M-20
INSTALLATION & OPERATING INSTRUCTIONS

CLOSE COUPLED VERTICAL TURBINE PUMPS

AURORA PUMPS
AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD · NORTH AURORA, ILLINOIS · 60542

OPEN LINESHAFT CONSTRUCTION

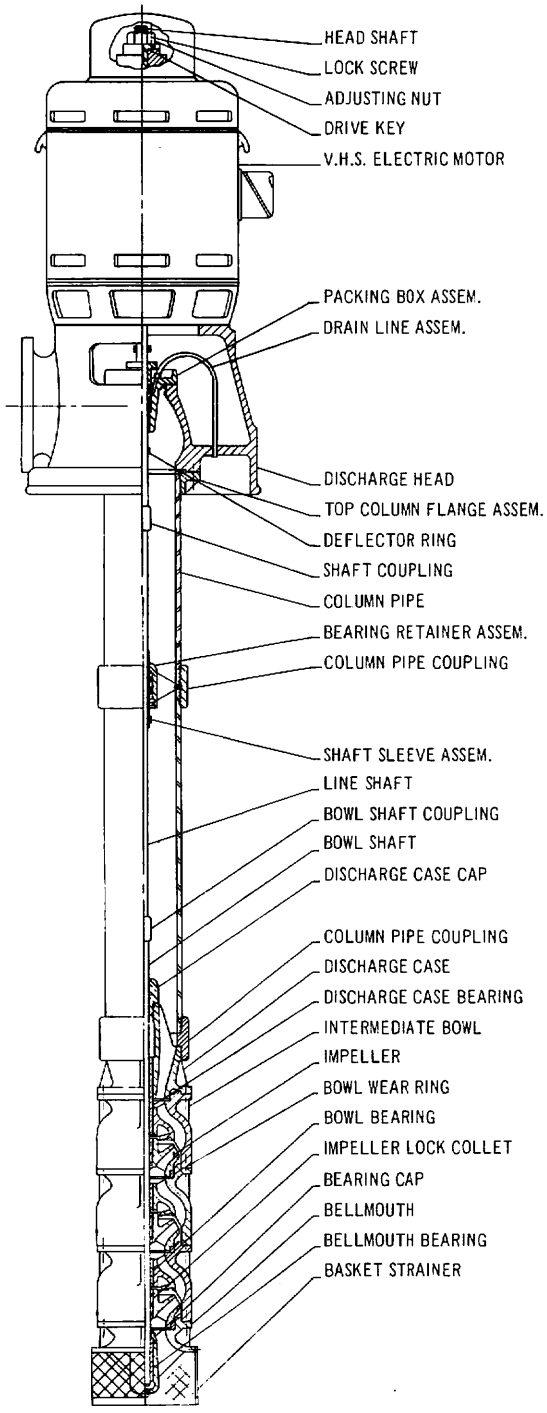

Fig. 1

ENCLOSED LINESHAFT CONSTRUCTION

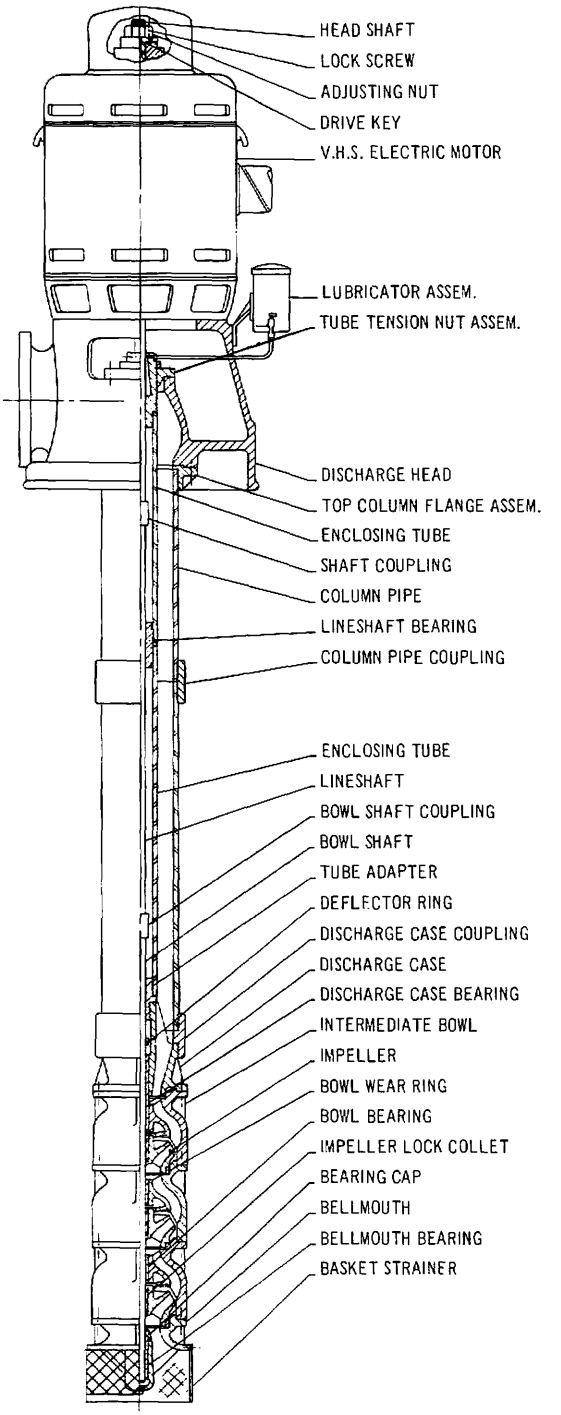

Fig. 2

INSTRUCTIONS FOR THE INSTALLATION AND CARE OF LAYNE & BOWLER VERTI-LINE PUMPS

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SECTION 1

INTRODUCTION

The satisfactory operation of the vertical turbine pump is dependent upon careful and correct installation and maintenance of the equipment. Because of the variations in installation requirements, the following instructions must of necessity be rather general in tone. The installer and maintenance man must use sound judgement to adapt the methods outlined to the conditions existent for each particular installation.

General assemblies of Layne & Bowler Vertical Turbine Pumps are shown in Figs. 1 and 2 with the component parts properly identified. This nomenclature will be used as a reference throughout these instructions. It must be understood that these are typical illustrations and may not conform in complete detail to the equipment as furnished. Please refer to any drawings that have been prepared for this specific installation and become thoroughly familiar with the construction of the pump in question before attempting to assemble, install, dismantle, or do repair work on the unit.

This type of equipment is often furnished with optional features at the specification of the user. Most of the available options will be described in this booklet. Please refer to those sections applicable to the construction of your unit, disregarding those that do not apply.

Close coupled vertical turbine pumps are usually shipped assembled and proper instructions for the handling of this type of machine will be presented here first. For equipment of a length too inconvenient to ship completely joined, the bowl unit and discharge head are assembled individually at the factory while the column parts may be shipped as components for job site assembly as suggested later in the following instructions.

If there is any doubt or question during the process of installation or operation, contact the factory or your nearest Layne & Bowler representative at once.

SECTION 2

PRELIMINARY PRECAUTION

Examine the installation site carefully before starting work.

If piping is already in place, make sure that it has been completely cleared of sand, silt, gravel, chips, or foreign material of any sort. If pump is to be installed in a sump, be sure sump has been cleared of debris and is equipped with provisions to prevent entrance of any more foreign material. The sump itself including inflow channel and pump mounting structure must be of a design adequate for the equipment to be installed. This consideration is the responsibility of the user.

During all steps of installation, care must be used to prevent strains from being imposed upon pump parts which might cause bending or misalignment of column or shafting. This also applies to piping connections.

If any parts are protected with permanent coatings, extreme care in handling will be necessary to prevent damage to coating. This might include such precaution as gloves for wrenches, etc. If coating is damaged, it should be repaired before installation is completed.

SECTION 3

PUMP FOUNDATION

A suitable pump foundation should always be provided, preferably of solid concrete construction. If this is not practical, adequate beams or timbers may be used. With a suction cased pump, the foundation will of course be under the vessel flange and the pump head will mount directly to the vessel flange.

The pump foundation must be built to carry the weight of the entire pump full of liquid and should be of a design to withstand and prevent any undue vibration. If the pump is mounted on beams, the beams should be heavy enough to prevent spring action between spans, also with lateral bracing to prevent side motion.

Pump foundation or mounting structure is not to be considered part of the pump and will be the responsibility of the user.

SECTION 4

SUCTION VESSEL

If pump is a suction cased booster, suction vessel may have been furnished with pump or may have been procured from another source. In either event, vessel should be lowered into its pit, leveled, and grouted in place, following which nuts may be tightened on anchor bolts.

It is important that vessel be set with machined portion of top flange perfectly level. Vessel bolt holes must be located so that suction and discharge nozzles are in proper orientation for jobsite piping.

In some installations, concrete is poured around outside of vessel after positioning. In other instances, vessel may be set in ground with a higher water table. In these or similar situations, proper measures must be taken to prevent vessel from floating out of position. This may be done by any suitable means, including firm anchoring and bracing, or vessel itself may be filled with water to eliminate its buoyancy.

Following installation of vessel, and during installation of pump, it will be necessary to provide protection for machined surface of vessel flange.

Typical assemblies of this type are shown in Fig. 3 and 4.

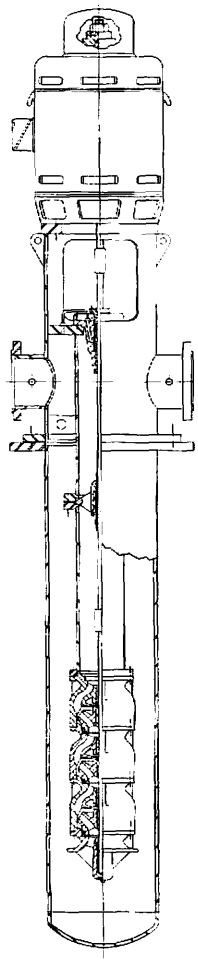


Fig. 3

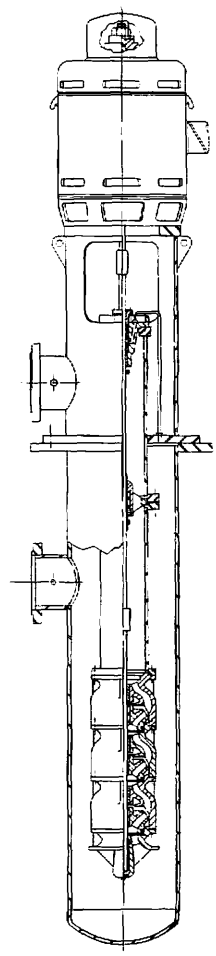


Fig. 4

SECTION 5

INSTALLATION EQUIPMENT

Required installation equipment will of course depend upon type and size of pump to be installed. Although portable derricks or tripods are sometimes used, a properly designed pump setting rig (See Fig. 5) or construction crane is recommended. The lifting device must be of sufficient height to allow the load hook to be raised about two feet higher than total length of unit if it is desired to handle the complete assembly.

Depending upon complexity of installation, following miscellaneous tools may be required:

Wooden friction blocks or steel clamps (Fig. 6)
Steel column lifting elevators of approved type and of proper size for the pump column (Fig. 6)
Cable sling approximately 10 feet long of adequate size for the loads involved
Two chain tongs
Two medium size pipe wrenches
Twelve foot length of 3/4" rope
Ordinary set of mechanics tools
Wire brush
Paint brush
A good grade of pipe joint compound
Gasoline, distillate or kerosene

If equipment is to be oil lubricated, provide at least one gallon of SAE #10 mineral oil with proper additives or a good turbine oil such as Standard Oil O.C. Turbine Oil #9.

If mating stainless steel parts are to be joined, particularly with threads, a lubricant containing molybdenum disulphide or some equally effective anti-galling compound should be provided and used per manufacturer's directions.

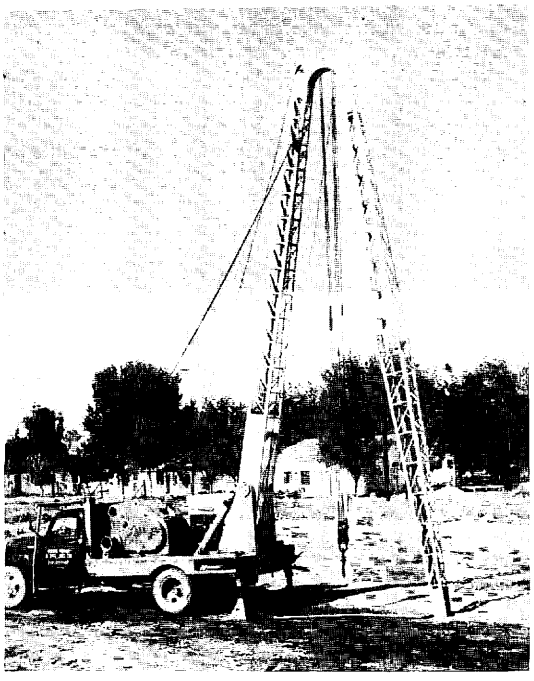


Fig. 5

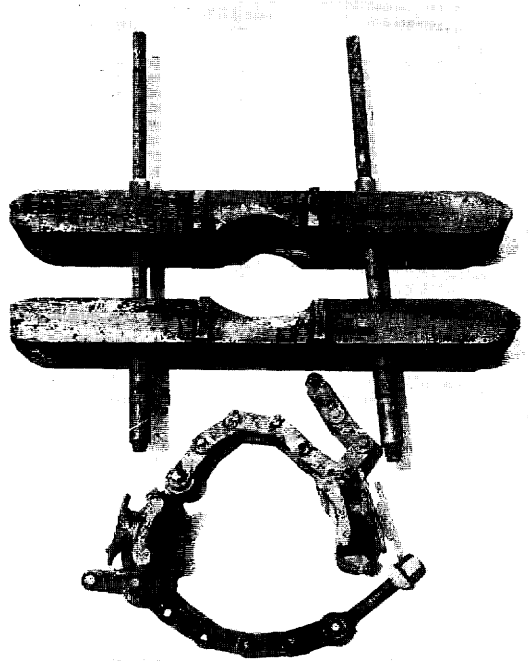


Fig. 6

SECTION 6

UNLOADING AND PREPARATION FOR INSTALLATION

Uncrate parts and inspect carefully to be sure nothing was damaged in shipment. Check in detail condition of any shafting. If any part of equipment or crating has been damaged or broken in shipment, please report immediately to factory and to transportation company involved, with full particulars, confirming all verbal understandings by letter. Do not accept shipments showing damage. Do not sign for incomplete shipments.

If pump is shipped assembled, see Section 7. If not, continue with this section.

If pump is shipped unassembled, clean all column and coupling threads of any slushing compound or foreign particles with wire brush. Keep threads clean at all times and use care in making up screwed joints to avoid cross threading and damage to threads. Use Permatex No. 2 Gasket and Thread Compound on all column joints and flanged pipe connections during installation.

If pump has been shipped in components, lay out column pipe and bowl assembly on suitable timbers or staging to keep all material out of dirt. Coupling ends should be located toward mounting position. Clean all threads thoroughly and apply joint compound with paint brush as they are installed. Inner column assembly consisting of shafting and/or tubing with lineshaft bearings will have been preassembled at the factory into proper lengths to match the column pipes. If furnished, tube faces should be inspected to see that they are free from burrs or nicks and are wiped clean. Sections of tubing which have been assembled at factory should be checked for tightness by installer at jobsite.

Examine lineshafting to make sure that it is straight, care being taken not to bend shafts or damage threads. Do not lay shafting lengths on ground or where they may be walked on or run over. KEEP THEM STRAIGHT. They must be placed on timbers and all rust preventive oil or slushing compound should be washed off with gasoline, distillate or solvent. Exercise great care in jobsite handling because, due to its length, a shaft can easily be sprung or bent. Any length that is bent should not be used. Keep shaft and tube ends covered until they are ready to be installed.

All other parts should be cleaned and laid out on a clean surface in the order in which they will be used. Check against packing list to be sure that none are missing.

Insert each length of intermediate shafting into the assembled enclosing tubes if furnished or into the column pipe if pump is of open lineshaft construction without tubing. Tube and shaft assembly, if furnished, should similarly be inserted into column pipe sections. Place with projecting lineshaft bearing and column coupling pointed toward the mounting position. See Figs. 7 and 8.

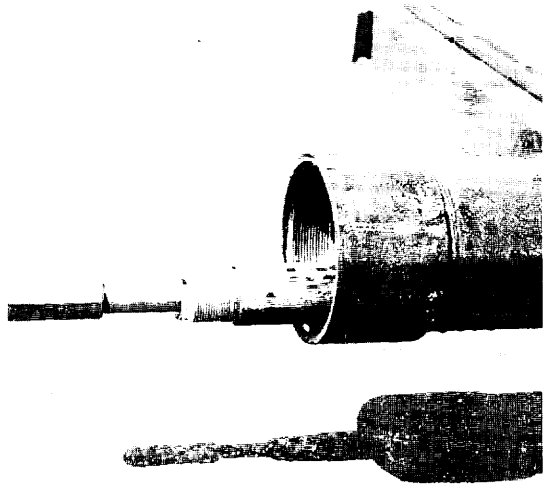


Fig. 7

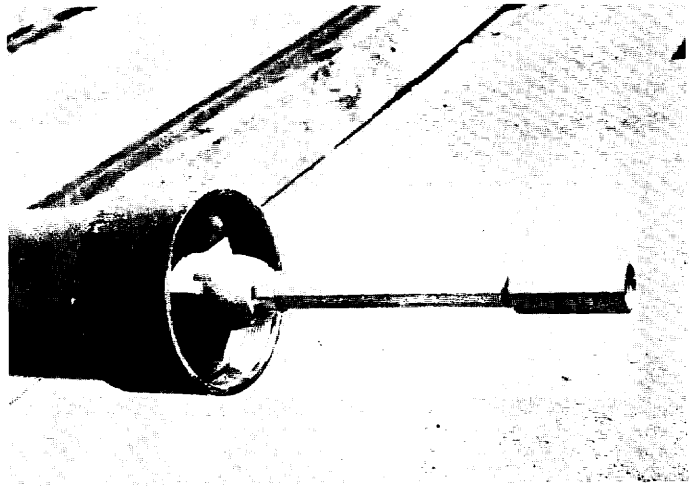


Fig. 8

SECTION 7

INSTALLATION OF FACTORY ASSEMBLED UNITS

Clean mounting structure at pump location. If this is a suction cased pump, clean top flange of vessel and install gasket or O ring as provided. Clean bottom face of discharge head mounting base or flange.

