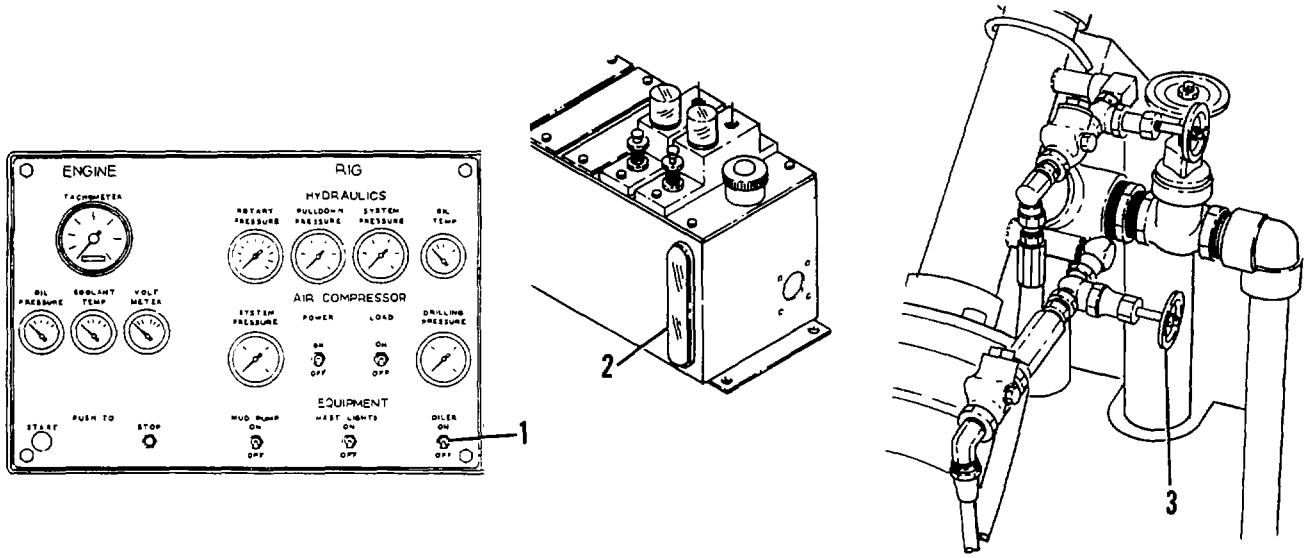


Figure 2-6 . Force Feed Lubricator Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Oilier switch	Turns lubricator motor on and off.
2	Lubricator sight gage	Indicates oil level in lubricator reservoir.
3	Lubricator shutoff valve	Regulates rate of lubrication oil being injected into discharge piping.

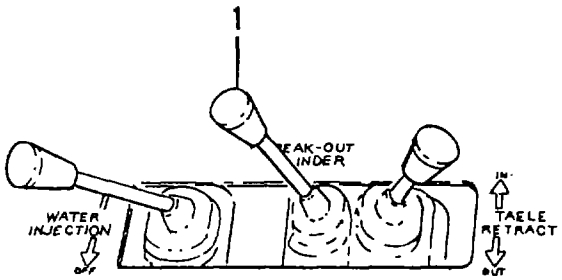


Figure 2-7 . Break-out Controls

g. Break-out Assembly.

KEY	CONTROL or INDICATOR	FUNCTION
1	Break-out cylinder control	Directs hydraulic pressure to actuate break-out cylinder.

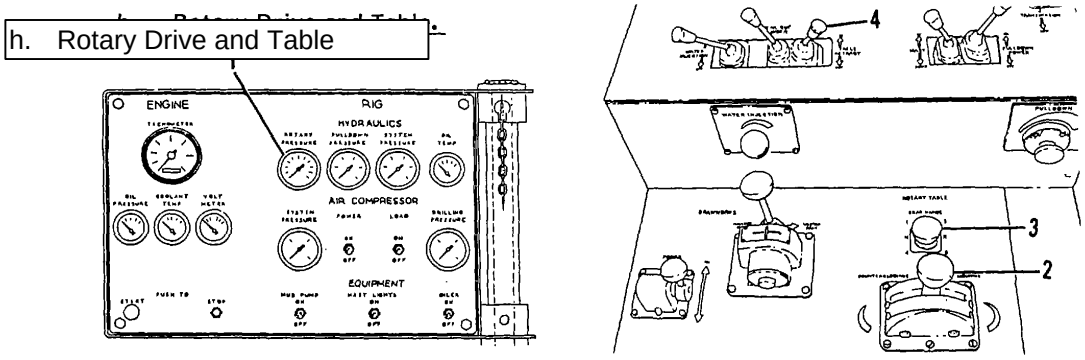


Figure 2-8 . Rotary Table and Drive Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Rotary pressure gage	Indicates hydraulic pressure to rotary table motor.
2	Table rotation control	Controls direction of table rotation; left for CCW rotation; right for CW. Speed increases with handle travel.
3	Transmission shift control	Selects gear range of rotary transmission from 1 - 4. Center is neutral.
4	Table retraction control	Directs hydraulic pressure to actuate retraction cylinders to move rotary table in and out.

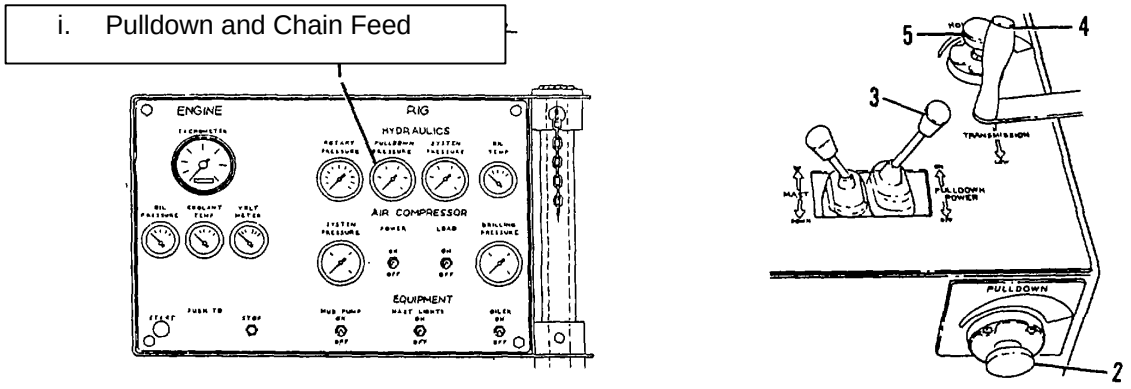


Figure 2-9 . Pulldown and Chain Feed Controls

KEY	CONTROL or INDICATOR	FUNCTION
1	Pulldown pressure gage	Indicates hydraulic pressure to pulldown motor.
2	Pulldown control knob	Rotary knob to control hydraulic oil flow to motor; turn CW to increase pressure.
3	Pulldown transmission lever	Selects the gear speed of the pulldown transmission. Rearward-low; forward-high.
4	Holdback control	Controls holdback pressure. Turn knob CW to increase pressure.
5	Pulldown power control	Turns pulldown power on and off. valve

j. Control Air System.

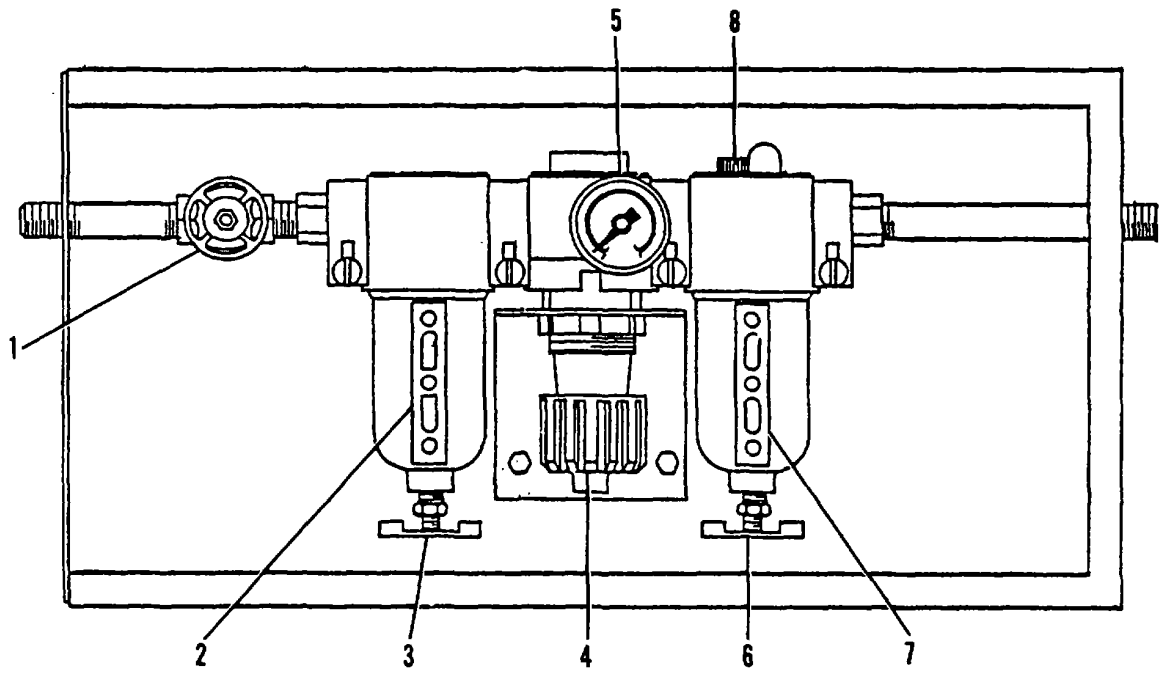


Figure 2-10 . Control Air System Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Control air shutoff valve	Regulates air supply to controls. Rotate hand-wheel CCW to open; CW to close.
2	Air filter sight glass	Visual indicator of amount of water in bowl.
3	Air filter draincock	Valve for draining water and relieving pressure in filter bowl.
4	Air pressure regulator	Valve to regulate pressure in control air system. Rotate knob CCW to increase pressure; CW to decrease.
5	Control air pressure gage	Gage that indicates pressure in control air system. Range: 110-130 psi.
6	Air lubricator draincock	Valve to drain lubricant or antifreeze and relieve pressure from lubricator bowl.
7	Air lubricator sight glass	Visual indicator of lubricant or antifreeze in lubricator bowl.
8	Air lubricator adjusting screw	Adjusts the flow rate of lubricant or antifreeze solution. Rotate CCW to increase; CW to decrease.

k. Operator's Station/Truck Controls.

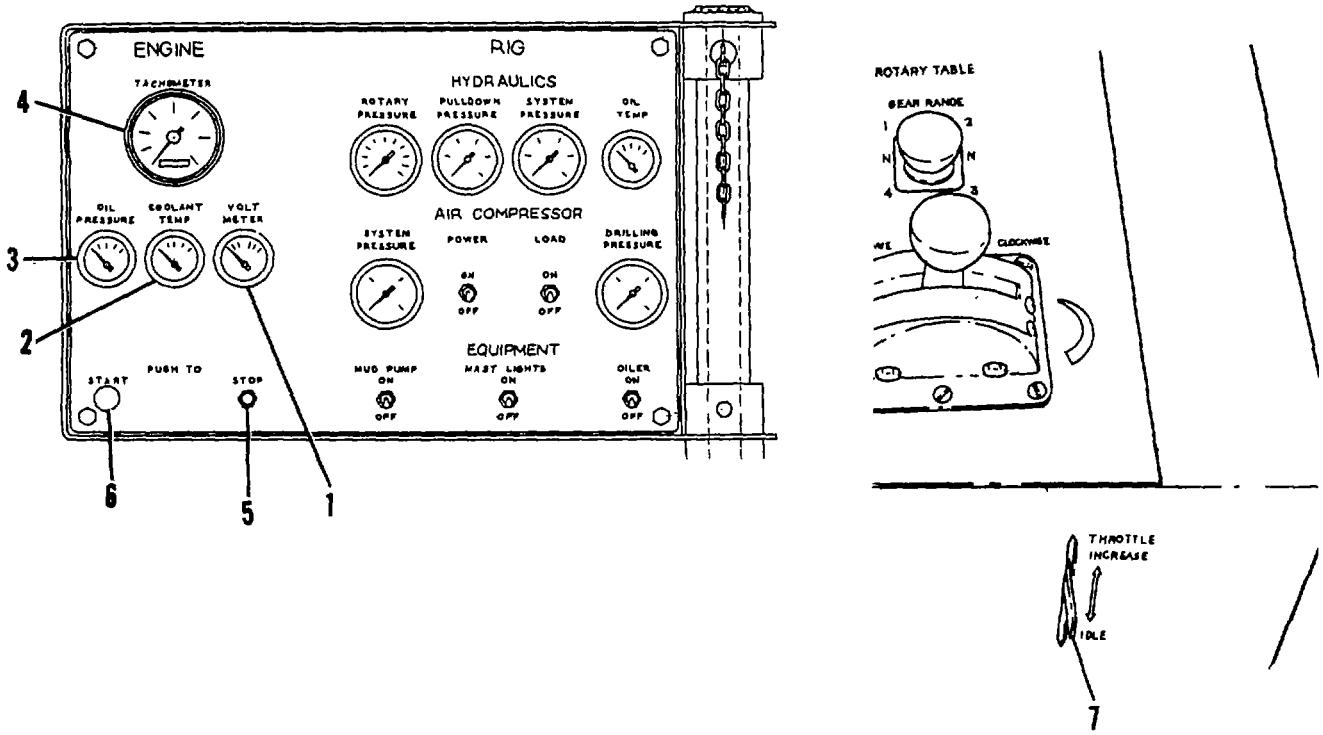


Figure 2-11 . Operator's Station/Truck Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Voltmeter	Indicates voltage in battery/generator at the rig operator ' s station.
2	Coolant temperature gage	Indicates temperature of truck engine's coolant. Range: 160 to 210 deq. F.
3	Oil pressure gage	Indicates oil pressure of truck engine's lubricat-inq system. Range: 25 to 30 psi.
4	Tachometer	Indicates engine speed in revolutions per minute (rpm) .
5	Stop switch	Push-to-stop switch to kill engine. Must be pulled out to start engine.
6	Start switch	Pushbutton switch that energizes truck's starter motor to crank engine.
7	Throttle control	Controls engine speed. Down position is idle; engine speed increases as lever moves up.

l. Hydraulics/Jacks.

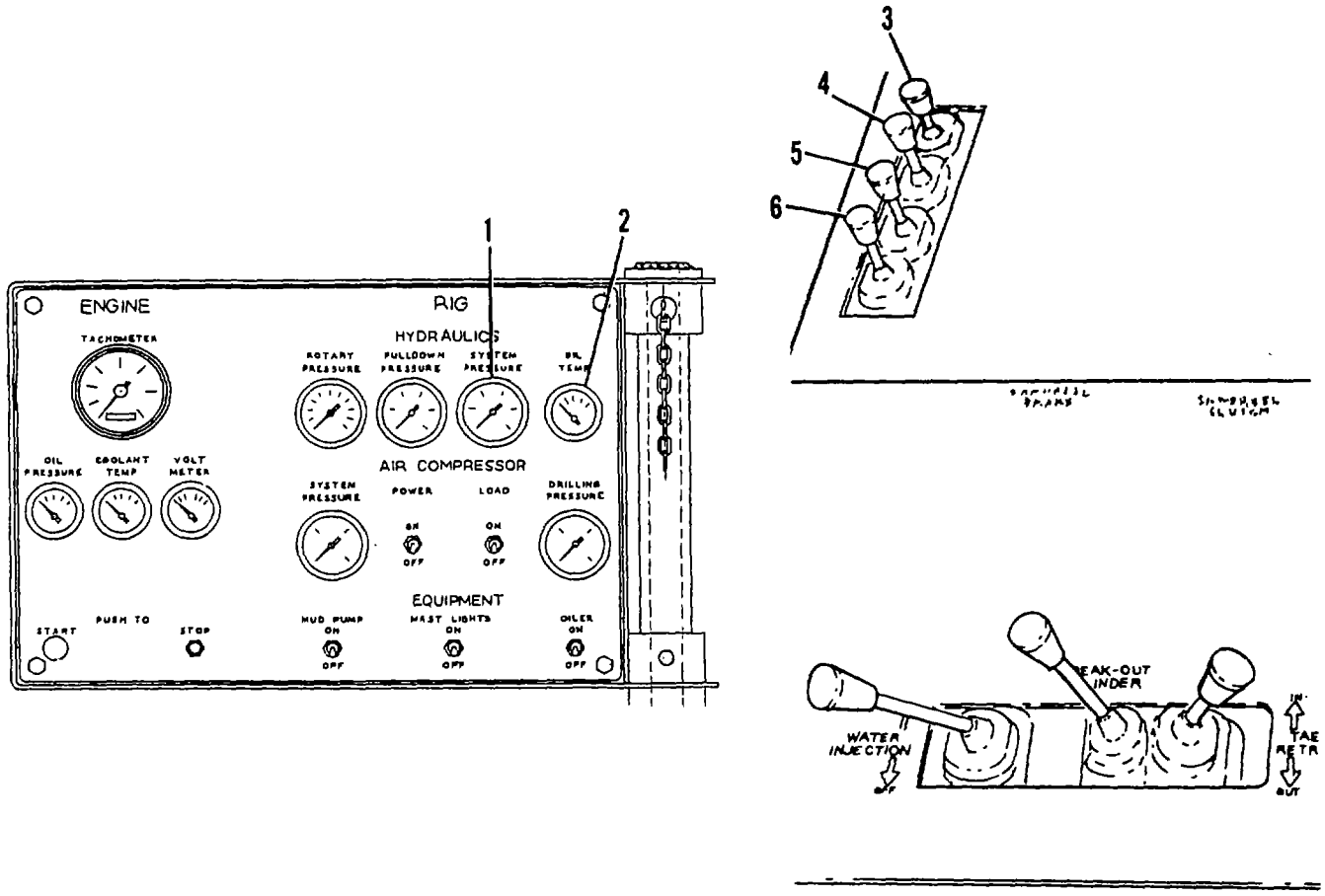


Figure 2-12 . Hydraulics/Jacks Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	System pressure gage	Indicates pressure in hydraulic system. Maximum pressure: 2000 PSI.
2	Oil temperature gage	Indicates hydraulic system's oil temperature. Range: 140 to 320 deq. F.
3	Leveling jack control (left front)	Valve for extending or retracting leveling jack. To extend jack, move to DOWN; to retract, move to UP.
4	Leveling jack control (right front)	Valve for extending or retracting leveling jack. To extend jack, move to DOWN; to retract move to U P.
5	Leveling jack control (left rear)	Valve for extending or retracting leveling jack. To extend jack, move to DOWN; to retract, move to UP.
6	Leveling jack control (right rear)	Valve for extending or retracting leveling jack. To extend jack, move to DOWN; to retract, move to U P.

m. Winch

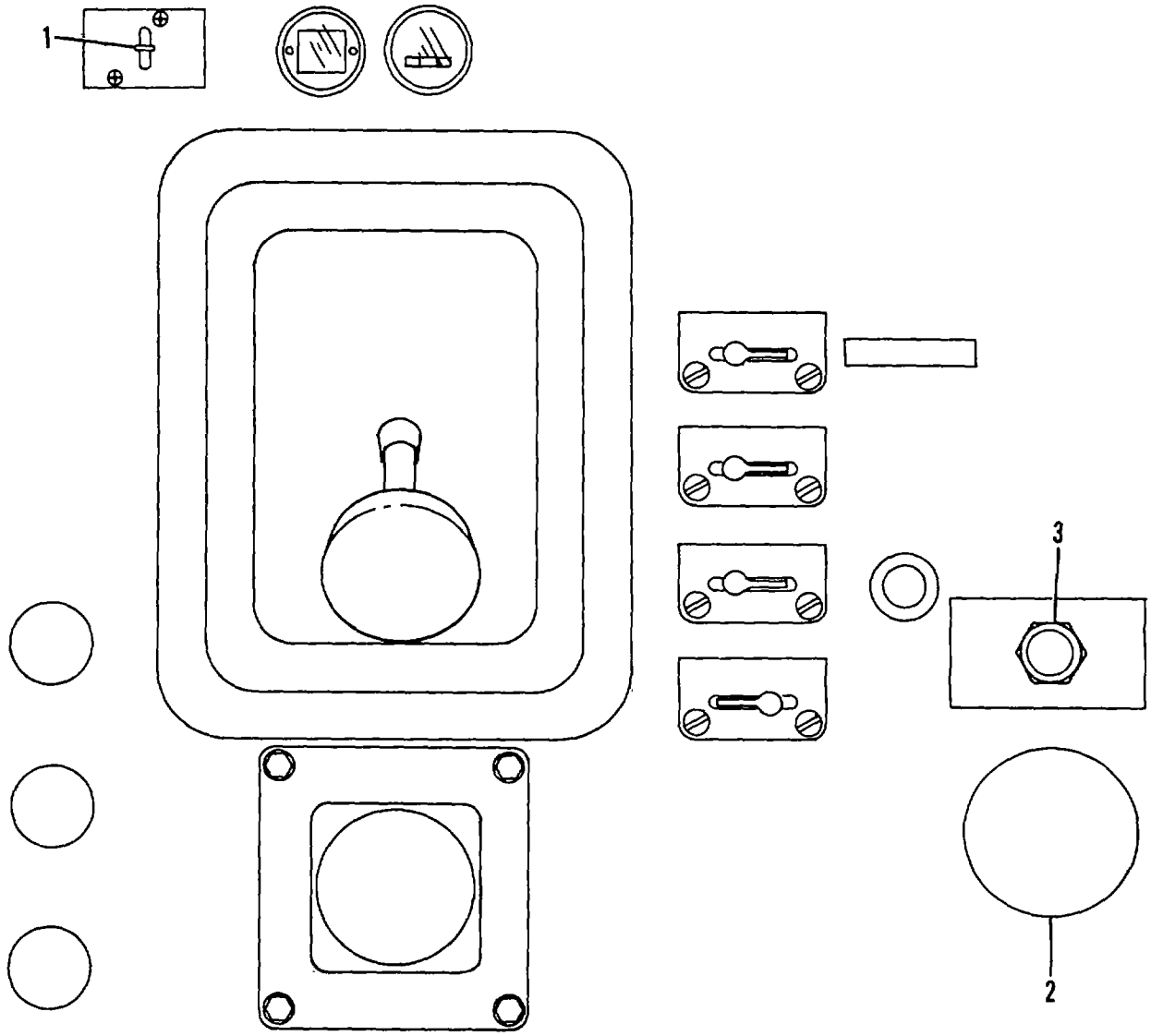


Figure 2-13 . Winch .

KEY	CONTROL or INDICATOR	FUNCTION
1	Winch control lever	Controls operation of front-mounted winch. Move lever to DOWN to unwind cable; move to UP to wind cable onto winch.
2	PTO control knob	Pull knob out to engage power take-off for front-mounted winch operation.
3	PTO indicator	Illuminates when PTO knob is pulled out.

n. Truck

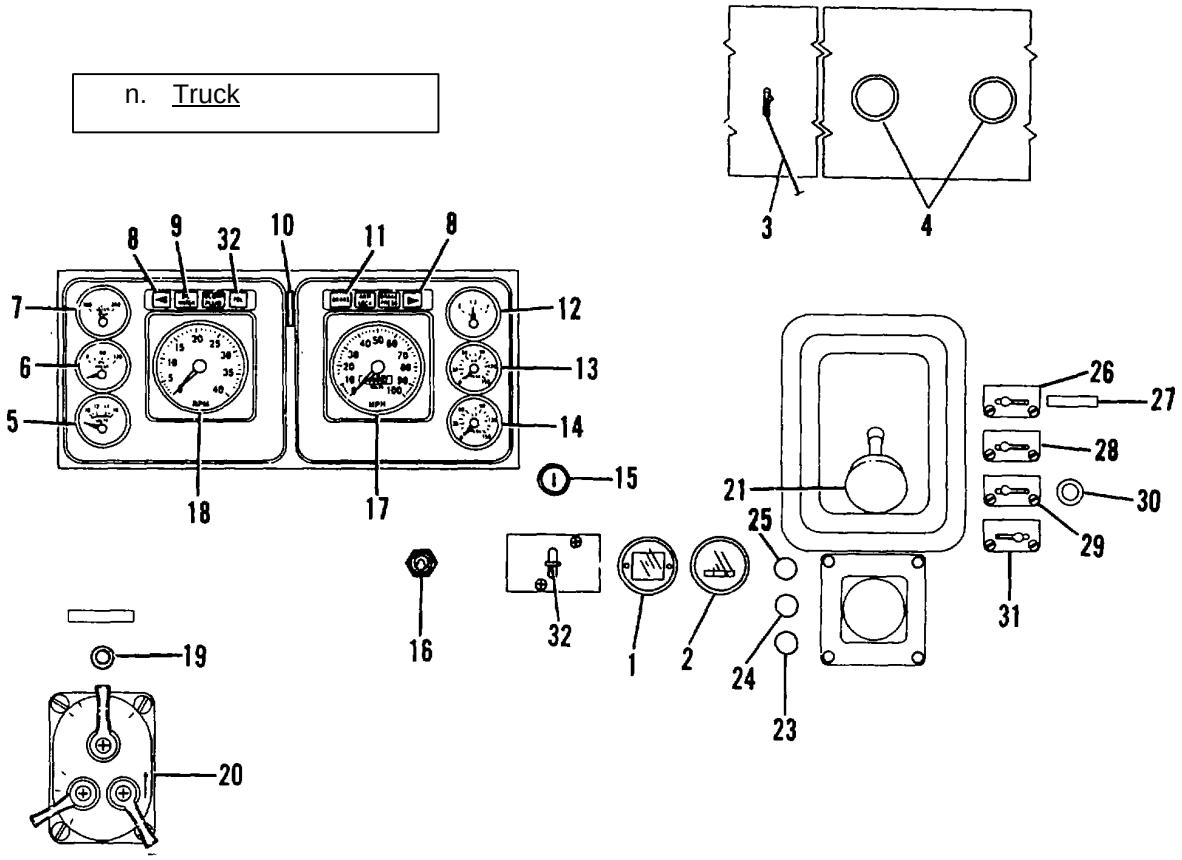


Figure 2-14 . Rig Truck

KEY	CONTROL or INDICATOR	FUNCTION
1	Engine air restriction gage	Indicates condition of engine air cleaner filter. Restriction limit is 25 in. of water vacuum.
2	Hourmeter	Indicates cumulative hours of engine operation.
3	Air horn	Lanyard controls air horn. Pull to sound.
4	Windshield wiper/washer controls	Controls operation of windshield wipers and washers. Left knob controls left-side windshield; right knob controls right-side windshield. Turn CW one position for slow; second position for fast. Push for washer.
5	Voltmeter	Indicates voltage in battery/generator system.
6	Oil pressure gage	Indicates pressure in engine lubricating system. Range is 25 to 30 psi.
7	Water temperature gage	Indicates temperature of engine coolant system. Range is 160 to 210 deq. F.
8	Turn signal indicator	Flasher indicates operation of left or right turn signal.
9	Oil pressure/water temperature indicator	Illuminates at low oil pressure or high coolant temperature.
10	High beam indicator	Illuminates when headlights are operated at high beam.

KEY	CONTROL or INDICATOR	FUNCTION
11	Parking brake indicator	Illuminates when parking brake is set.
12	Fuel gage	Indicates level of fuel in engine fuel tanks.
13	Air pressure gage	Indicates pressure in truck air system.
14	Air pressure gage	Indicates pressure in truck air system.
15	Starting switch	Key switch to energize truck electrical system and start engine. NOTE: Engine stop switch (5, Figure 2-11) must be out before engine will start.
16	Back-up alarm shut-off switch	Shuts off backup alarm. Up is ON; down is OFF.
17	Speedometer/odometer	Indicates vehicle speed in miles-per-hour (mph) and cumulative total of miles driven.
18	Tachometer	Indicates engine speed in revolutions per minute (rpm) .
19	Ether start switch	Injects ether into engine intake to aid in cold weather engine starts.
20	Lighting control unit	Controls vehicle lighting for regular service and blackout lighting operations.
21	Transmission shift lever	Selects transmission gear range. Shift pattern is indicated on knob.
22	Park brake	Pull to apply vehicle parking brake.
23	Heater/defroster fan control	Three position knob controls heater/defroster fan. Rotate knob CW from off to low and high speed.
24	Heat control	Pull knob out for heat.
25	Defrost control	Pull knob out for defrost.
26	Front axle lever	Select ENG to engage front axle drive; select DIS to disengage -front axle drive.
27	Front axle indicator	Illuminates when front axle drive is engaqed.
28	Transfer case lever	Select DIR (direct) for high speed; select UND (underdrive) for low speed.
29	PTO lever	Controls engine power take-off. Move to ENG to engage; to DIS to disengage PTO.
30	PTO indicator	Illuminates when PTO is engaqed.
31	Power divider lock indicator	Illuminates when Power Divider lever (32) is at IN position.
32	Power divider lock-out lever	Locks out inter-axle differential for maximum pulling power in slippery or poor road conditions. IN for additional traction; OUT for normal driving.

WARNING

Engage power divider lock-out (32) at slow speeds or when stopped and never when wheels are spinning. Do not operate the axles on dry pavement with the lock-out engaged for prolonged duration.

2-2 Rig Tender

a. Crane

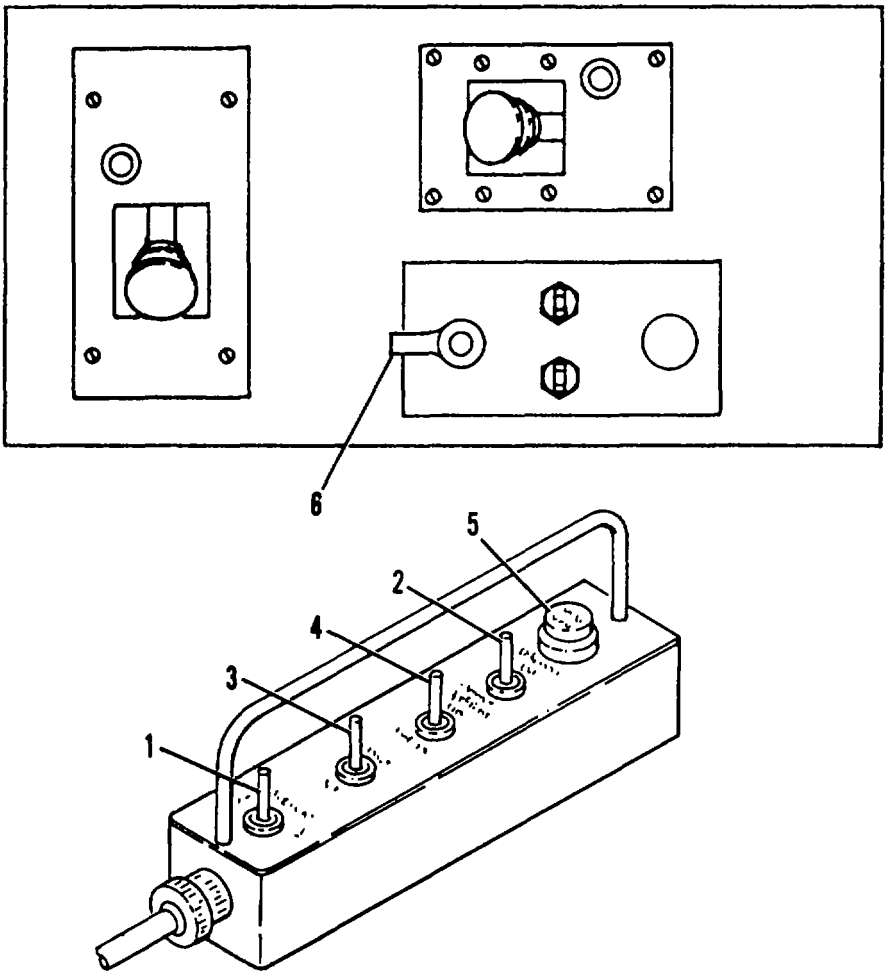


Figure 2-15 . Crane Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Boom rotate	Rotates the crane counterclockwise or clockwise.
2	Winch	Lowers and raises the snatch block.
3	Extension boom	Retracts and extends the hydraulic extension boom.
4	Main boom	Lowers and raises the main boom.
5	Engine stop	Kills the vehicle's engine.
6	Power	Turns the control unit on and off (located in cab).

b. Welder/Generator

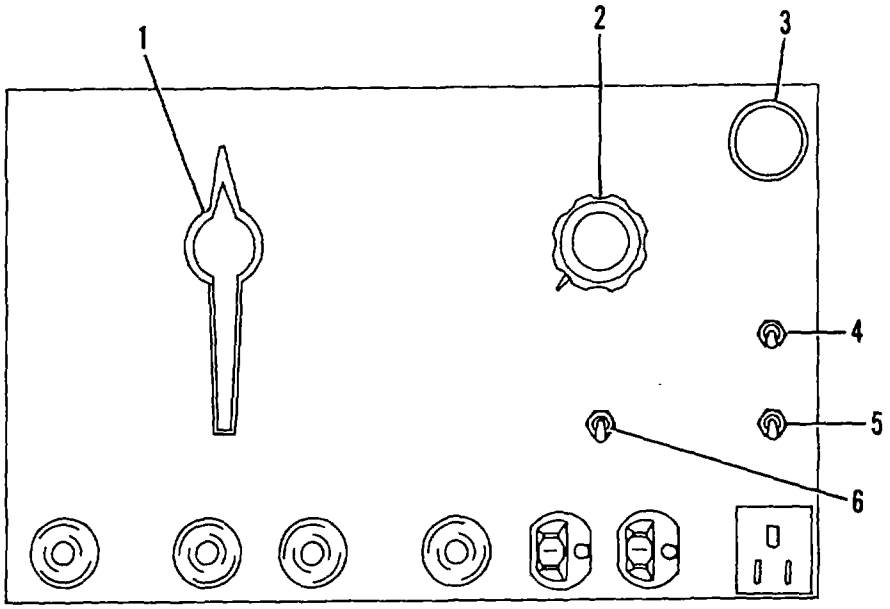


Figure 2-16 . Welder/Generator Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Range switch	Provides seven (7) coarse amperage ranges.
2	Fine amperage control	Provides voltage and amperage adjustment within each range selection.
3	Run/stop control	Controls the flow of fuel to the injector pump.
4	Start switch	Engages the starter to start the engine.
5	Idle control switch	Controls operation of the unit. Adjusts engine speed automatically when engaqed.
6	Weld/power switch	Provides selection of weld current or power plant output.

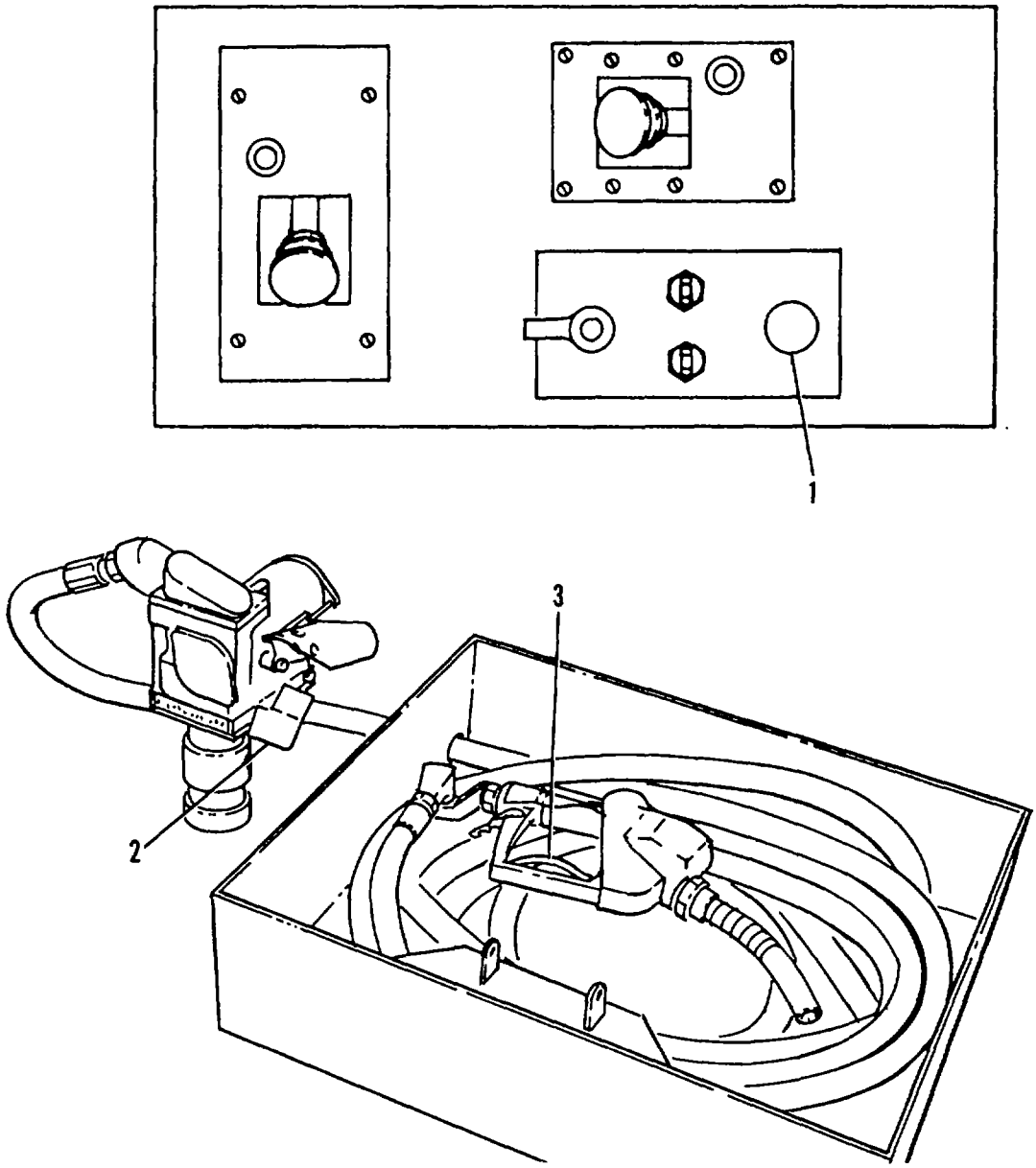


Figure 2-17 . Fuel Transfer Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Power switch (cab-mounted)	Controls electrical power to the 12-volt fuel transfer pump.
2	Power switch (pump-mounted)	Turns pump on and off.
3	Nozzle valve	Controls flow of fuel.

d. Water Heater

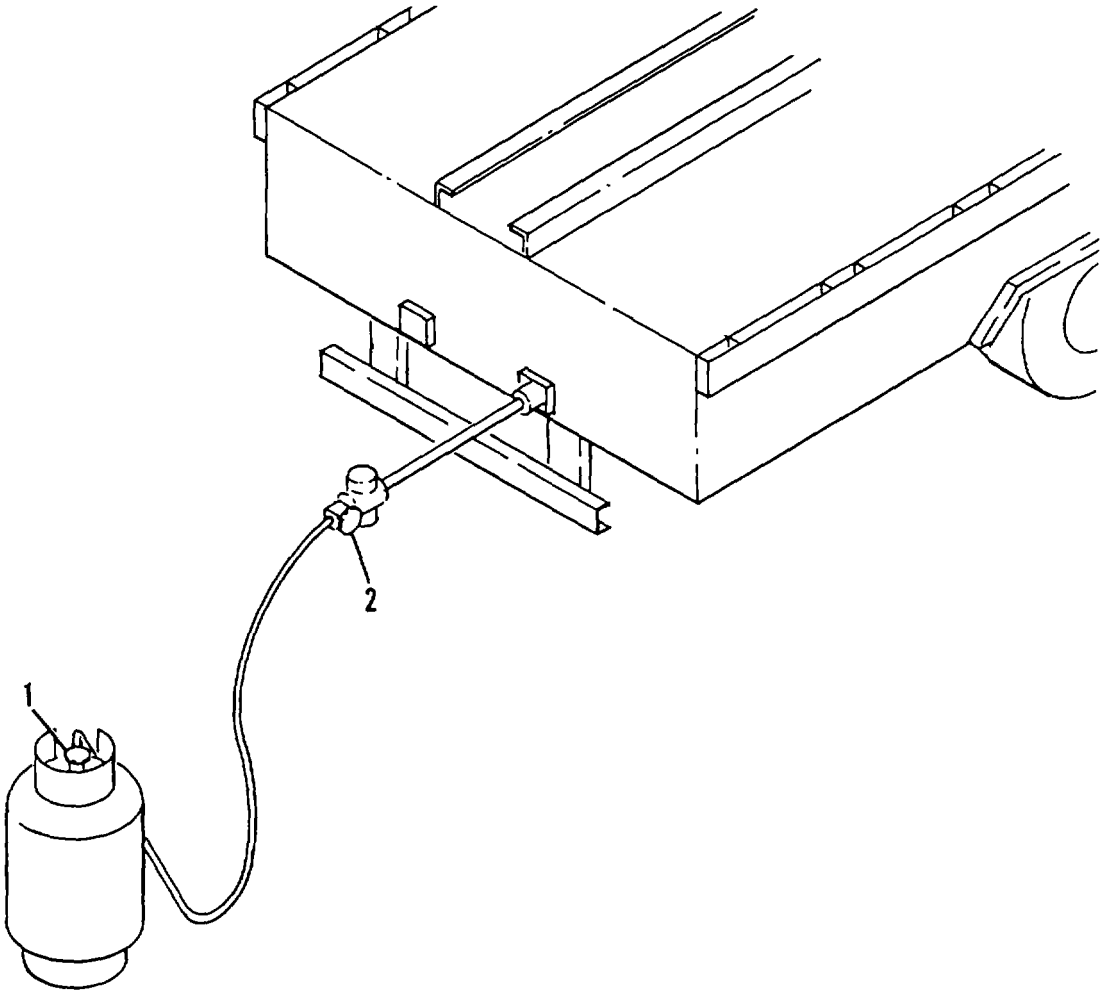


Figure 2-18 . Water Heater Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Propane tank control	Controls the amount of propane to the heating torch.
2	Heating torch control valve	Controls the amount of propane generating from the heating torch.

e. Waterbed

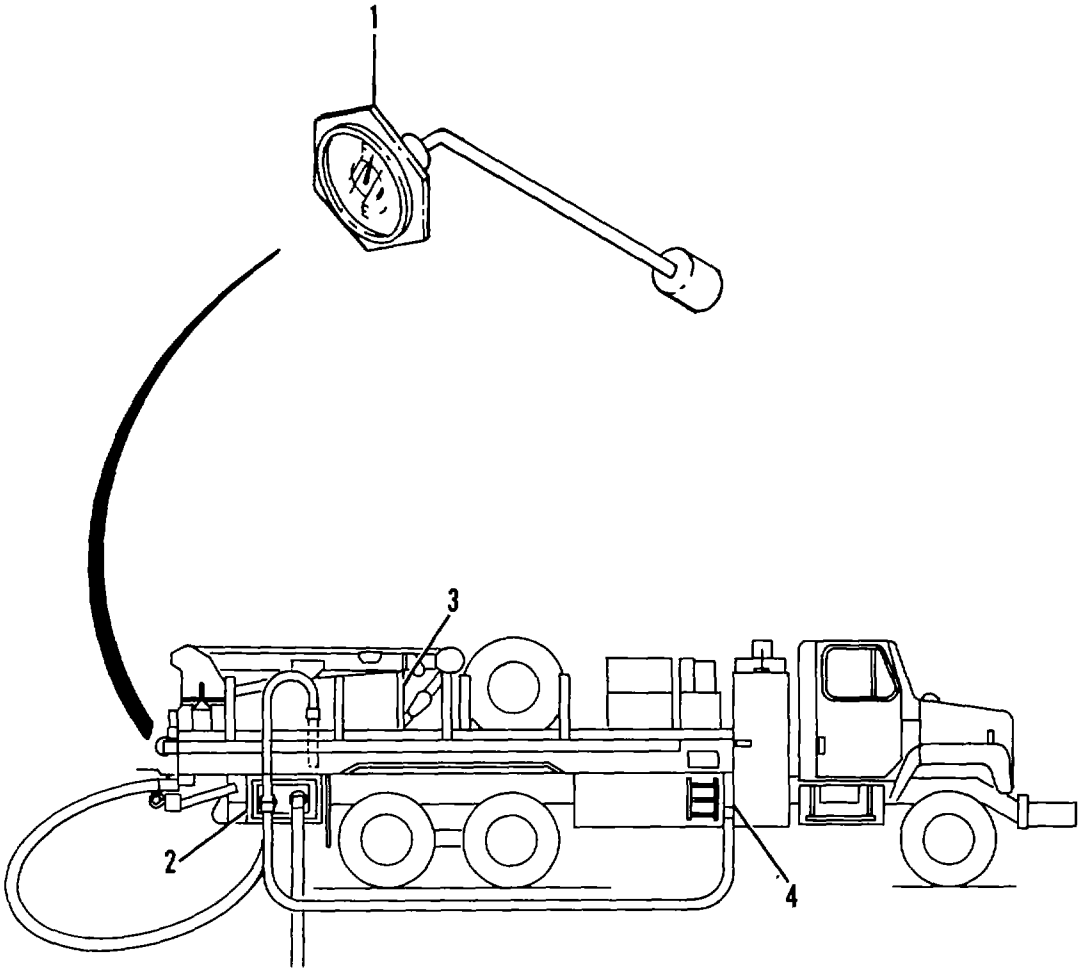


Figure 2-19 . Waterbed Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Water level gage	Indicates level of water in waterbed.
2	Water drain/fill valve	Valve for filling or draining water from waterbed.
3	Tank vent valve	Valve for venting air in or out of waterbed when filling or draining waterbed.
4	Water drain/fill (front)	Valve for filling or draining water to/from waterbed.

f. Water Pump

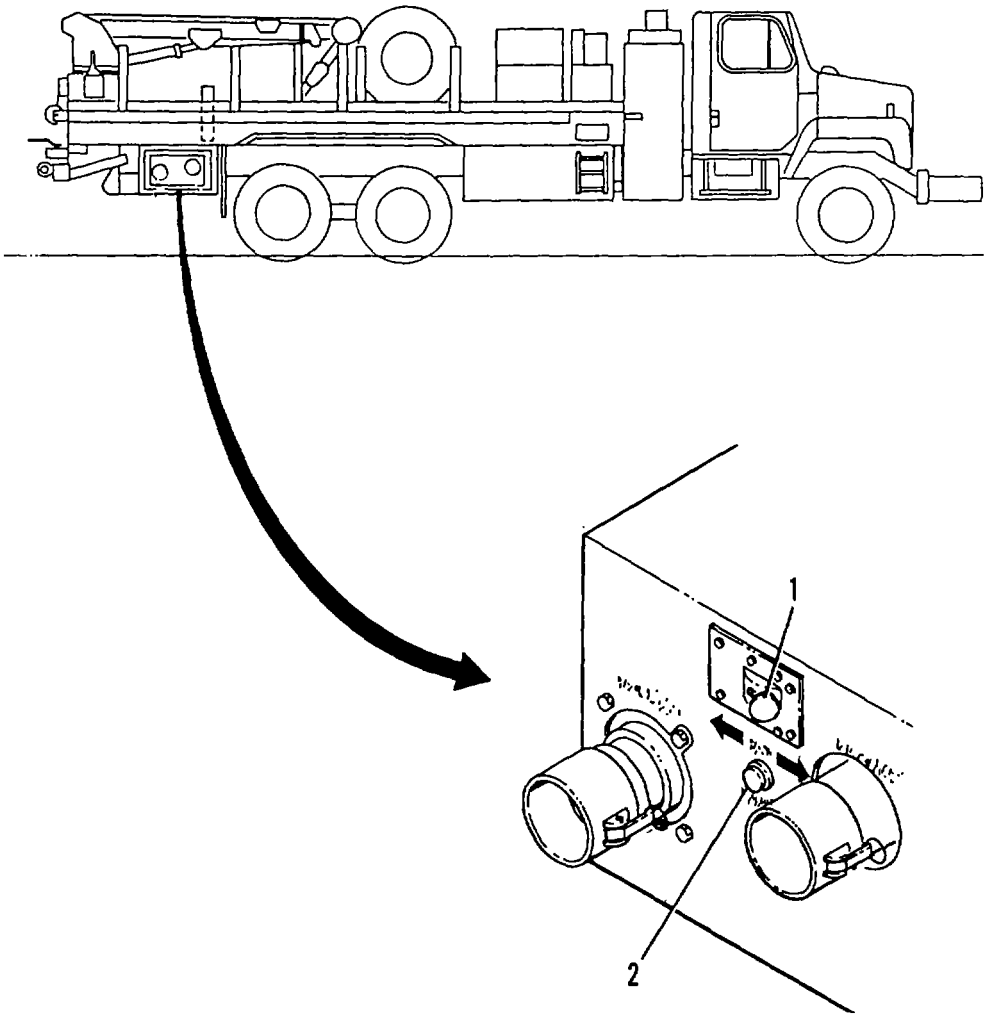


Figure 2-20 . Water Pump Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Water pump operator valve	Operates the water pump and allows directional control of water flow.
2	Indicator light	Illuminates when the water pump is engaqed.

g. Hydraulic Reservoir.

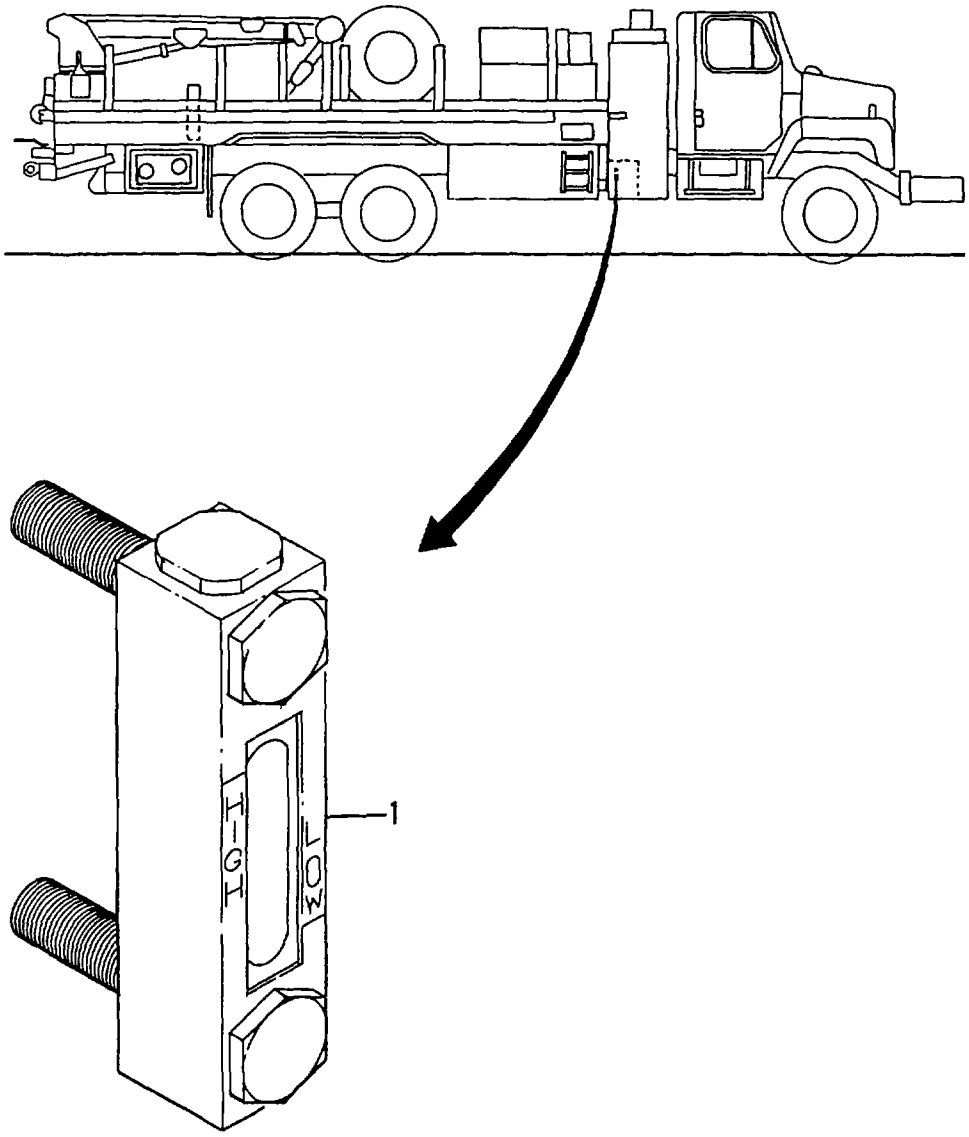


Figure 2-21 . Hydraulic Reservoir Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Oil sight gage	Indicates level of oil in hydraulic reservoir.

h. Winch

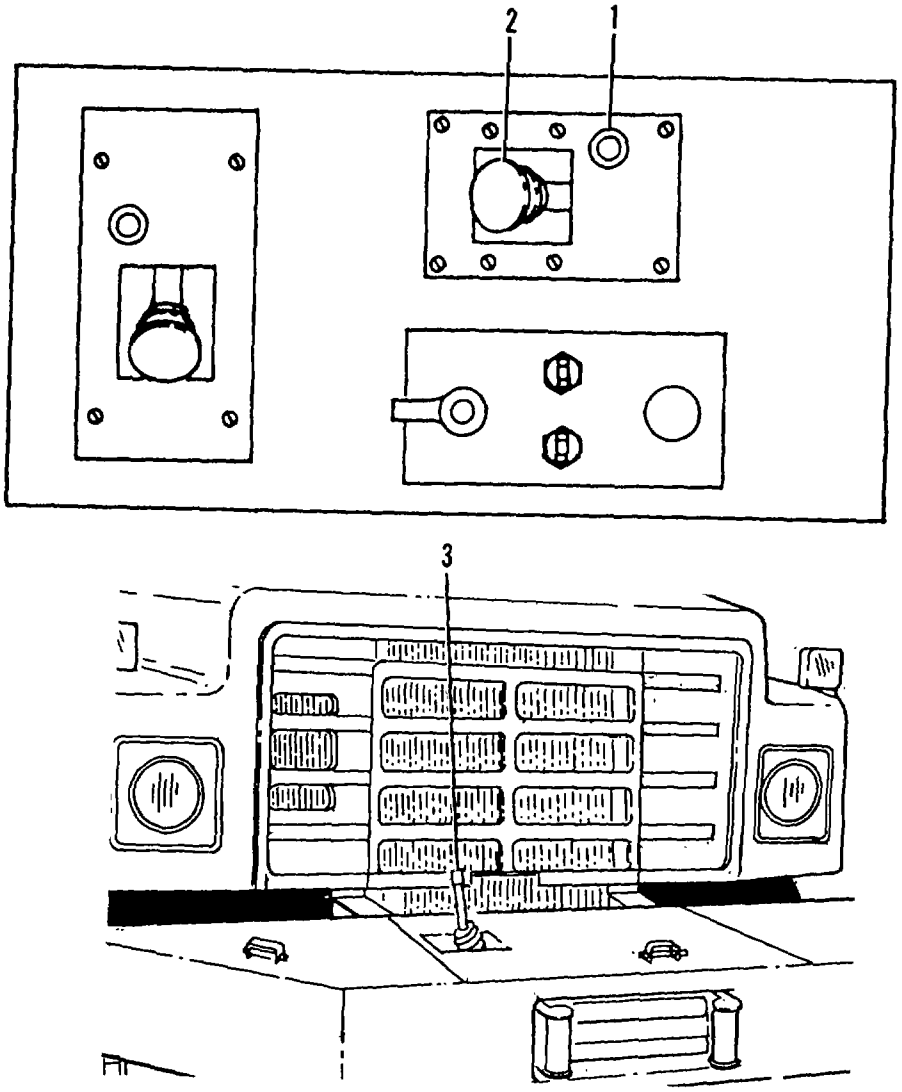


Figure 2-22 . Winch Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Winch indicator light	Illuminates when the winch is engaqed.
2	Winch operating valve	Operates the winch to wind or unwind cable.
3	Winch clutch control	Engages and disengages the winch clutch (located on truck front bumper).

