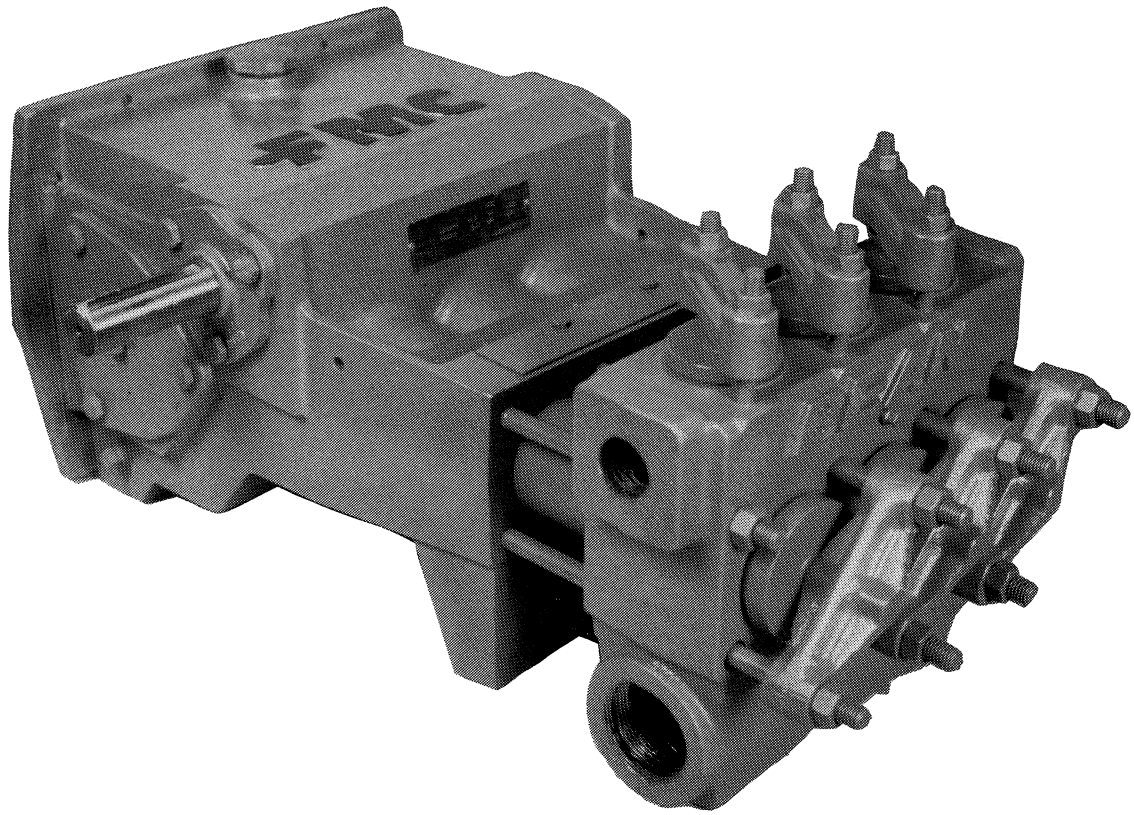
FMC

Manual No.
5262452

Owners Manual

Model L11
Industrial Pump



Section A
Safety Instructions

Accident occur every year because of careless use of industrial equipment. You an avoid hazards involved with high pressure pumping operations by following these safety instructions.

⚠WARNING

Always use a pressure gauge when operating pump. The pressure must not exceed specified 1200 PSIG or pump casing could be damaged causing leakage, resulting in injury to personnel in vicinity.

Do **not** adapt relief valves to maintain more pressure than their specifications state. This could result in relief valve or pump casing bursting due to too much pressure. Personnel in general area could be physically harmed.

Do **not** put a valve between the pump and relief valve. If the pump should be started with this valve closed this could put excessive pressure on the pump which could cause the pump case to burst and might injure personnel or other equipment in vicinity.

Be sure to use shields or covers on pumps used for pumping hot water or chemicals. This precaution can prevent service personnel from being burnt by hot water or exposed to chemicals when leaks might occur.

Be sure to use shields or covers on all sheaves, belts, and drives. Guards can prevent personnel from becoming seriously injured by being entangled in fast rotating parts.

Always disconnect pump from power source before performing any service to the pump. Failure to do this could cause electrical shock or injury from moving pump parts.

Always relieve pressure on the system before removing the suction or discharge chamber. Failure to do so may spray water or chemicals on service personnel causing water burns or chemical exposure.

Use extreme care when using solvents to clean pump and pump parts. Most solvents are highly flammable. Observe all safety instructions on packaging. Fires could result in serious burns to personnel and serious damage to equipment.

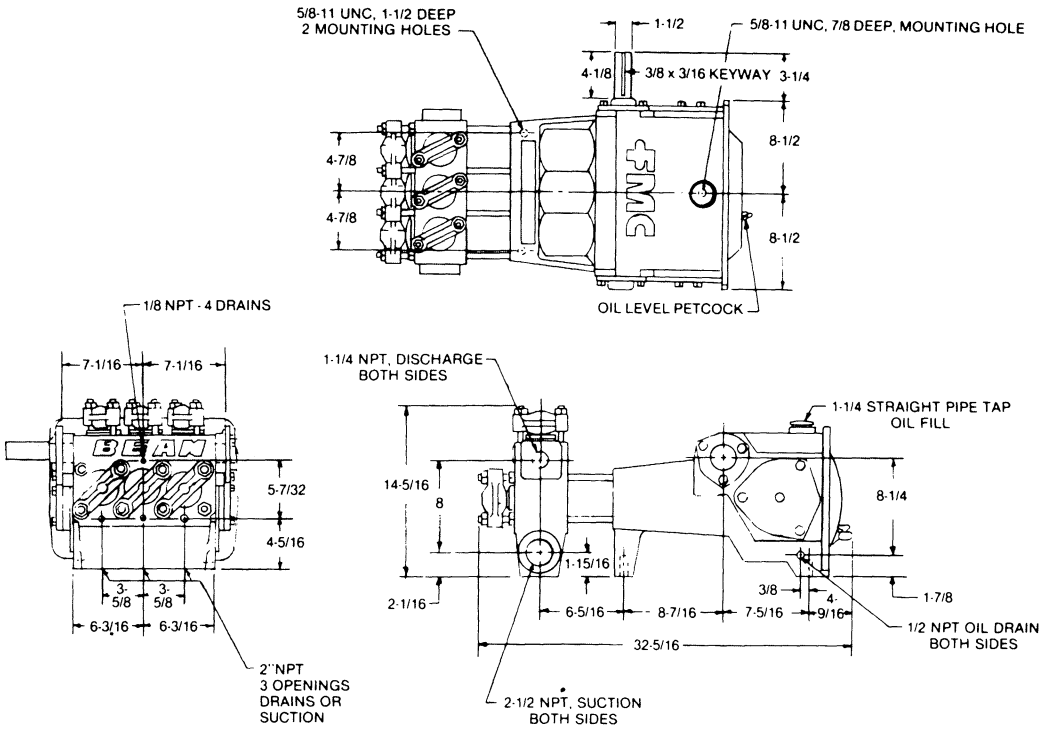
Do **not** modify the pump to function beyond its specifications.

Table of Contents

To Our Customer

We at FMC would like to express our appreciation in your decision to use one of our industrial pumps. This pump was designed by experienced engineers and built by skilled workmen to provide you with quality equipment.

FMC stands behind all its products. The warranty on your pump is printed on the back of the Delivery Report. Be sure your dealer has you sign a Delivery Report and supplies you with a copy.



	English				Metric			
	L1118B-1	L1118D-1	L1122B-1	L1122D-1	L1118B-1	L1118D-1	L1122B-1	L1122D-1
No. of cyl.	3	3	3	3	3	3	3	3
Bore; cyl.	2¼"	2¼"	2¾"	2¾"	57mm	57mm	69.9mm	69.9mm
Stroke	2¾"	2¾"	2¾"	2¾"	69.9mm	69.9mm	69.9mm	69.9mm
Capacity	GPM	GPM	GPM	GPM	LPM	LPM	LPM	LPM
Min.	14	14	20	20	53	53	76	76
Max.	27	50	40	75	102	189	151	284
Discharge pressure	PSI	PSI	PSI	PSI	KPA	KPA	KPA	KPA
Inter.	1200	1200	1000	1000	8273	8273	6895	6895
Input shaft RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM
Min.	350	350	350	350	350	350	350	350
Max.	690	1270	680	1275	690	1270	680	1275
Shaft diam.	1½"	1½"	1½"	1½"	38mm	38mm	38mm	38mm
Crankcase cap	4 qts.	4 qts.	4 qts.	4 qts.	3.7L	3.7L	3.7L	3.7L
Lubrication oil		S.	A.	E.	30			
Inlet opening diameter	2½ NPT	2½ NPT	2½ NPT	2½ NPT	2½ NPT	2½ NPT	2½ NPT	2½ NPT
Outlet opening diameter	1¼ NPT	1¼ NPT	1¼ NPT	1¼ NPT	1¼ NPT	1¼ NPT	1¼ NPT	1¼ NPT
Max. fluid Temperature	160°F	160°F	160°F	160°F	71°C	71°C	71°C	71°C
Dimensions	inches	inches	inches	inches	M.M.	M.M.	M.M.	M.M.
Height	14-5/16"	14-5/16"	14-5/16"	14-5/16"	362mm	362mm	362mm	362mm
Width	20¼"	20¼"	20¼"	20¼"	514mm	514mm	514mm	514mm
Length	32-5/16"	32-5/16"	32-5/16"	32-5/16"	820mm	820mm	820mm	820mm
Weight	385 lbs.	385 lbs.	385 lbs.	385 lbs.	175 Kg	175 Kg.	175 Kg.	175 Kg.

Section B
Specifications
Model L11 Industrial Pump

Description

The L11 is a high pressure triplex piston pump designed for long life in demanding industrial operating conditions. All pumps in these lines utilize durable, high quality materials such as ceramics and hardened stainless steel to minimize wear and corrosion of critical components. The disc valves are stainless steel and give maximum volume and quiet operation with a free flowing liquid. Stainless steel ball valves provide positive sealing by line contact for viscous liquids with small or suspended solids. Ceramic cylinders are standard on all L11 pumps. The drive end features a pump case made of SAE G3000 cast iron. The casting is internally ribbed for added strength and the crosshead guides are machined as an integral part of the crankcase. The ring gear is made of drop forged, fine grained alloy steel. The ring gear is precision machined and shrink fitted to the crankshaft - for positive alignment and concentricity.

Crankcase - totally enclosed design, iron alloy casting, adaptable to right or left-hand drive, oil bath.

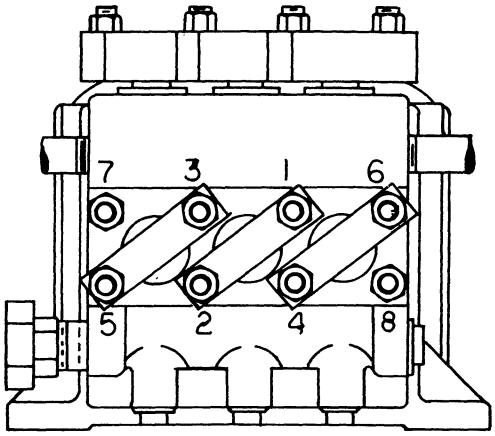
Connecting Rod - Forged steel split cap design, with shell type bearing inserts.

Crossheads - Cylindrical design cast iron with stainless steel crosshead rods.

Crankshaft - Ductile iron alloy.

Valve Chamber - Ductile iron construction or aluminum bronze is optional.

Cylinders - Non-wearing alumina ceramic.



TORQUE SEQUENCE FOR CYL. COVERS & CORNER STUDS.

TORQUE SPECIFICATION	
CONNECTING RODS	65 FT. LBS.
BEARING COVERS	50 FT. LBS.
CYLINDER COVERS	90 FT. LBS.
VALVE COVERS	60 FT. LBS.
PACKING NUT ASY	35 FT. LBS.
REAR COVER	15 FT. LBS.

Section C

Installation Procedures

Storing Before Installation
Your FMC pump will come to you prepared for any necessary storage periods before installation.

Selecting Pump Location
Always locate the pump as close to the source of supply as possible. The pump should also be located in a light, clean, dry space where adequate inspection and maintenance operations can be performed.