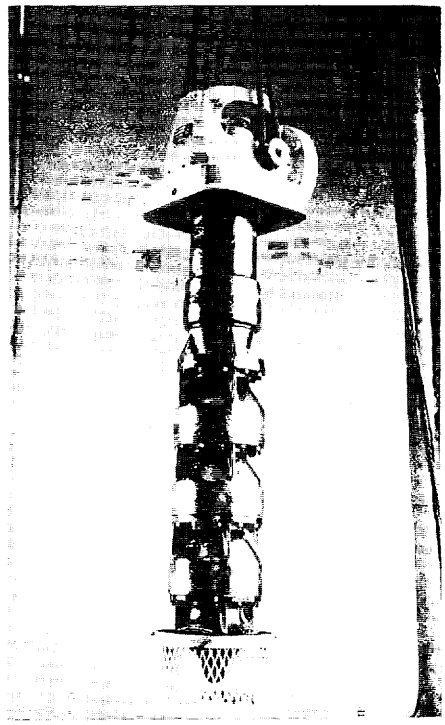


Fig. 9

Raise entire unit as shipped to a vertical position, using proper lifting lugs, (Fig. 9), taking care not to put strain on column or any exposed shafting. Install assembled unit in a plumb vertical position with full contact base to mounting surface. Assemble base or flange mounting bolts and/or nuts.

If driver is of vertical solid shaft construction, refer to procedures outlined in Section 10D. If driver is of vertical hollow shaft construction, continue with this section.

Clean all mounting surfaces and lower driver into position atop its mounting structure, fastening with capscrews as provided. Remove canopy and drive coupling, illustrated in Fig. 10. Check level indicators for amount of oil or grease in driver bearings. Do not add grease without first opening grease relief plugs, as high pressure might ruin grease seals. In general, lubrication instructions will be furnished with driver and these instructions should be followed implicitly.

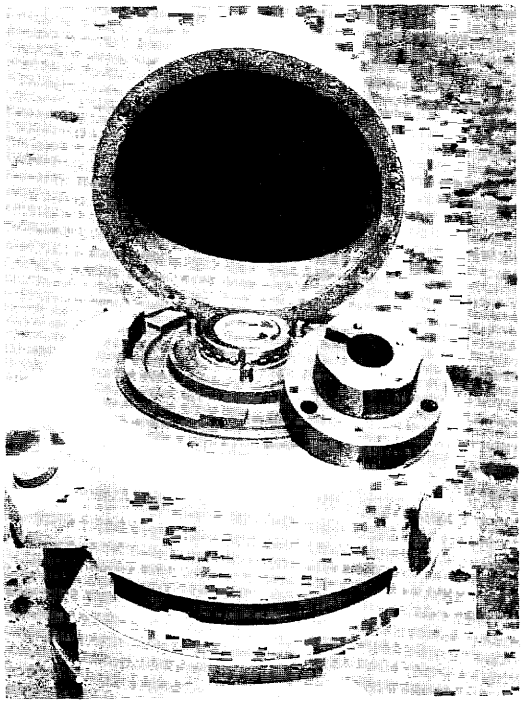


Fig. 10

On electric motor driven units of hollow shaft construction, connect motor terminals to leads in starter panel. CAUTION: Do not work on pump, motor, wiring, or other components of system without first opening main breaker or pump disconnect switch. Since many electric motors will be furnished as dual voltage machines, it is important that proper connections be made to suit voltage of power source. Therefore, check power source and motor instruction nameplate for proper method of connecting motor terminals.

Energize starter panel and buzz-start motor by switching it very quickly on and off, observing for proper rotation and inspecting to see that it spins freely and is in balance. Motor must run counter-

clockwise when viewed from the top. If rotation is clockwise, interchange any two motor connections on three phase motors. On single phase motors, follow manufacturer's instructions. After reconnection, again buzz-start the motor to check rotation. Make absolutely sure that it will drive the pump in a counterclockwise direction before making connection to pump shaft. De-energize panel at main breaker or pump disconnect switch before continuing.

Assemble headshaft, sliding it down through packing box or tube connector, snapping it to firm butt against pump shaft. If possible, hold shaft coupling by reaching through pump discharge opening if first joint is located below the head. Remember shaft threads are left hand. It may be necessary to loosen packing box gland to facilitate installation of top shaft.

Slide drive coupling over headshaft into place on driver. It should have a sliding fit and should be firmly seated in its proper position on top of driver without tendency to hang up as it is lowered into position or rotated. It must sit perfectly flat and without cocking. File, dress, and scrape if necessary to obtain proper assembly. Remove coupling.

Try drive key in headshaft keyway and coupling keyway. Make sure that this is also a sliding fit. Reassemble coupling in place on driver and insert key. Do not force key in place. Dress the key NOT THE KEYWAY until a free but not loose fit has been obtained. Top of key must be below adjusting nut seat when in place.

Thread adjusting nut onto headshaft, remembering shaft threads are left hand. Raise shaft about one half turn off bottom. Assemble lock screw through adjusting nut, threading it into nearest tapped hole in drive coupling. See Fig. 11.

Fig. 11

If packing box is furnished, see Section 10A. Fill packing box grease cup with standard water pump grease if not already done. Lubricate as required . Connect drain lines from top of packing box flange, draining to convenient location.

If pump is of normal oil lubricated design, examine oil reservoir and oil feed line, making sure they are clean. See also Section 10B for details of enclosing tube connection, which will already have been made up at factory. Connect lubricating system as described in Section 10B. Fill oil reservoir, using oil as described earlier. Adjust lubricator valve to permit oil to drip at a rate of approximately one drop per second. For solenoid operated lubricators, this adjustment can only be made with solenoid energized, which may not occur until time of startup.

It is also advisable to apply a few drops of oil at top of tubing connector with an oil can. Reservoir and connections are shown in place in Fig. 12.

If any other system of pump lubrication has been furnished, refer to Section 10 for proper procedures or to any special instructions which may have accompanied the shipment of your pump. If pump incorporates a mechanical seal, again refer either to Section 10C or to special instructions included with shipment.

Connect discharge manifold to pump without straining or distortion of any kind. Any other piping, including suction pipe to a "T" type head or to a suction vessel, must be assembled without strain being imposed on the pump in any way.

With a suction cased pump, remove vent plugs on suction and discharge. Open system suction line valve and flood pump. When as much air as possible has been released and liquid is above first stage of bowl assembly or as high above that as possible, open system discharge valve the equivalent of two turns of the wheel minimum. Replace vent plugs.

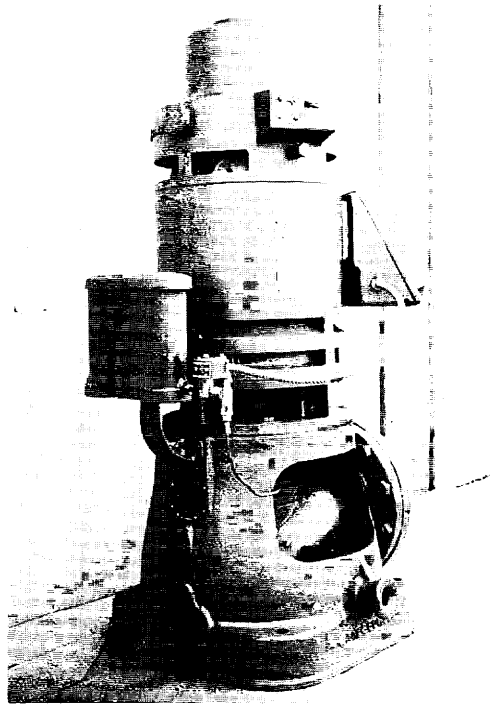


Fig. 12

With sufficient submergence over suction or with adequate NPSH available, pump is now ready to start. However, read through these instructions completely to establish procedure for any optional items before starting pump.

SECTION 8

INSTALLATION OF UNASSEMBLED UNIT

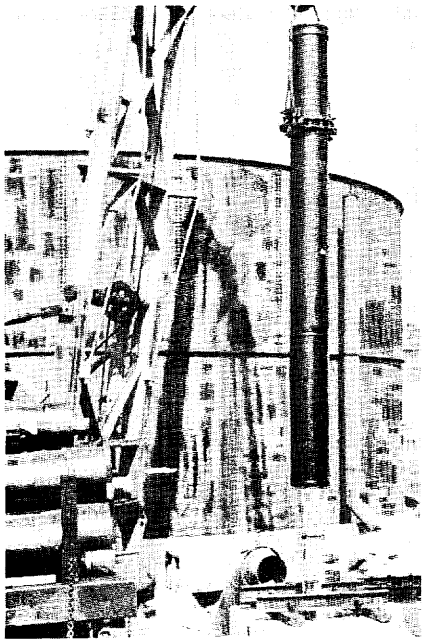


Fig. 13

Vertical turbine pumps of overall length less than 15 feet are almost invariably assembled complete at the factory less the driver. Equipment of overall length from 15 feet to 25 feet may or may not be shipped preassembled, depending upon a number of factors. Any units in excess of 25 feet overall length will invariably be shipped as components for jobsite assembly. The bowl unit and the discharge head will be assembled individually at the factory. Column components, driver, and other miscellaneous parts will then be shipped as separate items for jobsite assembly as suggested in this section.

Refer to Section 6 for preparation and location of parts prior to attempting the installation. Refer to Section 5 for suggested installation equipment.

Set pipe clamps over installation position and open up wide enough for suction pipe and/or strainer to pass through. If a suction assembly has been furnished, raise as shown in Fig. 13 with elevator assembly, lowering into position through opening in clamps. Clamp suction pipe at least two feet below coupling end so that pressure from clamp will not distort threads. Take care while raising suction assembly into vertical position to be sure that strainer (if supplied) is not damaged during this operation.

(a) OPEN LINESHAFT CONSTRUCTION

Examine bowl assembly carefully. Make sure that bowl assembly discharge case coupling is tightly butted in place and that all stage connecting nuts have been taken up securely. Examine bypass ports in discharge case to make sure that they are properly plugged. See Fig. 14. Raise bowl assembly as illustrated in Fig. 15, suspend directly over installation position and screw or bolt bowl unit onto pipe as required, making a tight joint. If no suction pipe is used, strainer may be assembled onto suction case before raising bowl assembly, but

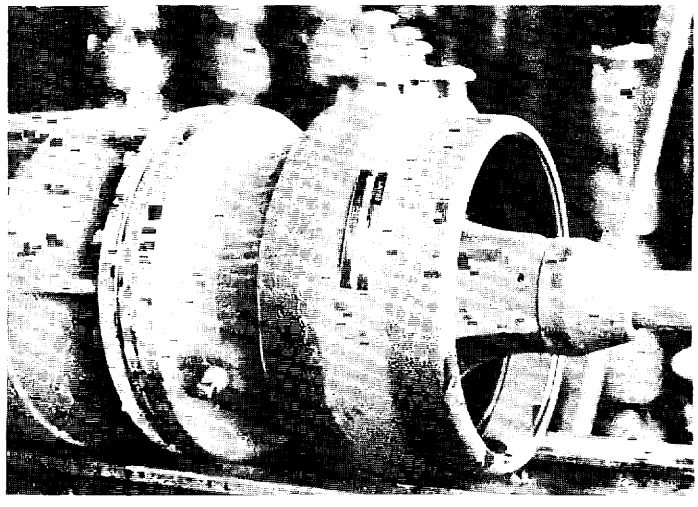


Fig. 14

care must be taken to prevent damage to strainer while raising to vertical position.

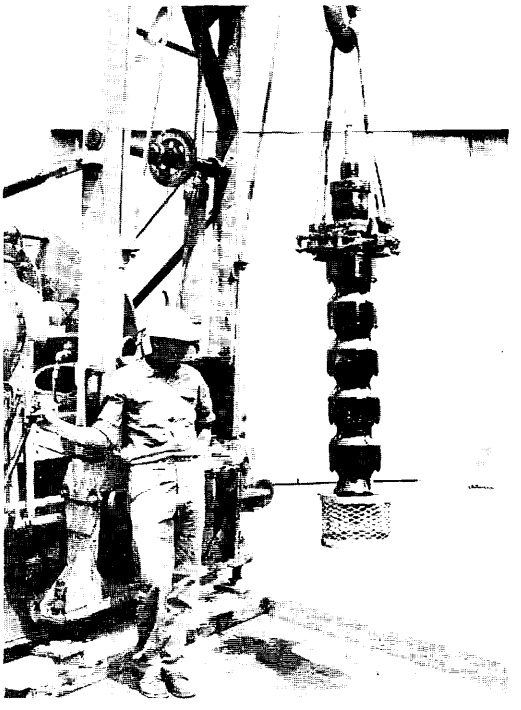


Fig. 15

Raise unit and remove clamps from suction pipe, then lower strainer, suction pipe, and bowl assembly as shown in Figs. 13 and 15. If two sets of elevators are used, column clamps can be tightened and assembled unit may then be lowered until elevator rests on clamp, Fig. 16. Clean and inspect all exposed threads and faces. Under no circumstances should the bowl assembly be lifted or handled by the pump shaft.

Bottom column pipe section will be marked as such. Attach elevators to this pipe immediately below column coupling. Use hemp rope and throw timber hitch around pipe about one foot from threaded end away from mounting position, double half hitch around shaft on top of threads to prevent slipping. This is illustrated in Fig. 16 and 17. Although other methods are acceptable, it is preferred that shaft coupling be on length of shafting already assembled as in Fig. 16 so that shaft is lowered into coupling much the same as pipe joint is made.

Crown block and load hook must be located exactly above center of installation position so that various components may be lowered and assembled true. Hoist column section in place above bowls as in Fig. 16. It will be necessary that free end of tail rope be held taut to prevent slipping on shaft. A soft board or pipe dolly should be laid out for end of column pipe to slide in on, so that threads will not be damaged as section is being raised.

Fig. 16

Fig. 17

Clean all threads and inspect shaft ends to be sure there are no burrs or dirt adhering to faces. Paint shaft threads with thread lubricant. Inspect and clean shaft coupling and assemble it as described. Lower column assembly and couple shaft, remembering that shaft thread is left-hand. Make sure that shaft ends are solidly butted together but do not use undue force in tightening

See Fig. 18. Lock shafts tightly with two small pipe wrenches, using one wrench on shaft coupling and the other on shaft just above threads. Wrench handles should be parallel when final tightening is made to prevent pulling shaft off center. If available, it is even better practice to use a shaft wrench rather than a pipe wrench. Do not allow coupling to ride up on "last scratch" or imperfect thread, as this will tend to cock the coupling and create misalignment. Both shafts should show same amount of threads above and below coupling, indicating that shaft butt is in exact center of coupling. If force is required, look for damaged or dirty threads. Forcing threads may cause misalignment.

Fig. 18

It is advisable to stuff sacking into discharge case or lower section of column pipe while assembling other parts. This will prevent dropping foreign material, tools, or parts into pump. If something is dropped in pump it must be removed before continuing installation. This could require returning everything to surface, and it can thus be seen that some form of cover is indicated. Remove sacking or cover before making up pipe joint.

Lower column pipe. Clean threads, apply lubricant, and screw up tightly with chain tongs, making absolutely sure that column joints butt solidly, metal to metal. These threads are right-hand. Start threads carefully to prevent cross-threading. In tightening column pipe joints, place one set of chain tongs on coupling and another on column pipe. Do not depend on friction clamps to hold lower section for tightening.

Fig. 19

To repeat, it is important that pipe ends butt solidly against mating parts. For flanged column, refer to Section 10F.

Raise entire unit sufficiently to remove holding clamp. Lower assembly until elevator clamp then rests on friction blocks as shown in Fig. 16. At this point, an inspection should be made to insure that shaft stands in center of pipe or that very slight pressure will center it.

Wipe all oil or grease from upper end of lineshaft down to and including journal area. Bearing retainer assembly may now be placed over projecting end of lineshaft with open end down as illustrated in Fig. 19. With threaded column, bearing retainer assembly is screwed into column coupling tightly against end of column pipe below, using hollow socket wrench provided with shipment. Obviously,

this must be done before starting to screw next column pipe into coupling. Shaft should now stand freely in center of bearing retainer without binding against side. Do not force shaft to center with bearing retainer. If shaft bears heavily to one side and bearing retainer is not cross threaded, column and shaft should be pulled up again, removed and inspected for misalignment. Never continue with installation if shaft does not center freely at bearing retainer. This indicates a misaligned column pipe or bent shaft which will eventually cause trouble.

For flanged column, bearing retainer is merely set into a recess in the flange and flanged joints are then made up with nuts and bolts. All other instructions still apply.

If all is centered properly at this time, proceed with installation of next column section. Repeat this installation procedure with all additional sections, remembering that pipes and shafts must butt solidly in center of each joint.

If lineshaft is furnished with sleeves at journal points, inspect to see that sleeve journal falls properly within the bearing location. Any attaching collet or projecting part must clear bearing retainer by approximately one inch minimum so that, when shaft is raised for impeller adjustment, no interference occurs at journal points. In applying thread lubricant to shaft threads, prevent lubricant from contact with rubber bearing in bearing retainer.

Top column pipe section is generally shipped without couplings on either end and will be marked as to its position in pump. Since this section will normally be of different length than intermediate joints, it is important that it be assembled in correct location.

Top column flange will be shipped loosely assembled to discharge head. Remove nuts attaching flange to head and remove flange from its position in bottom of head, taking care to protect gasket during this operation. Top column flange may now be threaded onto top end of top column pipe as pump hangs in position. To facilitate turning flange, two long bolts may be inserted through flange holes so that a bar may be used to tighten flange onto pipe as seen in Fig. 20. As in any pipe joint, it is important that top pipe make a solid butt against shoulder of flange. Clean face of flange and put a light even coating of grease on machined surface. Place gasket very carefully upon this surface.