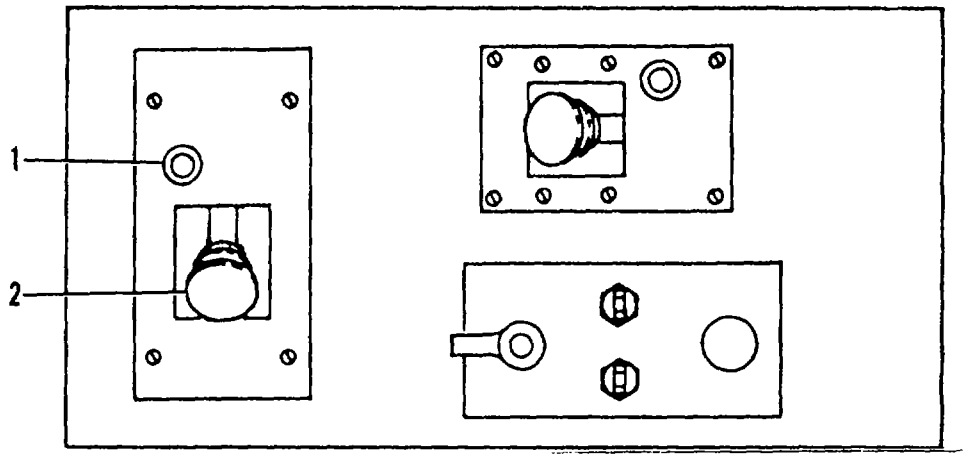


Figure 2-23 . Power Take-Off/Hydraulic System Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Indicator light	Illuminates when power take-off/hydraulic system is activated.
2	PTO/hydraulic system control	Engages and disengages the power take-off; thus activating the hydraulic system.

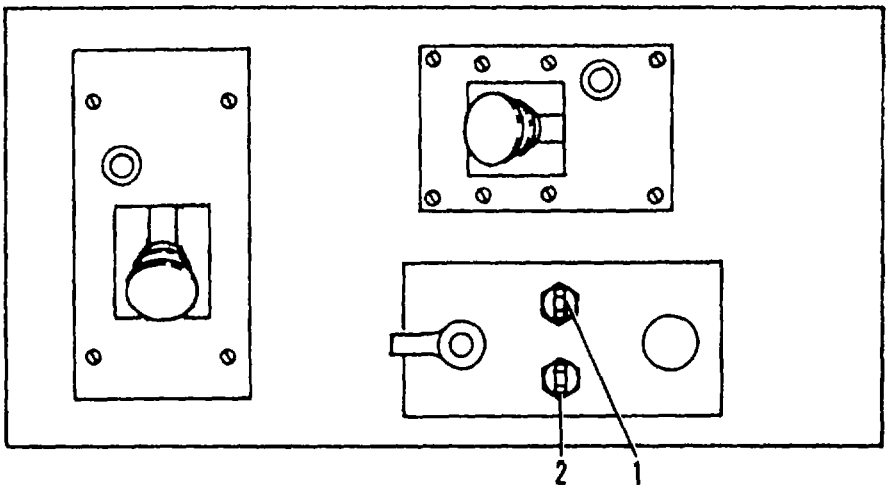


Figure 2-24 . Night Lighting Controls and Indicators

KEY	CONTROL or INDICATOR	FUNCTION
1	Driver's side floodlight switch	Turns the driver's side floodlight on and off.
2	Curb side floodlight switch	Turns the curb side floodlight on and off.

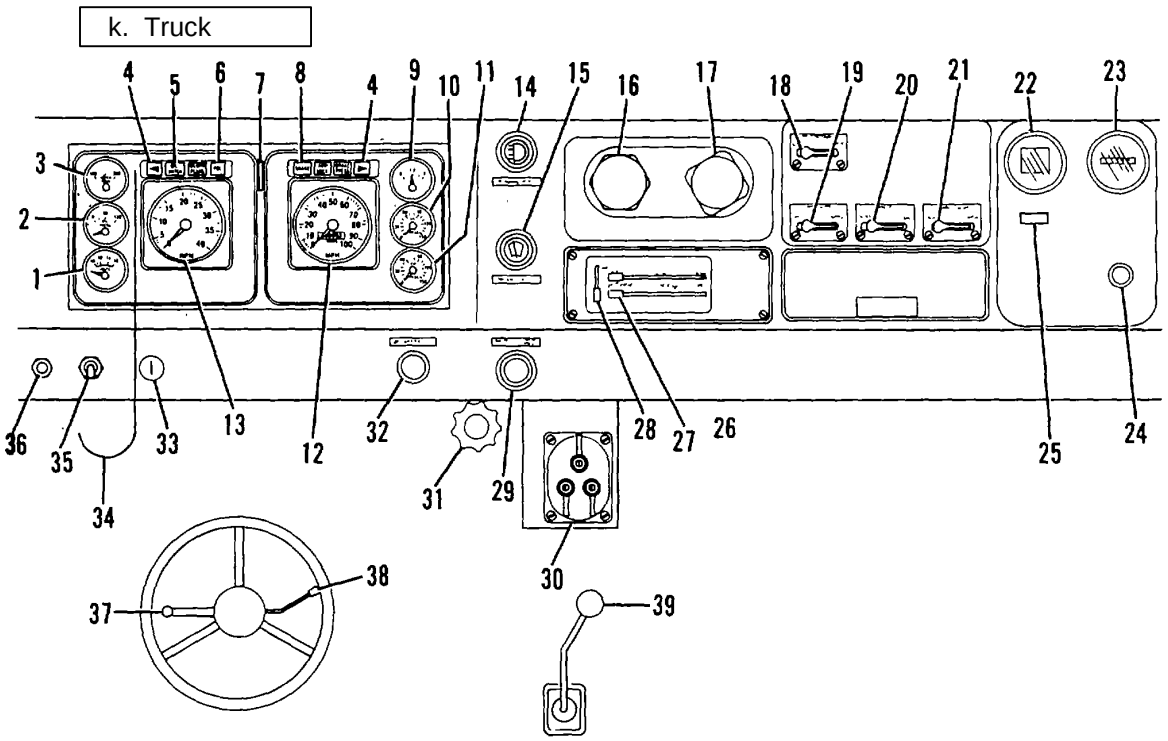


Figure 2-25 . Rig Tender Truck

KEY	CONTROL or INDICATOR	FUNCTION
1	Voltmeter	Indicates voltage in battery/generator system.
2	Oil pressure gage	Indicates pressure in engine lubricating system. Range is 25 to 30 psi.
3	Water temperature gage	Indicates temperature of engine coolant system. Range is 160 to 210 deq. F.
4	Turn signal indicator	Flasher indicates operation of left or right turn signal.
5	Oil pressure/water temperature indicator	Illuminates at low oil pressure or high coolant temperature.
6	Power divider lock indicator	Illuminates when Power Divider lever (18) is at IN position.
7	High beam indicator	Illuminates when headlights are operated at high beam.
8	Parking brake indicator	Illuminates when parking brake is set.
9	Fuel gage	Indicates level of fuel in engine fuel tanks.
10	Air pressure gage	Indicates pressure in truck air system.
11	Air pressure gage	Indicates pressure in truck air system.
12	Speedometer/odometer	Indicates vehicle speed in miles-per-hour (mph) and cumulative total of miles driven.
13	Tachometer	Indicates engine speed in revolutions per minute (rpm).

KEY	CONTROL or INDICATOR	FUNCTION
14	Not used	Former light switch; refer to item 30.
15	Windshield wiper/washer controls	Controls operation of windshield wipers and washers. Left knob controls left-side windshield; right knob controls right-side windshield. Turn CW one position for slow; second position for fast. Push for washer.
16	Trailer air supply control	Controls air supply to trailer connector at rear of truck. Push knob in to supply air; pull out to shut off air.
17	Park brake control	Pull to apply vehicle parking brake. Push in to release.
18	Power divider lock-out lever	Locks out inter-axle differential for maximum pulling power in slippery or poor road conditions. IN for additional traction; OUT for normal driving.

WARNING

Engage power divider lock-out (18) at slow speeds or when stopped and never when wheels are spinning. Do not operate the axles on dry pavement with lock-out engaged for prolonged duration.

19	Front axle lever	Select ENG to engage front axle drive; select DIS to disengage front axle drive.
20	PTO lever	Controls engine power take-off. Move to ENG to engage; to DIS to disengage PTO.
21	Transfer case lever	Select DIR (direct) for high speed; select UND (underdrive) for low speed.
22	Engine air restriction gage	Indicates condition of engine air cleaner filter. Restriction limit is 25 in. of water vacuum.
23	Hourmeter	Indicates cumulative hours of engine operation.
24	PTO indicator	Illuminates when PTO is engaqed.
25	Front axle indicator	Illuminates when front axle drive is engaqed.
26	Heater control	Lever for turning on and controlling degree of heat. Move from full left to ON; move further to the right for more heat.
27	Air outlet control	Controls heater air flow between heat (CAB) and defrost (DEF).
28	Heater fan control	Controls fan speed from LO to HI.
29	Vent control	Knob to control fresh air ventilation. CCW for ventilation; CW to close vent.
30	Lighting control unit	Controls vehicle lighting for regular service and blackout lighting operations.
31	Throttle control	Sets and holds engine throttle. To increase engine rpm, depress center button and pull out on control. To make fine throttle adjustments, turn knob CW to increase engine speed; CCW to decrease speed.
32	Engine start	Pushbutton for cranking the engine starter.
33	Key switch	Energizes truck electrical system.
34	Air horn	Lanyard controls air horn. Pull to sound.

Key	Control or Indicator	Function
35	Back-up alarm shut-off switch	Shuts off backup alarm. Up is ON; down is OFF.
36	Ether start switch	Injects ether into engine intake to aid in cold weather engine starts.
37	Turn signal/hazard warning light control	Move forward to signal right turn; back to signal left turn. Pull out on lever to activate the hazard warning signal. Push lever in to cancel hazard warning.
38	Trailer brake hand control	Hand control used to apply the trailer service brakes independently of the truck service brakes.
39	Transmission shift lever	Selects transmission gear range. Shift pattern is indicated on knob.

Section II. PREVENTIVE MAINTENANCE CHECKS AND SERVICES

2-3. General.

a. Before You Operate. Always keep in mind the **CAUTIONS** and **WARNINGS**. Perform your "before" (B) Preventive Maintenance Checks and Services (PMCS).

b. While You Operate. Always keep in mind the CAUTIONS and WARNINGS. Perform your "during" (D) PMCS.

c. After You Operate. Be sure to perform your "after" (A) PMCS.

d. If Your Equipment Fails to Operate. Troubleshoot with proper equipment. Report any deficiencies using the proper forms. See DA PAM 738-750.

2-4. Procedures. Your Preventive Maintenance Checks and Services procedures are listed in tables 2-1 through 2-30.

a. Purpose. Your Preventive Maintenance Checks and Services tables list the inspections and care of your equipment required to keep it in good operating condition.

b. Intervals. The interval column of your Preventive Maintenance Checks and Services table tells you when to do a certain check or service.

c. Procedure Column. The procedure column of your Preventive Maintenance Checks and Services table tells you how to do the required checks and services. Carefully follow these instructions. If you do not have the tools, or if the procedure tells you to, have organizational maintenance do the work.

d. Equipment is not Ready/Available if: Procedures: This column of your Preventive Maintenance Checks and Services tells you when and why your equipment cannot be used.

NOTE

The terms ready/available and mission capable refer to the same status: equipment is on hand and is able to perform its combat missions. (Refer to DA PAM 738-750.)

e. Reporting and Correcting Deficiencies. If your equipment does not perform as required, refer to Chapter 3 under Troubleshooting for possible problems. Report any malfunctions or failures on the proper DA form 2404, or refer to DA PAM 738-750.

f. Removal of Assemblies or Equipment. You should be able to perform your Preventive Maintenance Checks and Services without removing any assemblies or equipment.

2-5. Drilling Rig Preventive Maintenance Checks and Services.

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X			X		Mud pump discharge piping	Check flexible hoses for wear or damage.	Wire braid reinforcement is exposed.
		X					Check for leaks.	Unrepairable leaks cause significant pressure loss.
2		X				Mast lighting	If operating at night, check that lights illuminate.	Lights fail to illuminate.
3				X		Mast weldment	Check for damage and for cracked or rusted welds.	Mast is not structurally sound.
4				X		Crown block	Check for damage and wear to the sheaves.	Sheaves show signs of excessive wear or damage.
5				X		Pulldown chain and sprockets.	Check for damaged or worn chains or sprockets.	Sprockets show signs of wear; teeth cracked or missing; chain worn or broken.
6				X		Mast cylinders	Check that hardware is secure and properly lubricated.	Hardware is missing or loose.

Table 2-2. Mud Pump Drive Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Drive case	Check oil level. Fill as required.	Oil level is below recommended level.
2	X					Mud pump power end	Check oil level; fill as required.	Oil level is below recommended level.
					X	Mud pump fluid end	Check rubber inserts in valves. If worn, replace inserts.	Pump will not pressure up properly.

Table2-3. Air Compressor Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1		X				Shaft seal	Check for air leaks.	
2		X				Oil Cooler	Check cooler fins for damage and lines for leaky connections.	
3	X	X				Oil Filter	Check filter gage.	Gage indicates in the red area.
4		X				Cooler motor	Check for leaks.	
5	X					Intake air cleaner	Check filter condition. Check that ejection valve is not damaged or missing. If damaged or missing, notify unit level maintenance.	
6	X					Air/oil separator	Check oil level at sight gage. If low, fill to proper level.	
7		X				Air compressor panel	Check injection oil pressure reading on low oil pressure gage.	45 psig pressure cannot be maintained with compressor loaded.
		X					Check temperature reading on injection oil temperature gage.	Temperature exceeds 160 deg. F.
		X					Check temperature reading on air/oil temperature gage.	Temperature exceeds 200 deg. F.
		X					Check vacuum reading on water column vacuum gage. If intake air filter cartridge reading is 12 in. or higher, notify direct support maintenance.	

Table 2-4. Sub Drive Assembly Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL B	D	A	W	M	Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
1		X				Drive case Check oil level.		
2	X					Driveshafts	Lubricate driveshafts as recommended.	
		X				Driveshafts and bearings	Check for signs of worn bearings. Check if bearings are making noise or running hot.	
3	X					Power take-off	Check lubricant. Add lubricant as required.	
4	X	X				Hydraulic pumps	Check seals and hose connections for oil leaks. Listen for unusual noises.	

Table 2-5. Drawworks Assembly Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL B	D	A	W	M	Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
I		X				Bevel gear case	Check oil level. Add lubricant as required. oil level.	No oil or very low
		X					Check case for leaks.	
2	X					Driveshafts	Lubricate driveshafts as recommended.	
3				X		Brake bands	Check linings for wear.	Lining is less than 1/4: thick.
4	X					All drums	Check wire rope for frayed strands.	Wire rope is frayed or badly kinked.
5	X					Third drum	Check clutch control linkage connections are secure.	

Table 2-6. Hydraulic System Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL B	D	A	W	M	Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
I	X					Reservoir	Check oil level sight gage. Add hydraulic oil as required.	No oil or very low oil level.
2	X	X				Hydraulic oil filter	Check dirt alarm gage.	Gage indicates CHANGE.
3		X				Hydraulic oil piping	Check lines for leaks.	

Table 2-7. Water/Foam Injection Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Reservoir	Check water level in sight glass. Add water as required.	
2	X					Foam container	Check chemical level in container. Add chemical as required.	
3	X	X				Hydraulic motor	Check lines and fittings for leaks.	
4	X			X		Drive belt, motor	Check for cracks and fraying.	
5	X					Hydraulic oil piping	Check lines for leaks.	
6	X					Water injection pump	Check lubricant level. Add as recommended.	
7	X					Foam pulse pump	Check for leaks.	

Table 2-8. Force/Feed Lubricator Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
I	X					Reservoir	Check lubricant level in sight glass. Add lubricant as required.	
2		X				Lubricator	Adjust the flow of lubricant into air line during air drilling.	
3		X				Lines and fittings	Check for leaks.	

Table 2-9. Break-out Assembly Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X	X				Break-out tongs	Check tong dies for dirt accumulation or wear. Clean as required. Notify unit maintenance for replacement.	
	X						Check wire rope for fraying; check rope clips for loose nuts. Notify unit maintenance for repair.	
2	X					Hydraulic cylinder, lines and fittings	Check for leaks at hose connections. Check cylinder for leakage past the piston rod.	

Table 2-10. Rotary Table Drive Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Table Driveshaft	Check for signs of worn bearings. Lubricate shaft as recommended.	
2	X					Shift Linkage	Check linkage for secure mounting and correct adjustment.	
3	X					Hydraulic pump and fittings	Check for leaks.	
4	X					Hydraulic transfer cylinders	Check for leaks. Lubricate transfer table slides.	
5	X					Transmission	Check oil level in transmission. Fill as recommended.	
6				X		Table Base	Clean accumulations of mud as needed. Lubricate table as recommended.	

Table 2-11. Pulldown/Chain Feed Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Chains and Sprockets	Check for signs of worn or damaged chains.	
	X						Check sprockets for broken or missing teeth. Lubricate as recommended.	
2				X		Control linkage	Check for secure mounting; check for proper adjustment.	
3	X					Pulldown transmission	Check oil level in transmission. Add oil as required.	
4	X	X				Hydraulic motor	Check for leaks. Listen for any unusual noises.	

Table 2-12. Instrument Panels Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL B D A W M	Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
1	X	Operator's panel	Check for correct readings.	Gages indicate out of specified range.
	X X		Check for broken or cracked lens; be sure indicators function properly.	
2	X	Throttle	Check linkage for security and correct adjustment.	
3	X	Air compressor panel	Check for correct readings.	Gages indicate out of specified range.
	X X		Check for broken or cracked lens; be sure indicators function properly.	

Table 2-13. Control Air System Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL B D A W M	Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
1	X	Control valves	Check for proper operation.	Controls do not perform properly.
2	X	Air line conditioner	Check filter bowl for moisture accumulation. Drain moisture.	
	X		Check air regulator gage for correct pressure reading.	Required air pressure is not available to operate controls.
	X		Check lubricant level in line lubricator. Add lubricant as required.	
3	X	Air lines	Listen for hissing that would indicate a leak in air line.	Leakage prohibits adequate pressure for operating controls.

Table 2-14. Rig Frame/Jacks Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Frame lighting	For night transporting, check all clearance lights illuminate. Replace bulbs as required.	Clearance lights are not illuminating.
2	X					Mud flaps	Check mud flaps are in good condition. Replace worn out or damaged flaps.	
3	X					Driller's and helper's platform	Check for broken welds. Repair minor damage; replace if extensively damaged.	
	X						Check that locking bolts are in place.	
4	X					Jacks and jack pads	Check jack pads for broken welds. Check for leaks at hydraulic hose connections.	
5	X					Hand jack	Check operation; replace failed jack.	
6	X					Rig frame	Check for broken welds. Report any damage to unit maintenance.	Frame has broken welds or structural damage.

Table 2-15. Winch Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Winch covers	Check that props hold covers open during winch operation.	Radiator-protecting covers are not in place.
			X				Close covers.	
2	X					Winch Cable	Check cable for breaks or separated strands.	Wire rope is broken or strands separated.
					X		Lubricate cable.	
3	X					Guide rollers	Check for cracks, loose bolts, and free roller movement.	
X							Lubricate zerk fittings.	
4	X					Hydraulic motor	Check for leaks at hose connections.	Leakscannot be stopped.
5	X					Control Valve	Check for proper operation.	Control fails to Operate winch.

Table 2-16. Truck Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Cab/body group	Check for dents, damage, rust, or corrosion to the truck exterior and undercarriage.	
	X						Check interior of truck for damage. Check control console for broken or damaged knobs or handles.	
2	X					Windshield wiper/washer	Check wiper blades for wear. Replace worn or damaged wiper blades.	
	X						Check fluid level in windshield washer reservoir. Add washer fluid (or water) as necessary.	
3	X					Foot controls	Check pedals for ease of movement. Check brake pedal travel to insure proper braking action. Remove any mud accumulations.	Brake pedal travels to floor without stopping.
4	X					Shift Lever	With clutch engaged, check shift operation.	
5	X					Steering group	Check power steering fluid level. Add fluid as required.	
6	X			X		Exhaust system	Check tailpipe and muffler for signs of corrosion or damage. Inspect manifolds for rust or corrosion.	
7	X					Radiator	Check level of coolant. Add anti-freeze as required to fill. Check around inlet and outlet for signs of leakage. Check for obstructions in the fins; remove if any.	Coolant level is very low.
8				X		Drive belts	Check the condition of belts; look for fraying or cracking. Check that belts are properly adjusted. Tighten if necessary.	
9	X					Steering pump	Check for signs of fluid leaking from the hose connections.	
		X					While driving, listen for unusual noises during turns.	
10		X				Alternator	While driving, check voltmeter for correct indication.	
11	X					Starter motor	While starting engine, listen for unusual noises. Clicking sounds may indicate a bad motor or solenoid.	

Table 2-17. Engine Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1					X	Air cleaner	Inspect filter in air cleaner. Replace if dirty.	
2					X	Fuel lines and filter	Check lines from tank to engine for signs of fuel leaking. Check for clogged filter. Notify unit maintenance for replacement.	
3					X	Fuel injection pump	Check for leakage at fuel lines connections to the injection pump.	
4		X				Air compressor	During operation, check for proper air pressure indication on gages.	Air pressure is not adequate to operate air brakes.
5				X		Water pump and hoses	Check for leakage around pump inlet and outlet. Check hoses for leaks.	
6				X		Oil cooler and filter	Inspect tubes for obstructions. Replace filter at recommended intervals.	
7	X					Oil pan	Check for dripping or oil spots on the ground. Be sure drain plug is tight.	

Table 2-18. Drive Train Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available If:
	B	D	A	W	M			
1				X		Transmission	Check transmission lube oil level. Add fluid if required.	Transmission has little or no lube oil.
2					X	Transfer case Driveshaft	Check for signs of worn bearings. Lubricate shaft as recommended.	
3					X	Front axle driveshaft	Check for signs of worn bearings. Lubricate shaft as recommended.	
4				X		Transfer case	Check oil level. Add fluid as required.	
5					X	Interaxle drive driveshaft	Check for signs of worn bearings. Lubricate shaft as recommended.	
6					X	Rear axle driveshaft	Check for signs of worn bearings. Lubricate shaft as recommended.	
7					X	Front rear axle	Check lube oil level in gearcase. Add oil as required.	
8					X	Rear axle	Check lube oil level in gearcase. Add oil as required.	
9					X	Front axle	Check lube oil level in gearcase. Add oil as required.	

2-6. Rig Tender Preventive Maintenance Checks and Services

Table 2-19. Crane Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Hydraulic Fluid Reservoir	Check fluid level in sight gage. Add hydraulic as needed.	Fluid level is not visible.
2	X					Crane	Visually inspect crane for loose parts.	Parts are loose or missing.
3	X					Snatch Block and Crane Hook	Check for deformation or cracks.	Snatch Block or crane hook is deformed or cracked.
4	X					Boom Tip Sheave	Check for signs of grooving.	Wire rope has worn groove into sheave.
5	X					Wire rope/cable	Check wire rope for breaks, separated strands, kinks, bird-caging, or evidence of heat damage.	
6				X		Winch drum	Check for cracks or excessive wear.	Drum is cracked or excessively worn.
7	X					Manual pullout extension	Check for cracks. Extension is	cracked.
8	X					Hydraulic extension boom and cylinder	Check for hydraulic leaks in the cylinder and cracks in the boom.	Boom is cracked or leaks cannot be stopped.
9	X					Extension cylinder pins	Check for cracks around mounting holes. Check that pins are securely installed. holes.	Cracks are visible around mounting
10	X					Main boom and cylinder	Check for hydraulic leaks in the cylinder and cracks in the boom.	Boom is cracked or leaks cannot be stopped.
11	X					Main cylinder pins and bushings	Check for proper installation of pins. Check for cracks around bushing mounting holes. holes.	Cracks are visible around mounting
12	X					Main boom hinge pin and bushings	Check for proper pin installation. Check for cracks around mounting holes.	Hinge pin improperly installed. Cracks visible around mounting holes.
13				X		Boom turret	Check for cracks in plates and welds. Check for loose mounting bolts.	Plate or weld is cracked.
14	X	X				Hydraulic winch	Check winch motor for hydraulic leaks.	Leaks cannot be stopped.
15				X		Base assembly	Check for cracks and loose bolts.	Housing is cracked or bolts are loose.
16	X	X				Rotation Motor	Check motor for hydraulic leaks.	Leaks cannot be stopped.
17				X		Remote control pendant	Check for loose connections or cracked wire.	Wire loose or broken.

Table 2-19. Crane Preventive Maintenance Checks and Services (cont'd.)

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
18	X					Switches on remote control pendant	Check switches for malfunctions.	Any control fails to operate.
19				X		Crane hydraulic control valves	Check spools for sticking and failure to return to neutral position.	Valves stick or operate erratically.
20	X					Operator's platform	Check for loose mounting bolts and defective latch.	
21				X	X	Lubrication	Lubricate as required by chapter 3.	

Table 2-20. Welder/Generator Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
						WELDER/GENERATOR		
1				X		Engine Battery	Check electrolyte level. Add distilled water if required (Reference TM 9-6140-200-141.)	Battery is dead.
2	X					Fuel tank	Check fuel level. Add diesel fuel if needed.	
						ENGINE ASSEMBLY		
3	X					Engine oil level	Check oil level. Add oil, if needed, to raise level to full mark.	Oil does not show on dipstick.
4	X		X			Air cleaner	Check and clean oil bath air cleaner.	
5	X		X			Cooling fins	Clean as necessary.	
6	X					V-belt	Check that belt deflection between pulleys is not more than 3/8 in. (10mm- Check for cracks and frayed areas.	
7					*	Expendable fuel filter	Every 1,200 running hours, replace fuel filter.	
8					X	Manifold	Check intake and exhaust manifold for leaks. Check mounting bolts for tightness.	
						GENERATOR ASSEMBLY		
9					*	Circuit breaker	Every 1,200 hours, check breaker.	
10	X					Switches	Check for smooth switching operation. Check for broken switches and knobs.	Switches or knobs broken.
11	X					Welder Leads	Check for cracked insulation or damaged cables. Check for damaged prongs.	Insulation is cracked. Cable is damaged.
12	X	X				Ground clamp	Check for secure ground clamp connection.	Welder cannot be grounded.

Table 2-21. Fuel Transfer Pump Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Tank	Check fuel level. Add diesel fuel as needed.	
				X		Fill/Vent cap	Check fill cap strainer for debris. Check vent hole for obstruction.	
2	X					Nozzle	Check for bent or broken trigger and automatic trigger latch.	
		X					Check for sticking or binding or binding trigger. Check for leaks at hose connections.	Trigger sticks or leaks cannot be stopped.
		X					Check trigger latch for automatic close.	Nozzle will not close automatically.
3	X					Hose	Check for kinks, cracks, and abrasion.	Hose is cracked.
		X					Check for leaks.	Leaks cannot be stopped.
4	X					Cab-mounted fuel transfer switch	Check for malfunction or inoperative fuse.	Pump does not run.
				X			Check for loose or broken connections.	No electrical power from switch to pump.
5	X					Pump mounted fuel transfer switch.	Check for malfunction.	Pump does not run.

Table 2-22. Water Heater Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Hose,pre-set regulator, fittings	Make sure all connections are tight. Note: Left-Hand Threads.	Gas leaks from connections or hose.
2	X					Heating torch	Make sure valve is operating properly.	Valve not working properly.
3		X					Check for unusual odors or sounds.	A gas leak is suspected.
4		X					Check that flame is lit when valve is open.	Flame does not stay lit.
5	X					Propane tank	Check level of propane (by weight).	Propane tank is empty.
6						Tank valve	Check that valve is operating properly.	Valve not working properly.
7					X	Torch adapter bracket	Check for damage.	

Table 2-23. Waterbed Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
I	X					Water	Check water level. Add water as needed.	
2	X					Storage tank	Visually inspect for leaks or cracks in waterbed seams.	Waterbed is leaking excessively.
3	X					Water drain valve	Check for sticking or binding.	Valve cannot be operated.
4	X					Water gage	Check for proper register/broken face plate glass.	
5	X					Crane boom stand vent	Check for obstruction prior to filling.	Vent is plugged or obstructed.
6	X					Rear 3/4" ball valve vent	Open prior to filling waterbed.	Vent is closed.
7			X			Fill cap	Reinstall cap after filling.	
8				X		Steps/handrails	Check for bent or broken steps or handrails.	
9				X		Tool boxes and vertical cabinets.	Check for damaged hinges or latches.	
10				X		Vise	Check for broken or damaged chain and tightening screw.	Chain or screw is broken.
11				X		Workbench	Check for binding and/or damaged locking latch.	Workbench binds or latch is damaged.

Table 2-24. Water Pump Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Pump and motor	Check for corrosion and damage.	Pump casing is cracked or broken.
2	X					Pump and motor	Check for loose or missing bolts.	Loose or missing bolts.
3		X				Pump and motor	Check for water leakage during pumping.	Leaks cannot be stopped.
4		X				Pump and motor	Check for hydraulic fluid leaks.	Leaks cannot be stopped.
5		X				Pump and motor	Check for decrease in operating speed.	Pump operating speed varies while truck engine rpm does not.
6		X				Pump and motor	Check for unusual noises or vibrations.	
7	X					Hydraulic fluid	Check hydraulic reservoir sight gage.	Fluid level is not visible.
		X				Hydraulic fluid	Check reservoir for excessive heating.	Hydraulic fluid overheats.
8	X					Pump drain valve	Insure valve is closed.	
			X			Pump drain valve	Open valve to drain water.	Water remaining in pump freezes.
9	X					Hoses	Check for cuts, tears, or wear.	Wear or damage allows leakage.
			X			Hoses	Replace in storage chamber.	
10	X					Hose couplings	Insure couplings fit together properly.	
11	X					Suction strainer	Clean any debris from strainer.	
12	X					Water pump operating valve	Check for malfunction. flow as indicated.	Water does not
13	X					Indicator light	Check light is illuminated when valve is activated.	

NOTE: WATER PUMP HAS STAINLESS STEEL SHAFTS AND TEFLON BEARINGS - IT REQUIRES NO LUBRICATION.

Table 2-25. Hydraulic Reservoir Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X	X				Hoses and fittings	Inspect for sharp bends, leaks, abrasion, and chafing.	Hoses/fittings damaged or leaking.
2	X	X				Hydraulic reservoir	Inspect reservoir for leaks.	Reservoir leaks.
3	X					Sight gage	Check for proper oil level.	Oil level not visible.
		X				Sight gage	Check for leaks.	Leaks cannot be stopped.
4					X	Suction strainer	Check suction hose strainer (inside reservoir) for obstructions.	Strainer obstructed.
5					X	Return hose filter	Check for clogged filter.	Filter obstructed.
6					*	Hydraulic oil	Annually, drain, flush with diesel fuel, and fill with new oil.	Hydraulic oil is dirty or contaminated.

Table 2-26. Winch Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Winch covers	Check that props hold covers open.	Covers will not stay open to protect radiator if cable breaks under load.
			X			Winch covers	Check that covers are closed.	
2	X					Clutch lever	Insure clutch lever is engaged.	Clutch disengaged.
			X			Clutch lever	Insure clutch lever is disengaged.	
3	X					Winch cable	Check wire rope for breaks, separated strands, birdcaging, or evidence of heat damage.	Wire rope has broken or separated strands.
					X	Winch cable	Lubricate.	
4	X					Tail chain	Check for cracks, bad connection to cable, and broken hook loop.	Tailchain is cracked or broken or connection is bad.
			X			Tailchain	Check that tailchain is secured to loop.	Cable is not anchored.
5	X					Cable guide roller	Check for cracks, loose bolts and free movement of rollers.	Guide roller is loose or cracked.
					X	Cable guide roller	Grease zerk fittings.	Rollers will not turn.
6	X	X				Hydraulic motor	Check for hydraulic oil leaks.	Leaks cannot be stopped.
7	X					Hydraulic fluid	Check hydraulic reservoir sight gage.	Fluid level is not visible.
8	X					Winch operating valve	Check for malfunction.	Winch fails to function.
9	X					Indicator light	Check for illumination when valve is activated.	
10		X			X	Winch housing	Check for gear oil leaks around winch housing.	
11					X	Winch sump	Check oil level in sump.	Low oil level.
12					X	Winch mounting bolts	Check for loose or missing mounting bolts.	Loose or missing bolts.
13					X	Drum	Check drum to make sure it is not	Drum is cracked. cracked.

Table 2-27. Night Lighting Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available If:
	B	D	A	W	M			
I	X					Lamps	Check for cracks in glass.	Lamps are burned out.
2	X					Switches	Check for malfunction.	Lamps do not light.
3				X		Light brackets with shell assemblies	Check for dirt or corrosion; also for proper tilt and swivel.	
4				X		Electrical leads	Check for breaks, frayed insulation, rust, dirt or other damage.	
5				X		Mounting base and bolts	Check for cracks, damage, and rust; check mounting bolts are tight.	
6				X		Debris guard	Check for dents, cracks, or other damage.	
7				X		Lamp retainers	Check for dents, cracks, or other damage.	

Table 2-27A. Life-line, Self Retractable
Preventive Maintenance Checks and Services - continued

Item No.	Interval					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary	Equipment is Not Ready/Available If:
	B	D	A	W	M			
							WARNING To avoid injury or death, immediately remove any fall arrest device with suspected faults from service and notify supervisor.	
1	X		X	X		Shackle	Check that shackle moves freely and that nut is fully tightened. Check for worn parts, damage, and corrosion.	Shackle does not more freely; nut missing or damaged. Shackle is cracked or worn.
2	X		X	X		Main Body Castings	Check Main body castings for distortion or cracks, and that attaching hardware is fully tightened.	Main body casting damaged or missing screws.
3	X		X	X		Spring Retraction	Check that cable retracts properly.	Cable does not retract.
4	X		X	X		Cable	**WARNING** When inspecting cable, wear gloves. Broken wires on cable can cause severe cuts and lacerations.	
							Check cables for cuts, abrasion, kinking, corrosion, and rust.	Cable cut, worn, kinked, corroded, or rusted.
							Check swages for cracks, distortion or corrosion. Ensure they have been fitted properly and are not piercing cable. For DBU series, check rubber balls are sound.	Swages not properly installed.
							Pull cable out and visually inspect the entire length. Ensure locking action operates properly by jerking on the other end of the cable every 3 to 5 feet of cable extension. Cable should lock within 3 feet of jerk point.	Cable fails to lock on any jerk.

Table 2-27A. Life-line, Self Retractable
Preventive Maintenance Checks and Services - continued

Item No.	Interval					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary	Equipment is Not Ready/Available If:
	B	D	A	W	M			
5	X		X	X		Red Indicator Button	Models SB57 - SB150 and SB 330: Check that indicator button is flush with casing. Model C60/50: Check that indicator button is recessed. DBU Series: Check that visual service life dial indicator does not indicate RED DANGER.	Indicator button not situated where it should be; service life dial indicator indicates RED DANGER.
6	X		X	X		Red Ferrule/Bobbin	Check that Red Ferrule/Bobbin is NOT visible on cable.	If visible, cable has been used to arrest a fall. Remove from service immediately and notify supervisor.
7	X		X	X		D-rings	Check D-rings for wom parts, damage or corrosion.	D-Rings worm, damaged, or corroded.
8	X		X	X		Snap Hooks	Check that hooks have snap action and that there is no sideways play. Check for worn parts, damage, and corrosion.	Hook does not have proper snap action; snap hooks worn, damaged, or corroded.
9	X		X	X		Automatic locking hooks	Check that hooks lock. Check for worn parts, damage, and corrosion.	Hooks do not lock; hooks worn, damaged, or corroded.
10	X		X	X		Screwgate hooks	Check snap action and that screw ferrule function properly. Check for wom parts, damage, and corrosion.	Hooks do not snap properly; hooks worm, damaged, or corroded.

Table 2-28. Truck Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1	X					Cab/body group	Check for dents, damage, rust, or corrosion to the truck exterior and undercarriage. Check interior of truck for damage. Check control console for broken or damaged knobs or handles.	
2	X					Windshield wiper/washer	Check wiper blades for wear. Replace worn or damaged wiper blades. Check fluid level in windshield washer reservoir. Add washer fluid (or water) as necessary.	
3	X					Foot controls,	Check pedals for ease of movement. Check brake pedal travel to insure proper braking action. Remove any mud accumulations.	Brake pedal travels to floor without stopping.
4	X					Shift lever	With clutch engaged, check shift operation.	
5	X					Steering group	Check power steering fluid level. Add fluid as required.	
6				X		Exhaust system	Check tailpipe and muffler for signs of corrosion or damage. Inspect manifolds for rust or corrosion.	
7	X					Radiator	Check level of coolant. Add antifreeze as required to fill. Check around inlet and outlet for signs of leakage. Check for obstructions in the fins; remove if any.	Coolant level is very low.
8				X		Drive belts	Check the condition of belts; look for fraying or cracking. Check that belts are properly adjusted. Tighten if necessary.	
9	X					Steering pump	Check for signs of fluid leaking from the hose connections.	
		X					While driving, listen for unusual noises during turns.	
10		X				Alternator	While driving, check voltmeter for correct indication.	
11	X					Starter motor	While starting engine, listen for unusual noises. Clicking sounds may indicate a bad motor or solenoid.	

Table 2-29. Engine Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1					X	Air cleaner	Inspect filter in air cleaner. Replace if dirty.	
2					X	Fuel lines and filter	Check lines from tank to engine for signs of fuel leaking. Check for clogged filter and replace if necessary.	
3					X	Fuel injection pump	Check for leakage at fuel lines connections to the injection pump.	
4		X				Air compressor	During operation, check for proper air pressure indication on gages.	Air pressure is not adequate to operate air brakes.
5				X		Water pump and hoses	Check for leakage around pump inlet and outlet. Check hoses for leaks.	
6				X		Oil cooler and filter	Inspect tubes for obstructions. Replace filter at recommended intervals.	
7						Oil pan	Check for dripping or oil spots on the ground. Be sure drain plug is tight.	

Table 2-30. Drive Train Preventive Maintenance Checks and Services

ITEM NO.	INTERVAL					Item to be Inspected	Procedures Check for and have repaired or adjusted as necessary.	Equipment is not ready/ available if:
	B	D	A	W	M			
1				X		Transmission	Check transmission lube oil level. Add fluid if required.	Transmission has little or no lube oil.
2					X	Transfer case driveshaft	Check for signs of worn bearings. Lubricate shaft as recommended.	
3					X	Front axle driveshaft	Check for signs of worn bearings. Lubricate shaft as recommended.	
4				X		Transfer case	Check oil level. Add fluid as required.	
5					X	Interaxle drive driveshaft	Check for signs of worn bearings. Lubricate shaft as recommended.	
6					X	Rear axle driveshaft	Check for signs of worn bearings. Lubricate shaft as recommended.	
7					X	Front rear axle	Check lube oil level in gearcase. Add oil as required.	
8					X	Rear axle	Check lube oil level in gearcase. Add oil as required.	
9					X	Front axle	Check lube oil level in gearcase. Add oil as required.	

Section III. DRILLING RIG OPERATION UNDER USUAL CONDITIONS

2-7. Assembly and Preparation for Use. The drilling rig is shipped fully assembled and ready for use. Position the rig on flat, solid ground that has been cleared and leveled. Before you settle on the final position, check that the mast will have adequate overhead clearance when raised; consider where the rotary table hole center will be when aligning the rig over the hole site. Visually check for any damage that may have occurred during transit.

2-8. Initial Adjustments, Daily Checks, and Self Test.

a. Perform the necessary "before" preventive maintenance checks and services (PMCS): also perform any weekly or monthly checks and services that may apply.

b. Check that lubricant levels are in accordance with the PMCS and lubrication charts for the following items:

(1) Air compressor air/oil separator.
(2) Hydraulic oil reservoir.
(3) Drawworks bevel gear case.
(4) Mud pump drive case.
(5) Mud pump power end.
(6) Sub-drive case.
(7) Force feed lubricator reservoir.
(8) Water injection pump crankcase.
(9) Rotary table transmission.
(10) Rotary table housing.
(11) Pulldown transmission.
(12) Air line conditioner lubricator bowl.

c. Fill the water injection tank with fresh water.

d. Install a foam container in the bracket on the end of the water injection tank. Cut a hole in the container's lid and insert the plastic tube from the foam pulse pump.

2-9. Preparation for Drilling.

a. Mud pits. Remove the primary and secondary mud pits from the support vehicle. Temporarily, set the primary pit under the rotary table area and set the secondary pit at a right angle to the primary. See Figure 2-26. Connect the mud pump suction hose to the suction fitting on the secondary pit. When required, prepare mud storage and settling pits (refer to FM 5-166).

b. Worker's platforms. Remove the locking bolts from the operator's and helper's platforms. Lower both platforms to the operating position. Install the locking bolts.

c. Start-up. Perform the following steps:

CAUTION

To avoid damage, ensure controls are in proper position before starting engine.

(1) At the driller's station, check that all controls are in the OFF or NEUTRAL position.

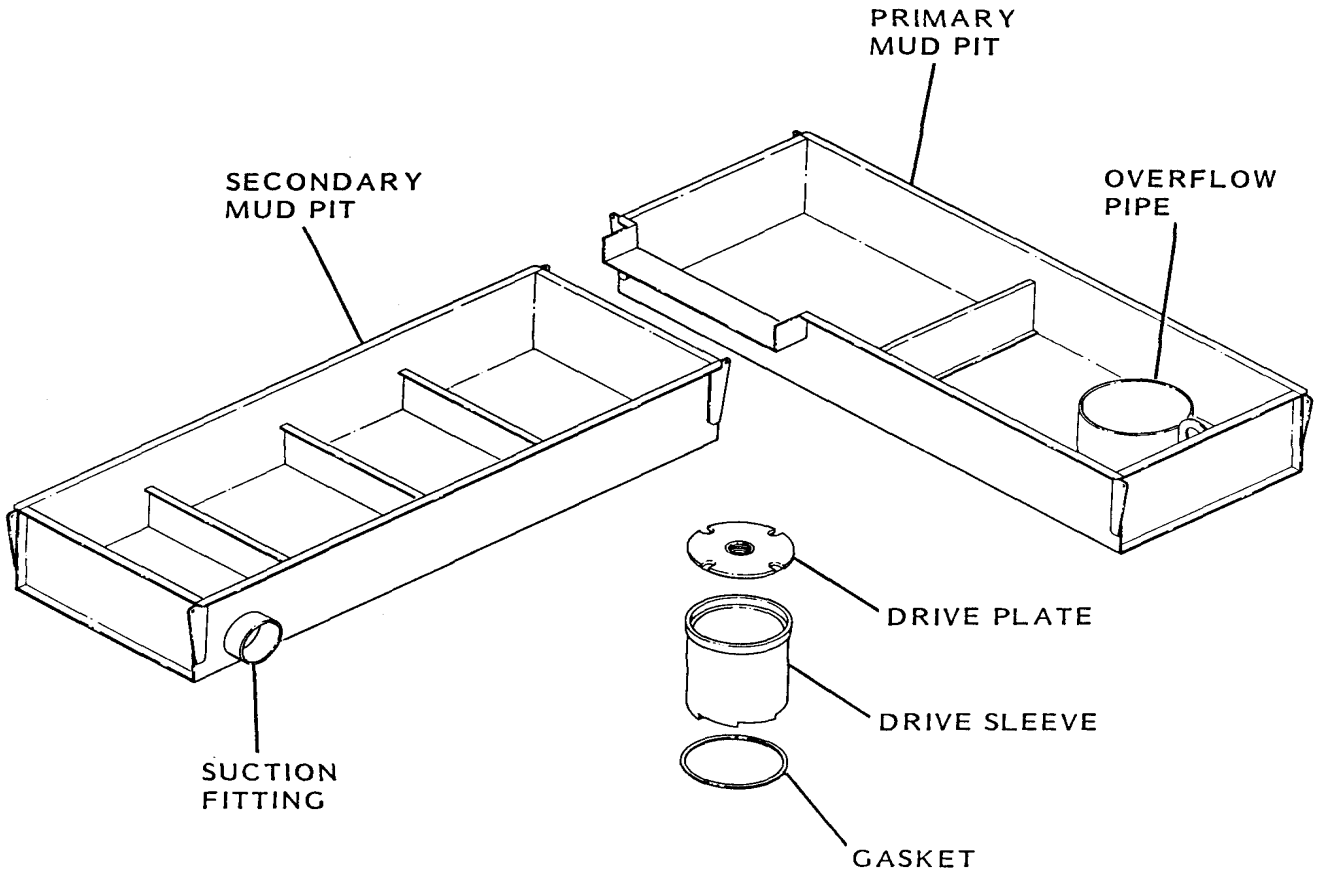


Figure 2-26. Mud pit system.

(2) Make sure that all hose safety chains are fastened.

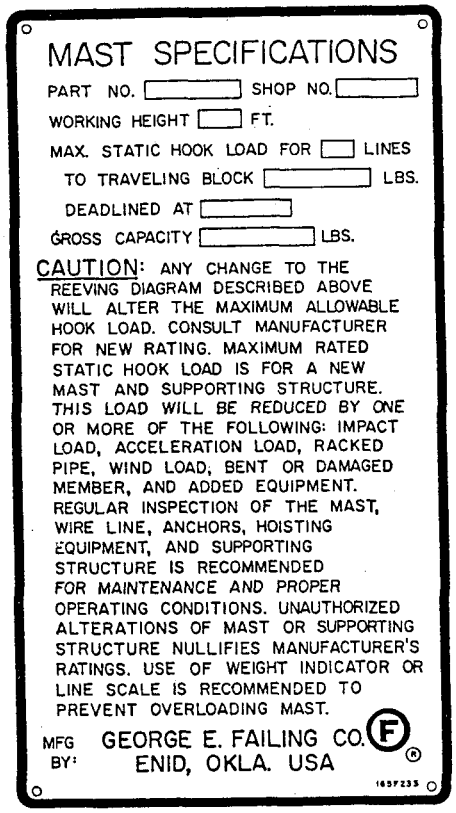
(3) Read and comply with all warning and caution plates (See Figure 2-27.)

(4) Push in clutch and set transmission shift lever (21, figure 2-14) in fifth gear. Move transfer case lever (28) to DIR and PTO lever (29) to ENG.

(5) Start the truck engine as follows:

(a) In the truck's cab, set the starting switch (15, figure 2-14) to ON.

(b) At the operator's control console, pull out the STOP switch (5, figure 2-11) and position the throttle (7) at partial position. Press the start switch (6) and hold until the engine starts. If engine does not start within 30 seconds, release the start switch and allow the starter motor to cool before attempting to start again. If the engine does not start after three attempts, investigate and resolve the problem before attempting to start engine again.



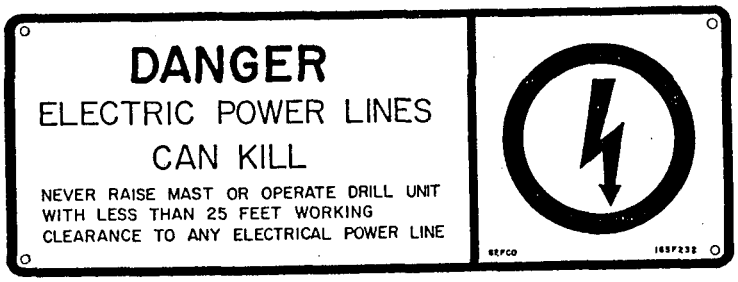


Figure 2-27. Rig Warning and Caution Plates

NOTE

An engine at or near operating temperature may be started with the throttle (7) at IDLE or partial throttle.

(c) After the engine is running, reduce engine speed to approximately 1000 RPM and allow engine to warm up three to five minutes before applying a load. During warm-up, observe all gages for proper readings.

CAUTION

Do not increase engine speed until the oil pressure gage (3, figure 2-11) indicates normal (25-30 PSI). Shut engine down if oil pressure does not register on the gage within 20 to 30 seconds after starting.

(6) Set the throttle (7, figure 2-11) to the desired engine rpm. Read the rpm's on the tachometer (4).

d. Extend rotary table. Remove the jib pins from the rotary table sliding base. Check that there are no obstructions that would interfere with the tables movement from its retracted position to the extended position. Operate the table retract control (4, figure 2-8) to the OUT position and extend the table to its extended position; then release the control. Reinstall jib pins in the rotary table sliding base.

e. Leveling the rig.

NOTE

Before leveling the rig, sight through the rotary table opening to see if the rig is positioned correctly over the hole site. If not, reposition the rig before proceeding.

(1) If terrain or ground conditions dictate, place supporting timbers under the hydraulic jacks. Unsnap the safety chain that holds each jack in the retracted position.

(2) Check that tachometer indicates the desired rpm's; adjust throttle accordingly. Check that gages--hydraulic pressure (1, figure 2-12) and oil temperature (2) indicate within prescribed operating ranges.

(3) Observe the level gage on frame near jack controls and determine which corner of the drill frame is lowest. Move the corresponding jack control (3, 4, 5, or 6, figure 2-12) to DOWN and hold until the corner is raised to approximately level.

(1) Extend the other three jacks in like manner, observing the level both laterally (side-to-side) and longitudinally (front-to-rear) until rig is level. You can "fine tune" the level by quickly tapping and releasing the controls.

f. Raising the Mast.

WARNING

Electric shock can cause serious injury or death. Never raise the mast or operate the rig with less than 25 feet working clearance to any electric power line.

NOTE

Ensure leveling jacks are in position before raising mast.

(1) Raising the mast requires a large volume of hydraulic fluid. Check the hydraulic oil level in the reservoir. Refill as required.
(2) Make sure all pre-operation checks and services have been performed and the rig has been correctly leveled.
(3) Remove the Retractable life-line from the storage area and attach it to the top of the mast. Perform the "Before" PMCS for the life line, then extend the cable and attach it to the bottom of the mast.

WARNING

- To avoid serious injury to personnel, never work above the anchorage point. Personnel could fall at least 10 feet before the locking mechanism engages, causing sudden jerking to back and neck.
- Never connect more than one person at a time to the life-line cable.
- Unit must be removed from service if a fall has taken place. Unit must be kept out of service until it has been inspected and recertified by manufacturer. If any device is suspected to have damage, it should be immediately removed from service until it has been recertified by the manufacturer.

(4) When necessary to climb the mast, put on the safety harness/belt with the 6-foot lanyard attached. Remove the life-line cable from the bottom of the mast and attach it to the D-ring on the safety harness/belt.

NOTE

On chest harnesses and Fully Safety harnesses, attach to the rear D-ring.
On belts, attach to one of the side D-rings, then rotate the belt around the waist until the attachment point is at the center of the back.

(5) Check that there are no obstructions that would interfere with the mast as it moves to the raised position.
(6) Open the mast locks at the rear of the drill frame, on either side of the rotary table.
(7) Move the mast control (1, figure 2-1) to the UP position and raise the mast about 1 foot. Then move the control to the down position and lower the mast onto the mast support.
(8) Repeat Step 7 two or three times to make sure that the mast cylinders are full of hydraulic oil.

WARNING

Before raising the mast, alert all personnel in the immediate area to be aware of the operation and to stand dear of the drilling rig during the procedure in event a malfunction should occur. NO maintenance or repair may be attempted during the mast-raising operation.

(9) Operate the mast control (1, figure 2-1) and raise the mast approximately one-third of the fully raised position. Release the control to stop movement.

CAUTION

Do not leave the mast in a partially-raised condition. This causes internal cylinder strain far beyond the cylinder's capacity.

(8) Operate the hoist drum brake control (5, figure 2-4) slightly to release brake and allow slack in the cable and lower the kelly in the mast. Then reset the brake. Repeat this procedure to slack the cable on the auxiliary and third drums, using brake controls (4 and 6, figure 2-4).

CAUTION

If mast does not raise properly or mast binds, stop operation. Lower mast and determine problem before proceeding. Otherwise, damage may result.

(9) Operate the mast control (1, figure 2-1) and raise the mast approximately two-thirds of the fully-raised position. Release the control to stop movement. Then repeat Step 8.

(10) Operate the mast control (1, figure 2-1) and raise the mast to the fully-raised position and release the control. Close both mast locks.

(11) Recheck the level of the rig.

g. Connect discharge piping.

(1) Be sure there is no pressure on the discharge line between the air compressor/ mud pump and the standpipe at the mast. If there is, release the pressure with the blowdown valve (3, figure 2-5). Close the valve after pressure is released.

NOTE

If the discharge piping is routed to the desired unit (air compressor or mud pump) disregard the next step.

(2) Use a hammer to break the hammer union connection. Unscrew the union; then connect the routing hose (2, figure 2-28) to either the air compressor hammer union (3) or mud pump hammer union (7). Use a hammer to tighten the union. Open discharge valves (4 and 5) by positioning the handles to run parallel to the piping. If using the mud pump, be sure valve (8) is closed (handle perpendicular to piping).

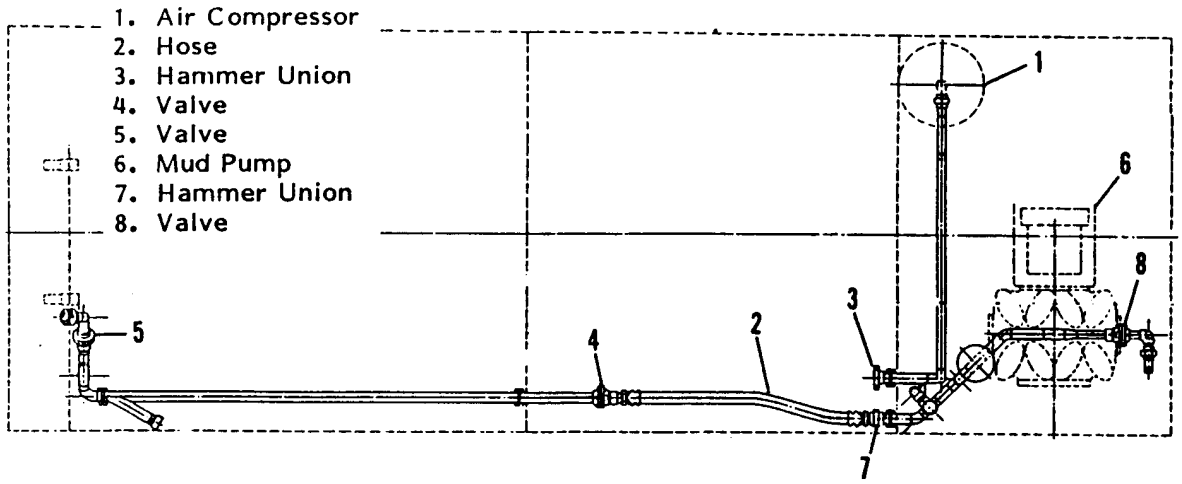


Figure 2-28. Connecting Discharge Piping

2-10. Drilling System Operating Procedures.

NOTE

These operating procedures assume that the pre-operation procedures have been completed, the truck engine is started and the power take-off is engaged. If those steps have not been completed, refer back to the appropriate paragraphs and complete those steps before continuing.

a. Drawworks. Move the drawworks power control (1, figure 2-4) to the ON position and hold momentarily to assure that the power take-off that drives the drawworks is engaged. Release the control.

