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OPERATION & MAINTENANCE MANUAL

FOR

SHORT COUPLED

VERTICAL TURBINE PUMPS

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IMPORTANT NOTE

The descriptions and instructions included in this book cover the standard design of the equipment and any common deviations when possible. This book does not cover all design details and variations nor does it provide for every possible contingency which may be encountered. When information cannot be found in this book, contact the nearest Patterson representative.

SAFETY PRECAUTIONS

WARNING

Never operate this equipment in excess of its rated speed or other than in accordance with the instructions contained in this manual.

The equipment has been found satisfactory for the conditions for which it was sold, but operation in excess of these conditions may subject it to stresses and strains for which it is not designed.

When working on or around equipment described in this instruction book, it is important to observe safety precautions to protect personnel from possible injury.

The following is an abbreviated list of safe practices to keep in mind:

- avoid contact with rotating parts,
- avoid by-passing or rendering any safeguards or protective devices inoperative,
- avoid extended exposure in close proximity to machinery with high noise levels,
- use proper care and procedures in handling, lifting, installing, operating and maintaining the equipment,
- do not modify this equipment - consult factory if modification is deemed necessary,
- use only O.E.M. repair parts
- observe all caution and danger tags attached to the equipment or included in this manual.

Safe maintenance practices with qualified personnel are imperative.

Failure to heed this warning may result in an accident causing personal injury.

The following instructions should be completely read before starting to install the unit. The unit is capable of many years of trouble-free operation when properly applied, installed and maintained. These instructions present the basic information and methods required for proper installation and maintenance.

PROTECTIVE GUARDS

The responsibility for the installation of protective guards lies with the equipment owner. Protective guards for rotating equipment must be in place at all times during equipment operation.

STUDY THIS INSTRUCTION MANUAL

SECTION I GENERAL INFORMATION AND DESCRIPTION

I-1. GENERAL INFORMATION

The length of satisfactory service obtained from the equipment will, in part, depend on proper installation and maintenance. This instruction manual is provided to present the basic information for operation, maintenance and management personnel. Due to the many variations and custom designed units it is impossible to cover every design variation or contingency which may arise, however, the basic information contained herein will cover most applications.

I-2. IDENTIFICATION

Should questions arise concerning the pump, the factory will require the complete serial number to be of assistance. The serial number is stamped on a metal nameplate affixed to the discharge head assembly. The driver will have a separate nameplate attached to it. When requesting information on the driver both the driver serial number and pump serial number will be required.

I-3. GENERAL DESCRIPTION

The basic components of close coupled pumps are the driver, discharge head assembly, column assembly (when used), and bowl assembly. The pumps are normally shipped assembled and ready for installation. The drivers, couplings and strainers (when used) are shipped loose to prevent damage.

I-4. DRIVER

A variety of drivers may be used, however, electric motors and right angle gears are most common. For the purposes of this manual, these types of drivers can be grouped into two categories:

1. Hollow shaft drivers - the pump shaft extends through a tube in the center of the rotor and is connected to the driver by a clutch assembly at the top of the driver.
2. Solid shaft drivers - the rotor shaft is solid and projects below the driver mounting base. This type driver requires an adjustable coupling between the pump and driver.

I-5. DISCHARGE HEAD ASSEMBLY

The discharge head supports the driver and bowl assembly as well as supplying a discharge connection (the underground discharge connection will be located on one of the column pipe sections below the motor stand). A shaft sealing arrangement is located in the discharge head to seal the shaft where it leaves the liquid chamber. The shaft seal will usually be either a packing box or mechanical seal assembly.

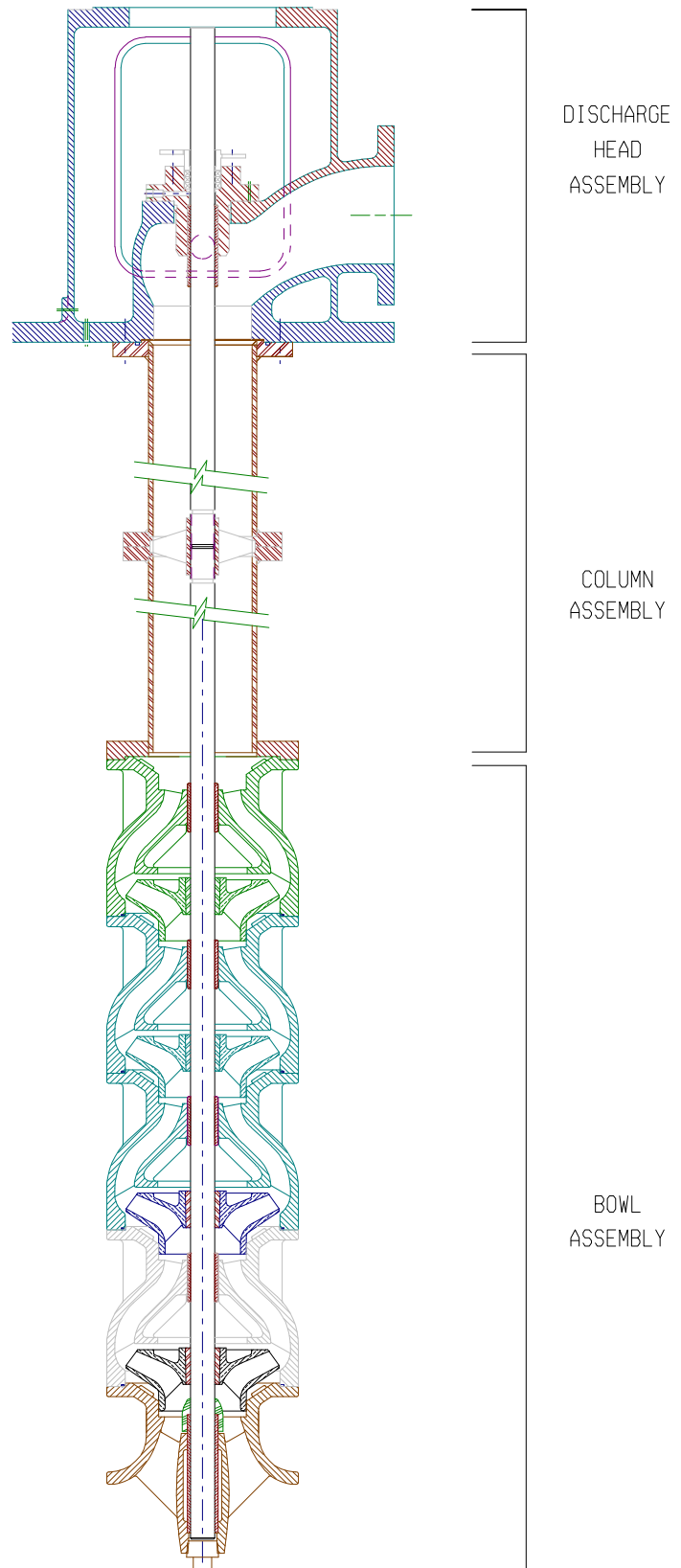


Fig. 1-A

1-6 COLUMN ASSEMBLY

The column assembly is of two basic types, either of which may be used on close coupled units:

1. Open lineshaft construction utilizes the liquid being pumped to lubricate the lineshaft bearings.
2. Enclosed lineshaft construction has an enclosing pipe around the lineshaft and utilizes oil, grease or injected liquid to lubricate the lineshaft bearings.

The column assembly will consist of column pipe, which connects the bowl assembly to the discharge head and carries the pumped liquid to the discharge head, the shaft, which connects the bowl assembly to the discharge head, the headshaft which connects the lineshaft to the driver. Column pipe may be either threaded or flanged and may contain bearings if required for the particular unit.

Note: Some units will not require a column assembly, having the bowl assembly connected directly to the discharge head.

1-7 BOWL ASSEMBLIES

The bowl assembly consists of impellers rigidly mounted on the bowl shaft which rotate and impart energy to the fluid. The bowls (or diffusers) contain the fluid at increased pressure and direct it vertically to the next stage and eventually to the column pipe. The suction bell or case directs the fluid into the first stage impeller. Bearings are located in the suction bell, discharge case, and between each impeller.

SECTION II STORAGE & PROTECTION

All pumps are shop serviced and ready for operation when delivered, but there are occasions when considerable time elapses between the delivery date and the time the pump is put into operation. Equipment which is not in service should be kept in a clean, dry area. If equipment is to be stored for long periods of time (6 months or more), the following precautions should be taken to insure that the equipment remains in good condition:

1. Be sure that bearings are fully lubricated.
2. Unpainted machined surfaces which are subject to corrosion should be protected with corrosion resistant coating.
3. The shaft should be rotated 1/4 to 1/2 revolution by hand periodically to insure that the pump shaft does not begin to sag. Suitable intervals are from one to three months.
4. Space heaters on motors and controllers should be connected and fully operable if atmospheric conditions approach those experienced in operation. Consult instruction manuals for other precautions concerning storage of individual components of pump unit.
5. Fresh lubricant must be applied to bearings (where applicable) upon removal of equipment from storage. Do not use petroleum or oil based lubricants on rubber bearing.