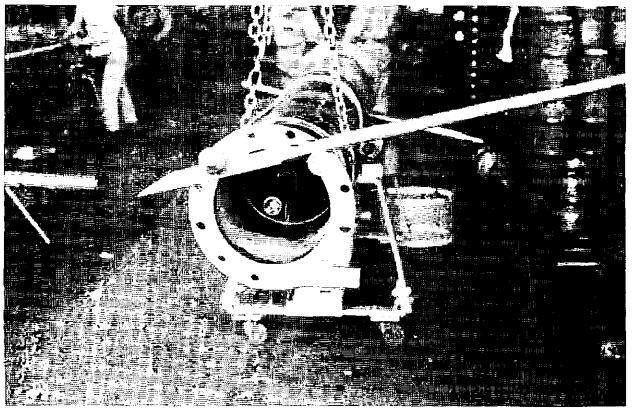


Fig. 20

Clean bottom face of discharge head, including all machined surfaces. Coat these surfaces with a very light even coating of grease.

Lower head carefully into position on top of column flange, making sure centering registers are fully engaged and that outer flange face

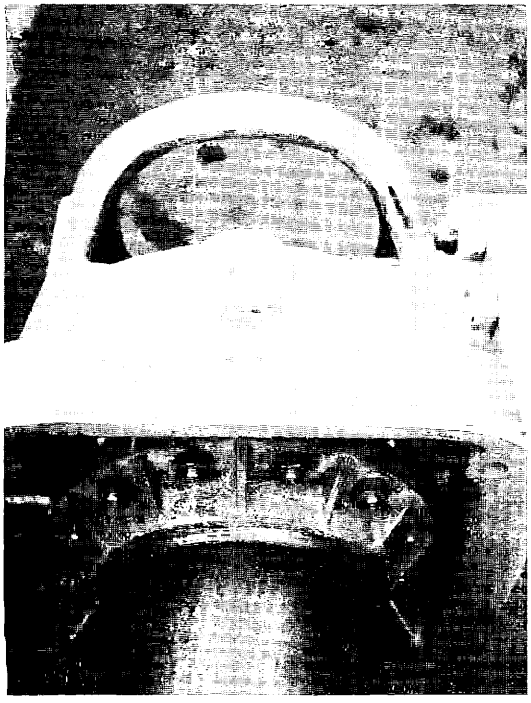


Fig. 21

seats firmly, evenly, and with no cocking. Assemble and tighten nuts uniformly on studs. See Figure 21.

See Section 10A for details of normal packing box. For any other options, see other portions of Section 10 or other special instructions furnished with job.

Clean mounting structure and make sure it is level. If pump mounts on a sealed surface, install gasket or O ring. Lower entire unit carefully to final installed position and assemble base or flange mounting bolts and/or nuts.

Proceed at surface from this point as described in Section 7.

(b) ENCLOSED LINESHAFT CONSTRUCTION

Enclosed lineshaft parts are assembled in a manner similar to that used for open lineshaft construction, except that there will also be enclosing tube to handle. Again examine bowl assembly carefully to make sure that bowl assembly discharge case coupling is tightly butted in place and that all stage connecting nuts have been taken up securely. Inspect bypass ports in discharge case to make sure that they are properly open and not plugged in any way. See Section 10G and Section 10H for possible exceptions. Remove shaft protector pipe by unscrewing from bowl assembly tube adapter. See Fig. 22 for illustration for bowl assembly.

After attaching elevators to column pipe immediately below column coupling, use hemp rope to throw timber hitch around pipe about one foot from threaded end away from installation position, then apply double half hitch around tubing section, and double half hitch around shaft on top of threads to prevent slipping . This is illustrated in Fig. 23 and 24.

As described earlier, hoist column section into place above mounting position as illustrated in Fig. 24. It will be necessary that free end of rope be held taut to prevent slipping on shaft. A soft board or pipe dolly should be laid out for end of column pipe to slide in on so that threads will not be damaged during raising of section.

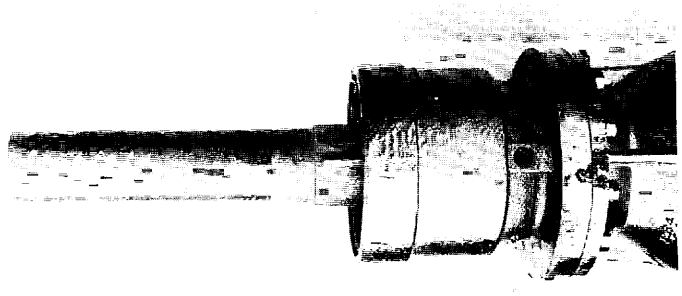


Fig. 22

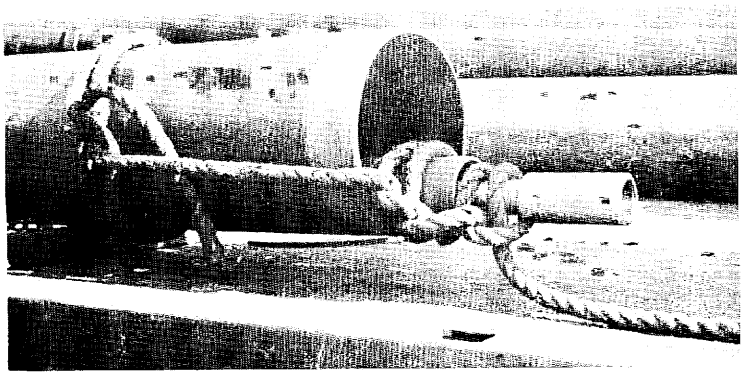


Fig. 23

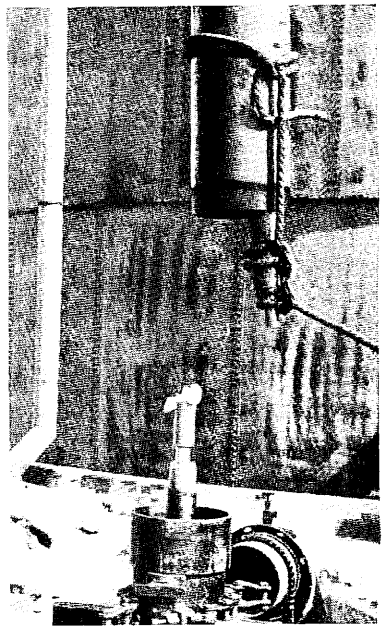


Fig. 24

Clean all threads and inspect shaft ends and enclosing tube faces to be sure that there are no burrs or dirt adhering to faces. Paint shaft and tube threads with thread lubricant. Inspect and clean shaft coupling, which will usually be found in boxed parts, and assemble it as described.

Lower column assembly and couple shaft, remembering that shaft thread is left hand. Make sure that shaft ends are solidly butted together but do not use undue force in tightening. See Fig. 25. Lock shafts tightly with two small pipe wrenches, using one wrench on shaft coupling and the other on shaft just above threads. Wrench handles should be parallel when final tightening is made to prevent pulling shaft off center. If available, it is even better practice to use a shaft wrench rather than a pipe wrench. Do not allow coupling to ride up on "last scratch" or imperfect thread, as this will tend to cock the coupling. Both shafts should show same amount of threads above and below coupling, indicating that shaft butt is in exact center of coupling. If force is required, look for damaged or dirty threads. Forcing threads may cause misalignment.

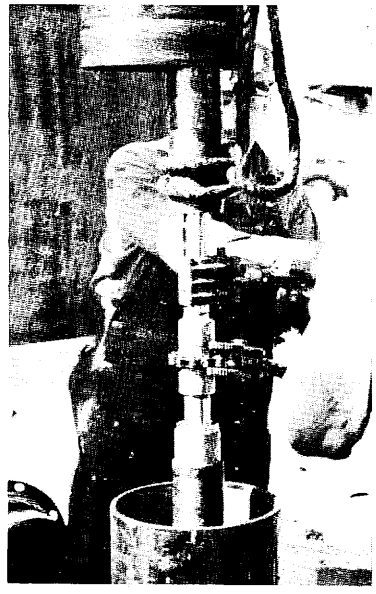


Fig. 25

Lower enclosing tube and thread it onto tube adapter at top of bowl assembly, tightening it with pipe wrench or small chain tong. These are right hand threads. On following tube sections, two wrenches or small chain tongs should be used, one holding lower tube stationary and the other to tighten upper section into place onto projecting lineshaft bearing. In all cases, wrenches must be held parallel for final tightening.

It is advisable to stuff sacking into discharge case or lower section of column pipe while assembling shaft and tube. This will prevent dropping foreign material, tools or parts into pump. If anything is dropped into pump, it must be removed before continuing installation. This could require returning everything to surface and it can thus be seen that some form of cover is indicated. Remove sacking or cover before making up pipe joint.

Lower column pipe. Clean threads, apply lubricant and make up tightly with chain tongs, again taking care that column joints butt solidly, metal to metal. Start threads carefully to prevent cross threading. In tightening column pipe joints, place one set of chain tongs on coupling and another on column pipe. Do not depend on friction clamps to hold lower section for tightening. Make sure that pipe ends butt solidly.

These threads are also right hand. For flanged column, refer to Section 10F.

Raise entire unit sufficiently to remove holding clamps. Lower assembly until elevator clamps again rest on friction blocks as shown in Fig. 24. Remove lineshaft bearing from projecting oil tube and pour into tube not more than one half pint turbine oil as described earlier. Replace lineshaft bearing using half the bearing threads, allowing half the lineshaft bearing to project out of tube to connect with next joint. At this time, position of tubing and column pipe should be observed so as to make sure it is centered. If all is centered properly at this time, proceed with installation of column section. Repeat this installation procedure on all additional sections.

Top column pipe section is generally shipped without couplings on either end and will be marked as to its position in pump. Top column pipes over 5 feet in length will usually have pads welded on about 20 inches from top end. These pads are to assist in installation work and are used for back-up to elevators or clamps when lifting assembly.

Shaft enclosing tube to be assembled in top column parcel will usually consist of three sections, one of which is a standard 5 foot joint. The other two are shorter lengths of tube. Length of tube connector at top of this tube section has been established to provide about 3 inches of adjustment at head, far more than usually required with short setting pumps.

Top lineshaft may also be of different length than standard 10 foot joints. It will have been designed to terminate at a predetermined point with respect to top column flange.

Make up top section as if it were an intermediate section of column assembly, except that pipe will not have a coupling at top. The long tube connector should be made up as a tubing joint before the discharge head is set down. See Section 10B. This is to permit use of back up tongs on tube while making up a tight joint with connector. If lock collar is furnished, it should be assembled on connector at this time but set screws should be left loose.

Top column flange will be shipped loosely assembled to discharge head. Remove nuts attaching flange to head and remove flange from its position in bottom of head, taking care to protect gasket during this operation. Top column flange may now be threaded onto top end of top column pipe as pump hangs in position. To facilitate turning flange, two long bolts may be inserted through flange holes so that a bar may be used to tighten flange onto pipe as illustrated in Fig. 20. As in any pipe joint, it is important that top pipe make a solid butt against shoulder

of flange. Clean face of flange and put a light even coating of grease on machined surface. Place gasket very carefully upon this surface.

Clean bottom face of discharge head, including all machined surfaces. Coat these surfaces with a very light even coating of grease.

Lower head carefully into position on top of column flange, making sure centering registers are fully engaged and that outer flange face seats firmly, evenly, and with no cocking. Assemble and tighten nuts uniformly on studs. See Figure 21.

See Section 10B for details of normal enclosing tube connection. For any other optional features, see other applicable portions of Section 10 or other special instructions furnished with job.

Clean mounting structure and make sure it is level. If pump mounts on a surface to be sealed, place gasket or O ring in position. Lower entire unit carefully to final installed position and assemble base or flange mounting bolts and/or nuts. See Figure 26.

Proceed at surface from this point as described in Section 7.

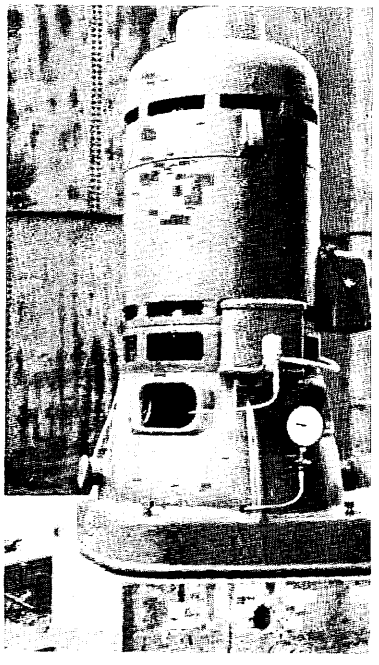


Fig. 26

SECTION 9

PUMP ADJUSTMENT PROCEDURE

The perihedral seal on enclosed impellers provides two sealing surfaces. The cylindrical seal or skirt on lower end of impeller is generally adequate for most installations. It is simplest to adjust and should be used as the only seal, unless it becomes badly worn. An enclosed impeller is shown in Fig. 27.

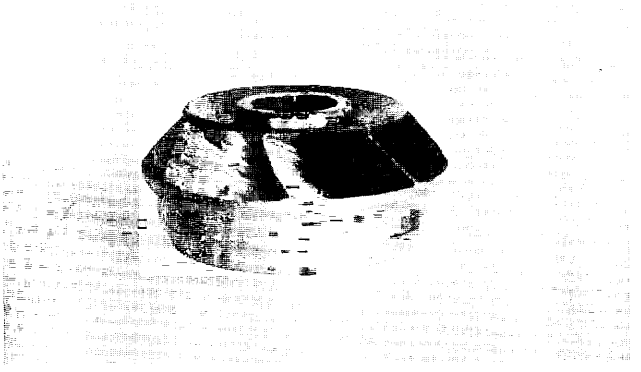


Fig. 27

These instructions are intended to cover pumps of minimum overall length to settings not in excess of 40 feet. Therefore, initial adjustment is not too critical and impellers may be set at approximate center of their possible travel. Adjust pump by turning adjusting nut on the left-hand shaft threads so that impellers just come off their seats. This is break-free point and should be marked, nut to drive coupling. Then, by continuing to turn adjusting nut raising shaft until impellers contact top of impeller cavity in bowl, upper limit of impeller adjustment is established and should be marked, again nut to drive coupling. Number of turns of adjusting nut between the two marks should be recorded and nut should be backed off from its upper position half the total number of turns registered above. This should locate impellers in approximately the center of impeller cavity in bowl.

If, after a period of time, the cylindrical seal has become worn, the wear compensation feature of the perihedral seal can be brought into use. The seal under these conditions is established between upper or horizontal face of bowl seal ring and lower horizontal face of impeller shoulder, as illustrated in Fig. 28. Again, adjust pump to break-free point. Raise shaft further one-third turn of adjusting nut. Run pump and, by checking power and/or capacity, determine that capacity has been increased. Make a record of power and capacity and stop the pump. Lower impellers an amount not to exceed one-sixth turn and start pump again. If faces of seal are rubbing, a slight vibration will be felt. A moderate increase in power and capacity indicates impellers are not dragging. An increase in power without increase in capacity indicates these faces are rubbing. Under these conditions, if power increase is moderate and vibration slight impellers will rub

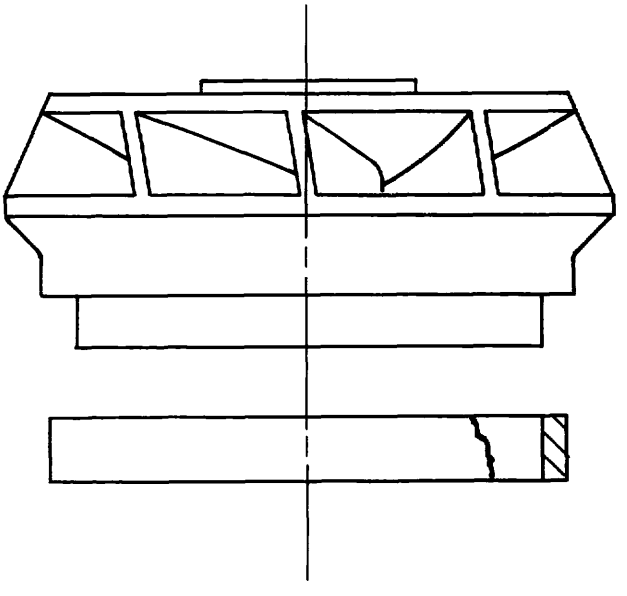


Fig. 28

free after a short period of time. This type of operation will probably be characterized by a fluctuation in power such as might be shown with an ammeter. If pump vibrates obviously and power increase is great, raise impellers until condition is relieved.

Semi-open impellers must be adjusted in same manner as described above for lateral faces of perihedral seal. However, it must be remembered that, with semi-open impellers, as illustrated in Fig. 29, accuracy of initial adjustment is much more critical at the very beginning of operation inasmuch as there is no cylindrical seal.

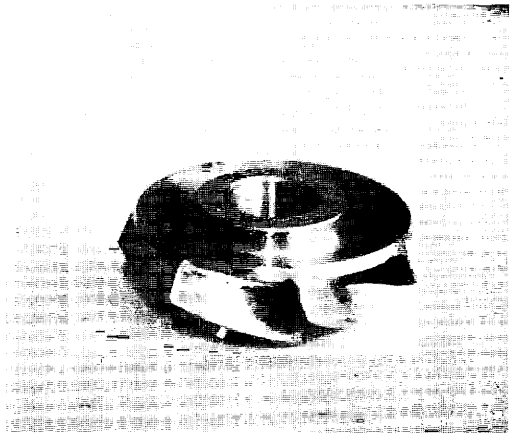


Fig. 29

It should be noted that hydraulic downthrust increases with any increase in operating pressure. While shaft elongation on close coupled and very short pumps is minimal, it must be remembered that some deflection will occur, however minor. Pumps that must be subjected to varying operating heads should be adjusted with respect to the highest head to avoid excessive dragging of impellers under these conditions.