CAUTION

Spooling cable onto the drawworks drums is a simultaneous operation of two controls. Keep your hands on both controls (clutch control and brake) from start of task to completion. NEVER release the brake to allow "free-spooling" of any drum. Do not allow the blocks to hit the crown nor the rotary table. Proceed slowly when near the crown or table.

NOTE

To release a brake, release its ratchet by squeezing it. Then, engage the clutch control and move the brake control forward at the same time. Unwind cable by releasing the brake, controlling its speed by occasionally re-applying the brakes. The speed at which the blocks travel depends on how much weight it supports. Operate these controls slowly at first, until you have a "feel" for how fast the blocks travel up and down the mast. When resetting the brakes, move the brake lever back until the drum completely stops. Be sure the ratchet locks the lever in place.

(1) Hoist drum.

NOTE

Be sure the pulldown power control (5, figure 2-9) is off and the pulldown transmission (3) is set to NEUTRAL before hoisting.

(a) To spool cable onto the hoist drum (kelly), move the clutch control (2) to the left while, at the same time, releasing the hoist drum brake control (5). When the kelly is at the desired position, set the brake (5) and move the clutch control (2) to the center (neutral) position.

(b) To spool cable off the hoist drum, release the brakes until the kelly is lowered to the desired position; then reset the brake (5).

(2) Auxiliary drum. To spool cable onto and off the auxiliary drum, operate the the clutch control (2) and the auxiliary drum brake (6) like the steps detailed for the hoist drum, above. Instead of moving the kelly up and down the mast, you will move the auxiliary drum traveling blocks. Move the clutch control (2) to the center position and immediately reset the brake (6) when finished.

(3) Third drum. To spool cable onto the third drum, pull back on the clutch control (3) while releasing the brake (4). Release clutch (2) and reset brake (4) to stop. To spool cable off the drum, release the brakes and allow the necessary cable to spool off the drum. Then reset the brakes.

b. Rotary table.

(1) Position the rotary table transmission control (3, figure 2-8) in the desired gear range.

(2) To begin rotation, move the table rotation control (2) to the left for counterclockwise rotation or to the right for clockwise rotation. Control the table's speed by moving the handle more or less in the desired direction. Stop rotation by returning control (2) to center (N) position.

c. Mud system.

(1) Mud pits.

(a) Be sure discharge piping hose is connected to the mud pump outlet. Be sure the overflow pipe in the mud pump primary pit is lined up with the rotary table hole.

(b) Install the gasket (see figure 2-26) over the drive sleeve and then place the sleeve in the overflow pipe on the primary pit.

(c) Operate the hoist drum to lower the kelly through the rotary table. Attach the drive plate to the kelly. Lower the plate onto the drive sleeve. Operate the rotary table counterclockwise slowly to rotate the drive plate and screw the drive sleeve into the ground until the flange seals against the bottom of the pit.

(d) Retract the kelly and remove the drive plate.

(2) Mud pump.

NOTE

Before operation, be sure that all mud pump suction and discharge connections have been made and drill string is in the drilling position (in the hole or ready to start drilling the hole). Do not operate the pump with the kelly retracted in the mast.

(a) Prime the mud pump by removing the suction valve covers and filling the fluid end completely with water. Reinstall the valve covers.

(b) Adjust the engine throttle (7, figure 2-11) to bring the engine speed to 1400 rpm as observed on tachometer (4).

(c) Check that the on/off switch on the air compressor panel (11, figure 2-3) is ON. Check that the mud pump reset switch (2, figure 2-2) is pushed in.

(d) At the operator's control panel, set the mud pump switch (1, figure 2-2) to ON. (Use this same switch to stop mud pump operation.).

(e) Upon completion, flush and clean system with water.

d. Air compressor system.

NOTE

Before operating the compressor, connect the discharge line to the compressor. The drill string should be in drilling position (in the hole or prepared to start drilling the hole). Do not operate the compressor with the kelly retracted in the mast.

(1) Connect the discharge piping to the air compressor. (See paragraph 2-9, g.) Open discharge valve (4, figure 2-28); close discharge valve (5).

(2) Check that the on/off switch on the air compressor panel (11, figure 2-3) is ON. Check that compressor reset switch (10) is pushed in.

(3) Adjust the engine throttle (7, figure 2-11) to bring the engine speed to 1 200 rpm as observed on tachometer (4).

(4) At the operator's control panel, set the compressor switch (4, figure 2-3) to ON to engage the compressor clutch and operate compressor.

(5) After the compressor runs for approximately 20 seconds, increase engine speed to 2100 rpm.

(6) When air pressure gage (1, figure 2-3) reaches approximately 45 psi, set the load switch (3) to ON. The compressed air system will develop maximum pressure of 215 psi (during drilling, pressure will fluctuate slightly.) (7) To shut down the compressor, set the load switch (3, figure 2-3) to OFF to unload the compressor. Lower engine speed to 1200 rpm. When the gage (2) pressure indicates about 90 psi, set the power switch (4) to OFF. Open blowdown vavle (3, figure 2-5) to release trapped air.

e. Force feed lubricator. The force feed lubricator supplies oil to the air discharge line during hard-rock, air-drilling operations using a down-the-hole hammer. (See FM 5-166 for information about when to use the hammer and lubricator.) To operate the lubricator, proceed as follows:

(1) Be sure the reservoir has been filled with oil. Check sight glass (2, figure 2-6). Open the force feed lubricator shutoff valve (3).

(2) Start the air compressor (see above).

(3) Set the oiler on/off switch to ON.

(4) Check the volume of flow by observing, through the pump sight glass (6), how many drops of oil fall from the end of the tube with each stroke of the pump. If adjustment is needed, loosen the locknut (4) and turn the adjusting screw (5) out (counterclockwise) to increase the volume or in (clockwise) to decrease volume. Tighten the locknut when adjustment is complete.

(5) To stop the oiler, set oiler switch (1) OFF and close valve (3).

f. Water/foam injection system. Water and foam is injected into the air discharge line during air-drilling operations. (See FM 5-166 for information about when water/foam injection is required.) To operate the water and foam injection system, proceed as follows: (1) Be sure the water tank has been filled with water. Be sure a foam container has been installed and the pulse pump suction tube is positioned in the container.

(2) Start the air compressor (see above).

(3) Open the water/foam injection valve (4, figure 2-5).

(4) Move the water injection control (1) to ON. Rotate the water injection volume control (2) counterclockwise to operate water injection pump. Pump speed and the rate of water delivery increases the further you turn the knob counterclockwise.

(5) To add foam, open the valve between the foam pulse pump and the water injection pump. Close the valve when foam is no longer needed.

(6) To stop injection, move the water injection control (1) to OFF and close the water/foam injection valve (4). Leave the volume control (2) set if you wish to inject the same volume the next time you use the injection system.

g. Break-out assembly. The breakout assembly is used as a mechanical leverage for loosening pipe joints when removing pipe from the hole. Operate the break-out assembly as follows: (1) After a joint of pipe is above the rotary table, set the slips to suspend the drill string in the rotary table.

(2) Operate the break-out control (1, figure 2-7) OUT to provide slack in the wire rope that links the cylinder to the break-out wrench.

(3) Attach the wrench to the drill pipe, above the joint to be separated.

(4) Momentarily, move the break-out control (1) to the IN position to take the slack out of the wire rope line. When the line is taut, continue using the break-out control (1) IN to break the joint.

(5) Repeat steps 2, 3, and 4 until pipe turns easily.

NOTE

Normally, the hydraulic cylinder is used for the initial breaking of the joint. After that, use the rotary table to unscrew the pipe, and use the break-out wrench as a back-up to hold the top joint of pipe from turning. If a joint is extremely tight and the lower pipe turns inside the slips, use another pipe wrench to hold a backup on the lower joint.

h. Pulldown/chain feed drive assembly. The chain feed drive transmits power to the roller chain that is fastened to a chain pulldown. The chain pulldown is located in the mast. When the chain feed drive is operated, the chain pulldown applies downward pressure on the water swivel. The downward pressure is transferred to the drill string components below the water swivel, to increase the bit cutting force. When additional cutting force is needed, operate the chain feed drive as follows:

(1) Make sure the pulldown power control (5, figure 2-9) is in the OFF position.

(2) Select the pulldown transmission high/low lever (3) to either the HIGH or LOW speed, whichever is most suitable for the drilling conditions.

(3) Move the pulldown power control (5) to ON.

(4) Observe the hydraulic pulldown pressure indicated on the pulldown pressure gage (1).

(5) Turn the pulldown control knob (2) and holdback control knob (4) to obtain the required pulldown pressure.

(6) To stop the pulldown chain feed drive, move the pulldown power control (5) to OFF and shift the transmission control lever (3) to NEUTRAL.

NOTE

If operation will be resumed, control knobs (2 and 4) may remain set for the selected pressure. To resume operation, perform Steps 2 and 3.

(7) When pulldown operations are complete, rotate the pulldown and holdback knobs (2 and 4) fully counterclockwise.

i. Air line conditioner.

(1) Look through the air filter sight glass (2, figure 2-10) to see if moisture has accumulated in the bowl. If so, use the valve handwheel (1) counterclockwise to close the shutoff valve before draining moisture.

(2) Open the filter draincock (3) to release the moisture accumulation from the bowl. Close draincock when bowl is empty.

(3) Check the oil lubricator. If low, remove the lubricator filler cap and add SAE 10 non-detergent engine oil. Replace the cap.

(4) Open the control air shutoff valve (1).

(5) During drilling operations, observe the air compressor system pressure gage (5). Pressure should indicate approximately 125 psi. If not, adjust the regulator (4) to obtain 125 psi.

(6) Check the rate of lubricant flow by observing the drops of oil in the air lubricator sight glass (7). One to three drops should fall; if more or less, change the flow with the adjusting screw (8).

Section IV. RIG TENDER OPERATION UNDER USUAL CONDITIONS

2-11. Crane.

a. Assembly and Preparation for Use. Position the rig tender on flat, solid ground to insure maximum lifting ability.

b. Initial Adjustments, Daily Checks, and Self-Test.

(1) Inspect crane daily. Check for loose, worn, or damaged parts. Report, or correct, any unsafe conditions; do not operate the crane until unsafe conditions have been corrected.

(2) Before and during crane operations, check hydraulic lines, fittings, and cylinders. Check for overheating winch motor. Check winch for worn or bent wire line.

c. Operating Procedures.

(1) Start truck engine. Engage hydraulic system/PTO from inside the truck cab. Set engine RPM at 1000.

CAUTION

Exceeding 1000 engine RPM may cause crane malfunction or damage.

NOTE

To reduce crane speed, reduce engine RPM.

(2) Turn on remote control unit power switch from inside truck cab.

WARNING

Crane misuse can result in death or serious injury to personnel.

(3) Remove the remote control pendant (1, Figure 2-29) from the storage box (2) near the crane base.

(4) Release the crane from its traveling position by moving the winch switch to the DOWN position. Unwind enough wire line to relieve tension from the wire line.

WARNING

When handling the winch wire line, use leather gloves. Wire rope can seriously injure bare flesh.

(5) Unhook the snatch block (3) from the boom-stand hook. Make sure there is nothing in the way of the snatch block or wire line.

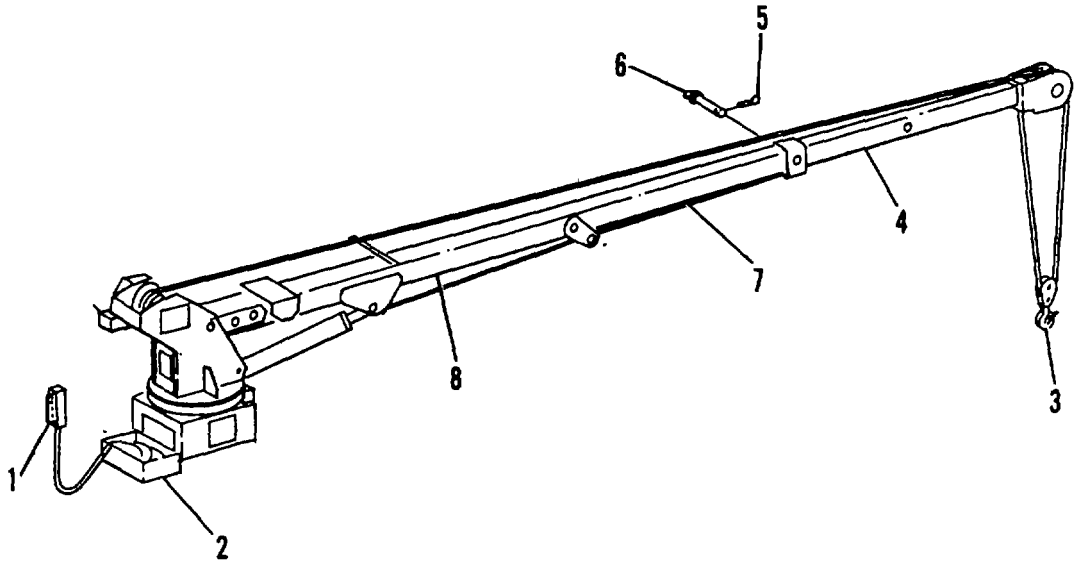


Figure 2-29. Crane Operating Instructions

WARNING

When raising the boom, keep the boom top at least 10 feet away from any type of electrical line or other electrical source.

(6) Move the boom switch to the UP position to raise the crane main boom (8). Elevate the boom to a position where rotation will not be blocked by any part of the truck or deck load.

WARNING

Make sure all personnel are a safe distance from the crane when rotating or extending the boom.

(7) Move the rotation switch to the left for counterclockwise rotation, or move it to the right for clockwise rotation.

CAUTION

On telescoping booms, operate the winch to unwind wire line when extending the boom. Be sure to wind up the wire line when retracting the boom.

(8) Extend the manual-pullout extension boom (4) as follows:

(a) Remove clinch pin (5) and pull out the manual extension pin (6).

(b) Pull out the manual-pullout extension boom (4) to the intermediate or fully extended position.

(c) Aline the pin holes and reinstall the manual extension pin and clinch pin.

(9) Extend or retract the hydraulic extension boom (7) by moving boom switch out or in.

WARNING

Before attempting to lift a load, check the load lifting chart (see figure 2-30) on the crane base. Never exceed the manufacturer's rating. Always keep your eyes on a moving load.

(10) If the load is greater than 3,800 pounds and crane is rigged with one-part line, change to two-part line as follows (see figure 2-31):

(a) Snap winch line hook over pin at rear of boom point to form a two-part line loop.

(b) Loosen the handwheel bolt on the snatch block and open the side plate. Slip the snatch block over the two-part line loop.

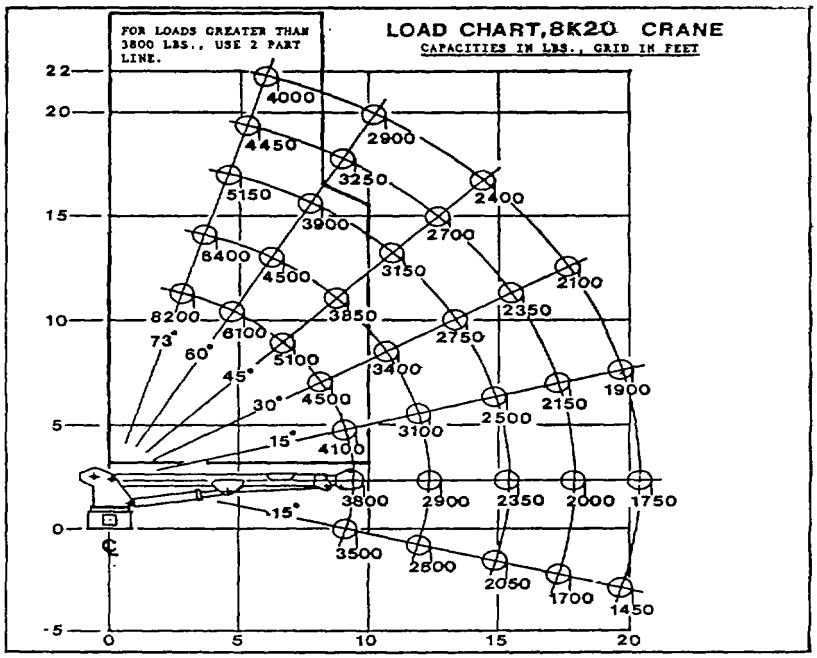


Figure 2-30. Crane Load Chart

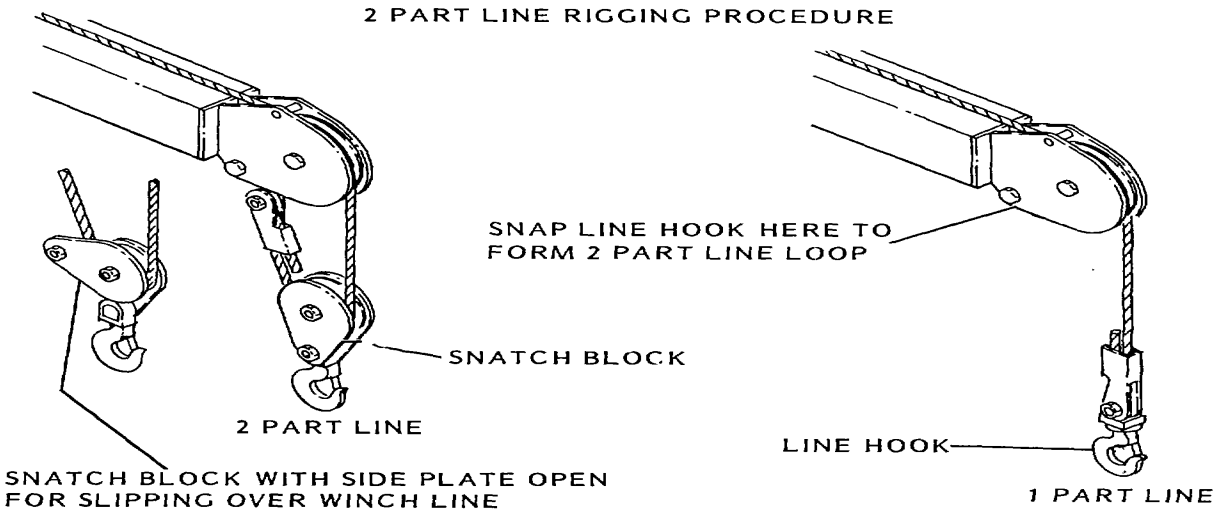


Figure 2-31. Two-part Line Rigging Procedure

(c) Re-position side plate and tighten handwheel bolt on the snatch block. Operate the winch down as needed.

(11) Position crane boom point directly over the load to be lifted.

(12) Check load chart for proper lifting angle.

CAUTION

Do not hoist two or more separately rigged loads in one lift, even if combined load is within the crane's rated capacity.

(13) Attach hook securely to the load to be lifted.

(14) Lift the load a minimum of 2 feet before rotating it.

WARNING

Do not suspend the load over personnel. Rotate the crane smoothly to avoid outward movement (swinging) of the load.

(15) Move the load to the desired location.

(16) Lower the load to a stable position. Be sure all tension is off the wire line.

(17) Disconnect the hook from the load.

d. Preparation for Movement.

(1) Retract manual extension boom as follows:

(a) Remove clinch pin (5, figure 2-29).

(b) Pull out the manual extension pin (6).

(c) Rewind the hoist line while pushing in the manual-pullout extension boom (4).

(d) Aline the pin holes and reinstall the manual extension pin (6) and clinch pin (5).

(2) Operate the remote controls (1) to retract the hydraulic extension boom (7) while rewinding the hoist line.

(3) Position the crane main boom (8) so it is centered over the boom stand.

(4) Lower the main boom until it rests onto the boom stand.

(5) Attach the crane snatch block (3) to the boom stand hook.

CAUTION

Do not torque the crane too tightly to the boom stand.

(6) Tighten the crane winch enough to secure the crane to the boom stand.

(7) Replace the remote control pendant (1) in the storage box (2); close and latch the box.

(8) From inside the truck cab, turn off the remote control power switch and disengage the PTO/hydraulic system.

2-12. Welder/Generator

a. Assembly and Preparation for Use.

(1) Initial Setup. Set up the rig tender as level as possible (within 5 degrees from level); keep unit level during operation.

WARNING

Battery acid can burn your eyes and skin, and can destroy clothing and other material. Wear correct eye and body protection when working with batteries. Failure to follow this warning may result in injury to personnel.

CAUTION

Abnormal voltage can cause damage to the engine electrical components. Do not operate the engine without the battery connected. Do not disconnect the battery while the engine is running.

(2) Power Connections. First, connect the positive (+) battery cable to the positive (+) battery terminal. Then connect the negative (-) battery cable to the negative (-) battery terminal.

WARNING

Engine fuel can cause fire or explosion. Do not spill any fuel. Do not refuel near sparks or open flame. Do not smoke while refueling. Do not fill tank to top; allow 3/4 inch from fuel level to top of tank.

CAUTION

Do not use gasoline to fuel the engine, gasoline will damage engine. Failure to follow this caution will result in engine damage.

(3) Fueling. Fill the fuel tank up to 3/4 inch from the top with fresh diesel fuel.

(4) Grounding Procedures. The engine generator unit must be grounded prior to operation. To ground the generator, proceed as follows:

WARNING

Do not operate the engine generator unless ground cable has been connected to the ground terminal stud and ground rod. Failure to follow this warning may result in death or injury to personnel.

(a) Insert ground cable into slot in the ground terminal stud. Tighten the ground terminal stud nut.

(b) Connect coupling to the ground rod. Insert driving rod into coupling. Make sure driving rod is bottomed on the ground rod.

(c) Drive the ground rod into the ground using driving rod. Stop driving when the coupling is just above ground surface.

(d) Connect additional ground rod to grounding system. Remove driving stud from coupling. Install another ground rod in the coupling. Make sure ground rod is bottomed on the ground rod previously installed. Connect another coupling on new ground rod and insert driving rod.

(e) Repeat steps (c) and (d) until first ground rod is 8 feet into the ground.

(f) Remove driving stud and top coupling.

(g) Connect the clamp and ground cable to the top of exposed ground rod. Tighten screw on the ground rod clamp.

(5) Weld Output Receptacle Connections.

(a) To insert jack plug, turn plug one-quarter turn. To remove jack plug, turn plug one-quarter turn in opposite direction.

WARNING

Electric shock can kill. Arcing can burn skin or damage electrical connections. Do not touch live electrical parts. Make sure the unit is completely shut down before making any weld output connections. Do not change position of welding cable jack plugs while welding. Failure to follow these warnings may result in death or injury to personnel.

(b) Connect weld cables to appropriate weld output receptacles.

1 To obtain DC straight polarity weld output, connect work cable jack plug to positive (+) receptacle. Connect electrode cable jack plug to negative (-) receptacle.

2 To obtain DC reverse polarity weld output, connect work cable jack plug to negative (-) receptacle. Connect electrode cable jack plug to positive (+) receptable.

3 To obtain AC weld output, connect work cable jack plug to WORK receptacle. Connect electrode cable jack plug to ELECTRODE receptacle.

b. Initial Adjustments, Daily Checks, and Self-Tests.

(1) Initial Adjustments.

WARNING

Engine fuel can cause fire or explosion. Do not spill any fuel. Do not refuel near sparks or open flame. Do not smoke while refueling. Do not fill tank to top; allow 3/4 inch from fuel level to top of tank. Failure to follow this warning may cause death or injury to personnel.

(a) Fill fuel tank with fresh diesel fuel before starting engine for first time.

(b) Examine inside of fuel cap. Open valve if cap is equipped with a valve.

(c) Check oil level using oil level dipstick. Add oil, if necessary, until oil level is at the MAX mark on the dipstick.

(d) Check battery terminal connections. Tighten connections if necessary.

(2) Daily Checks.

WARNING

Engine fuel can cause fire or explosion. Do not spill any fuel. Do not refuel near sparks or open flame. Do not smoke while refueling. Do not fill tank to top; allow 3/4 inch from fuel level to top of tank. Failure to follow this warning may cause death or injury to personnel.

(a) Check fuel tank. Fill tank if tank is not full of fuel.

(b) Check oil level using oil dipstick. Add oil, if necessary, until oil level is at MAX mark on the dipstick.

c. Operating Procedures.

(1) Starting Engine. See Figure 2-32.

WARNING

Keep all covers and panels in place while operating. Protect yourself with dry insulating gloves and clothing. Stop and disable the engine before inspecting or servicing. Stay clear of moving parts. Failure to follow this warning may result in death or injury to personnel.

(a) Push run/stop control fully into RUN position.

(b) Place automatic idle control switch in AUTO IDLE ON position.

(c) Place the starter switch in START position. Release starter switch when engine engages. Allow the engine to run for a few minutes before applying a load.

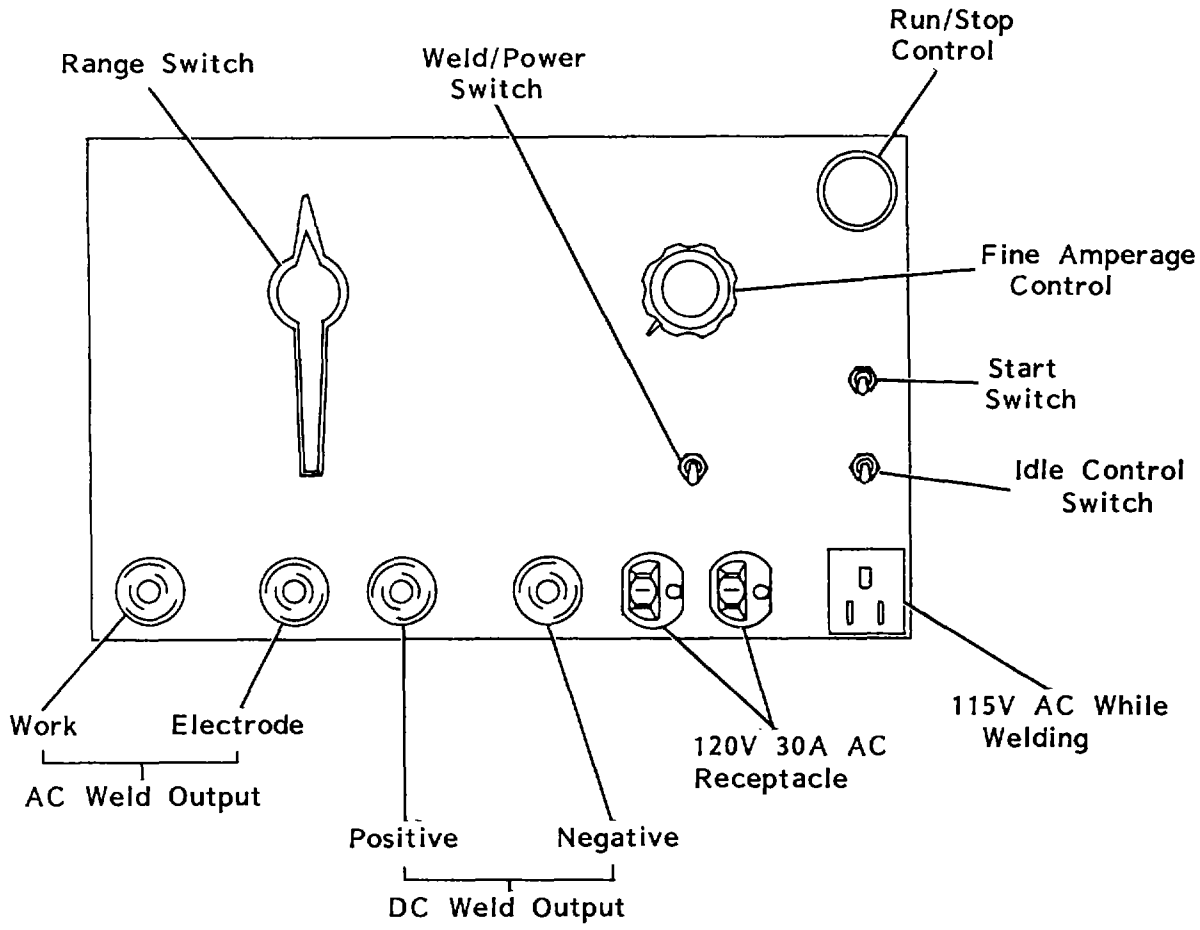


Figure 2-32. Welder/Generator Control Panel

(2) Stopping Engine. (See figure 2-32.)

(a) Remove all weld and power loads from the unit.

(b) Place automatic idle control switch in AUTO IDLE ON position.

(c) Operate the engine at idle speed for 2 minutes.

(d) Pull the run/stop control fully to STOP position. When engine stops, place run/stop control in RUN position.

(3) Shielded Metal-Arc Welding. (See figure 2-32.)

WARNING

Arc rays, hot slag, and sparks can burn the eyes and skin. Noise can damage hearing. Hot metal, spatter, slag, and exhaust or arc sparks can cause fire. Use welding mask and protective covering.

CAUTION

Do not change position of range switch while welding or under load. Failure to follow this caution may result in damage to equipment.

(a) Rotate the range switch to desired position. Range switch provides seven coarse amperage ranges. Range is indicated on scale surrounding the range switch handle.

(b) Rotate the fine amperage control to desired setting. Scale surrounding control is calibrated in percentage of the scale and does not indicate an actual amperage value.

(c) Place the weld/power switch in WELD Position.

(d) Connect work clamp to the object to be welded. Place an electrode, appropriate for the material to be welded, into the electrode holder.

(e) Start engine per instructions in paragraph "c", step (1) above.

(f) Connect the desired accessory equipment to 115 vac receptacle. Make sure that auxiliary equipment is turned off or disconnected.

CAUTION

Do not operate equipment rated only for 50 or 60 Hz from this receptacle. Use receptacle power only for operating incandescent lights, universal power tools, and resistance heaters without fans.

(g) Place the automatic idle control switch in AUTO IDLE OFF position when using power from the 115 vac receptacle. Place automatic idle control switch in AUTO IDLE ON position to weld.

(4) Power Plant Operation.

WARNING

Electric shock can kill. Do not touch live electrical parts. Do not connect to any electrical system normally supplied by utility power unless a proper transfer switch and grounding procedure are employed. Disconnect welding cables when using auxiliary power. Failure to follow these warnings may result in death or injury to personnel.

(a) Make connections to 120 volt, 30 amp ac receptacle. If a connection to 120/240 vac terminal strip is desired, follow steps (b) through (d); otherwise, skip to step (e). See Figure 2-33.

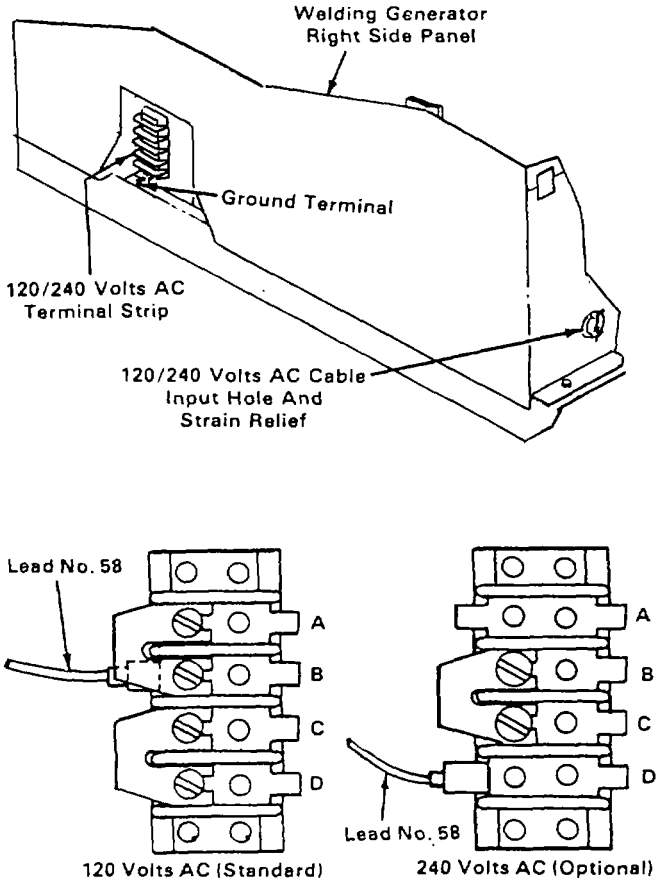


Figure 2-33. 120/240 Volts AC Terminal Strip

(b) Make connections to 120/240 vac terminal strip. See Figure 2-33.

(c) Remove the right side panel from the welder/generator.

(d) Insert leads through strain relief on the generator rear panel. Take leads over to terminal strip. See Figure 2-33.

(e) To obtain 120 vac auxiliary power, see Figure 2-33 and proceed as follows:

1 Connect one lead to terminal A or B on terminal strip IT.

2 Connect remaining lead to terminal C or D on terminal strip 1T.

3 Make sure that the jumper links on terminal strip iT are positioned for 120 vac.

4 Connect the ground lead to ground terminal below terminal strip IT.

5 Tighten strain relief on the generator rear panel.

6 Install right side welder/generator panel and resume operation.

(f) To obtain 240 vac auxiliary power, see Figure 2-33 and proceed as follows:

1 Remove and retain jumper links from terminal strip iT.

2 Move lead no. 58 to terminal D on same side of terminal strip IT.

3 Position jumper links on terminal strip iT for 240 vac.

4 Connect line leads to terminals A and D on terminal strip 1T.

5 Connect ground lead to ground terminal below terminal strip 1 T.

6 Tighten strain relief on the generator rear panel.

7 Install right side welder/generator panel and resume operation.

(g) To obtain 120/240 vac auxiliary power, see Figure 2-33 and proceed as follows:

1 Remove and retain jumper links from terminal strip iT.

2 Move lead no. 58 to terminal D on same side of terminal strip 1T.

3 Position jumper links on terminal strip IT for 240 vac.

4 Connect line leads to terminals A and D on terminal strip 1T.

5 Connect neutral lead to terminal B on terminal strip 1T.

6 Connect ground lead from terminal C on terminal strip 1T to ground terminal below terminal strip 1T.

7 Connect ground lead to ground terminal below terminal strip 1T.

8 Tighten strain relief on the generator rear panel.

9 Install right side welder/generator panel and resume operation.

(h) Place weld/power switch in POWER position. See Figure 2-32.

NOTE

Fine amperage control can be adjusted while welding. However, fine amperage control must be set at 100 to obtain the full-rated output from the 120 Volt, 30 Amp ac receptacle when the welder/generator is used to supply ac power.

(i) Rotate fine amperage control to 100.

(j) Start engine per instructions in paragraph "c", step (1), above.

(k) Turn on auxiliary equipment when engine is at proper speed.

2-13. Fuel Transfer System.

a. Assembly and Preparation for Use. The fuel transfer system is pre-assembled and ready for use.

b. Initial Adjustments, Daily Checks, and Self Test. This equipment requires no initial adjustments or self-tests.

c. Operating Procedure. The fuel transfer pump, a 12-volt electric power pump, is not a continuous duty pump. It has a 12-volt electric motor that is subject to overheating and burnout with prolonged usage. The fuel pump has a 13-gallon per minute delivery, and the diesel fuel tank has a 200-gallon capacity.

CAUTION

When using maximum delivery capacity, do not operate the fuel pump longer than 20 minutes to pump the tank dry.

(1) Set the cab-mounted ON/OFF switch (1, figure 2-17) in ON position.

(2) Unlock and open the fuel storage box.

(3) Remove the pump nozzle and fill hose from the storage box and insert the nozzle into the diesel fuel tank opening.

(4) Set the pump-mounted ON/OFF switch (2) to the ON position.

(5) Squeeze the nozzle valve (3) at the base of the nozzle; set the automatic latch and continue pumping until the fuel tank is full. Nozzle will automatically close when tank is full.

(6) Remove the nozzle from the fuel tank and replace nozzle and hose in the fuel hose storage box.

(7) Set the pump-mounted ON/OFF switch to the OFF position.

(8) Set the cab-mounted ON/OFF switch to the OFF position.

2-14. Water Heater.

a. Assembly and Preparation for Use.

(1) Remove the propane tank (1, Figure 2-34), pre-set regulator (2), and hose assembly (3) from the left forward storage compartment and place at rear of vehicle.

(2) Locate the torch adapter bracket (4) mounted at the rear of the curbside manifold (5).

(3) Connect the hose to the torch. (**Note**: Left-hand threads.).

b. Operating Procedures.

WARNING

Prior to turning on propane gase, make sure all connections are tight. Make sure all valves are operating properly. Check for unusual odors or sounds that would indicate gas leaking.

(1) Turn the propane tank control valve (6, Figure 2-34) counterclockwise to open.

(2) Hold the torch in one hand. Open torch control valve (7) a very minimal amount. This will permit gas to flow from the torch.

(3) Light a match, cigarette lighter, or striker from cutting torch assembly. Hold it at the gas outlet of the torch mixer.

WARNING

If the heat manifold (5) is filled with non-burned gas and then lit, you will get a "blowgun" effect. If you suspect the presence of gas in the manifold, wait 10 to 15 minutes to allow the gas to dissipate.

(4) Insert the torch into the adapter (4) through the manifold (5). Figure 2-34 shows the completed installation.

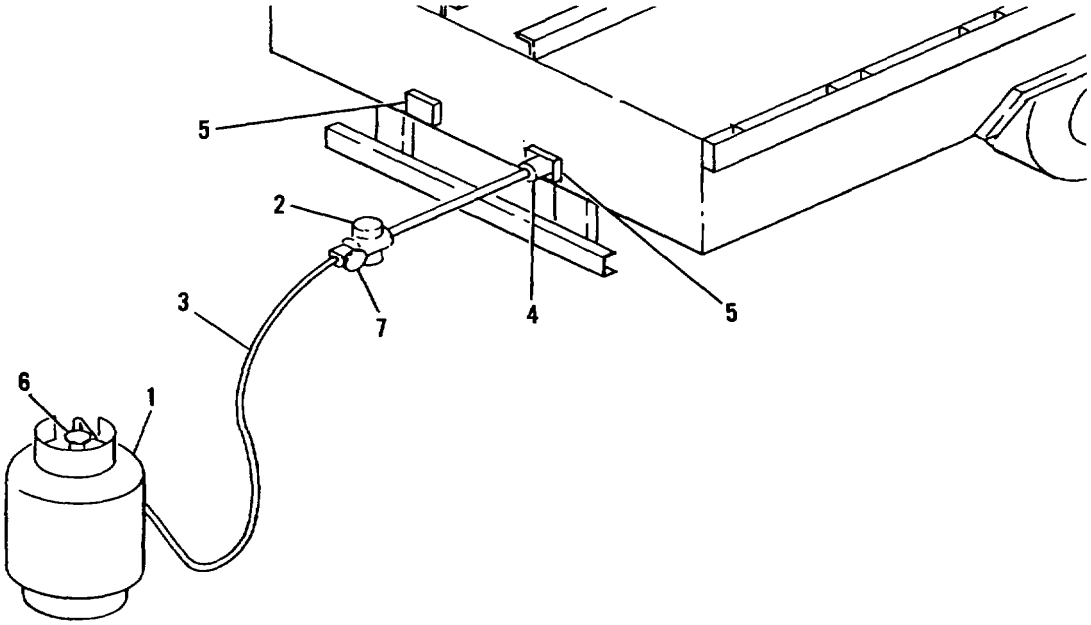


Figure 2-34. Water Heater Installation

(5) Adjust the flame with the torch control valve (7).

NOTE

If the thermocouple on the safety control valve senses no heat or light, it will automatically shut off the gas supply.

(6) If gas to the torch has been automatically shut off, you must wait 10 to 15 minutes before re-lighting the torch to avoid the "blow gun" effect.

(7) To turn off the water heater, turn the torch control valve (6) off.

(8) After flame has gone out, turn gas off by turning propane tank control valve (6) clockwise.

(9) Release pressure in the hose by turning torch control valve (7, ON, then OFF.

(10) Remove the torch and adapter from the manifold.

(11) Disconnect the hose from the torch.

(12) Store the complete assembly in the left forward storage compartment.

2-15 Water Pump System.

a. Assembly and Preparation for Use.

(1) If hoses and/or fittings are wrapped, remove protective wrappings.

(2) Inspect the female ends; be sure rubber gaskets are installed.

b. Initial Adjustments, Daily Checks, and Self Test.

(1) Check water hoses and couplings to make sure they fit together properly with no damage or leaks.

(2) Make sure there is no debris or corrosion on the suction strainer.

c. Operating Procedure.

NOTE

Prior to turning on the water pump, start the truck engine and engage the hydraulic system/PTO Lever located on the control panel in the truck cab. Set the engine rpm at 1000. (To reduce water flow, reduce engine rpm.)

CAUTION

Exceeding 1000 engine rpm's may cause water pump malfunction or damage.

(1) Remove the hoses from the heat manifold (5, figure 2-34) storage location by unhooking the cable and carefully pulling out one hose at a time.

NOTE

There are four (4) identical (2" x 20') hoses for use as suction and discharge lines. Each hose has a male coupling on one end and a female coupling on the other. Each hose may be used separately or, to increase the length of one or both lines, may be assembled by snapping together the mating quick-couplers. See Figure 2-35.

(2) Open the storage compartment (7, figure 1-5) where the water pump is housed.

(3) Close the water pump drain valve.

NOTE

The self-priming pump is reversible, operating with equal efficiency in either direction. Water flow direction is controlled by moving a 3-position valve to the desired position: ON/LEFT-OFF--ON/RIGHT. See Figure 2-36.

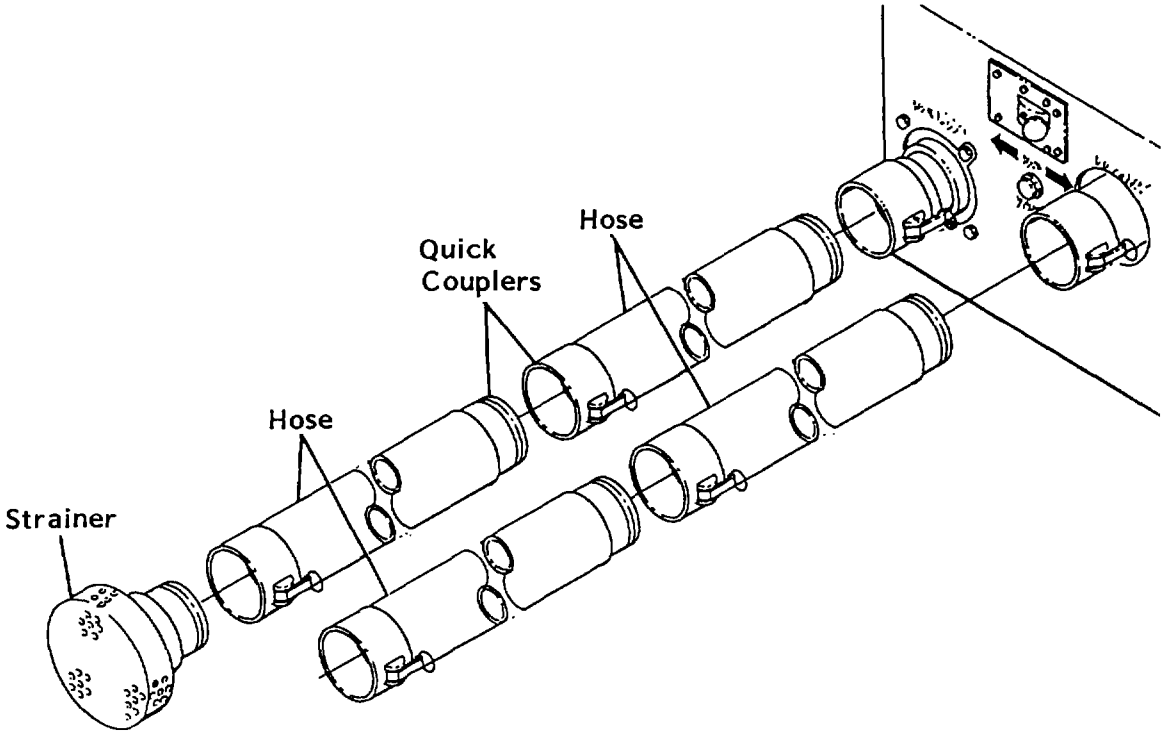


Figure 2-35. Suction and Discharge Hoses, Fittings and Strainer.

(4) You can pump water into the tank, out of the tank, and transfer water slurries. Determine which alternatives you require and follow the procedure for the selected method.

WATER PUMP OPERATING - 3 POSITION

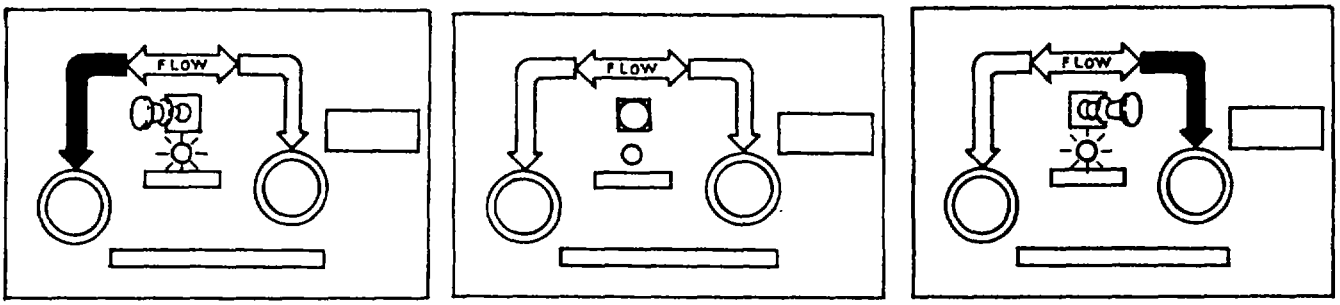


Figure 2-36. Water Pump Operating Valve.

(a) Pump Water Into Tank. (See Figure 2-37).

1 Couple the suction strainer (1) to the female end (2) of the one hose; couple the male end (3) to the pump outlet.

2 Submerge the stainer in the water source.

3 Couple the male end of another hose to the other pump outlet and couple the female end to either the: fill pipe (4); rear valve (5); or front valve (6). Be sure to open the valve if using either front or rear valve. If using the fill pipe, first remove the cap.

CAUTION

Never operate the water pump against a closed valve.

NOTE

An automatic bypass backplate, which will internally bypass the pump if you try to operate with a closed valve, is built into the pump. This safety feature should not be used longer than 5 to 10 minutes.

4 Open the rear vent valve (7).

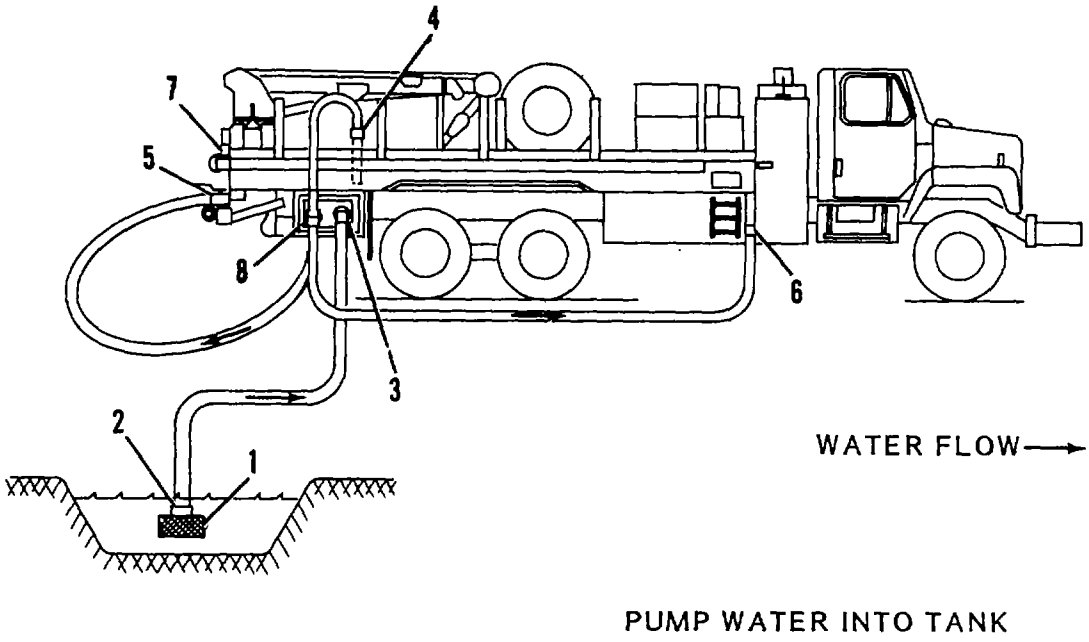


Figure 2-37. Pump Water Into Tank

5 Close the pump drain valve (8).

6 Move pump operating valve knob (1, figure 2-20) in the direction the water should flow. Lift up the lower sleeve of the knob with two fingers, move knob to right or left; then release sleeve. The indicator light (2) should come on.

7 Continue pumping until tank water level gage (1, figure 2-19) reads "F" (FULL); then shift operating valve knob to center, OFF, position.

WARNING

Overfilling will cause water to shoot out the rear vent valve and boom-stand vent and may injure personnel or cause damage to the tank or other equipment.

8 Close the rear vent valve (7, figure 2-37).

9 Open the pump drain valve (8).

10 If front (6) or rear (5) valve was used to fill tank, close the valve first; then uncouple hoses; replace in storage chamber and secure.

11 Replace fill pipe cap (if removed).

12 Disengage hydraulic system/PTO Lever (2, figure 2-23) on the control panel in the truck cab and kill the engine.

(b) Pump Water Out of Tank. (See Figure 2-38).

1 Couple the male end (1) of one hose to the pump outlet; place the female end (2) in the discharge area.

2 Couple the male end (3) of another hose to the other pump outlet and couple the female end (4) to either the: fill pipe (5); rear valve (6); or front valve (7). Be sure to open the valve if using either front or rear valve. If using the fill pipe, first remove the cap.

CAUTION

Never operate the water pump against a closed valve.

NOTE

An automatic bypass backplate, which will internally bypass the pump if you try to operate with a closed valve, is built into the pump. This safety feature should not be used longer than 5 to 10 minutes.

3 Open the rear vent valve (8).

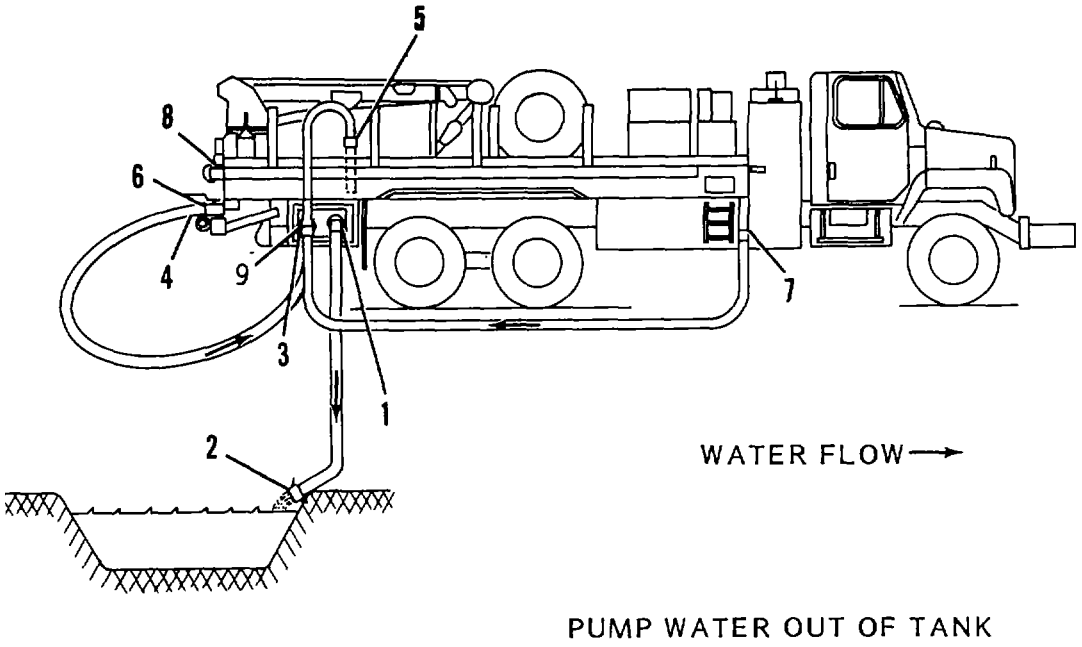


Figure 2-38. Pump Water Out of Tank

4 Close the pump drain valve (9).

5 Move pump operating valve knob (1, figure 2-20) in the direction the water should flow. Lift up the lower sleeve of the knob with two fingers, move knob to right or left, then release sleeve. The indicator light (2) should come on.

6 Continue pumping until tank water level gage (1, figure 2-19) reads "E" (EMPTY); then shift operating valve knob to center, OFF, position.

CAUTION

Do not run the pump dry. Doing so will cause heat damage to internal rubber pumping gears.

7 Close the rear vent valve (8, figure 2-38).

8 Open the pump drain valve (9).

9 If front (7) or rear (6) valve was used to empty tank, close the valve first; then uncouple hoses; replace in storage chamber and secure.

10 Replace fill pipe cap (if removed).

11 Close the pump storage compartment.

12 Disengage hydraulic system/PTO lever (2, figure 2-23) on the control panel in the truck cab and kill the engine.

(c) Transfer Water Slurries. (See Figure 2-39).

1 Couple the suction strainer (1) to the female end of one hose (2); couple the male end to the pump outlet.

2 Submerge the strainer in the water slurry/source.

3 Couple the male end of another hose (3) to the other pump outlet and position the female end in the discharge area.

CAUTION

Never operate the water pump against a closed valve.

NOTE

An automatic bypass backplate, which will internally bypass the pump if you try to operate with a closed valve, is built into the pump. This safety feature should not be used longer than 5 to 10 minutes.

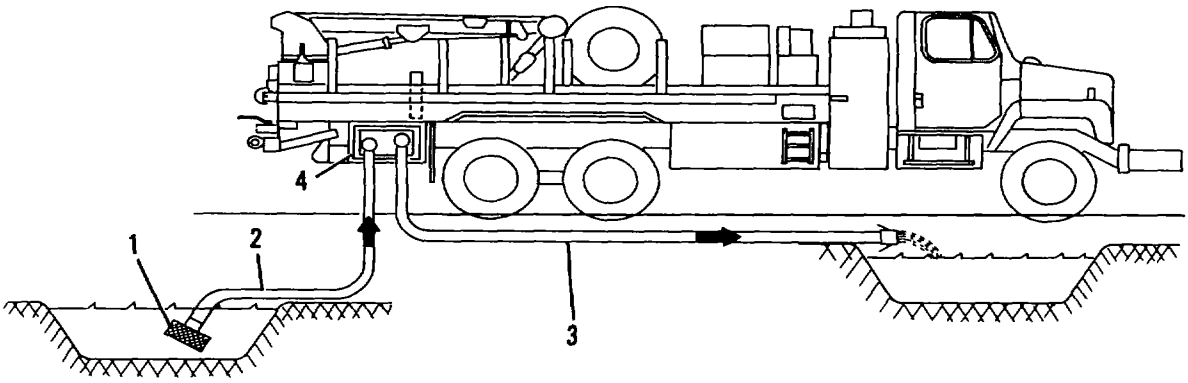


Figure 2-39. Transfer Water Slurries

4 Close the pump drain valve (4),

5 Hove pump Operating valve knob (1, figure 2-20) in the direction the water should flow. Lift up the lower sleeve of the knob with two fingers, move knob to right or left, then release sleeve. The indicator light (2) should come on.

6 Continue pumping until transfer is complete; then shift operating valve knob (1) to center, OFF, position.

NOTE

If dirty water or slurries were transferred, pump some clean water afterwards to flush out the hoses and pump.

7 Open the pump drain valve (4),

8 Uncouple hoses; replace in storage chamber and secure.

9 Close the pump storage compartment, 10 Disengage hydraulic system/PTO Lever (2, figure 2-23) on the control panel in the truck cab and kill the engine.

