Technical Manual

PREVENTIVE MAINTENANCE

Machine downtime is costly to owners in lost ore production. All mechanical or electrical components and devices will eventually stop. The task of identifying when this machine shut down could occur is the purpose of preventive maintenance.

WARNING: Do not perform inspection activities while machine is in operation.

Due to variations in operational wear rates of machine components and machine application conditions, component life cycles are different. A-scheduled program of machine inspection with accurate record keeping can identify machine component and their rates of wear.

A continuous careful inspection routine can spot unusual conditions or fatiguing components before a failure occurs. Maintenance, repair and component replacement schedules should conform to scheduled machine shutdowns. If during daily, weekly or monthly inspection routines any part shows wear or distortion beyond expected normal patterns replace them with genuine Marion parts at the next scheduled maintenance interval. The cost of parts is small when compared to unscheduled breakdowns with their resulting lost manhours and machine production.

Machines which operate 24 hours, 7 days per week should have a scheduled 8-hour preventive maintenance period each 7-day period. See Section 10 for recommended inspection schedules.

Preventive maintenance inspection procedures listed below are suggested as an example of specific typical inspection activities. Each owner should establish his own preventive maintenance inspection schedule based on machine application conditions and production cycle.

WARNING: Maintenance and operating personnel should be aware of mechanical, hydraulic and electrical hazards inherent in servicing this machine.

INSPECTION CHECKLIST

- Check condition of roller chain and chain sprockets
- Test all hold down bolts with impact wrenches
- Check crawler shoes, load rollers and shoe sprocket for wear
- Inspect steel structures for cracks
- Check auto-lube system for loose or damaged fittings and injector conditions
- Inspect rotary gear box alignment in hoist and pull down

DANGER: Remove electrical power from machine whenever inspection of electrical components is performed. Use extreme care in removing guards and protective devices.

12. TEST – Push button to test the lights on the annnunciator. See Annunciator Panel for detail.

13. RESET – Push button to reset the lights on the annunciator panel. See Annunciator Panel.

14. PSI OR BIT LOAD – In DRILL MODE ONLY; move toggle switch up (PSI) for hydraulic system pressure (PSI) in hoist on item 18 and pull down on item 19. Move switch down (Bit Load) to read on item 19 actual weight on drill bit in pounds.

NOTE: Readouts can be obtained in English or Metric by the position of the top toggle switch located on the enclosed panel above.

15. INITIAL – This push button establishes base "0" on Hole Depth readout (item 8). Press this button AFTER the depth (of hole) is determined on item 16 and drill bit at ground line.

16. HOLE DEPTH – Adjustable indicator to set depth of hole to be drilled. Functional only in automatic drill mode.

17. ALARM – An On/Off toggle switch to silence the depth beeper item 21.

18. HOIST L.H. CRAWLER – Indicates hydraulic pressure in the hoist direction OR pressure to the left hand crawler propel motor depending on the machine mode.

19. PULL DOWN R.H. CRAWLER – Indicates hydraulic pressure in the pull down direction OR pressure to right hand crawler propel motor if machine is in propel mode.

20. WARNING – This buzzer alerts the operator of a malfunction on the Annunciator Panel. Silence by depressing the ACK button.

21. DEPTH – This beeper sounds when the drill bit reaches the hole depth set on the Hole Depth indicator (item 16).

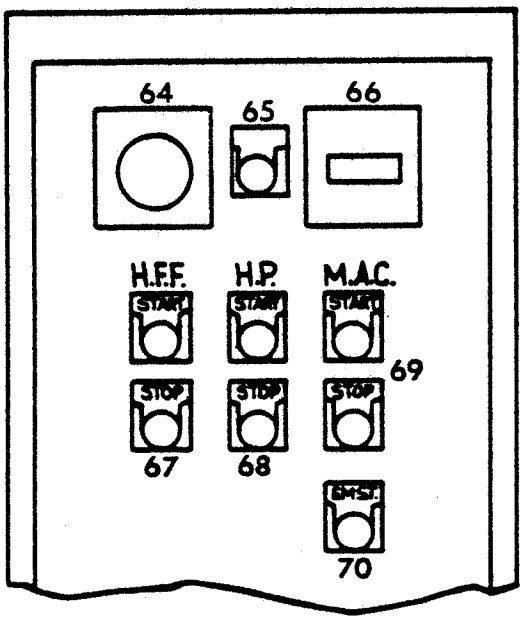
22. PROPEL – Red light indicates that the machine is in the propel mode and the Propel Control station is energized with item 23 in the propel mode.

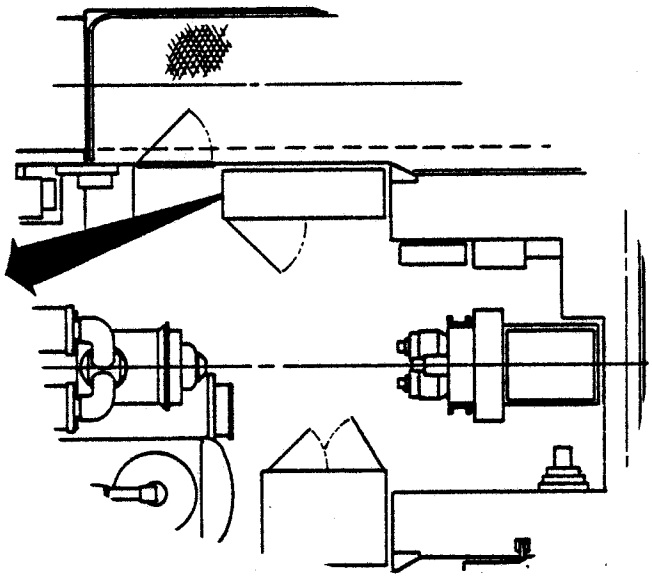
23. HOIST/STANDBY/PROPEL SWITCH – This selector switch determines the drilling or propel mode, sets hoist brakes and energizes or de-energizes the leveling system.

    PROPEL/LEVELING SET. This position automatically sets hoist brakes, deactivates the levers on the drilling control station and actuates the Propel Control Station.

STARTING PANEL is located on the end of the A.C. cabinet (inside machinery house) and is used by the operator for start-up and shut down of the machine.

NOTE: See Start-up and Shut Down for operation of this panel.





64. VOLTMETER – A.C. voltage of the transformer secondary. Normal voltage is 480 V.

65. PHASE SEQUENCE – Lamp will light when incoming A.C. power (trail cable) has correct phase rotation. This light must be on before starting the machine.

66. ELAPSED TIME METER – Indicates the operating hours of the hydraulic system.

67. HOUSE FILTER FAN – Start and stop push buttons for the machinery house filter system.

68. HYDRAULIC PUMP – Start and stop push buttons for the motor that drive the hydraulic pumps.

69. MAIN AIR COMPRESSOR – Start and stop push buttons controls for the drill air compressor.

70. EM. ST. – Emergency stop push button will shut down all systems except diesel engine for diesel operated machines.

MACHINE LEVELING uses the hydraulic jacks, controlled by levers in cab, mounted on the machinery frame in conjunction with the spirit levels mounted on the Drilling Control Station.

One jack (second jack optional) mounts at front and one jack at each side of the drill table. On a four jack machine, one control lever operates the front jacks as though only one existed.

REQUIRED METHOD OF LEVELING begins by extending (lowering) both REAR jacks until the rear of machine is slightly higher than front of machine as indicated by the level.

NOTE: The level and hydraulic pressure gauges should be watched throughout this operation.

With this accomplished, LATERALLY LEVEL the machine by extending (lowering) the rear jack on low side until the level indicates lateral leveling. Now, extend front jack(s) until machine levels front to rear.

CAUTION: **Never raise machine with front jack(s) when the mast is in the lowered position.**

Once machine is level and the jack(s) control lever is returned to neutral position, hydraulic valves hold the machine in position.

If machine does not remain level (assuming ground does not yield), check for leaks at cylinders.

WARNING: **Leveling of machine must be completed before starting the drilling operation.**

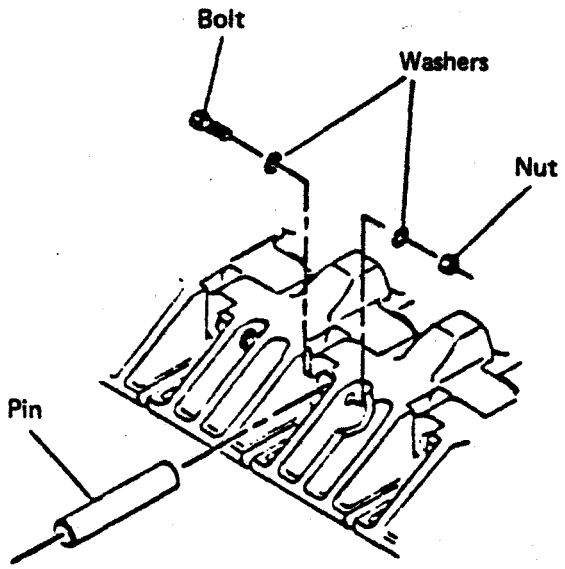
RETRACTING JACK – Reverse the above operation to lower machine. The front jack(s) MUST ALWAYS be retracted first.