SECTION 10

OPTIONAL FEATURES AND SPECIAL INSTRUCTIONS

Examine this section as outlined in the table of contents for those features applicable to the equipment in question. Also check shipment for any special instructions and/or drawings that have been included to cover items not described in this booklet.

(a) Packing Box

If a packing box has been furnished, as is the normal case with short coupled open lineshaft industrial equipment, it will usually be shipped assembled in its proper position in discharge head or driver pedestal. Normal packing box assembly will usually include packing container item 111-15, at extreme lower end of which is a bushing or throttle sleeve item 111-18. Immediately above this are assembled a given number of packing rings item 111-20, then a lantern ring item 111-17 positioned so as to allow leakage into proper drain port, then more packing rings and, at the top, a two piece gland item 111-16 which can be removed without disturbing shaft. Ordinarily, a gasket item 115 seals housing flange to head, although an O ring may sometimes be used. Housing is secured in position with capscrews item 114. See Fig. 30.

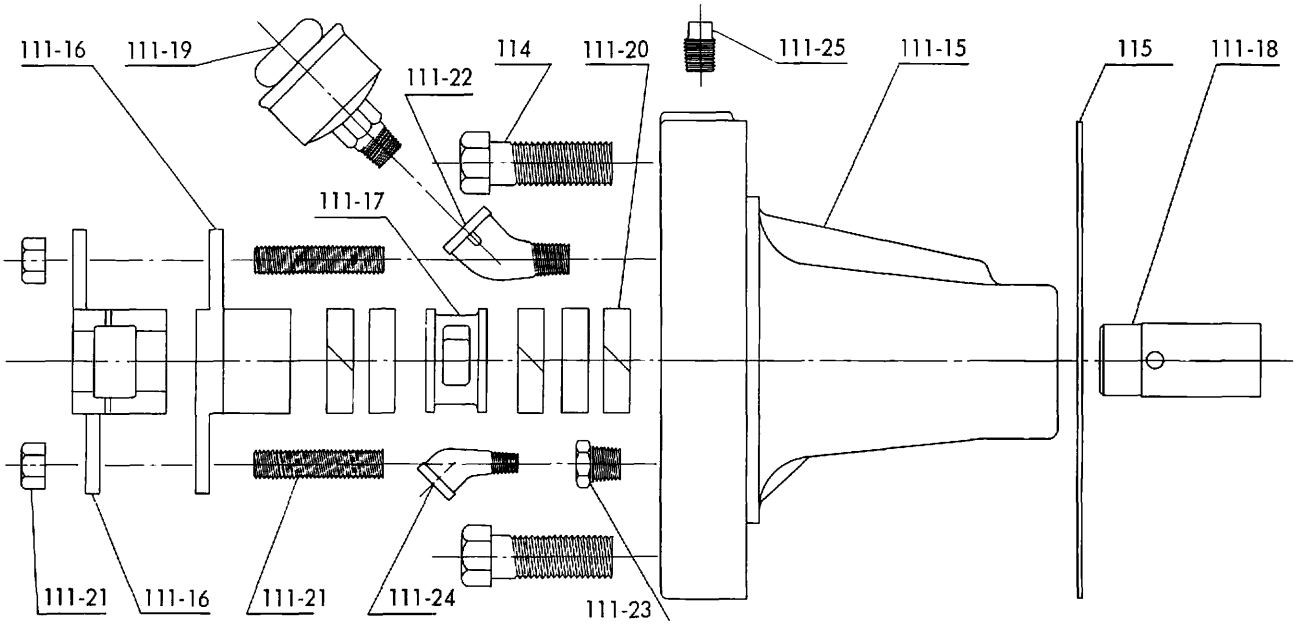


Fig. 30

When assembling headshaft as described in Section 7, packing gland nuts item 111-21 should be loosened so that shaft threads will not drag excessively on packing rings as shaft passes through box. After assembly of headshaft, packing gland nuts should be tightened initially only finger tight.

Grease cup item 111-19 should be filled with standard water pump grease. A small amount should be forced down into bushing area before starting pump. Periodic injection of grease by turning top of grease cup will add life to journal area and packing. When empty, refill grease cup with same type of grease as originally supplied.

Drain lines from drain port item 111-24 and flange lip are to be connected and routed to some convenient drainage location.

At time of first operation, start pump and run for 10 to 15 minutes. Let pump leak at least 100 drops per minute during first operation. If leakage slows down, loosen gland nuts to keep leak rate constant. Gland temperature should level off, and then drop slightly toward the end of 15 minute operation. Gland nuts may then be drawn up about one sixth turn every five minutes until leakage is minimized. If, during this operation, gland heats up so that it will vaporize water, back off gland nuts and repeat run-in procedure as described until temperature stays down after gland nuts are retightened.

During first four or five hours of operation, packing gland should be gradually tightened as packing becomes broken in and formed to completely fill chamber. If it can be tolerated, a small trickle allowed to come through box during this breaking in period will result in a better packed box. During this time, frequent checks should be made to insure that box is not overheating. Should box become overheated, slackening off on the gland nuts may be all that is needed, as described above. Should overheating continue, check to be sure bypass is open and fluid is passing through it.

In repeated tightening of gland nuts as packing wears, packing will also be compressed in packing chamber, lowering gland into chamber. Additional rings may be installed as required to compensate, but not more than two additional rings of packing should be inserted above lantern ring, as otherwise drain port will be blocked. After adding any rings, check drain port to see that it has not become plugged.

To repack, old packing must be removed by means of packing hooks, cleaning out chamber thoroughly. Lantern ring item 111-17 is provided with two #10-24 tapped holes at 180° apart in the upper face. Thus, it may be lifted from box by means of two #10-24 x 3-1/2" or longer machine screws or similar means. Gland item 111-16 may be removed completely because of its split design and lantern ring may be held up out of the way during repacking by means of a couple of turns of string tied around shaft.

At time of repacking, check shaft alignment and surface finish. Finish should be smooth, without burrs or scratches. Avoid shaft run-outs over .005". Packing may be butt or diagonal cut, with the latter preferred.

It is recommended that die formed rings be used for repacking, naturally of same size as original parts. If rings are cut and fit at jobsite, length of rings should be such that ends just meet when packing is wrapped around shaft. Joint in rings should be located 90° to 180°

from joints in rings immediately above and below it in box. Packing rings may be flattened slightly to aid in starting into box.

In packing a new pump before driver is assembled, a short piece of pipe passed over headshaft can be used to press individual rings down into box and tamp them firmly into place. This expedient is not possible after driver has been installed, however, although a split tube may be used in a similar manner.

Insert three rings of packing into bottom of packing chamber, or whatever number is required to bring top of packing up to bottom of drain port. Put these rings in individually, one by one. Before reinstalling lantern ring, check to see that port through box has not been plugged by packing or other material. This can be done by means of wire run through drain port into packing chamber.

Lantern ring may now be placed above first set of packing rings item 111-20. It is by means of this lantern cage that pressure is relieved from top rings of packing, any fluid seepage being returned to atmosphere or suction through drain port in drain line tubing. Also, be certain to install lantern ring with the 10-24 tapped holes facing upward as these are used for removal when repacking box.

Install necessary additional rings of packing one by one above lantern cage as required to obtain proper location of gland. Gland may now be reinstalled and gland nuts may be reassembled on studs but they should not be tightened at this time. Follow run-in procedure as described earlier in this section.

Packing box as described is a normal design for intermediate pressure service. For higher pressures, similar construction is used except that more lantern rings, more packing rings, and possibly more drain lines will be incorporated into the design. Material of packing may vary according to service and pressure and this should be checked before attempting to repack. Material for repacking should be identical to that shipped in the original installation.

A packing box assembly properly adjusted is a most suitable and practical sealing device, requiring only nominal skills and instruction to maintain. It should be packed quite loosely when first starting pump, with fairly free leakage. Gland nuts may then be taken up evenly and gradually, preferably with fingers, until proper control of leakage rate is obtained. It should be emphasized that packing should never be run too tight or without minor leakage since it is possible otherwise to generate extreme heat, consume excess power, wear or score journals, and destroy packing itself. A regular maintenance program will insure trouble free service with a properly designed unit.

(b) Enclosing Tube Head Connection

If pump is of enclosed lineshaft construction, parts for connecting enclosing tube and lubrication system as discharge head or driver pedestal will usually be shipped assembled in head. Before making up top inner column assembly, remove these parts, which are illustrated in

Fig. 31, from their assembled position and lay them out separately on a clean surface.

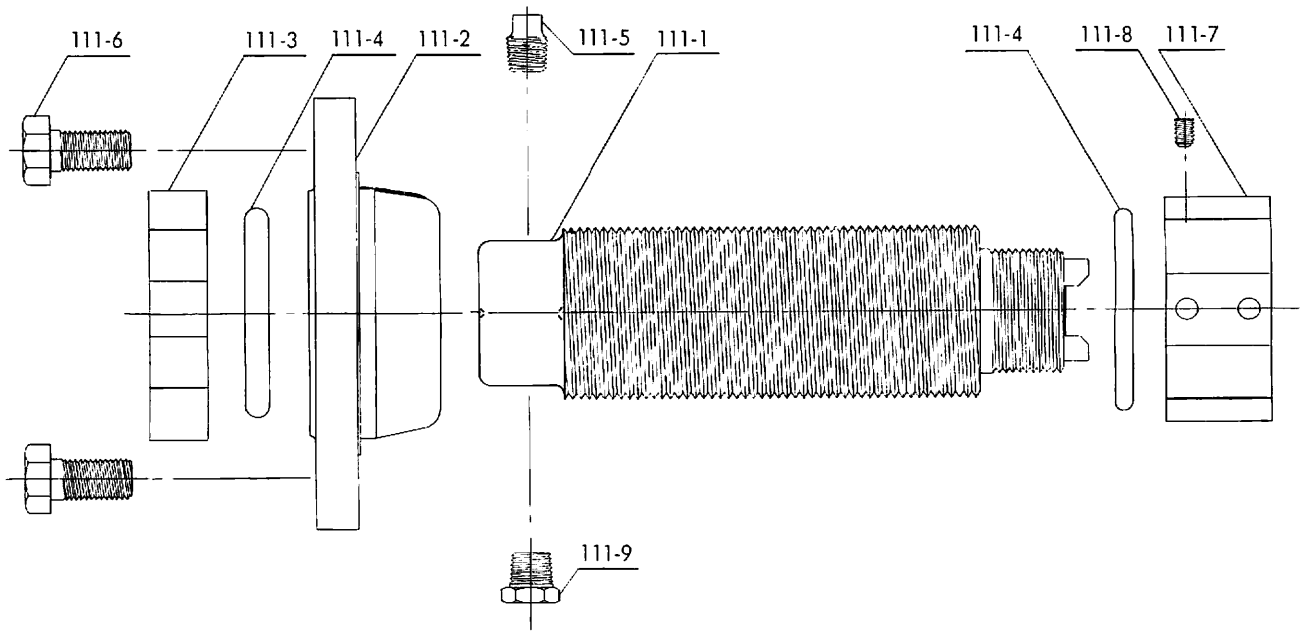


Fig. 31

After making up lengths of tubing that comprise top inner column assembly, together with any shafting to be assembled therein, the long tube connector item 111-1 should be made up as an additional joint at top end. Use back up tongs on tubing while making a tight joint with connector. If a lock collar item 111-7 is furnished, it should be assembled on connector at this time, but set screws item 111-8 should be left loose.

After top column joint is completely assembled as described before discharge head may be installed and the job completed to this point according to the instructions in Section 8b. With head in place and pump resting properly on its foundation, the long threaded tube connector should project up through and in the exact center of the hole provided in the head or mounting pedestal for this purpose.

Examine and clean threads, bore, and faces of tube tension nut, item 111-2. Inspect mating face in discharge head for any burrs, rough spots, or projections, particularly at location of tapped holes. Apply thread lubricant. Thread tube tension nut down over connector and into position. It may be necessary to remove pipe bushing and plug items 111-5 and 111-9 from ports at top of tube connector to do this.

It should be possible to run tube tension nut down until it is seated against mating face in head by hand. Inspect to see that centering register is properly engaged. At this point, tighten tension nut with a tube tension nut wrench until weight of tube is well supported. With all tubing joints solidly butted and with tension nut seated firmly in discharge head, apply enough additional tension to tubing to rotate

tension nut to next matching hole in flange. Tension nut flange must seat firmly in its location in discharge head or driver pedestal in order to prevent leakage through top of elbow. Put thread lubricant on capscrews item 111-6, place them in tension nut flange and thread them firmly in position in discharge head assembly.

If a lock collar has been furnished, back it down on connector far enough to insert packing ring item 111-4. Then screw collar up on connector until it butts against bottom of tension nut. Back collar off slightly until set screws line up with first keyway in connector. Tighten set screws securely reaching through discharge opening in head.

Second packing ring item 111-4 may now be laid in place in chamfer top of tension nut around connector. Care must be taken to see that ring remains properly seated as tubing locknut item 111-3 is assembled and tightened with chamfered face down. Tightening locknut for last two or three turns may be accomplished with a spanner wrench or by tapping nut using a block of wood and hammer. Never tap nut around with a metallic object. Tubing joint is not complete and pipe bushing and plug may be reassembled in ports in position most convenient for oil line from reservoir.

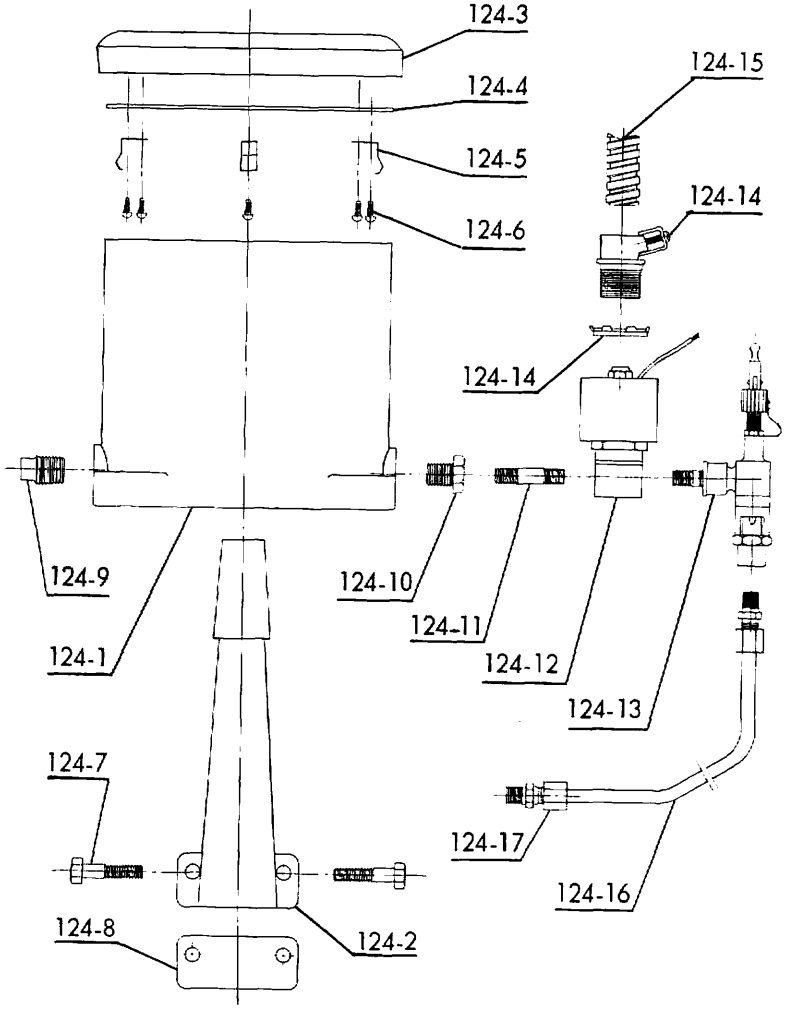


Fig. 32

Examine oil reservoir and oil feed line, making sure that they are clean. Fig. 32 shows parts involved. Attach bracket item 124-2 to driver pedestal using capscrews 124-7, placing dampener gasket 124-8 between bracket and mounting surface. Reservoir item 124-1 will slide on wedge end of bracket. Bushing 124-10 must be located on that side of reservoir most convenient to bring out oil line to tube connector. It may be necessary to interchange bushing and plug item 124-9 to accomplish this.

If lubricator is automatic, assemble pipe nipple item 124-11, solenoid operated valve item 124-12, and manual feed regulator valve item 124-13 in relative positions shown. If lubricator is not automatic, pipe nipple and solenoid operated valve will not be furnished; manual feed regulator is then to be assembled directly into bushing item 124-10. Keep cover assembly item 124-3 on reservoir at all times to keep foreign material out of container.

Connect up lubricating system as illustrated in Fig. 33, using tube item 124-16 and fittings item 124-17. Fill oil reservoir using oil as described earlier. Adjust lubricator valve 124-13 to permit oil to drip at a rate of approximately one drop per second. With solenoid operated lubricators, complete electrical connections to valve. Remove pipe plug at top of tubing connector and fill upper cavity with oil just before first start. This will insure an adequate supply of oil at each bearing for first start.

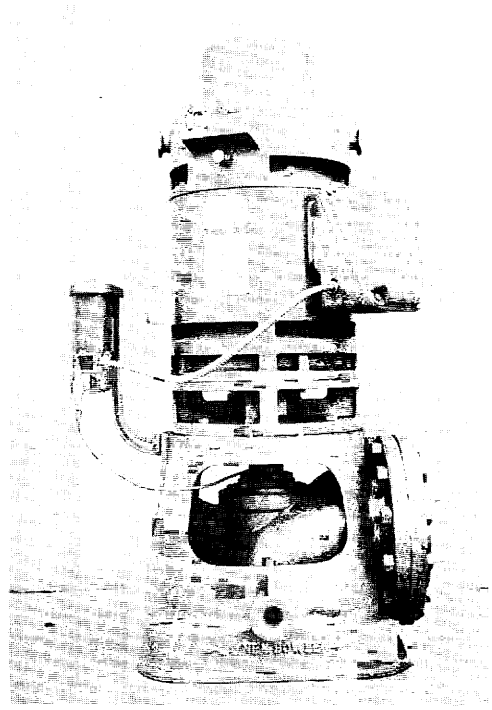


Fig. 33

Before first start, verify that oil reservoir is full and lubricant can flow freely into enclosing tube. Then start pump. Be sure oil continues to flow into pump during running time. It may be found necessary to apply a small amount of oil from an oil can at point where shaft emerges from tubing in discharge head. This should only be necessary during first few minutes of operation.