(d) Cleaning Equipment.

1 Fabricate a nozzle from a hose coupling and pipe fittings.

WARNING

The orifice of a fabricated nozzle may not be smaller than 3/4 in and the truck engine may not be operated above 1000 rpm while performing cleaning operations.

2 Use procedures in para 2-15 band attach the fabricated nozzle to the discharge end of the hose..

2-16 Winch

a. Clutch Operating Procedures. The clutch is controlled by a lever located directly beside the winch, which is mounted on the front of the truck. See Figure 2-40.

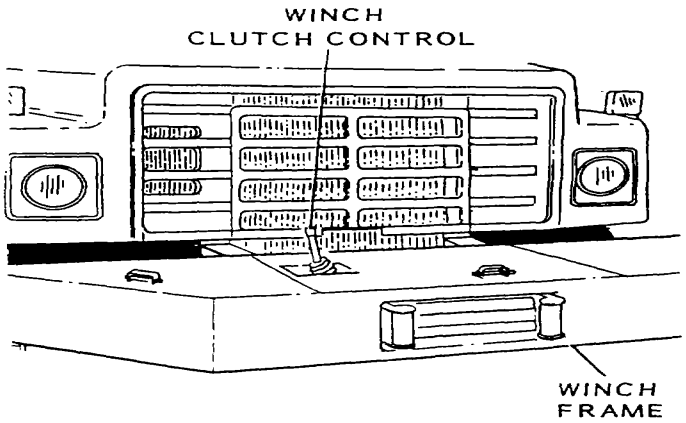


Figure 2-40 Winch Operation.

(1) Grasp clutch handle firmly.

(2) While pushing on the top with your thumb for leverage, lift up until the pin clears the latching slot.

WARNING

Do not attempt to disengage with a load on the winch. Death or injury could result.

(3) Unlatch handle and push to the FREE WIND position to disengage clutch.

(4) Fully insert pin into latching slot.

b. Winch Operating Procedures.

(1) Unlatch the winch clutch and set it to the FREE WIND position.

(2) Unhook tail chain from the ring under winch frame and manually free wind out enough cable to connect to a selected anchor point.

NOTE

Normally, the winch is used to assist the rig tender or the drilling rig over extremely rough terrain, up or down steep inclines, and in other instances when either vehicle becomes immobile

(3) When adequate anchoring is complete, shift the winch clutch handle to POWER WIND position and continue to free wind winch approximately one-quarter turn or until the winch internal clutch jaws have engaged.

(4) Start truck engine. With the truck clutch depressed and the transmission in neutral, engage the power takeoff (2, Figure 2-23) and shift winch operating valve (2, Figure 2-22) to WIND position.

(5) Release truck clutch and slowly take up the slack in cable.

(6) With the operator remaining in the truck cab's seat, continue winching until the task is complete.

(7) When finished, rewind the cable fully onto winch drum and rehook the tail chain into ring under winch frame.

(8) Place the winch control to the center (OFF) position.

2-17. Power Take-Off. To operate the power take-off, proceed as follows:

NOTE

Listen for unusual noises when engaging the powertake-off. It should not make loud noises or screeching sounds It should not cause vibrations.

a. Depress clutch.

b. Place truck transmission in neutral position.

c. Start truck engine.

d. Engage power take-off control (2, Figure 2-23); PTO Indicator (1) will light.

e. Release clutch.

2-18. Night Lighting. Light switches are located on the control console in the truck cab. Use to turn night lights on and off. (See Figure 2-24).

Section V. WELL DRILLING TECHNIQUES AND PROCEDURES.

2-19. Drilling techniques and procedures.

WARNING

Drilling speed RPM must be reduced from the 2100 RPM while truck is in 5th gear. If this procedure is not followed, a shock load is applied to the draw works drive chain, resulting in chain breakage.

a. General Information. The information that follows pertains, for the most part, to the use of equipment. Refer to FM5-1 66, Well Drilling Operations, for general information about drilling wells. Because there are many types and formations of earth, different methods of drilling may apply to every hole drilled. The information herein is intended to be generic; it applies to all wells, although you may or may not utilize some of the procedures described.

b. Starting the hole (wide mud circulation).

(1) Attaching bit and sub.

(a) Use the third drum line to maneuver small drill string components, such as the bit and the bit sub. A hoisting plug is provided for connecting to those items.

(b) Set the bit inside the drive sleeve below the rotary table. Disconnect the hoist plug and retract the third drum line. Use tool joint compound on the drill bit's threads.

(c) Connect the hoisting plug to the bit sub. Lower the bit sub through the rotary table opening and hold it there with the break-out wrench. Remove the hoisting plug. Apply tool joint compound to the sub's threads.

(d) Operate the hoist drum and lower the kelly into position on top of the bit sub. Use a (36") pipe wrench to screw the kelly into the bit sub. Remove the break-out wrench.

(e) Lower the kelly and sub into position on top of the bit. Use the break-out wrench to hold the bit upright. With the kelly drive bushings engaged in the rotary table, rotate the table to screw the kelly onto the bit. Remove the break-out wrench.

(2) Drilling down the kelly.

(a) Fill the mud pits with water for circulating.

NOTE

The primary and secondary mud pits have a limited capacity. As the hole is drilled, the circulation system requires more and more fluid to continue circulation. Add water as necessary to ensure the pump always has an ample fluid supply.

(b) Lower the bit to the ground surface. Start the mud pump and use minimum throttle at first. Start the rotary table rotation. Allow the weight of the kelly and the table rotation to drill several feet of hole. If the weight of the kelly is not enough to penetrate the earth, apply pulldown pressure.

NOTE

When starting the hole, stop the table rotation occasionally and, using a level vertically against the kelly, check that the hole is being drilled straight down and is not drifting. It may be necessary to "fine-tune" the rig's leveling jacks.

(c) Drill the kelly all the way down. Just before the kelly has completed its full travel, stop pulldown (if being used), then stop table rotation. Do not stop the mud pump circulation at this time; allow ample circulation to raise all the cuttings out of the hole. Then raise the kelly a few feet off the bottom of the hole. Stop the mud pump.

(d) Raise the kelly until the top of the bit sub extends above the top of the rotary table. Install the break-out fork on the bit sub and lower the kelly. Use the break-out tong to break the bit sub from the kelly. Unscrew the kelly, raise and retract it into the mast.

(3) Add a drill collar.

(a) Install the hoisting plug in the drill collar. Use the auxiliary drum line to lift the drill collar above the bit sub being held in the rotary table.

WARNING

Be careful when picking up and handling drill collars and drill pipe. Be sure you do not damage the threads by setting the open end directly on the ground. Use thread protectors when handling drill collars and pipe joints.

(b) Lower the drill collar onto the bit sub.

(c) Rotate the rotary table to connect the drill collar to the bit sub. Lift the drill string slightly and remove the break-out fork. Lower the drill collar into the hole until the top of the collar extends just above the rotary table.

(d) Insert the break-out fork to hold the drill collar. Remove the hoisting plug.

(e) Operate the hoist drum and lower the kelly until the kelly sub joins the top of the drill collar. Operate the rotary table counterclockwise to connect the drill collar to the kelly sub. Use the break-out wrench on the drill collar and hold a back-up on the kelly. Torque the connection.

(f) Raise the kelly slightly, remove the break-out fork, and lower the drill string until the kelly drive bushings are engaged in the rotary table. Begin mud circulation and table rotation. Lower the kelly to resume drilling. Drill down the kelly, using pulldown if required, as before.

(4) Add drill pipe (making connections).

(a) Drill the kelly all the way down. Just before the kelly has completed its full travel, stop pulldown (if being used), then stop table rotation. Do not stop the mud pump circulation until all the cuttings have risen to the surface and after you have raised the kelly a few feet off the bottom of the hole.

(b) Raise the kelly until the top of the drill collar extends above the top of the rotary table. Install the break-out fork on the collar and lower the kelly. Use the break-out tongs to break the collar from the kelly. Unscrew the kelly, raise and retract it into the mast.

NOTE

Drill collars supply extra weight on the bit. Several collars may be used. Add subsequent collars as the first.

(c) Install the hoisting plug in the joint of drill pipe to be added to the string. Use the auxiliary drum line to lift the drill pipe above the tool joint being held in the rotary table. (d) Apply tool joint compound on the pipe threads; then lower the drill pipe into the tool joint.

(e) Rotate the rotary table to screw in and tighten the drill pipe to the drill string held in the rotary table. Lift the drill string slightly and remove the break-out fork; then lower the drill string into the hole until the top of the added pipe joint extends just above the rotary table.

(f) Insert the break-out fork to hold the drill string. Remove the hoisting plug from the top pipe joint.

(g) Operate the hoist drum and lower the kelly until the kelly sub joins the top of the drill pipe. Operate the rotary cable counterclockwise

to connect the kelly to the drill string. Use the break-out wrench on the drill string and hold a back-up on the kelly. Torque the connection.

(h) Raise the kelly slightly, remove the break-out fork, and lower the drill string until the kelly drive bushings are engaged in the rotary table.

NOTE

Using a level vertically against the kelly, check that the hole is being drilled straight down and is not drifting.

(i) Begin mud circulation, table rotation, and lower the kelly to resume drilling. Drill down kelly, using pulldown, if required, as before.

(j) Add more drill pipe using the same connection procedures described above until the hole is drilled to required depth.

c. Mud drilling techniques.

(1) Mud mixing.

(a) In order to carry the cuttings to the surface, especially when at greater depths, the mud must be kept at certain weight and viscosity levels. Additives, such as bentonite, are entered into the circulation system to accomplish this. Refer to FM 5-166 for more information about mud treatment.

(b) Install the mud mixing hopper assembly on the water hose line. Slowly add bentonite into the mud hopper in accordance with instructions on the bag. Mix the material thoroughly and allow sufficient time for it to attain final consistency. Continue mud circulation while testing the mud for the correct weight and viscosity.

(2) Weight/density test.

(a) Use a mud balance to determine the density of drilling mud in pounds per gallon. Remove the lid and fill cup to top with a fresh mud sample. Tap the cup to cause any trapped air bubbles to break out.

(b) Replace lid and tighten until firmly seated, making sure some mud seeps out the vent hole. Wipe any mud off the outside of the balance. Place the balance on the base with the knife edges on the fulcrum rest.

(c) Move the balance rider until the level indicates balanced. Read the mud weight (in pounds per gallon) indicated at the edge of the rider nearest the fulcrum. Record the mud weight in the drilling log.

(3) Mud viscosity test.

(a) Use the marsh funnel viscometer, a graduated cup, and a stop watch to determine the viscosity of the mud. Hold the funnel upright with

your index finger holding the outlet closed, and pour fresh mud through, and completely up to, the screen.

(b) Position the completely empty graduated cup under the outlet and simultaneously start the stop watch and remove your finger from the outlet. When exactly one quart has drained into the cup, stop the watch. Log the time, in seconds, required to drain one quart. Clean and dry the cup and funnel after each use. Be careful not to damage the brass orifice on the bottom of the funnel.

(4) Sand content test.

(a) Use the baroid sand content set (200-mesh sieve, funnel, and glass measuring tube) to determine the percentage of sand by volume. Pour a fresh mud sample into the glass tube to the mark labeled "Mud to Here." Cover the mouth of the tube with your thumb and shake it vigorously.

(b) Pour the mud through the screen, discarding the fluid and keeping the sand. Rinse clear water in the tube and pour through the screen to catch any remaining sand particles.

NOTE

Do not force any solid residue through the sieve. Allow whatever will to accumulate.

(c) Wash the sand in the screen with a slow stream of clean water. Fit the funnel over the sieve and slowly turn the funnel over, guiding the funnel's tip into the glass tube. Aim a fine spray of water over the back side of the sieve to wash sand back into the tube.

(d) After allowing the sand to settle in the tube, record the quantity of sand in the calibrated tube as the sand content of the mud in percent by volume. Clean and dry the screen, funnel, and tube after each use, making sure the sieve is clean and dry.

(5) Cutting samples.

NOTE

Samples of the cuttings should be taken at intervals dictated by certain drilling conditions, such as a decrease in time required to drill a foot of hole. Refer to FM 5-166 for more information.

(a) Use a 6-inch strainer to catch fresh cuttings as they emerge from the drill sleeve.

(b) Rinse the cuttings in clear water and record their characteristics in the drilling log.

d. Air drilling techniques.

NOTE

If the well is to be drilled using air drilling methods, the mud pits need not be used. It will be necessary to install the drive sleeve.

(1) Position the drive sleeve under the rotary table. Lower the kelly through the rotary table and attach the drive plate. Lower the plate into the sleeve and rotate the table to screw the drive sleeve into the ground. Remove the drive plate from the kelly sub and attach a tri-cone bit.

(2) Operate the hoist drum to lower the kelly so that the bit contacts the ground inside the drive sleeve. Be sure the kelly bushings are properly engaged in the rotary table. Begin rotation of bit and lower the kelly to put weight on the bit.

(3) Operate the air compressor to begin blowing cuttings up away from the bit.

(4) Operate the water injection pump to inject enough water into the air stream to settle the dust coming out of the hole.

NOTE

If drilling a large diameter hole (12"), you may need to inject foam into the air stream. (Refer to FM 5-166 for more information.) (5) If more weight is needed on the bit for drilling, operate the pulldown system to add the required weight.

(6) Drill down the kelly. Stop rotation but continue air circulation until cuttings stop coming up.

CAUTION

Do not raise the bit out of the ground with the air compressor operating. The rush of air, dust, and dirt can cause injury to eyes and skin.

(7) Operate the hoist drum to raise the kelly partially up the hole; shut off the air compressor before exiting the hole.

(8) Add pipe (make connections) just like you would if you were drilling with mud.

e. Percussion drilling.

NOTE

Drilling conditions dictate whether or not down-the-hole percussion tools are needed. (See FM 5-166 for information regarding its use.) The percussion tool may be installed when first beginning to drill or after some of the hole has been drilled using another drilling method. Regardless of when the decision is made to use percussion tools, the down-the-hole (DTH) hammer and a button bit must be installed in place of the tri-cone bit. If this means removing existing drill string from the hole, see "Coming out of the hole," below.

CAUTION

When working around a hole that has been partially drilled, be careful not to drop anything down the hole, especially metal objects (hammers, wrenches, handtools, etc.,) that cannot be drilled up. After the drill string has been completely removed from the hole, install the drive plate onto the drive sleeve.

(1) Assemble a button bit onto the bottom of the DTH hammer and a hoisting plug on the top. Use the auxiliary drum to position the DTH hammer and bit assembly through the rotary hole. Use the break-out wrench to hold the hammer.

NOTE

If drilling has not started yet, the hammer will come to rest on the ground inside the drive sleeve. If drilling has already begun, the hammer will rest on the drive plate.

(2) Remove the hoisting plug from the hammer and set it aside.

NOTE

If the hole has been drilled to some depth, you must insert the drill string first. It is, however, a good idea to test the hammer's operation before lowering it all the way to the bottom of the hole. If you choose not to test the hammer, insert the drill string (see "Going into the hole," below), then skip to Step 7.

(3) Operate the hoist drum and lower the kelly (with kelly sub attached) into position over the hammer.

(4) Rotate the rotary table to screw the hammer onto the kelly sub.

(5) Test the hammer before drilling as follows:

(a) Turn on the air but not the rotation.

(b) Position a piece of timber, larger than the hole, under the hammer. Lower the hammer onto the timber.

(c) Apply enough pulldown pressure to keep the bit pushed against the hammer. The hammer piston should begin striking the bit at high frequency; the air gage should read 100 to 110 psi.

(d) Turn off the air and remove the timber.

(6) When starting a new hole, begin drilling as follows:

(a) Lower the bit to just above the ground.

(b) Turn on the air for 100 to 110 psi.

(c) Start slow rotation at about 5 rpm.

(d) Lower the bit to the surface.

(e) Apply pulldown pressure to start penetration. Proceed carefully to keep the bit from "walking" on the surface.

(f) Start the water injection to control dust.

(g) After the hole is 18 to 24 inches deep, increase rotation to approximately 25 rpm. Maintain enough pulldown pressure to effect an adequate drilling rate.

(7) When continuing a hole, you may not be able to add all the joints of pipe that were removed, depending on whether or not the kelly was drilled down completely, and considering the added length of the hammer. Before adding the last joint of pipe removed, attach the kelly. Then proceed as follows:

(a) Lower the bit to the bottom of the hole.

(b) Turn on the air for 100 to 110 psi.

(c) Start rotation at about 25 rpm.

(d) Apply pulldown pressure to start penetration.

(e) Start the water injection to control dust.

(8) Continue drilling. Start the force feed lubricator to inject lubricant for the DTH hammer.

f. Coming out of the hole.

(1) When the hole is drilled to the required depth, when the bit is worn out, or when drilling conditions warrant the use of the down-the-hole hammer, all the pipe must be withdrawn from the hole. This is accomplished by removing

the kelly in the same manner as it is removed to make a connection, and retracting it into the mast.

(2) Attach and tighten the hoisting plug to the joint being held in the rotary table; use the auxiliary drum to raise the drill string to the next tool joint; reset the break-out fork; repeat the breaking-out procedure; then lay the joint of pipe into the rig tender storage compartment or onto pipe racks (if available).

(3) Repeat this procedure until all joints of pipe are out and the last drill collar has been removed. If a new bit is to replace a worn bit, leave the bit sub/ drill collar (or DTH hammer/pipe) joint intact. Otherwise, first remove the bit (according to the following instructions); then break the sub/drill collar (or DTH hammer/pipe) joint.

g. Changing the bit: attaching/removing down-the-hole hammer.

(1) Install the drive plate in the drive sleeve.

(2) Raise the collar and bit sub until the bit is just below the rotary table, and attach the break-out wrench onto the bit. Rotate the table (counterclockwise) to break the connection. (Use similar procedures to remove the button bit from the DTH hammer.) (3) Install the new bit (or if changing to percussion drilling, install the DTH hammer and button bit). Tighten with the break-out wrench and rotary table.

h. Going into the hole.

(1) After a new bit (or the DTH hammer and button bit) is installed and tightened, remove the drive plate from the drive sleeve.

(2) Operate the auxiliary drum to raise the drill string from the rotary table. Remove the break-out fork and lower the joint into the hole. Install the break-out fork and allow the joint to rest in the rotary table.

(3) Remove the hoisting plug, then insert and tighten it into the next joint to be attached to the drill string.

(4) Raise the pipe joint into the mast, being sure to catch the tailing end of the pipe before it reaches the rotary table area. Apply the pipe joint compound on the threads; then insert the male pin into the box. Use the table to screw the joint together; then tighten the joint with the break-out wrench.

(5) Repeat Steps 3 and 4 until all the pipe joints are installed in the hole. Finally attach the kelly as you would in making an ordinary connection (adding pipe).

Section VI. OPERATING UNDER UNUSUAL CONDITIONS

2-20. Drilling Rig.

a. Cold Weather Operation.

(1) Engine coolant. Make sure the truck engine is filled with the proper engine coolant. Add anti-freeze coolant, NEVER WATER, as necessary.

(2) Lubrication systems. Change oil and lubricants with lubricants recommended for cold weather operation. Refer to the lubrication instructions in Chapter 3 for recommended lubricants.

CAUTION

Use caution during entire warmup procedure. Run the truck engine at the slowest possible speed and actuate all controls slowly.

(3) Hydraulic system.

CAUTION

The hydraulic oil provides lubrication to the hydraulic pump. When the oil in the suction line is too cold and stiff to flow easily, it cannot keep the pump inlet supplied with oil, thus cavitation occurs. If this condition continues for more than a few moments, serious damage may result.

(a) To prevent cavitation, "jog" the PTO/hydraulic pump on and off by depressing and releasing the clutch until oil has warmed enough to permit adequate flow to the pump.

(b) If jogging the pump for 10 minutes does not produce acceptable results, do not attempt to operate the unit until the rig can be taken inside a heated enclosure and serviced for cold weather operation. Refer to the lubrication instructions in Chapter 3.

(4) Water injection. Do not fill the water injection tank with water until just before you intend to use water injection. If necessary, use external heat or a small immersion heater to keep the water from freezing. After use, drain the water tank, pump, suction lines, and discharge lines. Also, drain the foam chemical reservoir and its lines.

(5) Mud circulation system. After use, remove the drain plugs and drain the mud pump fluid end. Drain all discharge lines, allowing all fluid to drain from the swivel and kelly hose. Under severely cold conditions, it may be necessary to erect temporary shelter around the mud pits and use portable heaters to keep the mud above freezing temperatures. Maintain circulation of the fluid as much as possible.

(6) Control air system. Check the control air system for moisture accumulation more frequently, draining the bowl as necessary.

b. Hot Weather Operation.

(1) Engine coolant.

(a) Make sure the truck engine is filled with the proper engine coolant. Check coolant level more frequently, adding coolant as necessary.

(b) During operation, check the engine coolant temperature gage frequently. If temperature rises above 212 deg. F (100 deg. C), reduce the engine load by temporarily slowing or stopping drilling operations. Resume drilling after the temperature drops below 194 deg. F (90 deg. C).

(2) Lubrication systems. Change oil and lubricants with lubricants recommended for hot weather operation. Check oil levels more frequently, adding oil as required to maintain proper levels. Refer to the lubrication instructions in Chapter 3 for recommended lubricants.

(3) Hydraulic system.

WARNING

Hydraulic operations become erratic when the fluid is at an elevated temperature. DO NOT perform critical operations, such as raising the mast, when the hydraulic oil temperature is too high. Allow the temperature to drop below 190 deg. F (88 deg. C) before performing the critical task.

Check the hydraulic oil temperature gage frequently. If the temperature rises above 220 deg. F (104 deg. C), temporarily slow drilling operations. Resume normal drilling after the temperature drops below 190 deg. F (88 deg.C).

(4) Air drilling system. When air drilling, check the air compressor injection oil temperature gage frequently. If the temperature rises above 148 deg. F (70 deg.C), temporarily stop drilling while allowing the compressor to run. Resume air drilling after the temperature drops below or near 150 deg. F (65 deg. C).

c. Sandy or Dusty Conditions.

(1) Shorten the intervals for changing air filters and oil filters. See lubrication instructions in Chapter 3.

(2) Lubricate equipment frequently and watch fluid levels closely. Use liberal amounts of grease when lubricating pressure grease points to force out any contaminated grease.

(3) Change hydraulic oil two or three times more frequently.

(4) Keep the rig as clean as possible at all times. Pay particular attention to hydraulic cylinder rods and other exposed moving parts.

(5) To the extent possible, erect barriers to protect against blowing sand or dust.

d. High humidity conditions.

(1) Protect cylinder shafts and painted or polished surfaces by keeping them well lubricated or coated with a thin layer of grease or similar preservative.

(2) Check for and remove any rust and corrosion as it appears and repaint affected surfaces.

(3) Keep pressure grease points well lubricated to prevent entry of moisture.

2-21. Rig Tender Crane.

a. Cold Weather Operation.

(1) Change oil and lubricate equipment with lubricants recommended for cold weather operation. Refer to lubrication instructions in Chapter 3 for recommended lubricants.

CAUTION

Use caution during entire warmup procedure. Run the truck engine at the slowest possible speed and actuate all controls slowly.

CAUTION

The hydraulic oil provides lubrication to the hydraulic pump. When the oil in the suction line and reservoir is too cold and stiff to flow easily, it cannot keep the pump inlet supplies with oil, thus cavitation occurs. If this condition continues for more than a few moments, serious damage will result.

(2) To prevent cavitation, "jog" the PTO/hydraulic pump on and off by depressing and releasing the clutch until oil has warmed enough to permit adequate flow to the pump.

(3) If jogging the pump for 10 minutes does not produce acceptable results, do not attempt to operate the unit until the vehicle can be taken inside a heated enclosure and serviced for cold weather operation. Refer to the lubrication instructions in Chapter 3.

b. Hot Weather Operation.

(1) Use lubricants that are more viscous and resist breakdown at high tempera

tures. Refer to the lubrication instructions in Chapter 3 for recommended viscosity's.

(2) Check oil levels frequently and add oil as required to maintain proper levels.

c. Sandy or Dusty Conditions.

(1) Lubricate equipment frequently and watch fluid levels closely.

(2) Change hydraulic oil two or three times more frequently.

(3) Use liberal amounts of grease when lubricating pressure grease points to force out any contaminated grease.

(4) Keep equipment as clean as possible at all times.

d. High Humidity and/or Salt Water Conditions.

(1) Protect cylinder shafts and painted or polished surfaces by keeping them well lubricated or coated with a thin layer of grease or similar preservative.

(2) Remove rust and corrosion as they appear and repaint affected surfaces.

(3) Keep pressure grease fittings well lubricated to prevent entry of moisture.

2-22. Welder/Generator Engine.

a. Cold Weather Operation.

(1) Cold weather can cause clogged fuel lines and filters. Paraffin oil should be mixed with the diesel fuel in the following proportions, according to the temperature:

Temperature	Fuel Content
32 to 5 deg F (0 to -15 deg C)	100%° diesel fuel
4 to -4 deg F (-16 to -20 deg C)	75% diesel, 25%° paraffin
-5 to -25 deg F (-21 to -32 deg C)	50% diesel, 50%° paraffin

(2) Condensation in the fuel tank can affect the fuel flow to the engine. Keep tank as full as possible during cold weather. Refill fuel tank more often than normal. If fuel tank becomes contaminated with water, drain and flush tank and refill with new fuel.

(3) Change engine oils and lubricate equipment with lubricants recommended for cold weather operation. Refer to lubrication instructions in Chapter 3.

b. Hot Weather Operation.

(1) Use lubricants that are more viscous and resist breakdown at high tempera-

tures. Refer to the lubrication instructions in Chapter 3 for recommended viscosities.

(2) Check oil levels frequently and add oil as required to maintain proper levels.

(3) Run engine only as required to complete necessary task. Avoid prolonged idling.

c. Sandy or Dusty Conditions.

(1) Change engine oil two or three times more frequently.

(2) Check oil bath air cleaner daily; clean and change its oil as needed.

(3) Clean cooling fins every 100 hours of operation.

d. High Humidity and/or Salt Water Conditions.

(1) Protect painted or polished surfaces by keeping them well lubricated or coated with a thin layer of grease or similar preservative.

(2) Remove rust and corrosion as they appear and repaint affected surfaces.

e. High Altitudes.

(1) At high altitudes, less oxygen is available for combustion of the engine fuels. Above 5,000 feet elevation, the engine fuel injectors may have to be changed to ensure proper performance.

(2) Watch engine temperatures closely for signs of overheating.

2-23 Welder/Generator.

a. Cold Weather Operation.

(1) Keep battery fully charged and filled to proper fluid level.

(2) Keep snow and ice away from battery terminals.

(3) Keep terminals tight and free from corrosion.

(4) During periods of extreme cold, remove battery and store it in a heated area overnight or until equipment is needed for operation.

b. Hot Weather Operation.

(1) Check battery fluid level frequently because evaporation increases at higher temperatures.

(2) Keep air intakes and exhaust clear of obstructions and airborne matter that could cause clogging and restrict air flow.

c. Sandy or Dusty Conditions. Clean air intakes daily.

d. High Humidity and/or Salt Water Conditions.

(1) Protect painted or polished surfaces by keeping them well lubricated or coated with a thin layer of grease or similar preservative.

(2) Remove rust and corrosion as they appear and repaint affected surfaces.

e. High Altitudes. Keep air intakes and vents clean and clear of obstructions.

2-24 Fuel Transfer.

a. Cold Weather Operation.

(1) Cold weather can cause clogged fuel lines and filters. Paraffin oil should be mixed with the diesel fuel in the following proportions, according to the temperature:

Temperature	**Fuel Content**
32 to 5 deg F (0 to -15 deg C)	100% diesel fuel
4 to -4 deg F (-16 to -20 deg C)	75% diesel, 25% paraffin
-5 to -25 deg F (-21 to -32 deg C)	50% diesel, 50% paraffin

(2) Condensation in the fuel tank can affect the fuel flow. Keep tank as full as possible during cold weather. Refill fuel tank more often than normal. If fuel tank becomes contaminated with water, drain and flush tank and refill with new fuel.

b. High Humidity and/or Salt Water Conditions.

(1) Protect painted or polished surfaces by keeping them well lubricated or coated with a thin layer of grease or similar preservative.

(2) Remove rust and corrosion as they appear and repaint affected surfaces.

c. High Altitudes. Keep vents clean and clear of obstructions.

2-25 Water Heater and Waterbed.

a. Cold Weather Operation. The water heater will be used more frequently as the temperature falls below freezing. No unusual operating conditions affect the water heater.

b. Hot Weather Operation. Check the waterbed fluid level often. During hot weather, water will evaporate more quickly.

c. High Humidity and/or Salt Water Conditions.

(1) Protect painted or polished surfaces by keeping them well lubricated or coated with a thin layer of grease or similar preservative.

(2) Remove rust and corrosion as they appear and repaint affected surfaces.

2-26 Water Pump.

a. Cold Weather Operation.

CAUTION

Use caution during entire warmup procedure. Run the truck engine at the slowest possible speed and actuate all controls slowly.

CAUTION

The hydraulic oil provides lubrication to the hydraulic pump. When the oil in the suction line and reservoir is too cold and stiff to flow easily, it cannot keep the pump inlet supplied with oil, thus cavitation occurs. If this condition continues for more than a few moments, serious damage will result.

(1) To prevent cavitation, "jog" the PTO/hydraulic pump on and off by depressing and releasing the clutch until oil has warmed enough to permit adequate flow to the pump.

(2) If jogging the pump for 10 minutes does not produce acceptable results, do not attempt to operate the unit until the vehicle can be taken inside a heated enclosure and serviced for cold weather operation. Refer to the lubrication instructions in Chapter 3.

b. High Humidity and/or Salt Water Conditions.

(1) Protect cylinder shafts and painted or polished surfaces by keeping them well lubricated or coated with a thin layer of grease or similar preservative.

(2) Remove rust and corrosion as they appear and repaint affected surfaces.

2-27 Winch.

a. Cold Weather Operation.

(1) Change oil and lubricate equipment with lubricants recommended for cold weather operation. Refer to lubrication instructions in Chapter 3 for recommended lubricants.

CAUTION

Use caution during entire warmup procedure. Run the truck engine at the slowest possible speed and actuate all controls slowly.

CAUTION

The hydraulic oil provides lubrication to the hydraulic pump. When the oil in the suction line and reservoir is too cold and stiff to flow easily, it cannot keep the pump inlet supplied with oil, thus cavitation occurs. If this condition continues for more than a few moments, serious damage will result.

(2) To prevent cavitation, "jog" the PTO/hydraulic pump on and off by depressing and releasing the clutch until oil has warmed enough to permit adequate flow to the pump.

(3) If jogging the pump for 10 minutes does not produce acceptable results, do not attempt to operate the unit until the vehicle can be taken inside a heated enclosure and serviced for cold weather operation. Refer to the lubrication instructions in Chapter 3.

(4) With adequate oil flow, continue to run pump until oil reservoir feels warm to the touch. Then begin jogging the winch functions to circulate warmed oil. Slowly cycle all winch functions, one at a time, actuating each cylinder in turn, operating winch in both directions.

CAUTION

If, at any time, the sound of the pump changes from its normal "hum" to a "screaming" noise, stop the pump immediately. The "screaming" indicates cavitation.

(5) Resume jogging procedures until the pump can again be run continuously without cavitating.

b. Sandy or Dusty Conditions. Clean wire rope as needed.

c. High Humidity and/or Salt Water Conditions.

(1) Protect painted or polished surfaces by keeping them well lubricated or coated with a thin layer of grease or similar preservative.

(2) Remove rust and corrosion as they appear and repaint affected surfaces.

(3) Coat wire rope often with wire rope lubricant or grease.

2-28 Hydraulic Reservoir.

a. Cold Weather Operation. Use hydraulic fluid recommended for cold weather operation. Refer to lubrication instructions in Chapter 3 for recommended lubricants.

b. High Humidity and/or Salt Water Conditions.

(1) Protect painted or polished surfaces by keeping them well lubricated or coated with a thin layer of grease or similar preservative.

(2) Remove rust and corrosion as they appear and repaint affected surfaces.

2-29 Power Take-Off/Hydraulic Pump.

a. Cold Weather Operation.

CAUTION

Use caution during entire warmup procedure. Run the truck engine at the slowest possible speed and actuate all controls slowly.

CAUTION

The hydraulic oil provides lubrication to the hydraulic pump. When the oil in the suction line and reservoir is too cold and stiff to flow easily, it cannot keep the pump inlet supplied with oil, thus cavitation occurs. If this condition continues for more than a few moments, serious damage will result.

(1) To prevent cavitation, "jog" the PTO/hydraulic pump on and off by depressing and releasing the clutch until oil has warmed enough to permit adequate flow to the pump.

(2) If jogging the pump for 10 minutes does not produce acceptable results, do not attempt to operate the unit until the vehicle can be taken inside a heated enclosure and serviced for cold weather operation. Refer to the lubrication instructions in Chapter 3.

(3) With adequate oil flow, continue to run pump until oil reservoir feels warm to the touch.

CAUTION

If, at any time, the sound of the pump changes from its usual "hum" to a "screaming" noise, stop the pump immediately. The "screaming" indicates cavitation.

(4) Resume jogging procedures until the pump can again be run continuously without cavitating.

b. High Humidity and/or Salt Water Conditions.

(1) Protect painted or polished surfaces by keeping them well lubricated or coated with a thin layer of grease or similar preservative.

(2) Remove rust and corrosion as they appear and repaint affected surfaces.

Section VII. WELL COMPLETION.

2-30. Well Completion General Information.

a. Scope. This section details the steps necessary to complete the water well after drilling is complete. The paragraphs that follow give information for: logging the well to precisely locate the depth at which the well will produce; setting the casing (pipe) that forms the wall of the water well; cleaning out the well; and finally, installing the pump and flow line that raises the water from the bottom of the well to the surface.

b. Auxiliary Equipment. The special tools and equipment needed to complete the water well are the following:

(1) Electric logging system (part no. 149F923). This equipment is used after drilling is complete, or near completion, to determine the type and locations of formations in the well.

(2) Well completion kit (part no. 165F004). This kit contains all the components necessary to complete a water well, to a depth of 600 feet. It includes those components listed in the Department of the Army Supply Catalog, SC 3820-97-CL-3.

(3) Well sounder (part no. 149F924). This instrument is used to determine water levels.

(4) Dart valve bailer (part no. 149F917). This equipment is used to remove accumulations of sand or mud from the well.

c. 1500 Foot Well Drilling. Capabilities to drill 1500 feet have been added to this system by using a rig auxiliary kit (part no. 168F530 or part no. KT-1992-TRSC). Refer to paragraph 2-44.

2-31. Well Logging Equipment.

a. Description. The electric logging system consists of a well probe that is manually lowered down the well and an instrument at the surface that receives electrical information from the probe. The operator takes readings at different points up the well and plots the data on a graph, recording a spontaneous potention (SP) curve, three 'normal' resistively curves and two lateral resistively curves.

b. Well probe.

(1) The well probe is attached to a 500-foot multi-conductor cable by means of waterproof connectors. The brass current electrode is drilled so that an insulated 'sinker rod" can be attached to the probe, by means of a leather thong, if greater weight is needed to carry the probe to the bottom of the well.

(2) The probe contains a brass current electrode and three lead-oxide potential electrodes. The potential electrodes are spaced at 0.25, 2.5, and 10 feet from the current electrode. Each electrode is potted in epoxy resin in short lengths of PVC tubing; each is internally insulated from the others; and each is connected to the surface by a separate conductor (wire).

c. Resistivity Instrument. The resistivity instrument uses direct current and is of the 'null' reading type. The instrument reads directly in ohm-feet. The instrument's controls, shown in figure 2-41, operate as described In the following paragraphs.

(1) Galvanometer. Zero-centered micro-ammeter. All operations involve returning the meter to its zero position.

(2) SP shut-off switch. Located in upper left corner of the panel. Spring loaded switch to automatically disconnect the circuit from the 1-1/2 volt 'C' battery when the instrument lid is closed.

(3) Self-potential potentiometer. Balances the spontaneous potential that always exists between any pair of potential electrodes. Do this before making any resistivity reading. Balance is indicated when the galvanometer needle goes to zero. If the SP curve is desired, merely record potentiometer reading. Each small division equals one millivolt; full scale is 1 volt.

(4) SP Polarity-reversing switch. Located directly below the Self-potential potentiometer; it indicates the polarity of the particular cable electrode being used and enables the operator to change the polarity of the injected voltage as required by bore-hole conditions.

(5) Function switch. A three-position selector switch located under the galvanometer. Its three positions are:

(a) CUR (current), to check the system to be sure whether or not the proper amount of current is being used;
(b) CAL (calibrate), to calibrate the instrument, as is required at the start of the logging operation and after every 50 feet of logging; (c) LOG, to set the instrument for logging operations.

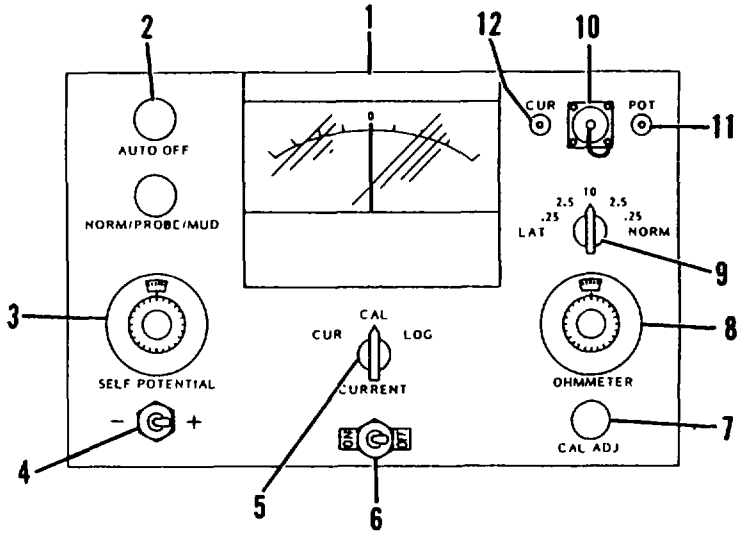


Figure 2-41. Resistivity Instrument

(6) Current switch. ON/OFF switch, located directly below the function switch. It is a momentary spring-return toggle switch that turns on the electrical current to take resistivity measurements. The spring-return feature prevents leaving on the current and subsequent battery drainage.

(7) Cal adjust. Located in the lower right hand corner of the panel; used to zero the galvanometer when calibrating the instrument.

(8) Ohmmeter Potentiometer. Located directly above "cal adjust," it reads the earth resistivity directly in ohm-feet. Select a position on the electrode selector switch and interpret the readings as follows:

Electrode selector switch position	**One division equals:**	**Full scale equals:**
.25 ft NORMAL	1 ohm-feet	1000 ohm-feet-
2.5 ft NORMAL	10 ohm-feet	10,000 ohm-feet
10 ft NORMAL	40 ohm-feet	40,000 ohm-feet

(9) Electrode selector switch. Five position switch located directly above the ohmmeter. On the right side, it makes circuit connections for either the 0.25 or 2.5 ft NORMAL arrangement, as marked. When the switch points straight up, the connections are for 10 ft NORMAL. On the left side, the connections are the 0.25 and 2.5 ft LATERAL arrangement, as marked. In the LATERAL arrangements, the 10 ft electrode serves as the reference in both cases.

(10) Cable jack. The cable jack is the four-pronged receptacle (furnished with a dust cover) located in the upper right corner of the panel. The jumper cable from the logger cable case is plugged in here, thus connecting the instrument to the well probe.

(11) POT receptacle. Black plug receptacle for connecting the surface potential ground lead (lead-oxide flag) wire to the instrument.

(12) CUR receptacle. Red plug receptacle for connecting the surface current ground (steel stake) wire to the instrument.

d. Power Supply. The instrument requires three voltages: 1-1/2 volt ("C" cell battery), 9 volts (9 volt battery), and 45 volts (5, 9-volt batteries in series). (Refer to figure 2-42.)

e. Test Set. The test set provides a means for checking the instrument operation and battery condition without using the logging cable. It is normally kept in the base of the instrument. To use it: plug it into the cable jack; plug the single red plug into the CUR receptacle and plug the black plug into the POT receptacle. Then follow the usual logging procedure. You will, or course, have little, or no, "SP." The electrode selector switch may be in any of the NORMAL logging positions.

f. Logging Cable. The cable used to lower the probe has four conductors covered with a durable 60% natural rubber jacket. The cable is marked at five-foot intervals with numbered markers.

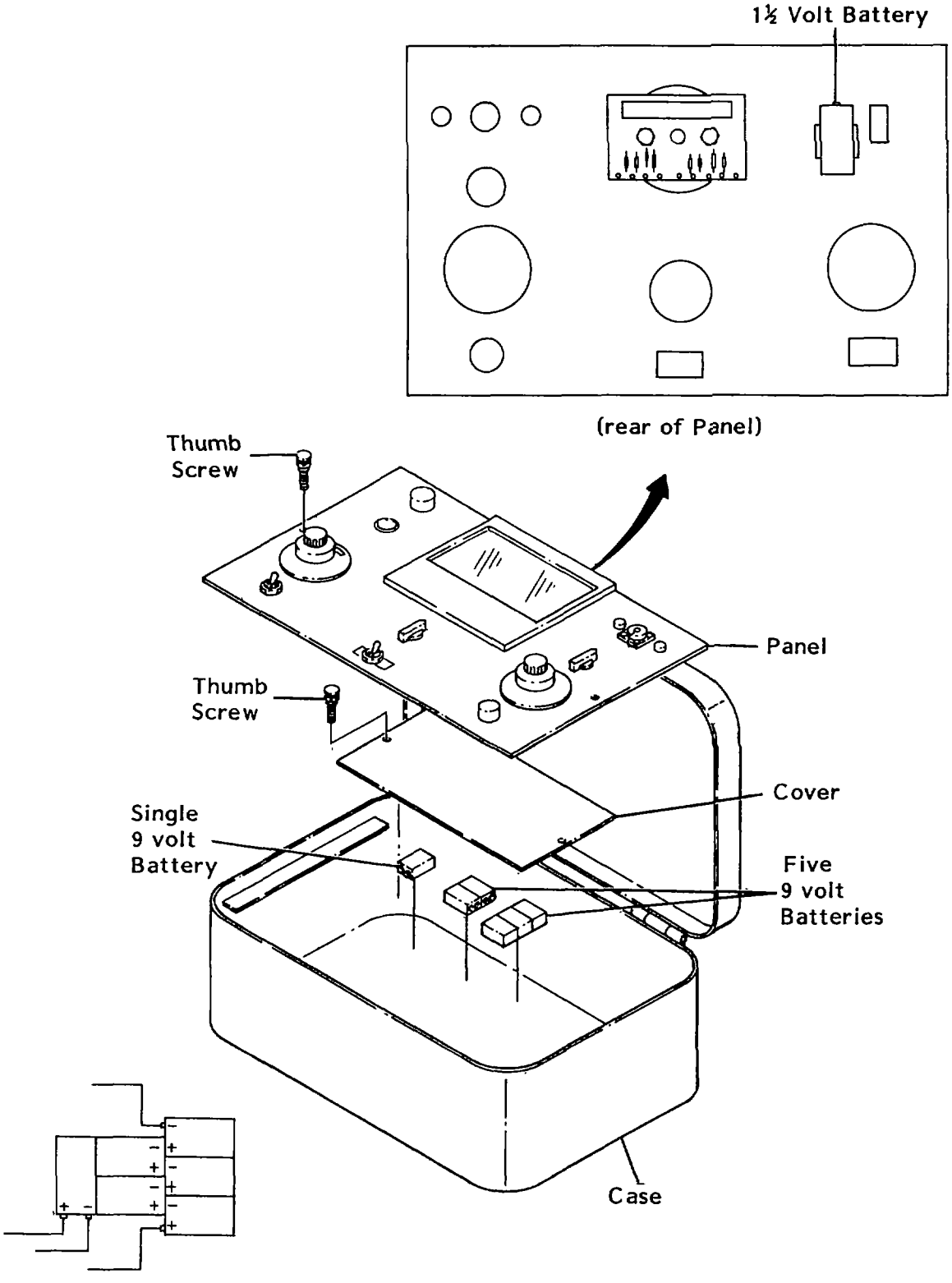


Figure 2-42. Logging Instrument Batteries

g. Cable and Reel. The reel is made of aluminum. Wherever practical, nonferrous metals have been used in construction of the logging gear.

h. Surface Wires. Two small lengths of insulated, stranded conductor wire are included with the unit. The surface current wire has a red plug on one end that connects to CUR on the instrument, and a red clamp to fasten to a grounded steel stake (not furnished) at the other end. The surface potential wire has a black plug on one end that connects to POT on the instrument, and a piece of oxidized lead attached to the other end.

NOTE

If these wires should become worn or broken, they may be replaced by any 18-20 gauge, stranded conductor, insulated wire. Because of the size of these lines (and their reel) they are not contained within the instrument cases but are carried separately.

2-32. Logging with NORMAL Arrangement.

a. Setting Up Equipment.

(1) Set up the equipment as shown in figure 2-43. Plug the red and black plugs into the instrument (red in CUR, black in POT), and extend each wire about 75 feet to opposite sides of the hole. The steel stake should be 1/4 to 1/2 inch in diameter and 2 to 3 feet long. Drive the stake two-thirds into the ground and attach the red clamp. Position the lead-oxide flag, equally distanced from the hole on the opposite side. Attach the wire to the flag and bury flag and wire about 1 foot deep. Moisten and tamp the soil down firmly.

(2) Before connecting the waterproof connectors on the probe and on the logging cable, clean both halves thoroughly and make sure each is dry. Aline and mate the pins and socket; when properly mating, you should hear a "POP" as the connectors join, (3) Lower the probe to the bottom of the well, being careful not to let the probe "free-fall." Then connect the jumper cable into the cable receptacle on the instrument panel.

b. Operating the Instrument.

(1) Calibrating. Set the function switch to the CAL position; set the electrode switch to one of the NORMAL positions; hold the CUR switch in the ON position; and zero the galvanometer needle by adjusting the "cal adjust" knob. Do this at the start of every job and repeat it after every 50 feet of logging.

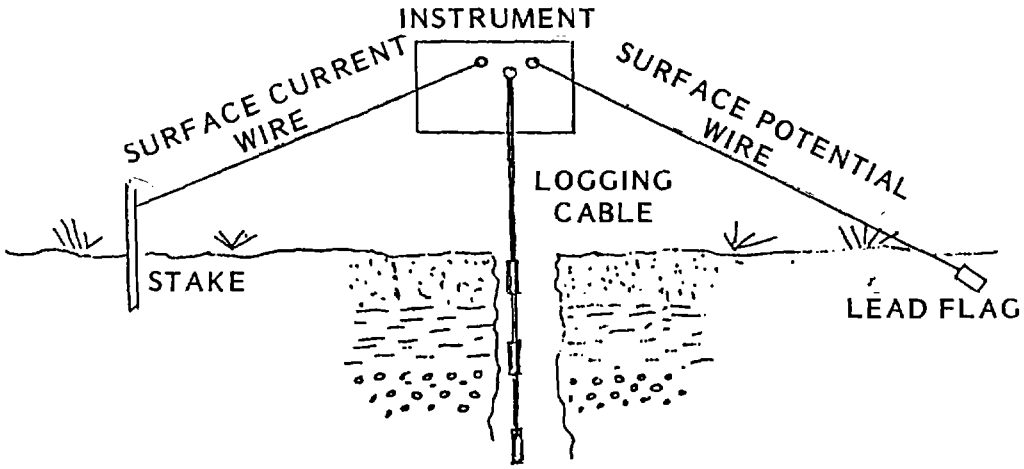


Figure 2-43. Setting up Logging Equipment

NOTE

If unable to zero the galvanometer, the instrument probably has too little current flow. See Troubleshooting the Well Logging Equipment later in this section.

(2) Logging.

(a) To balance out the "SP", set the electrode selector switch to 0.25-foot NORMAL; set the function switch to LOG; zero the galvanometer needle by adjusting the self-potential potentiometer. The dial reading on the potentiometer thus obtained is the SP in millivolts with the polarity of the probe electrode as indicated on the reversing switch. If unable to zero the galvanometer, reverse the polarity switch and try again.

(b) To measure resistivity (after balancing the SP), hold the current switch ON and return the galvanometer needle to zero by adjusting the ohmmeter; then release the current switch. The dial reading of the ohmmeter is the resistivity in ohm-feet (each division equals 1 ohm foot) for the 0.25-foot NORMAL electrode spacing.

(c) Turn the electrode selector switch to the 2.5-foot position and repeat Steps (a) and (b). The dial reading on the ohmmeter now needs to be multiplied by 10 to obtain the apparent earth resistivity for this electrode spacing.

(d) Logging notes: The 0.25 and 2.5-foot NORMAL readings are preferred for most wells. If an SP curve is desired, it should be read with the electrode selector switch in the 0.25 foot position. In some cases, for example with a large bore-hole or with exceedingly high formation resistivity, it may be advantageous to use the 10-foot NORMAL position. The instrument is not direct reading; multiply the reading by a factor of 40.

In logging mud-filled or deep holes, attach a sinker rod to the probe so that there is enough weight that you can feel the bottom of the hole. Such a weight should be wrapped with friction or electricians tape; attach it to the probe with a leather thong.

The distance between readings depends on how much detail is being sought. For most situations, a reading every 2.5 feet is adequate; however, if formations of 1 to 2 feet thickness is sought, take readings at every 1 or 2 foot distances.

Remember, that in order to obtain a log, the well probe must be below the level of fluid in the well. When the probe is pulled out of the water, the resistivity instrument will go "dead." A quick means of checking depth to the fluid level is by turning the function switch to CUR and holding the current switch in the ON position. When the well probe is pulled out of the fluid, the galvanometer needle will return to zero.

2-33. Logging with LATERAL Arrangement.

a. General. In areas with extremely high resistive surface materials or large and varying ground potentials, it may not be possible to make a NORMAL log. The former condition is found where a large thickness of dry sand is found at the surface (desert or dune areas) and the latter in high industrialized areas where large DC generator's are in use. The LATERAL log will generally overcome such conditions.

b. Setting up and logging. Set up the equipment similar to the NORMAL arrangement except that the lead oxide surface electrode (POT) is not required. Furthermore, the current circuit may be completed by attaching the surface current wire to the well casing or any other good ground. Set the electrode selector switch in one of the two lateral positions. The procedure for taking readings is the same as described for NORMAL arrangement, however the meter is not direct reading. For 0.25-foot lateral the factor is 1.025; for 2.5; the factor is 13.33.

2-34. Interpreting Electrical Logs.

a. Preparing the Log.

(1) In order to interpret electrical log data, you must first prepare the graphical log data properly. Any suitable graph paper may be used.

(2) The cable markings have been measured from the current electrode. Therefore, when preparing the log, plot the 0.25 foot reading at the depth as read from the marked cable, however, plot the 2.5 foot readings about one-foot above this point. (This applies to NORMAL and LATERAL arrangements.) If the 10-foot NORMAL setting is used, plot its readings about 5 foot above the marked cable reading.

b. Significance of 0.25-Foot Spacing. The reading obtained with the 0.25-foot spacing is heavily influenced by the fluid in the well bore and therefore reads only a fraction of the formation resistivity. However, the short spacing enables you to see changes in resistivity with greater detail. With this electrode spacing, formation having a thickness of about 6 inches or greater can be detected. Because of this ability to see small detail, the 0.25-foot curve should be used to "pick" formation boundaries.

c. Significance of 2.5-Foot Spacing. The 2.5-foot electrode spacing provides you with very nearly the true formation resistivity for wells having diameters up to about 16 inches and for formations thicker than about 5 feet. For larger diameter wells or thinner formations, the measured resistivity will depart somewhat from the true. For qualitative interpretation, this departure is not significant. Because the 2.5-foot curve provides you with the formation resistivity, it is used to identify the type of material penetrated.

d. Significance of LATERAL Log. The LATERAL Log obtained with the equipment is made by a combination of the 10-foot electrode and either the 0.25-foot or 2.5-foot electrode. Because the 10-foot electrode is at a distance fairly large compared with either of the other two, the interpretation is essentially the same as for the NORMAL log after using one of the following correction factors:

(1) For 0.25-foot LATERAL log: 1.025 meter factor.

(2) For 2.5-foot LATERAL log: 13.33 meter factor.

e. Interpreting Resistivity Values.

(1) Clays and shales have low resistive values; sands, gravels, sandstone, and limestone have high resistive values. Igneous and metamorphic rocks (such as granite and gneiss) have, generally, very high resistive values.

(2) The exact range of numerical values depends on the following:

(a) the type of earch material making up the formation,
(b) the degree of cementation of the formation,
(c) the quality of the formation water,
(d) the porosity of the formation,
(e) the diameter of the well bore, and
(f) the resistivity of the fluid in the well bore.

(3) The unknows are, generally, (a), (b), (c), and (d), above. Granular materials will have high resistivity compared to fine materials, such as silt and clay; crystalline materials, such as limestone and granite, will have high resistivity compared to granular materials.

(4) The quality of the formation water greatly affects the measured resistivity, and generally, the resistivity of a formation varies in an inverse proportion to the total dissolved solids. For example, all other conditions remaining the same, if the total solid content increases, the formation resistivity decreases. Therefore, a clean sand, filled with salty water, may actually have extremely low resistivity.

(5) Porosity of the formation also has an effect on the resistivity. It is not as pronounced as the effect from water quality. In the logging of chemical precipitates, such as limestone, changes in porosity may enable you to detect the water producing zones. Increased porosity will lower the formation resistively; therefore, in such material, a low resistive zone (where no shale is present) indicates increased porosity and enhances the possibility of that zone producing water.

(6) The exact range of values for clean sand, gravel, or sandstone is something learned by experience in your geographical area. In the midwest United States, for example, clean sand and gravel generally exhibit resistivity values in the range of from 350 to 1000 ohm-feet. The lower values apply to formations having water quality in the range of 300 to 400 ppm (parts per million) total solids and the upper values apply for formation waters having 100 to 150 ppm total solids. The above example is general and included for guidance only.

f. Selecting Formation Contact. When "picking" the formation boundaries, the 0.25-foot curve should be used wherever possible. The inflection point (the point midway between changes in curvature of the resistivity curve) of the resistivity curve is used to make the contact between different formations.

g. Correlation by Electrical Logs.

(1) A useful application of the electrical logs is in correlating formation thickness and depths from one well to another. For example, two wells within a few feet of each other invariably will give identical electrical logs. When the wells are farther apart, the correlation will still be recognizable and the changes which do occur, e. g. thinning or thickening of formations, are exactly the information needed to guide further explorations.

(2) Correlation is commonly possible to considerable distances in bedrock formation, in the order of thousands of feet. Because of the variable nature of unconsolidated glacial and alluvial deposits, do not expect such distances, except in special cases of a single, widespread type of deposit.

h. Effect of Metal on Resistivity Logs.

(1) Because metal is such a good conductor, its presence in a zone being measured will cause a major decrease in the resistivity and make the log unusable for determining formation type. This effect, however, may be used in locating steel lost in the well.

(2) When making the log, the bottom of the well casing will be detected when the probe enters it. The effect on the curves will be that both fall off to extremely low values, 5 to 20 ohm-feet, and then remain fairly constant. Where the casing is seated into very low resistive shale, it may be rather difficult to determine the exact position of the casing by this method.

i. The SP Curve.

(1) The spontaneous potentials measured in a well are of great value in deep oil wells where saline waters are encountered. For these situations, the SP curve exhibits a great deal of character and can be related to relative changes in formation permeability.

(2) When logging in fresh water horizons, the SP curve usually has too few features to provide any useful information.