Securing Pump to Foundation

Steps	Procedures
1	Locate the pump so the power will turn the top of the pump sheave away from the fluid end of the pump.
2	Align the power source drive sheave and pump sheave. To check the alignment, use a straight edge, square or rule. Place the straight edge against the sides of the sheaves to be sure they are in line and running exactly parallel to each other.
NOTE: Proper alignment of the drive sheaves is very important to prevent excessive pump bearing and V-belt wear.	
3	Mount the pump on either a concrete or rigid metal-base using the mounting supplied with the pump and ½" bolts. (Use shims, to level the pump if necessary, to prevent straining the pump case.)
4	Secure the pump to maintain alignment and to prevent vibration.

Installing the Pump Suction Line

Steps	Procedures
1	Determine the shortest most direct route possible for the suction hose.
2	Make a preliminary design of suction piping. Remember the line should be as large, direct, and short as possible.

NOTE: Line must be laid out so there are no high spots to cause air pockets. Any air pockets in the line could make priming the pump difficult or impossible.

3	Analyze the Net Positive Suction Head that would be available in your preliminary design. The NPSHA (Net Positive Suction Head Available) is a characteristic of your pumping system determined by: a. The elevation of the suction supply in relation to the pump suction port (static head)

NOTE: Static head is (+) plus when liquid is above the pump's center line, and (-) minus when liquid is below (or suction lift).

	b. Altitude of the installation above sea level (atmospheric head) c. Friction in suction line (friction loss) d. Liquid vapor pressure (p) e. Amount of suction head required to accelerate fluid in the suction pipe to prevent cavitation (acceleration head)

NOTE: NPSHA = ± static head + atmos. head-friction loss-acceleration head-VP

4	Compare available NPSH with required NPSH for your pump at your particular RPM requirements.

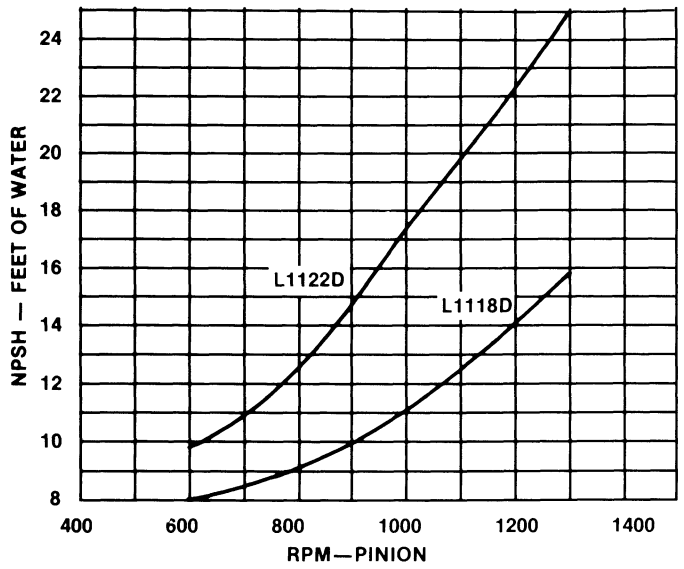
NOTE: There must be at least two additional feet of NPSHA over the required NPSH to compensate for variations in atmospheric pressure and other similar variables.

5	After determining the correct suction line for your required needs install the line. The suction line should be supported independently of the pump. Install a union as close to the pump as possible, to allow for easy removal of the valve chamber during servicing.

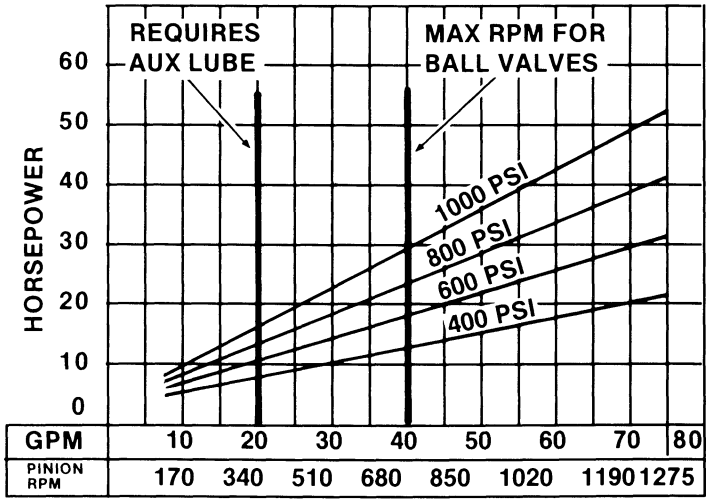
NOTE: It is advisable to use a flexible connection such as a hose between the hard pipe and pump suction opening to isolate vibrations.

NOTE: Be sure all parts are free of dirt, scale, burrs, or other foreign material which might interfere with pump operation.

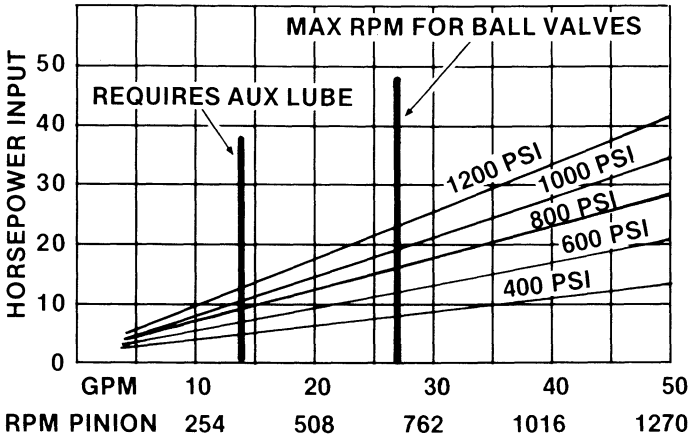
NPSH—CURVES MODEL L11



L1122 PUMP
2¾ BORE x 2¾ STROKE
GEAR RATIO 3.6

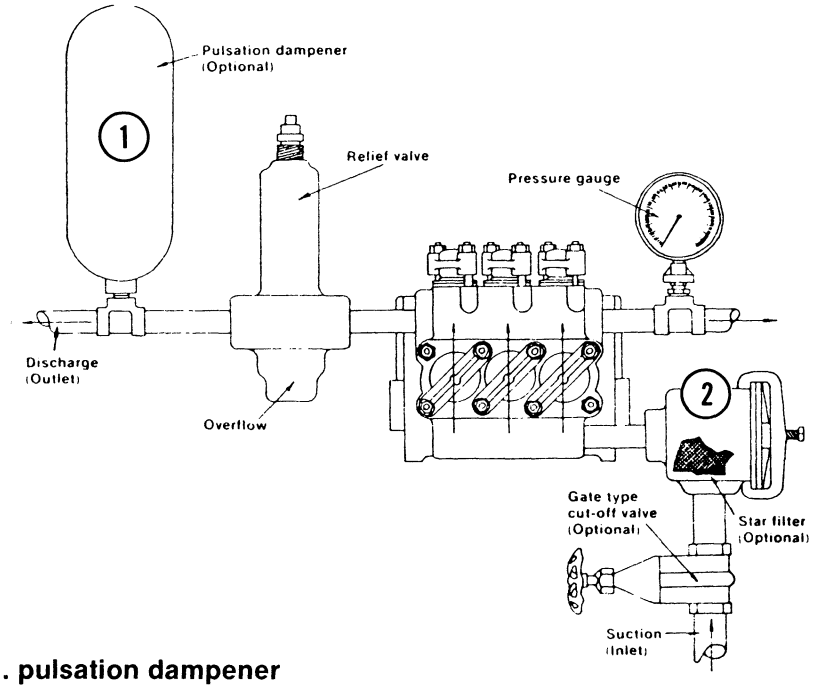


L1118 PUMP
2¼ BORE x 2¾ STROKE
GEAR RATIO 3.6



Installing the Pump Suction Line - Con't.

Steps	Procedures
6	Install a foot valve when there is suction lift. The foot valve should be installed in the suction line near the fluid source. The foot valve will keep the lines to the pump filled and avoid the necessity of priming at each start.
7	If the supply of liquid is delivered from a pressurized line or through rigid pipe, it is advisable to install a suction line air chamber close to the pump inlet to reduce the possibility of water hammer. On pressurized suction lines an accumulator should be used and precharged to 2/3 of the maximum anticipated suction pressure.
8	Install drain plugs or drain cocks in low points of suction lines.
NOTE: This is highly important where temperature conditions are below freezing.	
9	Install suction strainer (2) in the suction line to remove particles that could damage internal pump components.
NOTE: Use only full opening gate valves for minimizing flow restriction.	
10	Make sure all joints are air tight.
NOTE: Air leaks reduce pump capacity and cause cavitation.	



1. pulsation dampener
2. suction strainer

Installing Pump Discharge Lines

Steps	Procedures
1	Determine the shortest most direct route for the discharge line.
2	Determine the length of hose or pipe required and determine the size of the hose or pipe by considering pressure loss per foot of hose required.
3	Select weight of pipe required to meet pressure requirements from adjacent chart. Hose ratings are clearly marked on outer surface of hose.

WARNING
Always use hose or pipe that is designed for your parcicular pressure requirements. Inadequate hose could burst resulting in possible personal injuries and equipment damage.

4	Install pipe or hose to pump.

NOTE: It is advisable to use a flexible connection between the pump and the rigid pipe (if used) and the discharge opening to isolate vibrations and to allow for easier service.

NOTE: Be sure all parts are free of dirt, scale, burns, or other foreign material which might interfere with pump operation.

5	Install the pressure gauge onto the discharge chamber. The pressure gauge will indicate the fluid pressure so that pressure can be adjusted to the proper level.(1)
6	Install the relief valve onto the discharge chamber. (2)
7	Install the relief valve by-pass. If the fluid is drawn from a tank, the relief valve by-pass should be returned to the tank. The flow may be returned to the suction line (when other means of return are not possible) if it is returned into the line a far as possible from the pump to reduce the possibility of turbulence and cavitation in the suction line.

NOTE: The relief valve by-pass line must be as large as the pipe outlet in the relief valve. Never install valves in the bypass line or between the pump and relief valve.

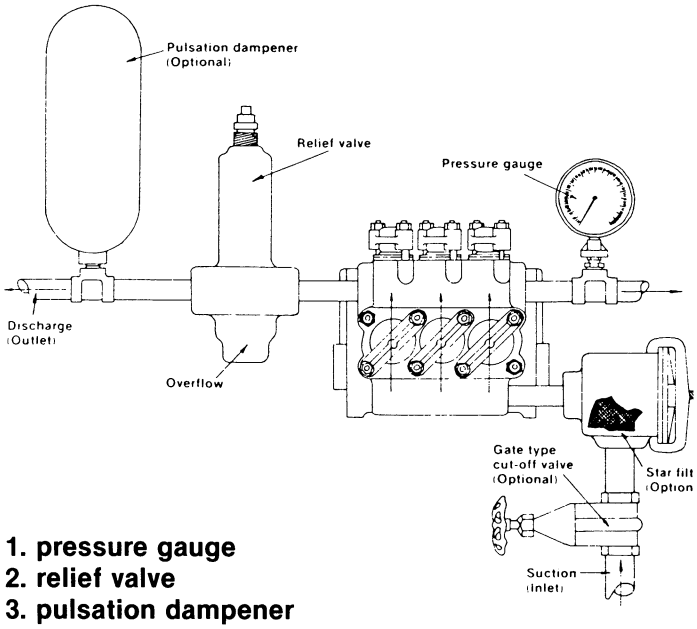
Optional 8	A pop-off valve may be used in the discharge line to limit the pressure. However, provisions should be made to detect leakage past the valve.
Optional 9	A discharge pulsation dampener may be installed to absorb pulsations, pounding and prevent water hammer. It should be installed very near the pump. Bladder type pulsation dampners should be pre-chartered to approximately 2/3 of the maximum anticipated pump pressure.