SECTION III PRE INSTALLATION

III-1. RECEIVING AND UNLOADING

When the shipment is received, extreme care should be exercised while unloading. Heavy parts should be skidded to the ground if lifting equipment is not available. Do not drop the unit, or any parts, as damage may cause trouble in assembly and operation of the units.

Inspect the unit for signs of transit damage before beginning to uncrate or put into storage. If damage is evident the local transporting company agent should be notified before uncrating and a claim filed with the agent.

III-2. UNCRATING & CLEANING

If the unit appears undamaged proceed to uncrate. The pump is shipped as a unit from the factory and it is advisable to lift it into the vertical position before uncrating. If this is not possible the longer units must be supported at more than one place when raising to the vertical position.

Clean all parts of dirt, packing materials and other foreign matter. Flush the pump inside and out with clean water. Clean all machined surfaces **C** these are coated with a rust preventative which must be removed. Remove any rust spots found on the machined surfaces with fine emery cloth. Clean all threaded connections and any accessory equipment.

Note: Parts and accessories may be placed inside shipping containers or attached to skids in individual packages. Inspect all containers, crates and skids for attached parts before discarding.

III-3. INSTALLATION EQUIPMENT & TOOLS

No installation should be attempted without equipment adequate for the job. The following list covers the principal items required for an installation.

1. Mobile crane capable of hoisting and lowering the weight of the pump or motor.
2. Cable sling for attaching to the pump and motor lifting eyes.
3. Ordinary hand tools **C** end wrenches, socket set, screw drivers, allen wrenches, etc.

4. Wire brush, scraper and fine emery cloth.
5. Thread compound and light machinery oil.

III-4. PRE-INSTALLATION CHECK LIST

The following checks should be made before starting actual installation to assure proper installation and prevent delays:

1. Where more than one unit is received, check the pump serial number against the packing slip to be sure the correct unit is being installed.
2. Compare the driver horsepower and speed indicated on the driver nameplate, and the pump nameplate (located on the discharge head) to be sure they agree within 2%.
3. With motor driven units be sure the voltage and frequency on the motor nameplate agrees with the service available. Also make sure the horsepower and voltage rating of the control box or starter agrees with the horsepower and voltage rating of the motor.
4. Check the depth of the sump against the pump length to be sure there will be no interference.
5. Check the proposed liquid level in the sump against the pump length **C** the bottom stage of the pump must be submerged at all times.
6. Clean the sump and piping system before installing the pump.
7. Check the installation equipment to be sure it will safely handle the equipment.
8. Check all pump connections (bolts, nuts, etc.) for tightness. These have been properly tightened before leaving the factory, however, some connections may have worked loose in transit.
9. On hollow shaft drivers check the clutch size against the shaft size which must go thru the clutch. Sometimes the shaft size coming thru the discharge head is different from the shaft size going thru the driver **C** be sure you check against the shaft which will go thru the driver.
10. On solid shaft drivers check the motor shaft size against the coupling bore size.

SECTION IV INSTALLATION

IV-1. LOCATION

Several factors should be considered when selecting a location for the pumping unit (pump, base, drive, and coupling). The unit should be accessible for both inspection and maintenance. Head room should be provided for the use of crane, hoist or other necessary lifting devices. The location should require a minimum of elbows and fittings in the discharge line to minimize friction losses. The unit should be protected against flooding.

IV-2. FOUNDATION

The foundation should be sufficiently substantial to absorb vibration and to form a permanent rigid support for the pump. Concrete is most widely used for foundations. Before pouring a foundation, locate anchor bolts per the outline drawing. Anchor bolts should be installed in sleeves twice the anchor bolt diameter to allow for alignment with the holes in the soleplate or discharge head, see Fig. IV-A. Allow for 3/4 inch to 1 1/2 inches of grout between foundation and discharge head or soleplate. The top surface of the foundation should be roughened to provide a good bond for the grout.

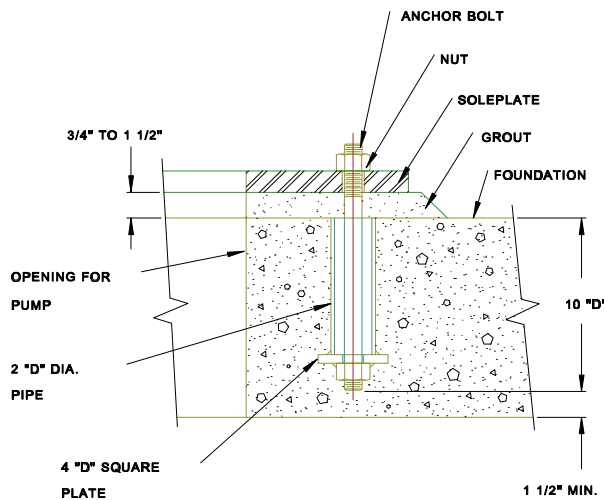


FIG. IV-A

IV-3. GROUTING

Grout compensates for unevenness in the foundation and distributes the weight of the unit uniformly on the foundation. It also prevents lateral shifting of the baseplate and reduces vibration. Use a non-shrinking

grout. Foundation bolts should be tightened evenly but not too firmly. Grout the unit as follows:

1. Build a strong form around the baseplate to contain the grout.
2. Soak the foundation top thoroughly, then remove the surface water.
3. Pour grout. Tamp liberally while pouring to fill all vacancies and prevent air pockets. The space between the foundation and baseplate should be completely filled with grout. Wedges may be left in place. Adjust the metal shims or wedges until the top flange of the discharge head is level. Tighten the foundation bolts snugly, but not too firmly, and recheck the alignment before grouting.
4. After grout has hardened (usually about 48 hours), thoroughly tighten foundation bolts.
5. Approximately 14 days after the grout has been poured or when it is thoroughly cured and dry, apply an oil base paint to exposed edges of the grout to prevent air and moisture from coming in contact with the grout.

IV-4. PIPING

Connect pipe lines after the grout has thoroughly hardened. The piping should be installed with the shortest and most direct runs. Elbows should be of the long radius type and pipes should line up naturally. Exterior strain must not be transmitted to the pump. The most common cause of trouble in this respect is forcing the piping to mate with the pump. This is especially critical on pumps with an underground discharge where the discharge may be several feet below the supporting structure and a relatively small strain can cause misalignment.

Discharge piping should be installed with a check valve and gate valve, with the check valve located between the pump and gate valve. The check valve prevents reverse flow and protects the pump from excessive back pressure. The gate valve is used for starting and to isolate the pump for maintenance.

IV-5. INSTALLING THE PUMP

1. Position lifting equipment so it will center over the foundation opening.

Note: Sump and piping should be thoroughly cleaned of all loose debris before starting installation.

2. If a soleplate is used, level the mounting surface and grout and anchor in place. (See grouting in previous section.)
3. Clean pump discharge flange.

Note: All machined surfaces are coated with rust preventative prior to shipment. This must be completely removed along with any paint over-spray or rust which might be on the machined faces. The faces should be scraped and wire brushed first and then fine emery cloth used to remove any stubborn spots. Use a fine file to remove any nicks or burrs.

Note: All threads should be checked for damage and repaired if necessary. If filing is necessary, remove the part from the pump if possible, or arrange a rag to catch all filings so they do not fall into other parts of the pump. Clean all threads with wire brush and cleaning solvent. Ends of shafts must be cleaned and any burrs removed since alignment depends on the shaft ends butting squarely. Lubricate all screwed connections with a thread lubricant **C** an anti galling compound such as "Never-Seez" should be used on stainless and monel mating threads.

CAUTION!! Apply thread lubricant sparingly to male shaft threads only when making up shaft connections **C** excess lubricant should not be allowed to get between the ends of the shafts.

4. Lift pump, mount strainer if required, and lower slowly into the sump. Hand guide the pump as it is lowered and watch for any obstructions or binding of the pump which can be felt thru the hands. Stop lowering unit when still a few inches off the foundation.

Note: Be particularly careful not to damage any piping which may extend down along the column and/or bowl assembly. This piping (when used) must remain open **C** should it be damaged it should be removed and replaced.

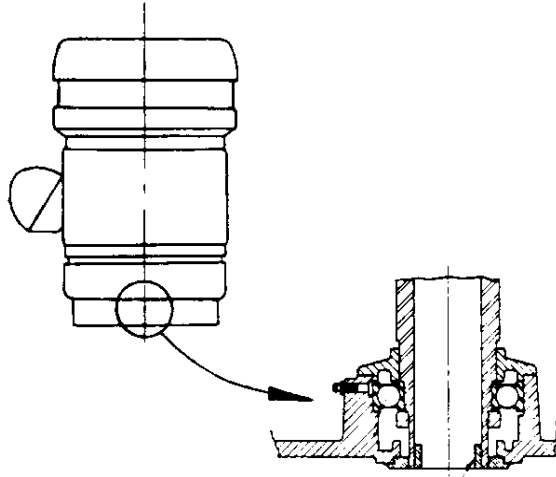
5. Rotate pump until discharge flange faces proper direction for alignment with piping and align anchor bolt holes.
6. Slowly lower pump onto foundation.
7. Install anchor bolts or nuts, but do not tighten.
8. Pipe from discharge shifting the pump slightly on the foundation if required to facilitate alignment.