After logging about 1/2 hour running time, adjust flow on manual lubricator to about 30 drops per minute and operate at this flow rate for first 20 operating hours. Unless solenoid control is furnished, shut off manual lubricator during idle periods. After running about 20 hours, reduce oil flow rate to an amount between 8 and 10 drops per minute for permanent operation.

(c) Mechanical Seal

Mechanical seals may be furnished in a variety of types and sizes, depending upon conditions of service. Therefore, this manual can only cover a general description, together with certain procedures common to all seals. Please refer to specific instructions furnished with the shipment before operating the pump or handling the seal in any way.

A mechanical seal used in a vertical turbine pump is a face type seal. Regardless of service and rating, it attains its closure between two spring loaded sealing surfaces, one rotating with the shaft and one stationary in the housing. Basic design concepts depend upon the presence of a film of liquid on these sealing faces for lubrication, just as is necessary in plate bearings.

Therefore, before starting up a pump equipped with mechanical seals, it is imperative to insure that the seal housing contains liquid so that faces will not overheat, wear or gall. This will necessitate bleeding air or vapor out of the seal area as well as admitting fluid to the pump before start-up. In the case of a vessel pump, the suction cavity must be vented of air or vapor and filled with liquid. Starting a seal dry can cause immediate malfunction. Fluid supply must be constant to insure complete filling of the critical cavities under all operating conditions. An intermittent flow into the seal area must be avoided, whether resulting from adverse suction conditions, flashing of volatile fluids, or whatever cause.

The seal assembly, in certain environments, may require external cooling or heating for proper operation. Bypass or recirculating provisions may be necessary also. Where solids in solutions may precipitate out, a clean liquid flush will protect the seal. Same precaution will assist when dealing with solids in suspension, although abrasive particles are extremely destructive to almost any arrangement. Under such conditions, the use of a filter or separator is recommended. It is important to preserve and maintain a film of CLEAN liquid between the sealing faces.

The presence of a mechanical seal must be considered even before pump start up. In checking driver rotation, for instance, the shaft should not be connected to the driver since the system may be devoid of fluid at this time. In addition, the seal assembly cannot be adjusted until the pump shaft has been placed in its proper adjustment axially, which may not take place until immediately before start up.

Consideration of the seal must even be carried to conditions extant when the pump is NOT operating. In some systems, for instance, the pump is subjected at all times to high suction pressure. The shaft then becomes a piston and, with no downward thrust to oppose axial motion, tends to force upward opening the seal, allowing undesirable leakage. When the pump is started and hydraulic thrust forces the shaft down again, the seal faces may come together hard enough to break the film and cause damage. Therefore upthrust protection is absolutely necessary in such cases and will be provided at the factory if the driver is furnished as part of the pump order. If the driver is obtained and furnished by the user, he must make sure that this protection is included in whatever driver he may install. Solid shaft driver is preferred for use with mechanical seals. If hollow shaft driver is used, it should have a centralizing bushing at bottom of hollow shaft.

It is recommended that a thorough review be given to any detailed instruction accompanying this shipment, particularly those furnished by the seal manufacturer. It is also recommended that pumps equipped with seals be started or turned over once a day if not in continuous operation.

(d) Flanged Adjustable Coupling

After installation of all pump components through discharge head, including shaft seal parts, assembly of flanged shaft coupling must be

commenced before setting driver in place. Check and clean all coupling parts before attempting assembly. Flange mating faces must be flat and free from any burrs, nicks, dents, defects or foreign material. If parts are matchmarked, assemble accordingly. Refer to Fig. 34, which illustrates spacer type coupling, assembly of flanged coupling without spacer is similar.

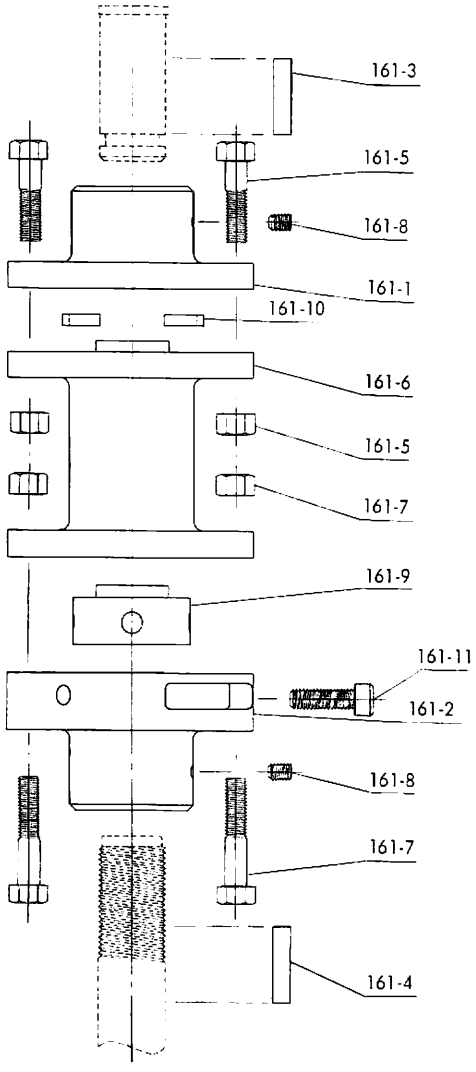


Fig. 34

Inspect and clean pump shaft threads, painting lightly with good thread lubricant. Insert key item 161-4 in pump shaft keyway and slip pump shaft coupling item 161-2 well down over shaft, flange face up, leaving shaft threads projecting above coupling. Screw adjusting nut item 161-9 onto pump shaft with rimmed end up, turning counterclockwise until pump shaft protrudes through threaded portion of nut by at least two threads.

Set driver on beams or blocks on discharge head or pedestal with ample clearance between driver shaft and pump shaft. Secure driver firmly against torque with chain or cable restraints. Connect motor and energize to check rotation, which must be counterclockwise when viewed from top. See Section 7. Stop Motor.

Insert key item 161-3 in driver shaft keyway and slip driver shaft coupling item 161-1 up onto driver shaft, flange face down. With flange above driver shaft ring groove, insert both halves of thrust collar item 161-10 into groove and slide coupling back down on shaft until it rests firmly on thrust collar, retaining collar halves in place in coupling recess. Assemble and tighten setscrew item 161-8 securely. Remove blocks and lower driver onto its mounting flange, seating it firmly. Assemble fasteners loosely but do not tighten. If necessary, dress keys to a sliding but not loose fit. Do not file keyways.

If coupling is furnished with spacer spool item 161-6, clean spacer flange faces, then assemble spacer between driver shaft coupling and pump shaft coupling flange faces. Allow spacer lower flange face to rest upon pump shaft coupling item 161-2 flange face. Insert flange bolts item 161-5 in driver coupling and spacer upper flange and tighten nuts item 161-5 by hand until they are snug against flange. Use a light oil on machine bolt threads.

With impellers firmly seated in bowls, screw adjusting nut 161-9 up on pump shaft by turning clockwise until its outer shoulder is spaced approximately .030 inches to .060 inches below face of driver coupling flange or spacer lower flange, if spacer is provided. Pull pump coupling up and insert flange bolts item 161-7 through both coupling flanges. Assemble nuts item 161-7 and run up by hand until they are snug, using a light machine oil on the bolt threads. CAUTION: Use only bolts and nuts furnished with pump.

With all nuts drawn up and with flanges meeting evenly both at faces and at outer circumferences, put all bolts under uniform tension, using torque wrench if available. Five hundred inch pounds will be sufficient torque; i.e., a 50 pound pull on a 10 inch wrench, etc. Make sure pump shaft key is flush with coupling hub and tighten setscrew item 161-8 securely.

Pump is now set so that impellers are about .030 inches to .060 inches off endseal seats. Any desired adjustment may now be obtained by rotating adjusting nut on shaft with a 1/2 inch bar inserted into adjusting nut holes through pump shaft coupling slot. Accurate settings are best accomplished by lowering impellers to bottom, turning nut clockwise, then raising to desired position by turning nut counterclockwise. When proper adjustment is obtained (.020 inches to .120 inches, depending on pump), move adjusting nut slightly until nearest hole lines up with tapped hole in outer circumference of pump coupling flange. Insert socket head capscrew item 161-11 making certain that it projects into adjusting nut hole, then tighten securely.

Coupling is now completely assembled and locked. Tighten motor fasteners firmly. See that pump turns freely by hand. Follow motor lubrication instructions before operating.

(e) Flanged Non-Adjustable Shaft Coupling
(Two-Piece Flanged Coupling for
Combination Gear Drive)

Two-piece flanged coupling may be installed after assembly of discharge head, packing box component parts, headshaft and adjusting nut. Lower gear drive and yoke onto mounting flange and fasten into place. See Fig. 35 for coupling design.

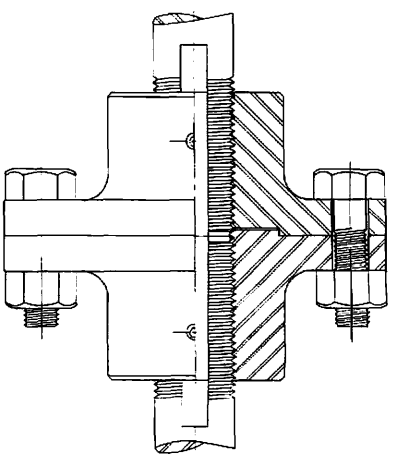


Fig. 35

Clean headshaft and headshaft coupling threads thoroughly and paint with a good thread lubricant. Clean coupling flange face and screw coupling onto head shaft, flange face up. Shaft face may be .005 to .100 below flange face but must not project beyond flange face. Line up keyways, insert key and tighten set screw firmly.

After cleaning driver shaft threads, clean driver shaft coupling threads and flange face. Paint driver shaft and coupling threads with

thread lubricant. Screw coupling onto driver shaft, flange face down. Shaft face may be recessed .005 to .100 into coupling but must never project beyond flange face. Line up keyways, insert drive key and tighten set screw firmly.

Raise motor, insert driver shaft into driver hollow shaft with driver coupling flange facing down. Thread on driver shaft adjusting nut to lock shaft in position in motor while lowering motor onto gear drive yoke. Lower driver onto gear drive yoke and fasten into place.

Insert bolts and screw on hex nuts by hand until snug against flange, using a light oil on machine bolt threads. After all nuts are drawn up and flange coupling meets evenly, put all machine bolts under uniform tension, using a torque wrench if available.

Installation of adjusting nut, adjustment of impellers, etc., can be completed as suggested in previous operating instructions, using applicable sections.

(f) Flanged Column Pipe Open Lineshaft Construction

Refer to Fig. 36 and to any assembly drawing which is included with these instructions to become thoroughly familiar with the construction before assembling flanged column. See also Section 6 and Section 8a.

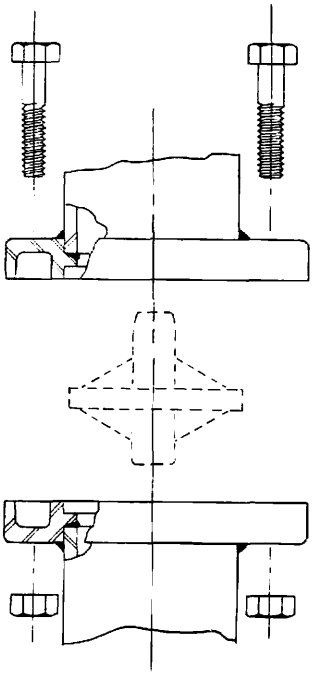


Fig. 36

Clean all column flanges, centering fits, and contact surfaces thoroughly of any slushing compound or foreign particles with wire brush, then wash flange faces clean, using distillate or kerosene. It is very IMPORTANT that column flange centering fits and contact surfaces are clean and free from burrs, as this could cause misalignment and rough operation. Separate top and bottom column sections from intermediate column sections. These pieces are stencilled "Top Column" and "Bottom Column" at factory for easy identification at jobsite. Upper flange on top column section and lower flange on bottom column section may have different centering fits and bolt circles than intermediate column flanges for adaptation to discharge head and to discharge case or bowl flanges.

Before raising column pipe into place, insert drive shaft into column and snub with a rope hitch. Raise column and shaft into position. Handle very carefully to prevent damaging lineshaft. Section 8a describes this operation generally, except for pipe flanges.

Check discharge case flange for tightness. Clean centering fit and contact surfaces on both discharge case and column flanges thoroughly. Place flange gasket onto discharge case flange face, lower suspended column pipe, guiding column so that column flange slips down over projecting male fit on discharge case. Tighten nuts evenly. Use thread

lubricant on bolt threads. Bolted flanges must be tight enough to support weight of pump assembly and hold liquid pressure.

Use same type of pipe elevators and wooden clamp blocks that are used for screwed column. Before raising column section, insert bolts into column flange holes, thread end down, place elevator in position with elevator rim located to leave wrench room for nuts. At same time, take care to avoid chafing sling on flange or creating pull-off forces.

Intermediate flanged column joints are made up in same manner except that bearing retainer is installed in centering fit at each flange joint. Clean centering fits, contact faces, and bearing retainer rim thoroughly before assembling. Wipe upper end of shaft down beyond journal point free of oil or grease.

Before lowering bearing retainer into place, make sure shaft stands in center of pipe or that very slight pressure will center it. Bearing retainer is now placed over projecting end of lineshaft with open end down and into annular centering recess in column flange. Retainer rim forms a centering ring for column pipe flanges and also forms a gasket for flange joint. Shaft should now stand freely in center of bearing retainer without binding against side.

Lower next section of flanged column pipe, with its length of drive shaft supported inside by a rope hitch, onto projecting half of retainer rim. Be very careful not to damage retainer rim.

Tighten nuts evenly all around, first lightly setting up opposite bolts, then applying greater torque all around until all bolts are tightened evenly. If available, use a torque wrench which indicates amount of foot-pound torque applied to each bolt.

Refer to previous instructions included in this manual for installing and assembling lineshaft, making up lineshaft coupling, etc.

Repeat this installation procedure and precaution through entire length of column. Return to Section 8a for procedure at top joint and discharge head.

(g) Flanged Column Pipe Enclosed Lineshaft Construction

Refer to Fig. 37 and to any assembly drawing which is included with these instructions to become thoroughly familiar with the construction before assembling flanged column. See also Section 6 and Section 8b.

Clean all column flanges, centering fits, and contact surfaces thoroughly of any slushing compound or foreign particles with wire brush, then wash flange faces clean, using distillate or kerosene. It is very IMPORTANT

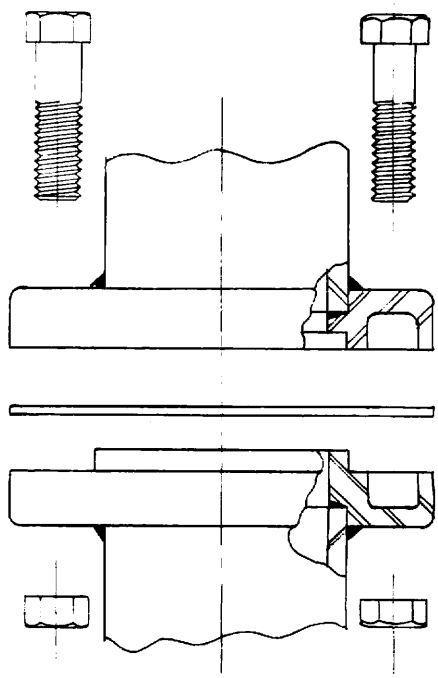


Fig. 37

that column flange centering fits and contact surfaces are clean and free from burrs, as this could cause misalignment and rough operation. Separate top and bottom column sections from intermediate column sections. These sections are stencilled "Top Column" and "Bottom Column" at factory for easy identification at jobsite. Upper flange on top column section and lower flange on bottom column section may have different centering fits and bolt circles than intermediate column flanges for adaptation to discharge head and discharge case flanges.

Before raising flanged column pipe into position, drive shaft and enclosing tube should be placed into column and snubbed with a rope hitch. Raise column, enclosing tube and lineshaft into position. Handle very carefully to prevent damaging enclosing tube and lineshaft. Section 8b describes this operation generally, except for pipe flanges.

Check discharge case flange for tightness. Clean centering fit and contact surfaces on both discharge case and column flanges thoroughly. Place flange gasket onto discharge case flange face, lower suspended column pipe, guiding column so that column flange slips down over projecting male fit on discharge case. Tighten nuts evenly. Use thread lubricant on bolt threads. Bolted flanges must be tight enough to support weight of pump assembly and hold liquid pressure.

Use same type of pipe elevators and wooden clamp blocks, that are used for screwed column. Before raising column section, insert bolts into column flange holes, place elevator in position with elevator rim up against bolt heads, thus holding them in place. This procedure must leave wrench room. At same time, take care to avoid chafing sling on flange or creating pull-off forces.

Intermediate flange column joints are made up in same manner. Clean centering fits and contact surfaces on both intermediate column flanges thoroughly, then place flange gasket onto flange face. Lower next section of flanged column pipe, with its length of enclosing tube and lineshaft supported inside by a rope hitch, guiding column so that column flange slips down over projecting male fit on column flange below.

Tighten nuts evenly all around, first lightly setting up opposite bolts, then applying greater torque all around until all bolts are tightened evenly. If available, use a torque wrench which indicates amount of foot-pound torque applied to each bolt.

Refer to previous instructions included in this manual for installing and assembling lineshaft, making up lineshaft couplings, enclosing tube, etc.

Repeat this installation procedure and precaution through entire length of column. Return to Section 8b for procedure at top joint and discharge head.

(h) External Source of Water Lubrication

Refer to Fig. 38 and to any assembly drawing which is included with these instructions to become thoroughly familiar with the construction before assembling the tube tension/ packing head assembly.