Pipe pressure chart

Pounds per square inch
For cold water, minor shock conditions

Working Pressures

	Seamless Steel Pipe ASTM A120				Butt Welded Pipe ASTM A120			
Pipe Size	Std. Wt. Sch 40	Extra Heavy Sch 160	Heavy	Double Extra	Std. Wt. Sch 80	Extra Heavy Sch 160	Heavy	Double Extra
1/2	1650	3000	4500	8480	1000	1800	2700	5100
3/4	1370	2460	4300	6980	820	1480	2590	4200
1	1220	2190	3780	6340	730	1320	2280	3818
1-1/4	1040	1850	2850	5230	630	1120	1720	3148
1-1/2	900	1650	2830	4680	540	990	1700	2800
2	800	1480	2900	4030	480	890	1750	2430
2-1/2	800	1450	2380	4160	480	870	1430	2500



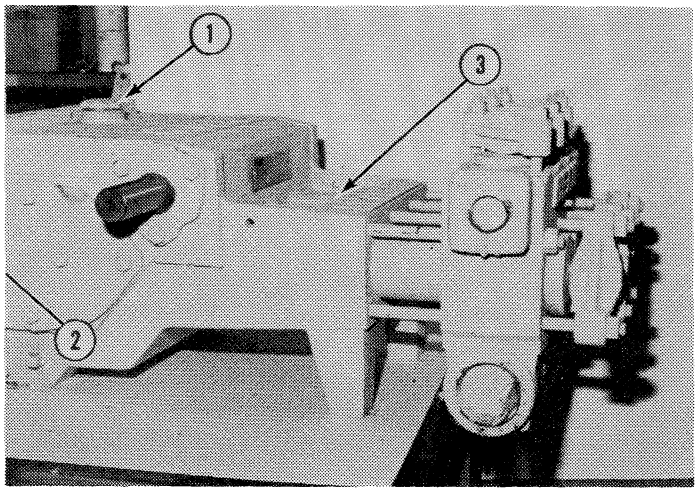
1. pressure gauge
2. relief valve
3. pulsation dampener

Section D

Operation

Check Points Before Starting — Always make the following checks before starting the pump.

Steps	Procedures
1	Make sure the magnetic drain plug in the bottom of the pump case is tight.
2	Check the oil by means of the petcock if necessary add a good grade of SAE 30 non-detergent oil through the filler opening (1).
NOTE: The oil should come up to the petcock (2) on the back of the drive end.	
3	Inspect the entire pump installation to make sure all the joints are tight.
4	Apply grease to the 3 grease fittings (3) and regrease every 1000 hours or twice a year.
NOTE: Grease with a good grade of water resistant grease. (Refer to Lubrication Procedures.)	



1. filler cap
2. petcock
3. grease fittings

HORSEPOWER CURVES MODEL L11

Selecting Operating Speeds

The capacity (gallonage) in a positive displacement pump, such as the L11 is determined by the RPM of the crankshaft.

To achieve the proper capacity desired, select the capacity on the chart then go up and find the RPM required to produce that gallonage.

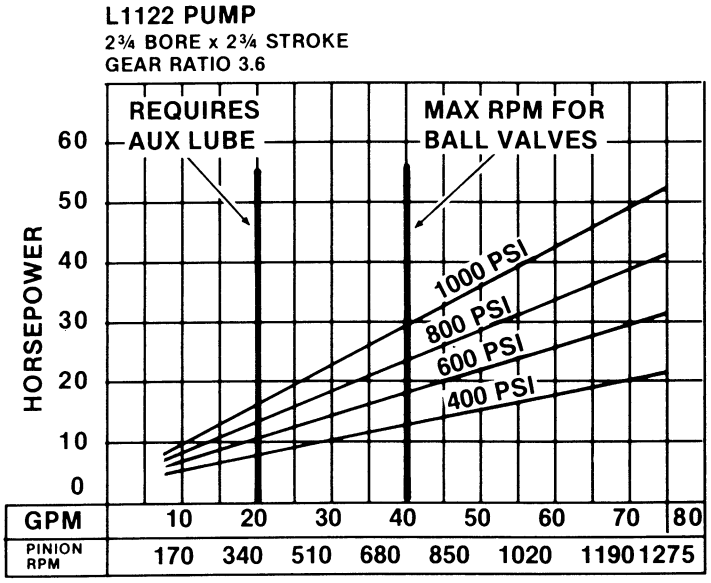
Selecting Operating Procedures

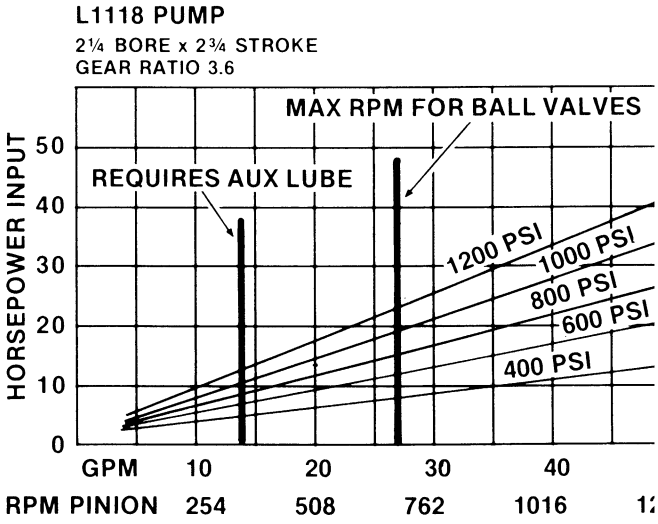
The pressure can be adjusted to the required value by adjusting the relief valve nut.

CAUTION

Do not run the pump beyond the rated pressure or the maximum rated RPM. Exceeding the pump ratings will result in reduced pump life and could cause damage to the motor and piping.

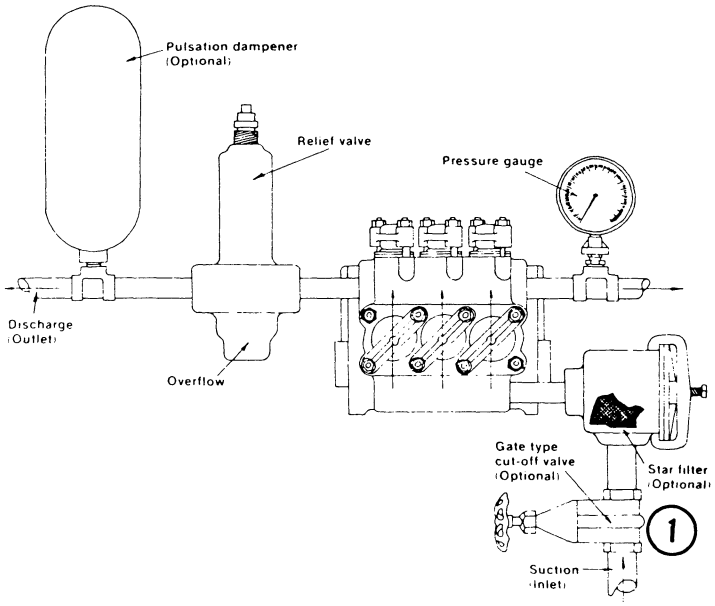
To determine the proper horsepower required to run at a specific pressure producing the required gallonage refer to the chart.

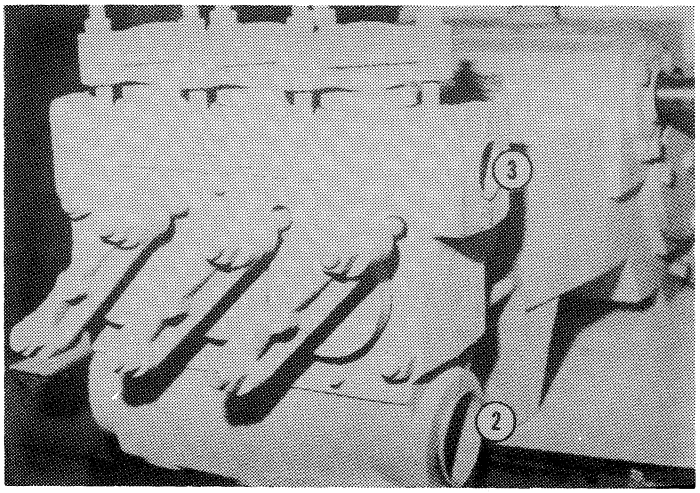




Starting the Pump - The following procedures should be followed when starting the pump for operation.

Steps	Procedures
1	Open the gate valve in the suction line. (1)
NOTE: The gate valve must remain fully open during operation of the pump.	
2	Check to assure power is off.
3	Turn the pump over by hand to make sure the crankshaft is free.
	WARNING **Never try to turn the pump over when the power is on. Service personnel could be entangled in moving sheaves.**
4	Fill the suction line with fluid, if necessary to prime pump.(2)
5	Start the pump, and for a few seconds listen for erratic noise or for unsteady flow which indicates the pump is not primed.
NOTE: Never run the pump over 30 seconds not primed.	
	If flow is not continuous (pulsing) shut the pump off and prime.





1. gate valve
2. suction line
3. discharge portion of valve chamber

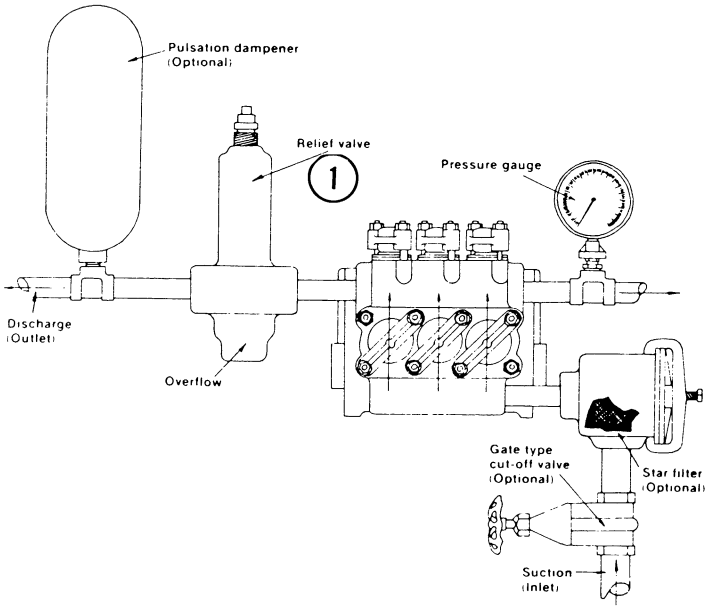
Priming the Pump - The following procedures should be followed for priming the pump.

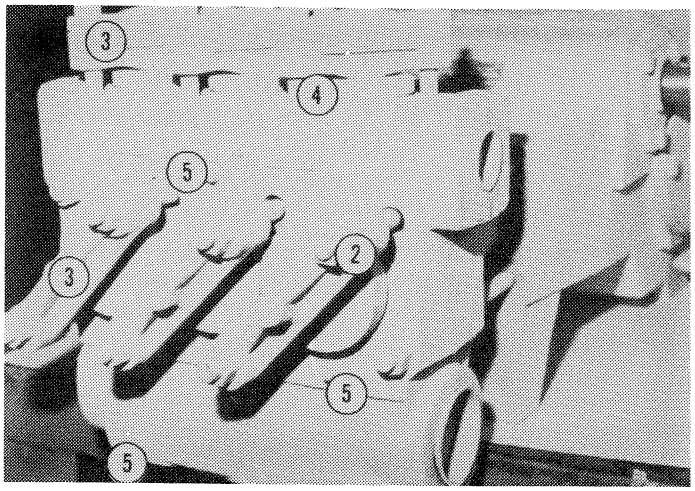
Steps	Procedures
1	Fill the suction line and filter.
2	Remove the accumulator or the pressure gauge by unscrewing.
3	Fill the discharge portion of the valve chamber with fluid.(3)
4	Jog the pump until the fluid is pumped from the discharge ports in a steady, even flow.
5	Reinstall the accumlator or pressure gauge.
6	Start the pump and listen for unsteady flow or erratic noises.
	If unsteady flow persists repeat steps 1-6 until pump is properly primed.
7	If pump continues not to prime, check the plunger packing to see if there is excessive leakage through the packing. Should the packing be leaking 15 to 20 drops per minute shut the pump off and replace the packing. (Refer to Service, Section F)

Shutdown Procedures During Freezing Temperatures

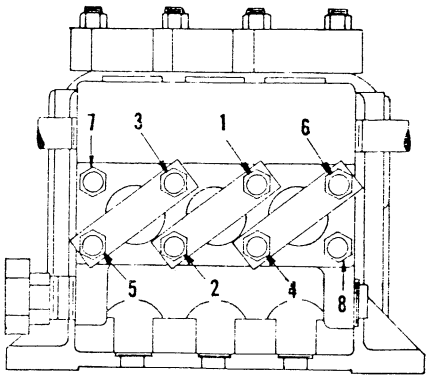
The following procedures should be followed when stopping or storing the pump during freezing weather.