CAUTION!! Exterior stresses should not be transferred to the pump **C** all piping must be carefully aligned and supported to prevent this.

9. Tighten discharge flange bolting **C** be sure the flanges mate without forcing.
10. Tighten anchor bolting.

IV-6. INSTALLING HOLLOW SHAFT DRIVER

1. Clean driver mounting flange on discharge head and check for burrs and nicks on the register and mounting face. Oil lightly.
2. Remove driver clutch.
3. Lift driver and clean mounting flange, checking for burrs and nicks.
4. Some electric motors will be supplied with a "lower guide bushing" which is installed at the bottom of the motor to stabilize the shaft. Some motor manufacturers mount this guide bushing before shipping while others will ship the guide bushing with instructions for field mounting. Check the packing slip to see if a guide bushing is required; if so, determine if the bushing is already mounted or not and proceed accordingly. See Fig. IV-B.
5. Raise and center driver over pump.
6. Lower carefully until about 1/4 inch above mounting flange. Rotate driver until junction box on motor or input shaft on gear drive is in correct position. Align bolt holes and insert bolts.



**GUIDE BUSHING
LOCATED AT BOTTOM OF MOTOR
INSIDE HOLLOW SHAFT**

Fig. IV-B Motor Guide Bushing Location

7. Lower carefully into place making certain that the female register on the driver mates over the male register on the pump.
8. Tighten mounting bolts.
9. Check driver manufacturer's instruction manual for special instructions including lubrication instructions and follow all "start up" directions.
10. Electric drivers should be checked for rotation at this time. Make electrical connections and jog motor momentarily to check rotation. **DRIVER MUST ROTATE COUNTER CLOCKWISE** when looking down from top end of motor. To change the direction of rotation on a three phase motor, interchange any two line leads.

CAUTION!! Reverse rotation with the pump connected can cause extensive damage to the pump **C** ALWAYS check rotation before connecting the driver to the pump.

11. Mechanical seal should be installed at this time if the pump is so equipped and the mechanical seal was shipped not installed **C** see paragraph IV-11 for further details.

Note: On units equipped with one piece headshaft (no lineshaft coupling between driver and pump) Steps 12, 13 and 14 will not be applicable.

12. Clean all shaft threads (both ends of head shaft and top shaft). Try the lineshaft coupling and headshaft nut on their respective threads. These should thread on by hand **C** if not clean up threads with fine three cornered file. Check ends of shaft where they will butt inside lineshaft coupling, ends must be square and clean.
13. Lubricate top shaft threads and thread (LEFT HAND threads) lineshaft coupling half way onto top shaft.

CAUTION!! Apply thread lubricant only to male shaft threads and sparingly to avoid build-up between ends of shaft which could cause misalignment.

14. Lubricate head shaft threads and lower head shaft carefully down thru driver. Install flinger and thread into lineshaft coupling. Shafts must butt against each other.

Note: Head shaft should stand centered (long shafts may lean slightly from own weight; however, they can be centered without effort) in the driver hollow shaft **C** if not check driver mounting flange for improper mounting and reclean ends of shaft where coupled inside discharge head.

15. Install clutch on driver being careful that it fits down properly. SEE Fig. IV-C.
16. Install gib key in clutch and shaft.
17. Thread adjusting nut down (LEFT HAND threads) on shaft until it bears against clutch.

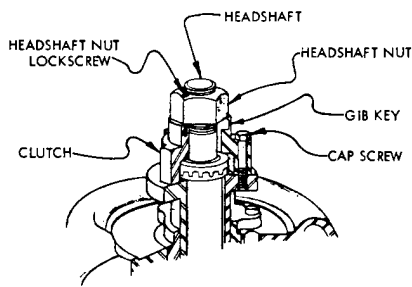


Fig. IV-C Hollow Shaft Driver Clutch

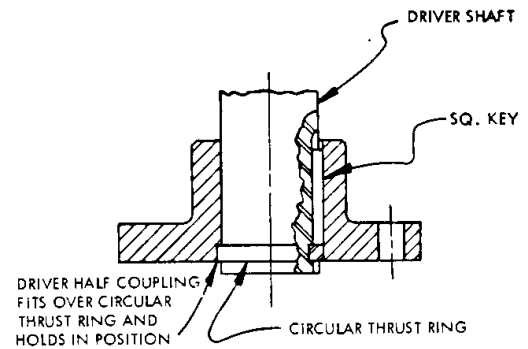


Fig. IV-D Driver Half-Coupling Correctly Positioned

18. See paragraph IV-9 for impeller adjustment.
19. Adjust mechanical seal AFTER adjusting impellers.

IV-7 INSTALLING SOLID SHAFT DRIVER

1. Clean driver mounting flange on discharge end and check for burrs or nicks on the register and mounting face. Oil lightly.
2. Clean headshaft threads, lubricate and try adjusting nut. The adjusting nut should run down on the threads by hand.
3. Lift driver and clean mounting flange, checking for burrs and nicks.
4. Install driver half-coupling on driver shaft-See Fig IV-D.
 - a. Place straight key into keyway, be sure the key is far enough up to clear the groove cut around the shaft near the end.
 - b. Slide driver half-coupling onto shaft far enough to insert the circular thrust ring into the shaft groove.
 - c. Install circular thrust ring in shaft groove C when properly positioned the half-coupling will slip down over the circular key and hold it in position C see Fig. IV-D.

5. The mechanical seal should be installed at this time if the pump is so equipped and the mechanical seal was shipped not installed - see paragraph IV-11 for further details.
6. Install pump half - coupling on head shaft:
 - a. Slide pump half-coupling onto shaft.
 - b. Install key and push down to clear threads.
 - c. Thread adjusting nut (LEFT HAND threads) on to shaft until end of shaft is even with top of adjusting nut.
7. Center motor over pump and rotate to align mounting holes.
 - a. Electric motors-rotate junction box into desired position.
 - b. Gear drives-rotate input shaft into desired position.

Note: Some gear drive units are supplied with an adapter plate where the gear BD does not match the head BD. This plate should be installed to the head prior to installing the gear.

8. Lower driver carefully into place making certain that the female register on the driver mates over the male register on the pump.
9. Bolt driver to discharge head.
10. Check driver manufacturer's instructions for special instructions including lubrication instructions and follow all Astartup@ instructions.

11. Electric drivers should be checked for rotation at this time. Make electrical connections and jog motor momentarily to check rotation. DRIVER MUST ROTATE COUNTER CLOCKWISE when looking down from top end of motor. To change the direction of rotation on a three phase motor, interchange any two line leads.

CAUTION!! Before jogging motor make sure coupling halves are not touching and that the driver can rotate freely without rotating the pump. Driver half-coupling must be in proper position as shown in Fig. IV-D so the circular thrust ring will not come out.

CAUTION!! Reverse rotation with the pump connected can cause extensive damage to the pump-ALWAYS check rotation before connecting the driver to the pump.

12. On pumps using the spacer type coupling, bolt the spacer to the driver half-coupling.
13. Thread adjusting nut up until there is 3/16 inch gap between nut and spacer or driver half-coupling.
14. See paragraph IV-10 for impeller adjustment.

Note: Adjust mechanical seal AFTER adjusting impellers.

IV-8 IMPELLER ADJUSTMENT - GENERAL

Proper impeller adjustment positions the impeller inside the bowl assembly for maximum performance. The impellers must be raised slightly to prevent dragging on the bowls. Enclosed impellers should be raised 2 to 2 1/2 turns of the adjusting nut or approximately 1/4 inch.

CAUTION!! The impellers must be down against the bowl seat when starting impeller adjustment. All dimensions and instructions given above assume the impellers are initially all the way down. When pumps are subjected to suction pressure the pressure acting against the shaft tends to raise it. If the suction pressure is great enough it can raise the shaft. Make sure the shaft is down when starting to adjust the impellers.

If, after making the above adjustment, the pump does not deliver its rated capacity, the impellers can be lowered 1/4 to 1/2 turn at time until the lowest possible adjustment is achieved without the impellers dragging. On the other hand, if the impellers appear to be dragging after the initial adjustment, the unit should be stopped and the impellers raised 1/4 to 1/2 turn. Dragging impellers will increase the load markedly and can usually be heard and felt as increased vibration.

IV-9. IMPELLER ADJUSTMENT - HOLLOW SHAFT DRIVER

Impeller adjustment when using hollow shaft drivers is accomplished at the top of the driver by the following procedure. The driver canopy will have to be removed before beginning.

1. Install headshaft as outlined in paragraph III-4, if not already in place.
2. Install driver clutch in accordance with driver instruction manual and bolt into place.
3. Install gib key, making sure top of gib key pushes down below top of clutch.
4. Check shaft position C raise shaft slightly by hand and lower until there is a definite feel of metal contacting metal. This indicates the impellers are "on bottom" and is the correct starting position for impeller adjustment.
5. Thread headshaft nut down (LEFT HAND threads) until the impellers are just lifted off their seat and the shaft will rotate freely.
6. Adjust impellers as outlined in paragraph IV-8.
7. Lock headshaft nut with lock screws inserted down through holes in headshaft nut and threaded into driver clutch.