Installation and assembly of tube connector, tubing tension nut, and tubing locknut is the same as described in Section 10b with additional instruction as follows:

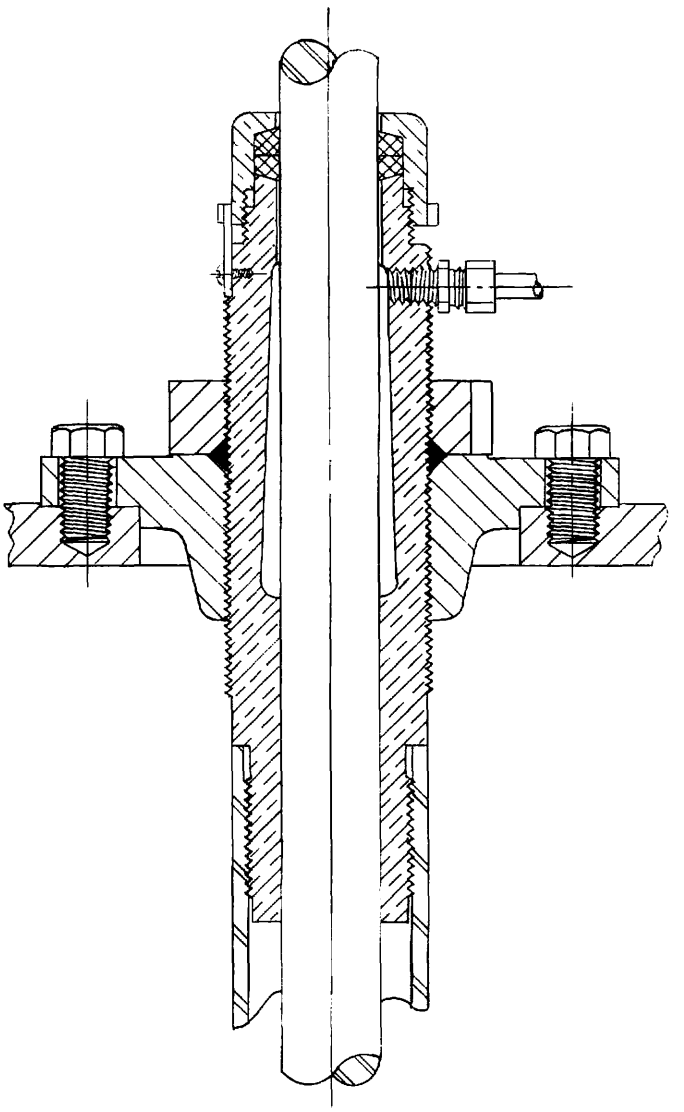


Fig. 38

After installation of tube connector and component parts, clean tube connector and packing gland threads. Apply thread lubricant. Length of packing rings should be such that ends just meet when packing is wrapped around shaft. Joint in ring should be located 180° from joint in ring above or below it. Packing may be flattened slightly to aid in starting gland over packing rings. Each ring should be coated thoroughly with lubricating grease before installation.

Place packing rings upon camfered face, and screw packing gland into tubing connector. Packing gland should be tightened initially only finger-tight at this time. During first two or three hours of operation, packing gland should be gradually tightened, as packing becomes broken in or formed to fill packing gland chamber. At no time should gland be tightened more than just barely enough to prevent leakage. In fact, minor leakage is desirable. During this time, frequent checks should be made to insure that gland is not overheating. Should gland become overheated, slacking off gland may be all that is needed.

Place lock strap in position and tighten lock strap screw firmly. Connect lubrication line to tubing connector port.

For most installations, 3 to 5 GPM at 40 to 50 PSIG is ample supply of fresh water for lubricating lineshaft bearings, as long as bowl assembly bypass ports are open. If ports are plugged, lubricating water must be admitted to tubing under heads greater than that generated in the bowl assembly. Higher pressures will of course necessitate more frequent maintenance of packing.

Do not exceed 75 PSIG injection pressures with design pictured here. Over this amount, a different arrangement will be furnished.

(j) Fresh Water Flush System

When pumping fluids containing abrasive particles, it is often advisable to inject clean liquid directly into journal areas to provide lubrication and to prevent entrance of abrasive particles into bearing zones. One method by which this can be accomplished is to flush bearings continuously during operation with clean or filtered water.

In the case of the bowl assembly, refer to Fig. 39 & 40. The suction case is provided with a pipe tap in bottom of hub and lubricating fluid may be injected here. Bowls themselves may be cast with a port leading through a vane from outside into bearing area so that lubricating fluid may be admitted. At discharge case, if one is furnished, fluid is often injected into one of the bypass ports. Bowl assemblies must be ordered from factory in this condition so that porting will

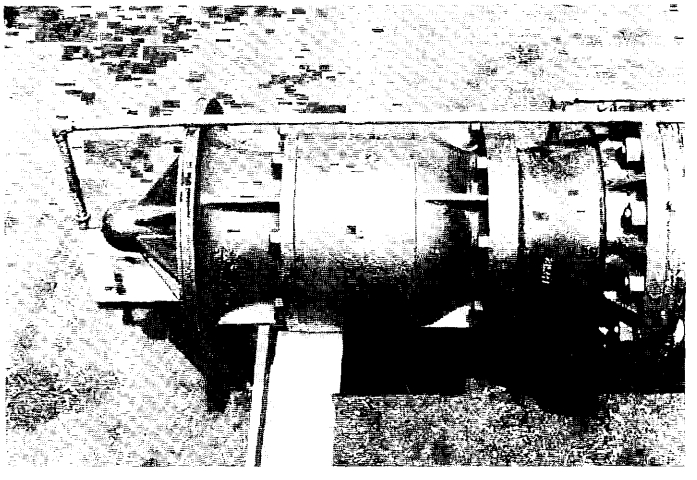


Fig. 39

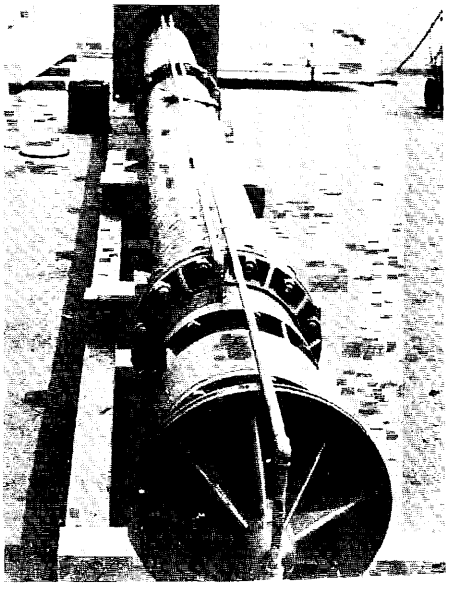


Fig. 40

be available. Piping is usually installed at jobsite, connecting each port either individually or from a common line to surface where user must furnish a source of proper fluid. However, short pumps are occasionally shipped with piping in place, ready for user's connections. In handling pumps with external piping, take care to avoid damage to pipe or tubing. Pinching or perforating a line could render the lubrication system inoperative.

The lubricating liquid must be free from abrasives and other foreign particles, must have sufficient lubricating properties to do the job, and should not be allowed to increase above 85° F in temperature. It must be injected at a pressure in excess of that

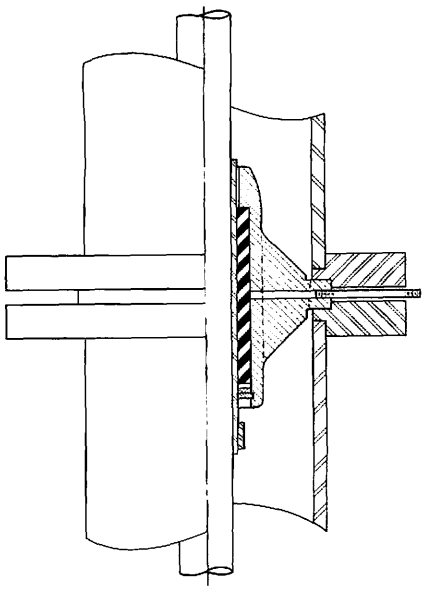


Fig. 41

existing across journal area in question, which usually means something greater than total discharge head on pump.

Open lineshaft bearings, if necessary, may be lubricated in much the same way as illustrated in Fig. 41. Again, piping is connected as shown and run from surface source of supply. It must be injected into bearing at a pressure in excess of that existing in column pipe at that point.

Flushing at packing box may be accomplished in a manner as depicted in Fig. 42. Similar arrangements are made in case of mechanical seals, as shown in Fig. 43.

Occasionally, a water flush arrangement is used in connection with tube enclosed construction and may be accomplished as described in Section 10h.

Although subject option is referred to as a fresh water flush system, any suitable

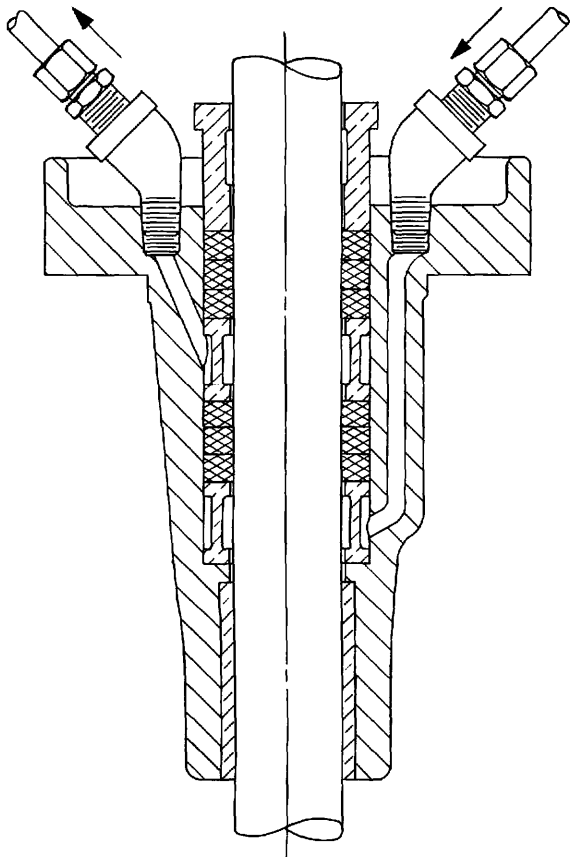


Fig. 42

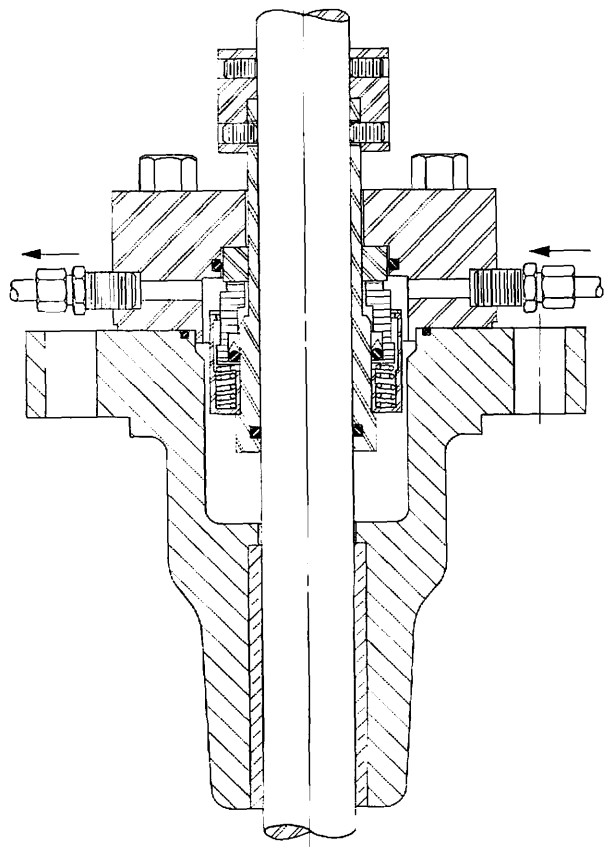


Fig. 43

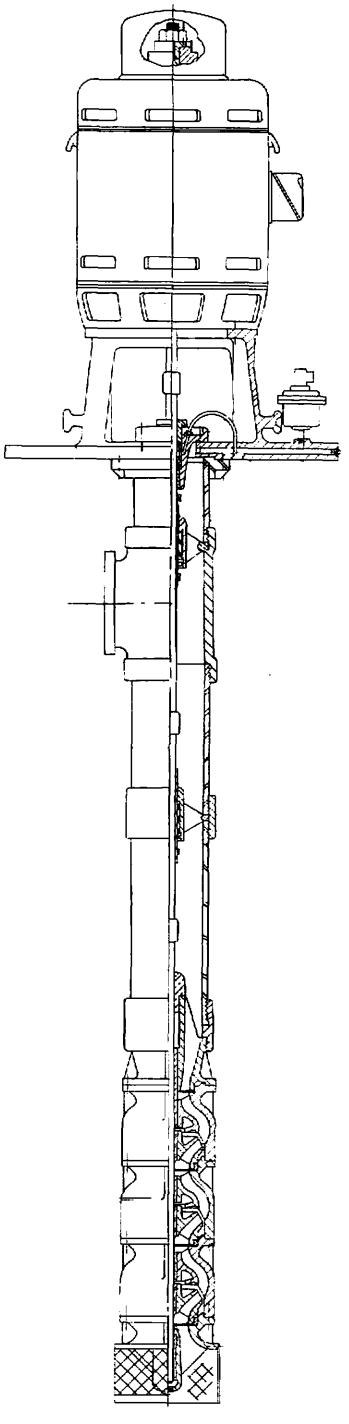


Fig. 44

lubricant that is compatible with the pumped liquid may be used so long as conditions of flow and pressure permit. In general, capacity of a water flush system must be approximately 1 GPM for each journal to be served, up to 1 inch shaft; 2 GPM for each journal, up to 2 inch shaft; 5 GPM each journal up to 3 inch. For diameters in excess of 3 inches, consult factory.

Available capacity could be reduced slightly when oil is used as a lubricant. If grease is used, it is only necessary to keep lines full under adequate pressure. Grease lines on completely assembled pumps will be filled with grease at factory.

(k) BELOW BASE DISCHARGE

Although most pump assemblies are so constructed that the discharge elbow is above the mounting surface and is usually an integral part of the driver pedestal, some pumps are designed for specific customer requirements to place the discharge outlet at a position below the mounting base. This type of construction is illustrated in Fig. 44.

The discharge elbow in this arrangement is actually a tee, in which the run portion is a part of the column and the side outlet becomes the discharge connection. Vertical location of centerline discharge may vary within reason according to user requirements. However, there are limitations as to how close the discharge may be located to bottom of base. This will depend on clearance with mounting structure and upon size and shape of discharge tee.

Because column pipe dead ends above discharge tee, it is possible to entrap air in this area. Therefore, all mounting pedestals are furnished with a port from which air may be released. It is recommended that, in each case, user shall make provisions for either manual or automatic release of air. Air release should preferably occur continuously during operation but at least at each startup. See suggested arrangement in Fig. 45.

As may be seen in Fig. 46, mounting base is part of driver pedestal. All connections at this point may be handled in same manner as that used for above base discharge construction. Provisions for shaft sealing, tube connection, column pipe attachment, pre-lubrication connections that may be necssary, and other details will feature components identical to those found in above base discharge pumps. Therefore, please refer to the proper sections of these instructions for assembly and operation procedures.