Steps	Procedures
	Let the pump pump air for a few seconds with the discharge outlet and suction line open. This will flush the valves and discharge lines.
	NOTE: When pumping liquids that cannot be contaminated by using a diesel fuel, pump diesel fuel through the system. By doing this, you will eliminate the need for steps 2-12.
	WARNING **Do not use this procedure when pumping fluids that can be contaminating by having diesel fuel in the pump or suction and discharge lines.**
2	Shut the pump off.
3	Relief pressure on the relief valve by turning the top of the valve counterclockwise(1).
	WARNING **Failure to do this could cause fluid to shoot out when discharge manifold is removed and fluid could possibly splash in operator's eyes.**
4	Remove the four 1/8" drain plugs in the valve chamber. Also remove plugs in the valve chamber. Also remove plugs from under the suction valve area of the valve chamber.





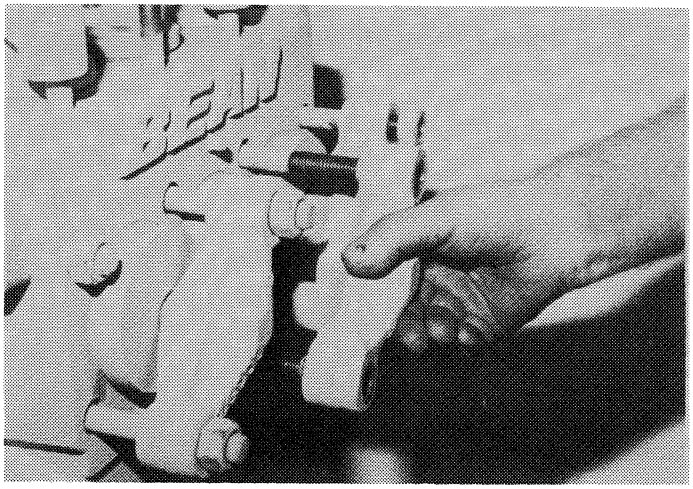
TIGHTENING SEQUENCE

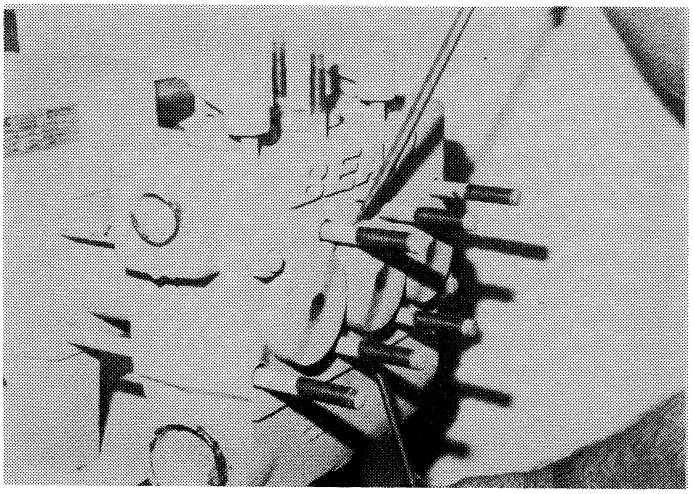


1. relief valve
2. hex nuts
3. cover clamps
4. valve covers
5. drain plugs

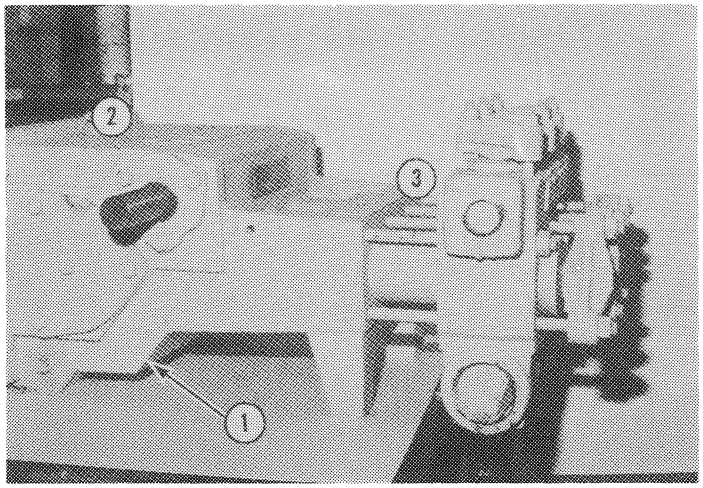
Shutdown Procedures During Freezing Temperatures- cont'd

Steps	Procedures
5	Remove the six hex nuts and the three clamps from the cylinder chamber.
6	Slide the cylinder cover from the valve chamber.
7	Drain all trapped fluid fom inside the valve chamber by lifting the suction valve with the end of a wooden dowel or screwdriver.
8	Coat the valve cover with a rust preventative agent.
9	Replace the valve cover clamps and hex head screws.
NOTE: FMC recommends lubricating bolts before replacing nuts.	
10	Torque the hex head nuts in the sequence shown. Nuts must be torgued to 90 ft. lbs. (81 Newton meters).
11	Replace drain plugs in valve chamber.
12	If a drain plug is used under relief valve, remove plug.
13	Remove drain plugs in all low points of piping.
14	Leave all cutoffs open.





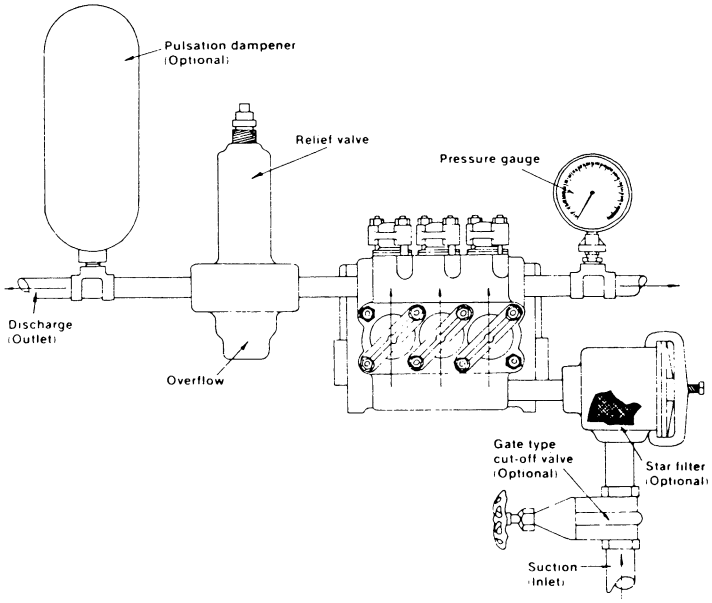
Section E
Maintenance Procedures



The L11 pumps require four quarts (3.7 liters) of grade SAE 30 lubricant in the crankcase. After the first fifty hours of operation, drain oil from the crankcase and remove any metal adhering to the magnetic drain plug. Thereafter, at the end of each 2000 hours of operation, the oil must be drained and the drain plug (1) should be cleaned of any metal adhering to it. Should oil have a milky appearance, this indicates water is leaking past the plunger rod seals in the pump. The plunger rod seals should be checked and replaced if necessary. After draining all the oil, replace the drain plug and add the oil through the oil fill opening (2). Another area of the pump requiring lubrication are the fittings on the plunger oil seal holders. These fittings should be greased once yearly (3).

CAUTION

Do not overgrease fittings to the plunger oil seal holders or damage could occur to oil seal and holders.



Filters should be installed in the suction line to prevent contaminated material from entering the pump and reducing its life and efficiency. During the initial break-in period, the pump filter screen should be inspected frequently. The amount of material trapped in the filter during these inspections will indicate how often the filter screens should be checked. A regular inspection schedule should be developed from this information.

Periodic Maintenance Chart

Components	Description of Service	Remarks
	Break-in Period	
Crankcase	Drain oil from crankcase by removing plug. Clean any metal adhering to plug before replacing. Refill pump case with new oil.	After the first 50 hours of operation.
Pump Filter Screen	Should be inspected frequently to determine a regular inspection schecule.	The amount of material collected in the filter with each check will indicate how often the filter should be inspected.

Components	Description of Service	Remarks
	Daily	
Complete Pump	General inspection of pump in operation to determine if it is functioning properly.	This inspection should take place once each shift of operation.
Plunger Rod Oil Seals	Inspect plunger rod oil seals for leakage.	Leaking at the rate of one or two drops per minute indicates the need for replacing the oil seals (refer to Servicing Oil Seals, page F-7.)
Packing (Plunger)	Inspect packings for leakage.	Excessive dripping at this point indicates worn plunger packing. Adjust or replace as necessary. (Refer to Replacing Plunger Packings, page F-3.)
Pump System	Use water or a suitable solvent and flush the entire system.	For overnight shutdown when using materials that might harden or corrode the pump. Drain all water from pump chambers and piping when freezing temperatures are anticipated.

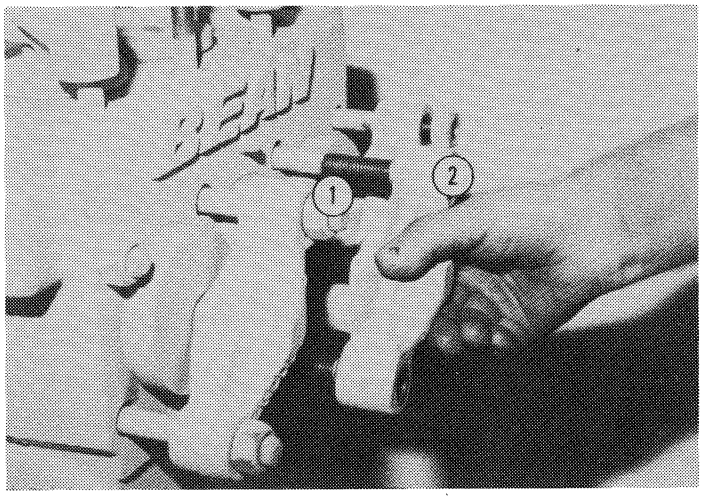
Periodic Maintenance Chart - Con't.

Components	Description of Service	Remarks
	Weekly	
Crankcase	Check oil level in crankcase by opening the petcock on the end of the pump.	With pump stopped, oil level with petcock opening indicates proper oil level.
NOTE: Do not over-fill, oil will run out of oil fill petcock when too full.		

Components	Description of Service	Remarks
	Every 2000 Hours (equals 2.7 months of continuous use)	
Crankcase	Change oil and clean magnetic plug.	SAE 30 grade (non-detergent)
	Long Term Storage	
Pump System	Drain Pump (Refer to page D-4, Storing Pump During Freezing Weather.)	During freezing temperatures.

Section F
Service

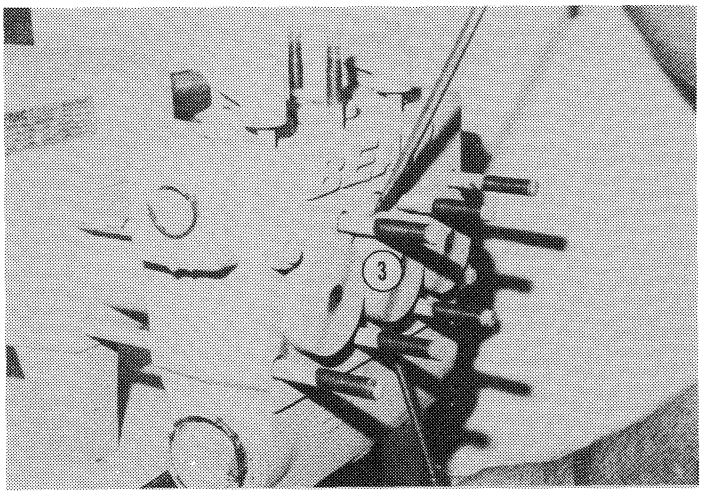
In this section we will cover how to service the pump. The first portion will cover step-by-step procedures for servicing the different areas of the pump. Then at the end of this section you will find a quick reference troubleshooting chart.

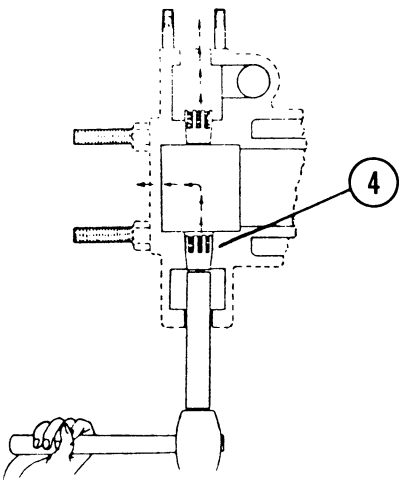


Servicing the Fluid End

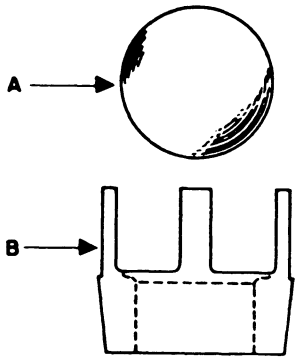
Servicing the Valves - Malfunctioning valves are identified by a uniform hammering or vibration and by reduced pump capacity (volumetric efficiency).