ASSEMBLY OF DRILL STRING after mast is raised and machine is level, place hoist brake switch at Release position and mode switch at Manual. Hoist gear box high enough to clear top of stem that is in rack. Then set the brake.

Next, place the deck bushing over the upper end of the stabilizer. Screw the lifting bail onto the stabilizer and attach the winch line to lifting bail, lift the assembly and lower it into position in drill table opening until the deck bushing seats. Engage the stabilizer with the stem locks by moving the lock lever to the hold position. Remove the winch line and lifting bail from the stabilizer. Lubricate the threads of the stabilizer with a good quality drill pipe thread lubricant.

CRAWLER TRACKS on each side frame consists of forty (40) separate shoes. The shoes interconnect with two, hardened steel pins, each locked in place by a bolt thru the shoe web. Every third shoe is a cleated type.

Periodically check shoe pin(s) lock bolts. Replace missing bolts at once. Propelling without lock bolts causes the shoe pins to work out and separates the track.



ADJUST TRACK tension by moving the front roller assembly forward to tighten or to rear to loosen.

The crawler is in proper adjustment when the bottom of track is straight and tight, with six to eight inches of sag in top strand between front roller and center support roller. A crawler too tight causes loss of power. A loose crawler track results in serious damage as it may climb the drive sprocket.

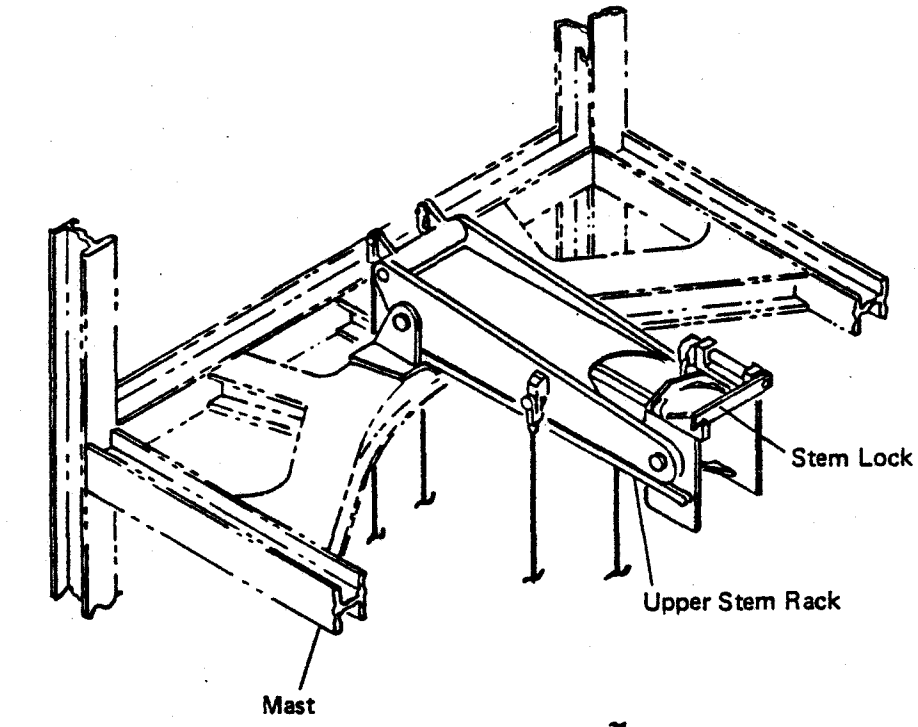
The front roller mounts on two adjusting blocks fitted into rectangular openings at each side of the crawler side frame. Two shoulder pins install thru the adjusting blocks and roller shaft and extend thru rear wall of openings. These pins lock roller assembly in place and facilitate moving assembly for adjustment.

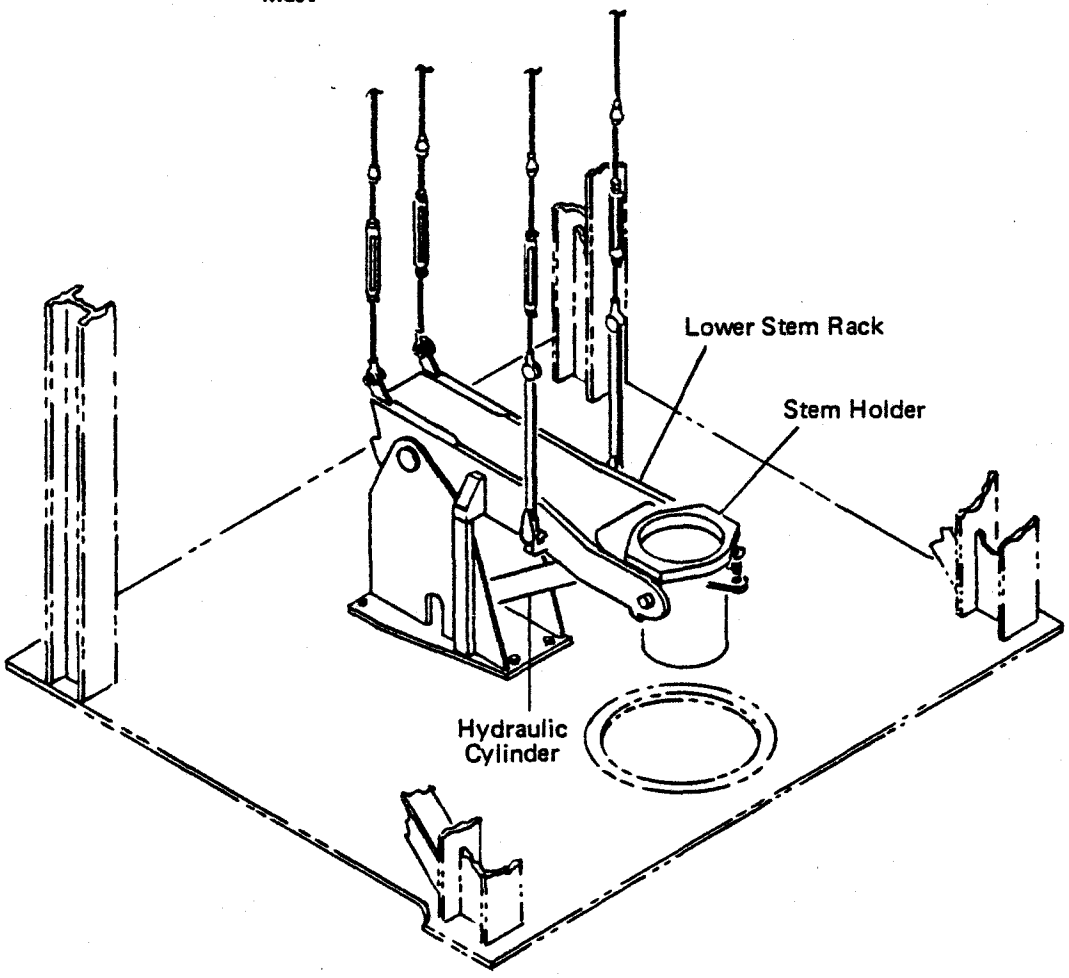
Two (2) hydraulic jacks are required to make the crawler track adjustment.

Remove the cover plate from each side of crawler side frame. Place hydraulic jacks, one at each side, in space behind front roller adjusting block and against shoulder pin. Operate jack enough to release shims and remove ALL shims. Now blocks freely move forward or to rear.

IMPORTANT: Move both roller shaft ends at SAME time and SAME amount to keep roller shaft at right angles to crawler side frame.

Move adjusting block (front roller assembly) forward by operating hydraulic jacks. If weight of tracks will not move roller assembly to rear when jacks are retracted; carefully propel machine back and forth until block releases.


Stem Lock
Upper Stem Rack
Mast


Lower Stem Rack
Stem Holder
Hydraulic
Cylinder

TROUBLESHOOTING (Insufficient hood control) cont.

CAUSE: Closed air passages.

REMEDY: Clogged ducts, closed dampers or closed gates will shut off the air flow.

IDENTIFICATION: Fabric bag problems.

CAUSE: Over temperature.

REMEDY: Operating temperature should not exceed 180 degrees F. (82 degrees C.).

CAUSE: Humidity.

REMEDY: Humidity can blind bags. Moisture will cause the collected dust to become muddy or cement to the bag. Drawing dry air thru collector may dry the dust enough to allow the collector to clean with the fan off. If this doesn't work the bags must be dry cleaned or new bags installed.

CAUSE: Dust characteristics.

REMEDY: Each bag material is selected for specific physical and chemical characteristics which are compatible with the gas stream composition and temperature.