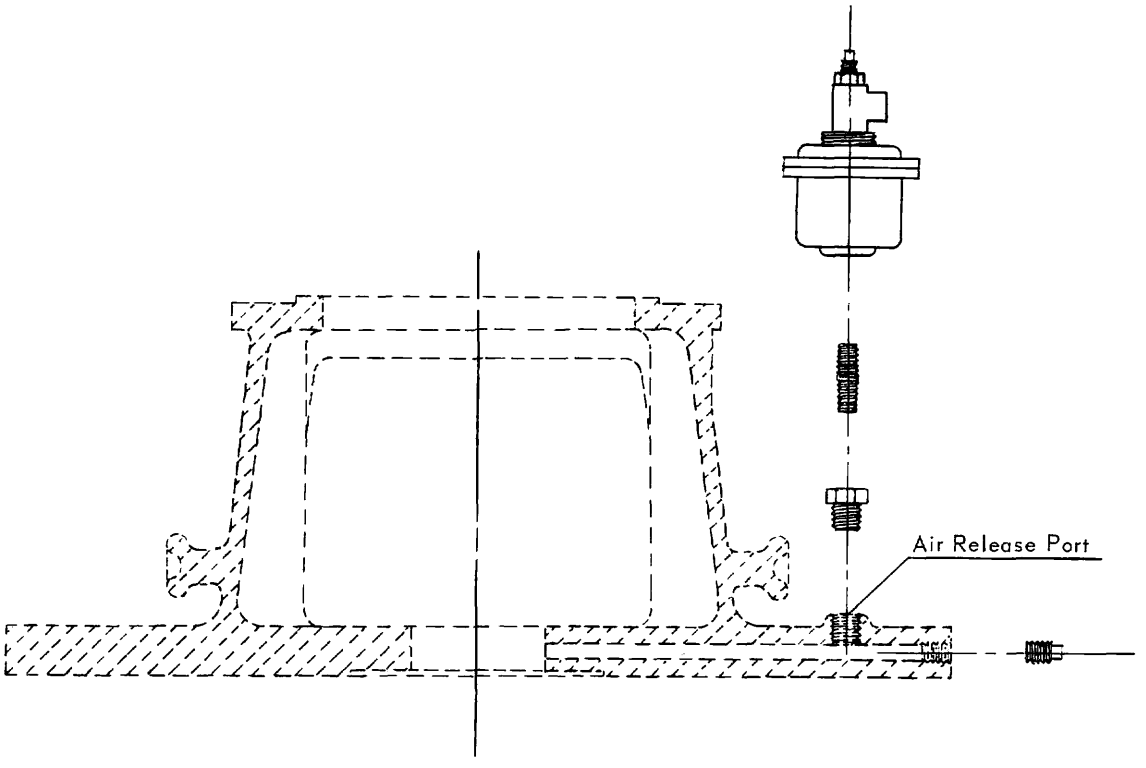

Air Release Port

Fig. 45

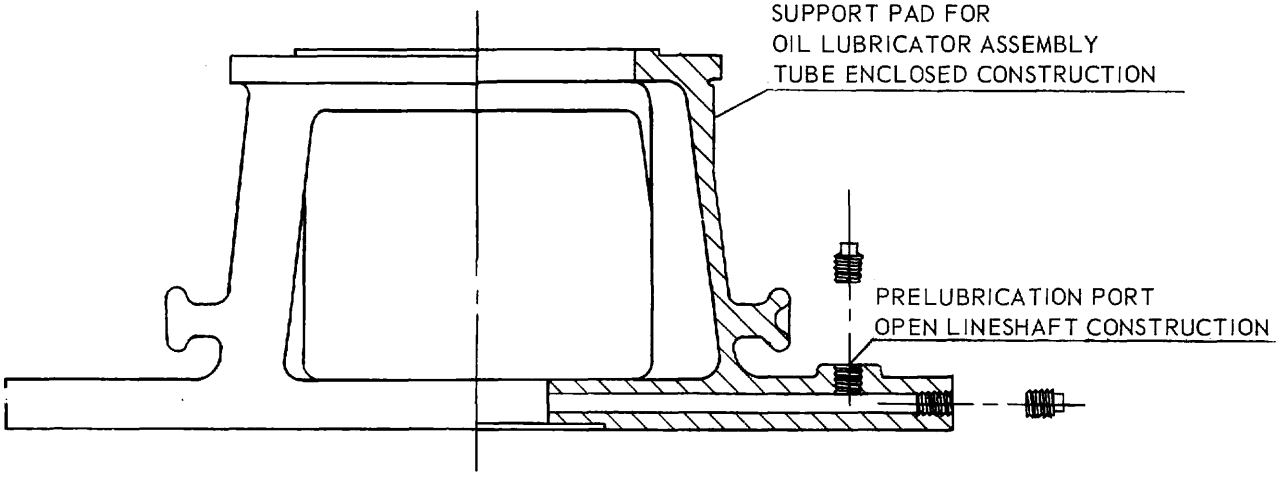

SUPPORT PAD FOR
OIL LUBRICATOR ASSEMBLY
TUBE ENCLOSED CONSTRUCTION
PRELUBRICATION PORT
OPEN LINESHAFT CONSTRUCTION

Fig. 46

Fig. 47

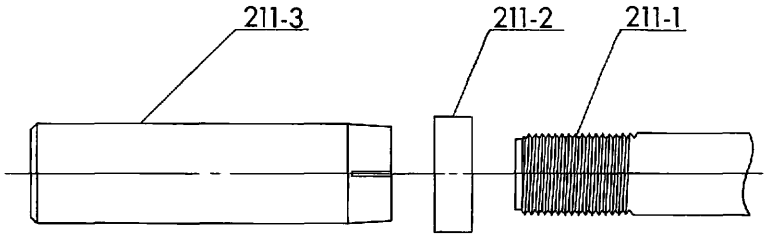


Fig. 48

(m) OPEN LINESHAFT REPLACEABLE SLEEVE

Lineshafting may be furnished with a sleeve at journal points, using several different designs. Fig. 47 depicts a collet attached field replaceable sleeve arrangement often used in open lineshaft construction. Individual parts are identified in Fig. 48.

If it is necessary to remove sleeve in field for repair or relocation, this may be accomplished by driving collet down off sleeve taper as shown in Fig. 49. Collet is driven in either direction by a two piece collet driver as illustrated in Fig. 50. Thus, the tool may be used both for assembly and removal of journal sleeve.

To replace sleeve at jobsite, coat shaft with an epoxy adhesive such as Loc-Tite or, failing that, a filler material based on shellac. Slip collet item 211-2 over shaft item 211-1 with open end of taper away from threads. It must be moved away from threads to a point beyond eventual sleeve location. Slide sleeve item 211-3 onto shaft with tapered end away from threads to a point at which it will run in bearing. It is imperative that journal point be properly located and this may be done by reference to position of bearing. Having established sleeve in proper

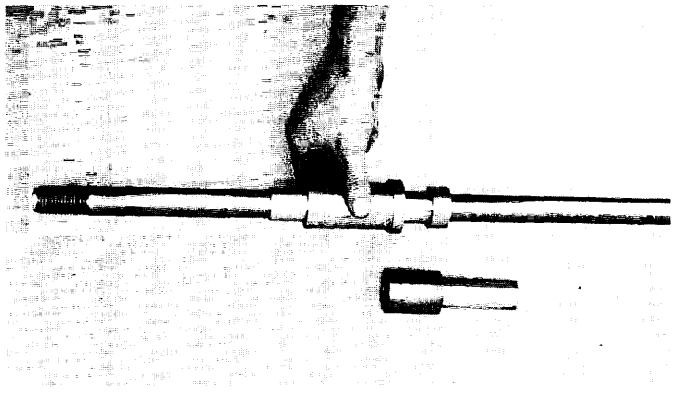


Fig. 49

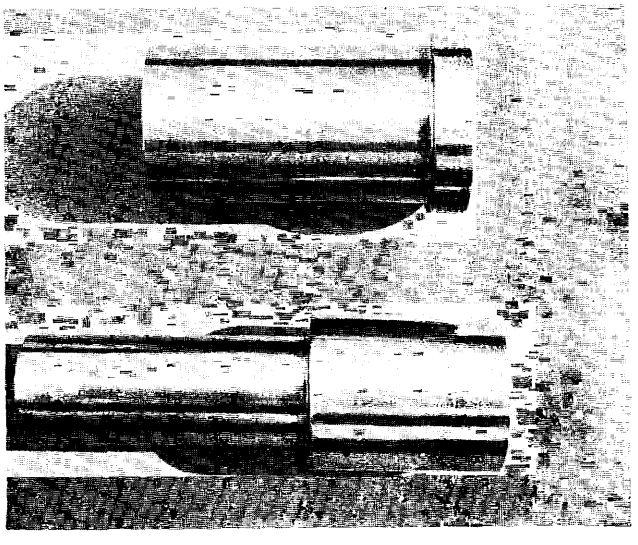


Fig. 50

location, it is advisable to construct a stop for end of shaft and also end of sleeve so that the latter will not move with respect to shaft. Collet may then be driven on sleeve taper firmly with collet driver, working as indicated in Fig. 51.

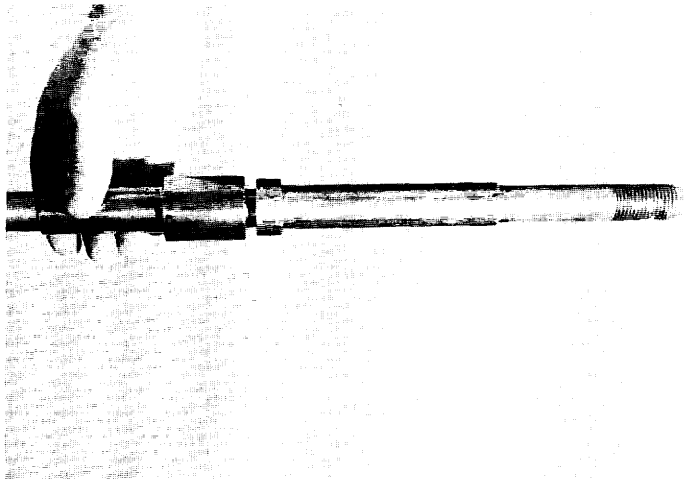


Fig. 51

SECTION 11

BOWL ASSEMBLY PROCEDURE

Gather together all parts required for the assembly, using applicable assembly drawing if necessary. Procure all tools necessary for various operations, including following:

Impeller collet driver.

Thin bladed screw driver or special wedge tool for spreading collet.

Bolt to fit tapped hole in bottom of shaft, washers as necessary.

Open end or box wrench for above bolt.

Open end or box wrench for nuts on bowl studs, if flanged bowls.

Strap wrench or pipe wrench for tube adapter.

Chain tongs for pipe coupling and for bowls if threaded.

Using information on Fig. 52, locate lower impeller on shaft. To attach impeller securely, slip collet over shaft down into impeller hub opening, small end down. Using screw driver blade or wedge tool in collet slot will facilitate sliding it on shaft. Slip collet driver on shaft from top or threaded end as shown in Fig. 53 and drive collet in place, holding impeller location as noted above. Collet may be firmly wedged into position by sliding driver rapidly along shaft and striking top of collet with a sharp blow several times. On a new unit, assembled collet will project above opening from 0 to 1/8". Subsequent re-assembly operations may find collet driven further into opening to effect a secure attachment.

Slide bearing cap, if any, onto shaft from bottom, small end up. Do not lock set screws.

Slide suction case onto shaft from bottom, seating impeller firmly in suction case. Locate bearing cap to cover bushing projection and lock in place with set screws. Insert bolt through grease filler hole in bottom of suction case hub, threading it into tapped hole in shaft; pull up tight, using washers or spacer so that impeller is firmly and securely seated against wear ring.

Slide an intermediate bowl onto shaft from top end into position against suction case. Attach firmly with two or three nuts on studs, if flanged bowls; screw in place if threaded.

Slip next impeller down over shaft and set firmly against bowl wear ring; slide collet in place and drive collet in as before. See Fig. 54.

Continue as above for required number of stages. Loosen tie down bolt in bottom of shaft after each impeller is set and check to see that

shaft will rotate freely by hand without dragging or hanging up. Make this check with the shaft all the way in and again all the way out, while at the same time observing lateral movement of shaft to be sure of adequate end play.

Top bowl has no bushing, and therefore discharge case is assembled onto shaft so that its bushing projects into top bowl hub when flanges butt. Again, fasten in position with two or three nuts, if flanged. Some installations require no discharge case at all. If this is the case, ignore next three paragraphs.

Deflector collar may now be slipped over shaft by forcing a screw driver blade into slot of collar, thus spreading it open somewhat. Collar may be poked down into hub of discharge case with screw driver so that it is roughly opposite bypass ports. It should never be set so close to bottom of tube adapter that it restricts shaft end play.

Tube adapter or cap may now be screwed into hub of discharge case and seated firmly against shoulder. If assembly is for open lineshaft pump, screw pipe plugs into bypass ports, plugging ports securely. If pump is of enclosed lineshaft design, ports must be open except as noted in Section 10r. If cap is used in discharge case, assemble setscrew through tapped hole in case hub. Setscrew must not displace cap for enough to hang up on shaft.

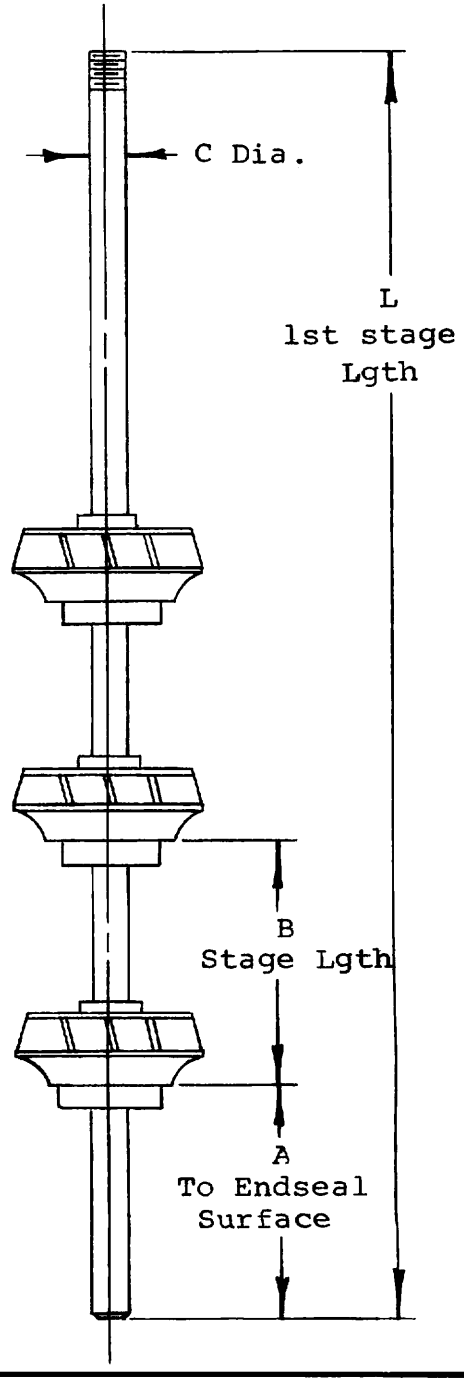
Column and/or suction pipe couplings (if any) may now be assembled by threading onto discharge case and suction case respectively. Column coupling or flange must butt solidly; suction coupling or flange may occasionally be taper thread, but must be made up tight.

At this point, check shaft for ease of rotation and proper amount of end play. Check also for projection above pipe butt. Assemble all nuts, each stage, leaving none loose.

Check shaft again as above and assemble shaft coupling so that end of shaft is in middle of coupling. Fill suction case hub with recommended grease. Screw in pipe plug. Bowls should now be ready to re-assemble on pump. Check all available instructions for complete installation according to specific pump in question.

BOWL	A	B	C	L	SHAFT PART NO.
4R	2.63	3.000	.625	15.16	HS3450
4RC	2.41	3.000	.625	15.16	HS6108
6LL	3.94	3.625	.750	17.75	HS3111
6T	5.19	3.500	1.000	24.13	HS4368
6EH	3.38	4.500	1.000	23.25	HS5191
6R	5.25	5.125	1.000	25.50	HS5132
6FH	5.25	4.750	1.000	25.75	HS5730
7R	8.50	7.250	1.500	36.25	HS4455
8EL	5.13	4.500	1.000	30.50	HS2434
8ED	5.50	5.000	1.188	30.44	HS6094
8EH	5.25	5.813	1.188	30.31	HS2046
8R	5.63	6.500	1.188	33.38	HS6780
8GH	6.00	6.750	1.188	33.13	HS5766
8FH	6.38	7.500	1.188	35.00	HS3564
10EXL	5.94	7.063	1.188	32.94	HS3017
10EH	8.63	7.063	1.500	36.56	HS2080
10R	8.56	8.375	1.688	38.38	HS3250
10JK	8.25	7.625	1.500	36.63	HS2997
10FH	9.00	8.750	1.688	39.00	HS4930
12EL	9.00	7.000	1.500	36.75	HS2203
12EH	8.75	9.125	1.500	40.75	HS2087
12R	8.53	10.000	1.938	41.00	HS6181
12KH	7.63	8.500	1.688	39.50	HS2107
12FH	8.00	11.000	1.938	41.25	HS3930
14TM	8.56	9.750	1.938	41.50	HS3097
14KH	9.88	11.000	1.938	42.75	HS1953
14R	12.63	13.375	2.188	50.38	HS3347
14MS	9.63	11.000	1.938	43.00	HS2418
14FH	11.88	12.312	2.188	47.63	HS5443
16EH	9.56	12.000	1.938	45.38	HS2679
16KH	9.69	12.000	2.188	45.06	HS2654
16FH	12.75	14.500	2.188	51.00	HS4623
18EH	11.25	14.000	2.188	49.00	HS2653
18FXH	10.13	14.000	2.188	47.00	HS2348
18CF	11.25	15.000	2.438	50.00	HS3523
20EH	12.25	15.000	2.438	52.13	HS2667
20K	10.16	18.250	2.438	54.00	HS7646
22MS	11.81	17.000	2.688	53.00	HS3681
24EH	11.88	18.000	2.688	54.00	HS2926
28SK	11.00	22.500	2.688	62.25	HS3141
30K	*	28.500	3.250	73.50	LS9007
36EH	*	29.313	3.250	75.38	LS8537
46FH	*	45.500	5.500	131.50	LS4430

Note: For semi-open impellers 4R and 6L, dimension A refers to lowest point of vane.