2-35. Setting Surface Casing. (See figure 2-44). Surface casing is used when the overburden near the surface is prone to "caving in". The following procedures are performed after only a shallow portion of the hole has been drilled.

a. Lubricate the o-ring in the coupling and assemble the coupling to the leader pipe assembly. Install the nylon locking spline.

b. Install the elevators around leader pipe just below the coupling.

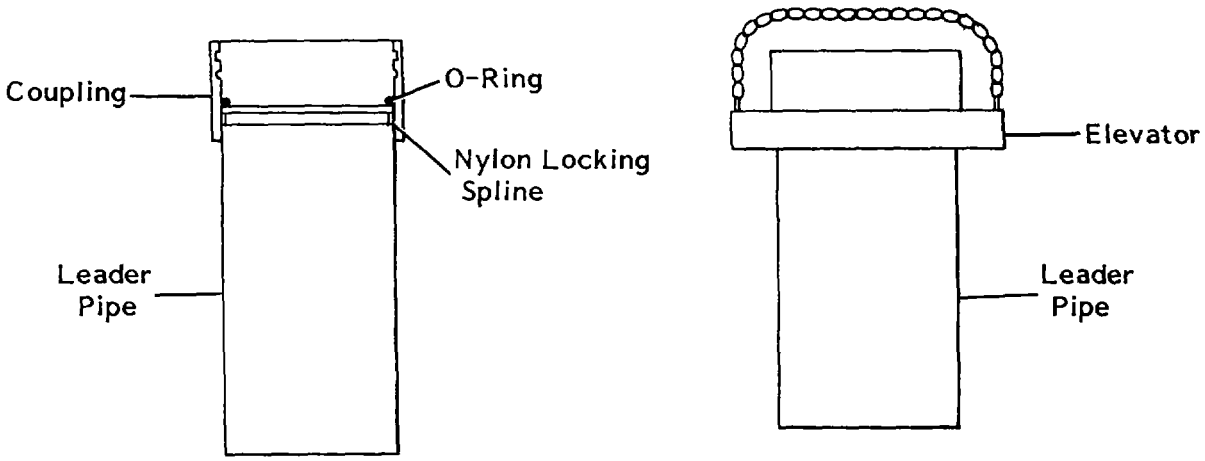


Figure 2-44. Setting Surface Casing

c. Connect the auxiliary drum line to the elevators. Use the auxiliary drum to lift the leader pipe and position it above the overflow pipe in the mud pit. Lower the leader pipe into the overflow pipe until the elevators rest on the mud pit. Disconnect the auxiliary drum line.

d. Assemble a coupling to a section of casing in the same manner as to the leader pipe. Attach the elevators to the casing and use the auxiliary drum line to raise it into position over the leader pipe. Set the casing into the leader pipe coupling and insert a nylon locking spline.

e. Operate the auxiliary drum to raise the entire assembly high enough to remove the lower elevators. Then lower the casing into the hole, resting the second elevator on the mud pit overflow pipe.

f. Repeat the procedure to add as much surface casing as is required to support the overburden. When the required casing is in place, cut the top section of casing so that it is flush with the top of the mud pit overflow pipe. Now resume drilling.

2-36. Setting Well Casing.

a. When samples and tests indicate the desired bearing formation has been located, drill the hole about one foot past the formation. Then remove all drill pipe, collars, and the bit or down-the-hole tools.

b. Cut the interlocking end from a section of strainer (See figure 2-45). Bond a cap to the cut end of the strainer.

c. Assemble another section of strainer and rotate 1/4 turn to make the connection.

d. Assemble a strainer clamp to the top strainer and attach the auxiliary drum line to the clamp chain.

e. Operate the auxiliary drum to raise the strainers and position them above the mud pit overflow pipe.

f. Lower the auxiliary line until the strainer clamp rests on top of the mud pit. Disconnect the auxiliary drum line.

g. Assemble another strainer clamp to the next strainer section and move it into place on the first strainer using the auxiliary drum line. Lock the strainer sections together by rotating 1/4 turn. Lift the assembled strainer enough to remove the bottom clamp, then lower strainers to rest on the top clamp.

h. Continue to add strainer sections until the required length of strainers is attained, then assemble a strainer coupling to the top strainer. Always lubricate the coupling o-rings prior to assembly.

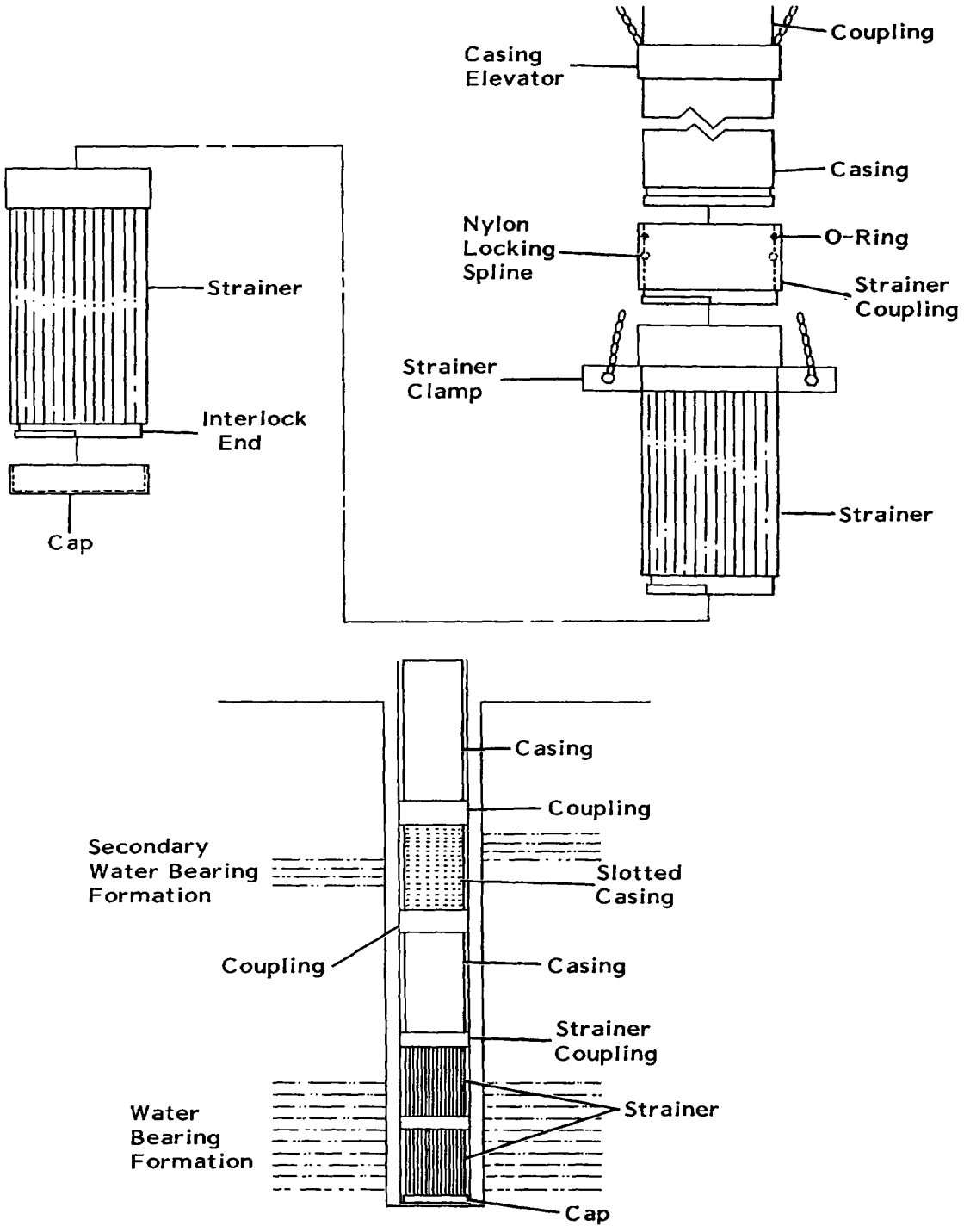


Figure 2-45. Setting Well Casing

i. Assemble a coupling to a section of casing and install the casing elevators below the coupling.

j. Use the auxiliary drum line to lift and position the casing over the strainer coupling. Lower casing into strainer coupling and install nylon locking spline.

k. Lift the assembly to remove the clamp; then lower until the elevators rest on the mud pit overflow pipe.

l. Repeat the procedure, adding casing as needed for the full depth of the well.

NOTE

In the event there is a second water bearing formation above, sections of slotted casing (see figure 2-45) may be substituted for regular casing at that point. Slotted casing is similar to strainers, except that slotted casing does not provide as effective filtration as the strainers.

m. When all the casing is set in place, cut the top of the casing so that it is flush with the top of the mud pit overflow pipe.

n. Remove the mud pits, then use scrap plastic or styrofoam packing materials to seal around the outside of the casing at the top of the hole. Cover these materials with dirt so that the ground is level around the casing and nothing can enter the hole.

2-37. Preparing to Set Pump.

a. Bailing the Hole. When there is an accumulation of dirt or sand in the well, use a bailer to remove this accumulation (see figure 2-46).

(1) Attach the third drum line to the bailer.

(2) Operate the drum to lift the bailer, then lower it into the hole. Do not allow the bailer to fall too fast, and slow down when approaching the bottom of the hole.

(3) When the bailer contacts the bottom of the hole, the valve at the base of the bailer opens, and the bailer fills with sand, dirt, and water. Tie a piece of twine or cord on the cable to mark the depth at which the bailer stops.

(4) Raise the bailer. As it lifts off the bottom the valve closes, trapping the sand and dirt inside. Continue raising, slowing up as the bailer nears the surface, until the bailer is out of the hole. Lower the bailer to the ground away from the rig. When it contacts the ground, the bailer valve opens and discharges the bailer's contents.

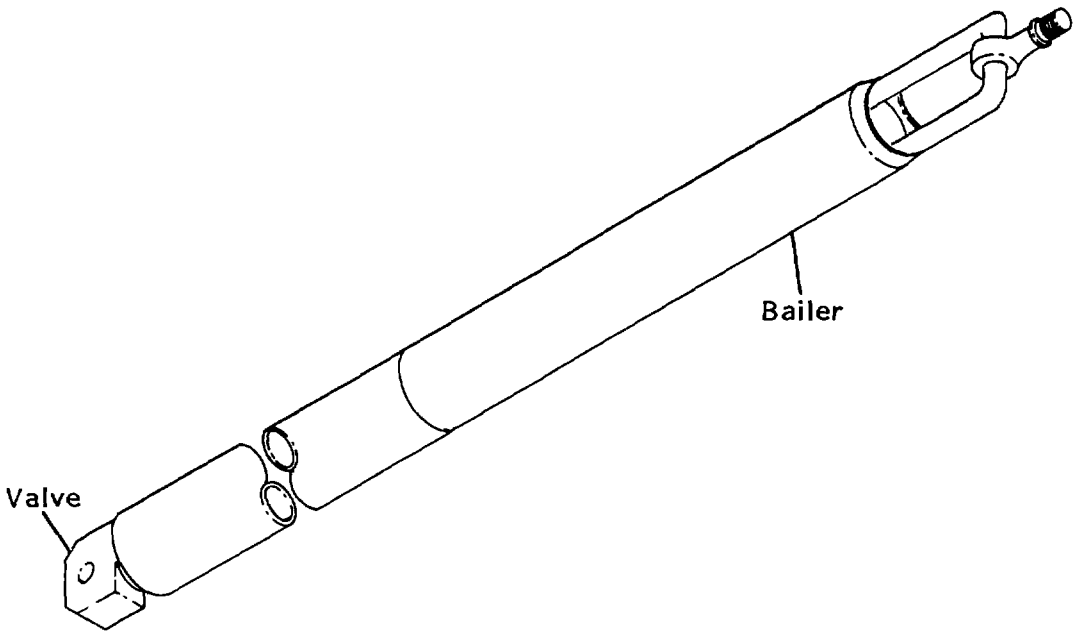


Figure 2-46. Bailer

(5) Repeat steps 2, 3, and 4 until all the sand and dirt is cleared from the hole.

b. Sounding Well . The well sounder (See figure 2-47) is an instrument designed to test water wells to determine the static or standing water level. The sounder is also used after pump installation to test for draw-down with pump running.

(1) Open the lid of the well sounder and reel off the cable, lowering the electrode tip into the well slowly.

(2) Depth is indicated in one-foot increments on the cable. Observe the meter as you lower the cable in the hole. When the electrode tip reaches water level, the meter will register a steady positive reading. Stop lowering the cable and note the depth marker on the cable.

(3) Operate the crank handle to roll up sounder cable, wiping water off the cable before it wraps onto the reel. When cable has been rolled up, close lid to shut off the well sounder.

c. Water Treatment.

(1) Prior to installing the pump, pour the contents of one or two 3.75 lb packages of calcium hypochlorite (included in the well-completion kit), into the well.

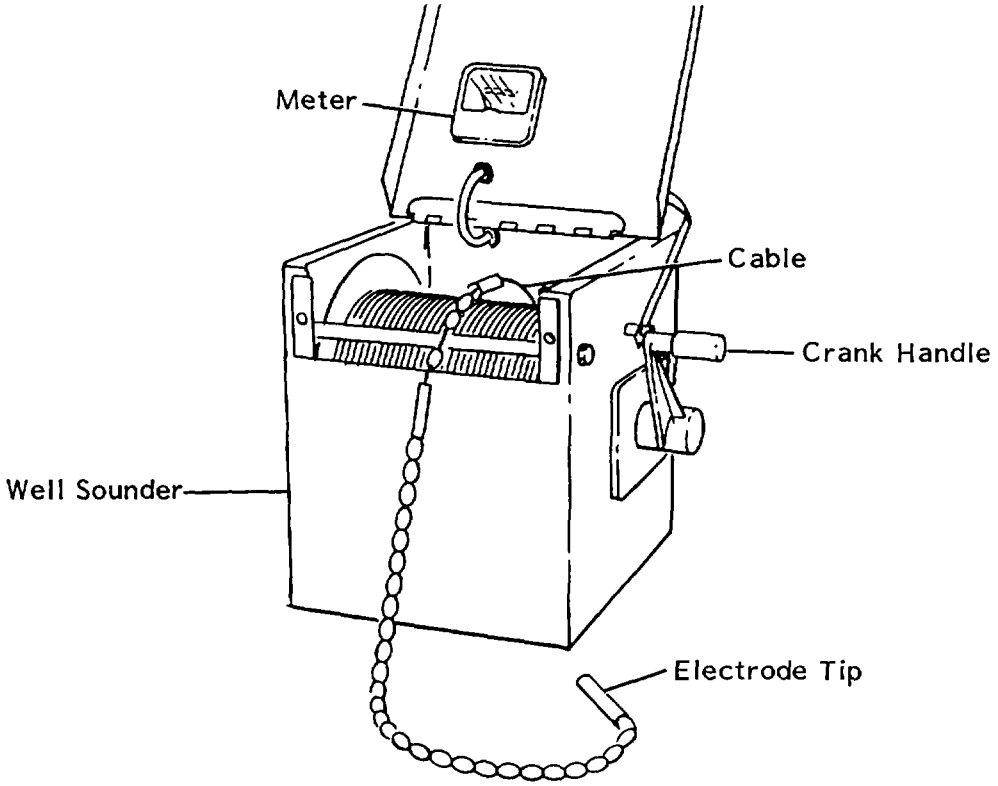


Figure 2-47. Well Sounder

(2) Chemicals should remain in water 10 to 12 hours before starting pump.

(3) After the pump is activated, water may be tested and chemicals added as needed through the draw-down hole in the well seal plate (see figure 2-52).

2-38. Installing the Pump.

a. Assembling Pump, Motor, and Drop Hose.

(1) Check to see that the drop hose end is cut square. Use a sharp knife or hacksaw to cut the hose. Then install the hose coupling into the end of the drop hose (see figure 2-48). If insertion is difficult, cut a 1/2" slit in the end of the hose. This will help you start the coupling into the hose.

NOTE

Do not use any form of lubrication on the hose or the coupling.

(2) Push the hose fully onto the shank of the coupling. The end of the coupling may be tapped lightly on a wood surface, if necessary.

(3) Cut away about six inches of the cable ridge from the hose. Use a file to smooth the ridge even with the outer hose surface.

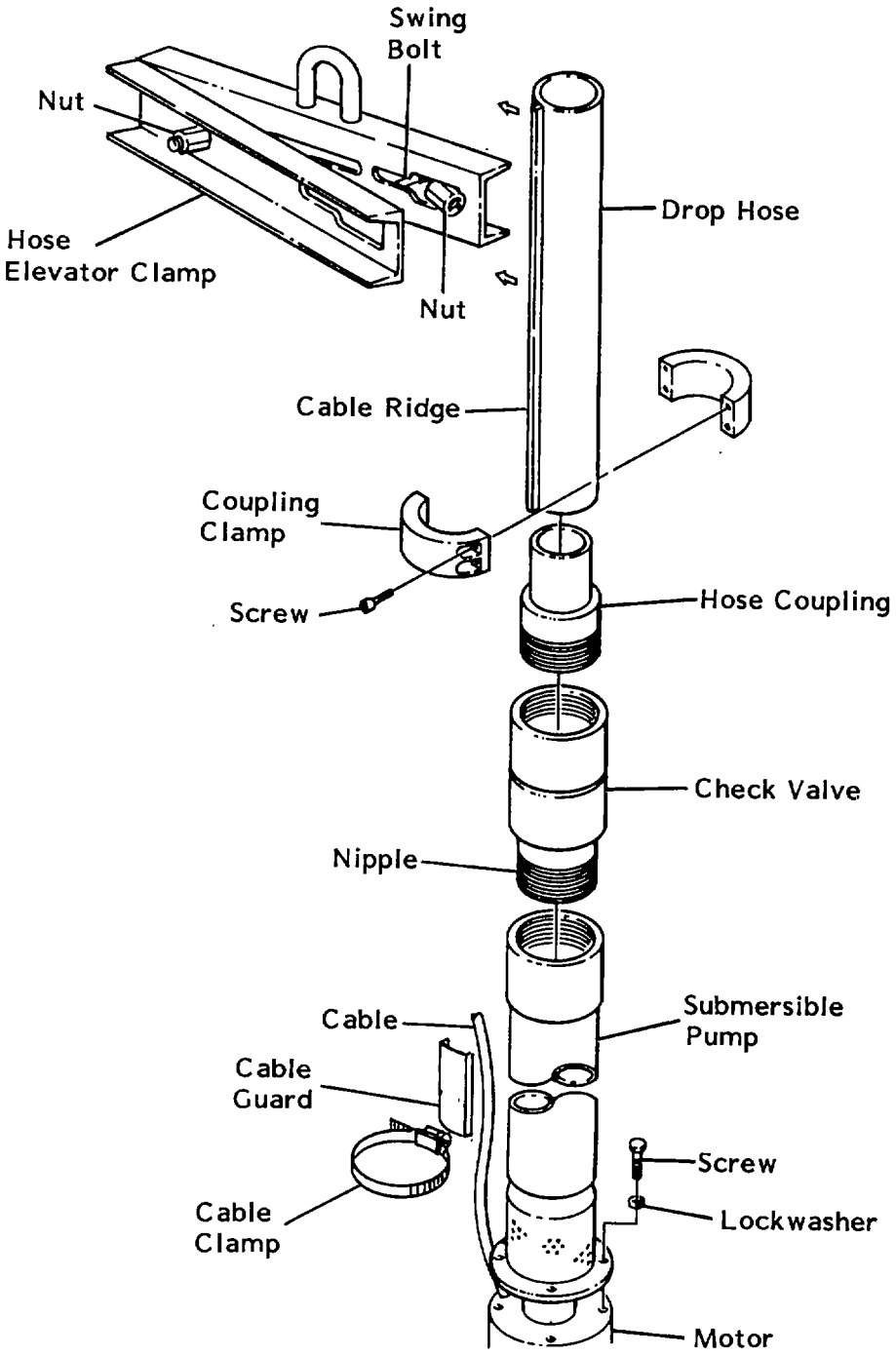


Figure 2-48. Setting the Pump.

NOTE

The coupling clamp contains a grooved portion on the inside. Locate the grooved part toward the coupling. The clamp halves may not close completely before screws are tight; 1/32-inch is an acceptable gap, however, if the clamp closes completely before the screws are tight, loosen screws and move the clamp higher on the coupling taper.

(4) Assemble the coupling clamp onto the hose and install the screws. Tighten the screws evenly. Then, using a torque wrench, tighten the screws to 4.4 ft-lbs.

(5) Install the nipple in the check valve; then install the check valve to the hose coupling. Attach the submersible pump to the hose assembly.

(6) Loosen both nuts of the hose elevator clamp and move the swing bolt aside. Position the clamp half with the lifting loop to the side of the drop hose opposite the cable ridge.

(7) Close the hose elevator clamp on the hose and reposition the swing bolt. Tighten both nuts finger tight; be sure the hose is square and centered in the clamp. Tighten both nuts equally, torquing to 40 ft lbs. Be sure the clamp faces remain parallel.

(8) Attach the auxiliary drum line to the hose elevator clamp. Operate the auxiliary drum to lift the hose and attached submersible pump.

(9) Position the pump motor upright on a block of wood and maneuver the pump directly over the motor. Slowly lower the pump, guiding by hand until the pump coupling is over the motor shaft. Rotate the pump to line up coupling slots with key in motor shaft.

(10) Slowly lower the pump until the pump is very close to contacting the motor; then install screws and lockwashers.

NOTE

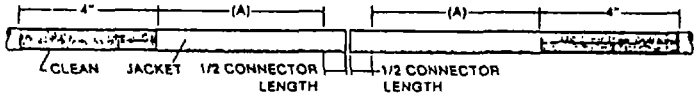
The hardware provided to attach the pump to the motor is stainless steel. No other material may be substituted.

(11) Check that the pump and motor are lined up properly; then tighten the screws.

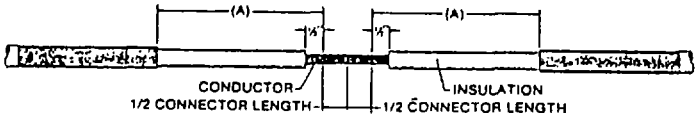
b. Splicing Submersible Power Cable. (See details in figure 2-49).

NOTE

When the power cable and motor leads are not the same size, select a connector for the larger size cable. Strands of copper wire should be used together with smaller cable to fill connector.

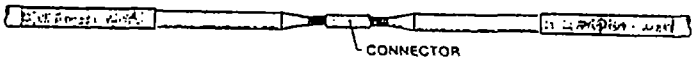


DETAIL A

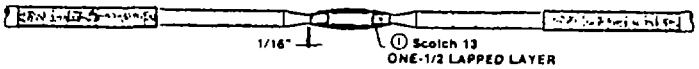


DETAIL B

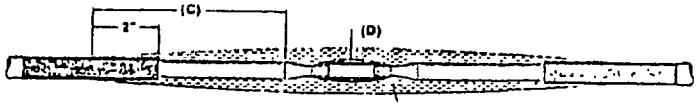
DETAIL C



DETAIL D



DETAIL E



DETAIL F

DETAIL G

Figure 2-49. Cable Splicing Details

(1) Cut the motor lead and power cable so that ends will butt squarely. Thoroughly clean the cable jacket for 4 inches beyond dimension A (see detail A) with non-conductive abrasive cloth provided in the cable splicing kit.

(2) Remove the cable jackets for dimension A (see detail B), plus one half the connector length. DO NOT cut into cable insulation. If jacket is bonded to insulation, do not remove; treat it as insulation. Remove cable insulation and strand shielding from end of conductors for 1/2inch plus one-half the length of the connector. DO NOT nick conductor.

(3) Pencil-taper the insulation for dimension B(see detail C) and smooth it with abrasive cloth provided in cable splice kit.

(4) Join the conductors using crimp connector (see detail D). Using cloth saturated with solvent in the splice kit, clean entire splice area.

CAUTION

The splice area must be entirely free of all solvent residue (especially in conductor strands) before applying any tape.

(5) Fill any connector indents with small pieces of semi-conducting tape. Tightly level-wind tape across connection area, overlapping 1/16-inch onto each edge of the tapered insulation. Form smooth, concentric buildup as shown in detail D.

(6) Tightly, half-lap tape across connector area, building up to dimension D (see detail E) with a smooth taper along distance C, reaching maximum diameter over the tapered insulation.

NOTE

Stretch and half-lap the tape to produce a void-free, uniform buildup.

(7) Tightly, half lap two layers of vinyl plastic electrical tape over the entire splice, extending for one inch onto each cable jacket.

c. Inserting Pump Into Well.

(1) Attach the power cable to the submersible pump using the cable guard and cable clamp (see figure 2-48).

(2) Position the pump and motor over the hole and slowly lower the pump into the hole until hose elevator clamp is resting atop the casing.

(3) Install the well-head roller above the well with the hose positioned over the roller (see figure 2-50).

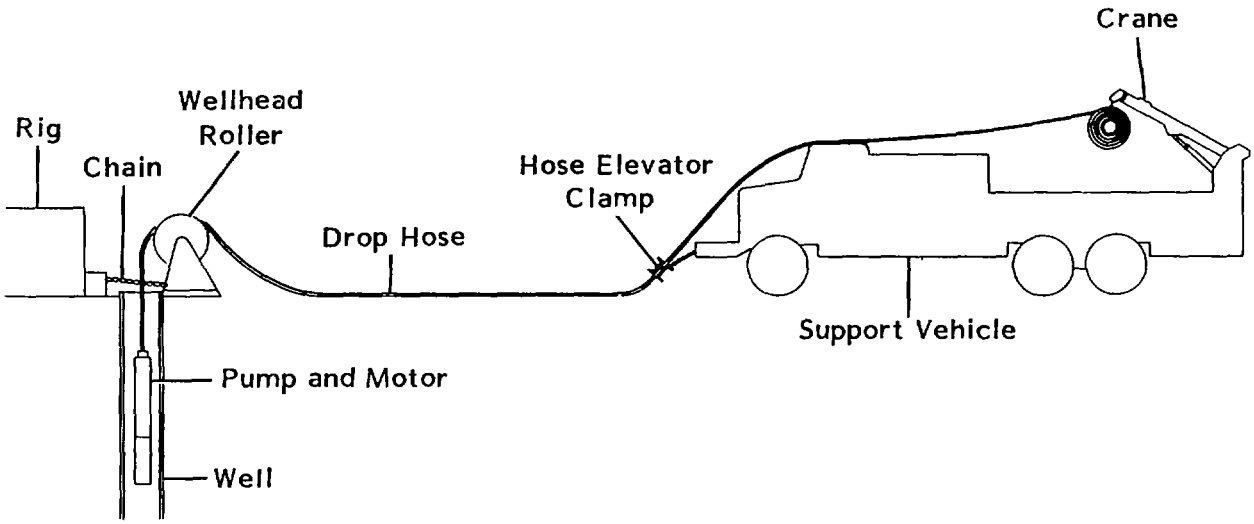


Figure 2-50. Installing Submersible Pump.

(4) Anchor the well-head roller to the rig using anchor chains or cable.

(5) Using the rig tender crane, pick up the roll of drop-hose and position it so that the hose lays across the truck cab. Slowly back the rig tender away from the hole, unrolling 50 feet of hose along the ground.

(6) Attach another hose elevator clamp, anchoring the clamp to the front of the rig tender. Loosen both nuts of the hose elevator clamp and move the swing bolt aside. Position the clamp half with the lifting loop to the side of the drop hose opposite the cable ridge.

(7) Close the hose elevator clamp on the hose and reposition the swing bolt. Tighten both nuts finger tight; be sure the hose is square and centered in the clamps. Tighten both nuts equally, torquing to 40 ft lbs. Be sure the clamp faces remain parallel.

(8) Roll the power cable out alongside the drop hose. Attach the cable to the hose using cable straps as shown in figure 2-51. Straps should be inserted at 6-foot intervals. Allow slack in the cable between straps as shown in the illustration, to allow for extension of the drop hose under service. The cable should be approximately 2% longer than the hose length.

(9) Drive the rig tender in reverse to raise the well-head clamp sufficiently for removal; then remove the clamp.

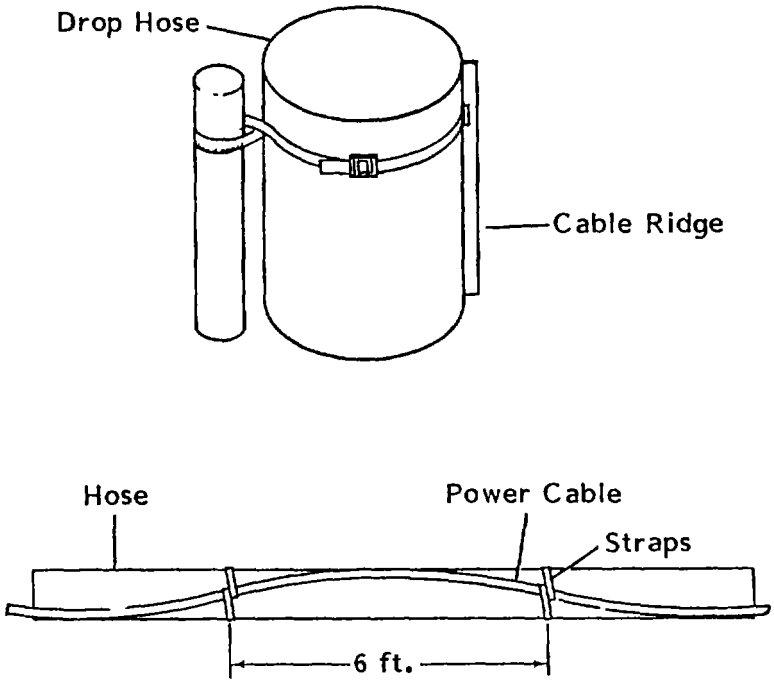


Figure 2-51. Strapping Cable to Hose

(10) Slowly drive the rig tender toward the well, lowering the pump, motor and hose into the well. When vehicle is near the well-head, stop the truck and reinstall the hose elevator clamp at the top of the well. Then drive forward enough to rest the clamp on the casing.

(11) Remove the clamp at the rig tender; drive vehicle in reverse, unrolling another length of hose. As before, attach hose elevator clamp and attach power cable to hose.

(12) Repeat steps 9, 10, and 11 as many times as necessary to lower the pump and motor to within 4-5 feet from bottom of well.

d. Sealing the Well.

(1) Assemble a hose clamp to the hose at the top of the well casing, relieving the weight on the clamp at the rig tender. Then, use a sharp knife or hacksaw to cut the drop hose, squarely, about 10-12 inches above the clamp at the well (see figure 2-52).

(2) Install the nose coupling in the hose and assemble the coupling clamp in a manner similar to that of the opposite end of the hose.

(3) Unroll the power cable to the length necessary to reach the starter panel and cut the power cable. Insert power cable through the smaller hole in the well seal.

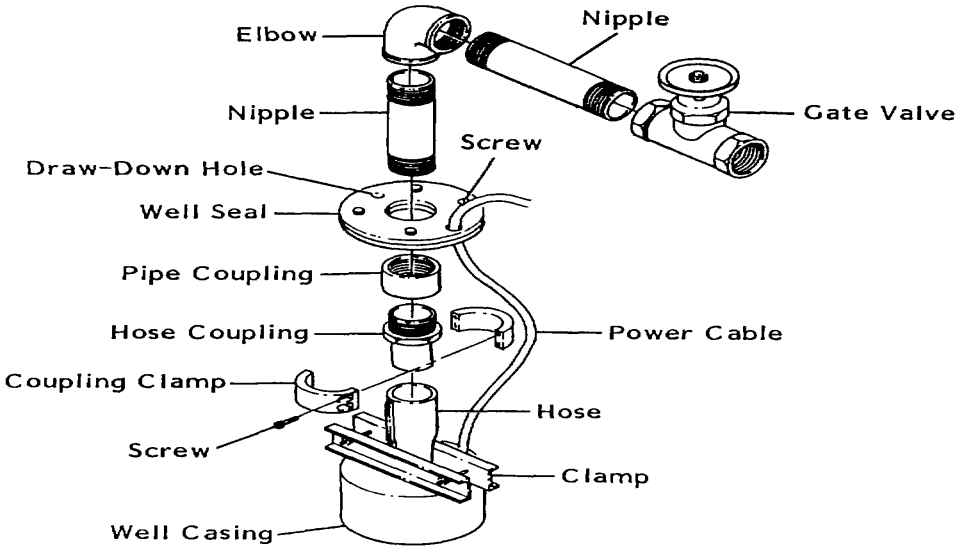


Figure 2-52. Sealing the Well.

(4) Assemble the nipples to the elbow and insert one end through the well seal plate. Connect the nipple to the hose with the pipe coupling. Install a gate valve on the other nipple.

(5) Attach the auxiliary drum line to the elbow and lift the assembly enough to release the weight from the clamp atop the well casing. Remove the clamp from the hose.

(6) Lower the assembly into the well, guiding the well seal into the casing. Tighten the screws on the well seal to compress and expand the seal's rubber center. Finally, remove the auxiliary drum line.

2-39. Pump Starter Panel. (Figure 2-53)

a. Attach starter panel to panel stands, using screws, lockwashers and nuts that are stored on panel standfoot.

b. Stabilize the panel by placing sandbags on the stand feet or by driving stakes into the ground at holes in stand feet.

c. Turn the door locking screws one-half turn to disengage door locks. Open panel door.

d. Cut outer insulation back on pump cable about twelve inches. Strip insulation on each lead to expose approximately 3/4 inch of wire.

e. Insert the pump leads through the hole in bottom of panel.

f. Connect the leads as follows: black to T1, red to T2, yellow to T3, and green to ground.

g. Strip away approximately six inches of outer insulation from power source cable and strip away approximately 3/4 inch of insulation from each lead.

h. Insert the power source cable through hole in side of panel and connect leads at Line 1, Line 2, Line 3 and Ground.

i . Close panel door and turn door locking screws to engage door locks.

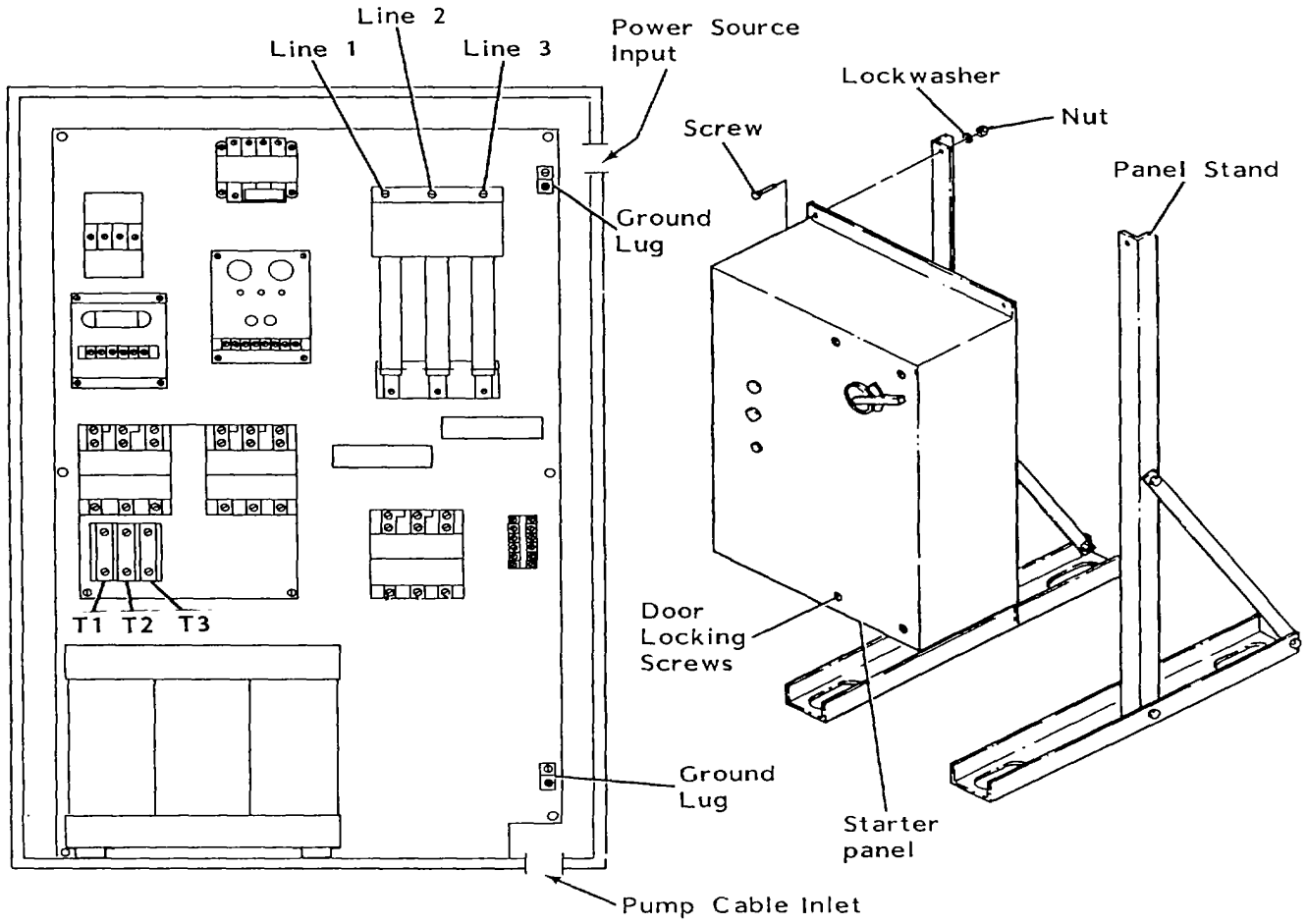


Figure 2-53. Starter Panel Installation

2-40. Pump Start-up.

WARNING

HAZARD VOLTAGE CAN CAUSE SEVERE INJURY OR DEATH. Switch must be off and contacts open before contacting fuses or load end terminals. If contacts are not visible, use voltmeter to make sure no voltage is present .

a. Apply power to starter panel.

NOTE

Gate valve at wellhead should be open.

b. Turn main power switch to ON (figure 2-54). Turn H-O-A switch to HAND position. Push START switch.

c. Observe water discharge as pump operates. If pumping volume does not appear to be sufficient, stop pump by turn H-O-A switch to OFF and perform following steps. Otherwise, proceed to d.

(1) Turn main power switch to OFF.

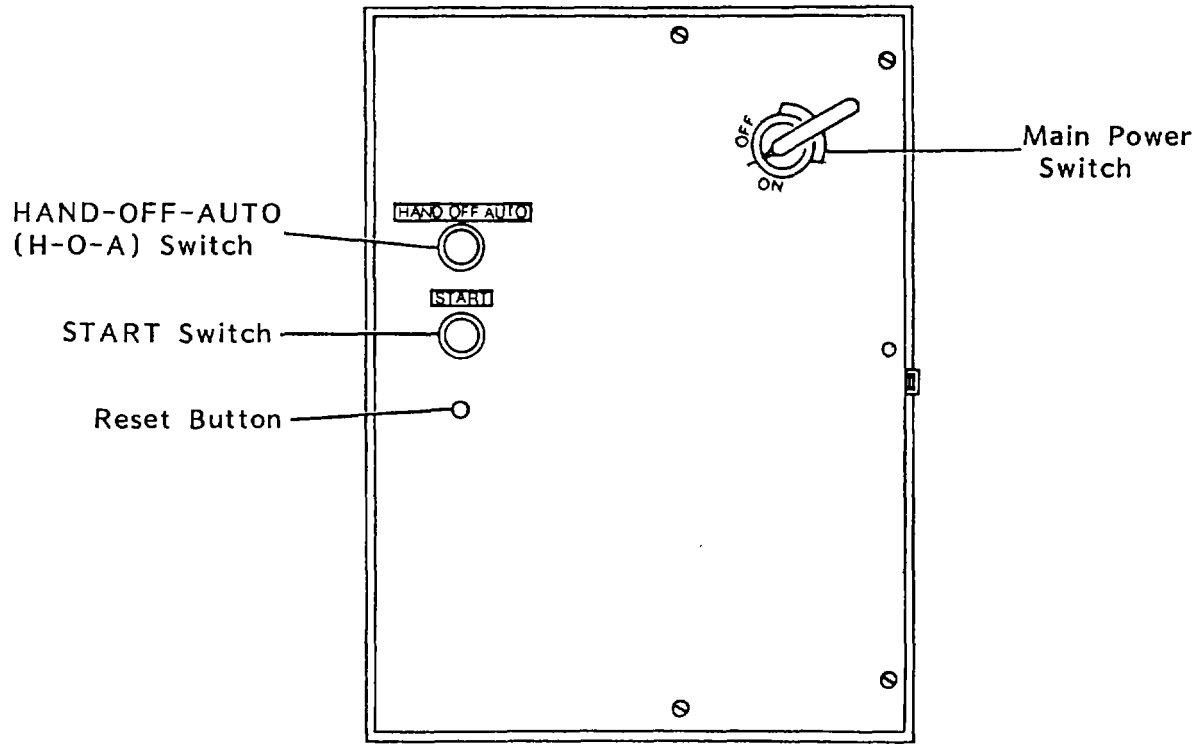


Figure 2-54. Starter Panel Controls

(2) Unlock door locks and open panel door.

(3) Disconnect pump cable leads at T1 and T2 and reverse their locations.

(4) Close and lock the panel door and re-start pump (refer to step b. above) .

(5) If pumping volume increases, pump is now performing at maximum. If volume is less, repeat steps (1) through (4) to return leads to their original locations.

d. Turn H-O-A switch and main power switch to OFF. Wait one minute, then open panel door.

e. Turn the TRIP DELAY and RESTART DELAY switches to OFF, then install a temporary jumper to load monitor terminal board across the normally open (N.O.) contacts. (See figure 2-55).

f. Temporarily close panel door and turn main power switch to ON. Turn H-O-A switch to AUTO and push START button to start pump motor. Open panel door.

g. With the motor running, turn the TRIP LEVEL adjust until the UNDERLOAD (red) and MOTOR RUNNING (green) LEDs alternately illuminate. This will set the base running amperage.

h. Connect a DC voltmeter to the load monitor by installing voltmeter plugs into positive and negative jacks. (The red jack is positive, the black is negative.) Note the voltage reading.

i. For purposes of making the final adjustment, consider the voltage reading above as 10096, and adjust the "trip adjust" to 809% of that reading.

EXAMPLE:

1009% of voltage reading is 8.5 volts
x .80
Final setting is 6.8 volts

j. While observing the voltmeter, turn the TRIP LEVEL adjust until the voltmeter indicates the voltage calculated (as in example: 6.8 volts). Remove voltmeter.

NOTE

The 80% setting may be further adjusted to suit unusual installations. If the unit trips when an underload condition appears to be present, adjust to a lower percentage of the 100% reading. Likewise, if the unit fails to trip on an underload, adjust for a higher percentage.

k. Temporarily close panel door and turn H-O-A switch to OFF, and main power switch to OFF. Wait 1 minute, then open panel door and remove jumper from load monitor terminal board.

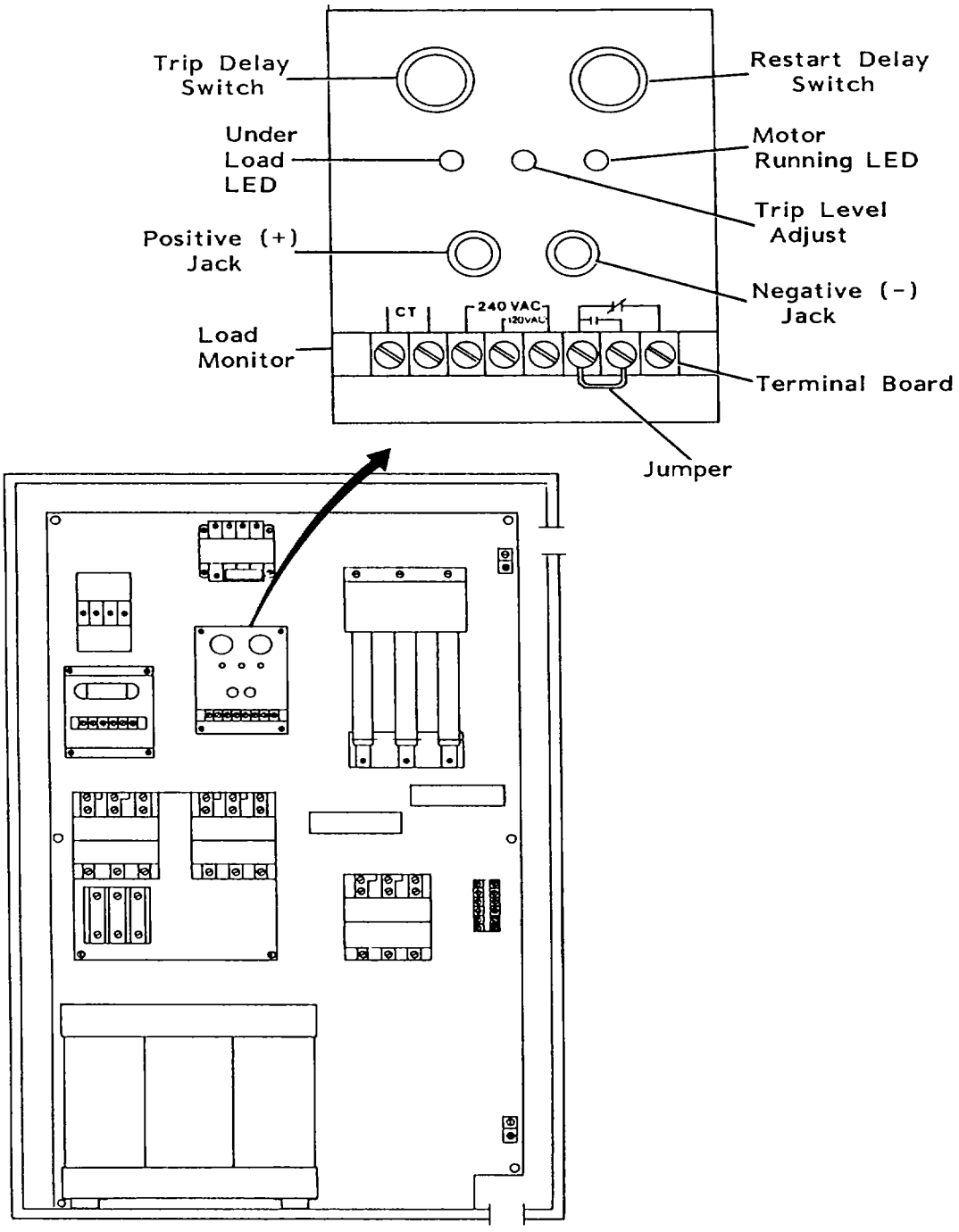


Figure 2-55. Setting Load Monitor

l. The monitor is now ready for operation. Set the TRIP DELAY and RE-START DELAY switches to the desired setting. Close and lock the panel door.

2.41. Producing Water.

a. Connect the desired length of hose to the wellhead gate valve, and locate hose to a desired water discharge location.

b. Turn panel main power switch to ON. Set H-O-A switch to AUTO.

c. Push START button to start pump motor.

d. Open gate valve to dispense water.

2-42. Determining Draw-Down.

a. Remove the plug from the draw-down hole in the well seal.

b. Using the Well Sounder, determine the static water level as instructed in paragraph 2-39.b., Sounding Well.

c. Start pump; then, as water level drops below the electrode tip, the meter reading will drop to zero.

NOTE

When testing with the pump running and the electrode is in falling water, you may get an oscillating movement on the meter, but when the electrode tip reaches the water level, the meter will give a steady reading.

d. Lower the cable until a steady reading is attained.

e. Continue this procedure until the water level remains constant. Read the marker on the cable to determine draw-down level.

2-43. Wellhead Slab.

a. After pump is set and operational, move vehicles and equipment away from immediate area of well.

b. Set up forms in at least a three feet square around the well.

c. Using the cement supplied with well completion kit, pour a concrete slab in the forms. The packing materials and dirt packed around the hole previously will prevent concrete from entering hole.

d. In order to provide an anchor for the wellhead roller in subsequent operations, measure off and set long studs In the slab at points that will correspond to anchor holes in the wellhead roller stand.

e. Allow concrete to cure, then remove forms.

2-44. 1500 Foot Well Completion.

WARNING

Inspect welds on working base for cracks or breaks before setting casing. Have welds repaired before use to prevent injury or damage to equipment.

a. A rig auxiliary kit (see Appendix B) used with the 1500 Foot Well Completion Kit provides the capability to drill and complete wells to a depth of 1500 feet. A spider base (168 F 530), or working base (KT-1992-TRSC) included in the kit provides a support for the additional weight of the extra 900 feet of steel casing in the completion kit.

WARNING

Do not use the H-1 75-B hoisting plug furnished with the 600 Foot Well Drilling System to handle loads in excess of 20,000 pounds. Failure to observe this warning could result in serious injury to personnel or damage to equipment.

b. The following procedures are for handling and setting various sizes of casing.

NOTES

Casing handling adapters or hoisting plugs are used in place of the elevators furnished with the 600 Foot Well Drilling System.

Do not use spider base or working base when drilling and using the mud pits.

When using kit (168F530) with spider base, the spider should be permanently installed, taper pointing upward, using the four 1-inch bolts.

(1) Place spider base (1, Figure 2-56), or working base (5), on ground beneath rear of rig, centering the opening in base with the rig rotary table.

(2) Use spider base, or working base, only when you set casing or the drop pipe as you install the pump.

(3) To set casing or drop pipe, use the appropriate slips (2) or split bushings (6) in the base to hold the sections while adding additional joints. The slips (168F530) and split bushings (KT-1992-TRSC) used for various sizes of casing and drop pipe are as follows:

Slip	Bushing	Pipe or Casing
7063-J	N/A	2 1/2' drop pipe
C-692-MG	DW2378-01C	4 1/28 OD casing
C-692-MC	DW2378-01 D	6 5/88 OD casing
C-692-MF	DW2378-01 E	8 5/8' OD casing
C-692-TB	DW2378-01 F	10 3/4' OD casing

NOTES

Spider base can be used for setting casing when using steel mud pits by removing the steel mud pits and installing spider base as described above.

When using kit with spider base, spider bushings must be used for all sizes except 10 3/4" OD casing. The 10 3/4' OD casing slips can only be used by removing the bushing and slips being inserted directly into the spider.

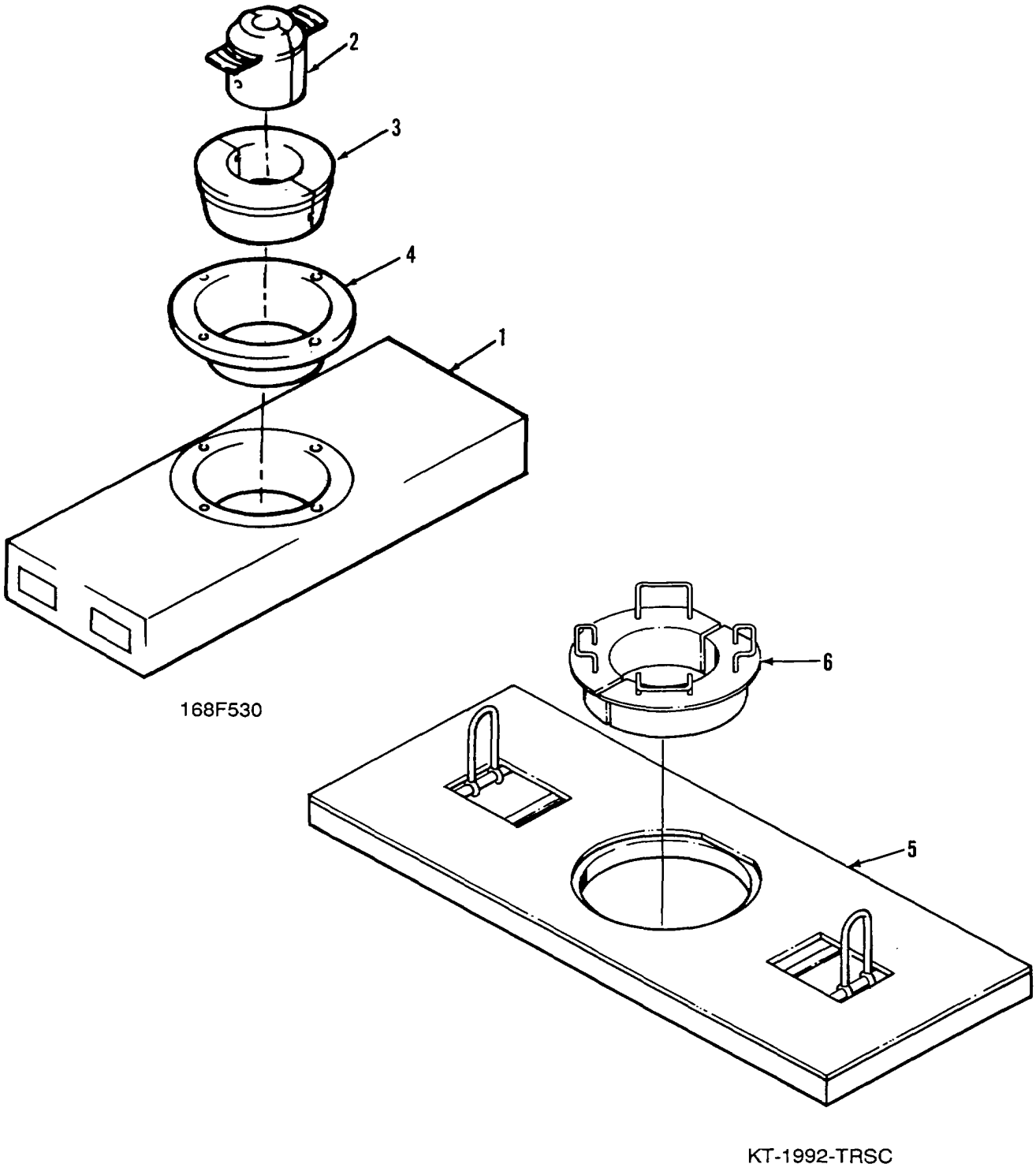


Figure 2-56. Spider, Base and Slips; Working Base and Split Bushings

(4) To use slips (2), install spider bushing (3) into opening of spider (4). This will reduce the size of the opening to accommodate the slips. To use split bushings (6), install the bushing Into the working base (5).

NOTE

When using drop pipe, use the hoisting plugs supplied with the 1500 Foot Well Completion Kit.

(5) Set the steel casing by either installing the appropriate casing adapter (1, Figure 2-57) in the casing coupling (4) and screwing hoisting plug (2) into adapter, or screw the appropriately sized hoisting plug (3) into casing coupling. The casing adapters furnished in auxiliary kit (168F530) and hoisting plugs furnished in auxiliary kit (KT-1992-TRSC) are as follows:

Adapter	Hoisting Plug	Casing
167F384	DW1293-04	4 1/2' OD casing
167F386	DW1 293-05	6 5/SN OD casing
167F386	DW1293-06	8 5/8" OD casing
167F387	DW1 293-07	10 3/4' OD casing

(6) Once the hoisting plug is installed, pick up the casing using the auxiliary drum on drill rig and lower it over the hole.

(7) Lower the first casing joint into the hole through the slips or split bushing installed in the base.

NOTE

Step (7) will hold the casing joint at proper elevation.

(8) Unscrew the adapter, or hoisting plug, from casing coupling and install it on the next casing joint to be added.

(9) Pick up the next casing joint using the auxiliary drum on the drill rig, lower it and screw it into the collar on the top joint setting in the well bore.

(10) Tighten the casing joint to proper torque.

(11) Raise the casing string slightly and remove slips or split bushings. Then lower casing string until top of string is at appropriate location and slips or split bushings are installed.