Steps	Procedures
	**WARNING** **Always disconnect pump from power source before performing any service to the pump. Failure to do this could cause electrical shock or injury from moving pump parts.**
1	Remove all plugs in discharge or suction inlets.
2	Remove the six nuts on the studs. (1)
3	Slide the three cover clamps off the studs (2)
4	Slide the three cylinder covers from the valve chamber (3)
5	Remove 6 nuts on valve cover studs.
6	Remove valve cover clamps.
7	Remove valve covers.
8	Rotate the shaft so one plunger is on the complete down stroke.
9	Place the valve seat remover tool (FMC #1285079) or a blunt rod against the suction valve seat and by using a hammer, drive the suction valve seats loose. (4)
10	Remove all three suction valves in the same manner.
11	Insert the blunt tool through the opening for the suction valves and position against the discharge valve seat.
12	Using the hammer, drive the discharge valve out the chamber discharge opening.
13	Remove the valve through valve cover opening.
14	Repeat until all discharge valves are removed.

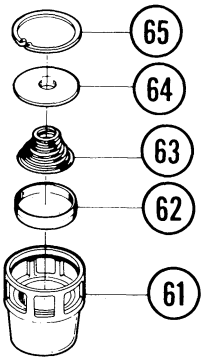




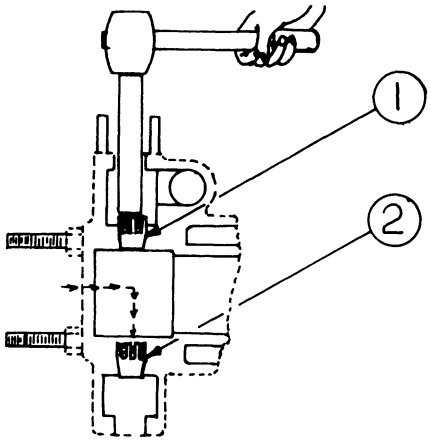
Steps	Procedures
NOTE: The complete valve assembly is available for easy and quick servicing of the pump, or individual valve assembly parts are available. (Refer to parts list.)	
12	Complete valve assemblies can be replaced or just the individual damaged parts. To check the parts of the disc valve, remove the snap ring with a pair of snap ring pliers. This and step 13 are not necessary for ball valves.
13	Once the snap ring has been removed the valve parts may be easily removed and inspected for damage.
14	Check that all surfaces on the valve are free from nicks, burrs and dirt and are dry. Replace any necessary parts.
NOTE: If all valves show wear, replace all valve assemblies to prevent down time during critical periods.	
15	Reassemble the valve parts in the order shown in the illustrations. Making sure the disc on the disc and spring assembly is positioned level in the seat.
16	Check that the spring and disc assembly work freely in the disc valve, and the ball moves freely in ball valves.
17	Insert suction valves squarely in the suction valve openings through the cylinder cover openings. (1) **WARNING** **Incorrectly installed valves could result in severe damage to the pump and/or injury to personnel.**
18	Use a dowel approximately the diameter of the valve and drive the valve firmly in the valve chamber.
19	Insert discharge valves through the valve cover opening so the snap ring or ball is toward the outside of inlet openings. (2)
20	Drive the discharge valves firmly in place as in step 18.
21	Inspect the O-rings on the valve cover, if damaged replace. Carefully replace valve covers taking care not to damage O-rings (3)
22	Replace valve cover clamps
23	Replace six nuts and torque to 60 ft. lbs. (81 N. M)

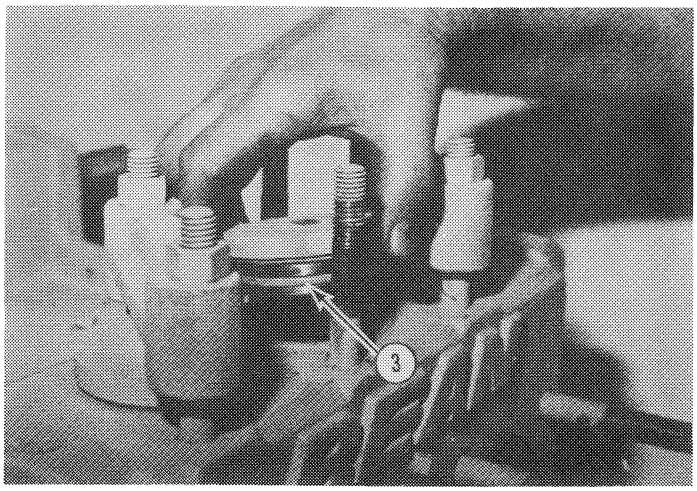


Ball Valve



Disc Valve

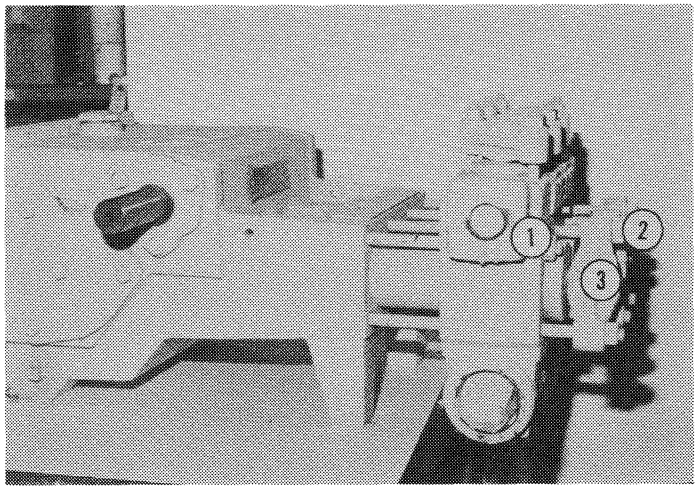


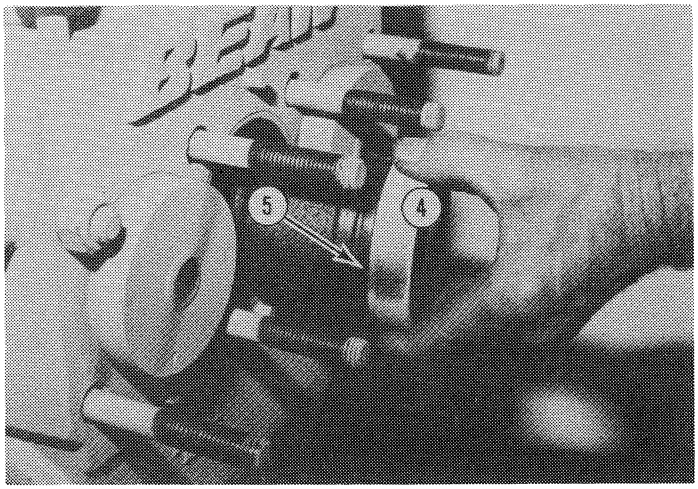


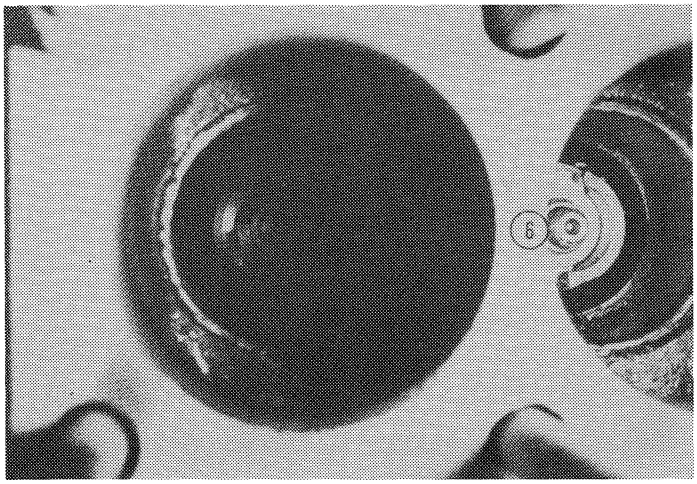
Replacing the Plunger Packings

Plunger packings must be replaced whenever the leakage around the packings affects the pump's efficiency. A small amount of leakage past the packings is normal and is actually desirable to help cool and lubricate the packings. However, leakage of 15-20 drops per minute indicates worn or damaged packings. To change, follow the steps listed below:

Steps	Procedures
	**WARNING** **Always disconnect the pump from the power source before performing any service to the pump. Failure to do so could result in electrical shock or injury from moving pump parts or drive parts.**
1	Check the corner nuts on the valve chamber to assure that they are at 90 ft. lbs. or 81 Newton meters. (1)
2	Remove the six hex nuts (2) on the front of valve chamber.
3	Slide the three cylinder cover clamps (3) off of the valve chamber studs.
4	Remove the three cylinder covers. (4) It may be necessary to tap on the side of the covers to free them from the chamber.
5	Inspect o-rings (5) on the cylinder covers. If damaged, replace with new o-rings.
6	Insert a socket wrench into the valve chamber onto the hex nut (6) in the packing assembly to remove nut.

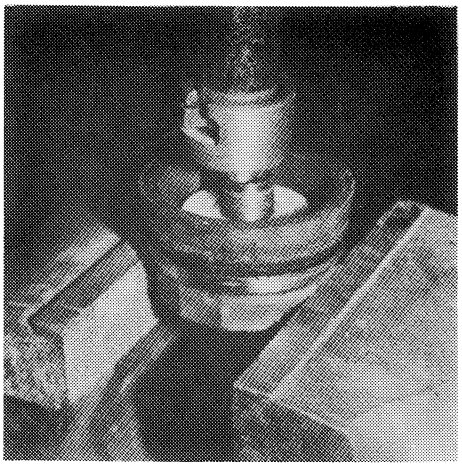


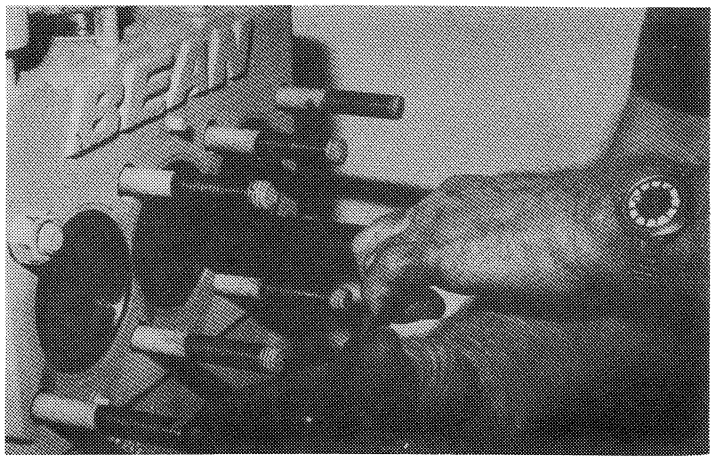


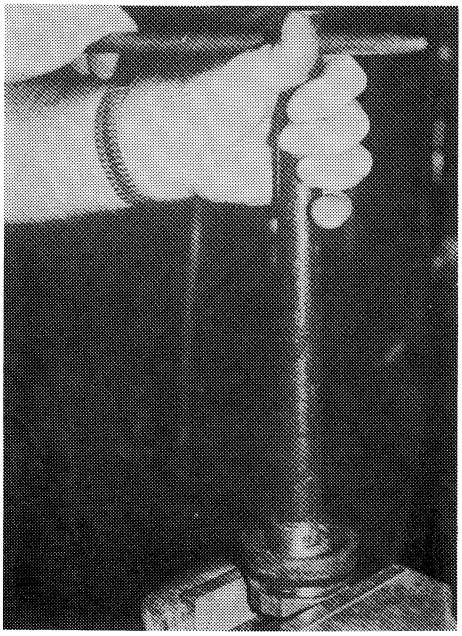


Replacing plunger packings - cont'd.