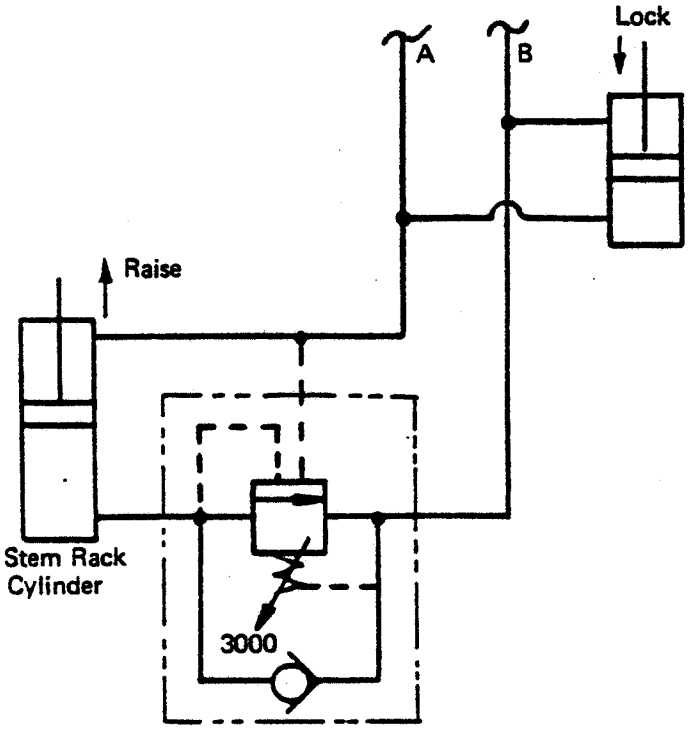
CAUSE: Dust build-up hoppers.

REMEDY: Dust build-up into the bag area will result in excessive abrasion on the bags. The build-up may be caused by a malfunction of the discharge device or condensation in the hopper. A vibrator or hopper heater with insulation may have to be added to the hoppers.

CAUSE: Bag wear on the inside.

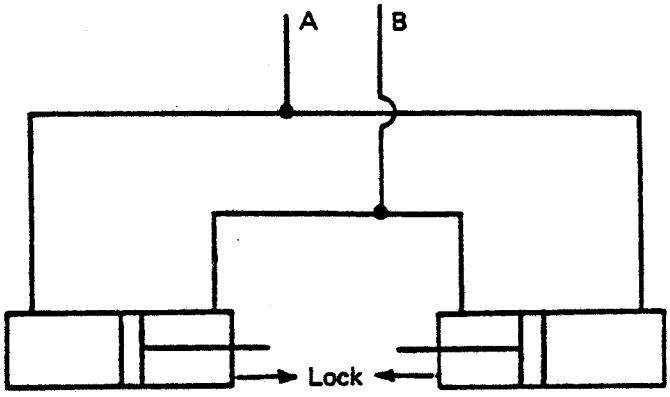
REMEDY: Dust on clean side of bags will wear the bags out from inside. This could be the result of a broken bag or incorrect bag installation or an improper tube sheet seal. Vacuum the clean air side, replace the bag, correct the seal and reseal the cartridge. Do not blow dirt inside the bags. If the bags have dust inside them, vacuum them out.

BREAKOUT TONG CIRCUIT consists of a double acting cylinder capable of operating at full system pressure when loosening the stem threaded joints.



STEM RACK CIRCUIT, Typical all Racks – A double acting cylinder actuates each stem rack assembly. A counterbalance valve with check bypass is in the raising line to cylinder. This valve is pressure released at 1000 psi (6895 kPa) from the lowering line or 3000 psi (20685 kPa) from the head end of the cylinder, due to a 3 to 1 pilot ratio. The oil is held in the cylinder (anchor end) until lowering pressure exceeds 1000 psi (6895 kPa), or head end pressure exceeds 3000 psi (20685 kPa). The safety lock cylinder is piped parallel to the actuating cylinder.

STEM LOCK CIRCUIT consists of two, double acting cylinders operating with full system pressure.



MAST RAISING AND LOWERING CYLINDERS – The mast is raised and lowered by two, double acting cylinders connected in parallel. A counterbalance valve in the lowering line holds the oil in cylinder rod end until the 1000 psi (6895 kPa) pilot pressure from the raising line releases the valve. The circuit bypasses the counterbalance valve thru a check valve.

At the base of each cylinder is a sequence valve. These two valves hold the oil in the head end of the cylinder until pilot pressure of 100 psi from the lowering line releases the valve. Adjust BOTH valves the same. The raising circuit bypasses these valve thru a check valve.

Do not break container seal until ready for use.

Before transferring fluid from shipping container into hydraulic system reservoir, cycle fluid thru transfer pump and filter and return to shipping container. This purges pump and hoses.

Never use galvanized container to transport hydraulic fluid. Certain fluid additives react with the zinc and forms a soapy compound.

Not all contaminates are introduced into hydraulic system from an external source. The chemical reaction between fluid and system interior surfaces, metal particles from worn parts or gasket fragments, packing or sealing compounds, also play a part. Oxidation, polymerzation or condensation reaction results in an insoluble gum, sludge or varnish. These things result in sluggish action, reduce clearance to the point of plugging passages or ports.

Filter solid particles from system using a 10 micron filter element.

CHANGE SCHEDULE FOR HYDRAULIC FLUID – The frequency to drain hydraulic oil and replace with new oil, depends on the oil nature and operating conditions. It is difficult to establish a drain schedule to apply categorically to all machines.

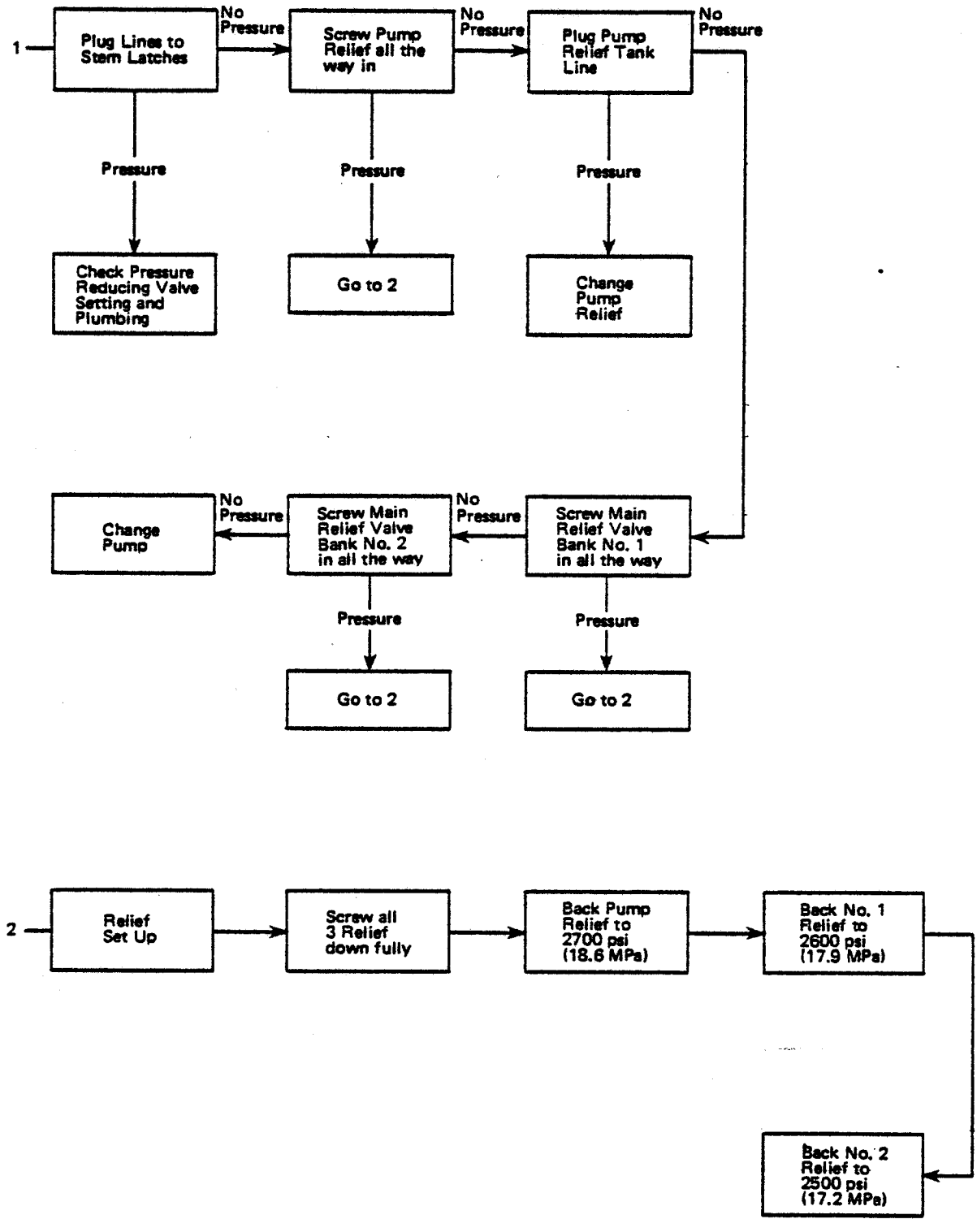
Visual oil inspection notes any change in appearance, such as darkening or thickening serves as a rough guide to indicate when change is imminent.

Periodic oil testing is the best determination for replacing oil. With laboratory facilities unavailable, the oil supplier usually provides this service. Change oil when characteristics, such as viscosity and acidic properties change at an accelerated rate. If oil is changed at a proper interval, the system remains relatively clean. If oil remains in the machine, the system cleaning and flushing process is expensive and time consuming.

Take sample from initial (start up) hydraulic oil after first 500 operational hours and submit to a laboratory for evaluation; thereafter, take oil samples from main pump case drain after every 1,200 hours of operation. Have the samples checked for particle contamination and chemical properties. If the particle count is not excessive and the chemical properties meet the HDF spec., then leave oil in.