NOTE

In certain applications, the first part of the string may be screen instead of solid casing. The procedure remains the same.

(12) Repeat procedure until complete string is installed.

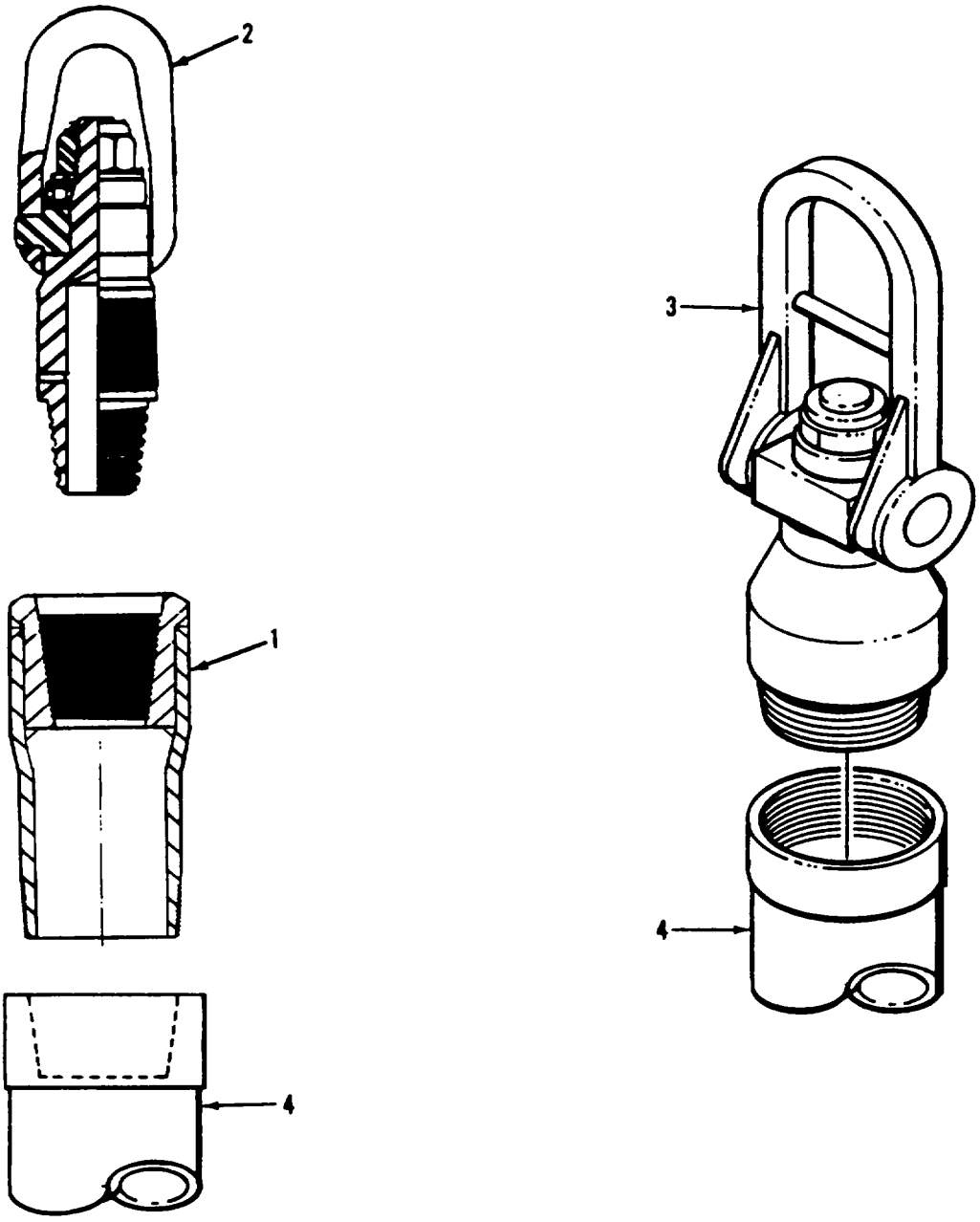


Figure 2-57. Hoisting Plug with Adapter (168F530) and Casing Hoisting Plug (KT-1992-TRSC)

Section IX. PREPARATION FOR MOVEMENT.

2-45. Preparation for Movement.

a. Drilling Rig.

(1) Mud pump suction and discharge lines. Be sure there is no pressure on any lines. Disconnect the pump suction hose and store it on the rig. Disconnect the mast bend hose. Disconnect and store the mud mixer and hoses. Store the mud pits on the rig tender.

(2) Mast.

NOTE

The following instructions assume that the rig's engine is running, that all the controls are in the OFF or neutral position, and that the truck transfer PTO case is engaged.

(a) Observe the tachometer and set the throttle to the desired engine rpm.

(b) Make sure all the drill pipe has been removed and properly stored on the rig tender. The kelly must be retracted in its transport position in the mast.

WARNING

It is very important that you make sure the mast cylinders are full of fluid before you begin lowering the mast.

(c) Momentarily operate the mast control to the UP position and check the hydraulic indication on the pulldown pressure gage. The pressure should rise rapidly when the up side of the mast raising cylinders are full of hydraulic fluid.

(d) Open both mast locks at the base of the mast.

(e) Move the drawworks power control to the ON position.

(f) Move the mast control to the DOWN position and lower the mast in one continuous operation, while alternately operating the drum clutch levers to spool-up excess wire rope slack.

(g) When the mast is resting solidly on the mast supports and all excess wire rope slack has been taken up, set the drum brake levers, making sure the ratchet locks each in the locked position.

(h) After lowering the mast and securing it, detach the Retractable Life-line cable from the bottom of the mast and perform the “After" PMCS while retracting the cable into the life-line housing. Detach the life-line from the top of the mast and store in dry well ventilated storage area away from corrosive materials.

(3) Rotary Table. Ensure that rotary table driveshaft is free from dirt and debris, then retract rotary table.

(4) Hydraulic jacks.

(a) Check the pressure in the truck tires; inflate any that are low.

(b) Operate the hydraulic jack controls to raise the jacks evenly, returning the weight of the rig to the truck's tires. Release the jacks to the center (neutral) position when each jack is fully raised.

CAUTION

The hydraulic jacks may "creep" down if the safety links are not snapped into place after the jacks are fully raised.

(c) Snap each safety link in place on each hydraulic jack so that the jacks are secured in the raised position.

(d) If supporting timbers were placed under the hydraulic jacks, remove and stow them or dispose of them properly.

b. Rig Tender.

(1) Store all drill pipe and drill collars.

(2) Disconnect and store all water discharge hoses and suction hoses and strainer.

(3) Store the propane tank and heating torch, if removed, (4) Store the fuel nozzle and hose, if removed.

(5) Position the crane in its travel position and secure it. Return the remote control pendant to its storage box.

(6) Close all storage compartments and secure.

c. Well Completion Equipment. Store the well probe, instruments, test set, well sounder, bailer, and wires and cables in their appropriate storage compartments.

CHAPTER 3
MAINTENANCE INSTRUCTIONS

Section I. Drilling Rig Lubrication Instructions

3.1 Lubricated Items. Lubrication instructions for each component of the drilling rig requiring lubrication are contained in the Figures 3-1 through 3-1 3. These components or subassemblies are:

a. mast
b. mast components
c. mud pump
d. air compressor system
e. subdrive assembly
f. drawworks
g. hydraulic system
h. water/foam injection system
i. force feed lubricator
j. rotary table, table drive, slide
k. chain feed drive
l. air control system
m. drive shafts.

3-2. Non-Lubricated Items. Components of the drilling rig which do not require lubrication include:

a. hydraulic jacks
b. break-out assembly
c. driller's platforms
d. drill frame.

LUBRICATION INSTRUCTIONS

MAST, 32 - FOOT

NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type If or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

LUBRICANT - INTERVAL

INTERVAL - LUBRICANT

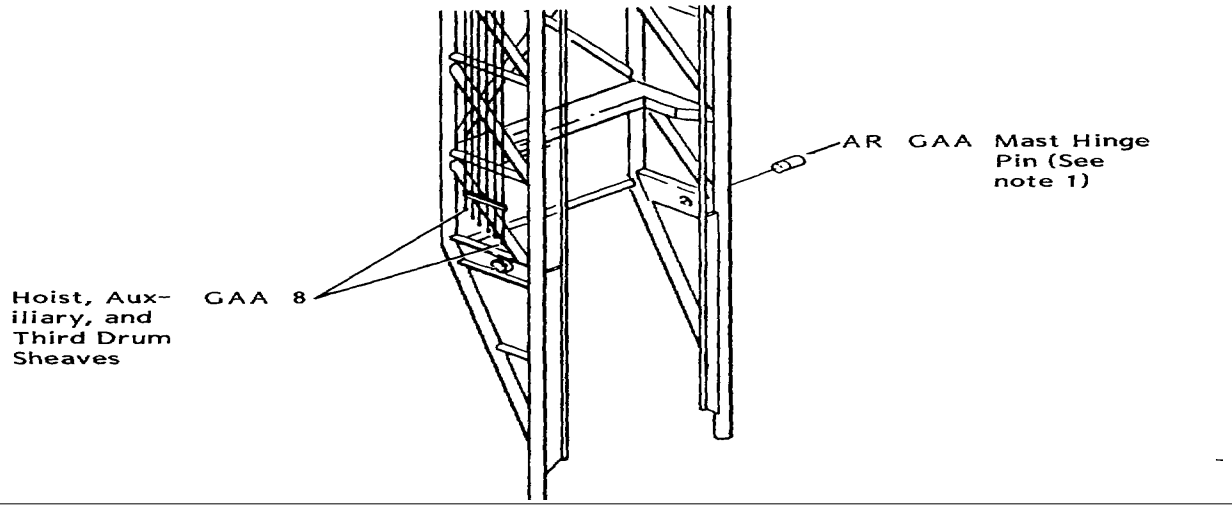


Figure 3-1. Lubrication Instructions for Mast (Sheet I of 2)

TOTAL MAN-HOURS:	INTERVAL	MAN-HOURS
	8	0.2
	M	0.2
	AR	0.2

KEY

LUBRICANTS	CAPACITIES	EXPECTED TEMPERATURES: Above +100 F (Above +38C	+40 to +100 F (+4 to +38 C)	Below +40 F (Below +4 C)	INTERVAL
GAA (MIL-G-10924C) Grease, automotive and artillery		ALL TEMPERATURES			8 - 8 hours of normal operation M - monthly AR - As required
Lubrication fittings	As required				

NOTE:

1. Replace the pipe plug with a 1/2" x 1/4" hex bushing fitted with a grease fitting. Use a grease fitting. Use a medium pressure grease gun to pump grease into cavity until you feel the pressure on the grease gun. Remove the bushing and grease fitting and reinstall the pipe plug.
2. Apply grease with a medium pressure gun. Apply prior to raising or lowering the mast.

Figure 3-1. Lubrication Instructions for Mast (Sheet 2 of 2)

LUBRICATION INSTRUCTIONS

MAST COMPONENTS

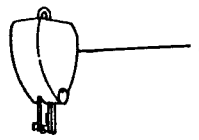
NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type II or equivalent. Dry before lubricating.

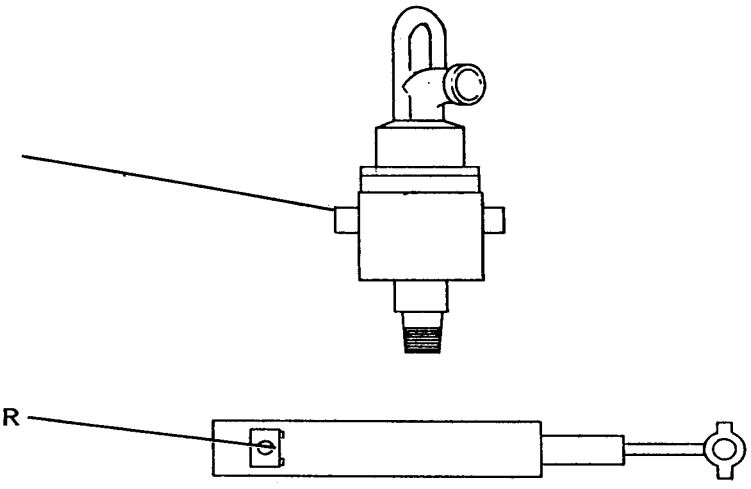
The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (O).

LUBRICANT - INTERVAL			INTERVAL - LUBRICANT		
			M	GAA	Traveling Blocks



TRAVELING BLOCKS

Water Swivel (See note 1)	GAA	8	
Pillow Blocks (See note 2)	GAA	AR	



MAST RAISING CYLINDER

Figure 3-2. Lubrication Instructions for Mast Components (Sheet 1 of 2)

TOTAL MAN-HOURS:	INTERVAL	MAN-HOURS
	8	0.2
	M	0.2
	AR	0.2

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES: Above +100 F (Above +38C	+40 to +100 F (+4 to +38 C)	Below +40 F (Below +4 C)	INTERVAL
GAA (MIL-G-10924C)	Grease, automotive and artillery		ALL TEMPERATURES			8 - 8 hours of normal operation M - monthly AR - As required
	Lubrication fittings	As required				

NOTE:

1. Replace the pipe plug with a 1/2" x 1/4" hex bushing fitted with a grease fitting. Use a grease fitting. Use a medium pressure grease gun to pump grease into cavity until you feel the pressure on the grease gun. Remove the bushing and grease fitting and reinstall the pipe plug.
2. Apply grease with a medium pressure gun. Apply prior to raising or lowering the mast.

Figure 3-2. Lubrication Instructions for Mast Components (Sheet 2 of 2)

LUBRICATION INSTRUCTIONS

MUD PUMP

NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type II or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (O).

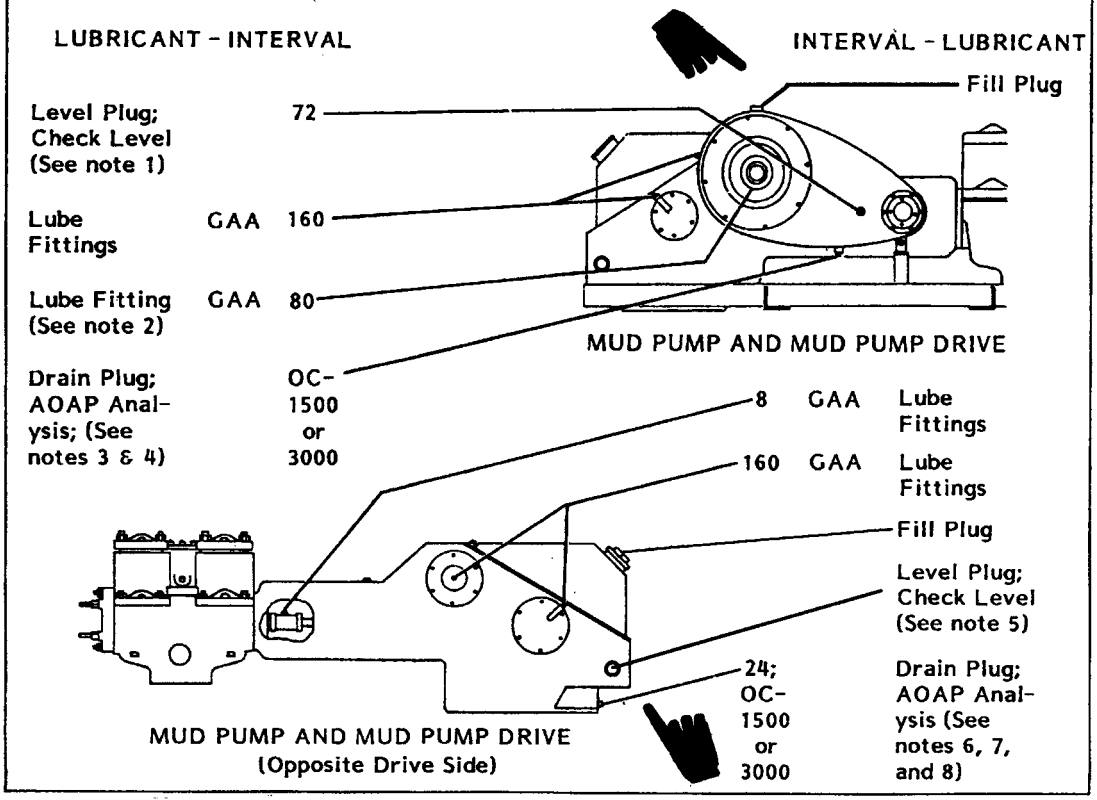


Figure 3-3. Lubrication Instructions for Mud Pump (Sheet I of 2)

TOTAL MAN-HOURS			
INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
8	0.2	160	0.2
24	0.2	336	0.1
72	0.1	1500 or	
80	0.1	3000	1.0

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES			INTERVAL
			Above +90 F (Above +32 C)	+40 F to + 90 F (+4 to + 32 C)	Below +40 F (Below +4 C)	
	Lubricating oil, gear, multipurpose		SAE 50-60	SAE 40	SAE 30	Intervals given are in hours of normal operation.
	Mud Pump Crankcase	12 qts 11.3 1				
GAA (MIL-G-10924C	Grease, automotive and artillery		ALL TEMPERATURES			
	Lubrication fittings	As required				
	Lubricating oil, gear, multipurpose		SAE 50-60	SAE 40	SAE 30	
	Mud Pump Drive Case	12 gal (45 1)				

NOTES:

1. Remove level plug to check lubricant level in mud pump drive housing. Lubricant should be even with the bottom of the check plug hole. If needed, add oil through the fill plug opening. Reinstall plug.
2. Do not overgrease. Pump the lubricating gun one or two times only. Overgreasing may affect the clutch plates.
3. A sample of the oil from the mud pump drive housing shall be sent to an AOAP laboratory for analysis at a 1500-hour or 9-month intervals. Refer to TB 43-0210 for sampling requirements.
4. When AOAP laboratory support is not available, drain and refill the mud pump drive housing at 3000 hours or 18 months.
5. Remove level plug to check lubricant level in mud pump crankcase. Lubricant should be even with the bottom of the check plug hole. If needed, add oil through the fill plug opening. Reinstall plug. One level plug located on each side of case.
6. After each 24 hours operation, drain a small quantity of oil from the mud pump crankcase. Inspect the sample for grit or water contamination. If either is found, change the oil at once.
7. A sample of the oil from the mud pump crankcase shall be sent to an AOAP laboratory for analysis at 1500-hour or 9-month intervals. Refer to TB 43-0210 for sampling requirementS
8. When AOAP laboratory support is not available, drain and refill the mud pump crankcase at 3000 hours or 18 months.

Figure 3-3. Lubrication Instructions for Mud Pump (Sheet 2 of 2)

LUBRICATION INSTRUCTIONS

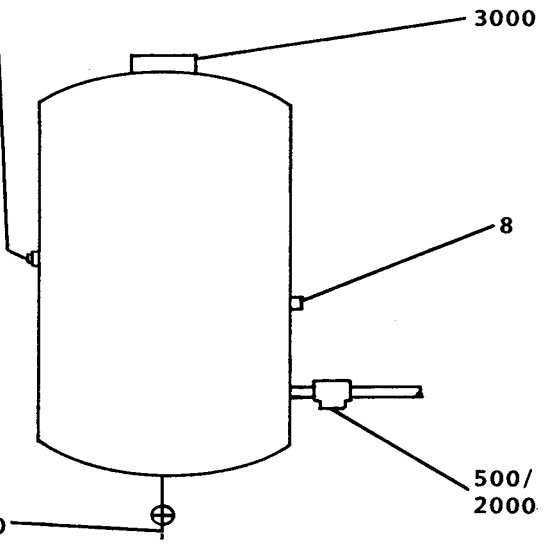
AIR COMPRESSOR, MODEL CF-128-G
NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type II or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (O).

LUBRICANT - INTERVAL			INTERVAL - LUBRICANT	
Filling Plug	RARUS	500/2000	3000	Coalescent Filter (See note 1)
			8	Oil Level Indicator (Check Level)
			500/2000	Pipe Plug (See Note 2)
Drain Valve (See Note 2)		500/2000		



AIR OIL SEPARATOR

Figure 3-4. Lubrication Instructions for Air System (Sheet 1 of 3)

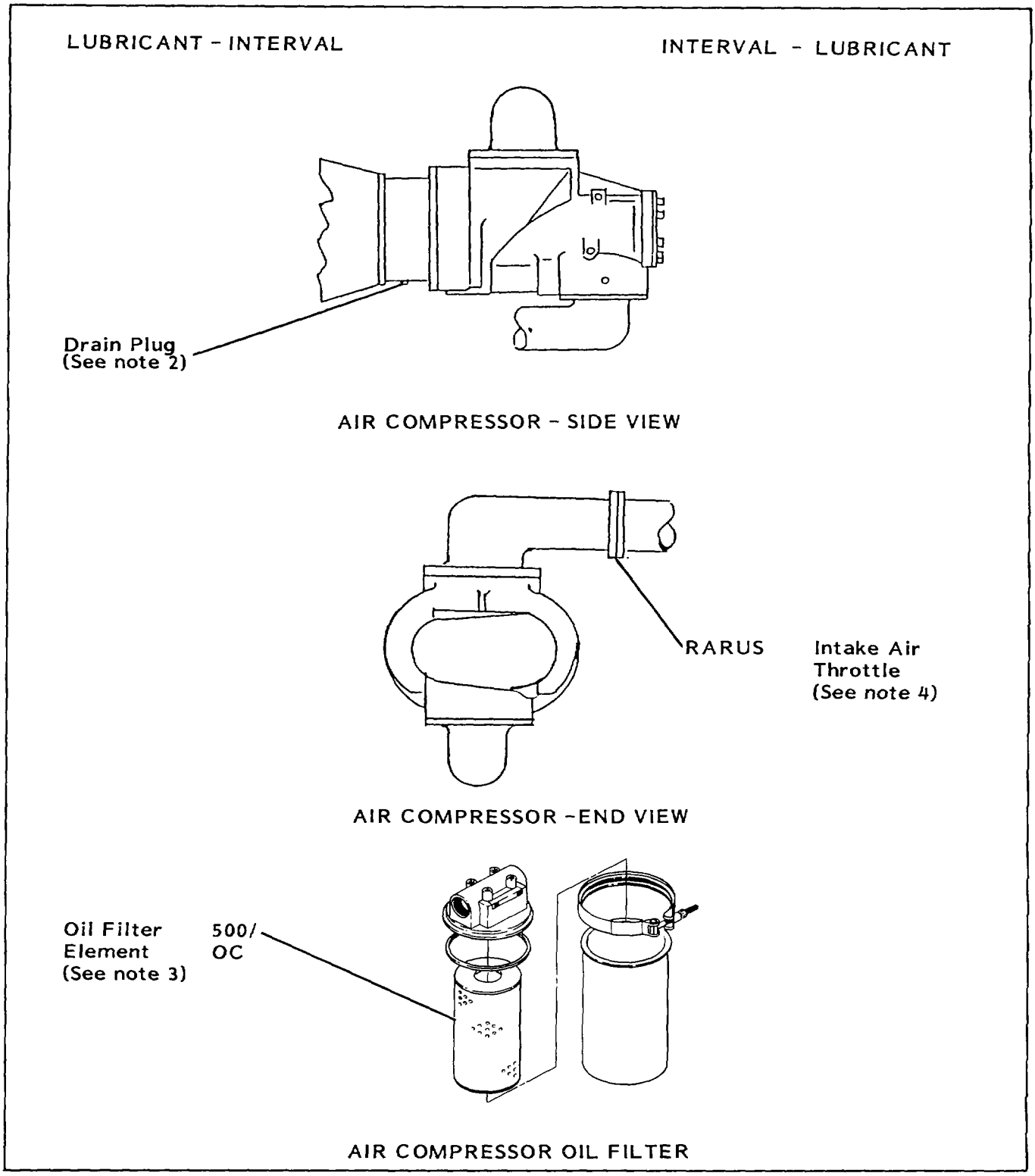


Figure 3-4. Lubrication Instruction for Air System (Sheet 2 of 3)

TOTAL MAN-HOURS:

INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
8	0.1	3000	0.3
500/2000	1.0	OC	0.3

KEY

LUBRICANTS	CAPACITIES	EXPECTED TEMPERATURES: Above +90 F / Above 32 C	EXPECTED TEMPERATURES: Below +90 F / Below 32 C	INTERVAL
RARUS (Mobil Oil Corp.) Lubricating oil, synthetic	5 Gal (19 l)	RARUS 926	RARUS 924	Intervals given are in hours of normal operation.

NOTES:

1. Every 3000 hours, check the coalescent filter element and change if necessary. In extremely dusty environment, inspect more frequently.
2. Perform first oil change 500 operating hours after initial start-up or after major system repair. Thereafter, change oil after each 2000 operating hours or yearly at the latest. Change oil as follows:
   a. Drain the air-oil separator through the drain valve.
   b. Drain the oil injection piping through the drain plug.
   c. Drain the compressor through the drain plug.
   d. Drain the oil cooler through the drain plug at the bottom left header.
   e. Remove and clean the oil filter bowl. Inspect and replace the bowl seal if necessary. Replace the filter cartridge.
   f. Drain the air-oil piping through the drain plug at the bottom of the check valve.
   g. When the system is empty, reinstall all plugs using polytetrafluorethylene (PTFE) Teflon tape sealant.
   h. Fill the air-oil separator to the top of the filling nozzle with new oil.
   i. Perform procedures described in Note 4.
   j. Start and run the compressor for about 5 minutes; then shut it down and check the oil level in the air-oil separator. Add oil as needed.
3. Change the oil filter cartridge with the first oil change and after 500 operating hours. Thereafter, perform regular oil filter cartridge changes just before the visual indicator on the filter moves to the red zone.
4. Perform the following procedures after a prolonged storage period, after changing the oil, or after any maintenance of the discharge piping or the air compressor unit:
   a. Disconnect the intake air throttle.
   b. Pour approximately 1 quart of the correct oil into the intake piping.
   c. Reconnect the intake air throttle.

Figure 3-4. Lubrication Instructions for Air System (Sheet 3 of 3)

LUBRICATION INSTRUCTIONS

SUBDRIVE ASSEMBLY

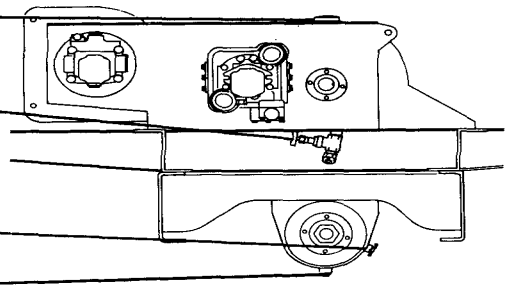
NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

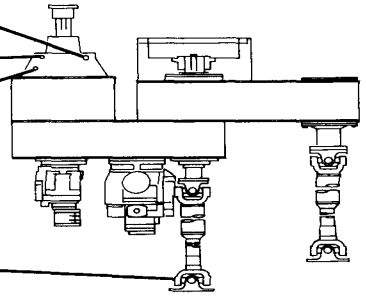
Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type II or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (O).

LUBRICANT	INTERVAL
Fill Cap (See Note 1)	OE/HDO
Upper Case Drain Valve; AOAP analysis (See note 2 and 3)	OC-1500 or 3000
Oil Level Petcock (Check Level; See note 1)	160
Drain Valve	OC-1500 or 3000
Lube Fittings (See note 4)	GAA 72
Lube Fitting	GAA 50
Lube Fitting (See note 5)	GAA 8
Universal Joint and Spline Lube Fittings	GAA 24



SUB-DRIVE - TOP VIEW



SUB-DRIVE - FRONT VIEW

Figure 3-5. Lubrication Instructions for Sub-Drive (Sheet 1 of 2)

TOTAL MAN-HOURS:

INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
8	0.1	72	0.2
24	1.0	160	0.1
50	0.1	1500/3000	1.0

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES: Above +32 F Above 0 C	EXPECTED TEMPERATURES: Below +32 F Below 0 C	INTERVAL
OE/HDO (MIL-L-2104D)	Lubricating oil, internal combustion engine		OE/HDO 30	OE/HDO 10	Intervals given are in hours of normal operation.
	Sub-drive case	14 qts (13.2 1)			
GAA (MIL-G-10924C)	Grease, automotive and artillery		ALL TEMPERATURES		
	Lubrication fittings	As required			

NOTES:

1. Open the oil level petcock before filling or adding oil to the subdrive case. Oil poured into the fill cap opening will fill the upper case first, then flow over into the lower case. The oil level is correct when oil begins to flow from the oil level petcock. Close the petcock and reinstall the fill cap.
2. A sample of the oil from the sub-drive case shall be sent to an AOAP laboratory for analysis at a 1500-hour or 9-month intervals. Refer to TB 43-0210 for sampling requirements.
3. When AOAP laboratory support is not available, drain and refill the sub-drive case at 3000 hours or 18 months.
4. On two fittings, one near each end of the yoke shaft, pump the lubricating gun one or two times for each fitting. Do not overgrease.
5. This fitting is for the throw-out collar. Pump the lubricating gun one or two times only. Do not overgrease. Overgreasing may cause the clutch to slip.

Figure 3-5. Lubrication Instructions for Sub-Drive (Sheet 2 of 2)

LUBRICATION INSTRUCTIONS

DRAWWORKS

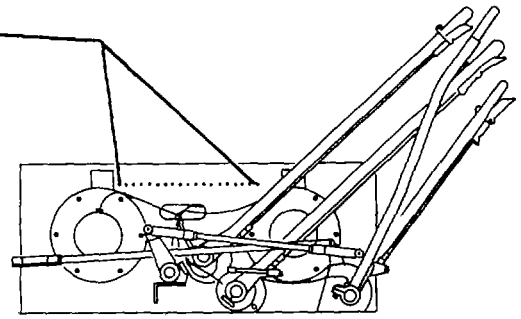
NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type 11 or equivalent. Dry before lubricating.

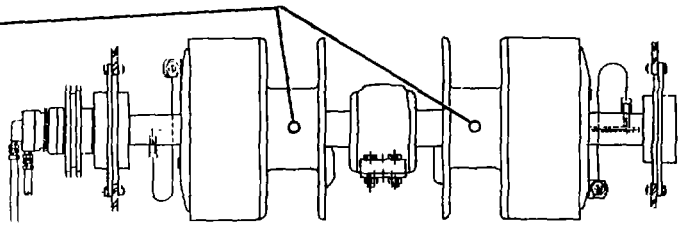
The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

Lube Fittings (19 Total; See note 1)	GAA	160



DRAWWORKS CONTROLS LUBE FITTINGS

Drum Bearings (See note 2)	GO-80/ 90	3000

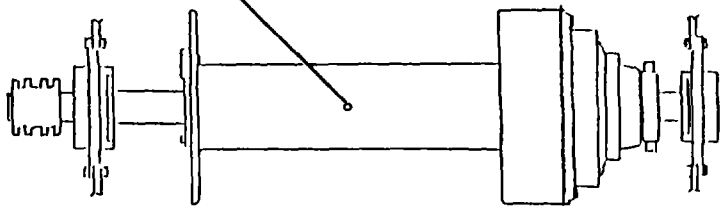


HOIST/AUXILIARY DRUM LUBE FITTINGS

Figure 3-6. Lubrication Instructions for Drawworks (Sheet I of 3)

LUBRICANT - INTERVAL

Drum Bearings (See note 2) GO-80/90 3000

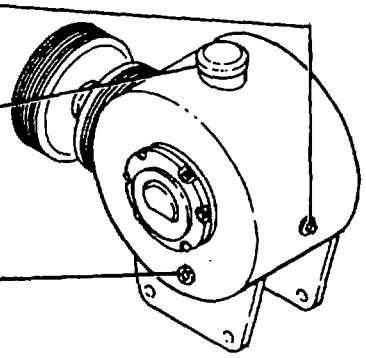


THIRD DRUM LUBE FITTINGS

Level Plug (Check Level; See note 3) 160

Fill Cap GO-85/145

Drain Plug AOAP Analysis (See notes 4 and 5) OC-1500 or 3000



BEVEL GEAR BOX ASSEMBLY

Roller Chain (See note 6) OE/HDO AR

ROLLER CHAINS

Figure 3-6. Lubrication Instructions for Drawworks (Sheet 2 of 3).

TOTAL MAN-HOURS:			
INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
160	1.0	AR	1.0
3000	1.0	1500/3000	0.5

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES: Above +100 F (Above +38 C)	EXPECTED TEMPERATURES: +40 to +100 F (+4 to +38 C)	EXPECTED TEMPERATURES: Below +40 F (Below +4 C)	INTERVAL
GAA (MIL-G-10924C)	Grease, automotive and artillery		ALL TEMPERATURES			Intervals given are in hours of normal operation.
	Lubrication fittings	As required				
GO-80/90 (MIL-L-2105C)	Lubricating oil, gear multipurpose		ALL TEMPERATURES			
	Drum bearings	As required				
GO-85/140 (MIL-L-2105C)	Lubricating oil, gear multipurpose		ALL TEMPERATURES			
	Bevel Gear Box	3 qts (2.84 l)				
OE/HDO (MIL-L-2104D)	Lubricating oil, internal combustion engine		OE/HDO 30		OE/HDO 10	
	Roller chains case	As required				

NOTES:

1. Pump two or three times for each fitting.
2. Spool enough wire rope off each drum to gain access to each pipe plug. Remove the pipe plugs. Pour 1/2 pint (0.24l) of GO-80/90 into each drum. Reinstall pipe plugs. Spool wire rope onto each drum to take up the slack.
3. Remove level plug to check lubricant level in the bevel gear box. Lubricant should be even with the bottom of the check plug hole. If needed, add oil through the fill cap opening. Reinstall level plug.
4. A sample of the oil from the bevel gear box shall be sent to an AOAP laboratory for analysis at a 1500-hour or 9-month intervals. Refer to TB 43-0210 for sampling requirements.
5. When AOAP laboratory support is not available, drain and refill the bevel gear box at 3000 hours or 18 months.
6. Apply oil periodically between the chain link plate edges. Apply with a paint brush or spout can. After each 3000 hours operation, remove the roller chains and inspect for wear. Bathe the roller chains in dry cleaning solvent (SD, type II or equivalent). Dry thoroughly; then bathe in OE/HDO. Finally, inspect, lubricate, and reinstall.

Figure 3-6. Lubrication Instructions for Drawworks (Sheet 3 of 3)

LUBRICATION INSTRUCTIONS

HYDRAULIC SYSTEM

NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type 11 or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

INTERVAL - LUBRICANT

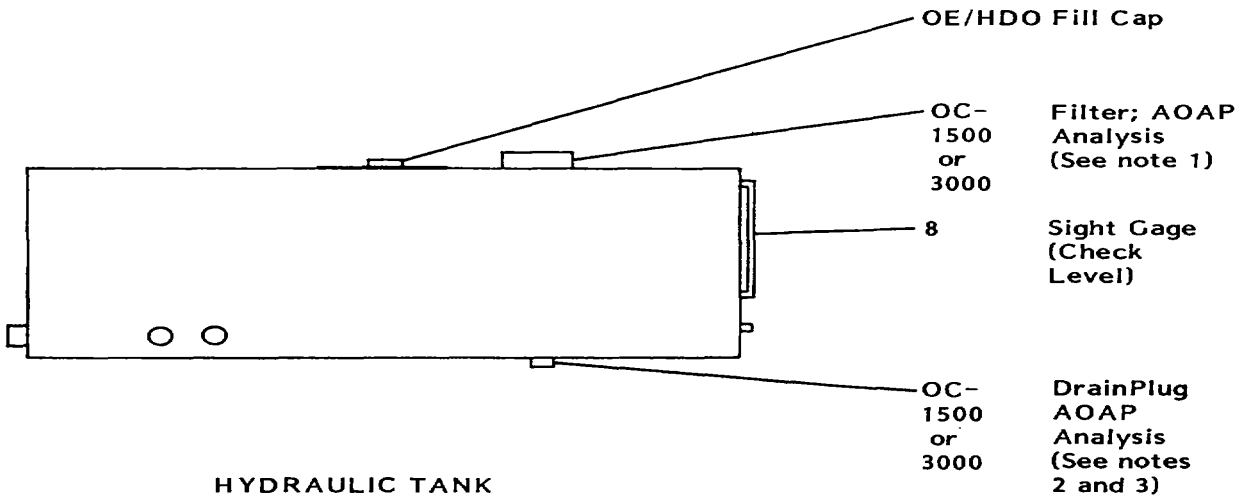


Figure 3-7. Lubrication Instructions for Hydraulic System (Sheet I of 2)

*U.S. GOVERNMENT PRINTING OFFICE: 1993 -755-028/M3O4

TOTAL MAN-HOURS

INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
8	0.1	1500/3000	2.0

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES +5 to +90 F -15 to +30 C	EXPECTED TEMPERATURES -15 to +40 F -25 to +5 C	INTERVAL
OE/HDO (MIL-L-2104D)	Lubricating oil, internal combustion engine		OE/HDO-15/40	OE/HDO-10	Intervals given are in hours of normal operation.
	Hydraulic tank	79 gal (299 l)			

NOTES:

1. Service the filter each time the oil is changed. Remove the filter cover, then remove the filter element. Clean the inside of the reservoir and the filter cover. Install new elements; reinstall the filter cover.
2. A sample of the oil from the hydraulic tank shall be sent to an AOAP laboratory for analysis at 1500-hour or 9-month intervals. Refer to TB 43-0210 for sampling requirements.
3. When AOAP laboratory support is not available, drain and refill the hydraulic tank at 3000 hours or 18 months.

Figure 3-7. Lubrication Instructions for Hydraulic System (Sheet 2 of 2)

LUBRICATION INSTRUCTIONS

WATER AND FOAM INJECTION

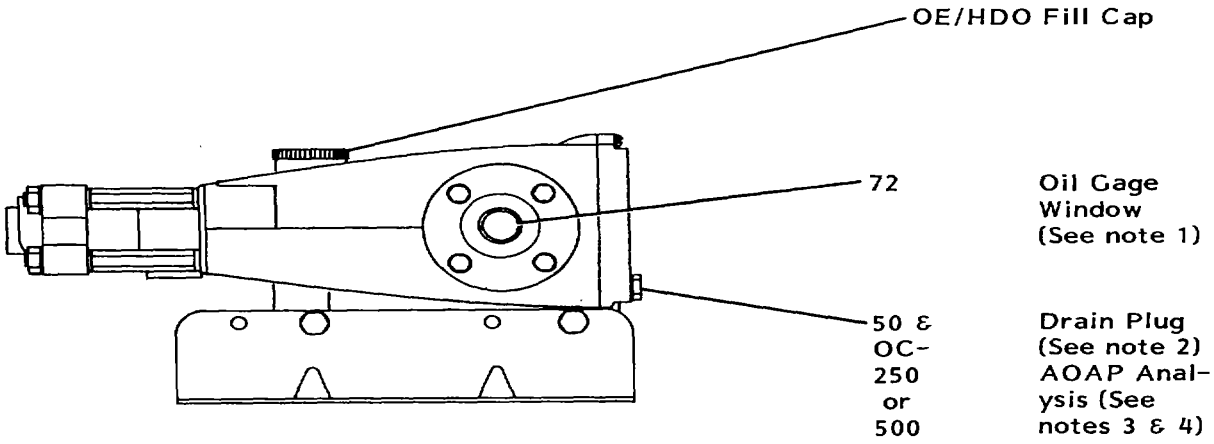
NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type 11 or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

INTERVAL - LUBRICANT



WATER INJECTION PUMP

Figure 3-8. Lubrication Instructions for Water Injection System (Sheet 1 of 2)

TOTAL MAN-HOURS:

INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
72	0.1	50,250,500	0.5

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES +5 to +90F -15 to +30 C	EXPECTED TEMPERATURES -15 to +40 F -25 to +5 C	INTERVAL
OE/HDO (MIL-L-2104C)	Lubricating oil, internal combustion engine		OE/HDO-15/40	OE/HDO-10	Intervals given are in hours of normal operation.
	Water Injection pump crankcase	1.25 qt (1.1 l)			

NOTES:
1. Correct level is at the dot on oil gage window.
2. Change initial oil after 50 hours of operation.
3. A sample of the oil from the water injection pump crankcase shall be sent to an AOAP laboratory for analysis at 1500-hour or 9-month intervals. Refer to TB 43-0210 for sampling requirements.
4. When AOAP laboratory support is not available, drain and refill the crankcase at 3000 hours or 18 months.

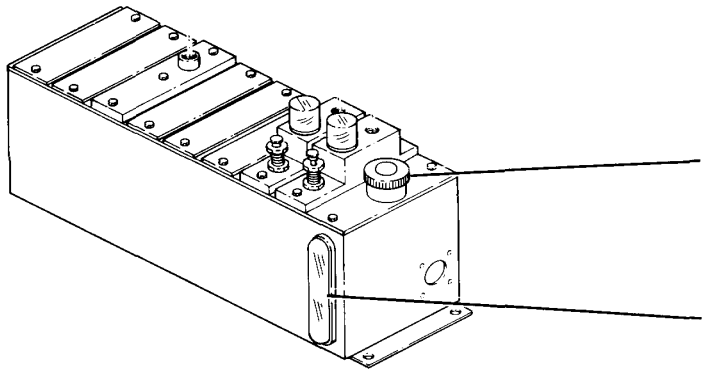
Figure 3-8. Lubrication Instructions for Water Injection System (Sheet 2 of 2)

FORCE FEED LUBRICATOR
NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type II or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organization Maintenance (O).



FORCE FEED LUBRICATOR

TOTAL MAN-HOURS:	INTERVAL	MAN-HOURS
	4	0.1

KEY

LUBRICANTS	CAPACITIES	EXPECTED TEMPERATURES	INTERVAL
(See note) Rock drill oil Reservoir	6 qts (5.7 l)	ALL TEMPERATURES	Intervals given are in hours of normal operation

NOTE: Use Rock Drill Oil, DAROCKDRILL 500 (CAGE 54527), NSN 9150-00-142-9320.

Figure 3-9. Lubrication Instructions For Force Feed Lubricator

LUBRICATION INSTRUCTIONS

ROTARY TABLE DRIVE

NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type 11 or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

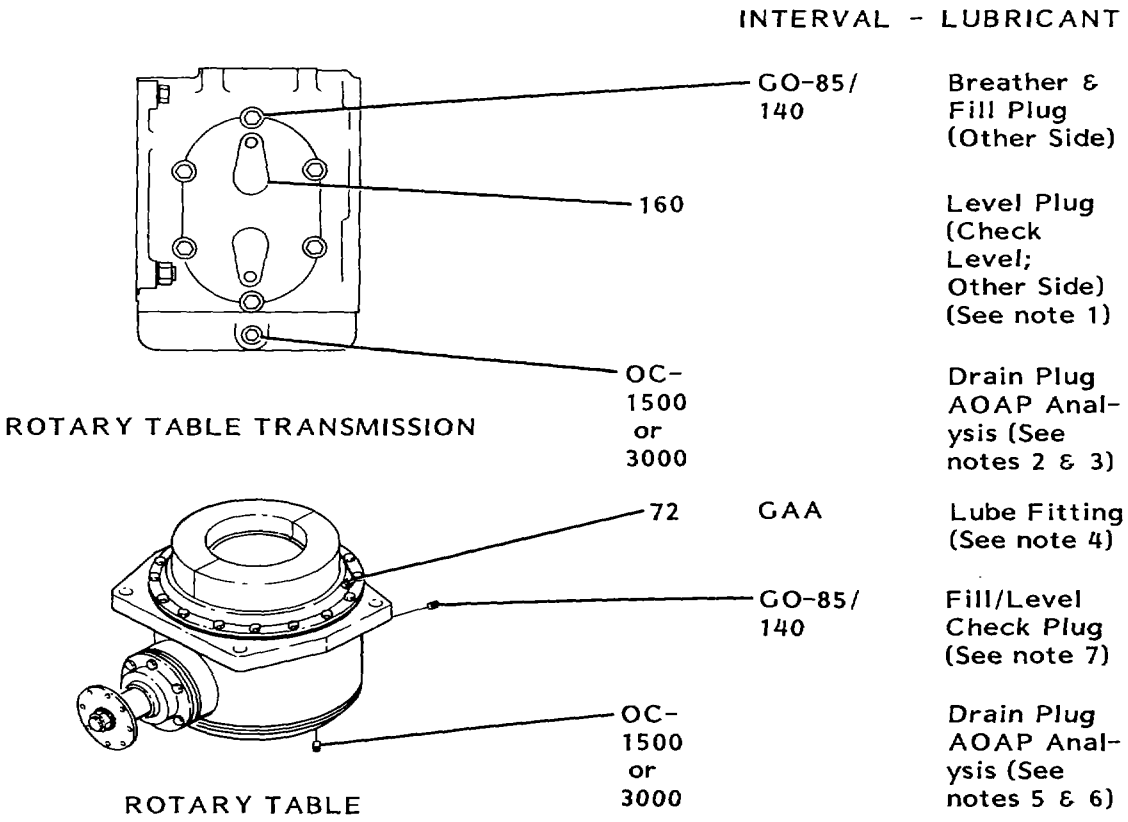
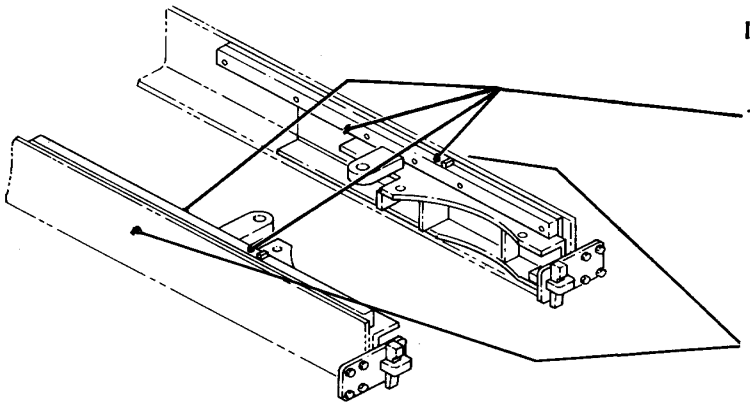


Figure 3-10. Lubrication Instructions for Rotary Table Drive System (Sheet 1 of 3)



INTERVAL - LUBRICANT

160	GAA	Lube Fittings
160	GAA	Lube Fitting (This and other side)

ROTARY TABLE SLIDING BASE

TOTAL MAN-HOURS:

INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
72	0.1	1500/3000	0.6
160	0.4		

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES	INTERVAL
GO-85/140	Lubricating oil, gear, multipurpose		ALL TEMPERATURES	Intervals given are in hours of normal operation.
	Rotary table transmission	3 qts (2.84 l)		
	Rotary table	5-1/2 lb (2500 g)		
GAA (MIL-G-10924C)	Grease, automotive and artillery		ALL TEMPERATURES	
	Lubrication fittings	As required		

NOTES:

1. Remove the level plug to check lubricant level in the rotary table transmission. Lubricant should be even with the bottom of the level plug hole. If needed, add oil through the breather and fill plug opening. Reinstall the level plug.
2. A sample of the oil from the rotary table transmission shall be sent to an AOAP laboratory for analysis at 1500-hour or 9-month intervals. Refer to TB 43-0210 for sampling requirements.
3. When AOAP laboratory support is not available, drain and refill the transmission at 3000 hours or 18 months.
4. Do not overgrease. If the bearing and bearing cavity are completely filled with grease, the bearing may overheat.

Figure 3-10. Lubrication Instructions for Rotary Table Drive System (Sheet 2 of 3)

NOTES (Continued):

5. A sample of the oil from the rotary table shall be sent to an AOAP laboratory for analysis at 1500-hour or 9-month intervals. Refer to TB 43-0210 for sampling requirements.

6. When AOAP laboratory support is not available, drain and refill the rotary table at 3000 hours or 18 months.

7. Remove the fill/level check plug to check lubricant level in the rotary table. Lubricant should be even with the bottom of the fill/level check plug hole. If needed, add oil through this opening. Reinstall the fill-level check plug.

Figure 3-10. Lubrication Instructions for Rotary Table Drive System (Sheet 3 of 3)

LUBRICATION INSTRUCTIONS

CHAIN FEED DRIVE

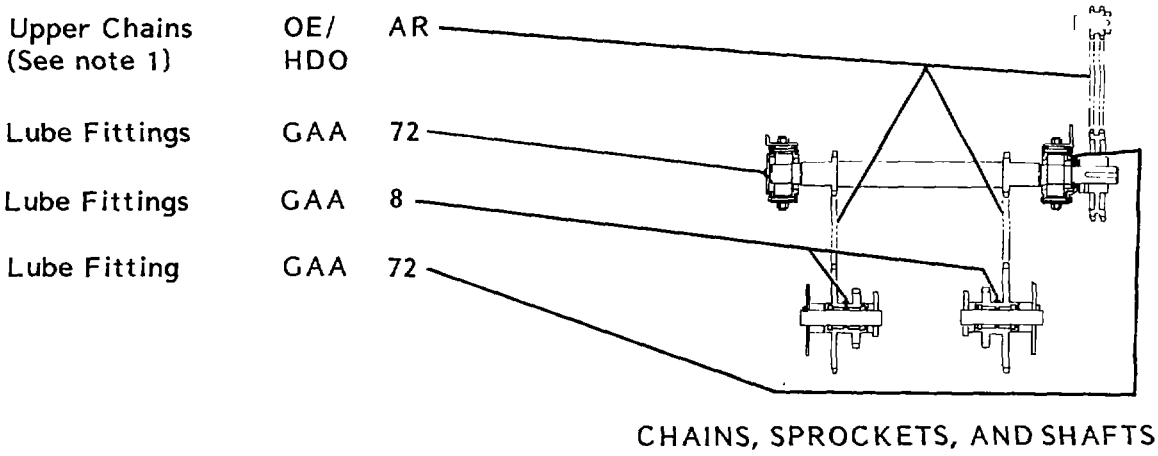
NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type 11 or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0) .

LUBRICANT - INTERVAL



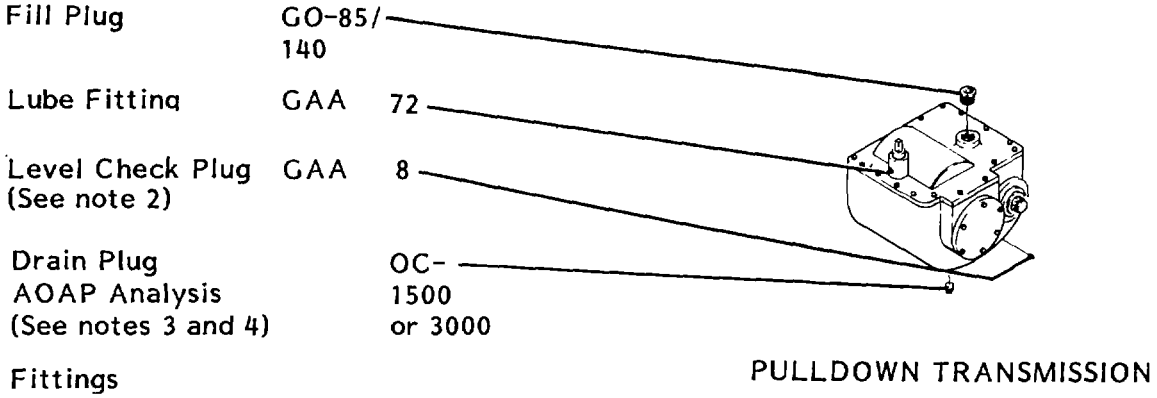


Figure 3-11. Lubrication Instruction for Chain Feed Drive (Sheet 1 of 2)

TOTAL MAN-HOURS:

INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
AR	1.0	160	0.1
8	0.1	1500/3000	0.4
72	0.1		

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES: Above +100 F (Above +38 C)	EXPECTED TEMPERATURES: +40 to +100 F (+4 to +38 C)	EXPECTED TEMPERATURES: Below +40 F (Below +4 C)	INTERVAL
OE/HDO (MIL-L-2104D)	Lubricating oil, internal combustion engine		OE/HDO 40	OE/HDO 30	OE/HDO 20	Intervals given are in hours of normal operation.
	Roller chains	As required				
GAA (MIL-G-10924C)	Grease, automotive and artillery		ALL TEMPERATURES			
	Lubrication fittings	As required				
GO-85/140	Lubricating oil,gear, multipurpose					
	Pulldown transmission	3 qts (2.84 l)				

NOTES:

1. Apply oil periodically between the chain link plate edges. Apply with a paint brush or spout can.
2. Remove the level check plug to check lubricant level in the pulldown transmission. Lubricant should be even with the bottom of the level plug hole. If needed, add oil through the fill plug opening. Reinstall the level plug.
3. A sample of the oil from the pulldown transmission shall be sent to an AOAP laboratory for analysis at 1500-hour or 9-month intervals. Refer to TB 43-0210 for sampling requirements.
4. When AOAP laboratory support is not available, drain and refill the pulldown transmission at 3000 hours or 18 months.

Figure 3-11. Lubrication Instructions for Chain Feed Drive (Sheet 2 of 2)

LUBRICATION INSTRUCTIONS

AIR CONTROL ASSEMBLY

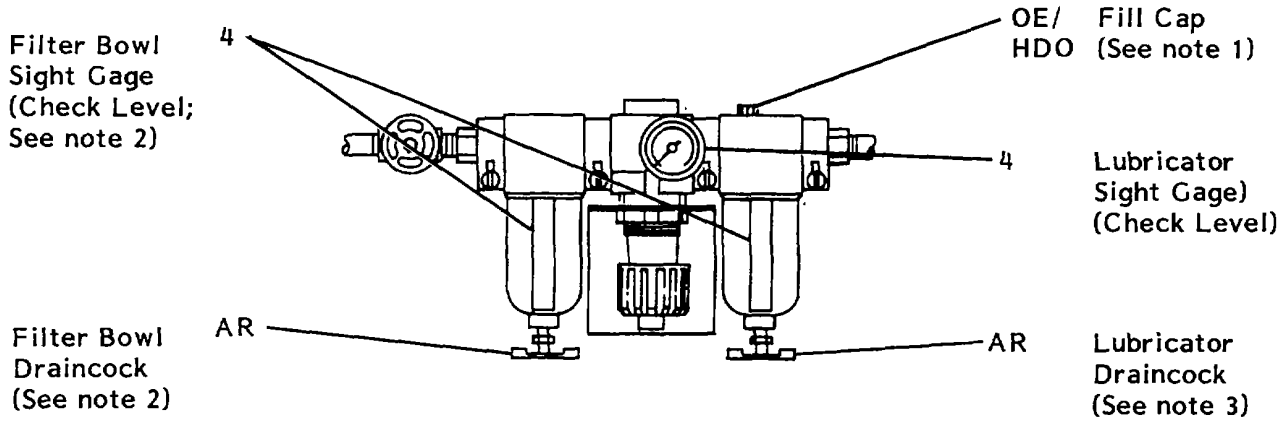
NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type 11 or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

LUBRICANT - INTERVAL INTERVAL - LUBRICANT



AIR CONTROLS ASSEMBLY

Figure 3-12. Lubrication Instruction for air controls Assembly (Sheet I of 2)

TOTAL MAN-HOURS:

INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
4	0.1	AR	0.1

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES	INTERVAL
OE/HDO (MIL-L-2104D)	Lubricating oil, internal combustion engine		OE/HDO 10	4 - 4 hours of normal operation
	Lubricator bowl	10 oz (0.3 1)		AR - As required

NOTES:

1. Shut off air by closing inlet valve before removing the fill cap. Refill the lubricator bowl as indicated by check of the lubricator sight gage. Reinstall and tighten the fill cap. Re-open the inlet valve after servicing the air line conditioner unit.
2. Shut off air by closing inlet valve before removing the filter bowl draincock. When moisture is present, as indicated by check of the filter bowl sight gage, drain the bowl by opening the draincock. Close the draincock after draining. Re-open the inlet valve after servicing the air line conditioner unit.
3. Shut off air by closing inlet valve before opening the lubricator draincock. If oil is contaminated by moisture, as indicated by check of the filter bowl sight gage, drain the lubricator bowl by opening the draincock. Close the draincock after draining the bowl. Refill the lubricator with clean oil. Re-open the inlet valve after servicing the air line conditioner unit.