Steps	Procedures
7	Insert the packing removal tool (FMC part no. A5049). While rotating the tool to the right, pull the packing assembly from the cylinder and out through the valve chamber.
8	Place the packing holder in a vise. Now rotate the nut to the left using the FMC packing tool.
9	Remove the old packing from the packing holder and replace with new packing. Grease the back of the packing to help it conform to the packing holder. Then reinsert packing washer and packing nut into packing holder and reassemble packing nut.
10	Inspect the o-ring on the end of the plunger rod and replace if necessary.
11	Pump should be rotated by hand to bring the crosshead to the front of the cylinder before installing the packing. This will reduce the distance the packing must be driven into the cylinder and minimize the chance of damage or misalignment.
12	Packing assembly can now be installed with one or two sharp raps against the tool with a 24 oz. or heavier hammer. If installation is not accomplished by two or three blows, lubrication is necessary.



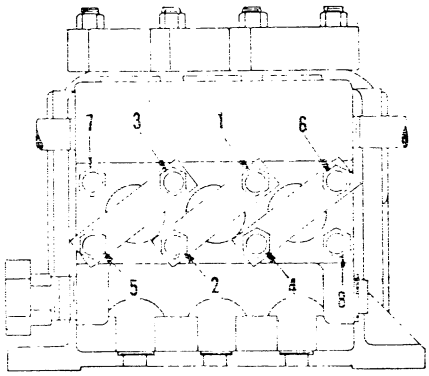




Replacing plunger packings - cont'd.

Steps	Procedures
13	Replace crosshead rod with a socket hand wrench by turning to the right.
14	Replace the cylinder covers and cylinder cover clamps.
15	Place hex head nuts in the sequence shown and torque to 90 ft. lbs. or 81 Newton meters.

TIGHTENING SEQUENCE



Servicing the cylinders

Excessive wear of packings may be due to buildup inside ceramic cylinders. Ceramic cylinders may be removed and cleaned. To clean cylinders, follow the steps listed below (See F-6, Item 5). It is virtually impossible to wear out a ceramic cylinder under normal service conditions, however, they are quite brittle like all ceramic materials and can be cracked or chipped if subject to mechanical impacts or severe thermal shock. Caution should be used when changing from hot to very cold fluids via fast acting solenoid valves. In the event the cylinder is cracked, broken, or needs cleaning, the cylinder can be easily changed or cleaned by the following steps listed.

Steps	Procedures
	**WARNING** **Always disconnect the pump from the power source before performing any service to the pump. Failure to do this could result in electrical shock or injury from moving pump or drive parts.**
1	Disconnect the suction and discharge piping from the valve chamber.

Steps	Procedures
2	Remove the two corner holddown nuts and slide the valve chamber off the studs.
NOTE: Leave the packing in place to retain the ceramic cylinders while the valve chamber is being removed.	
3	Remove the crosshead rod nuts and remove the cylinders. The packing assembly can then be pushed out of the cylinder.
4	To clean build up from cylinders, submerge the cylinder in uncut muratic acid (28% hydrochloric acid) for 3 minutes. Then rinse in clear water and wash with a strong soap. Submerge the cylinder in the acid for two more minutes and rinse in clear water and wipe off.
NOTE: Check oil seals at this point once cylinders are removed and if necessary, replace. To replace, follow procedures listed under changing oil seal.	
	WARNING **When removing the valve chamber and removing the cylinders, be careful to avoid striking the cylinders against a sharp object as they will chip or crack.**
5	Replace gaskets on each end of the cylinder.
6	Install the valve chamber cover and tighten the two corner nuts to ½ the specified torque. (90 ft. lbs. or newton meters).
7	Follow steps 6-14 for replacing plunger packing (refer to page F-4 and F-5).
	CAUTION **Take care when repositioning valve chamber and tightening nuts not to put cylinders in a bind or bump with a sharp object; damage could occur to ceramic cylinders.**

Servicing the cylinders- cont'd

Steps	Procedures
8	Replace the cylinder covers, cylinder clamps, and clamp nuts and tighten nuts until they are tight. Then tighten nuts to ½ of the full torque in the sequence indicated in the illustration (45 ft. lbs.). Then repeat tightening sequence bringing to full torque (90 ft. lbs.) This should include the two corner nuts.
9	After one to two hours of pump operation, check torque on the clamp nuts and if necessary, tighten.

TIGHTENING SEQUENCE

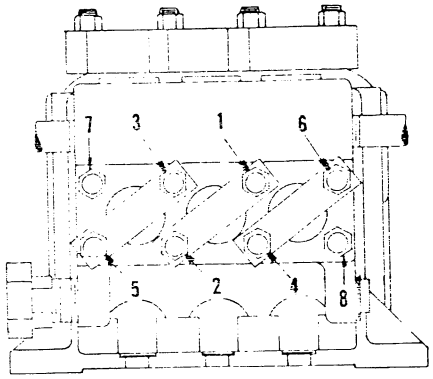
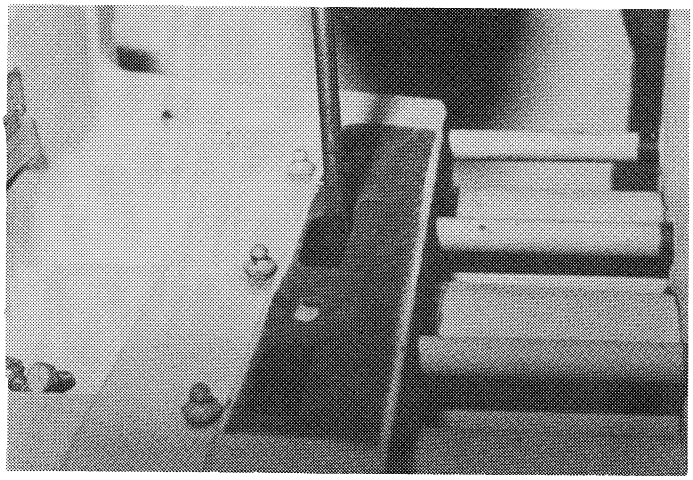


Fig. 5

6

Servicing the Plunger Rod Oil Seals

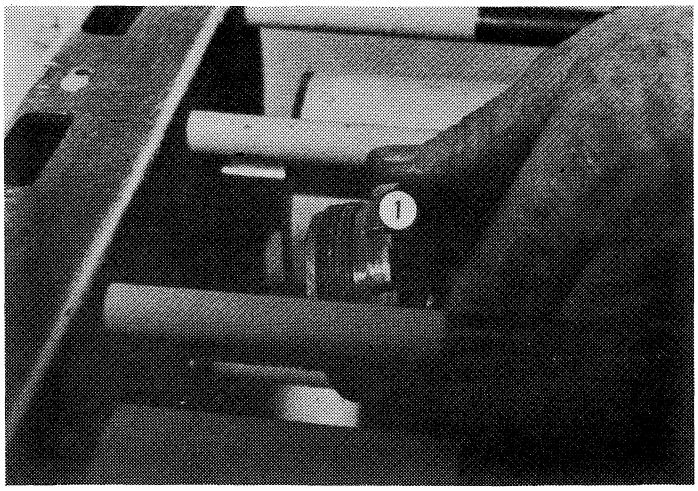
These seals retain oil in the pump case and prevent dirt and fluids from entering the case by way of the plunger rods. Oil leakage around the plunger, dirt on the case, or milky colored oil are signs of worn or damaged crosshead seals. The seals may be replaced without disassembly of the drive end; however, the fluid end must be disassembled. To change the seals, follow the steps below.

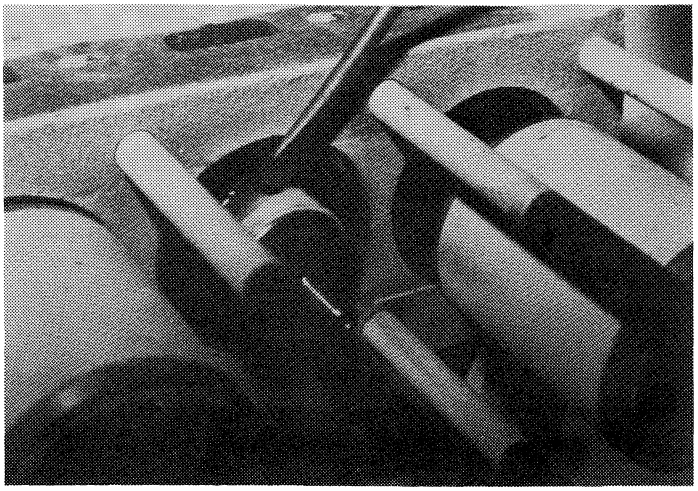


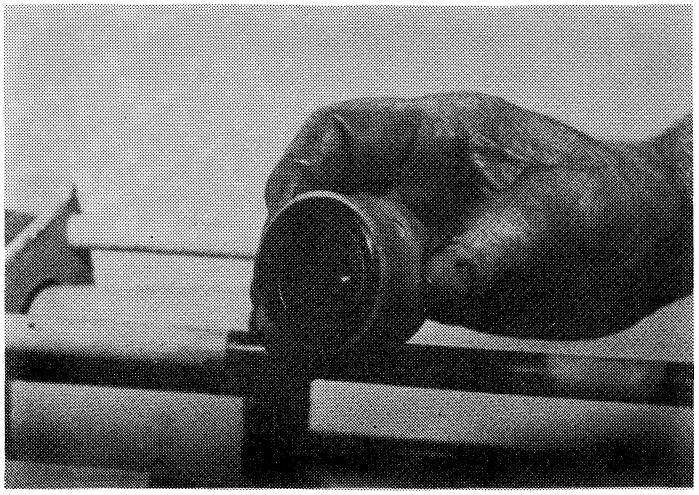
Steps	Procedures
	**WARNING** **Always disconnect the pump from the power source before performing any service to the pump. Failure to do this could result in electrical shock or injury from moving pump parts or drive parts.**
1	Break down the fluid end of the pump following the steps listed under servicing the cylinders.
2	Once valve chamber and cylinder packings have been removed, remove the cover at the pump separation chamber by removing the two screws.

Servicing the plunger rod oil seals- cont-d

Steps	Procedures
3	Insert a large screwdriver into the opening under the separation cover. Using the screwdriver, rotate the oil seal nut to the left until it is unthreaded from the pump case.(1)
4	Remove the oil seal sleeve and oil seals from each plunger rod opening. Slide the sleeve and oil seals from the plunger rod using a simple hook-shaped tool.
NOTE: It is never advisable to reuse oil seals which have been removed from the pump.	
5	Next replace the outer seal so that the lip on the seal faces the valve chamber. Position seal into sleeve until it bottoms out. Replace inner seal so the lip faces the drive end of the pump.
6	Pack the area between the seals inside the sleeve with a Dow corning valve seal "A" before installing them in the pump.
7	Position a piece of thin walled tubing, ground to a thin edge, or thin shim stock or piece of heavy paper rolled in a tube inside the seal. This will protect the lips on the seal while passing them over the plunger rods. Now slide the sleeve and seals with the protection piece of tubing or paper over the rod and into the case. **CAUTION** **Care must be taken to avoid folding the lip under when the seals are passed over the end of the plunger rods. Failure to do this could damage seals resulting in leakage around seals.**
8	Once sleeve and oil seals are in place on plunger, replace oil seal nut and tighten. **(Do not over tighten as it will damage the Delren washer.)**
9	Replace the fluid end parts by repeating steps found in Servicing the cylinders.





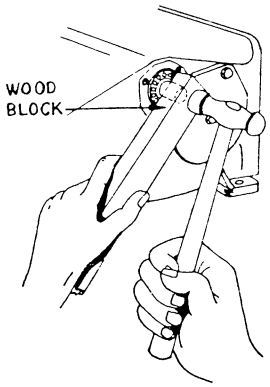


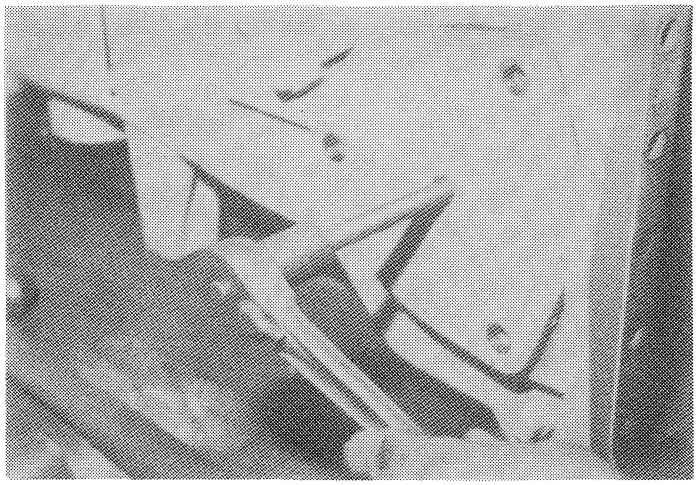
Servicing the Drive End

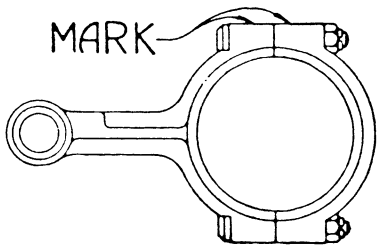
Servicing the eccentric shaft and connecting rods; these components seldom need servicing or replacing unless the pump has been run without oil or with severely contaminated oil. Problems with the shaft and rods will be indicated by knocking noise or excessive pump case temperature.

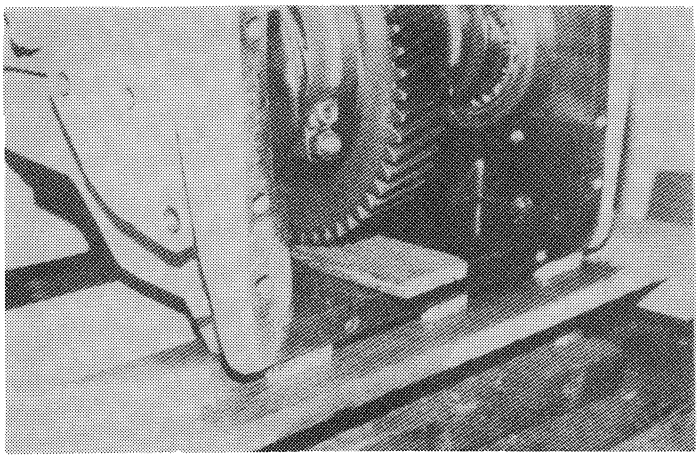
Steps	Procedures
	**WARNING** **Always disconnect pump from power source before performing any service to the pump. Failure to do this could result in electrical shock or injury from moving pump parts or drive end parts.**
1	Disconnect piping to valve chamber.
2	Remove the pump from its mounting and place on a bench or other convenient place for servicing the power end.
3	Place container under the drain plug in the drive end and remove the drain plugs and drain all oil from the drive end. Also position a couple of 2x4's under the drive end of the pump.
4	Remove the 8 nuts on the valve chamber studs.
5	Slide the 3 cover clamps off the studs.
6	Remove the valve chamber from the pump
NOTE: To prevent unnecessary down time, valves, packing, and other wear areas should be changed while breaking down the pump.	
7	The packings must now be removed. Follow step 3, page F-6.

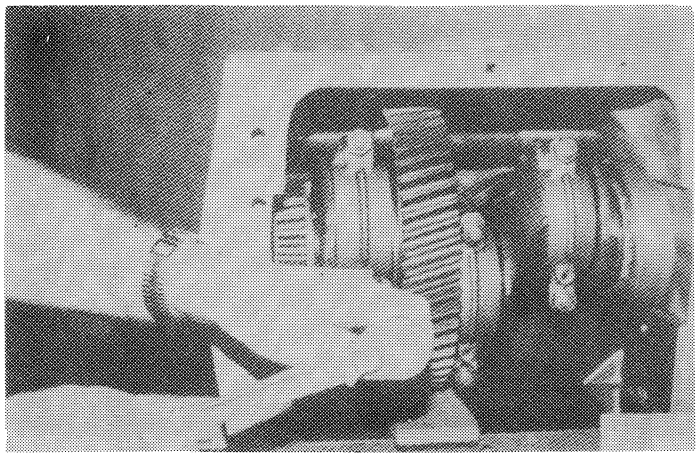
Steps	Procedures
10	Loosen the oil seal nut. Step 3, page F-8.
11	Remove the oil seal sleeve and oil seal (refer to page F-7).
12	Remove the capscrews, washers, cover and gasket from the power end of the pump.
13	Remove the three ½" - 13x1¼ capscrews, pinion bearing covers and gaskets at each side of the pump case.
14	Use a wood block and hammer to drive the pinion shaft from the pump case.
15	Use a press and suitable blocks to press the bearings from the shaft.
16	Remove the self locking nuts, connecting rod caps, and bearing from each connecting rod assembly and mark as suggested in illustration.
17	Remove the ½-13x¾" capscrews from the center of the crankshaft bearing cap.
18	Place wooden block supports under the crankshaft and gear assembly to avoid possible damage by dropping when bearings cups are removed.
19	Remove the three capscrews which hold the crankshaft bearing housing at each side of the pump case.
20	Insert a ½" - 13 tap bolt about 4" long into the hole at the center of each housing and turn the screw as suggested in illustration, to remove the housing from the pump.







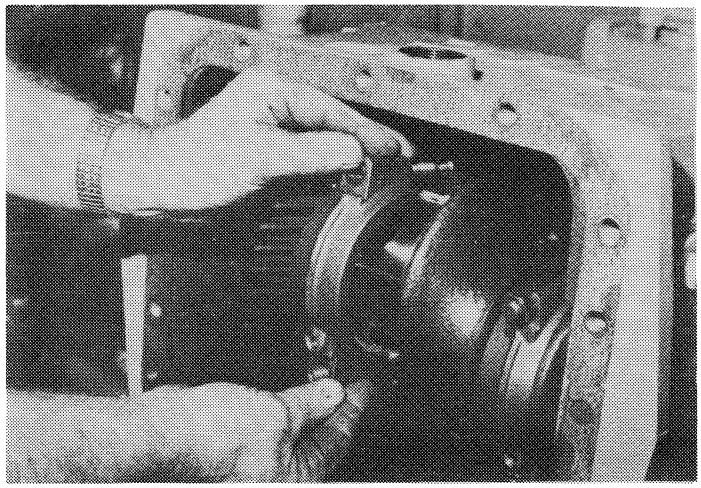




Servicing the Drive End cont'd.

Steps	Procedures
	CAUTION **Be sure to match and mark each cap and connecting rod for matching when reassembling the pump. Failure to do so could cause damage to connecting rods.**
22	Remove crankshaft through rear opening in the case.
23	Pull connecting rods and crosshead assemblies from case taking care to place parts so they will be reassembled in the same bore from which they were removed.
24	Remove the two set screws used to lock each crosshead pin in the crosshead assembly and remove crosshead pin.
25	Press bushings out and replace with new bushings if necessary. Bring the bushings in position to 1.2505 in. plus .001 to .000.
26	Using automotive type puller to remove the bearing cones from the crankshaft.
27	Inspect the eccentric shaft bearings for (a) cleanliness (b) rust spots when rotated (c) visible wear or damage (d) slack between the inner and outer races of the bearing.

NOTE: All damaged bearings must be replaced with new bearings. If one bearing is faulty, it is a good practice to replace both bearings even though no damage is visible on the other bearing.



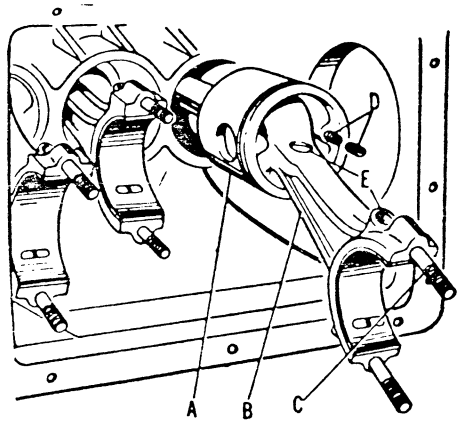
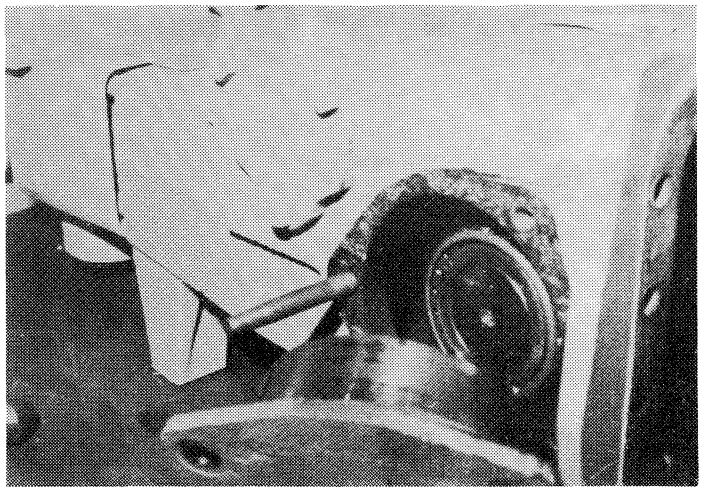


Fig. 12



Steps	Procedures
28	Inspect the eccentric shaft for damage, excessive scoring or pitting on the eccentric shaft indicates a need for replacement.
29	Inspect the connecting rods for damage; excessive scoring or pitting on the connecting rods indicates a need for replacement.
30	Inspect the crosshead assemblies and replace if any wear is visible.
31	Clean all parts in a solvent and apply thin coat of oil (grade SAE 30) before installing.
32	Thoroughly clean casing cap in solvent and blow dry.
33	Press new bearings in place. **CAUTION** **Use extreme care when installing bearings. They can be easily damaged shortening their life and efficiency.**
34	Reassembly the crosshead assemblies and connecting rods. Be sure to return both set screws to each hole to lock the pins in place with the inner screw seated in the indention on the outer face of the pin.
35	Replace connecting rods in their original openings from which they were assembled. Be sure connecting rod oil pockets are in the up position. See Fig. 12
36	Install pinion shaft reverse procedures on page F-10, steps 14, 15 and 16.
37	Replace the pinion bearing cover. The pinion bearing cover has grooves inside as shown in the illustration. This groove serves as an oil seal only when the cap is centered carefully around the shaft before final tightening of the capscrews.
38	Install crankshaft reverse procedures page F-10, step 18.

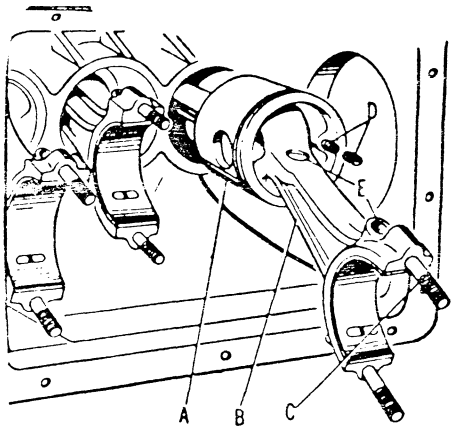


Fig. 12

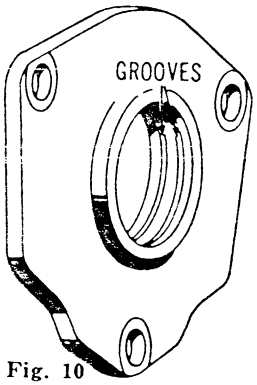
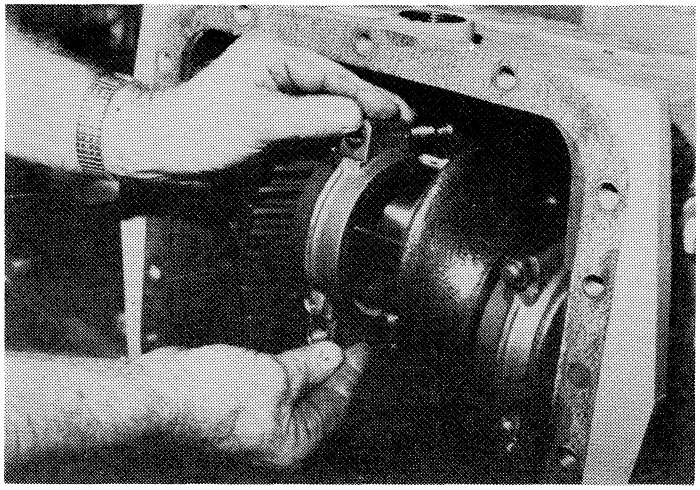


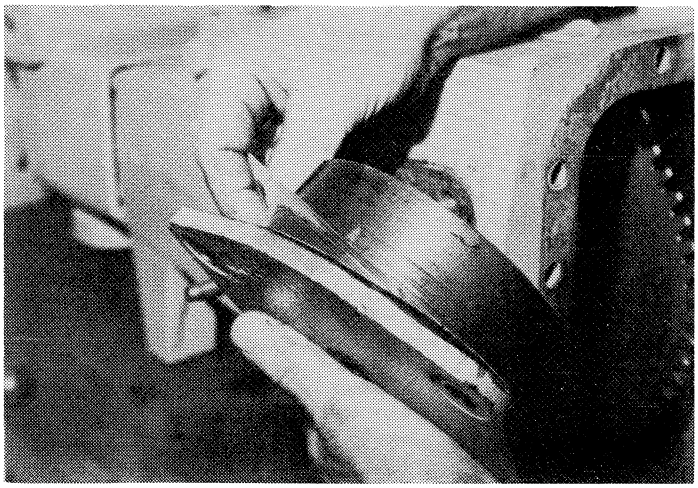
Fig. 10

The pinion bearing cover has grooves inside as shown on Fig. 10. These grooves serve as an "oil seal" only when the cap is "centered" carefully around the shaft before final tightening of the cap screws (32).

Servicing the Drive End cont'd.

Steps	Procedures
39	Replace gaskets on crankshaft bearing housings.
40	Replace the crankshaft bearing housings with their original shims and tighten capscrews.
41	Replace connecting rod caps with original connecting rods. Leave loose until Step 47.
	CAUTION **Be sure to match each cap and connecting rod as they were originally assembled. Failure to do so could cause premature wear in connecting rods or shaft.**
42	Proper end play adjustment in the assembled crankshaft and bearings is required to avoid excessive bearing wear. The crankshaft should have between .002 tight and .003 free endwise movement. Before checking inplay the connecting rods should be loosened to allow free movement to the crankshaft.
43	Move the crankshaft fully to one end and place dial indicator against the face of the gear as shown in the illustration.
44	Set the dial indicator at zero and move the crankshaft indicating its total endwise movement.
NOTE: The force required to move the crankshaft should be only enough to insure total endwise movement but not enough to spring the sides of the pump case.	





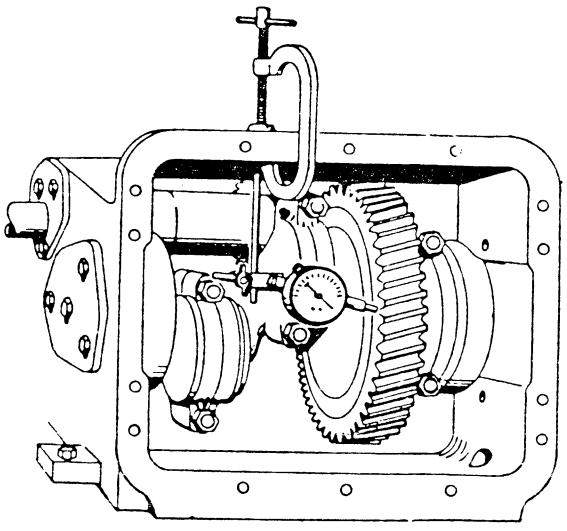
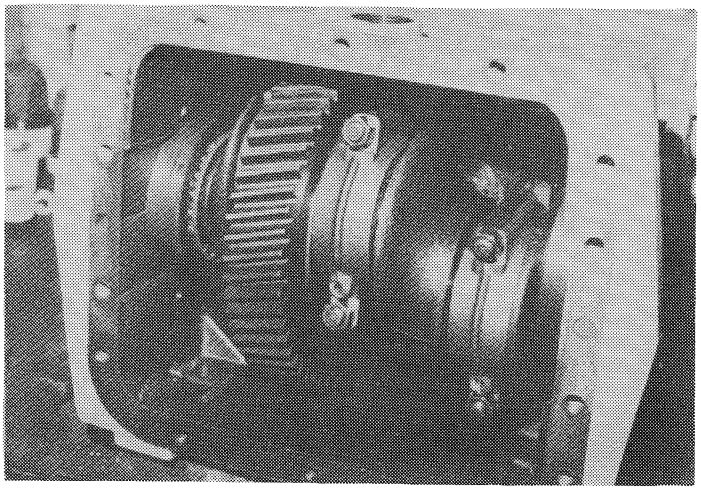
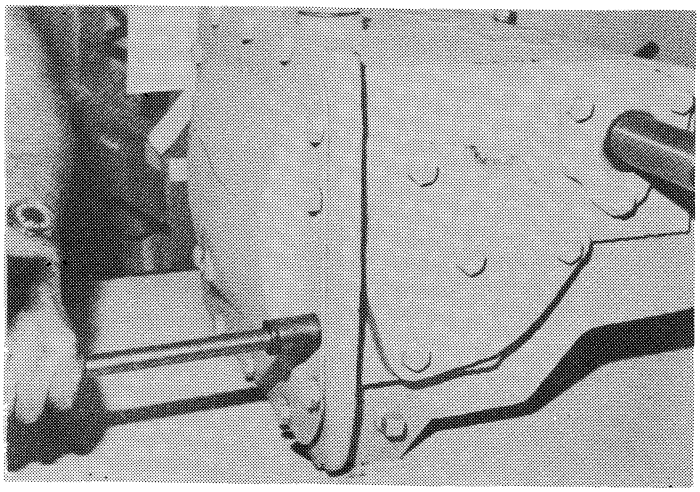


Fig. 11

Steps	Procedures
45	If inplay is not between .002 tight and .003 free remove crankshaft bearing housings and adjust shim. Shim should be equally distributed between the two ends of the shaft.
46	Replace the magnetic drain plugs in the side of the pump case.
47	Torque connecting rod nuts to 65 ft. lbs.
48	Replace the capscrews, cover and gaskets from the power end of the pump.
49	Refill the case with 4 qts. of clean high grade SAE 30 weight oil.
50	Turn the pump a few revolutions by hand to be sure that all parts are properly installed and adjusted before returning the pump to its mounting.
51	Replace fluid end of the pump as described under Servicing the Cylinders.





Servicing the Bearings - A knocking sound around the bearing or excessive heat coming from the pump case adjacent to the bearing are indications of faulty bearings. To replace or inspect bearings the crankshaft must be removed to allow access to the bearings. (Refer to Servicing the Drive End.)

Reading the Troubleshooting Chart

The following chart is designed to help you easily define and correct problem areas. As you can see the chart is divided into two columns. The first item is the Symptom, this is the signal that something is wrong. Once you have noticed the symptom you must determine the Cause because one symptom may be the signal for any one of various problems. The column titled Test and Result will be your aid for determining the Cause and Remedy.

Troubleshooting Chart

Symptom
Discharge Pressure too Low

Test/Result	Cause/Remedy
Connect a hose to the overflow port in the relief valve and start the pump: 1. Close all guns and/or nozzles and check overflow. RESULT: No overflow, see item 1, then recheck pressure. RESULT: Flow through overflow hose, see item 2, then recheck pressure. 2. Open all of the discharge guns or nozzles. RESULT: No flow in the overflow hose, see items 3 and 4, recheck pressure. RESULT: Flow through the overflow hose, see items 5 and 6, or 7, recheck pressure.	1. Restriction in suction line. Checked for clogged strainers, closed valves, empty suction tank. 2. Incorrect relief valve adjustment. To increase the relief pressure, tighten the nut on top of the valve by turning clockwise. (Refer pg. D-1.) **Warning** **Do not exceed the rated pressure of the pump.** 3. Incorrect nozzle size. Worn nozzles or nozzles with capacity in excess of the pump capacity, will reduce the discharge pressure - replace where required. Refer nozzle manufacturer's literature. 4. Pump speed too low. Change the sheave combination to obtain the desired speed. **Caution** **Do not exceed the maximum rated speed.** 5. Worn seat or stem in the relief valve. Replace parts as required. 6. Worn packing cup in the relief valve. Replace the packing if water is leaking through the openings in the relief valve body. 7. Foreign material lodged in the relief valve. Relieve the spring tension and flush the interior of the valve to remove foreign material.

Symptom

Discharge gallonage too low - low discharge gallonage will be caused by slow pump speed or low volumetric efficiency.

Test/Result	Cause/Remedy
1. Calculate displacement gallonage of the pump as follows: a. Measure pinion shaft speed with a tachometer. b. Multiply speed x gal./rev. (Factors are figured assuming 100% volumetric efficiency.) Gal./Rev. L1118 = .0394, L1122 = .0589 RESULT: Displacement gallonage lower than required, see item 1. RESULT: Displacement gallonage equal to or larger than required gallonage, see next test. 2. Volumetric efficiency is a measure of how much the actual output is less than the displacement. To determine vol eff.: a. Measure the actual gallonage from the pump. Close all guns and discharge valves and measure the number of gallons coming from the overflow hose for one minute. NOTE: One gal. of water weighs 8.33 lbs. and fills .1337 cu. ft. NOTE: Measured flow is actual gallon per minute (GPM) output. b. Divide the actual GPM found in Step a. by the displacement GPM found earlier then multiply by 100 to get the volumetric efficiency. Vol. Eff. I = Actual GPM x 100 / Displ. GPM Normal Volumetric Efficiency — 85-90% RESULT: Normal volumetric efficiency but gallonage less than required, see item 1. RESULT: Volumetric efficiency less than normal, see items 2,3, and 4 or cavitation.	1. Pump speed too slow. Change the sheave combination to obtain desired speed.(Refer to Selecting Operating Speed, pg. D-1 and installation Procedures, page C-1.) **Warning** **Do not exceed maximum Rated speed.** 2. Leakage from the pump plunger packings. Leakage exceeding 15-20 drops per minute indicates that the packing should be replaced. (Refer to pg. F-3) 3. Suction or discharge valve seats worn, pitted, or broken. Inspect and replace where necessary. (Refer to page F-1.) 4. Restriction in the suction line. Check for clogged strainers, closed valves, empty suction tank.

Symptom

Noise coming from bearings and crankcase area

Test/Result	Cause/Remedy
See Item 1.	1. Worn or damaged bearings Change bearings (Refer to Servicing, page 1.)

Symptom

Cavitation - Cavitation in the pump occurs when the cylinders do not completely fill with water during the suction stroke. Resultant pressure pulsations can severely damage the pump and related piping if the condition is not recognized and corrected immediately.

Test/Result	Cause/Remedy
Check the following to determine if cavitation exists: 1. Volumetric Efficiency $\text{Vol. Eff.} = \frac{\text{Actual GPM}}{\text{Displ. GPM} \times 100}$ (See Discharge Gallonage refer to preceding page) RESULT: Less than normal vol. eff. with good valves and plunger packings indicates cavitation. 2. Discharge Pressure RESULT: Less than expected and fluctuating erratically indicates cavitation. 3. Pulsations in suction or discharge line. RESULT: Erratic pulsations of abnormal magnitude indicate cavitation. 4. Listen for sharp erratic hammering sounds in the valve chamber. Do not confuse the sharp regular sounds of the valves with the erratic sound that indicates cavitation. NOTE: There are several causes of cavitation. Once the problem has been determined as cavitation from the above test the following test must be performed to determine the cause. 1. Reduce the temperature of the pump liquid to room temperature. RESULT: If cavitation stops, see item 1. 2. If the relief valve overflow is piped into the pump suction line, disconnect the overflow line. RESULT: If cavitation stops, see item 2. 3. Disconnect the suction inlet piping and replace it with a short hose connected to a barrel or tank. RESULT: If cavitation stops, see items 3, 4, and 5. 4. Disconnect the discharge piping and connect a short hose to the pump outlet. RESULT: If cavitation stops, see item 6. 5. Replace the pump plunger packing and inspect the valve assemblies. RESULT: If cavitation stops, see item 7.	1. Vapor pressure too high at pumping temperature. Reduce the temperature or increase the suction pressure by an amount sufficient to overcome the vapor pressure. Refer to Section C, Installations, page C-2. 2. Turbulence in the pump suction inlet. Relocate overflow lines further from the pump inlet. If necessary, propvide a tank to supply undistributed suction flow conditions to the pump. 3. Suction or discharge valves' seats worn, pitted, or broken. Inspect and replace, where necessary. (Refer to page F-1.) 4. Excessive losses in the suction piping. Increase the suction pipe diameter, increase the suction pressure or reduce the length of the suction line. In some cases, an air chamber may be required to sufficiently reduce the suction losses. (Refer to Installations, page C-2.) 5. Air leaking into the suction system. Inspect and tighten all the hose and pipe connections. 6. Water hammer in the discharge line. Install an air chamber or an accumulator in the discharge piping. (Refer to Installations, page C-4.) 7. Weak and partially worn plunger packing. Partially worn plunger packing may draw air on suction stroke but not leak on the discharge stroke. This will cause the pump to operate as if cavitating. Replace the packing. (Refer to Servicing, page F-3.)