Fluid leaks and seepage is inherent with high pressure hydraulic systems. Internal leakage within components returns to reservoir thru drain lines. Careful installation of fittings and joints keeps seepage to a minimum. All replacement parts, including hose, tubing and fittings, must be in mint condition. Install hoses and tubing so no mechanical strain on the parts exists. Use tube benders to prevent short radii bends that kink or reduce tube diameter. Use proper tools to install fittings. Tighten fittings, but NOT to point of part damage or distortion. Do not use tube or hoses of smaller diameter than original or parts

AUXILIARY SYSTEM WILL NOT BUILD PRESSURE

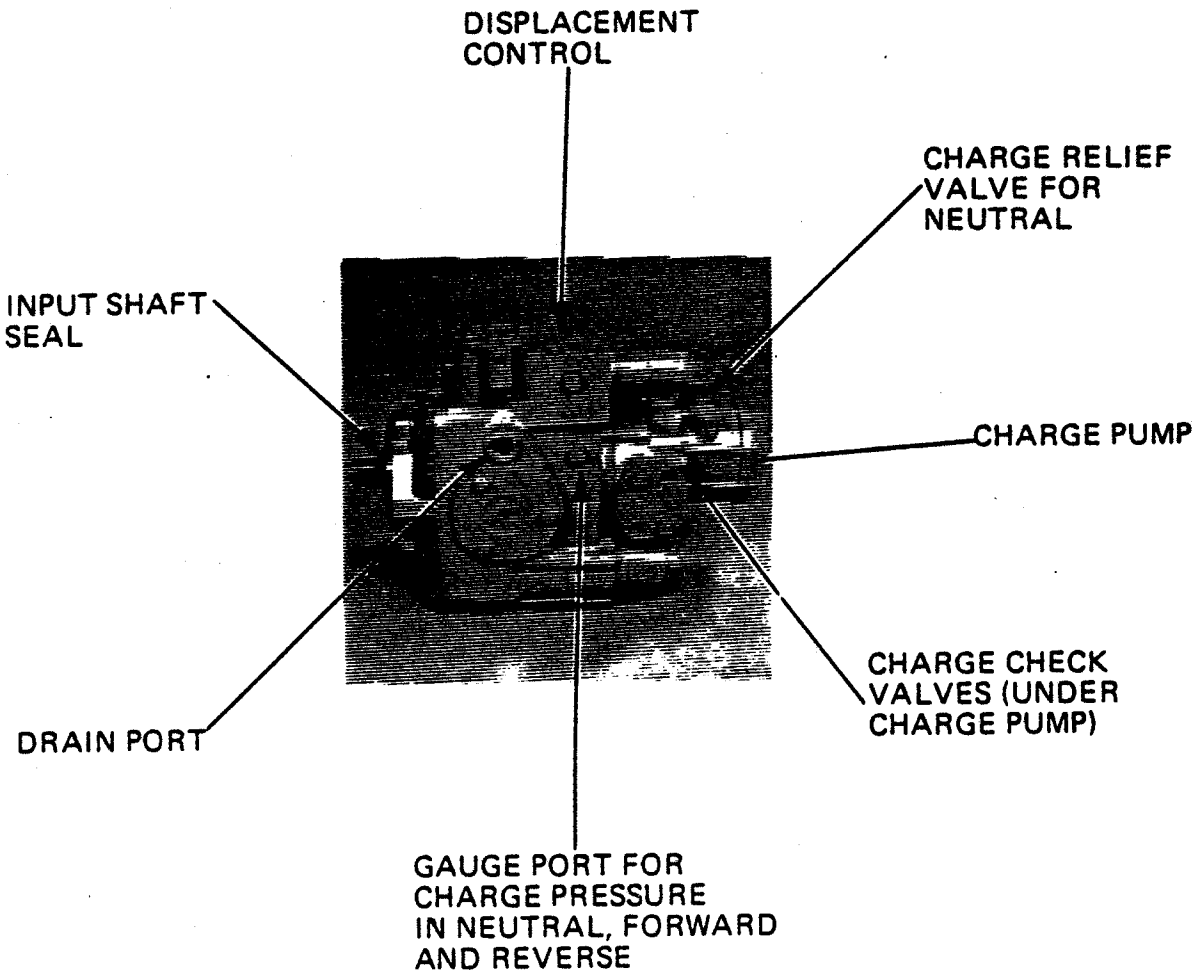


NOTE: If No. 1 and 2 Relief do not consistently hold set pressure, replace cartridge.

MINOR REPAIRS, VARIABLE DISPLACEMENT PUMP

The areas of repair indicated may be serviced, following the procedures in this manual, without voiding the warranty.

Installation torque values for cap screws and other parts are given in the table found later in this section.



RADIAL PISTON HYDRAULIC MOTOR – All four hydraulic motors used on the drill are identical.

NOTE: Stripping and assembly of the unit is work which should not normally be attempted by the operator unless circumstances dictate otherwise. Claims under guarantee cannot normally be entertained if the unit in question has been stripped by the operator.

The normal overhaul period is based on the anti-friction bearing life. If the unit fails or otherwise gives unsatisfactory service, replace at once with standby unit and return to manufacturer for repair and overhaul.

During scheduled maintenance, tighten all loose bolts.

Fill any unit held in storage with oil, block off ports and protect from corrosion.

Before **REMOVING HYDRAULIC MOTOR**, clean complete areas next to ports and drains. Remove pipes. Cover pipes and ports to prevent dirt entrance.

Clean motor completely, and transport to clean work area. Drain all hydraulic fluid before disassembly.

REMOVE MOTOR BRAKE by supporting unit with shaft pointing upward on bench. Remove actuator and release brake.

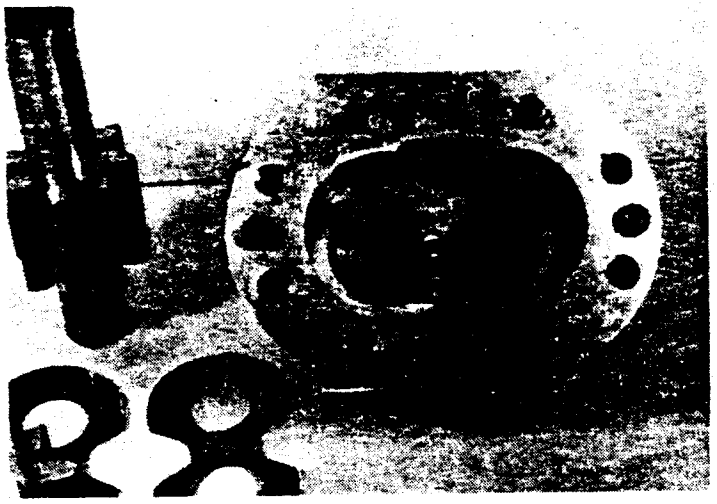
Remove the nuts holding brake to motor, then lift brake unit off motor.

VALVE ASSEMBLY REMOVAL AND DISASSEMBLY begins by supporting motor with drive shaft pointing straight down. Remove cap screws bolting valve housing to motor case. Take off valve assembly with care to prevent damage of Oldham coupling, (it may fall off).

Remove Oldham coupling and any shim(s) next to rear bearing. NOTE: Some motors have shim(s) at rear, others at front bearing plate or front cover.

Remove cap screws from valve housing at end and pull out end cap.

11. To remove bottom pressure plate, insert expandable bearing puller in shaft bore of plate. See Fig. 6. Apply a light back and forth motion on the puller to dislodge plate. After plate has been dislodged, lift it straight up out of gear bores. If bearing puller is not available, grind a screwdriver-type flat on the short end of Allen wrench. Insert Allen wrench in shaft bore and lift plate up slightly, moving the wrench from one bore to the other until plate has been dislodged. Once plate has been dislodged it should slide freely out of gear bore. Use **extreme care** in removing the plate. DO NOT pry or force out.



12. Remove the ring retainer, O-ring, back-up ring and isolation plate. See Fig. 7.

13. Wash all pump parts thoroughly with clean solvent and blow dry. This should remove any foreign material collected in pump. Lay out parts in disassembled order.

14. Visually inspect all parts. If any of the internal parts show excessive wear, replace all the parts.

    A. Measure the depth of the gear track. If the track is less than .015 inch (.381 mm) the body is all right for assembly, provided it is not cracked or damaged otherwise.