Figure 3-12. Lubrication Instructions for Air Controls Assembly (Sheet 2 of 2)

LUBRICATION INSTRUCTIONS

DRIVE SHAFTS AND UNIVERSAL JOINTS

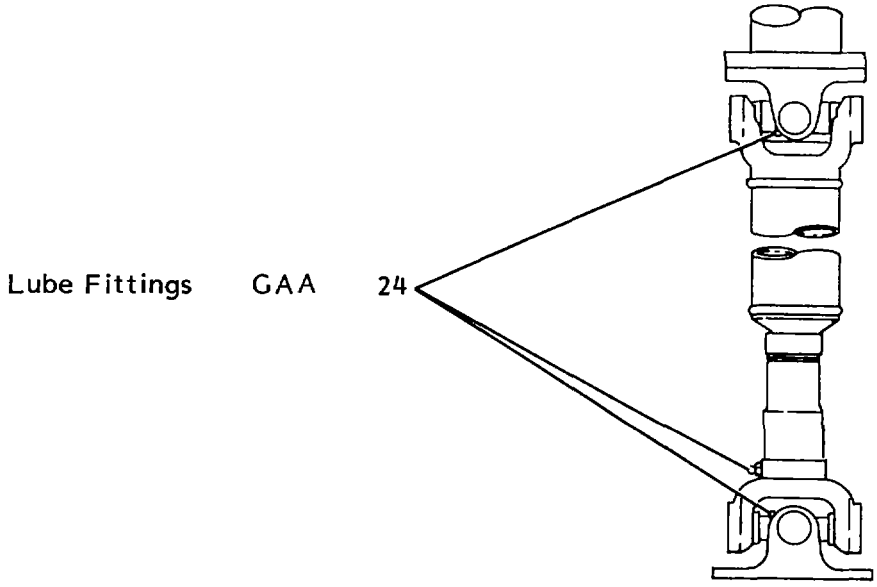
NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with cry -cleaning solvent (SD), type 11 or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

LUBRICANT - INTERVAL



DRIVE SHAFTS/UNIVERSAL JOINTS

Figure 3-13. Lubrication Instructions for Drive Shafts and Universal Joints (Sheet 1 of 2)

TOTAL MAN-HOURS:		INTERVAL	MAN-HOURS
		24	1.0

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES	INTERVAL
GAA (MIL-G-10924C)	Grease, automotive and artillery		ALL TEMPERATURES	Intervals given are of normal operation.
	Lubrication fittings	As required		

NOTE: Pump new grease until old grease and abrasive contaminants are purged from each joint and each slip spline.

Figure 3-13. Lubrication Instructions for Drive Shafts and Universal Joints (Sheet 2 of 2)

LUBRICATION INSTRUCTIONS

TRUCK

NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type 11 or equivalent. Dry before lubricating.

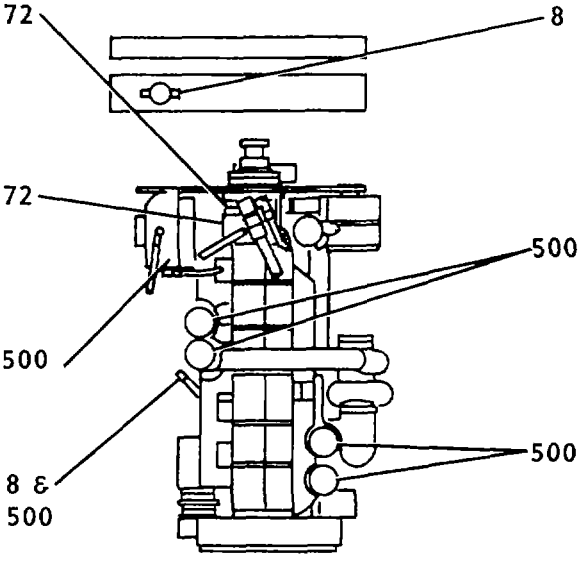
The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

LUBRICANT - INTERVAL

Power Steering Pump (Check Level)	OE/HDO	72
Power Steering Gear (Check Level)	OE/HDO	72
Air Cleaner (Replace)		500
Engine Oil (Check Level; See note 1)	OE/HDO	8 & 500

INTERVAL - LUBRICANT

8	Engine Oil Coolant
500	Fuel Filters (Replace)
500	Engine Oil Filters (Replace)



DIESEL ENGINE

Figure 3-14. Lubrication Instructions for Truck (Sheet 1 of 5)

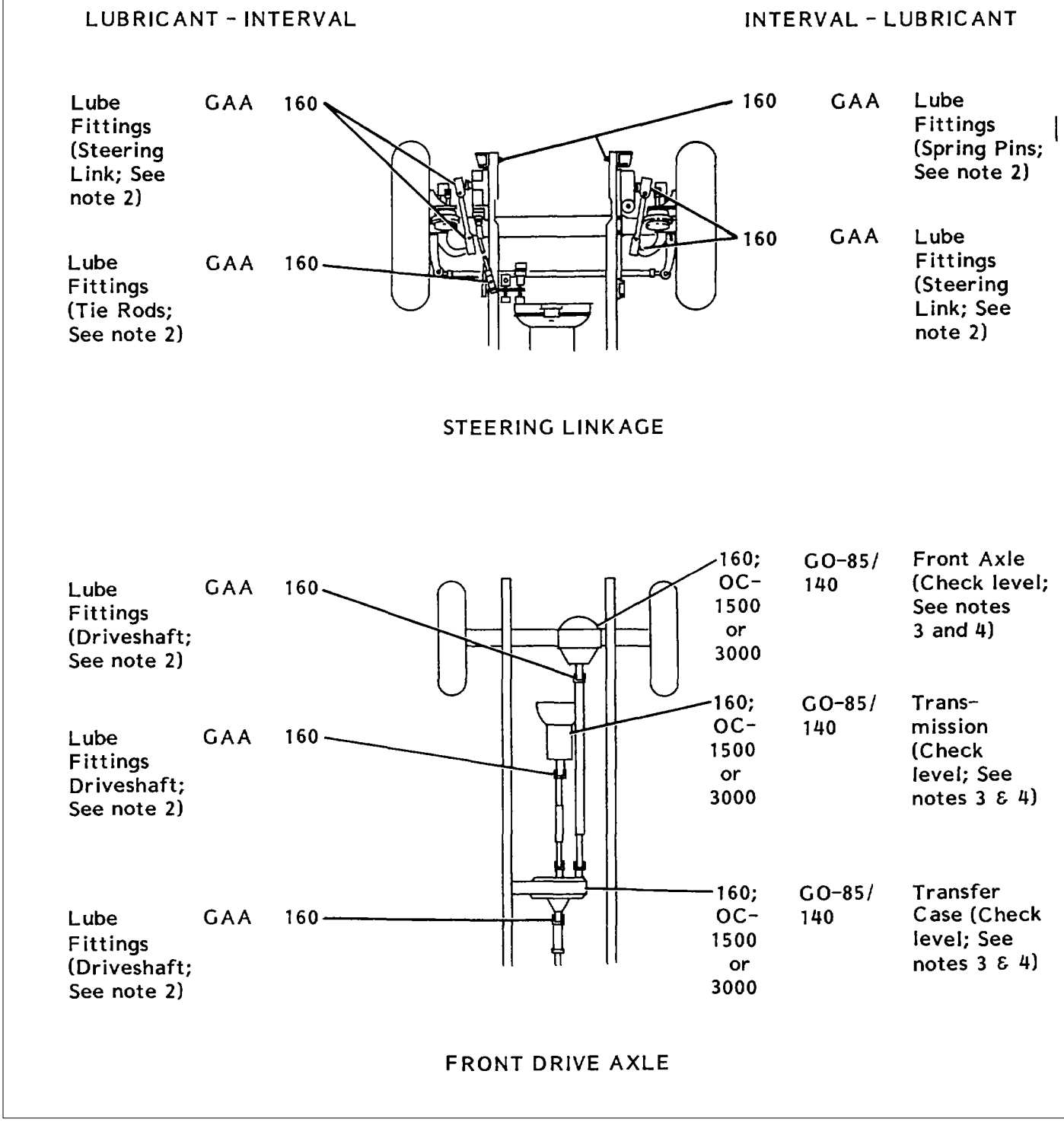


Figure 3-14. Lubrication Instructions for Truck (Sheet 2 of 5)

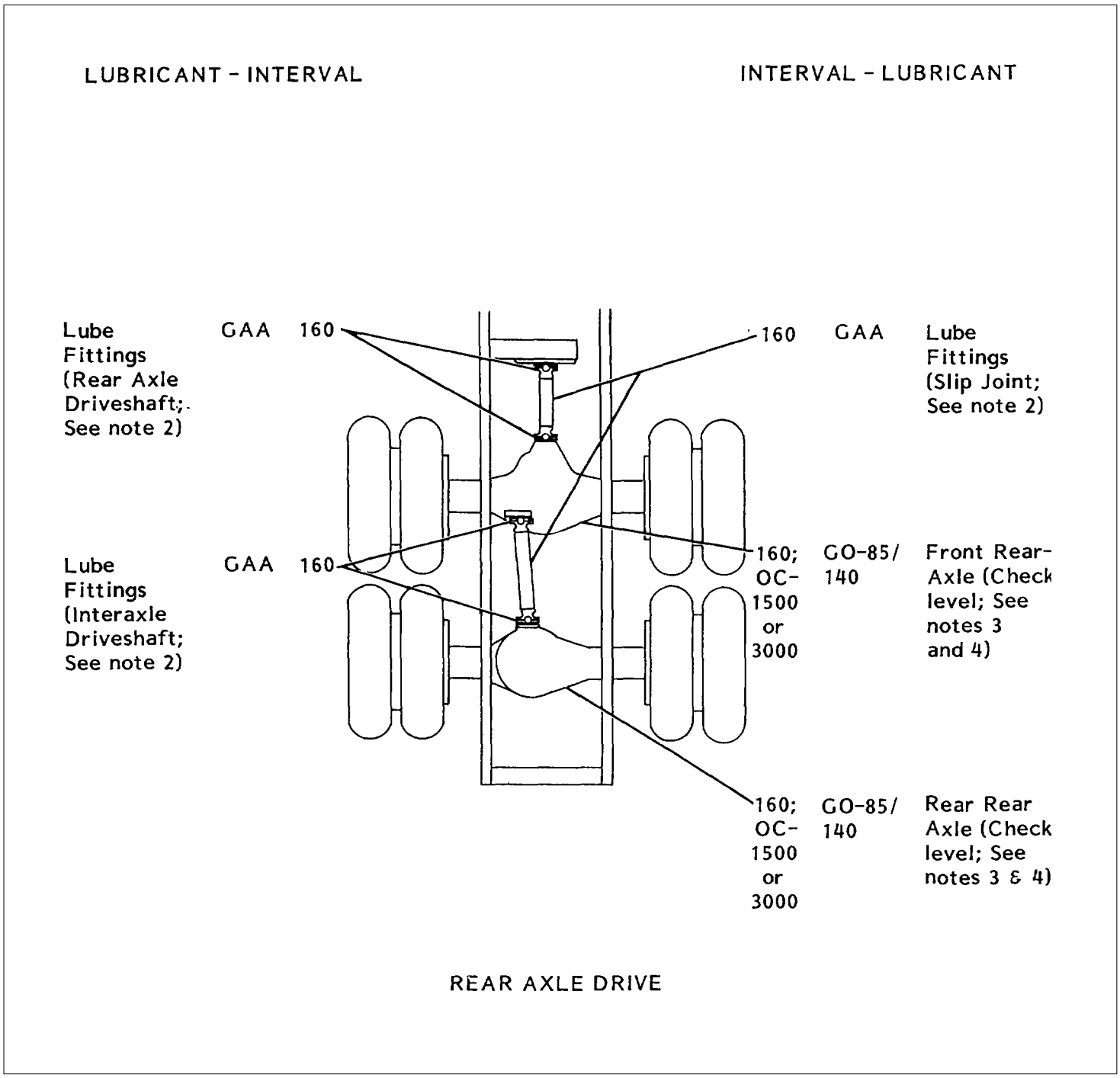


Figure 3-14. Lubrication Instructions for Truck (Sheet 3 of 5)

TOTAL MAN-HOURS:			
INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
8	0.3	160	2.0
72	0.2	1500/3000	2.0
500	1.0		

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES: Above +100 F (Above +38 C)	+40 to +100 F (+4 to +38 C)	Below +40 F (Below +4 C)	INTERVAL
OE/HDO (MIL-L-2104D)	Lubricating oil, internal combustion engine		OE/HDO 40	OE/HDO 30	OE/HDO 20	Intervals given are in hours of normal operation.
	Engine crankcase	22 qts (17 1)				
	Power Steering Pump	1 qt (1.11)				
	Power Steering Gear	1 qt (1.11)				
GAA (MIL-G-10924C)	Grease, automotive and artillery		ALL TEMPERATURES			
	Lubrication fittings	As required				
GO-80/90 (MIL-L-2105C)	Lubricating oil, gear multipurpose		OE/HDO 30		OE/HDO 10	
	Transmission	17 pts (8 1)				
GO-85/140 (MIL-L-2105C)	Lubricating oil, gear multipurpose		OE/HDO 30		OE/HDO 10	
	Transfer Case	19 pts (9 1)				
	Front Axle Housing	18 pts (8.5 1)				
	Front Rear Axle Housing	32 pts (15 1)				
	Rear Rear Axle Housing	24 pts (11.4 1)				
	Manual Steering Gear	1 qts (1.1 1)				

Figure 3-14. Lubrication Instructions for Truck (Sheet 4 of 5)

NOTES:

1. Change oil and oil filters at the same time.
2. Apply grease with a medium pressure grease gun.
3. A sample of the oil from the following truck assemblies shall be sent to an AOAP laboratory for analysis at 1500-hour or 9-month intervals:
   - Front Axle Housing
   - Front Rear Axle Housing
   - Rear Rear Axle Housing
   - Transfer Case
   - Transmission

   Refer to TB 43-0210 for sampling requirements.
4. When AOAP laboratory support is not available, drain and refill the above assemblies at 3000 hours or 18 months.

Figure 3-14. Lubrication Instructions for Truck (Sheet 5 of 5)

Section II. Rig Tender Lubrication Instructions

3.3 Lubricated Items.

Lubrication instructions for each component of the rig tender requiring lubrication are contained in the Figures 3-15 through 3-18. These components or subassemblies are:

a. crane
b. welder/generator
c. hydraulic reservoir
d. winch

3-4. Non-Lubricated Items.

Components of the drilling rig which do not require lubrication include:

a. fuel transfer pump
b. water heater
c. waterbed
d. water pump
e. night lighting

LUBRICATION INSTRUCTIONS

CRANE, MODEL 8K20

NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type 11 or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

LUBRICANT - INTERVAL

Winch Gearbox	GO-85/140	M	
Winch Shaft Bearing	GAA	M	
Rotation Bearing (See note 1)	GAA	M	
Rotation Gearbox Plug (Check level; See note 2)	GO-85/140	A	
Boom Extension (See note 3)		AR	

INTERVAL - LUBRICANT

M	GAA	Extension Boom Top Surface
M	GAA	Rotation Gearbox Output Shaft
M	GAA	Boom Cylinder Pivot Pins
M	GAA	Extension Cylinder Rod End Pins
M	GAA	Boom Tip Sheave

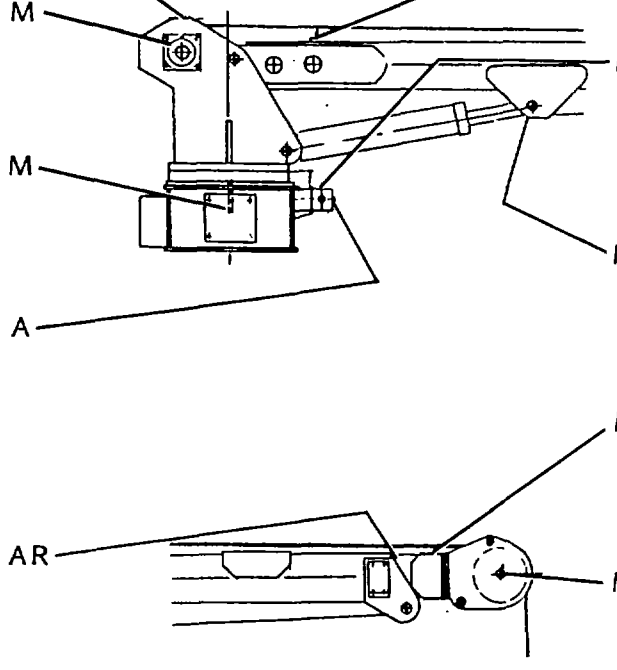


Figure 3-15. Crane Lubrication Instructions (Sheet 1 of 2)

TOTAL MAN-HOURS:

INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
M	1.0	A	1.0
AR	0.2		

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES: ALL TEMPERATURES	INTERVAL: Intervals given are in hours of normal operation.
GAA (MIL-G-10924C)	Grease, automotive and artillery			
	Lubrication fittings	As required		
GO-85/140 (MIL-L-2105C)	Lubricating oil, gear multipurpose		SAE 140 EP	
	Winch Gearbox	3 pts (1.42 l)		
	Rotation Gearbox	3 pts (1.42 l)		
(MIL-L-24131B)	Lubricant, Colloidal graphite			
	Extension Boom Surface	As Required		

NOTES:
1. Access bearing from inside crane base. Apply one or two pumps of grease; rotate boom 180 degrees and repeat.
2. Correct fill level is 1/2 to 1/3 full. Drain and refill annually.
3. Paint on liquid graphite as required and allow to dry.

Figure 3-15. Crane Lubrication Instructions (Sheet 2 of 2)

LUBRICATION INSTRUCTIONS

WELDER/GENERATOR, MODEL DEL-200 (60 Hz)

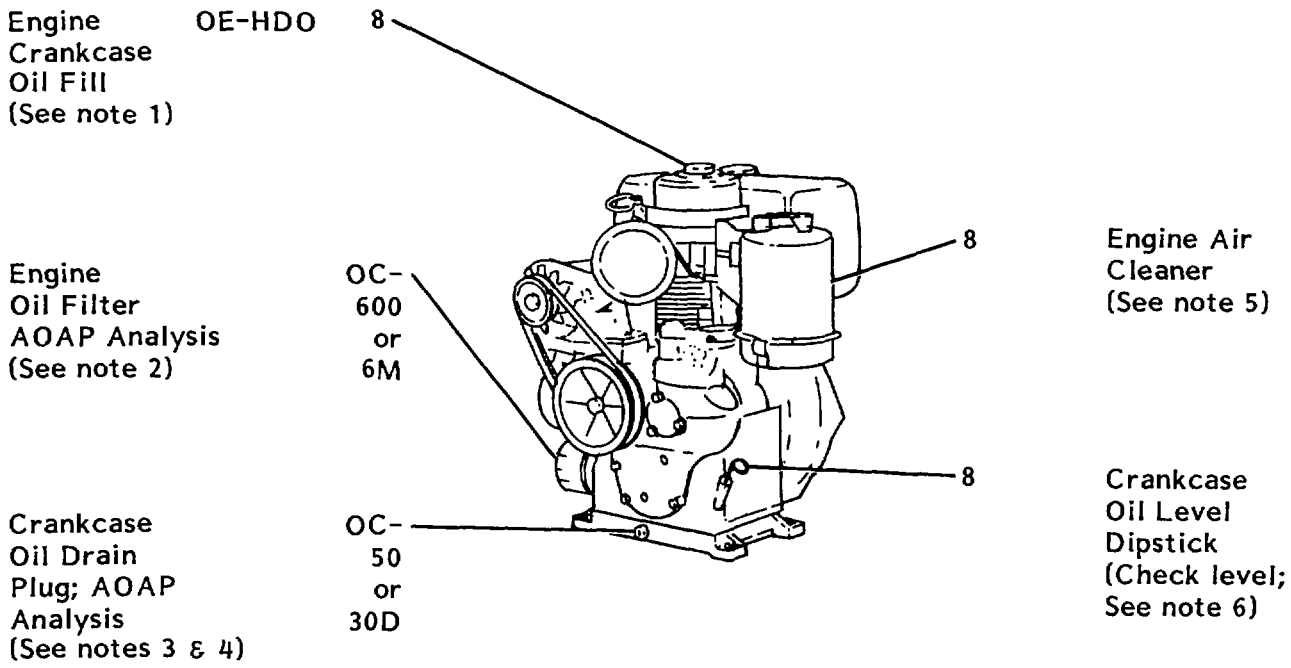
NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

LUBRICANT - INTERVAL

INTERVAL - LUBRICANT



WELDER/GENERATOR ENGINE

Figure 3-16. Welder/Generator Lubrication Instructions (Sheet 1 of 2)

LUBRICATION INSTRUCTIONS

HYDRAULIC RESERVOIR

NOTE: THESE LUBRICATION ISNTRUCTIONS ARE MANDATORY

TOTAL MAN-HOURS

INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
8	0.3	300 or 6M	.2
50 or 30D	.5		

KEY

LUBRICANTS	CAPACITIES	EXPECTED TEMPERATURES: Above +32 F (Above 0 C)	EXPECTED TEMPERATURES: +40 to - I0 F (+4 to -23 C)	EXPECTED TEMPERATURES: 0 F to -65 F (-18 to -54 C)	INTERVAL
OE-HDO (MIL-L-2104D) engine Lubricating oil, internal combustion Engine Crankcase	3 qt (2.84 L)	OE-HDO 30	OE-HDO 10	OEA	Intervals given are in hours of normal operation.
OEA (MIL-L-46167A) Lubricating oil, internal combustion engine Arctic					

NOTES:

1. For operation of equipment in protracted cold temperatures below -10 F (-23 C), remove lubricants prescribed in the key for temperatures above -10 F (-23 C). Re-lubricate with lubricant specified in the key for temperatures within 0 F (-18 C) and -65 F (-54 C).
2. Replace engine oil filter each time oil is changed.
3. A sample of the oil from the engine crankcase shall be sent to an AOAP laboratory for analysis at 50-hour or 30-day intervals. Refer to TB 43-0210 for sampling requirements.
4. When AOAP laboratory support is not available, drain and refill the engine crankcase oil at 300 hours or 6 months.
5. Remove and inspect the engine air cleaner bowl after 8 hours operation in dusty atmosphere. Wait at least 1 hour after engine is stopped before removing bowl. If there is sludge in the bottom of the bowl, empty oil and clean the bowl. Refill the bowl with OE/HDO to level mark in bowl. If air cleaner element is heavily contaminated, remove the element and wash it in clean diesel fuel. Allow all fuel to drip from the element before reinstalling element.
6. Check crankcase oil level while engine is stopped and unit is level. Refill to mark on dipstick.

Figure 3-16. Welder/Generator Lubrication Instructions (Sheet 2 of 2)

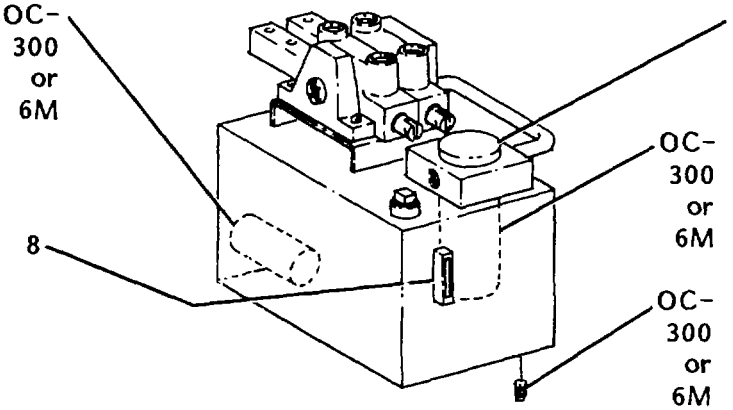
LUBRICATION INSTRUCTIONS

HYDRAULIC RESERVOIR

NOTE: THESE LUBRICATION ISNTRUCTIONS ARE MANDATORY

LUBRICANT - INTERVAL

INTERVAL - LUBRICANT



Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) Laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation pre- cautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

HYDRAULIC RESERVOIR

TOTAL MAN-HOURS

INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
8	0.1	300 or 6M	1.0

KEY

LUBRICANTS	CAPACITIES	EXPECTED TEMPERATURES	INTERVAL
OE/HDO (MIL-L-2104D) Lubricating oil, internal combustion engine	Hydraulic reservoir 7 gal (26.5 1)	OE/HDO 10	8 - 8 hours of normal operation. 6M - 6 months.

Figure 3-17. Lubrication Instructions for Hydraulic Reservoir (Sheet 1 of 2)

NOTES:

1. Service the filters each time the oil is changed. Remove the filter cover assembly, then remove the two filter elements. Clean the inside of the reservoir. Install new elements; reinstall the cover assembly.
2. A sample of the oil from the hydraulic tank shall be sent to an AOAP laboratory for analysis at 300-hour or 6-month intervals. Refer to TB 43-0210 for sampling requirements.
3. When AOAP laboratory support is not available, drain and refill the hydraulic tank at 1500 hours or 9 months.

Figure 3-17. Lubrication Instructions for Hydraulic Reservoir (Sheet 2 of 2)

LUBRICATION INSTRUCTIONS

WINCH, MODEL 800 DOW-LOK

NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

Intervals (on-condition or hard time) and the related man-hour times are based on normal operation. The man-hour time specified is the time you need to do all services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard time interval if your lubricants are contaminated or if you are operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The hard time interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard time intervals will be applied in the event AOAP laboratory support is not available.

Clean fittings before lubricating. Clean parts with dry cleaning solvent (SD), type 11 or equivalent. Dry before lubricating.

The lowest level of maintenance authorized to lubricate a point is indicated by one of the following symbols as appropriate: Operator/Crew (C) and Organizational Maintenance (0).

LUBRICANT - INTERVAL INTERVAL - LUBRICANT

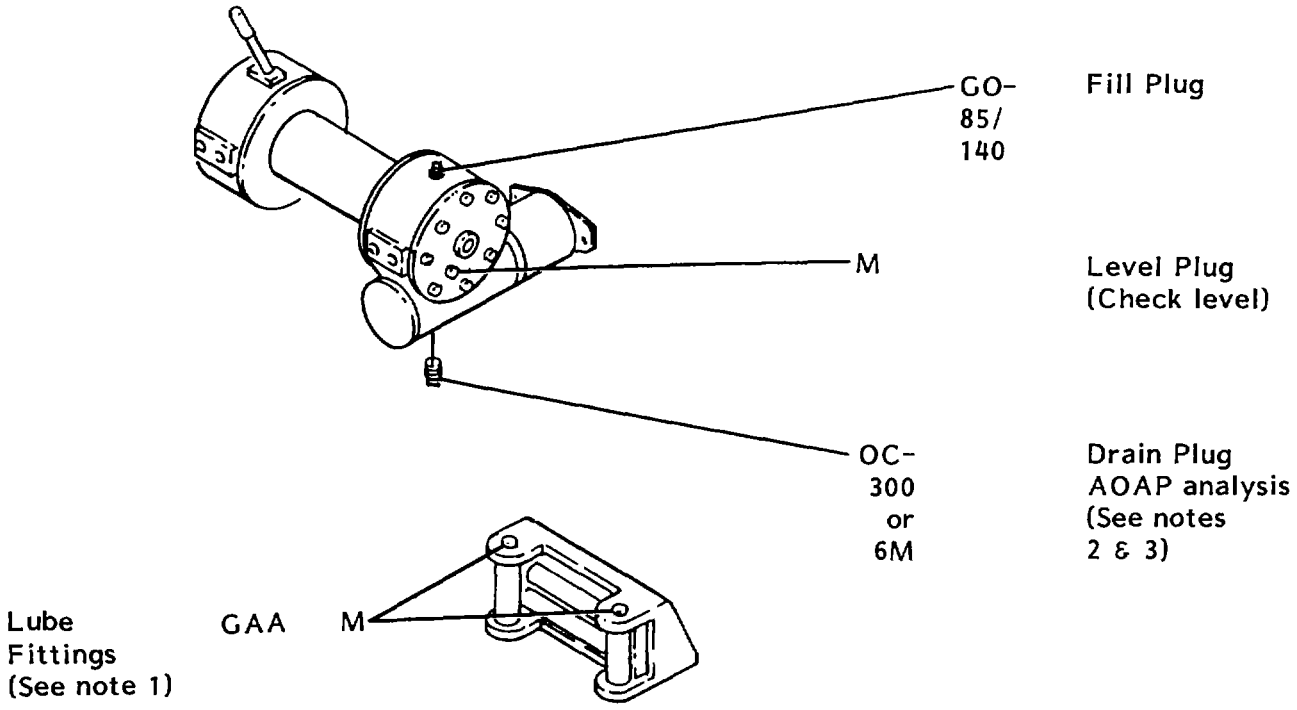


Figure 3-18. Lubrication Instructions for Winch (Sheet 1 of 2)

TOTAL MAN-HOURS

INTERVAL	MAN-HOURS	INTERVAL	MAN-HOURS
M	0.1	300 or 6M	0.5

KEY

LUBRICANTS		CAPACITIES	EXPECTED TEMPERATURES	INTERVAL
GAA (MIL-G-10924C)	Grease, auto-motive and artillery		ALL TEMPERATURES	M-Monthly 300-300 hours of normal operation
	Lubrication fittings	As required		
GO-85/140 (MIL-L 2105C)	Lubricating oil, gear multipurpose		SAE 140 EP	
	Gear Housing	3.75 pts (1.771)		

NOTES:

1. Apply one or two pumps of grease.
2. A sample of the oil from the winch housing shall be sent to an AOAP laboratory for analysis at 300-hour or 6-month intervals. Refer to TB 43-0210 for sampling requirements.
3. When AOAP Laboratory support is not available, drain and refill the gear housing at 1500 hours or 9 months

Figure 3-18. Lubrication Instructions for Winch (Sheet 2 of 2

Section III. DRILLING RIG TROUBLESHOOTING PROCEDURES

3-5. Mast. Troubleshooting procedures for the mast and mast components are listed in table 3-1.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the mast or its components. You should perform the tests/ inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-1. Troubleshooting the Mast

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	MUD PUMP DISCHARGE PIPING LEAKS.	Check for loose connections.	Tighten connections.
2.	MAST LIGHTS NOT LIT.	Check to see if mast lights switch is on.	Turn switch on.
3.	CHAIN PULLDOWN DOES NOT OPERATE.	Step 1. Check to see if pulldown power is on.	Set pulldown power control to ON position.
		Step 2. Check to see if pulldown transmission is engaged.	Move pulldown power control to OFF; move pulldown transmission lever to HIGH or LOW position, then return pulldown power control to ON.
		Step 3. Check to see if pulldown motor control is at fully counterclockwise position.	Rotate pulldown motor control clockwise.
4.	MAST RAISING CYLINDERS WILL NOT RAISE THE MAST.	Step 1. Check to see if mast control is in UP position.	Move mast control to UP position.
		Step 2. Check to see if truck transfer case power take-off is engaged.	Engage the truck transfer case power take-off.
5.	MAST RAISING CYLINDERS WILL NOT LOWER THE MAST.	Step 1. Check to see if mast locks are open.	Open the mast locks.
		Step 2. Check to see if mast control is in DOWN position.	Move mast control to DOWN position.

3-6. Mud Pump. Troubleshooting procedures for the mud pump are listed in table 3-2.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the mud pump or its components. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-2. Troubleshooting the Mud Pump

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	MUD PUMP DOES NOT START.	Step 1. Check to see if mud pump on/off switch is on.	Move mud pump switch to ON position.
		Step 2. Check to see if mud pump relay is tripped.	Press to reset relay switch.
		Step 3. Check to see if truck transfer case power take-off is engaged.	Engage truck transfer case power take-off.
2.	MUD PUMP DOES NOT DELIVER FLUID.	Step 1. Check to see if mud pump intake suction screen is submerged in slush storage pit.	Position and support suction screen properly in slush storage pit.
		Step 2. Check to see if mud pump intake suction screen is clogged.	Clean suction screen and re-install it in the slush storage pit.
		Step 3. Check to see if mud pump discharge piping valves are open.	Open mast hose connection shutoff valve and flow line shutoff valve.
		Step 4. Check for proper routing of mud pump discharge piping.	Connect discharge piping routing hose to mud pump discharge piping union.

3-7. Air Compressor Drive. Troubleshooting procedures for the air compressor drive are listed in table 3-3.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the air compressor or its components. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-3. Troubleshooting the Air Compressor Drive

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	AIR COMPRESSOR WILL NOT START.	Step 1. Check to see if air compressor power switch is on.	Move air compressor power switch to ON position.
		Step 2. Check to see if compressor relay switch is tripped.	Press to reset compressor relay switch.
		Step 3. Check to see if air line conditioner inlet valve is closed.	Turn inlet valve handwheel counterclockwise.
		Step 4. Check to see if air line conditioner outlet pressure indication or regulator dial is too low.	Turn regulator adjusting knob to increase pressure.
2.	AIR COMPRESSOR WILL NOT INCREASE PRESSURE ABOVE 55 PSIG.	Check to see if air compressor load switch is on.	Move air compressor load switch to ON position.
3.	AIR COMPRESSOR WILL NOT MAINTAIN DRILLING PRESSURE.	Check to see if engine speed is too low.	Set throttle to increase engine rpm.
4.	AIR COMPRESSOR PANEL DOES NOT OPERATE.	Check to see if panel on/off switch is on.	Move switch to ON position.

3-8. Drawworks. Troubleshooting procedures for the drawworks are listed in table 3-4.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the drawworks. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-4. Troubleshooting the Drawworks

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	WIRE ROPE WILL NOT SPOOL OFF HOIST DRUM.	Check to see if hoist drum clutch and brake are released.	Operate hoisting drum control and hoisting brake lever together to release clutch and brake. Do not allow suspended load to free-fall.
2.	HOIST DRUM BRAKE DOES NOT HOLD SUSPENDED LOAD.	Check to see if hoist drum brake is fully set.	Firmly grasp hoisting brake lever, squeeze ratchet release, pull hard on brake lever, let go of ratchet release, then let go of brake lever.
3.	HOIST DRUM DOES NOT HOIST SUSPENDED LOAD.	Step 1. Check to see if hoist drum brake is set too tightly. Step 2. Check to see if drawworks power is on.	Operate hoisting drum control and hoisting brake lever together to engage clutch and slip brake. Do not allow suspended load to free-fall. Move drawworks power control to ON position, then release it. Repeat step 1.
4.	WIRE ROPE WILL NOT SPOOL OFF AUXILIARY DRUM.	Check to see if auxiliary drum clutch and brake are released.	Operate auxiliary drum control and auxiliary brake lever together to release dutch and brake. Do not allow suspended load to free-fall.
5.	AUXILIARY DRUM BRAKE DOES NOT HOLD SUSPENDED LOAD.	Check to see if auxiliary drum brake is fully set.	Firmly grasp auxiliary brake lever, squeeze ratchet release, pull hard on brake lever, let go of ratchet release, then let go of brake lever.

Table 3-4. Troubleshooting the Drawworks (Continued)

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
6.	AUXILIARY DRUM DOES NOT HOIST SUSPENDED LOAD.	Step 1. Check to see if auxiliary drum brake is set too tightly. Step 2. Check to see if drawworks power is on.	Operate auxiliary drum control and auxiliary brake lever together to engage clutch and slip brake. Do not allow suspended load to free-fall. Move drawworks power control to ON position, then release it. Repeat step 1.
7.	WIRE ROPE WILL NOT SPOOL OFF THIRD DRUM.	Check to see if third drum clutch and brake are released.	Operate third drum clutch lever and brake lever together to release clutch and brake. Do not allow suspended load to free-fall.
8.	THIRD DRUM BRAKE DOES NOT HOLD SUSPENDED LOAD.	Check to see if third drum brake is set too tightly.	Firmly grasp third drum brake lever, squeeze ratchet release, pull hard on brake lever, let go of ratchet release, then let go of brake lever.
9.	THIRD DRUM DOES NOT HOIST SUSPENDED LOAD.	Step 1. Check to see if third drum brake is set too tightly. Step 2. Check to see if drawworks power is on.	Operate third drum clutch lever and brake lever together to engage clutch and slip brake. Do not allow suspended load to free-fall. Move drawworks power control to ON position, then release it. Repeat step 1.

3-9. Hydraulic System. Troubleshooting procedures for the hydraulic system are listed in table 3-5.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the hydraulic system. You should perform the tests/ inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-5. Troubleshooting the Hydraulic System

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1. HYDRAULIC PUMP NOT DELIVERING OIL.	Step 1. Check oil level in hydraulic tank.	Add oil as needed.
	Step 2. Check to see if hydraulic pump suction line is closed.	Stop truck engine, open valve, and restart engine.
	Step 3. Check for loose suction line connections.	Tighten loose connections.
2. HYDRAULIC PUMP DOES NOT DEVELOP NORMAL PRESSURE.	Check for leaks at hydraulic line connections.	Tighten loose connections.

3-10. Water and Foam Injection System. Troubleshooting procedures for the water and foam injection system are listed in table 3-6.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the water/foam injection system. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-6. Troubleshooting the Water and Foam Injection System

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1. WATER INJECTION PUMP DOES NOT DELIVER WATER.	Step 1. Check to see if water injection control is on.	Move water injection control to ON position.
	Step 2. Check water level in water tank.	Add water as necessary.
	Step 3. Check to see if water and foam injection isolation valve is open.	Open the valve.
	Step 4. Check to see if water injection pump drive belt is slipping or broken.	Report malfunction for correction by organizational maintenance.
2. FOAM PULSE PUMP DOES NOT DELIVER FOAM.	Step 1. Check to see if foam shutoff valve is open.	Open the valve.
	Step 2. Check to see if intake end of foam pulse pump suction tubing is inserted into foam chemical container.	Insert end of tubing through hole in lid of foam chemical container.
	Step 3. Check to see if container is empty.	Install a full container.

3-11. Force Feed Lubricator. Troubleshooting procedures for the force feed lubricator are listed in table 3-7.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the force feed lubricator. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-7. Troubleshooting the Force Feed Lubricator

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
FORCE FEED LUBRICATOR DOES NOT DELIVER OIL.	Step 1. Check to see if oiler switch is on.	Move oiler switch to ON position.
in force feed lubricator reservoir.	Step 2. Check oil level	Add oil as needed.

3-12. Break-out Assembly. Troubleshooting procedures for the break-out assembly are listed in table 3-8.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the break-out assembly. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-8. Troubleshooting the Break-Out Assembly

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
BREAK-OUT CYLINDER DOES NOT EXTEND OR RETRACT.	Step I. Check oil level in hydraulic oil reservoir.	Add oil as needed.
	Step 2. Check to see if hydraulic pump suction line valve is open.	Stop truck engine, open valve, and restart truck engine.
	Step 3. Check for loose suction line connections.	Tighten any loose connections.

3-13. Rotary Table Drive. Troubleshooting procedures for the rotary table drive are listed in table 3-9.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the rotary table drive. You should perform the tests/ inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-9. Troubleshooting the Rotary Table Drive

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	ROTARY TABLE DOES NOT ROTATE.	Step 1. Check to see if rotary table transmission is in gear.	Move rotary table control lever to center position, move rotary table gear range selector lever from neutral to gear range 1, 2, 3, or 4.
		Step 2. Check to see if rotary table control lever is in an operating position.	Move rotary table control lever from center position into an operating range for desired direction of rotation.
		Step 3. Check oil level in hydraulic oil tank.	Add oil as needed.
		Step 4. Check to see if hydraulic pump suction line valve is closed.	Stop truck engine, open valve, and restart truck engine.
		Step 5. Check for loose hydraulic pump suction line connections.	Tighten loose connections.
		Step 6. Check to see if truck transfer case power take-off is engaged.	Engage power take-off.
2.	ROTARY TABLE STALLS.	Step 1. If using pulldown, check to see if too much pulldown pressure is being used.	Move pulldown power control to OFF position. If rotary table restarts, continue drilling without pulldown or decrease pulldown pressure by rotating pulldown motor control counter-clockwise.
		Step 2. If not using the pulldown, check to see if enough, holdback pressure is being used.	Rotate holdback control clock-wise. If rotary table restarts, continue drilling.

3-14. Air Control Assembly. Troubleshooting procedures for the air control assembly are listed in table 3-10.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the air control assembly. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-10. Troubleshooting the Air Control Assembly

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
AIR OPERATED CONTROLS DO NOT RESPOND TO HANDLE MOVEMENTS.	Step 1. Check to see if air line conditioner inlet valve is closed.	Turn inlet valve handwheel counterclockwise.
	Step 2. Check to see if air line conditioner outlet pressure indication on regulator dial is too low.	Turn regulator adjusting knob to increase pressure.

3-15. Hydraulic Jacks. Troubleshooting procedures for the hydraulic jacks are listed in table 3-11.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the hydraulic jacks. You should perform the tests/ inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-11. Troubleshooting the Hydraulic Jacks.

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
HYDRAULIC JACK DOES NOT OPERATE.	Step 1. Check to see if truck transfer case power take-off is engaged.	Engage the truck transfer case power take-off.
	Step 2. Check to see if the hydraulic pump suction line valve is closed.	Stop truck engine, open valve, and restart truck engine.

3-16. Subdrive. The subdrive assembly transmits power from the truck to other rig components. Troubleshooting procedures for subdrive malfunctions are listed in the tables for the components that receive power through the subdrive.

3-17. Chain Feed Drive. See malfunction 3 of table 3-1.

3-18. Driller's Platform. The driller's platforms are not subject to operating malfunctions.

3-19. Drill Frame. Drill frame malfunctions are beyond the troubleshooting capabilities of the operator.

3-20. Drive Shafts and U-joints. Drive shafts and U-joint malfunctions are beyond the troubleshooting capabilities of the operator.

3-21. Troubleshooting Logging Equipment.

a. Set-up Test Set. A test set is provided so that you can check the instrument's operation independent of the cable assembly. If the instrument reads the correct value for the test set, then the instrument itself is functioning properly and the trouble is somewhere other than in the instrument's electronics. To sue the test set, plug it into the instrument as described in 2-31, d. Then follow the operating instructions in paragraph 2-32, b. The electrode selector must be in one of the NORMAL logging posit ions.

b. Checking Batteries. With the test set plugged into the instrument, turn the function switch to the CAL position and try to calibrate the instrument:

(1) If the instrument can be calibrated, then turn the function switch to CUR and check the current by throwing the current switch; if the current flowing is less than 8 mA (full scale on meter is 25 mA), then the complete set of six 9-volt batteries should be replaced (refer to figure 2-42).

(2) If the instrument cannot be calibrated, the complete set of six 9-volt batteries should be replaced.

NOTE

Refer to battery voltage checking procedure to check the batteries with a voltmeter.

c. Troubleshooting. The following are commonly encountered troubles and the procedures to correct the problems.

Table 3-11. Troubleshooting the Logging Instrument

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	UNABLE TO CALIBRATE INSTRUMENT.	Step 1. Check for low or no current.	If batteries low, replace. Make sure lines and plugs are properly connected.
		Step 2. Test for high resistance at the steel surface of current electrode.	If galvanometer shows less than 9 mA, and it cannot be increased by rotating cal adjust knob, then reduce resistance by driving the stake in deeper, or pour water around it, or by double staking. If 8 mA cannot be obtained, a situation not uncommon in thick dry sand or where the ground is frost-covered, use the LATERAL arrangement with CUR connected to the well casing.

Table 3-11. Troubleshooting the Logging Instrument (Cont'd.).

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
2.	FLUCTUATING "SP"; GALVANOMETER NEEDLE WILL NOT STEADY.	Step 1. Check for poor or bad connection in lead-oxide flag wire.	Repair or replace broken, frayed, or damaged wires.
		Step 2. Check that flag is properly buried.	Bury flag in moist soil; tamp down soil firmly.
		Step 3. Stray ground potential.	Use LATERAL arrangement of electrodes.
3.	CANNOT ZERO METER WITH SP POTENTIOMETER.	Step 1. Check for proper polarity.	Try reversing the SP polarity switch. NOTE SP polarity may change during logging.
		Step 2. Check for low battery.	Check 1-1/2 volt "C" battery; replace if necessary.
4.	NO METER RESPONSE TO SP POTENTIOMETER.	Step 1. Check for bad connections.	Re-insert connections and surface lines, particularly the potential surface line connected to lead flag.
		Step 2. Check SP shut-off switch is not stuck in OFF position.	Push the button up and down a couple times to release the switch.
5.	METER DEFLECTION WITH NO CONNECTION.	Check for moisture affecting current switch.	Apply a source of warm, dry air to the switch. If this happens frequently, install a rubber boot on the switch. NOTE If this condition exists although the test set indicates proper calibration, the instrument may function properly when current switch is activated.

d. Battery Voltage Check.

NOTE

Make the following checks with the test set connected. Also, a voltmeter is needed to make the tests. If batteries need to be replaced, any 9-volt transistor radio battery will work satisfactorily.

(1) Single 9-volt battery. Set the voltmeter function switch to +DC volts and the range switch at full scale reading closest to, but not lower than 10 volts. Connect the red (+) lead to the battery positive terminal and the black (-) lead to the battery negative terminal. Record the voltmeter reading. Place the function switch in CUR or CAL mode, energize the current switch, and record the battery voltage under load. The voltage should remain at or slightly below the open circuit load. If the voltage continues to drop with the current switch energized, the battery is weak and should be replaced.

(2) Five 9-volt batteries. Set the voltmeter function switch at +DC and the range switch at full scale reading closest to, but not lower than 50 volts. Connect the red (+) lead to an exposed battery positive terminal and the black (-) lead to an exposed battery negative terminal of the battery string. Record the voltmeter reading. Place the instruments function switch to CUR or CAL mode, energize the current switch, and record the battery voltage under load. The voltage should remain at or slightly below the open circuit load. If the voltage continues the drop with the current switch energized, the batteries are weak and all five should be replaced.

3-22 Troubleshooting the Pump. The following paragraphs describe some of the possible troubles that may be encountered. Tables 3-12 and 3-1 5 describe some possible malfunctions that may occur to cause those problems, with the checks and tests that must be made, and the action needed to correct the condition.

Table 3-12. Fuses Blow when Motor Starts

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	INCORRECT SUPPLY VOLTAGE.	Using a voltmeter, check the line terminals. Voltage must be within plus or minus 10% of nominal.	If voltage is not correct, contact Direct Support Maintenance.
2.	INCORRECT FUSES.	Check fuses for recommended sizes; also, check for loose, dirty, or corroded connections in the fuse receptacle.	Replace with proper fuses; clean any dirt or corrosion from connections.
3.	DEFECTIVE PRESSURE SWITCH	Check voltage at contact points. Improper contact of switch points can cause voltage less than line voltage.	Contact Direct Support Maintenance.

Table 3-12. Fuses Blow when Motor Starts (Cont'd.)

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
4. CONTROL BOX MALFUNCTION	CAUTION Make the following checks with power shut off to the control box.	
	Step 1. Check wiring against diagram in control box. Check for loose connections. Control box and motor must be within same voltage specifications.	Contact Direct Support Maintenance.
	Step 2. Check for defective relay. Check relay coil with an ohmmeter. No movement of needle (if capacitor is good), indicates defective relay point contact.	Contact Direct Support Maintenance.
	Step 3. Check for defective capacitor. Check resistance across capacitor terminals with an ohmmeter. The meter needle should jump at first, then fall back as the capacitor charges.	Contact Direct Support Maintenance.
5. PUMP IS BOUND.	Use an ammeter to help determine the problem. Amp readings 3 to 6 times higher than normal indicate the pump may be bound. Locked rotor conditions can result from misalignment between pump and motor caused by being wedged in a crooked well or by rough handling at installation. Binding can also result from the rotor being locked up by sand.	A sand-bound pump may be corrected by reversing the pump motor's red and black leads in the control box. This reverses the pump's rotation, dispelling the sand. If the pump does not rotate freely, it must be pulled from the hole and cleaned or realigned and/or the well condition corrected.
6. DEFECTIVE CABLE OR MOTOR WINDING.	Attach one ohmmeter lead to the drop pipe or well casing and touch the other lead	The pump must be pulled and the cable disconnected and inspected. Damaged cable should be correctly spliced or replaced. If the

Table 3-12. Fuses Blow when Motor Starts (Cont'd.)

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
6	DEFECTIVE CABLE OR MOTOR WINDING CONT'D.	to each motor lead. If the needle moves a lot, a ground is indicated in either the motor or the drop cable.	cable is good, the motor winding is grounded; then contact direct support maintenance.
7.	SHORTED OR OPEN MOTOR WINDING.	Disconnect the motor leads from the control box; note length and size of drop cable, then use an ohmmeter to check resistance. Low (or no) resistance will indicate a shorted motor winding. High resistance (no or very little needle movement) can mean an open circuit in winding or broken, but not exposed, lead cable conductor.	Pull the pump and repair or replace the motor or drop cable.

Table 3-13. Pump Runs, But Delivers Little or No Water.

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	PUMP IS AIR LOCKED.	Listen for pump running but no water noise is detected.	Start and stop pump at one minute intervals. Normal delivery may resume
2.	LOW WATER LEVEL IN WELL.	Water delivery is good at start up, but delivery diminishes after a time. Pump capacity is greater than well's ability to produce. Pump may be set in sand.	Throttle the pumps delivery through a restricting valve. Lower the pump setting if depth of well is adequate.
3.	PUMP ROTATING IN WRONG DIRECTION.	Low water delivery or low pressure may indicate the pump is operating in the wrong direction.	Correct pump (motor) rotation by properly connecting the drop cable wires.
4.	CHECK VALVE STUCK OR IMPROPERLY INSTALLED.	Step 1. If no water is being delivered, valve is installed against the flow.	Valve must be removed.
		Step 2. If drop pipe is screwed into the check valve too deep, it may be jamming the valve in the closed position.	Cut off a portion of the drop pipe threads.

Table 3-13. Pump Runs, But Delivers Little or No Water (Cont'd.)

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
5.	LEAK IN THE DROP PIPE.	Although water is being supplied to tank, the pump may not deliver enough pressure to shut off the system; the "ON" portion of the cycle increases.	Raise pipe; check for leak; replace any damaged pipe.
6.	PUMP SCREEN BLOCKED.	Restricted flow may indicate a clogged intake screen on the pump. Pump may be installed in the mud or sand.	Clean screen and reset at a lesser depth. It may be necessary to bail out sand and mud in the well.
7.	PUMP WORN OUT.	Check for symptoms similar to those of a leak in the drop pipe or low water level in the well; check for sand in tank. Reduce the pressure switch setting; if pump shuts off, parts maybe worn.	Contact direct support maintenance.
8.	LOOSE OR BRO KEN MOTOR SHAFT.	No water is delivered if coupling between motor and pump shaft is loose or if a jammed pump has caused the motor shaft to sheer off.	Check for damaged shafts if coupling is loose and replace worn or defective units.

Table 3-14. Pump Continues Running; Will not Cycle.

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	PRESSURE SWITCH.	Switch points may be "welded" in closed position.	Contact direct support maintenance.
2.	LOW WATER LEVEL IN THE WELL.	Pump's capacity may exceed well's capacity to produce water; shut off the pump and allow the well to recover ample water level. Check static level from the well head.	Throttle the pump output or reset the pump to a lower level. Do not lower if sand may clog the pump.
3.	LEAK IN THE SYSTEM.	Check pipe for leaks.	Contact unit level maintenance.

Table 3-14. Pump Continues Running; Will not Cycle (Cont'd.)

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
4.	WORN PUMP.	Abrasives in water indicate the pump may be wearing. Reduce pressure setting of switch until pump shuts off. If pressure is insufficient, unit must be replaced.	Contact direct support maintenance.

Table 3-15. Pump Starts Too Often.

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	DEFECTIVE PRESSURE SWITCH.	Check the setting on the pressure switch and examine for defects.	Contact direct support maintenance.
2.	LEAK IN THE SYSTEM.	Tank or delivery lines may be leaking air above water level.	Contact unit level maintenance.
3.	DEFECTIVE CHECK VALVE.	Damaged or defective check valve will not hold pressure.	Contact unit level maintenance.
4.	AIR SUPPLY (WATERLOGGED TANK).	Check air volume control or shifter valve for improper operation.	Contact unit level maintenance.

Section IV. RIG TENDER TROUBLESHOOTING PROCEDURES

3-23. Crane. Troubleshooting procedures for the crane and crane components are listed in table 3-16.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the crane or its components. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-16. Troubleshooting the Crane

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	UNIT WILL NOT OPERATE.	Step 1. Check to see if truck power take-off is engaged.	Engage truck power take-off.
		Step 2. Check that crane control power switch in cab is turned on.	Turn switch on.
		Step 3. Check to see if fluid level in hydraulic reservoir is low.	Add fluid as needed.
2.	WINCH WILL NOT PICK UP A LOAD.	Step 1. Check that loads weight is lower than cranes capacity.	Lighten the load, raise boom angle, retract boom extension, or rig a 2-part line.
		Step 2. Check to see if truck engine is running at the correct speed for pump operation.	Increase engine speed.
		Step 3. Check to see if fluid level in hydraulic reservoir is low.	Add fluid as needed.
3.	BOOM MOVEMENT IS SLOW	Step 1. Check to see if truck engine is running at the correct speed for pump operation.	Increase engine speed.
		Step 2. Check to see if fluid level in hydraulic reservoir is low.	Add fluid as needed.
4.	BOOM MOVEMENT IS ERRATIC.	Check to see if fluid level in hydraulic reservoir is low.	Add fluid as needed.
5.	RELIEF VALVE IS NOISY.	Step 1. Check that loads weight is lower than cranes capacity.	Lighten the load.

3-24. Welder/Generator. Troubleshooting procedures for the welder and generator are listed in table 3-17.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the welder/generator. You should perform the tests/ inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-17. Troubleshooting the Welder/Generator

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	ENGINE WILL NOT START.	Step 1. Check to see if fuel tank is empty.	Fill fuel tank with diesel fuel.
		Step 2. Check to see if battery cable terminals are loose.	Tighten terminals.
		Step 3. Check to see if battery cable terminals are corroded.	Disconnect terminals; clean both terminals and battery terminal posts; reconnect terminals.
		Step 4. Check for low battery voltage by noting whether engine cranks slower than usual.	Recharge battery or replace.
2.	NO POWER OUTPUT AT POWER RECEPTACLE.	Check to see if switch S1 is in POWER position.	Place power switch S1 in POWER position.
3.	LOW POWER OUTPUT AT POWER RECEPTACLES.	Check to see if FIN AMPERAGE control R1 is set too low.	Rotate R1 to 100.
4.	LOW WELD OUTPUT.	Check engine speed; if less than 3000 rpm, check for dirty air cleaner.	Clean or replace air cleaner.
5.	ERRATIC WELD OUTPUT.	Step 1. Check for damp electrodes or wrong type of electrodes.	Use different electrodes.
		Step 2. Check for loose connection to work piece.	Tighten connections.

3-25. Night Lighting. Troubleshooting procedures for the night lighting are listed in table 3-18.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the night lighting. You should perform the tests/ inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-18. Troubleshooting the Night Lighting

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
LAMP WILL NOT LIGHT.	Step 1. Check to see if floodlight switch in truck cab is in ON position.	Move switch to ON position.
	Step 2. Check to see if socket has become disconnected from lamp.	Reconnect socket to lamp.
	Step 3. Exchange lamp to see if it is burned out.	Replace burned out lamp.