*Impeller located by keyway in bowl shaft

Fig. 52

BOWL PARTS RELATIONSHIP

DURING ASSEMBLY ONTO BOWL SHAFT

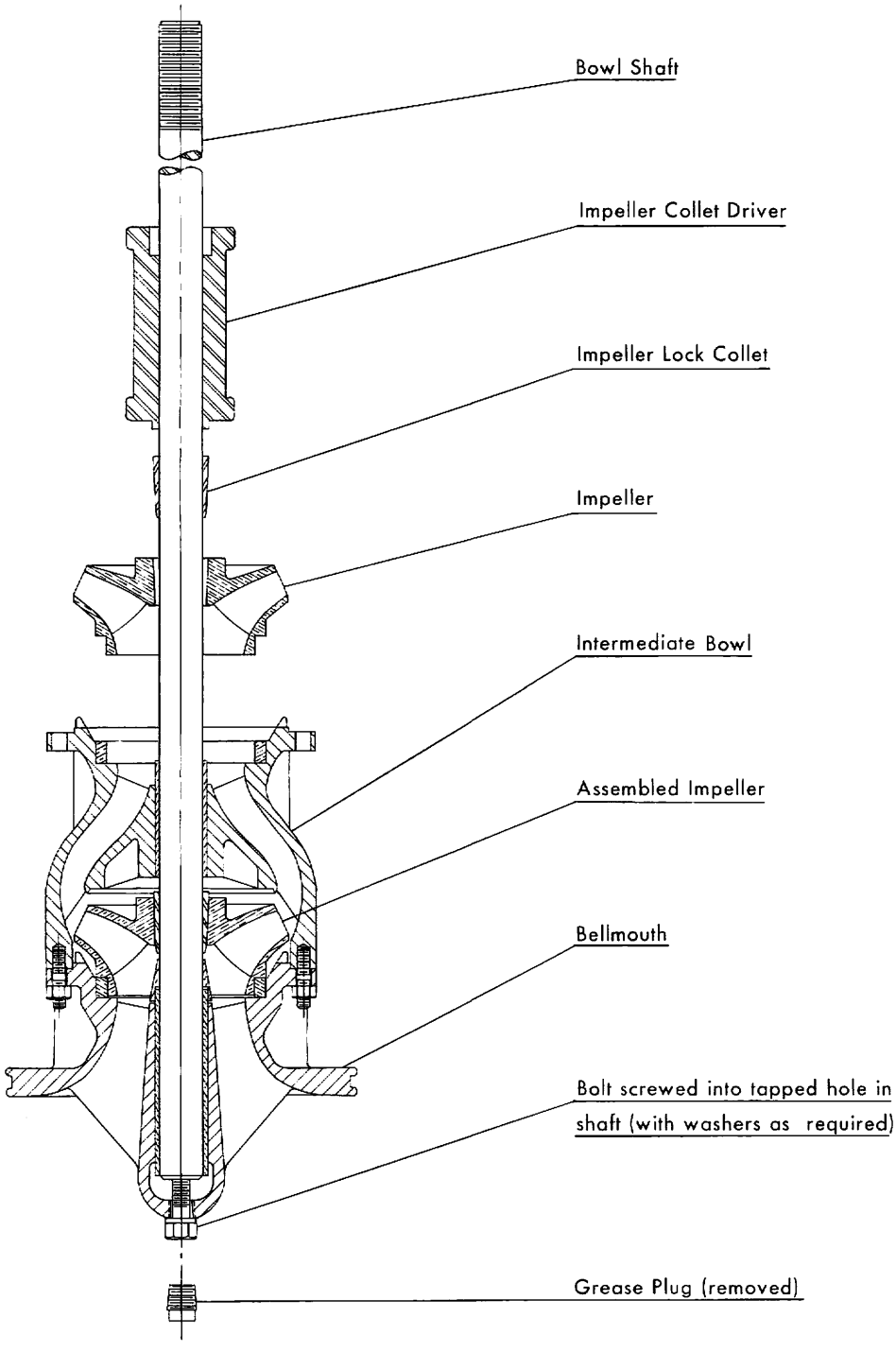


Fig. 53

IMPELLER ASSEMBLY

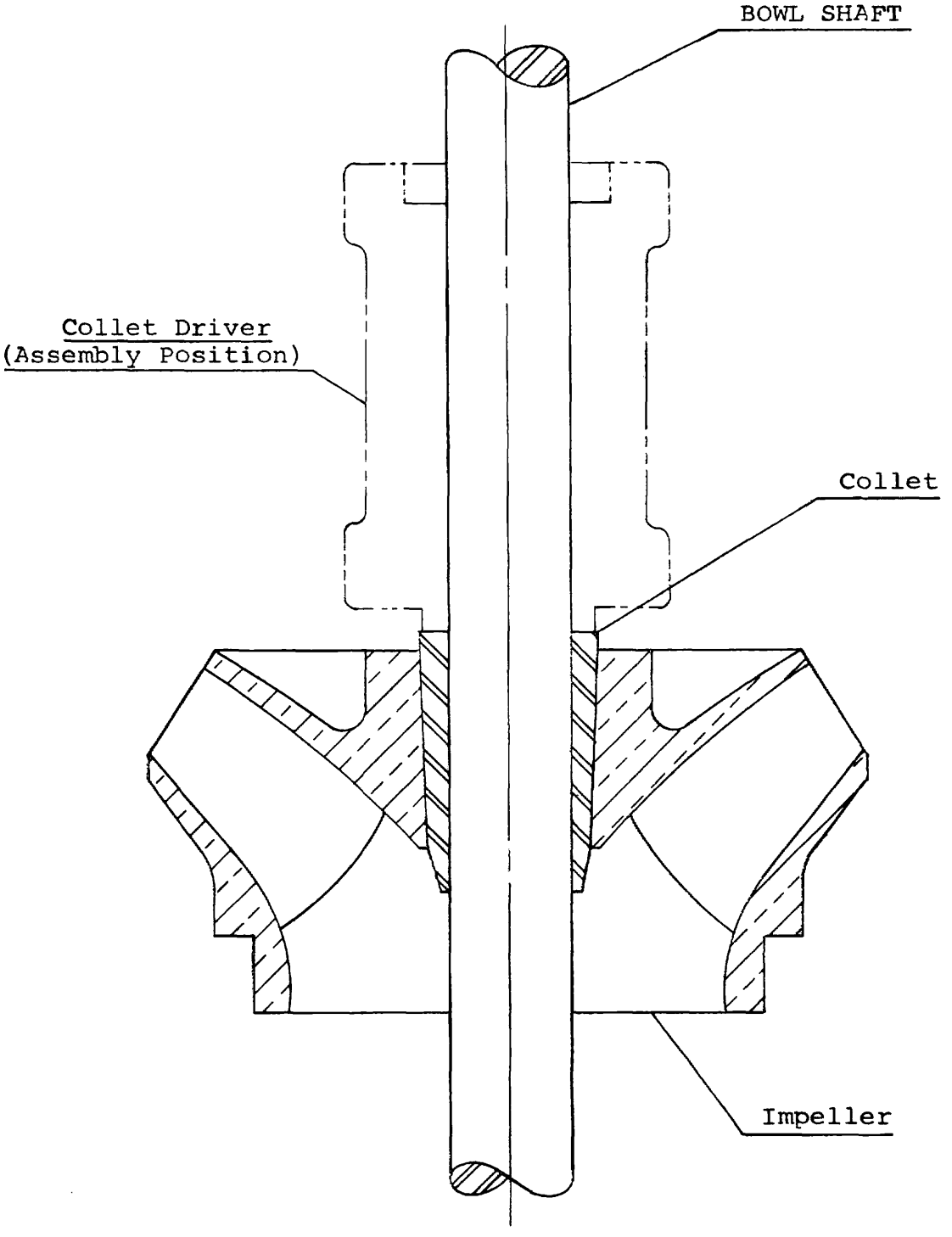


Fig. 54

SECTION 12

BOWL DISASSEMBLY PROCEDURE

Provide tools as listed in "Assembly Procedure," Section 11.

Remove shaft coupling and tube adapter. Remove deflector collar by reaching down into discharge case hub and insert screw driver blade into collar slot. Collar may then be withdrawn by pulling out with screw driver.

Remove nuts under top bowl flange and slide discharge case off shaft. In same manner, take top bowl off. If desired, discharge case and top bowl need not be separated, and may be handled as one part for disassembly operations.

Slip collet driver onto shaft from top into position as shown in Fig. 55 (reverse ends from assembly position.) Pull shaft out as far as possible so that impellers are well off seats and knock impeller off collet. Using screw driver to spread collet, remove collet from shaft by sliding along and off threaded end. Remove next bowl and continue operation as described.

GENERAL NOTE

In either assembly or disassembly operation, it is beneficial to oil shaft very lightly. This will facilitate sliding parts on and off shaft.

In making up pipe adapter coupling, tube adapter, threaded bowls, or other threaded joints, it would be advisable to use approved thread compound.

In taking apart an old unit in which shaft may be frozen in bushings or collet frozen to shaft, it may be necessary to apply heat with a torch in order to effect removal.

In all cases when assembling any threaded parts, threads must be perfectly clean.

For new units, impeller skirt and wear ring clearances should be as listed in Fig. 56.

For standard units, endplay characteristics will be as noted in Verti-Line Catalog Page 8.1 and 8.2, Section 2.1.

Before starting any disassembly work, shaft endplay should be checked so that, upon reassembly, same endplay may be maintained, unless more lateral is required.

Before starting any disassembly work, shaft and tube projections should be measured and recorded so that parts may be reassembled in same manner.

IMPELLER DISASSEMBLY

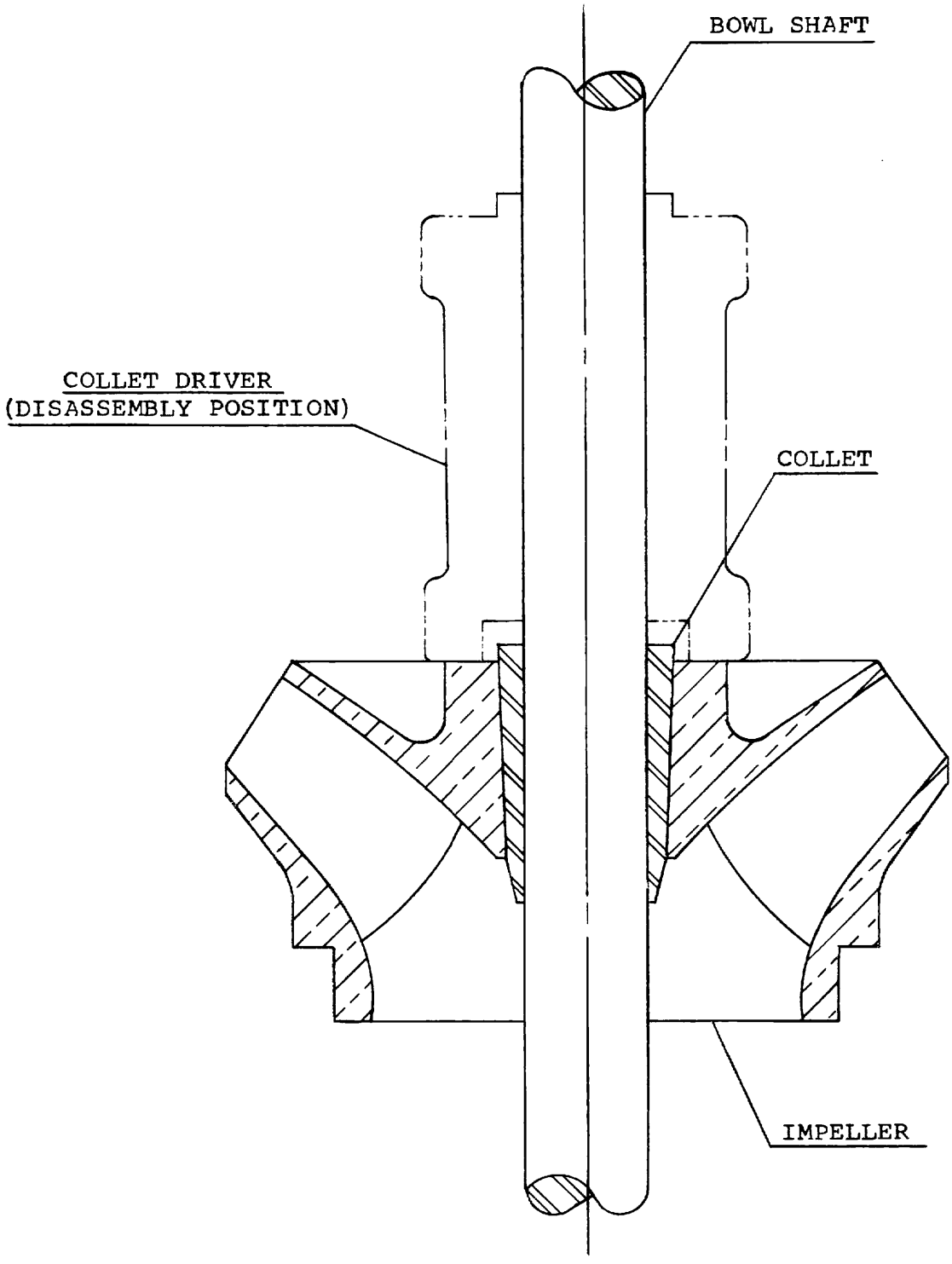


Fig. 55

BOWL	IMPELLER SKIRT O.D.		BOWL BORE I.D.		DIA. CLEARANCE	
	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
4RC	2.240	2.242	2.250	2.252	.008	.012
6T	3.237	3.238	3.250	3.252	.012	.015
6EH	2.615	2.616	2.625	2.627	.009	.012
6R	3.112	3.113	3.125	3.127	.012	.015
6FH	3.612	3.613	3.625	3.627	.012	.015
7R	4.235	4.237	4.250	4.252	.013	.017
8EL	3.237	3.238	3.250	3.252	.012	.015
8ED	3.612	3.613	3.625	3.627	.012	.015
8EH	4.110	4.112	4.125	4.127	.013	.017
8R	4.110	4.112	4.125	4.127	.013	.017
8GH	4.985	4.987	5.000	5.002	.013	.017
8FH	4.985	4.987	5.000	5.002	.013	.017
10EXL	4.110	4.112	4.125	4.127	.013	.017
10EH	4.860	4.862	4.875	4.877	.013	.017
10R	5.234	5.236	5.250	5.252	.014	.018
10JK	6.171	6.173	6.187	6.189	.014	.018
10FH	6.609	6.611	6.625	6.627	.014	.018
12EL	4.735	4.737	4.750	4.752	.013	.017
12EH	5.434	5.436	5.450	5.452	.014	.018
12R	6.171	6.173	6.187	6.189	.014	.018
12KH	6.798	6.800	6.814	6.816	.014	.018
12FH	7.233	7.235	7.250	7.252	.015	.019
14TM	6.484	6.486	6.500	6.502	.014	.018
14KH	7.733	7.735	7.750	7.752	.015	.019
14R	7.858	7.860	7.875	7.877	.015	.019
14MS	8.983	8.985	9.000	9.002	.015	.019
14FH	9.483	9.485	9.500	9.502	.015	.019
16EH	7.733	7.735	7.750	7.752	.015	.019
16KH	8.983	8.985	9.000	9.002	.015	.019
16FH	10.981	10.983	11.000	11.002	.017	.021
18EH	8.983	8.985	9.000	9.002	.015	.019
18FXH	9.483	9.485	9.500	9.502	.015	.019
18CF	10.233	10.235	10.250	10.252	.015	.019
20EH	10.233	10.235	10.250	10.252	.015	.019
20K	10.608	10.610	10.625	10.627	.015	.019
22MS	13.730	13.732	13.750	13.752	.018	.022
24EH	12.230	12.232	12.250	12.252	.018	.022
28SK	14.978	14.980	15.000	15.002	.020	.024
30K	15.998	16.000	16.020	16.022	.020	.024
36EH	18.748	18.750	18.770	18.772	.020	.024
46FH	29.965	29.970	30.000	30.005	.030	.040

Fig. 56

SECTION 13

DON'T

Don't pull discharge piping to pump discharge flange with bolts or capscrews. Install pipeline so that fasteners are used to prevent leakage only.

Don't hang weight of discharge line and fittings on discharge head alone. Support pipeline by blocking or concrete saddles according to best piping practice. Use dresser-type couplings wherever possible to eliminate piping strains imposed on pump.

Don't start pump while it is rotating in reverse direction after having shut down. It is advisable to install time delay relay on electric drives to prevent this. Non-reverse protection in driver could also be a solution.

Don't put heavier than recommended heaters in starter if pump load begins to trip those furnished originally. These are protective devices. Contact your Layne & Bowler Representative for assistance.

Don't add oil to driver while running. Don't add grease to grease lubricated driver without removing relief plug.

Don't drop parts into pump during installation or disassembly. Don't drop parts into motor when canopy has been removed and top is open. Parts must be removed before next operation.

Don't tighten shaft packing where provided except in increments, i.e., tighten gland nuts part of a turn and let pump run 5 to 10 minutes before tightening further. If leakage water is too hot to put on hand, back gland nuts off a little until water cools, then tighten again. Gland nuts must be adjusted evenly so as to prevent cocking gland, forcing it against shaft.

Don't start pump equipped with mechanical seal until air or vapor is vented from seal housing. Housing should be filled with liquid to avoid damage to seal faces.

Don't forget that this equipment contains rotating parts. Use CAUTION when working near such parts to avoid injury. Don't neglect to replace all guards, covers, and shields before start-up.

Don't run pump backward. Clockwise operation (looking down on pump). under power can unscrew threaded joints. Power requirements of impellers can increase when driven backward and can thus create undesirable overloads. These problems do not apply to pumps coasting backward due to return flow of water from system; overspeed is the circumstance to guard against then.

Don't throttle the suction of a pump in a closed system.

Don't change pump speed without checking effect on power, internal pressure, and other conditions.

Don't allow oil, grease, or thread lubricant to contact rubber bearings.

Don't work on pumps, wiring, or any pump or system components without opening energizing circuits such as at main breaker or pump disconnect switch. This will prevent "surprise" starts that may occur due to automatic control systems. It will also prevent other possibility of personal injury.

SECTION 14

MAINTENANCE HINTS

For pump lubrication, use light turbine oil equivalent to Standard Oil O.C. Turbine Oil #9 or good grade of mineral oil with proper additives having viscosity equal to SAE #10.

Remove old oil from driver once a year. Flush with kerosene and refill. Follow manufacturer's instructions carefully as to method and type of lubricant. Replace self-lubricated driver ball bearings in about 5 years. It is generally less expensive to replace these before they fail.

Replace all shaft packing on open lineshaft pumps after maintenance has required addition of two rings. Always let packing box leak slightly at top to add life to packing.

Be aware of changing conditions in system. Any change from original conditions or any variation in system can create an undesirable reaction in pump as the energizer of the system. Refer to Vertical Turbine Pump Association Environmental Data Brochure for some of the system variable conditions that might occur.

Don't attempt to remove or to repair your pump without consulting a company representative. If it becomes necessary to attempt any repair work on your equipment, be sure to review all instructions for operation and maintenance of unit.

SECTION 15

OPERATION AT SHUTOFF HEADS

In the usual application of Verti-Line vertical turbine pumps, no harm will result from operations under conditions of static flow heads. However, not all installations are "usual" and for this reason consideration should be given to any unit which may be subjected to this usage. The following points should therefore be checked and resolved before putting the equipment into operation at or near shutoff heads.

a. Thrust bearing capacity must be adequate

b. If prolonged operation at no flow is contemplated, the problem of heat dissipation may become acute since the entire shutoff horsepower is converted to heat in the available fluid.

c. For high pressure units, stresses at shutoff heads should be investigated. This information may be obtained from the factory upon request.

d. Certain impeller designs may have critical horsepower characteristics at low flows. Shutoff power requirements should be examined for driver overload.

e. It must be kept in mind that open lineshaft units depend upon pumped fluid for lubrication. Fluid temperatures, if raised excessively due to lack of flow, my impair lubrication efficiency.

To summarize, designs will easily accommodate most of the considerations listed above. However, to obtain the best possible application, the factory should be notified at the time of order if operation at static flow heads will be a possibility and this precaution must be observed to validate any warrantees.

NOTES

SERVICE RECORD