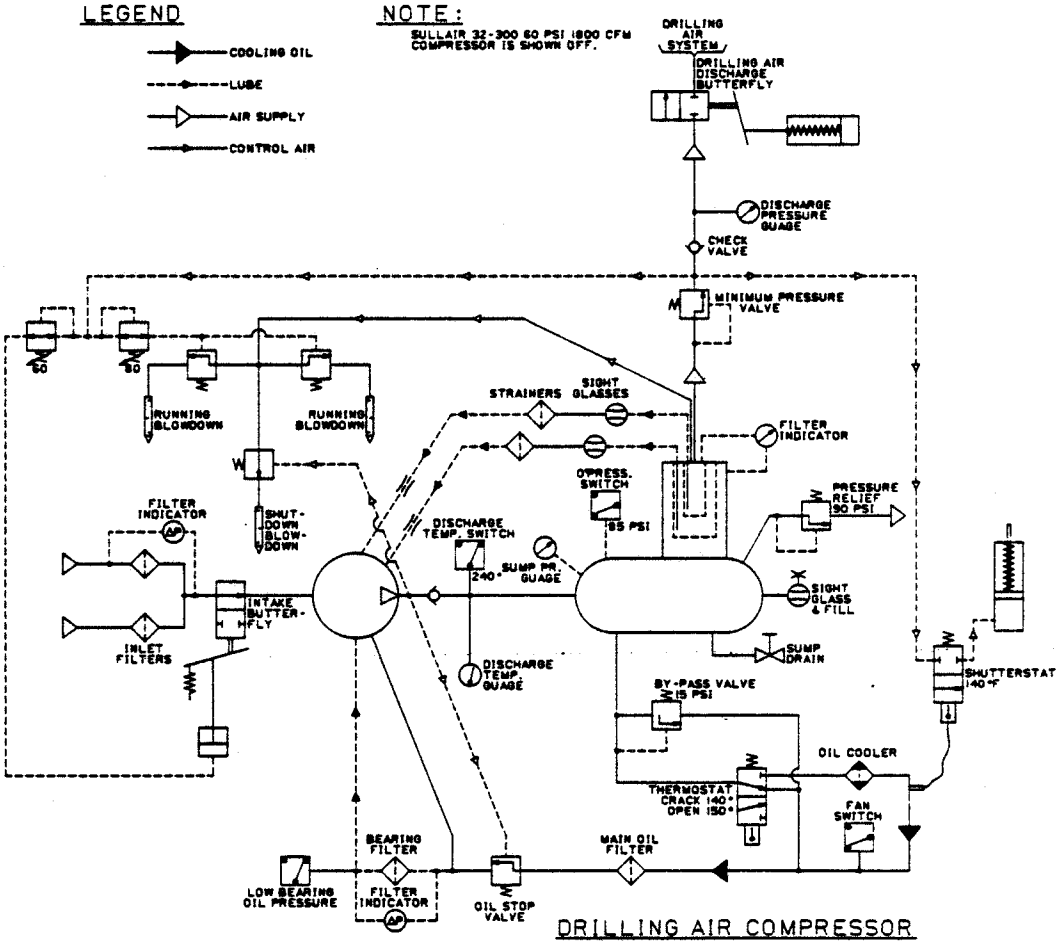
    B. Examine the pressure plates. They should not show excessive wear on the bronze side. If deep curved wear marks are visible, reject them.

    C. Examine the gears. If excessive wear is visible on the journals, sides or face of the gears or at the point where it rotates in the seal, reject them.

ASSEMBLY INSTRUCTIONS:

15. After all parts have been inspected, wash parts once more in clean solvent and blow dry.

16. Place pump body on workbench, (See Fig. 8), with discharge port facing you.



DRILLING AIR COMPRESSOR

DRILLING AIR, CONTROL AIR, LUBE, & COOLING OIL SCHEMATIC

SULLAIR SERIES 32 – SPECIFICATIONS

DIMENSIONAL:

Cooling	Model Series	Length		Width		Height		Weight	
		in	mm	in	mm	in	mm	lb	kg
Air (Remote)	32-300L HP	109	2769	84	2133	79	2006	–	–

COMPRESSOR:

Type	Rotary Screw
Maximum Operating Pressure	60 PSI (L) (413 kPa) (Unload Pressure)
Bearing Type	Anti-Friction
Ambient Temperature (Max)	105 degrees F. (40 degrees C.)
Cooling	Pressurized Oil
Lubricant	See Lubrication Guide below
Sump Capacity	65 Gallons (246 Liters)
Control	Pneumatic

MOTOR:

Type	Open Dripproof, 460 V, AC, Three Phase, 60 Cycles, 40 degrees C. (104 degrees F.) Max. Ambient Temperature
Size	300 HP (224 kw)
Speed	1800 RPM

LUBRICATION GUIDE – COMPRESSOR

Compressor oil should conform to the following specifications:

Ambient Temperature	-23 degrees C. to 32 degrees C. -10 degrees F. to 90 degrees F.
1,000 HR "Normal" oil change period.	MIL-L-2104B (API CC) API SE, CD SAE 10W Dexron II ATF D-A Torque Fluid

ELEMENT INSPECTION

1. Place a bright light inside the element to inspect for damage or leak holes. Concentrated light will shine thru the element and disclose any holes.

2. Inspect all gaskets and gasket contact surfaces of the housing. Should faulty gaskets be evident, correct the condition immediately.

3. If the clean element is to be stored for later use, it must be stored in a clean container.

4. After the element has been installed, inspect and tighten, if necessary, all air inlet connections prior to resuming operation.

PRIMARY SEPARATOR REPLACEMENT – When the separator maintenance indicator shows a red signal, separator replacement is necessary. Follow the procedure explained below for separator replacement.

1. Remove all piping connected to the sump cover to allow removal (return line, service line, etc.).

2. Remove cover bolts and lift cover from sump.

3. Remove separator element.

4. Scrape old gasket material from cover and flange on sump.

5. Install gaskets.

6. Install element.

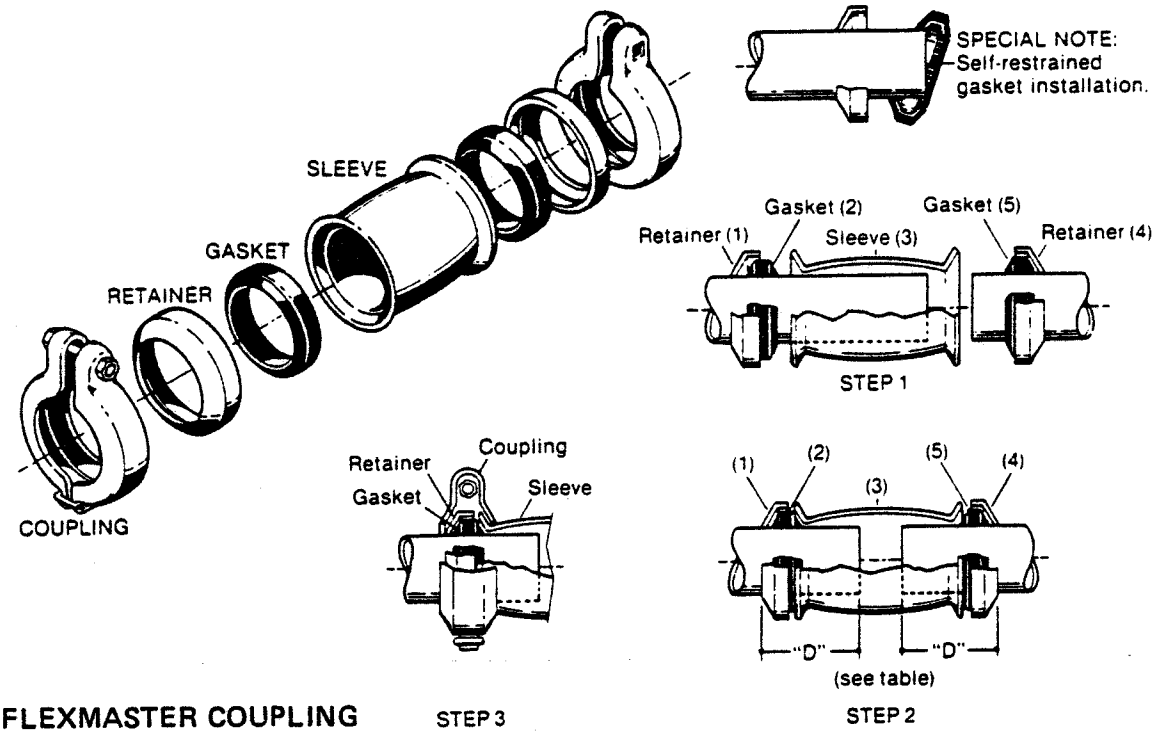
7. Inspect secondary separator element and replace if necessary (see Secondary Separator Replacement).

8. Replace sump cover and bolts.

9. Reconnect all piping. Return line tube should extend to the bottom of the separator element or no more than 1/2" (12.7 mm) up from the bottom. This will assure proper coolant return flow.

10. Clean the return line strainer prior to re-starting the machine.

FLEXMASTER COUPLING MAINTENANCE – Flexmaster coupling maintenance normally requires the replacement of the two (2) gasket rings on the coupling. The appropriate gasket rings for coupling No. 41085 and No. 41353. Follow the procedure below for proper installation.



FLEXMASTER COUPLING

PIPE END PREPARATION

1. Deburr and clean the pipe ends.

2. The pipe ends should be free of all deep scratches, gouges, dents, etc. A special finish is not required.

JOINT INSTALLATION

1. Install the retainer (1), gasket (2), and sleeve on one side of the pipe as shown in Step 1.

2. Install the remaining retainer (4) and gasket (5) on the other pipe end.

3. Position the retainer (4) and gasket to proper pipe insertion depth ("D") as shown in Table 1.

SECTION 6

AUXILIARY AIR SYSTEM

The **AUXILIARY AIR SYSTEM** is quite simple in operation. Reasonable care and maintenance ensures a long and trouble free life. This system supplies air to the lube system, horn, the valve on main air compressor intake and to the exhaust/discharge valve, also on main compressor.