3-26. Fuel Transfer Pump. Troubleshooting procedures for the fuel transfer pump are listed in table 3-19.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the fuel transfer pump. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-19. Troubleshooting the Fuel Transfer Pump

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1. PUMP MOTOR WILL NOT START.	Step 1. Check to see if cab-mounted pump switch is on.	Turn switch on.
	Step 2. Check to see if pump-mounted pump switch is on.	Turn switch on.
2. PUMP RUNS BUT DOES NOT DELIVER FUEL.	Step 1. Check to see if the fuel tank is empty.	Fill the fuel tank.
	Step 2. Check to see if fuel tank vent is obstructed.	Clean fuel tank vent.

3-27. Water Heater. Troubleshooting procedures for the water heater are listed in table 3-20.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the water heater. You should perform the tests/ inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-20. Troubleshooting the Water Heater

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1. TORCH WILL NOT LIGHT.	Step 1. Check for slight gas flow at outlet of torch mixer by placing hand at outlet.	If no gas flow, open torch control valve a very small amount to allow a slight gas flow. Repeat attempt to light torch.
	Step 2. Check to see if propane tank control valve is open.	Turn valve counterclockwise to open.
	Step 3. Check for gas flow that is too strong at outlet of torch mixer by placing hand at outlet. (Strong flow will blow out flame of lighting device.)	Close torch control valve. Re-open it a very small amount to allow a slight gas flow, and repeat attempt to light torch.
	Step 4. Check to see if propane tank is empty.	Replace propane tank with one that is not empty.
2. TORCH FLAME GOES OUT AFTER WORKING PROPERLY.	Check to see if propane tank is empty.	Replace propane tank with one that is not empty.

3-28. Water Pump. Troubleshooting procedures for the water pump are listed in table 3-21.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the water pump. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-21. Troubleshooting the Water Pump

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	PUMP MOTOR WILL NOT RUN.	Step 1. Check to see if truck power take-off is engaged.	Engage power take-off.
		Step 2. Check to see if fluid level in hydraulic reservoir is low.	Add fluid to hydraulic tank.
2.	PUMP RUNS BUT DOES NOT DELIVER WATER.	Step 1. Check to see if suction hose inlet is in water.	Place suction hose inlet in water.
		Step 2. If using a suction inlet strainer, check to see if strainer is obstructed.	Clean strainer.
		Step 3. Check to see if suction line connections are tight.	Tighten connections.

3-29. Winch. Troubleshooting procedures for the winch are listed in table 3-22.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the winch. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-22. Troubleshooting the Winch

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	WINCH WILL NOT UNWIND.	Step 1. Check to see if winch clutch handle is set to POWER WIND position.	Set clutch handle to POWER WIND position.
		Step 2. Check to see if winch control in truck cab is set to UNWIND position.	Set winch control to UN-WIND position.
		Step 3. Check to see if truck power take-off/hydraulic system is engaged.	Engage power take-off/hydraulic system.
		Step 4. Check to see if fluid level in hydraulic reservoir is low.	Add fluid to hydraulic reservoir.
2.	WINCH WILL NOT WIND. to POWER	Step 1. Check to see if winch clutch handle is set WIND position.	Set clutch handle to POWER WIND position.
		Step 2. Check to see if winch control in truck cab is set to WIND position.	Set winch control to WIND position.
		Step 3. Check to see if truck power take-off/hydraulic system is engaged.	Engage power take-off/hydraulic system.
		Step 4. Check to see if fluid level in hydraulic reservoir is low.	Add fluid to hydraulic reservoir.

3-30. Power Take-Off/Hydraulic System. Troubleshooting procedures for the power take-off/hydraulic system are listed in table 3-23.

a. The table lists the common malfunctions that you may find during the operation or maintenance of the power take-off/hydraulic system. You should perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests/inspections and corrective actions. If a malfunction is not listed or is not corrected by listed corrective action, notify your supervisor.

Table 3-23. Troubleshooting the Power Take-off/Hydraulic System

	MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1.	POWER TAKE-OFF/ HYDRAULIC SYS-TEM DOES NOT OPERATE.	Check to see if power take-off is engaged.	Engage power take-off.
2.	PTO HYDRAULIC PUMP RUNS BUT HYDRAULIC SYS-TEM DOES NOT OPERATE.	Check to see if fluid level in hydraulic reservoir is low.	Add hydraulic fluid to reser-voir.

Section V. MAINTENANCE PROCEDURES

3-31. Preventive Maintenance. Perform preventive maintenance checks and services as described in Chapter 2.

3-32. Corrective Maintenance. Report all corrective maintenance requirements to your supervisor. Corrective maintenance should be performed by organizational maintenance or a higher level maintenance activity as authorized by the Maintenance Allocation Chart (MAC).

3-33. Maintenance of Logging Equipment.

a. Introduction. It is very important that you keep all plugs and panel connections clean and dry. Moisture on connections can cause current leakage and result in improper equipment operation, and therefore, inaccurate formation readings. Also, keep the cable and reel case clean; as you remove the cable from the hole, wipe it clean before its wound onto the reel case. Do not allow water or mud to accumulate in the reel case.

b. Maintaining the Resistively Instrument.

(1) Keep the unit clean and replace the batteries when testing indicates the batteries are weak. Access the battery box by lifting the front panel of the instrument. (See figure 2-42).

(2) While operating the unit, take care that the Ohmmeter and Self-Potential Potentiometer indicators do not slam against their zero stops. When the adjust knobs are turned all the way counterclockwise, the indicators should be exactly at zero. If they are not, use the small hex wrench (provided with unit) to loosen the two set screws on the knob (located 90 degrees apart) and reset the knob to zero.

c. Maintaining the Cable and Reel. When handling the cable, take care you do not damage the insulation. Always wipe the cable clean before storing.

APPENDIX A
REFERENCES

A-1. SCOPE

This appendix lists all forms, field manuals, technical manuals and miscellaneous publications references in this manual

A-2. FORMS

Equipment Inspection and Maintenance Work Sheet	DA Form 2404
Quality Deficiency Report	SF 368
Recommended Changes to DA Publications	DA Form 2028

A-3. FIELD MANUALS

Drilling Operations	FM 5-166
First Aid	FM 21-11

A-4. TECHNICAL MANUALS

Unit Directs Support and General Support Maintenance Manual For Drilling System, Well, Rotary, Truck Mounted, Air Transportable, 600 Feet Capacity	TM5-3820-256-24
Operator's, Organizational, DS, and GS Maintenance Manual For Storage Batteries, Lead-Acid Type	TM9-6140-200-14
Repair Parts and Special Tools List Manual For Drilling System, Well, Rotary, Truck Mounted, Air Transportable, 600 Feet Capacity	TM5-3820-256-24P

A-5. DEPARTMENT OF THE ARMY PAMPHLETS

The Army Maintenance Management System (TAMMS)	DA PAM 738-750

APPENDIX B
COMPONENTS OF END ITEM AND BASIC ISSUE ITEMS LISTS

SECTION 1. INTRODUCTION

B-1. SCOPE

This appendix lists components of end item and basic issue items for the Well Drilling System to help you inventory items required for safe and efficient operation.

B-2 GENERAL

The Components of End Item and Basic Issue Items Lists are divided into the following sections:

a. Section II. Components of End Item. This listing is for informational purposes only, and is not anuthority to requisition replacements. These items are part of the end item, but are removed and separately packaged for transportation or shipment. As part of the end item, these items must be with the end item whenever it is issued or transferred between property accounts. Illustrations are furnished to assist you in identifying the items.

b. Section III. Basic Issue Items. These are the minimum essential items required to place the Well Drilling System in operation, and to perform emergency repairs. Although shipped separately packaged, Bll must be with the Well Drilling System during operation and whenever it is transferred between property accounts. The illustrations will assist you with hard-to-identify items. This manual is your authority to request/requisition replacement BII, based on TOE/MTOE authorization of the end item.

B-3. EXPLANATION OF COLUMNS

The following provides an explanation of columns found in the tabular listings:

a. Column (1)- Illustration Number (Illus Number). This column indicates the number of the illustration in which the item is shown.

b. Column (2)- National Stock Number. Indicates the National stock number assigned to the item and will be used for requisitioning purposes.

c. Column (3)- Description. Indicates the Federal item name and, if required, a minimum description to identify and locate the item. The last line for each item indicates the FSCM (in parentheses) followed by the part number.

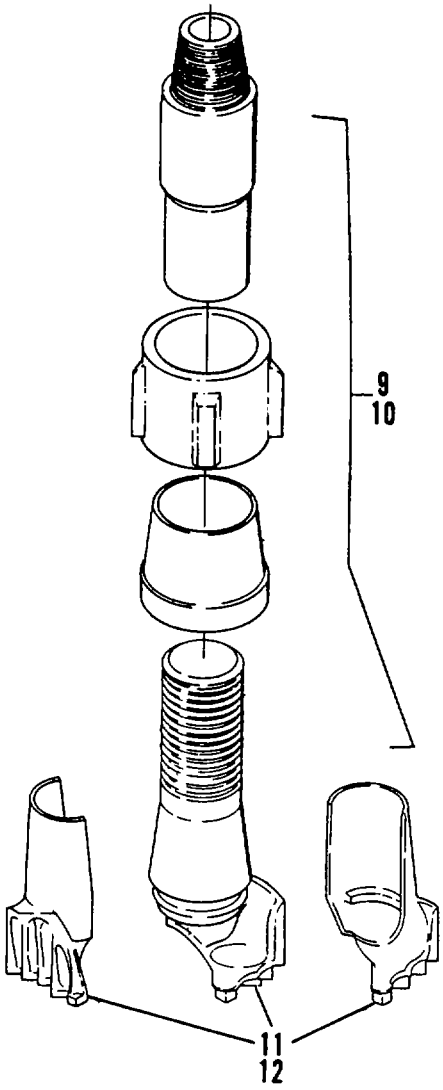
d. Column (4) - Unit of Measure (U/M). Indicates the measure used in performing the actual operational/maintenance function. This measure is expressed by a two-character alphabetical abbreviation (e.g., ea, in, pr).

e. Column (5) - Quantity required (Qty rqr). Indicates the quantity of the item authorized to be used with/on the equipment.

Section II. COMPONENTS OF END ITEM

(1) ILLUS NUMBER	(2) NATO STOCK NUMBER	(3) DESCRIPTION (FSCM) and Part Number	Usable On Code	(4) U/M	(5) QTY Rqr
1		BAILER, DART VALVE (21363) 149F917		EA	1
2		BIT, DRILL, HAMMER (40983) 16237-64A		EA	6
3		BIT, DRILL, ROCK, HARD, 6-INCH (22023) VH1-6		EA	2
4		BIT, DRILL, ROCK, HARD, 12-INCH (22023) V H 1-12-1/4		EA	2
5		BIT, DRILL, ROCK, MED.HARD, 6-INCH (22023) V1-6		EA	2
6		BIT, DRILL, ROCK, MED. HARD, 12-INCH (22023) V1-12-1/4		EA	2
7		BIT, DRILL, ROCK, MED. SOFT, 6-INCH (22023) V2-6		EA	2
8		BIT, DRILL, ROCK, MED. SOFT, 12-INCH (22023) V2-12-1/4		EA	2

(1) Illus Number	(2) National Stock Number	(3) Description (FSCM) and Part Number	Usable On Code	(4) U/M	(5) Qty rqr
9		BIT, INSERT, 6-INCH (21363) 149F913		EA	1
10		BIT, INSERT, 12-INCH (21363) 149F914		EA	1
11		BLADE KIT, DRILL BIT, 6-INCH (21363) 153F726		EA	1
12		BLADE KIT, DRILL BIT, 12-INCH (21363) 154F034		EA	1
13		COLLAR, DRILL (21363) 148F931		EA	2
14		DESANDER UNIT (20064) 188-102		EA	1
15		DRILLPIPE, 4 1/2" X 20' (21363) 165F058		EA	30
16		DRILLPIPE, 4112- X 5- (21363) 165F059		EA	3
17		FORK, BREAKOUT, 3-3/4, (21363) 100F266		EA	1
18		FORK, BREAKOUT, 3-7/8" (21363) 165F252		EA	1
19		GRINDER, BIT (21363)165F209		EA	1
20		HAMMER, PERCUSSION (40983) SD6-LV/4		EA	1
21		HOPPER, MUD MIXING (21363) D-2346-C		EA	1
22		LABORATORY, MUD TESTING (20064) 821		EA	1
22A	4240-00-311-6139	LANYARD, SAFETY BELT, 6-FOOT (75347) 5489N-6		EA	1
22B		LIFE-LINE, SELF-RETRACTABLE (55297) DBU15		EA	1
23		LOGGER, ELECTRIC (21363) 149F923		EA	1
24		OVERSHOT, ROTARY (21363) C-212-F		EA	1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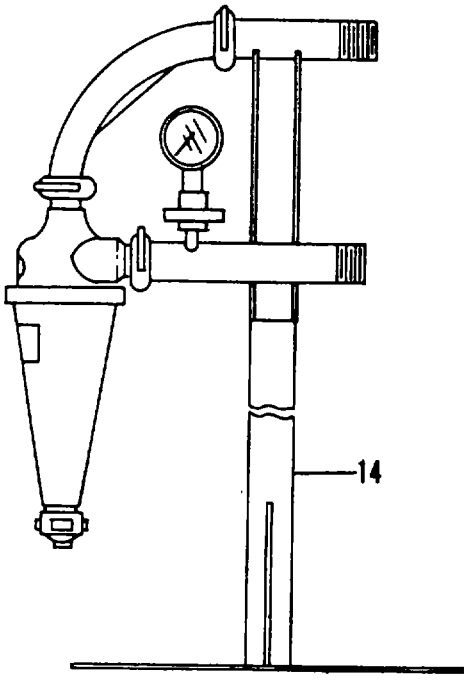
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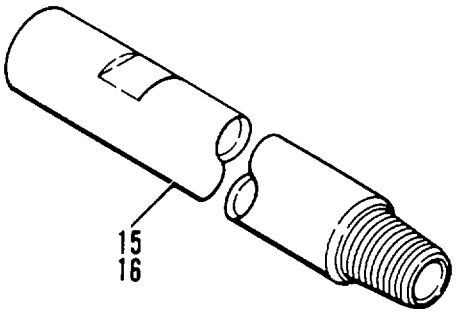
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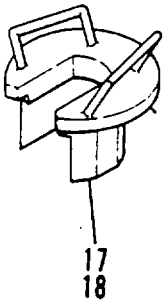
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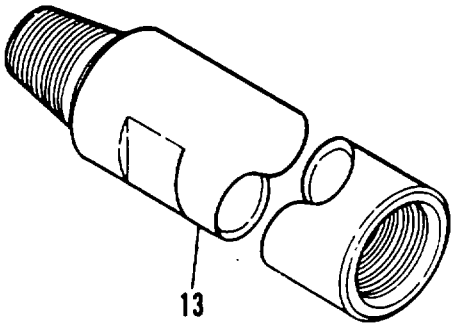
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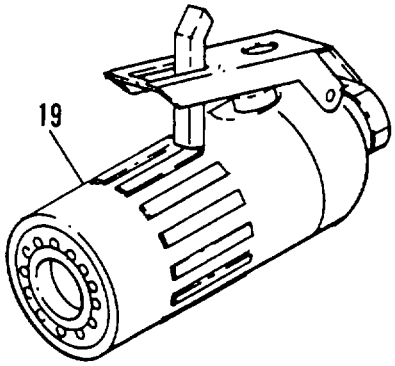
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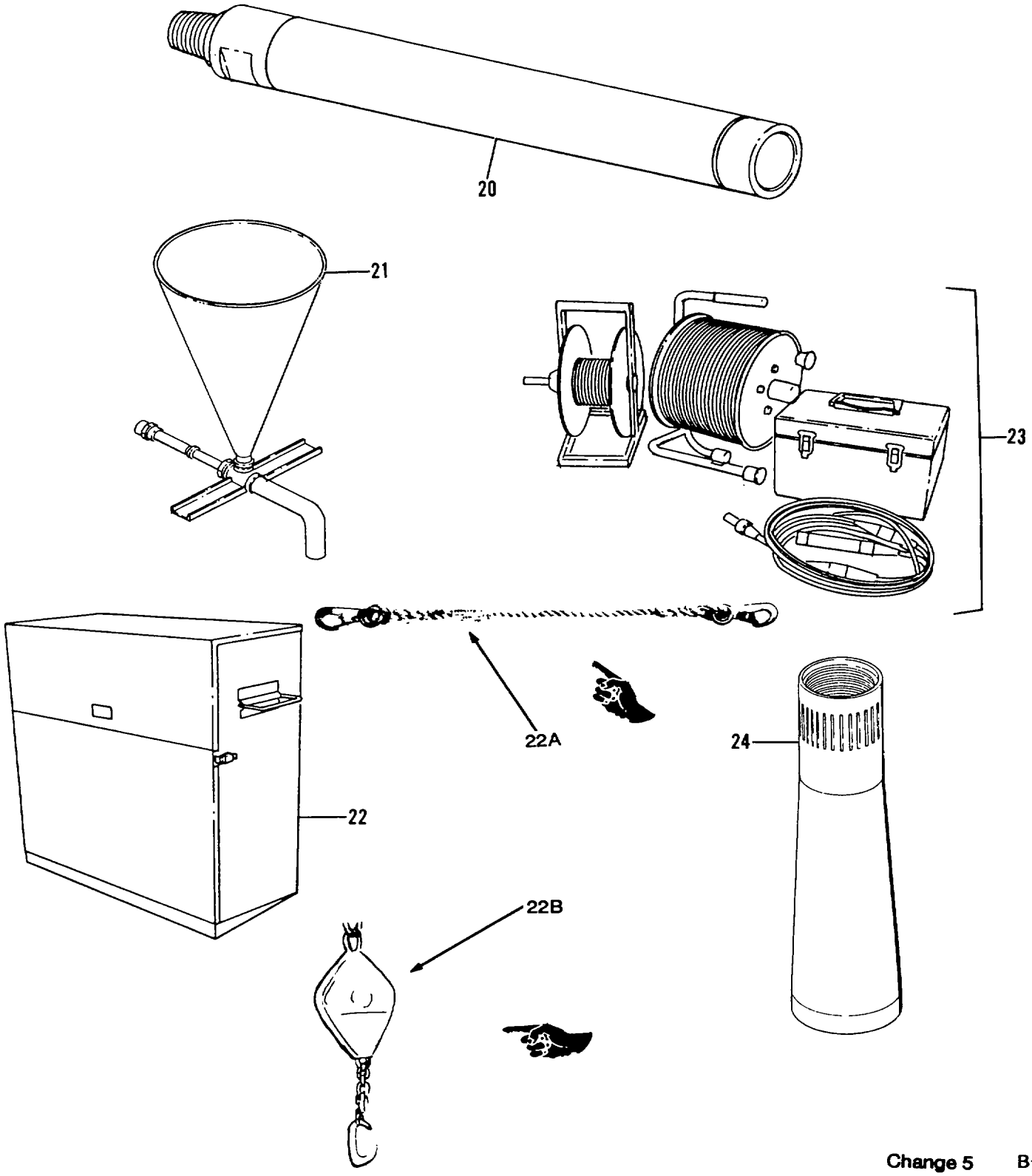

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(1) Illus Number	(2) National Stock Number	(3) Description (FSCM) and Part Number	Usable On Code	(4) U/M	(5) Qty rqr
25		PIT, PRIMARY MUD (21363) 165F223		EA	1
26		PIT, SECONDARY MUD (21363) 165F224		EA	1
27		PLATE, BREAKOUT, BIT (21363) 148F170		EA	1
28		PLATE, BREAKOUT, BIT (21363) 165F245		EA	1
29		PLATE, BREAKOUT, BIT (21363) 163F658		EA	1
30		PLUG, HOISTING (21363) H-175-B		EA	1
31		PLUG, HOISTING (21363) 166F680		EA	1
32		SOUNDER, WELL (21363) 149F924		EA	1
33		STABILIZER (21363) 165F066		EA	1
34		STRAINER, SUCTION (21363) D-1345-D		EA	1
35		SUB (21363) S-627-C		EA	1
36		SUB (21363) S-652-B		EA	1
37		SUB (21363) S-658-B		EA	1
38		SUB (21363) S-664-B		EA	1
39		SUB (21363) S-675-B		EA	1
40		SUB, BIT BREAKOUT (21363) 165F250		EA	1

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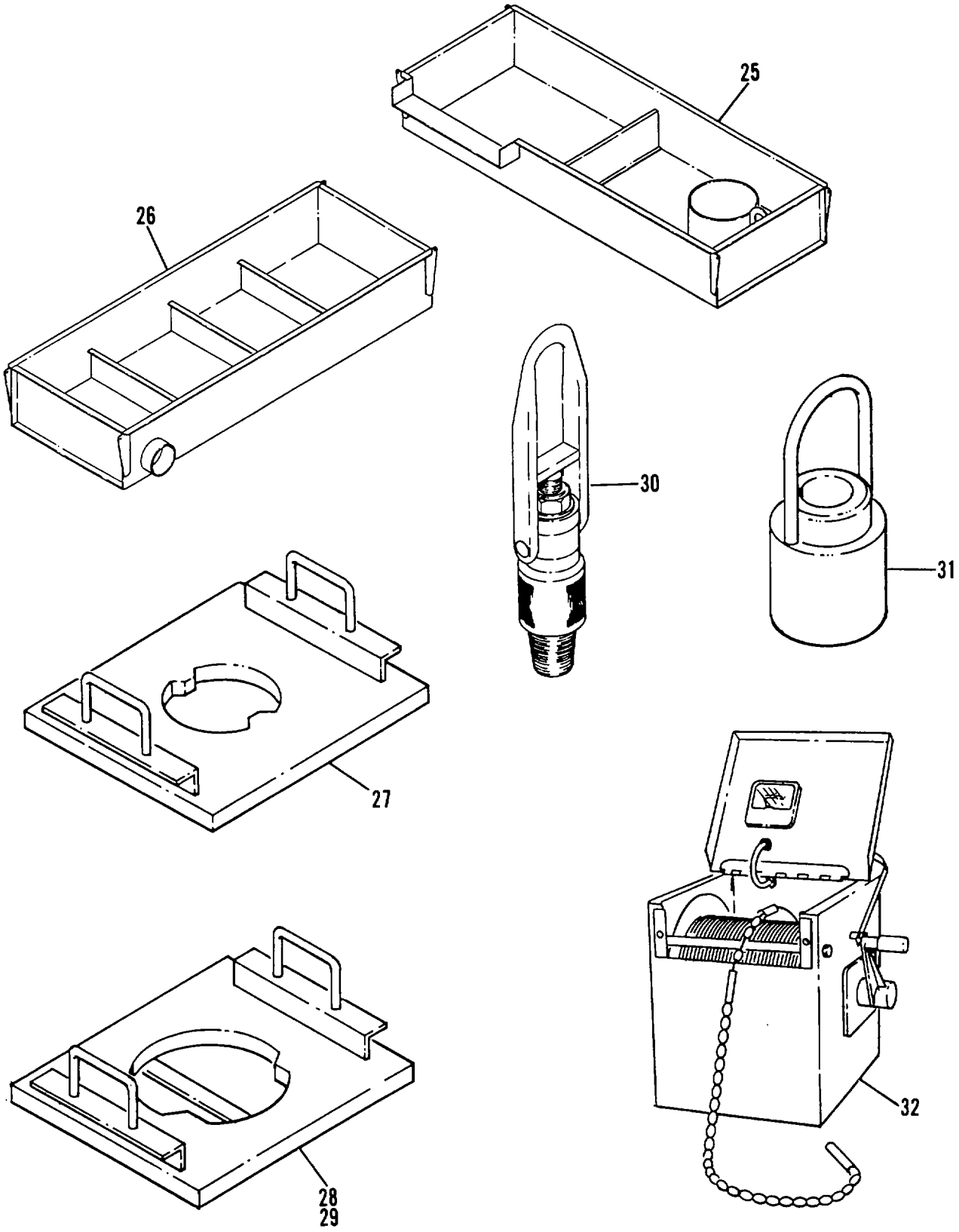
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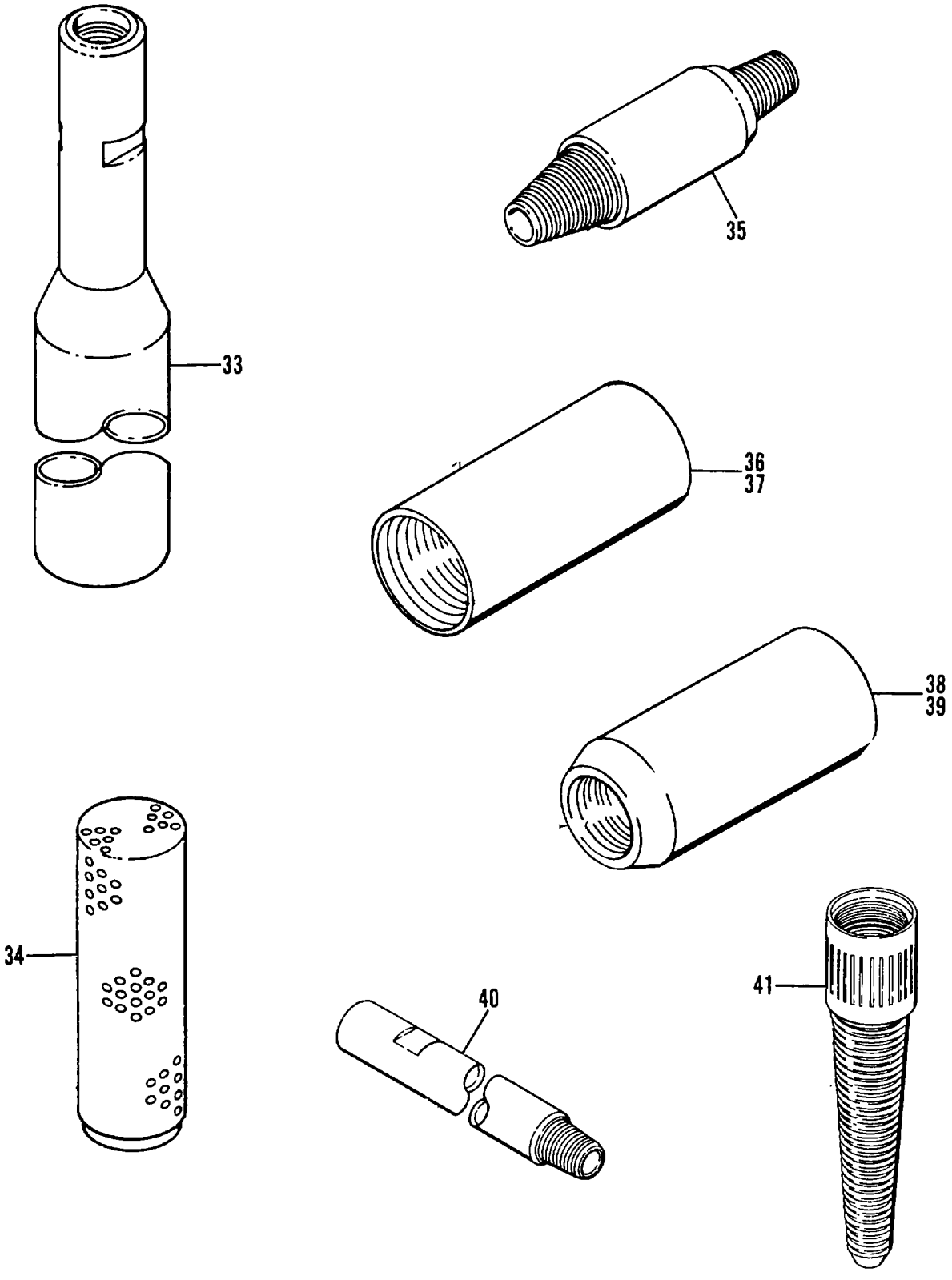
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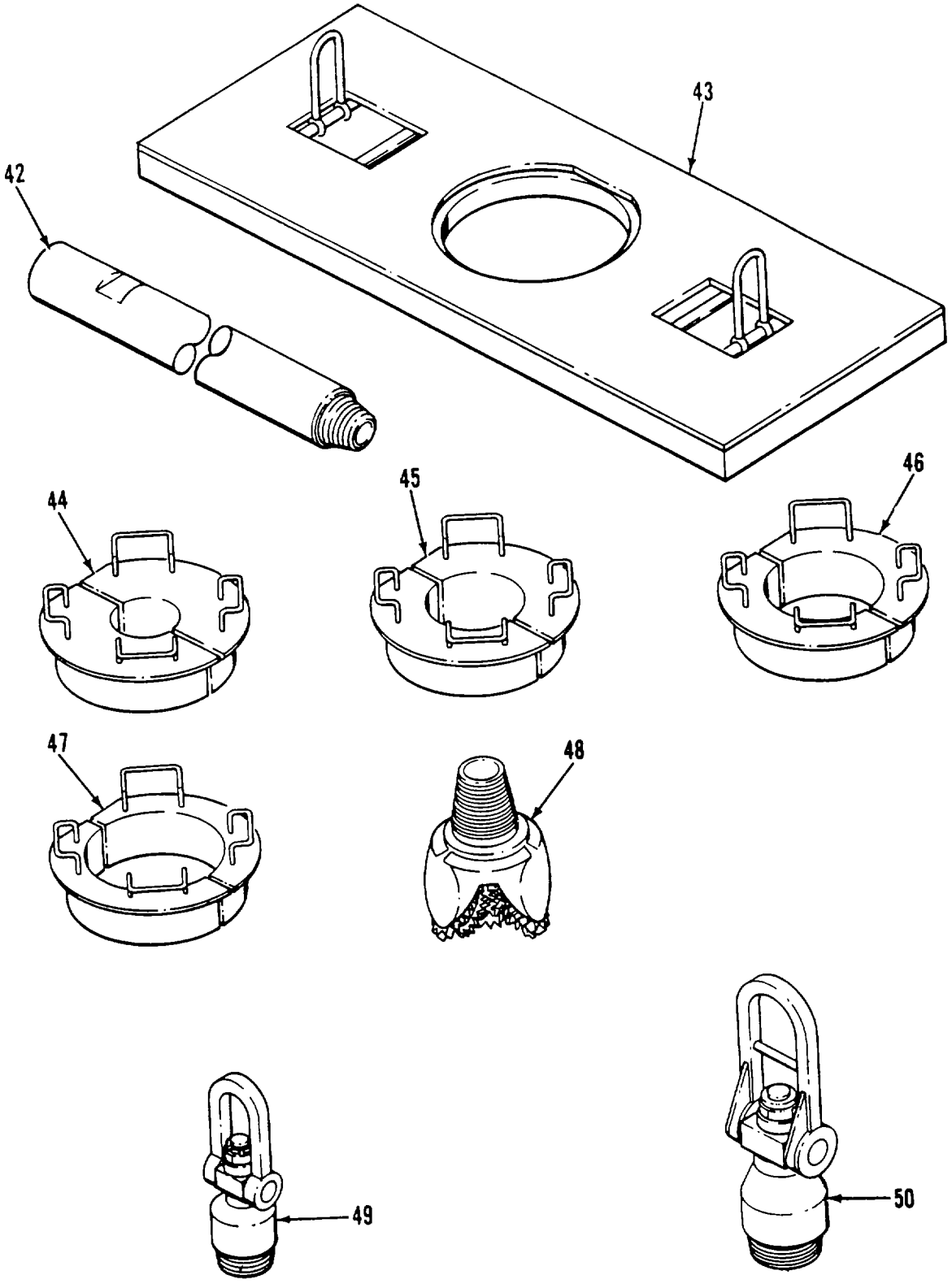
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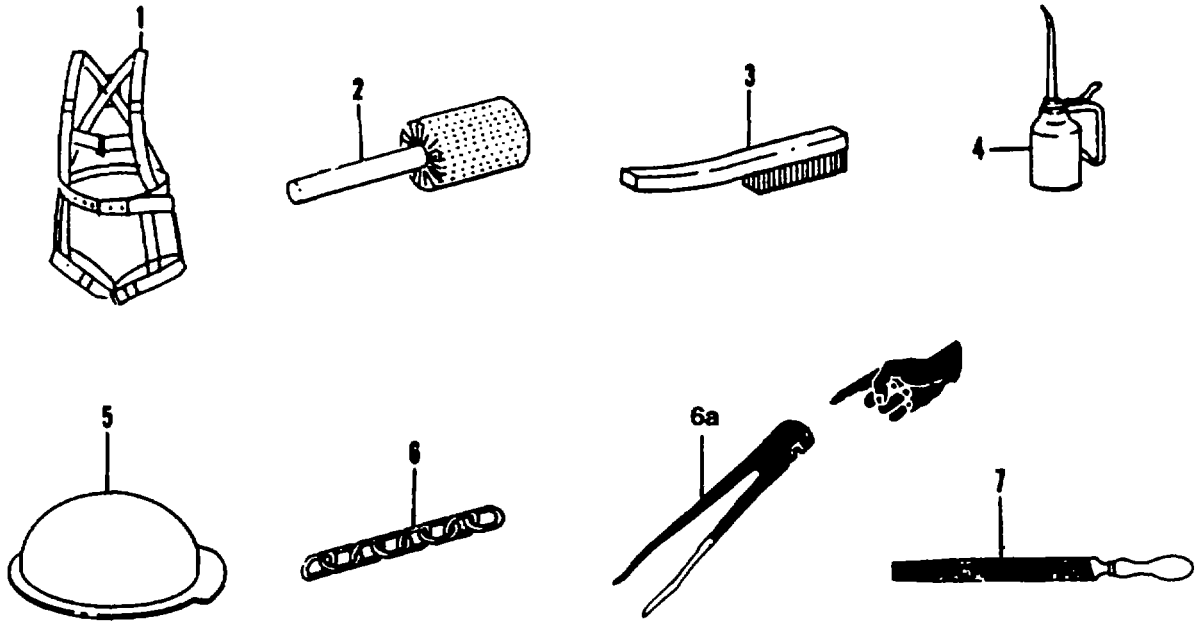
(1) Illus Number	(2) National Stock Number	(3) Description (FSCM) and Part Number	Usable On Code	(4) U/M	(5) Qty rqr
41		TAP, TAPER (21363) 158F636		EA	1
		1500 FT AUXILIARY KIT (DEAWS) KT-1992-TRSC Consisting of:		EA	1
42		DRILL ROD (OJ7B8) DW472-00		EA	45
43		BASE, WORKING (OJ7B8) DW2378-01		EA	1
44		BUSHING, SPLIT INSERT (OJ7B8) DW2378-01 C		EA	1
45		BUSHING, SPLIT INSERT (OJ7B8) DW2378-01 D		EA	1
46		BUSHING, SPLIT INSERT (OJ7B8) DW2378-01 E		EA	1
47		BUSHING, SPLIT INSERT (OJ7B8) DW2378-01 F		EA	1
48		BIT, ROCK DRILL 6-5/8" (22023) L3S-6-5/8 REG		EA	2
48		BIT, ROCK DRILL 6-5/8" (22023) L2-6-5/8 REG		EA	2
48		BIT, ROCK DRILL 6-5/8" (22023) LH1-6-5/8 REG		EA	2
48		BIT, ROCK DRILL 8-3/4" (22023) L3S-8-3/4 REG		EA	2
48		BIT, ROCK DRILL 8-3/4" (22023) L2-8-3/4 REG		EA	2
48		BIT, ROCK DRILL 8-3/4" (22023) LH1 -8-3/4 REG		EA	2
48		BIT, ROCK DRILL 10-5/8" (22023) V2-10-5/8 REG		EA	2
48		BIT, ROCK DRILL 13-3/4" (22023) L3-13-3/4 REG		EA	2

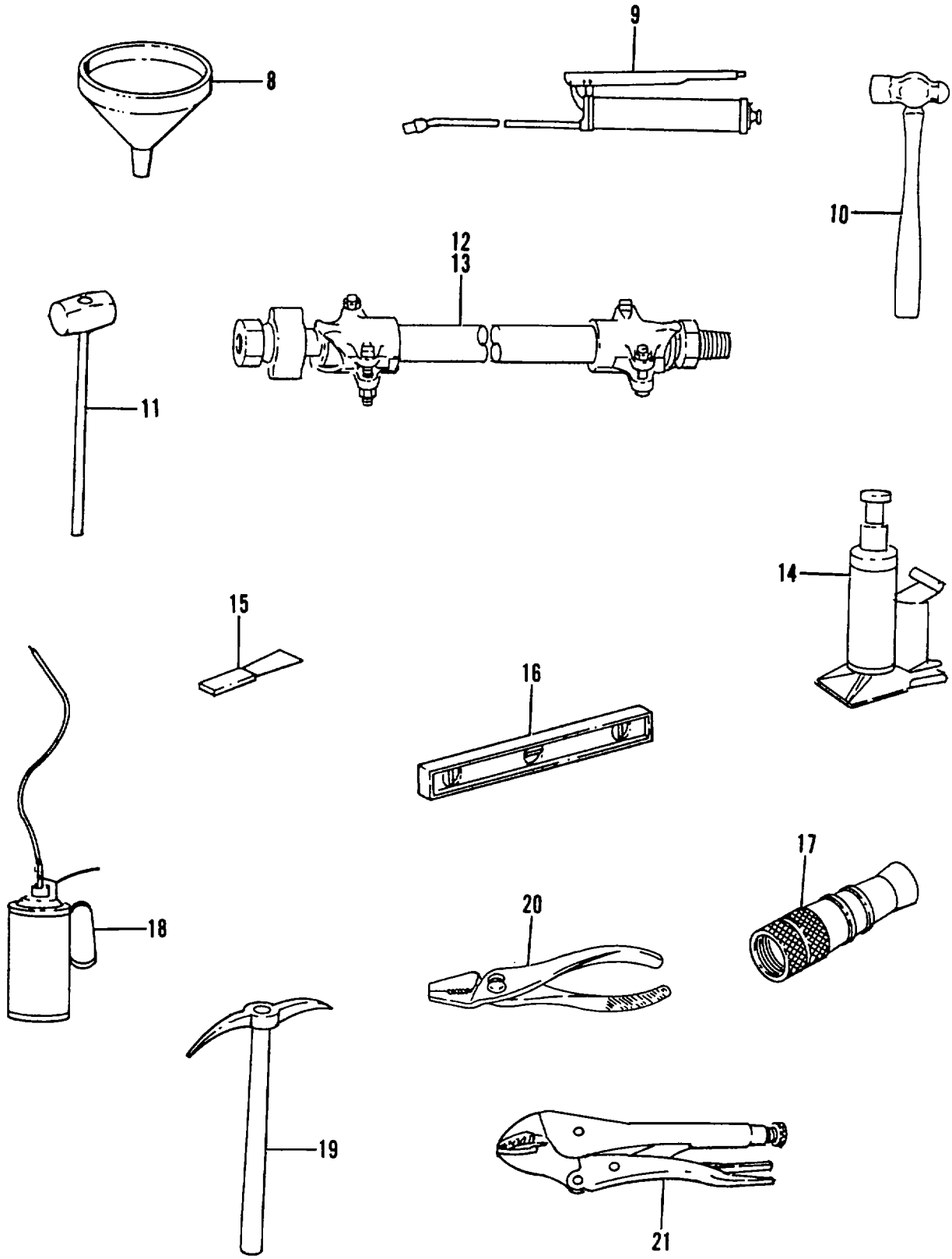
(1) Illus Number	(2) National Stock Number	(3) Description (FSCM) and Part Number	Usable On Code	(4) U/M	(5) Qty rqr
49		HOISTING PLUG (OJ7B8) DW1293-03		EA	1
49		HOISTING PLUG (OJ7B8) DW1293-04		EA	1
50		HOISTING PLUG (OJ7B8) DW1293-05		EA	1
50		HOISTING PLUG (OJ7B8) DW1293-06		EA	1
50		HOISTING PLUG (OJ7B8) DWI 293-07		EA	1

Section III BASIC ISSUE ITEMS



(1) Illus Number	(2) National Stock Number	(3) Description (FSCM) and Part Number	Usable On Code	(4) U/M	(5) Qty rqr
1		BELT, SAFETY (9J985) GSB-41A		EA	1
2		BRUSH,DOPE (21363) D-1933-DB		EA	4
3		BRUSH, WIRE (21363) D-1416		EA	4
4		CAN, OIL (21363) D-1415		EA	1
5		CAP, SAFETY (21363) D- 1 954-CA		EA	10
6		CHAIN, CLOSE LINK, PROOF COIL (21363)157F535		EA	1
6a		CRIMPING TOOL, TERMINAL (59730) WT115A		EA	1
7		FILE, 12 MILL BASTARD (21363) D-1419-A		EA	2

(1) Illus Number	(2) National Stock Number	(3) Description (FSCM) and Part Number	Usable On Code	(4) U/M	(5) Qty rqr
8		FUNNEL, 12-INCH, FILTER TYPE (21363) D-1494-12		EA	1
9		GUN, GREASE, CARTRIDGE TYPE (95879) 4039-A		EA	1
10		HAMMER, BALL-PEIN, 1-1/2 LB (21363) D-1412-B		EA	1
11		HAMMER, SLEDGE, 10 LB (21363) D-1423-B		EA	1
12		HOSE, WASHDOWN, 1-INCH X 25' (21363) H17-F25-A		EA	5
13		HOSE, WASHDOWN, 1-1(4-INCH X 50' (21363) H17-G50-A		EA	5
14		JACK, HYDRAULIC, 8-TON (21363) D-1622-B		EA	1
15		KNIFE, PUTTY, 1-1/4 INCH (21363) D-1933-PK		EA	2
16		LEVEL, 24-INCH (21363) D-1417-B		EA	1
17		NOZZLE, WASHDOWN (21363) D-1433		EA	1
18		OILER, HAND PUMP (72798) 120-Al		EA	1
19		PICK, RAILROAD (21363) D-1943		EA	1
20		PLIERS, SLIP JOINT, 10-INCH (21363) D-1414		EA	1
21		PLIERS, VISE GRIP, 10-INCH (21363) D-1414-V		EA	1
22		PULLER ASSY, LINER, MUD PUMP (21363) F-942	EA	1	
23		PULLER ASSY, VALVE SEAT, MUD PUMP (21363) F-908		EA	1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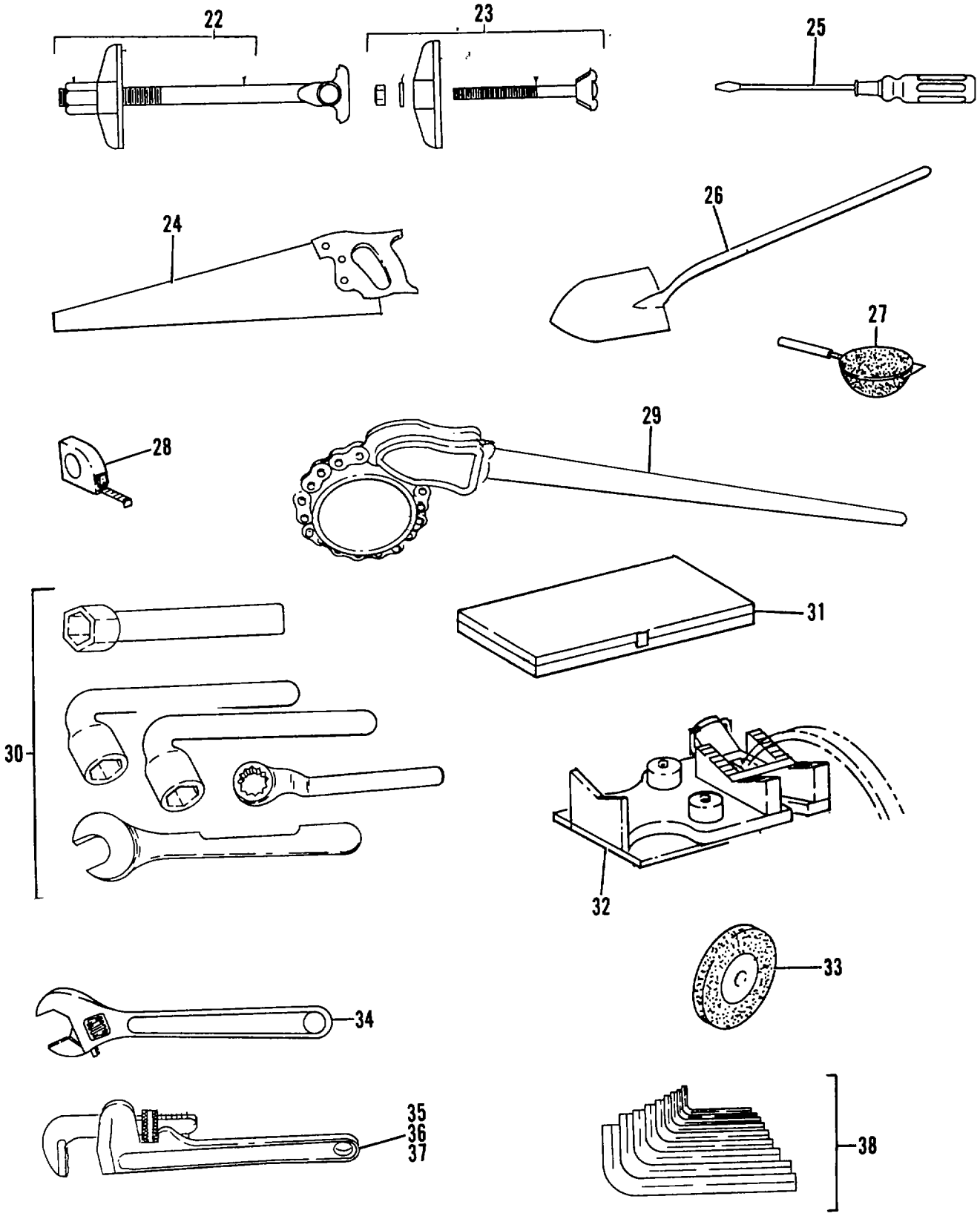
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(1) Illus Number	(2) National Stock Number	(3) Description (FSCM) and Part Number	Usable On Code	(4) U/M	(5) Qty rqr
24		SAW, HAND (21363) D-1422		EA	1
25		SCREWDRIVER, BLADE (21363) D-1413-A		EA	1
26		SHOVEL, ROUND POINT (21363) D-1424-A		EA	2
27		STRAINER, SAMPLE (21363) D-1431		EA	3
28		TAPE, MEASURING, STEEL, 50 FT (21363) D-1420-A		EA	1
29		TONG, CHAIN (21363) A-456-A		EA	2
30		TOOL KIT, MUD PUMP (21363) D-1440-B		EA	1
31		TOOL KIT, SOCKET, 1/211 DRIVE (21363) D-1441		EA	1
32		VISE, CHAIN (65814) CV-4		EA	1
33		WHEEL, GRINDER (21363) 149F921		EA	500
34		WRENCH, ADJUSTABLE (21363) D-1405		EA	1
35		WRENCH, PIPE, 24-INCH (21363) D-1395		EA	2
36		WRENCH, PIPE, 36-INCH (21363) D-1394		EA	2
37		WRENCH, PIPE, 48-INCH (21363) D-1398		EA	2
38		WRENCH SET, HEXAGON (21363) D-1406		EA	1

APPENDIX C
EXPENDABLE/DURABLE SUPPLIES AND MATERIALS LIST

SECTION I. INTRODUCTION

C-1. SCOPE

This appendix lists expendable supplies and materials you will need to operate and maintain the Well Drilling System. This listing is for informational purposes only and is not authority to requisition the listed items. These items are authorized to you by CTA 50-970, Expendable Durable Items (Except Medical, Class V, Repair Parts, and Heraldic Items), or CTA 8-100, Army Medical Department Expendable/Durable Items.

C-2. EXPLANATION OF COLUMNS

a. Column(1)Item number. This number is assigned to the entry in the listing and is referenced in the narrative instructions to identify the material (e.g., "Use cleaning compound, item 5, App. D").

b. Column(2)Level. This column identifies the lowest level of maintenance that requires the listed item.

C - Operator/Crew
O - Unit Maintenance
F - Direct Support Maintenance
H - General Support Maintenance

c. Column(3) National Stock Number. This is the National stock number assigned to the item; use it to request or requisition the item.

d. Column(4)Description. Indicates the Federal item name and, if required, a description to identify the item. The last line for each item indicates the Federal Supply Code for Manufacturer (FSCM) in parentheses followed by the part number.

e. Column(S)Unit of Measure (U/M). Indicates the measure used in performing the actual maintenance function. This measure is expressed by a two-character alphabetical abbreviation (e.g., ea, in, pr). If the unit of measure differs from the unit of issue, requisition the lowest unit of issue that will satisfy your requirements.

SECTION II. EXPENDABLE/DURABLE SUPPLIES AND MATERIALS LIST

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION	(5) U/M
1	C		COMPOUND,JOINT (29204) 949-002-15	LB
2	C		GAA (MIL-G-10924C)	LB
3	C		GO-85/140 (MIL-L-2105G) SAE 30	GAL
4	C		GO-85/140 (MI L-L-2105C) SAE 50-60	GAL
5	C		MOBIL RARUSSHC924(19135)	GAL
6	C		MOBIL RARUS SHC 926 (19135)	GAL
7	C		LUBRICATING OIL (MIL-L-2104D) OE/HDO 10,20,30,40	GAL
8	C		GO-80/90 (MIL-L-2105C) OE/HDO 10,30	GAL
9	C		GO-85/140 (MIL-L-2105C) OE/HDO 10,30	GAL
10	C		LUBRICATING OIL (MIL-L-2104D) OE/HDO 15/40	GAL
11	C		LUBRICATING OIL (MIL-L-2104C) OE/HDO 10,15/40	GAL
12	C	9150-00-142-9320	ROCKDRILLOIL	GAL
13	C		GO-85/140 (M IL-L-2105C) SAE 140 EP	GAL
14	C		GRAPHITE, COLLOIDAL (MIL-L-24131 B)	GAL
15	C		LUBRICATING OIL, OEA (MIL-L-46167A)	GAL

APPENDIX D

ADDITIONAL AUTHORIZATION LIST

Section 1. INTRODUCTION

D-1 SCOPE This appendix lists additional items you are authorized for the support of the Well Drilling System.

D-2. GENERAL This list identifies items that do not have to accompany the Well Drilling System and that do not have to be turned in with it. These items are all authorized to you by CTA, MTOE, TDA, or JTA.

D-3. EXPLANATION OF LISTING National stock numbers, descriptions, and quantities are provided to help you identify and request the additional items you require to support this equipment. The items are listed in alphabetical sequence by item name. If the item you require differs between serial numbers of the same model, effective serial numbers are shown in the last line of the description. If item required differs for different models of this equipment, the model is shown under the "Usable on" heading in the description column.

SECTION II ADDITIONAL AUTHORIZED ITEM LIST

(1)	(2)	(3)	(4)
NATIONAL STOCK NUMBER	DESCRIPTION CAGEC AND PART NUMBER USABLE CODE	U/I	QTY RECM
	Rig Accessory Kit (Pin 165F058) for Model LP-12 Drill Rig to use with 1500' Well Completion Consisting of:		
	Adapter, casing handling, hoisting plug to 412" casing (21363) 167F384	ea	2
	Adapter, casing handling, hoisting plug to 6%' casing (21363)167F385	ea	2
	Adapter, casing handling, hoisting plug to 8%"1 casing (21363) 167F386	ea	2
	Adapter, casing handling, hoisting plug to 103/4" casing (21363) 167F387	ea	2
	Base, Spider (21363) C-687-C	ea	1
	Bushing (21363) C-691-TM	ea	1
	Plug, hoisting, heavy-duty 40,000 lbs capacity with 27/8" API IF pin connection. (21363) H-185-F	ea	1
	Change 1 Change 1		

SECTION II ADDITIONAL AUTHORIZED ITEM LIST

(1)	(2)	(3)	(4)
NATIONAL STOCK NUMBER	DESCRIPTION CAGEC AND PART NUMBER USABLE CODE	U/I	QTY RECM
	Rock Bit, Soft Formation 6¾4" Tri-cone with 31/2½ API reg pin (21363) XVR-L3-6/4	ea	2
	Rock Bit, Medium Formation 6¾4" Tri-cone with 31/2" API reg pin (21363) XVR-LH2-6¾4	ea	2
	Rock Bit, Hard Formation 634" Tri-cone with 31/2" API reg pin (21363) XVR-LH1 -6V4	ea	2
	Rock Bit, Soft Formation 9i Tri-cone with 4½"n API reg pin (21363) XVR-L3-9	ea	2
	Rock Bit, Medium Formation 9"1 Tri-cone with 41/2" API reg pin (21363) XVR-LH2-9	ea	2
	Rock Bit, Hard Formation 9" Tri-cone with 41/2" API reg pin (21363) SVR-LH1-9	ea	2
	Rock Bit, Medium Hard Formation 11 " Tri-cone with 6%" API reg. pin (for 8%" casing) (21363) XVR-LH2-11	ea	2
	Rock Bit, Medium Hard Formation 13V4" Tri-cone with 6%11 API reg. pin (for 10V4 casing) (21363) XVR-LH2-13V4	ea	2
	Slips for 21/2 "1 steel drop pipe (21363) 7063w	st	1
	Slips for 41/2 " OD steel casing (21363) C-692-MG	st	1

SECTION II ADDITIONAL AUTHORIZED ITEM LIST

(1)	(2)	(3)	(4)
NATIONAL STOCK NUMBER	DESCRIPTION CAGEC AND PART NUMBER USABLE CODE	U/I	QTY RECM
	Slips for 6%5/ OD steel casing (21363) C-692-MC	st	1
	Slips for 8%' OD steel casing (21363) C-692-MF	st	1
	Slips for 10¾4" OD steel casing (fits C-690-T spider) (21363) C-692-TB	st	1
	Spider, 16" opening (21363) C-690-T	ea	1

*U.S. GOVERNMENT PRINTING OFFICE: 1990 754-124/20027

INDEX

F CONT'D.

L CONT'D.

M

N

0

P

Q

R

S

S CONT'D.

T

U

V

W

W CONT'D.

X

Y

Z

By Order of the Secretary of the Army:

CARL E. VUONO
General United States Army
Chief of Staff

Official:

WILLIAM J. MEEHAN, II
Brigadier Genera4 United States Army
The Adjutant General

DISTRIBUTION:
To be distributed in accordance with DA Form 12-25A, Operator's Manual for Drilling System, Well, Combination Rotary/Percussion, Semitrailer Mounted, Diesel, 1500 Ft, Model CF-15-S.

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The following format must be used if submitting an electronic 2028. The subject line must be exactly the same and all fields must be included; however only the following fields are mandatory: 1, 3, 4, 5, 6, 7, 8, 9,10,13,15, 16, 17, and 27.

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Subject: DA Form 2028
1 ***From***: Joe Smith
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3 ***Address***: 4300 Park
4 ***City*****:** Hometown
5 ***St***: MO
6 **Zip**: 77777
7 ***Date Sent***: 19-OCT-93
8 ***Pub no:*** 55-2840-229-23
9 ***Pub Title***: TM
10 ***Publication Date***: 04-JUL-85
11 Change Number: 7
12 Submitter Rank: MSG
13 ***Submitter FName***: Joe
14 Submitter MName: T
15 ***Submitter LName***: Smith
16 ***Submitter Phone***: 123-123-1234
17 ***Problem: 1***
18 Page: 2
19 Paragraph: 3
20 Line: 4
21 NSN: 5
22 Reference: 6
23 Figure: 7
24 Table: 8
25 Item: 9
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PREVIOUS EDITIONS ▸ ARE OBSOLETE.

P.S.—IF YOUR OUTFIT WANTS TO KNOW ABOUT YOUR RECOMMENDATION MAKE A CARBON COPY OF THIS AND GIVE IT TO YOUR HEADQUARTERS.

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

PIN: 065943-006