CAUTION!! Always lock head shaft nut before starting driver. Failure to do so could result in damage to the pump and driver.

IV-10. IMPELLER ADJUSTMENT - SOLID SHAFT DRIVER

Impeller adjustment when using solid shaft drivers is accomplished in the adjustable flanged coupling located below the driver.

1. Assemble coupling on pump and driver as outlined in paragraph IV-7.
2. Back adjusting nut up shaft (threads are LEFT HAND) until the nut bears firmly against spacer or driver shaft and head shaft will not move down. This will insure that the impellers are all the way down against their seat and in proper position for adjustment.
3. Thread adjusting nut down until the proper impeller adjustment as outlined in paragraph IV-8 can be measured between the adjusting nut and spacer or driver half-coupling as shown in Fig. IV-E.
4. Slide pump half-coupling up shaft and align adjusting nut bolt holes with those in pump half coupling. Rotate driver shaft until bolts can be inserted and tightened.
5. Tighten all bolts which will raise impellers to correct operating position.

Adjustable Flanged Coupling (Shown with spacer)

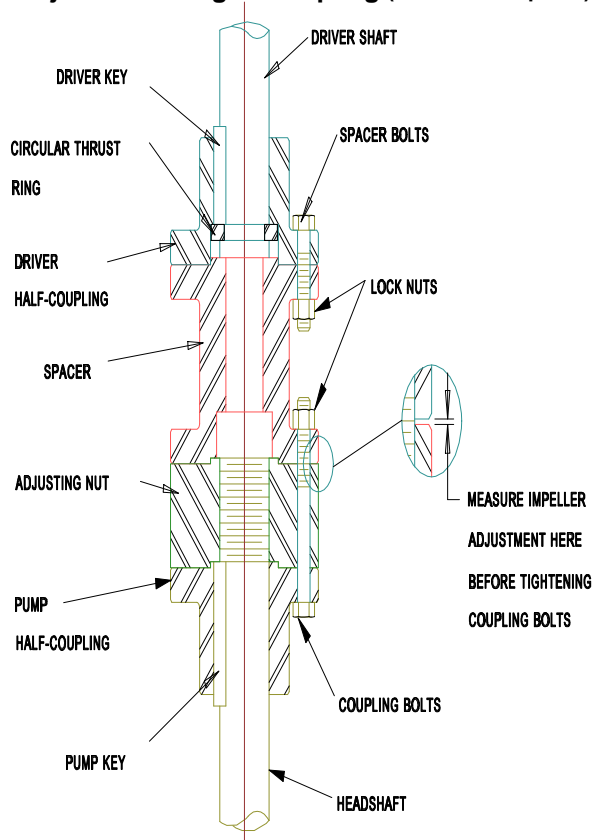


Fig. IV-E

IV-11 MECHANICAL SEAL

Because of the numerous mechanical seal arrangements available, separate instruction manuals are written covering installation and operation of the seal. There are, however, comments which apply to all seals.

1. The seal cavity must be clean before installing seal.
2. The faces and register of the seal housing and seal housing cover must be clean and free of burrs.
3. The shaft seal is a precision product. Treat it with care. Take particular care not to scratch or chip the lapped faces of the runner or seat.
4. Circulation lines must remain in place and open. Do not remove.
5. Impeller adjustment must be made PRIOR to seal adjustment.

READ THE MECHANICAL SEAL INSTRUCTION MANUAL FURNISHED WITH THIS UNIT

IV-12 PACKING BOXES

Packing boxes are pre-packed at the factory and will be factory installed. Do not tighten the packing gland. See Section VI for further information.

IV-13 ENCLOSING TUBE TENSION

The enclosing tube (enclosed lineshaft design) tension is preadjusted at the factory before shipping. Additional adjustment will not be required. See assembly instructions (Section VII) if assembly or adjustment is required for any reason.

SECTION V OPERATION

V-1. PRE-STARTING CHECKS

Before starting the pump the following checks should be made:

- Q 1. Rotate the pump shaft by hand to make sure the pump is free and the Impellers are correctly positioned.
- Q 2. Make sure the shaft adjusting nut is properly locked into position.
- Q 3. Be sure the driver has been properly lubricated in accordance with the instructions furnished with the driver.
- Q 4. Check the driver rotation. Remember the pump must be disconnected from the driver before checking. The driver must rotate COUNTER CLOCKWISE when looking down from the top of the driver.
- Q 5. Check all connections to the driver and control equipment.
- Q 6. Check that all piping connections are tight.
- Q 7. Check all anchor bolts for tightness.
- Q 8. Check all bolting and tubing connections for tightness (driver mounting bolts, flanged coupling bolts, seal housing cover bolts, seal piping, etc.).
- Q 9. On pumps equipped with packing box make sure the gland nuts are only finger tight **C DO NOT** tighten packing gland before starting.
- Q 10. On pumps equipped with mechanical seals clean fluid should be put into the seal chamber. With pumps not under suction pressure the seal chamber should be flushed liberally with clean fluid to provide initial lubrication.

Make sure the mechanical seal is properly adjusted and locked into place.

Note: After initial start up, pre-lubrication of the mechanical seal will usually not be required as enough liquid will remain in the seal chamber for subsequent start up lubrication.

- Q 11. On pumps equipped with enclosed lineshaft, lubricating fluid must be available and should be allowed to run into the enclosing tube in sufficient quantity to thoroughly lubricate all lineshaft bearings.

V-2. INITIAL STARTING

- 1. If the discharge line has a valve in it, it should be partially open for initial starting.
- 2. Start lubrication liquid flow on enclosed lineshaft units.
- 3. Start the pump and observe the operation. If there is any excess noise or vibration, or if the pump seems sluggish, or will not run, disconnect the pump immediately and refer to Section VI for probable cause.
- 4. If pump starts satisfactorily, open the discharge valve as desired.
- 5. Check complete pump and driver for leaks, loose connections or improper operation.
- 6. If possible, the pump should be left running for approximately 1/2 hour on the initial start up. This will allow the bearings, packing or seals, and other parts to "run-in" and reduce the possibility of trouble on future starts.

Note: If abrasives or debris are present upon start-up, the pump should be allowed to run until the pumpage is clean. Stopping the pump when handling large amounts of abrasives (as sometimes present on initial starting) may lock the pump and cause more damage than if the pump is allowed to continue operating.

CAUTION!! Every effort should be made to keep abrasives out of lines, sump, etc. so that they will not enter the pump.

V-3. PACKING BOX ADJUSTMENT

At the initial start-up, it is very important that the packing not be tightened too much. New packing must be "run-in" properly to prevent damage to the shaft and shortening of the packing life. See paragraph VI-3C for further information.

The packing box must be allowed to leak for proper operation. The proper amount of leakage can be determined by checking the temperature of the leakage. This should be cool or just lukewarm **C NOT HOT C** usually 40 to 60 drops per minute will be adequate.

When adjusting the packing gland bring both nuts down evenly and in small steps until the leakage is reduced as required. The nuts should only be tightened about 1/2 turn at a time at 20 to 30 minute intervals to allow the packing to "run-in".

When adjusted properly, a set of packing will provide good service. Occasionally a new ring of packing will need to be added to keep the box full. After adding two or three rings of packing, or when proper adjustment cannot be achieved, the packing box should be cleaned completely of all old packing and re-packed.

V-4. LINESHAFT LUBRICATION

Open lineshaft bearings are lubricated by the pumped fluid and on close coupled units (less than 30 feet long) will usually not require pre or post lubrication.

Enclosed lineshaft bearings are usually lubricated by oil or clean water, which is fed to the tensioner by either a gravity flow or pressure injection system. The gravity flow system utilizing oil is the most common arrangement. The oil reservoir must be kept filled with a good quality light turbine oil (about 150 SSU at operating temperature) and adjusted to feed 5 to 8 drops per minute.

Injection systems are designed for each installation **C** injection pressure and quantity of lubricating liquid will vary. Refer to packing slip or separate instruction sheet for requirements when unit is designed for injection lubrication.

The following oil can be recommended for Enclosed Lineshaft Bearing Lubrication under normal operating conditions.	
MANUFACTURER	TRADE NAME OF OIL
Continental Oil company	Conoco Turbine Oil, light
ESSO Standard Oil Company	Teresso 43
Mobil Oil Company	Mobil DTE 797
Magnolia Petroleum Corp.	Mobil DTE 797
Shell Oil company	Tellus 27
Standard Oil Co. of Calif.	Chevron OC Turbine 9
Socony-Mobil Oil Co., Inc.	Mobil DTE 797
Sun Oil Company	Sunvis 916
Texaco, Inc.	Texaco Regal A (R&I)
Tide Water Oil Company	Tycol Aturbrio 50
Union Oil Co. of Calif.	Redline Turbine Oil 150
If none of the above oils are available, an oil with the following specifications should be obtained: Turbine type oil with rust and oxidation inhibitors added. Viscosity 145-175 S.S.U. at 100 degrees F. with a 90 minimum viscosity index.	
It is recommended that detergent type oils not be used.	

Fig. V-A Recommended Lineshaft Oil

V-5. SHUT DOWN

The pump may be stopped with the discharge valve open without causing damage. However, in order to prevent water hammer effects, the discharge valve should be closed first.

1. Close discharge valve.
2. Stop driver.
3. Turn off lubrication on enclosed pumps.

V-6. MINIMUM FLOW LIMITATION

All centrifugal pumps have limitations on the minimum flow at which they should be operated. The most common limitation is to avoid excessive temperature build up in the pump because of absorption of the input power into the pumped fluid. Other less understood reasons for restrictions are:

1. Increased NPSHR at low flows.
2. Noisy, rough operation and possible physical damage due to internal recirculation. (The noise may be under water and not audible.)

3. Increased pulsation levels.

The size of the pump, the energy absorbed, and the liquid pumped are among the considerations in determining these minimum flow limitations. For example, some small pumps have no limitations, except for temperature build up considerations while many large, high horsepower pumps have limitations as high as 40 - 50% of the best efficiency point capacity. Safe flow for this pump is given under Pump Specifications.

SECTION VI MAINTENANCE

VI-1. GENERAL

A periodic inspection is recommended as the best means of preventing breakdown and keeping maintenance costs to a minimum. Maintenance personnel should look over the whole installation with a critical eye each time the pump is inspected. A change in noise level, amplitude of vibration, or performance can be an indication of impending trouble.

Any deviation in performance or operation from what is expected can be traced to some specific cause. Determination of the cause of any misperformance or improper operation is essential to the correction of the trouble - whether the correction is done by the user, the dealer, or the factory.

Variances from initial performance will indicate changing system conditions, wear, or impending breakdown of the unit.

VI-2. PERIODIC INSPECTION

A periodic (once a month) inspection is suggested for all units. During this inspection the pump and driver should be checked for performance and change in noise or vibration level, loose bolts or piping, dirt and corrosion. Clean and re-paint all areas that are rusted or corroded.

VI-3. PACKING BOX MAINTENANCE

Maintenance of the packing box will consist of greasing the box when required, tightening the packing gland occasionally as the leakage becomes excessive, and installing new packing rings or sets as required.

VI-3A. GREASING THE PACKING BOX

Under ordinary operation once a month greasing of the packing box will be adequate. A good grade of grease such as Standard of California #TB-medium or Texaco Multifax #2-medium should be used.

VI-3B. REPLACING PACKING

Remove gland and all old packing. If the box contains a lantern ring remove this and all packing below it. Inspect shaft or sleeve for score marks or rough spots. Be sure by-pass holes (if required) are not plugged. Repair or replace badly worn shaft or sleeve. If wear is minor dress down until smooth and concentric. Clean box bore.

Oil inside and outside of replacement rings lightly and install in box, staggering joints 90°. Be sure to replace lantern ring in proper position when used.

Note: Formed replacement packing rings are recommended and are available from the factory.

STANDARD TYPE				
SHAFT SIZE	NO. OF PACKING RINGS	PACKING RING SIZE	DEPTH OF BOX	O.D. OF PACKING
1 2	3	3/8	1 3/8	2 1/4
1 11/16	3	3/8	1 3/8	2 7/16
1 15/16	3	3/8	1 3/8	2 11/16
2 3/16	3	3/8	1 3/8	2 15/16

HI-PRESSURE TYPE				
SHAFT SIZE	NO. OF PACKING RINGS	PACKING RING SIZE	DEPTH OF BOX	O.D. OF PACKING
1 2	4	3/8	2 1/8	2 1/4
1 11/16	4	3/8	2 1/8	2 7/16
1 15/16	4	3/8	2 1/8	2 11/16
2 3/16	4	3/8	2 1/8	3 15/16

All hi-pressure boxes will have 3 packing rings located below upper lantern ring.

Recommended Packing: Graphite Impregnated Braided Fiber similar to John Crane C1065

Fig. VI-A Standard Packing Dimensions

Replace gland and tighten nuts, making sure gland enters box squarely. Keep the packing under moderate pressure for one minute to allow it to cold flow and adjust itself. Back off on the gland until loose before starting the pump.

VI-3C. START UP WITH NEW PACKING

Check that the by-pass line (if used) is connected and packing gland is loose. Start pump and allow to run for 20 to 30 minutes, do not tighten the gland during this "run-in" period even if leakage is excessive. If the

leakage continues to be more than normal, adjust as outlined in paragraph V-3. Should the new packing cause excess heating during "run-in", flush the shaft and packing box area with cold water or shut the pump down and allow to cool if necessary.

VI-3D. AUXILIARY PACKING BOX MAINTENANCE

Pumps equipped with mechanical seals may also be provided with an auxiliary packing box to restrict leakage should the mechanical seal fail. This packing gland must be left loose since under normal operation the packing will not be cooled and lubricated by the pumpage. This packing box arrangement is designed to help contain leakage past the mechanical seal, it is not designed as a primary seal and should not be used as such.

VI-4. MECHANICAL SEAL MAINTENANCE

Mechanical Seals should not be re-adjusted. Best results will be obtained if the seal is properly set on start up and left that way. If the seal starts to leak after an extended operating period some extra service may be obtained by re-adjusting, however, it is usually best to plan on replacing the seal at the next maintenance period.

After impeller re-adjustment, seal leakage may occur due to improper seal adjustment or improper seating of the seal parts. If re-adjustment of the seal will not correct the problem, refer to the Mechanical Seal Instruction Manual for further information.

VI-5. IMPELLER RE-ADJUSTMENT

Ordinarily impellers will not require re-adjustment if properly set at initial installation. Almost no change in performance can be obtained by minor adjustment of enclosed impellers.

Note: All adjustments of the impellers will change the mechanical seal setting. Unless the adjustment is to be very minor it is recommended that the seal be loosened from the shaft until the adjustment is complete and then re-set.

VI-6. PUMP LUBRICATION

Other than the packing box lubrication outlined in paragraph VI-3A and line shaft lubrication outlined in paragraph V-4 the pump will not require further periodic lubrication. The suction bearing on the bowl assembly should be repacked when repairs are made, however, no attempt should be made to repack until repairs to the bowl assembly are necessary.

VI-7. DRIVER LUBRICATION

Drivers will require periodic attention. Refer to the driver instruction manual for recommendations.

VI-B. TROUBLESHOOTING

CONDITION	PROBABLE CAUSE	REMEDY
Pump Will Not Run	<ol style="list-style-type: none"> 1. Motor overload protection contacts open. <ol style="list-style-type: none"> a. Incorrect control box. b. Incorrect connections. c. Faulty overloads. d. Low voltage. e. Ambient temperature of control box or starter too high. 2. Blown fuse, broken or loose electric connections. 3. Defective Motor. 4. Faulty control equipment. 5. Faulty switch. 6. Pump binding. 	<ol style="list-style-type: none"> 1. <ol style="list-style-type: none"> a. Check nameplate for HP and voltage. b. Check wiring diagram furnished with starter. c. Replace. d. Check voltage at pump side of control box. e. Use ambient compensated relays. 2. Check fuses, relays or heater elements for correct size and all electrical connections. 3. Repair or replace. 4. Check all circuits and repair. 5. Repair or replace 6. Pull master switch, rotate pump by hand to check. Check impeller adjustment or disassemble unit to determine cause.
Pump Runs But No Water Delivered	<ol style="list-style-type: none"> 1. Line check valve backward. 2. Line check valve stuck. 3. Unit running backwards. 4. Lift too high for pump. 5. Pump not submerged. 6. Excessive amounts of air or gas. 7. Intake strainer or impeller plugged, or pump in mud or sand. 8. Impeller(s) loose on shaft. 	<ol style="list-style-type: none"> 1. Reverse check valve. 2. Free the valve. 3. See Section IV. 4. Check with performance curve. 5. Lower pump if possible or add fluid to system. 6. Correct conditions. 7. Start & stop pump several times or use line pressure if available to back flush. Pull pump and clean. 8. Pull unit and repair.
Reduced Capacity	<ol style="list-style-type: none"> 1. Bypass open. 2. Lift too high for pump. 3. Motor not coming up to speed. 4. Strainer or impellers partly plugged. 5. Scaled or corroded discharge pipe or leaks anywhere in system. 6. Excessive amounts of air or gas. 7. Excess wear due to abrasives. 8. Impellers not properly adjusted. 9. Impeller(s) loose on shaft. 	<ol style="list-style-type: none"> 1. Check bypass valving. 2. Check performance curve. 3. Check voltage while unit is running. 4. Start & stop pump several times or use line pressure if available to back flush. Pull pump and clean. 5. Replace pipe or repair leaks. 6. Correct conditions. 7. Replace worn parts. 8. See Section IV. 9. Pull unit and repair.
Motor Overloaded	<ol style="list-style-type: none"> 1. Line voltage not correct. 2. Faulty equipment used to check. 3. Specific gravity higher than design. 4. Operation at point on pump curve other than design. 5. Motor speed too high. 6. Impellers dragging. 7. Pump in bind. 	<ol style="list-style-type: none"> 1. Check and correct. 2. Check equipment. 3. Correct specific gravity or re-evaluate system. 4. Check performance curve. 5. Line voltage too high or incorrect frequency. 6. Re-adjust. 7. Pull master switch, rotate pump by hand to check. Disassemble unit to determine cause.
Pump Vibrating Excessive and Noisy	<ol style="list-style-type: none"> 1. Unit running backwards. 2. Pump breaking suction and pumping air. 3. Loose fasteners. 4. Badly worn motor or pump bearings. 5. Impeller(s) loose on shaft. 6. Pump & Motor shafts misaligned. 7. Stress due to piping misalignment. 	<ol style="list-style-type: none"> 1. See "Initial Starting of Unit". Section V 2. Lower pump or reduce capacity. 3. Check all bolts, nuts, etc. 4. Pull unit and repair. 5. Pull unit and repair. 6. Pull unit and repair. 7. Correct.

VI-B. TROUBLESHOOTING (CONT.)

CONDITION	PROBABLE CAUSE	REMEDY
Excess Wear	<ol style="list-style-type: none"> 1. Abrasives. 2. Pump in bind. 3. Vibration. 	<ol style="list-style-type: none"> 1. Clean System. 2. Pull master switch, rotate pump by hand to check. Disassemble unit to determine cause. 3. Determine cause and correct.
Corrosion	<ol style="list-style-type: none"> 1. Impurities. 2. Corrosive liquid. 	<ol style="list-style-type: none"> 1. Analyze fluid. 2. Change to Corrosion resistant materials.
Pumped Liquid in Enclosing Tube	<ol style="list-style-type: none"> 1. Insufficient pressure and flow from lubricating system. 2. Worn bowl bearings. 3. Defective enclosing tube or connector bearing thread. 	<ol style="list-style-type: none"> 1. Adjust pressure/flow. Check for blockage. 2. Replace bearings. 3. Check and replace if necessary.
Excessive Packing Box leakage	<ol style="list-style-type: none"> 1. Gland not properly tightened. 2. Ends of packing not staggered. 3. Worn packing or sleeve. 	<ol style="list-style-type: none"> 1. Adjust as necessary. 2. Repack per Section VI-3B. 3. Replace worn parts.
Overheating	<p>A. Bearings</p> <ol style="list-style-type: none"> 1. Shaft bent. 2. Rotating elements bind. 3. Pipe strain. 4. Insufficient bearing lubrication. 5. Incorrect type grease or oil. 6. Flushing water not circulating through enclosing tube. <p>B. Packing Box</p> <ol style="list-style-type: none"> 1. Packing gland too tight. 2. Water flush line plugged. 	<p>A.</p> <ol style="list-style-type: none"> 1. Remove and straighten or replace. 2. Check for bent shaft. 3. Correct. 4. Increase lubrication. 5. Correct 6. Check for blockage or insufficient pressure. <p>B.</p> <ol style="list-style-type: none"> 1. Loosen gland until temp. Drop adjust per V-6. 2. Correct

Fig. VI-B Troubleshooting Chart

SECTION VII REPAIRS

VII-1. GENERAL

It must be borne in mind that eventually repairs will have to be made, either to the pump or to the motor. When regular maintenance checks indicate unusual vibration levels or a drop in performance, an overhaul is probably imminent.

Repairs will consist of removal of the unit and disassembly to the point necessary for replacement of worn parts.

Disassembly should be performed in a clean area with sufficient space to lay out the parts in order of disassembly. Cleanliness throughout repairs is important **C** remember this is a close tolerance, high speed machine and should be handled as such.

CAUTION!! Protect machined surfaces from burrs and scrapes which will cause misalignment on reassembly.

VII-2. EQUIPMENT AND TOOLS

Required equipment and tools will be as listed in Section III and VII of this manual.

Note: If bowl assembly repairs are anticipated, see Section VII-11. This manual should be read thoroughly before attempting repairs of the bowl assembly. .

CAUTION!! Always pull and lock the driver master switch before doing any work on the pump or driver.

VII-3. PACKING BOX REPAIRS

Packing box repairs can be done without removing the complete unit. Packing replacement as outlined in Section VI can be accomplished without disturbing the pump or driver. The packing box bearing can be replaced if necessary by removing the driver and sliding the packing box off over the shaft.

VII-4. MECHANICAL SEAL REPAIRS

Mechanical seal repairs can be effected without removing the complete unit. The mechanical seal assembly can be replaced by removing the spacer and lower half coupling on solid shaft units; or on hollow-shaft units the driver shaft and shaft coupling inside the discharge head must be removed or lifted out of the way.

VII-5. DISASSEMBLY

Note: Refer to Section VIII for parts drawings and identification.

1. Disconnect electrical leads from motor.
2. Loosen mechanical seal from shaft.
3. Disconnect pump shaft from driver:
 - a. Hollow Shaft **C** Remove headshaft nut lock screw , headshaft nut, gib key and driver clutch. Unscrew motor shaft (10A) from shaft coupling (70) inside the discharge head and remove.
 - b. Solid Shaft **C** Lower shaft and unbolt driver half coupling.
4. Remove bolts which attach driver to discharge head.
5. Lift driver off pump and set on wooden supports. With solid shaft drivers, be sure supports are high enough to clear shaft and coupling half.
6. Disconnect discharge piping from pump.
7. Remove anchor bolts (or nuts).
8. Lift pump vertically until pump suction clears foundation.
9. Cover opening in foundation.
10. Lower pump and position horizontally on suitable support and in suitable area for disassembly. Be sure and support the bowl assembly when lowering, so that weight is not carried by the suction bell.

Note: If more than minor repairs are anticipated it is recommended that the unit be taken to a shop or other clear area with a smooth floor and overhead lifting equipment.

11. Remove flinger (40) and gland (17).

Note: With sleeve mounted mechanical seals the seal and sleeve assembly should be removed with the cover. See Seal Instruction Manual for further details.

- 12a. Remove cap screws which attach the packing box or seal housing to discharge head

- 12b. Enclosed line shaft construction **C** remove tensioner bolts and lubrication line and unscrew tensioner assembly. Threads are **RIGHT HAND**. See Fig. VII-E.

13. Remove packing box tensioner or seal housing .

Note: Before proceeding further make sure the discharge head and bowl assembly are supported independently of each other.

14. Disconnect bowl assembly or top column from discharge head. This connection may be flanged or the column pipe or bowl assembly may be threaded into the discharge head. If threaded, the threads will be **RIGHT HAND**.

15. Remove discharge head (1) being careful not to damage shaft.

16. Disconnect top column pipe (101A) (if present) at first joint below top and remove from shaft.

- 17a. Open Lineshaft Construction **C** Each time a line shaft coupling (70) is exposed by removing a length of column pipe the line shaft (12) and coupling should be removed by holding the coupling and turning the upperlineshaft in **RIGHT HAND** direction (line shaft threads are **LEFT HAND**).

CAUTION!! When using wrenches on shafting always place the wrenches on the same side of the shaft as illustrated in Fig. VII-A to avoid excess side strain on the shafting.

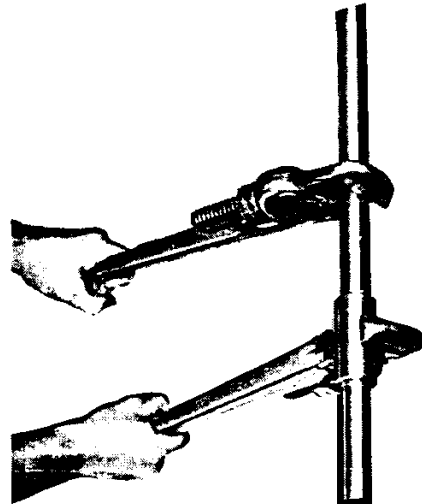


Fig. VII-A Correct Positioning of Wrenches on Shafting

- 17b. Enclosed line shaft construction **C** Each time a length of column pipe is removed the enclosing tube (85) and line shaft (12) must also be disassembled. Locate the joint (see Fig. VII-B) and unscrew (**RIGHT HAND** threads) the enclosing tube (85) from the line shaft bearing (103) (which acts as a bearing for the shaft and also as an enclosing tube coupling). Leave the line shaft bearing threaded into the enclosing tube not being removed (to support the line shaft). Slide the enclosing tube up to expose the line shaft coupling and uncouple as outlined in step 17a above.

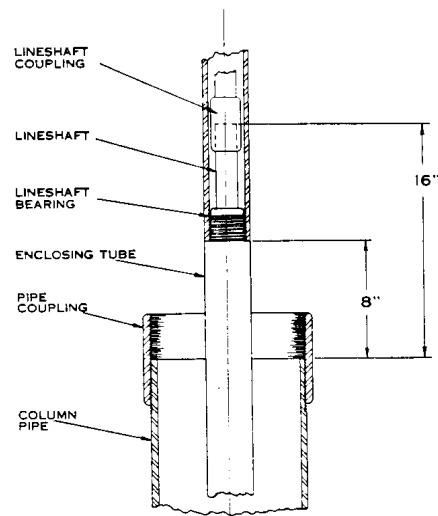


Fig. VII-B Standard Enclosing Tube and Lineshaft Projection

18. Disconnect each section of column pipe one at a time and remove along with shaft and enclosing tube as applicable until all are removed.
19. Remove bowl assembly to clear area and continue disassembly as outlined in Section VII-11.

VII-6. INSPECTION AND CLEANING

After disassembly, all components should be thoroughly cleaned and examined for physical defects, wear, corrosion and damage.

Check all bearings for total clearance over the shaft diameter. It is recommended that all bearing indicating wear be replaced. The following indicates the maximum allowable diametrical clearance over existing shaft diameter:

SHAFT SIZE	MAX. CLEARANCE
1" - 1 3/4"	.020"
1 15/16" - 2 7/16"	.025"
2 11/16" - 3 15/16"	.030"

Fig. VII-C Bearing Clearances

All bearings are pressed into their respective bores and can be either pressed out or machined on the inside diameter until the wall is thin enough to collapse. Rubber bearings are removed by collapsing the bearing and removing, or by trimming off one end and sliding the bearing out.

VII-7. REPLACEMENT PARTS

Parts showing signs of damage, cracks or excessive wear should be replaced. Use only genuine Patterson parts for replacements. Order replacement parts as indicated in Section VIII.

CAUTION!! When repairing a pump that has been in service for several years, the physical condition or strength of all parts such as cap screws, bowls, threads, etc., must be carefully checked to be sure these parts can continue to perform their function without failure.

VII-8. LUBRICATION

Re-pack suction bearing as outlined in Section VII-11.

Lubricate all metal bearings and impeller skirts with clean grease or oil. Thoroughly clean all threaded connections and flanges and paint with pipe joint compound.

VII-9. ASSEMBLY

Assembly of the unit is basically the reverse of disassembly. Before proceeding with assembly, clean thoroughly and check all threads, registers and mating faces for burr. Clean up with file where required. Lubricate as outlined above. Open lineshaft bearings can be lubricated with a soap solution. Do not use oil on rubber bearings.

Proceed with assembly in reverse order of disassembly as outlined in paragraph VII-5 above. Figure VII-D indicates recommended torque values for standard fasteners.

FASTENER SIZE	1/4	5/16	3/8	7/16	2	9/16	5/8	3/4
TORQUE (FT.-LB.)	5.4	10	17	27	40	60	84	135

Torque values shown are for standard fasteners lubricated with a high stress lubricant (graphite and oil, moly-disulphite, etc.).

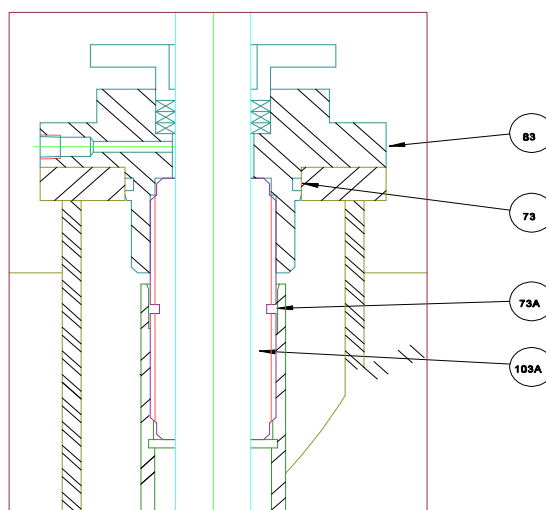
Fig. VII-D Torque Values for Standard Fasteners

CAUTION!! Cleanliness and proper lubrication are very important since one small chip, burr or one dry bearing can be cause for re-doing the whole job.

VII-10. STUFFING BOX/TENSIONER ASSEMBLY AND ADJUSTMENT

Enclosed line shaft units use a stuffing box/tensioner at the top of the enclosing tube which must be properly tightened for proper operation. General construction is shown in Fig. VII-E.

Fig. VII-E



1. Clean all "O" ring sealing surfaces and oil lightly.
2. Thread upper connector bearing (103A) into packing box (83) by hand until seated firmly.
3. Install "O"-rings (73A, 73) in connector bearing and lower part of packing box.
4. After assembling discharge head to column, slide stuffing box (83) over the shaft and thread (right hand threads) the connector bearing(103A) into the upper enclosing tube (85A) until it is snug. The upper enclosing tube has the threads recessed in about 1" from the upper end.
5. Tighten packing box/tensioner until the holes in the tensioner line up with the FIRST tapped hole in the discharge head (1/8 to 1/4 turn maximum past contact).

CAUTION!! It is necessary that the enclosing tube have tension on it which is accomplished by tightening the tensioner, however, excess tightening will distort or break the tensioner. Do not tighten more than 1/4 turn past contact on close coupled pumps.

6. Install lockscrew(s) and tighten.
7. Proceed with remainder of installation.

VII-11 BOWL DISASSEMBLY, INSPECTION, REPAIR, AND REASSEMBLY

A. DISASSEMBLY:

1. Match mark all flange butts. A punch mark on each flange will help.
2. With the bowl laying on a horizontal surface, remove the rubber bearing protector and unbolt and remove discharge case from top of assembly.
3. Remove the three (3) S.S. cap screws and two (2) set screws from the impeller bushing. Reinsert the cap screws into the two (2) threaded holes in the bushing.
4. Tighten down the screws in the bushing being careful not to strip the threads, and gently tap the impeller with a non-metallic hammer to loosen it from the bushing.
5. Slide the impeller and bushing off the shaft as a unit.

6. Unbolt and remove the top bowl making sure it is numbered and match marked.
7. Repeat steps 3 - 6 until the entire bowl assembly is disassembled.

B. INSPECTION:

After disassembly, all components of the bowl assembly should be thoroughly cleaned and examined for physical defects. The following components should be inspected for wear, corrosion and damage:

1. Impeller - Check water passageways for signs of damage from abrasion or corrosion, check impeller skirts against Aas new@clearance.
2. Shaft - Check shaft for pitting and wear. Check for straightness - shaft must be straight within .005 total indicator reading.
3. Bowls - check water passageways for signs of damage from abrasion or corrosion, check impeller seat against Aas new@clearance.
4. Bearings - check all bearings for total clearance over the shaft diameter. It is recommended that all bearings indicating wear be replaced. The chart below lists the most common observations, and corrective action required.

TROUBLE CHART

OBSERVATION	PROBABLE CAUSE	CORRECTIVE ACTION REQUIRED
Crooked shaft	Bent in handling	Replace shaft or have it straightened
Misalignment of tubing bearings and adapters	Improperly assembled	Reassemble and check. If still out of alignment, replace the parts.
Wear on shaft at seals	Natural wear, corrosive action	Replace shaft
Uneven wear on bearings	Misalignment on shaft	Replace bearings and straighten or replace shaft
Wear on bearings	Abrasive action	Replace bearings
Lateral seal ring wear	Abrasive action	Replace seal rings
Wear on side seal and impeller skirt	Abrasive action	Apply wear rings to impeller skirt and side seal if damage to bowl and impeller not too great.
Wear on bowl vanes and outside wall	Abrasive action	Replace bowls if wear is excessive

VII-F Trouble Chart

C. REPAIRS

Parts showing signs of damage, cracks or excessive wear should be replaced. Use only genuine Patterson parts for replacements. Order replacement parts as indicated in Section VIII.

CAUTION!! When repairing a bowl assembly that has been in service for several years, the physical condition or strength of all parts such as cap screws, bowls and bowl threads must be carefully checked.

CAUTION!! When attempting to re-work any part extreme care must be taken to maintain alignment of mating parts and Aas new@tolerances.

1. REPLACING BEARINGS

Replacement bearings are furnished Ato size@for press fitting into their respective bores with a .001" to .003" interference fit. If the bearing bore is heavily scarred or corroded the part should be replaced or reworked to provide a true bore for the bearing.

2. REPLACING SHAFT

Shaft damage is usually best corrected by replacing the shaft. Due to the possibility of interim damage, replacement shafts should always be checked for straightness before installing.

3. REPAIRING ENCLOSED IMPELLER AND BOWL SEAL SURFACE

Enclosed impeller skirt and bowl seal surface wear can be corrected by installing wear rings if the damage is not excessive. This is usually accomplished by turning the impeller skirt to obtain a smooth surface and then boring the bowl and installing wear rings on either, or both, surfaces. If the original unit was furnished with either bowl or impeller (or both) wear rings, these should be removed completely and replaced.

When wear rings are installed on the impeller it is recommended that a shrink fit be utilized - the interference should be heavy to prevent slippage, 0.010" on the smaller units and up to 0.015" to 0.020" on the larger sizes. Sufficient heat is then applied to the wear ring to expand it and allow the wear ring to drop over the impeller.

When wear rings are installed in the bowl a .003" to .005" press fit should be used. The wear ring can be installed by carefully tapping into place. A wooden block should be used to protect the wear ring.

D. LUBRICATION

Re-pack suction bearing with insoluble grease such as those shown in the table on the next page. Lubricate all bearings and impeller skirts with clean grease or oil. Thoroughly clean all bolts, nuts, threaded connections, and flanges and paint with white lead and oil, or pipe joint compound.

MANUFACTURER	For General Service (May be Water Resisting) Minus 20 deg. F to plus 250 deg. F	For Maximum Water Resisting Service Minus 20 deg. F to Plus 250 deg F
American Oil Co. & Standard Oil Div. Of American Oil Co.	Amolith Grease No. 2	Amolith Grease No. 2
The Atlantic Refining Co.	Atlantic Lubricant 54	Atlantic Lubricant 54
Cato Oil and Grease Co.	5335 Lith-flex C No. 2	5484 Mystic JT-6
Cities Service Oil Co.	Trojan Grease H-2	Trojan Grease H-2
Continental Oil Co.	Conoco Super Lube	Conoco Super Lube
*Gulf Oil Corp.	Gulfcrown No. 2 or EP-2	Gulfcrown No. 2 or EP-2
Exxon	Nebula EP-1	Nebula EP-2
*E.F. Houghton & Co.	Cosmolube No. 2 Grease	Cosmolube No. 2 Grease
*Imperial Oil 7 Grease	BRB-572	BRB-572
*Jesco Lubricants Co.	Jesco 822 Grease	Jesco 822 Grease
Keystone Lubricating Co.	Grease Nos. 81X LT or 51X LT	Grease Nos. 81X LT or 51X LT
*Mobile Oil Co.	Mobilux EP #2	Mobilux EP #2
*The Pennzoil Co.	Pennzoil 705 HDW	Pennzoil 705 HDW
Phillips Petroleum Company	Philube Multi-Purpose L-2	Philube Multi-Purpose L-2
*Quaker State Refining Corp.	Quaker State Multi-Purpose Lubricant	Quaker State Multi-Purpose Lubricant
*Shell Oil Co., Inc.	Shell Alvania Grease 2	Shell Alvania Grease 2
Signal Oil Co.	Signal Industrial Grease Med.	Signal Industrial Grease Med.
Atlantic Richfield	Litholine HEP 2	Litholine HEP 2
*Standard Oil Co. Of California	Chevron industrial Grease Med.	Chevron Industrial Grease Med.
Sunray DX Oil Co.	No. 646 DX All Purpose Grease	No. 646 DX All Purpose Grease
Sun Oil Co.	Sun 72 XMP Grease or Prestige 42	Sun 72 XMP Grease or Prestige 42
*Texaco, Inc.	995 Multifax EP2	995 Multifax EP2
*Tidewater Oil Co.	Veedol All-Purpose Grease	Veedol All-Purpose Grease
*Union Oil Co. Of California	Unoba A-1 Grease	Unoba F-1 Grease

*Internationally & Nationally Distributed

Fig. VII-G Recommended Grease

E. REASSEMBLY

Assembly of the unit is basically the reverse of disassembly. Before proceeding with assembly, clean thoroughly and check all threads, registers and mating faces for burrs. Clean up with file where required. Lubricate as outlined in paragraph D.

CAUTION!! Cleanliness and proper lubrication are very important since one small chip, burr or one dry bearing can be cause for re-doing the whole job.

1. Place the bowl shaft on a horizontal surface.
2. Check shaft closely for nicks or burrs - smooth with emory cloth as required.
3. Check shaft for straightness - shaft must be straight within .005" total indicator reading. If the shaft is not straight it must be straightened or replaced. If the deflection is gradual over a considerable length the shaft can usually be straightened by supporting on two blocks straddling the crooked section and applying pressure to the high side to deflect the shaft in the opposite direction. If the shaft has a sharp crook (dog-leg) it is recommended that the shaft be replaced since the shaft will not always remain straight even if satisfactorily straightened.
4. Slide the sand collar on to the shaft 2 - 3" from bottom end (unthreaded end).
5. Pack the bottom bearing with grease as shown in the table on the previous page and slide the suction bell onto the bottom end of the shaft.
6. Thread the end of the threaded rod or capscrew on the Tiedown Bolt assembly into the end of the shaft until it bottoms out.
7. Thread the plug portion of the Tiedown Bolt in to the suction bell. Tighten the plug.
8. Rotate the shaft (RH) so as to thread the shaft down tight against the plug.
9. Back the shaft off 2 full turns.
10. Slide the sand collar down the shaft until it touches the suction bell bearing.
11. Slide the first stage impeller down the shaft until it seats firmly in the suction bell.
12. Slide the bushing down the shaft and insert it into the impeller taking care that the three (3) untapped holes in the bushing line up with the three (3) tapped holes in the impeller. Inserting the capscrews at this time will assure alignment.
13. Drive the bushing tightly into the impeller with the bushing driver supplied with the pump. Install the three (3) cap screws and secure the bushing to the impeller. Reinstall the two (2) set screws. (Locktight on these threads is recommended)
14. Slide the first stage diffuser on to the shaft, taking care not to damage the shaft threads.. Position it above the suction bell, aligning the match marks made at disassembly. Bolt into place. It is a good idea to only tighten 3 or 4 bolts at each bowl during assembly, to facilitate disassembly should that become necessary later in the assembly process.
15. Check the shaft for lateral movement as follows:

With the Tiedown Bolt removed push the shaft toward the bottom of the pump as far as it will go. Scribe a mark on the shaft at the point where it enters the bowl hub. Then pull the shaft in the opposite direction as far as it will go. The distance from the top of the bowl hub to the scribed mark on the shaft should remain constant during assembly. Be sure that the shaft is free to rotate in the bowl. Check for free shaft lateral after each bowl is assembled.
16. Before placing the next impeller, pull the impeller(s) already installed down till they bottom out using the Tiedown Bolt. Do not over tighten, as this can cause the impeller to shift on the shaft.
17. Repeat steps 11 - 16 for each consecutive stage.
18. After the last bowl is installed, locate the discharge case and bolt it into place.
19. Remove the Tiedown Bolt - replenish grease as necessary being careful not to over pack the bearing. The shaft should not raise when the plug is installed.

20. Grasp shaft and rotate by hand to check for binding, also check end play by pulling all the way up and measuring distance traveled. Check this against end play recorded in paragraph 15 above.
21. Install the suction bell plug.
22. Screw column adapter in place if required.
23. Screw shaft coupling on to shaft.
24. If the lateral movement is correct (same as that checked with one stage installed) install and tighten the rest of the bowl bolts. See fig. VII-D for torque values.

Before replacing wear rings, be sure and check other surfaces and leading edges in the bowl for excessive wear. If the vanes or walls are not in satisfactory condition, the entire part should be replaced.

In the event that wear rings are replaced it is recommended that the bowl bearings also be replaced to avoid rubbing of the wear ring surfaces.

The wear rings are pressed in to the bowl side seal. After installation the I.D. of the ring should be machined to the dimension shown in the chart above.

F. DIMENSIONS & CLEARANCES

Listed below are the allowable clearances for bearings. If the measured clearance exceeds the high tolerance clearance shown below the part should be replaced. The clearance shown for wear rings are factory tolerances. If the pump shows more than a 5% deterioration in performance these should be replaced.

Bowl Size	12	13	14	17	18	19
Shaft Size	1 1/2	1 11/16	1 11/16	2 3/16	2 3/16	2 3/16
Bearing High Replace	.016	.020	.020	.020	.020	.020
Clearance Low	.006	.006	.006	.010	.010	.010
Wear Ring Factory Diametral Clearance	.020 .014	.018 .013	.018 .013	.020 .016	.026 .020	.021 .016
Bowl Wear Ring I.D.	5.392 5.394	7.954 7.956	7.954 7.956	9.016 9.018	7.954 7.956	12.016 12.018

Fig. VII-H

SECTION VIII PARTS LIST

VIII-1. ORDERING PARTS

When ordering spare or replacement parts the pump serial number and size and type of pump must be given. This can be found on the nameplate furnished with the unit. Give the complete name and reference number of each part as indicated on the applicable sectional drawing (Fig. VIII-A, VIII-B., or VIII-C) and the quantity required.

VIII-2. STOCKING SPARE PARTS

Spare parts to be kept in inventory will vary according to service, field maintenance anticipated, allowable down time and number of units. A minimum inventory of one complete set of bearings, gaskets, "O" rings, and packing (or Mechanical Seal) and one spare of each moving part is suggested.

VIII-3. RETURNING PARTS

All materials returned to the factory must be accompanied by a Returned Goods Authorization (RGA) Form. The RGA forms can be obtained directly from the factory or through your local Patterson representative. The RGA Form must be filled in completely and forwarded as directed thereon. Parts being returned under warranty claim must have a complete written report submitted with the RGA Form.

CAUTION!! Returned material must be carefully packaged to prevent transit damage. The factory cannot assume any responsibility for parts damage in transit.