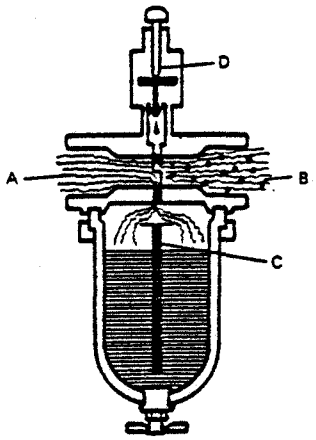
The auxiliary air provides a vital link in the safe operation of this machine. The operator MUST CONSTANTLY check the pressure gauge, Item 19 on drill control stand. If at any time this pressure DROPS below 80 psi (552 kPa), SHUT DOWN and investigate the cause.

NEVER OPERATE MACHINE WITHOUT FULL TANK PRESSURE OF 80 TO 100 PSI (552 to 690 kPa).

COMPRESSOR is located in the machinery house and mounts on the floor. It consists of an electric motor driven, single stage compressor, automatic pressure switch and a 60 gallon receiver tank mounted under floor.

INSPECT the belt drive often. Maintain proper belt tension which permits no more than one half inch deflection. Adjust by moving the electric motor on the base. CHECK crankcase oil level daily and keep at dipstick FULL mark. Every 500 operational hours, drain and flush the crankcase. Look in lubrication charts, (Section 7), for the proper NON-DETERGENT oil to use. Clean the intake air filter once a week, or daily if conditions require, with a non-explosive solvent and allow to dry before reinstalling.

LUBRICATOR – The lubricator is located in the main line coming from the receiver tank. Its purpose is to lubricate the air cylinders to prevent friction damage and corrosion caused by moisture in the air supply. The unit should be adjusted to provide 25 drops of oil per minute. This is done by adjusting the oil feed adjustment located on top of the unit, and counting the number of drops thru the sight-glass.



Operation of the lubricator is simple. Air enters the lubricator at point A. The oil bowl is pressurized by admitting air via the reversible venturi tube, B. Air flowing thru the lubricator creates a reduced pressure area as it passes thru the venturi section. Therefore, oil is forced to flow up the siphon tube, C, to the chamber above the drip gland. Here, the flow of oil is

LUBRICATION SPECIFICATIONS

SPECIFICATION – GREASES

CODE OR SYMBOL NO.	ASTM	MPG or TEST	RGL	OGL TYPE B	OGL TYPE H
Penetration Worked 60X					
Summer, NLGI	D-271	2	semi-	1	–
Winter, NLGI		1	fluid	0	–
Penetration Worked 10,000, Max. Change	D-217	10%	–	–	–
Dropping Point, Min. °F (°C)	D-566	350 (177)	–	325 (163)	–
Base Oil Viscosity @ 210°F (99°C), Min.	D-446	75 SUS	140 SUS	2000 SUS	2000 SUS
Oxidation Stability Max. psi (kPa) Drop–100 Hrs.	D-942	10 (68)	–	–	–
Water Resistance Max. Loss @ 100°F (38°C)	D-1264	20%	–	10%	10%
Texture	Visual	Buttery	–	Adhesive	Tacky
EP Timken, Min. OK, lbs. (kg)	–	35 (16)	–	35 (16)	35 (16)

SPECIFICATION – OILS

CODE OR SYMBOL NO.		ASTM or Test	MO	OIL PO
Pour Point °F (°C), Max.	Summer	D-97	5 (-15)	15 (-11)
	Winter		0 (-17)	15 (-11)
Flash Point °F (°C), Min.	Summer	D-92	450 (232)	410 (210)
	Winter		420 (216)	410 (210)
Viscosity @ 100°F (38°C) SUS		D-446	–	150 Min.

the hose. Connect hose to bearing and fill bearing. (The auto-lube system is not designed to provide initial filling of bearing, only to provide replenishing supply.)

Remove ALL plugs on main supply line, one at a time, including injector block end plugs. Pump lube into system until ALL air bleeds out and lube flows from opening. Proceed until ALL plugs have been removed; ALL lines filled and ALL plugs REPLACED. With these steps complete, the system is ready for automatic operation.

Check system by operation to be sure lubricant is delivered to EACH BEARING. In cases where it is not possible to see the lubricant delivered, disconnect line at bearing to be sure lubricant is pumped. Reconnect line and pump again to check for leaks.

Check operation of all indicator stems to insure that all operate properly. Check all operating pressure gauges and test all alarms and signal lights by blocking a line or causing some deliberate malfunction.

Each bearing (except anti-friction bearings) should be completely filled with lubricant before initial start-up. Automatic lubrication systems are designed to provide "make up" lubrication. They are not designed to provide the "initial fill" automatically.

The system is now ready for service. Check the system at regular intervals to make sure it lubricates on schedule and that no bearings are overheating.

LIQUID CAPACITIES OF MACHINE:	Gallons	Liters
1. A. Main Hydraulic Reservoir	12	45
B. Auxiliary Hydraulic Tank	40	152
C. Circuit Volume	50	189
D. Total Hydraulic System Volume	100	379
2. Propel Gearbox	10	38
3. Rotary Gearbox	120	455
4. Drill Air Cooling	30	114
5. Hydraulic Pump Transmission	2	8
6. Main Air Compressor Sump	50	189

5. Place seal on the shaft with lip turned toward the pressure and install garter spring in the slot with the hook and eye, 90 degrees from split. Butt seal ends together. If desired, apply to the split a small amount of Loctite #404 or Eastman #910 adhesive; but be very careful to keep adhesive AWAY from shaft, bore and seal edge. START seal into bore with the split at top of shaft. Tap seal into bore with hammer and wood block. Alternate from side to side until seal firmly seats in the bore. (Might be an idea to read the solid seal installation).

INSTALL OIL AND GREASE SEALS with the following procedure:

1. Carefully inspect seal for cuts, nicks or breaks. Rub a finger over lip and edges to feel roughness or pits that might cause a leak. A damaged seal is not worth installing. A properly sized seal is.

2. Check shaft for scratches, burrs or roughness that may cut or score the lip of seal. Look closely at area over which seal installs. Keyway and splines need a thimble or protective tape to safeguard seal.

3. Inspect bore for roughness or burrs that might cut or scrape seal when pressed into place. The bore and shaft need 1/16" chamfer. If not, carefully break the corner of seal.

4. Determine proper position of lip. (Ask the question: Is seal used to retain fluid or grease IN or rather to keep other material OUT). Position seal with lip turned to INSIDE when retaining oil or grease. Place seal with lip to OUTSIDE when other material OUT of bearing or case.

5. Lube the seal with light coat of oil or grease on ALL surfaces, particularly the lip and O.D. Lube shaft and bore also.

6. CAUTIOUSLY install seal on shaft. Be sure garter spring is IN SLOT and lip is TURNED correctly. Move seal from the shaft end to bore with a spiral motion.

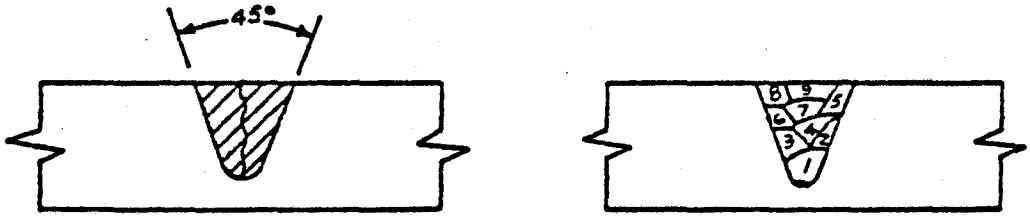
7. Align seal in bore and tap LIGHTLY with hammer on wood block. Change from side to side around the seal until firmly seated in bore. No retainer plate is needed.

TWO SEALS INSTALLED back to back retain grease or oil and keep out other material at the same time. Where this practice exists, fill the space between the two with MPG.

GEAR CASE SEAL used for ALL oil tight gear cases requires a coat on one surface of the gear case cover with aviation Form-a-Gasket #3 (Permatex Co.). Apply 1/64" thick. If using a paper gasket at cover, ALWAYS replace with a NEW manila paper gasket .010" thick. Apply aviation Form-a-Gasket #3 to BOTH sides of the gasket. Tighten the gear case cover bolts until the seal material extrudes from the joint.

b. Oxy-acetylene torch may be used, except for HSLA steels, to wash out metal for weld repairs. AVOID deep burn gouges and cuts to prevent trapping slag and any poor fusion. Remove slag and foreign matter by chipping and/or grinding.

c. REMOVE cracks with overall dimensions of eight inches or less by working from one end to middle; then from opposite end to middle of crack. Metal removed should form a V groove pattern. Cracks should be completely removed to give satisfactory repair.

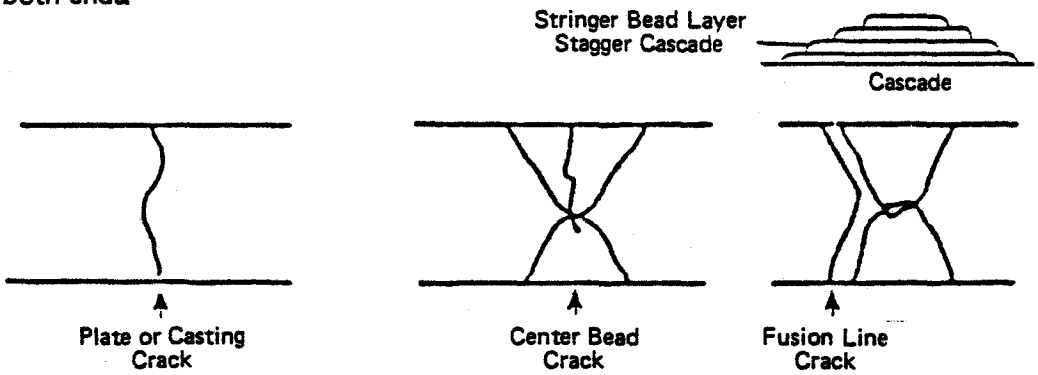


Use a small diameter rod in base of repair. Larger diameter rod or semi-automatic application may be used if full access to previous weld deposit can be obtained. Weld bead sequence is shown in sketch. AVOID applying wide beads or stringer bead technique.

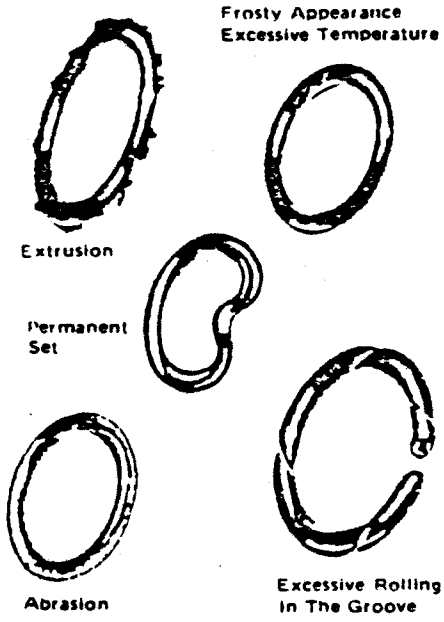
d. Repair cracks with overall dimension of eight to twelve inches in length with the V out method, starting at one end and continuing to the middle. Repair this opened area as in (c.) mentioned before; except that each succeeding layer should be applied in a cascade manner. In other words, each succeeding layer of deposited weld is shorter at starting point and at end. This permits proper tie-in of weld beads when the remaining portion of crack is opened up and repaired. NOTE: TAPER ends of ALL areas V-ed out. This allows proper fusion and access to the parent metal.

e. For cracks with dimensions OVER twelve inches.

Where possible, V out middle one-third of repair area to base of crack. Complete the repair of this area with each successive layer applied in a cascade manner on both ends.



O-rings in service undergo slight swelling and softening which may be non-visible, when worn. Increased damage can occur on re-installation, so use ONLY NEW RINGS. Inspection of old, damaged rings can identify failure from extrusion, wear, torsion set, excessive permanent set or rolling in the groove.



Excessive extrusion may indicate the use of the wrong ring or backup rings were not installed. Irregular wear may indicate a rough spot or eccentricity in the cylinder. The ring may also fail from defect that careful pre-installation inspection may have seen. Some O-rings, lacking proper resilience, might have been subjected to overtemperatures. Since rings are not designed for high temperatures, they should be replaced, regardless of appearance, once known rings have been subjected to unusual heat. Overheated rings are hardened, crack with flexing, take a set and lack resilience. Once old ring has been inspected, cut it in two pieces and THROW AWAY.

Before installing, check surfaces and rings. Metal surfaces must be free of dust, dirt and gunk. Stoddard solvent (kerosene base with rust inhibitor) cleans parts and leaves a good surface for lube to adhere to. However, these cleaning fluids can cause some rings to swell. So check that cleaning fluid does not harm the O-ring if left on surface.

Once the proper O-ring is selected and part number is rechecked; examine the ring closely for defects, dirt or lint.

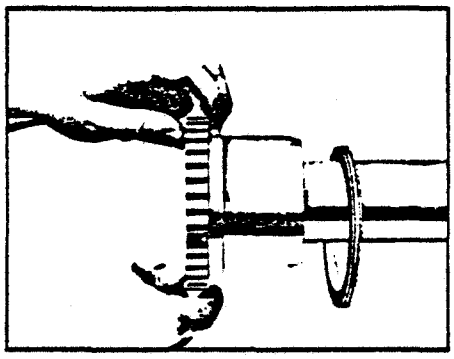
Throw out faulty rings after cutting so they do not get mixed with good ones. Discard new rings that are too tight once installed, do not return these to storage.

Once installed; an O-ring seats snugly, but freely in its groove.

PREPARATION requires checking the surface for scratches from fingernails, tools or fitting threads. DO NOT pinch ring between boss and fitting. Watch for sharp edges on groove shoulder or fitting. Thread burrs may be removed by running a nut onto the thread.

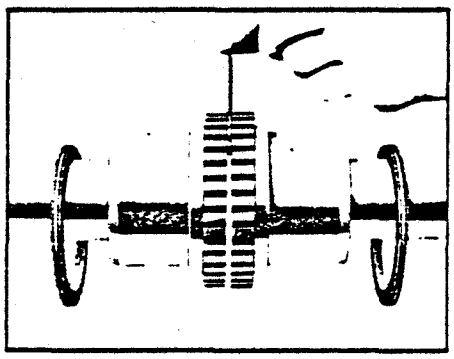
Before installing, lube ring and surface sparingly with a light coat of grease. Lubing helps eliminate a distorting stretch (causing a leak) and aids ring in seating naturally in groove without wrinkles or twists. Remember, the lube must be compatible with O-ring material and system fluid.

INSTALLATION OF TYPE T10 STEELFLEX TAPERED GRID COUPLINGS



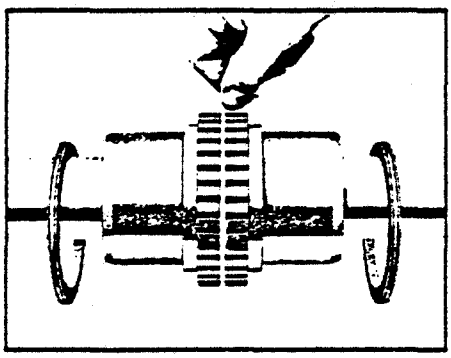
1 MOUNT SEALS AND HUBS

Lock out starting switch of prime mover. Clean all metal parts using a non-flammable solvent. Lightly coat seals with grease and place on shafts BEFORE mounting hubs. Mount hubs on their respective shafts so the hub face is flush with the end of its shaft. Tighten set screws when furnished.



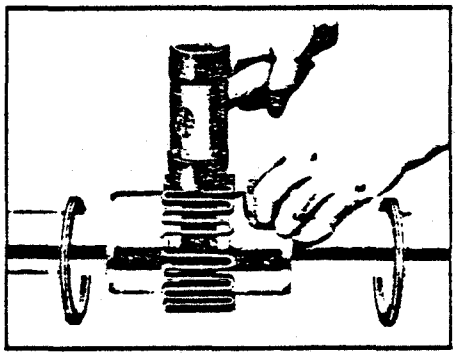
2 GAP & ANGULAR ALIGNMENT

Use a spacer bar equal in thickness to the normal gap specified in Table 1. Insert bar, as shown above, to same depth at 90° intervals and measure clearance between bar and hub face with feelers. The difference in minimum and maximum measurements must not exceed the ANGULAR limit specified in Table 1.



3 OFFSET ALIGNMENT

Align so that a straight edge rests squarely (or within the limits specified in Table 1) on both hubs as shown above and also at 90° intervals. Check with feelers. The clearance must not exceed the OFFSET limit specified in Table 1. Tighten all foundation bolts and repeat Steps 2 and 3. Realign coupling if necessary. NOTE: Use a dial indicator for more accurate alignment.



4 INSERT GRID

Pack gap and grooves with specified lubricant before inserting grid. When grids are furnished in two or more segments, install them so that all cut ends extend in the same direction; this will permit cover installation. Spread the grid slightly to pass it over the coupling teeth and seat with a soft mallet.

CONVERSION TABLE
Fractional Inch to Decimal Inch and Millimeters

Fractional Inch	Decimal Inch	Millimeters	Fractional Inch	Decimal Inch	Millimeters
1/64	0.015625	0.3969	33/64	0.515625	13.0969
1/32	0.03125	0.7938	17/32	0.53125	13.4938
3/64	0.046875	1.1906	35/64	0.546875	13.8906
1/16	0.0625	1.5875	9/16	0.5625	14.2875
5/64	0.078125	1.9844	37/64	0.578125	14.6844
3/32	0.09375	2.3812	19/32	0.59375	15.0812
7/64	0.109375	2.7781	39/64	0.609375	15.4781
1/8	0.125	3.1750	5/8	0.625	15.8750
9/64	0.140625	3.5719	41/64	0.640625	16.2719
5/32	0.15625	3.9688	21/32	0.65625	16.6688
11/64	0.171875	4.3656	43/64	0.671875	17.0656
3/16	0.1875	4.7625	11/16	0.6875	17.4625
13/64	0.203125	5.1594	45/64	0.703125	17.8594
7/32	0.21875	5.5562	23/32	0.71875	18.2562
15/64	0.234375	5.9531	47/64	0.734375	18.6531
1/4	0.25	6.3500	3/4	0.75	19.0500
17/64	0.265625	6.7469	49/64	0.765625	19.4469
9/32	0.28125	7.1438	25/32	0.78125	19.8438
19/64	0.296875	7.5406	51/64	0.796875	20.2406
5/16	0.3125	7.9375	13/16	0.8125	20.6375
21/64	0.328125	8.3414	53/64	0.828125	21.0344
11/32	0.34375	8.7312	27/32	0.84375	21.4312
23/64	0.359375	9.1281	55/64	0.859375	21.281
3/8	0.375	9.5250	7/8	0.875	22.2250
25/64	0.390625	9.9219	57/64	0.890625	22.6219
13/32	0.40625	10.3188	29/32	0.90625	23.0188
27/64	0.421875	10.7156	59/64	0.921875	23.4156
7/16	0.4375	11.1125	15/16	0.9375	23.8125
29/64	0.453125	11.5094	61/64	0.953125	24.2094
15/32	0.46875	11.9062	31/32	0.96875	24.6062
31/64	0.484375	12.3031	63/64	0.984375	25.0031
1/2	0.50	12.7000	1	1.00000	25.4000

CONVERSION TABLE
Millimeters to Inches

Millimeters	Inches	Millimeters	Inches	Millimeters	Inches
1	0.0394	36	1.4173	71	2.7953
2	0.0787	37	1.4567	72	2.8316
3	0.1181	38	1.4061	73	2.8740
4	0.1575	39	1.5354	74	2.9134
5	0.1968	40	1.5748	75	2.9527
6	0.2362	41	1.6142	76	2.9921
7	0.2756	42	1.6535	77	3.0315
8	0.3150	43	1.6929	78	3.0709
9	0.3543	44	1.7323	79	3.1102
10	0.3937	45	1.7716	80	3.1496
11	0.4331	46	1.8110	81	3.1890
12	0.4724	47	1.8504	82	3.2283
13	0.5118	48	1.8898	83	3.2677
14	0.5513	49	1.9291	84	3.3071
15	0.5905	50	1.9685	85	3.3464
16	0.6299	51	2.0079	86	3.3858
17	0.6693	52	2.0472	87	3.4252
18	0.7087	53	2.0866	88	3.4616
19	0.7480	54	2.1260	89	3.5039
20	0.7874	55	2.1653	90	3.5433
21	0.7874	56	2.2047	91	3.5827
22	0.8661	57	2.2441	92	3.6220
23	0.9055	58	2.2835	93	3.6614
24	0.9449	59	2.3228	94	3.7008
25	0.9842	60	2.3622	95	3.7401
26	1.0236	61	2.4016	96	3.7795
27	1.0630	62	2.4409	97	3.8189
28	1.1024	63	2.4409	98	3.8583
29	1.1417	64	2.5197	99	3.8976
30	1.1811	65	2.5590	100	3.9370
31	1.2205	66	2.5984		
32	1.2598	67	2.6378		
33	1.2992	68	2.6772		
34	1.3386	69	2.7165		
35	1.3779	70	2.7559		

1 millimeter = .03937 inch. 1 inch = 25.4 millimeter.

METRIC CONVERSIONS

To convert a metric unit to the equivalent English unit, multiply or divide by the conversion factor as indicated below.

To convert from an English unit to a corresponding metric unit, use the same conversion factors, but, reverse all multiplications to division and all divisions to multiplication.

Calories x 3.968 = British thermal units
Calories ÷ .252 = British thermal units
Centimeters x .3937 = Inches
Centimeters ÷ 2.54 = Inches
Cubic Centimeters ÷ 16.387 = Cubic Inches
Cubic Centimeters ÷ 3.70 = Fluid Drams (U.S.P.)
Cubic Centimeters ÷ 29.57 = Fluid Ounces (U.S.P.)
Cubic Meters x 35.314 = Cubic Feet
Cubic Meters x 1.308 = Cubic Yards
Grams x 15.432 = Grains
Grams ÷ 28.35 = Ounces avoirdupois
Grams per cu. cm. ÷ 27.7 = Pounds per cubic inch
Grams (water) ÷ 29.57 = Fluid Ounces
Hectares x 2.471 = Acres
Hectares x .003861 = Square Miles
Hectoliters x 2.84 = Bushels (2150.42 Cubic Inches)
Hectoliters x 3.53 = Cubic Feet
Hectoliters x .131 = Cubic Yards
Hectoliters x 26.42 = Gallons (231 Cubic Inches)
Kilo per cheval x 2.235 = Pounds per horse power
Kilo per cubic meter x .062 = Pounds per cubic foot
Kilo per meter x .672 = Pounds per foot
Kilogram Meters x 7.233 = Foot Pounds
Kilograms x 2.2046 = Pounds
Kilograms x 35.3 = Ounces avoirdupois
Kilograms ÷ 907.18 = Short Tons (2000 pounds)
Kilograms per sq. cm. x 14.223 = Pounds per square inch
Kilograms per sq. cm. ÷ .0703 = Pounds per square inch
Kilograms per sq. mm. x 1422.32 = Pounds per sq. inch
Kilometers x .621 = Miles
Kilometers ÷ 1.6u93 = Miles
Kilometers x 3280.8 = Feet
Kilowatts x 1.34 = H.P. (33,000 ft. lbs. per min.)
Liters x 61.025 = Cubic Inches
Liters ÷ 28.317 = Cubic Feet
Liters x 33.81 = Fluid Ounces (U.S.P.)
Liters x .2642 = Gallons (231 Cubic Inches)
Liters ÷ 3.785 = Gallons (231 Cubic Inches)
Meters x 3.28 = Feet
Meters x 39.37 = Inches
Meters x 1.094 = Yards
Metric Tons x 2204.6 = Pounds
Millimeters x .03937 = Inches
Millimeters ÷ 25.4 = Inches
Square Centimeters x .155 = Square Inches
Square Centimeters ÷ 6.45 = Square Inches
Square Kilometers x 247.1 = Acres
Square Kilometers x .3861 = Square Miles
Square Meters x 10.764 = Square Feet
Square Millimeters x .00155 = Square Inches
Square Millimeters ÷ 645 = Square Inches
Watts ÷ 746 = Horse Power
Watts x .00134 = Horse Power

is located, rather than a false lead. Where possible, make tests under two different conditions (i.e., stall and no-load) to confirm conclusions.

Once faulty stage is located, determine the actual part that failed. Often an ohmmeter helps here, but may offer erroneous indications. If a semi-conductor, magnetic amplifier or other complex device is suspected, replace it rather than try to prove it bad by test. This saves time and tests just as well. This assumes that spares exist, as they should.

PERFORMANCE: Replace or repair faulty part, than prove this action correct by checking that system function properly. Many electricians feel the job complete with machine in operation. A good electrician determines the cause of failure, then takes necessary steps to prevent further failure. Cause may be the improper function of another part or circuit, improper use or overloading of a device, either by supplier or user; perhaps the effect of external conditions of dirt, moisture, temperature or normal life exceeded. A good electrician determines cause of failure and takes preventative steps.

TYPES OF FAILURES: The preceeding material, general in nature, allowed development of a procedure of troubleshooting for any problem. The following discusses certain failures in more detail.

Most failures are circuit opening, wire breaks, resistors or coils opening, faulty contacts, etc. An open circuit's best feature is that current cannot flow, so the best check is for current flow.

Current measurements are difficult since opening a circuit and inserting the proper instrument is required. Generally, it's better to use Ohm's law and seek a voltage drop caused by the current using a voltmeter that connects easier.

Voltage measurements indicate an open circuit only if readings are properly understood. Voltage across an open circuit generally is higher than expected. Special conditions such as a sneak circuit provide nearly normal voltage across an open circuit. The following is one example.

Assume a motor field is open. If normal voltage is almost the same as exciter voltage, the reading across the field will be almost identical whether field is open or not. Likewise, if several motor fields connect in parallel, voltage across the group changes little with one open field. While the voltage differs somewhat, this difference well could be attributed to a change in exciter voltage or an inaccurate meter. In these cases, find the trouble by measuring voltage across each field coil. This emphasizes an earlier point, use care in selecting a test point and eliminate confusing readings.

has been removed and the circuit grounded. Feeling of excessive heat may indicate an overloaded condition and should be corrected.

TIGHTENING operation should be done on all connections that has worked loose due to vibration, etc. Loose parts are a definite hazard because they may fall out of place and damage nearby components. The importance of firm mounting and tight connections cannot be overemphasized. Always replace missing or broken bolts of proper size and use the correct tools.

ADJUSTING should be done when inspection indicates that it is required to maintain normal operating conditions. Specific adjustment is contained in the "Mechanical Adjustment Section" of this manual, the electrical manual or the component manufacturer's manual.

LUBRICATION refers primarily to the application of CORRECT LUBRICANT in the CORRECT AMOUNT to bearings and other rotating parts. It also means the application of a light oil to door hinges or other sliding surfaces. Use only clean and proper lubricant.

Planned maintenance, common sense and good judgment is less costly and more effective than panic maintenance. Action taken on recommendations made on the following suggested inspection Check List, or Lists by your maintenance department, should reduce repair, maintenance cost, and increase production.

Whenever a problem is indicated, the inspector should briefly explain it on the maintenance report (end of this section) along with his signature. Then, an authorized person should explain briefly a solution to the problem. Now, set a date and time to, and above ALL, CORRECT THE PROBLEM.

NOTES: