INSTALLATION

AND

OPERATION MANUAL

FOR THE

GOULDS 3310H

TABLE OF CONTENTS

1. Foreword and Guarantee

This erection and operating manual must in all cases, be read by your millwright before erection and start-up.

We are not liable for damage incurred through failure to observe the instructions for erection and operation. In this connection we refer to our general terms and warrantee.

During the period of guarantee, repair work and modification shall be carried out by our millwright only, or following our approval in writing.

If, contrary to our Acknowledgement of Order, you wish to use the pump for a different service please ask for our agreement. Otherwise the guarantee given for this pump will not apply.

2. Description of the Pump

2.1 Nameplate/Ordering Spare Parts/Spare Parts List

Every pump has a nameplate showing the following details:

Pump Type and Size
Goulds Serial Number

When ordering spare parts please state:

Pump Type and Size
Goulds Serial Number
Name and Part No. of the component
(see sectional drawings, section 9)

If you have received from Goulds along with the Order a Repair Parts Data Sheet relating to your pump (which also shows the Goulds Serial No.), please supply the Gould Serial Number, Part Item No. and the Part Drawing No. of the requested component.

2.2 Construction Features

The high pressure boiler feed pump is a multi-stage, ring section type pump with suction and discharge flanges (normally) vertically upwards. The pump feet are at the bottom of the suction and the discharge casing.

At the customer's request, the pump feet can be centerline mounted, and/or other flange positions can be provided.

The suction piping and the discharge piping are connected to the pump casing by flanged connections.

To completely dismantle the pump, it must be lifted off the baseplate after disconnecting the suction and the discharge piping.

The pump body, which consists of suction, stage, and discharge casings, are held together by external tiebolts. The pressure containing parts are sealed by confined O-rings. The stuffing box housings, which can be cooled, are bolted to the suction and discharge casing.

The shaft is sealed by packing as standard. Installation of a mechanical seal is possible. For pumps fitted with mechanical seals please refer to the specific mechanical seal installation drawings.

The rotating assembly of the pump is supported by bearing housings bolted to the suction and discharge side stuffing box housings, the former enclosing the cooling chamber of the stuffing box housing. The connections for the stuffing box cooling chamber are on the bearing housing. The bearings can be of the rolling contact type (grease or oil lubricated) or of the sleeve bearing type (lubricated by ring or pressure oil).

The axial thrust at the impeller is compensated by means of a balance disc/counter-balance disc or a balance drum and a residual thrust bearing. In the first case additional fitting of a balance disk lift-off device (grease or oil lubricated) is optional.

For details regarding the set-up of the pump please consult the sectional drawings as supplied in the data package.

The drive end is normally on the suction side.

Drive on the discharge side or on both sides is possible.

2.3 Direction of Rotation

Clockwise when facing the suction side of the pump.

3. Erecting the Pump

3.1 Assembling the Unit on the Baseplate

3.1.1 If assembly of pump and driver on a common baseplate is done in our factory, the whole unit will be carefully mounted and aligned. It is necessary to check the alignment of the coupling before starting the pump up, as the setting may have been distorted when connecting up the pipework (see sub-section 3.2.2).

Eyebolts which may be fitted to the pump or to the driver must never be used to lift the complete unit as they are meant to carry the weight of the driver or pump only.

3.1.2 If the driver is not mounted by Goulds, the distance between motor and pump coupling must be observed (see outline drawing provided with the customer data package).

Differences in level between the shaft center-lines of pump and driver must be equalized using suitable shims (plane parallel shims). When tightening up the foundation bolts avoid distortion of the baseplate.

IMPORTANT:

In accordance with OSHA requirements the coupling must be protected with a guard so as to prevent accidents from involuntary physical contact with rotating parts.

3.1.3 Where a pump is driven by an internally cooled electric motor, type of enclosure NEMA ODP (IP 23 S, formally P 22), it is imperative to ensure the baseplate is always dry. Otherwise there is danger of damage to the motor (short-circuit of the winding), because the motor fan may draw liquid. Thus a leakage pipe must be connected to the drip and leakage connection of the bearing housing, which must extend at least to the baseplate edge.

Also when performing cleaning work on the unit, motor failures may occur from careless handling of the water hose.

3.1.4 Hot Water Foot Fastening

If the temperature of the discharge liquid is above 220 °F (105 °C), the pump feet must not be bolted firmly to the baseplate. Otherwise the pump casing would be liable to distort due to thermal expansion.

If the pump is assembled on the baseplate in our factory, the hot water foot fastening will already be provided if required.

Instead of the cap screws generally used for the standard design, studs and fastening nuts are used for the hot water foot fastening (see Fig. 1).

Place (do not tighten) the fastening nut (2) lightly so that a "zero" clearance is maintained between this nut and the washer; it must be just about possible to move the washer by light tapping. In this position the fastening nut is located by tightening the lock screw (4) or by a nut of self locking design.

To avoid movement of the pump off its centerline and to ensure expansion exactly along its centerline, guide pins or dowels are set between pump and baseplate. The coupling must remain stationary. The casing on the drive side must also be dowelled in the transverse direction to the pump shaft centerline. (See Fig. 2)

3.2 Alignment Procedures

3.2.1 General

Alignment of the pump and driver is of extreme importance for trouble-free mechanical operation. The following are suggested steps to establish the initial alignment of the unit.

NOTE: THIS IS AN INITIAL ALIGNMENT. The final alignment is done after the unit has been run under actual operating conditions. The final alignment procedure must be followed.

CAUTION:

MAKE SURE THE DRIVER IS "LOCKED OUT" TO PREVENT ACCIDENTAL ROTATION.

The coupling manufacturer's instruction sheets, sent with the pump, should be studied and used when installing or servicing the coupling. Note that the coupling hubs are not necessarily mounted flush with the end of shafts. The alignment must agree with the recommendations of the pump and/or driver manufacturer.

IMPORTANT:

An alignment change in one direction may alter alignment in another. Recheck each alignment procedure after making any alignment alteration.

3.2.2 Angular Alignment

Unit is in angular alignment when the coupling gap, as measured at four points 90 degrees apart. does not vary by more than .002" TIR (0.05mm.)
Angular Alignment Check - measure coupling gap at four points 90 degrees apart- usually 12, 3, 6, and 9 o'clock positions with feeler gauge, taper gauge, or dial indicator (Fig. 3). Rotate both shafts together to eliminate the effect of shaft or coupling hub run out.

Angular Alignment Correction

Horizontal - To correct horizontal angular misalignment, driver can be shifted on its bedplate in the necessary direction.

Vertical - To correct vertical angular misalignment the driver can be tilted on its bedplate by installing or removing equal amounts of shims from the back or front feet as necessary.

3.2.3 Parallel Alignment

Horizontal - Unit is in horizontal parallel alignment when the shaft centerlines are within 0.002" TIR (0.05 mm).

Vertical - Unit Is in vertical parallel alignment when shaft centerlines are within recommended cold setting. It is recommended to set motor centerlines .002" - .004" (.05 - .10mm) low regardless of operating temperature. Driver manufacturers should be consulted for recommended cold setting for other types of drivers (steam turbines, engines. etc.)

Parallel Alignment Checks - Fasten dial indicator on one shaft to read on opposite coupling hub (Fig. 3) zero dial indicator at top position. Turning both shafts, observe and record reading at four points 90 degrees apart, usually 12, 3, 6 and 9 o'clock positions.

Parallel Alignment Correction

Horizontal - To correct horizontal misalignment, shift driver on its base evenly in necessary direction.

Vertical - To Correct vertical parallel misalignment, add or remove equal amounts of shim from under driver feet.

IMPORTANT:

Alignment change in one direction may alter alignment in another. Recheck each alignment procedure after making any alignment alteration.

Align the unit to the elevation required using a dial indicator mounted on one shaft and reading on the other (See Fig. 3). Turning both shafts together, take four readings at points 90 apart. Shim the driver as necessary to satisfy the elevation requirement. The alignment is satisfactory when the machines are within .002" (.05mm) TIR of the elevation established in step one and within .002" (0.05mm) TIR side to side.

3.2.4 Alignment - Final

Final adjustment can only be accomplished after the unit has been under actual operating conditions for a sufficient length of time to bring the unit up to operating temperature. After this warm-up period has elapsed, stop the unit and IMMEDIATELY DISCONNECT THE COUPLING. CHECK THE ALIGNMENT. Make sure the driver is "locked out" to prevent accidental rotation. Repeat each alignment procedure outlined in 3.2. Reconnect coupling. Check final alignment after approximately one week of operation.

3.3 Grouting the Bedplate

Bedplate mounted units are normally mounted on a concrete foundation of liberal thickness poured on a solid footing, using a one-three-five mix. The foundation should be substantial in order to absorb any vibration and to form a permanent, rigid support for the pumping unit.

The location and size of foundation bolts are shown on outline assembly drawing supplied for unit.

When unit is mounted on a concrete foundation, each foundation bolt should be installed with a pipe sleeve around it to allow for adjustment. The I.D. of the sleeve should be 2-1/2 to 3 times bolt diameter. Place a washer between bolt head and sleeve to hold bolts.

Leave 3/4" to 1-1/2" (19mm to 38mm) under bedplate for grout. Remove all water and /or debris from anchor bolt sleeves prior to grouting.

Fill bolt sleeves with rags or cotton waste to prevent concrete from entering between bolt and sleeve. Bolts should be of sufficient length so that they project through nuts approximately 1/4" (6.5 mm) after allowance has been made for grouting bedplate thickness and nut thickness.

Place unit in position on wedges or a minimum of four shims located under weight centers of pump and driver. Additional shims or wedges may be installed near the center if desired or, as required.

By adjusting wedges or adding or removing shims, bring bedplate to level and provide the proper distance above foundation for grouting (3/4" to 1 1/2" [19 - 38 mm]).

Tighten foundation bolts, but only finger tight. Maintain bedplate level.

4. Installation of Pipework

4.1 Connection of Suction and Discharge Piping

After grouting the bedplate the pipework may be connected. The diameters of the pipework are not determined by the pump discharge and suction flanges.

On short discharge pipe runs, the diameter should be such that the pipe resistance constitutes a small portion of the discharge head. On long pipe runs the most economic pipe diameter must be assessed for each particular case.

Typical flow velocities in the

suction line, $v_s \approx$ from 3.2 to 6.4 ft/sec. (1 - 2 m/sec.)

feed line, $v_d \approx$ from 4.8 to 8.0 ft/sec. (1.5 - 2.5 m/sec.)

Maximum velocity of either is 9.7 ft/sec. (3 m/sec.)

Avoid abrupt changes in diameter as well as sharp bends.

IMPORTANT:

The pump may absorb only very small pipe forces and moments. Do not use the pump as a locating point of the pipework. Unfavorably installed pipe runs, especially on the suction side (i.e. bends in various planes immediately before the suction casing) can affect pump performance or result in damage to pump components.

To check for proper piping fit:

Loosen the flange bolts. After loosening, the flanges must not yield more than the amount corresponding to the gasket thickness, nor must they be out of parallel or bear against each other under stress. See that the flange gaskets do not extend into the bore of the piping. Carefully clean all pipe parts, valves and fittings, and pump branches prior to assembly.

Provide vent and drain valves on the suction and discharge piping. the feed piping must be laid with a steady slope towards the pump to avoid air pockets in the piping. A horizontal run of the piping is not acceptable.

Avoid sudden changes in cross-section and sharp bends. If branching off is necessary, this should be done ensuring hydraulically favorable conditions. Shut-off valves should be installed in the feed and discharge piping, and in all piping connecting the pump to the system.

The valves enable the pump to be brought down to atmospheric pressure and dismantling without the need to empty the system. Flow control at constant speed may be accomplished on the discharge side only. During operation the gate valve in the suction piping must always be fully open. It must never be used to regulate the pump flow.

For the initial operation of the pump we recommend installing a strainer having a screen area of 3 to 4 times the pipe cross-section. This will protect the pump against gross impurities in the piping (See Fig. 4). The mesh in the suction strainer should be 30 mesh or finer. The pressure loss across the strainer must be monitored to prevent pump damage due to clogged strainer.

4.2 The Recirculation By-Pass Line

The bypass line serves to automatically recirculate a certain amount of water to the feed water tank when the pump is working at very low capacity. This is critical to prevent damage due to overheating. The amount of water to be recirculated may be gathered from the order data. This is the responsibility of the customer.

Up to and including the shut-off valve and the check valve, the recirculating by-pass line is to be designed to the same pressure as the discharge piping; thereafter in accordance with the pressure of the feed water tank. Permissible velocities in the recirculating by-pass line after the throttle pipe: 22 ft/sec. to 32 ft/sec. (7 to 10 m/sec.). The recirculating by-pass line may be combined with the "manual recirculating line". Care must be taken to ensure an unhampered flow of the liquid at the point of junction. It is imperative that the by-pass device be always switched to "by-pass open" if trouble arises with its actuators. Frequent checks are advisable. Since the valve disc is exposed to heavy wear it must be renewed early enough to avoid energy losses. The by-pass device must be installed near to the pump discharge casing, in any case, before the shut-off gate valve.

4.3 The Manual Recirculating Line

Can be provided by the customer. It permits starting the pump and running it at very low capacity with the recirculating by-pass line closed (thus saving the by-pass device; it will operate when the by-pass valve is not yet ready to work, etc.) The "manual recirculating line" runs from the discharge piping (before the shut-off gate valve) back to the feed water tank. It is fitted with a shut-off valve and a cascade throttle pipe. Up to and including the nearest shut-off valve, the pressure of the discharge branch determines the pipe sizing. Thereafter the pressure of the feed water tank. This line should be sized for about 30% pump capacity (permissible velocity (22.5 ft/sec. to 32.2 ft/sec. (7 to 10 m/sec.)). The cascade should be designed to provide 100% break-down of pump pressure.

IMPORTANT:

After connection of the piping, the coupling alignment must be rechecked as the set may have been distorted. It must be possible to turn the rotor easily by hand. The bearings, coupling, shaft seal, and wear rings may be damaged prematurely as a result of inadequate alignment.

4.4 The Balance Water Line

Is generally supplied already mounted, returning to the pump suction passage. It is not equipped with a throttling device nor with a shut-off valve.

On suction lift duty the connection of the balance water line must be relocated from the suction casing to the suction side stuffing box housing.

The balance water line may be connected straight to the feed water tank, or suction piping, by the customer. The line should be sized so that the pressure loss is as low as possible. In these two cases the items to be provided in the line are: an adjustable throttle valve, a non-return valve, a shut-off valve (sealed in the open position), as well as a safety valve with a discharge to the suction casing, or a safe drain.

The pressure in the relief water chamber before the entry into the balance water line should be 7.5 to 30 psi (.5 to 2 bar) maximum above suction pressure at design or working speed. At constant speed with increasing flow rates the pressure will decrease. With speed controlled pumps the pressure will likewise decrease as the speed is reduced.

The safety valve should operate at 45 psi (3 bar) above suction pressure.

4.5 The Cooling Water Line

If desired by the customer, Goulds can pipe, within the area of the bedplate, the cooling water lines. At the inlet end the cooling water supply line pressure should be 45 to 90 psi (3 to 6 bar), temperature normally up to 86 °F (30 °C), quantity as per order data is to be piped onto the bedplate.

Cooling requirements can include: the cooling chambers of the suction and discharge side stuffing box housings (connection at the top and bottom of the bearing housing); the oil for ring-oiled bearings; the circulating water for the mechanical seal (when mechanical seals have separate coolers).

IMPORTANT: Aggressive cooling water requires special provisions.

4.6 Lubricating Oil Lines

The inlet lines to the various feed points and the outlet lines are brought together to one line within the area of the bedplate; after installation of the unit they must be connected to the "oil-supplier" (e.g. turbine), unless this has already been done at the factory. Prior to the final fitting of these lines they should be cleaned (pickled) and flushed to remove scale and dirt.

Before entry into the bearings the oil inlet lines are fitted with throttling valves to regulate the flow. The oil outlet lines are provided with sight-glasses and thermometers.

4.7 Drain Line, Leakage Water Line

If so desired, a drain line can be provided from the suction and/or discharge casing.

Drip and leakage water connections on the bearing housing are provided for customer use.

5. Start-up and Stopping

5.1 Preparations before Start-up

Greasing the Bearings
On pumps fitted with roller bearings, initial greasing is provided at the factory. (See also sub-section 6.3)

Filling the Bearing Housing with Oil
Pumps with oil lubricated roller or sleeve bearings are supplied without oil.

If the pump is put into operation after prolonged shut-down, flush out the bearings and bearing housing with a light oil or kerosene to remove contaminations. During the flushing rotate shaft slowly. Sleeve bearings should be removed for cleaning. Finally, flush the bearing and housing with the proper lubricating oil to insure oil quality after cleaning.

Fill the bearing housing with oil through the filler opening until the level reaches the mark in the middle of the oil level sight-glass (see also subsection 6.3).

Pressure Oil Bearings
Clean pump bearings with extreme care. Install thermometers in the oil return lines. Fill oil lines using the oil pump. Vent lines, adjust pressure and flow provisionally with the aid of the throttling devices. Check oil return line and oil level at the "oil supplier".

Priming the Pump
Prior to priming the pump, open any pipes supplying the external sealing liquid and the cooling water for the shaft seal. Make sure the water flows. Before starting up the pump vigorously flush the suction line into the open to clear debris.

When priming the pump, please note:
Suction or feed line must in all cases be completely filled and properly vented. Open or loosen the following vent points until only water flows out: recirculating by-pass line or manual recirculating line, pressure gauges, vents on the suction and discharge casing. If suction head conditions exist, the isolating valve in the feed line may be opened in order to fill the pump.

WARNING:

When hot liquids are involved, quick priming of the pump should be avoided (distortion, and heat shock). Under no circumstances must cleaning of the boiler unit be effected by circulating chemicals with the feed pump, as dirt particles and solids may cause the pump to seize. Where pickling procedures are applied, we do not assume any guarantee with respect to corrosion of the materials of the pump.

Check of Direction of Rotation
The direction of rotation must correspond with the direction arrow on the bearing housing. The direction cannot be checked with the pump coupled. The driver may be started for a moment only.

Wrong direction of rotation will quickly do damage to the mechanical seal (if any), and the pump.

IMPORTANT:

Incorrect pump rotation will quickly do damage to the mechanical seal (if provided) and the pump internals.

5.2 Starting-up

The isolating valves in the suction line, the recirculating by-pass line and, if, installed, the manual recirculating line, should be fully open. The regulating valve in the discharge line, however, should be closed, or in the case of automatic operation, the full back pressure should be on the non-return valve.

FOR PUMPS WITH BALANCE DISK AND NO LIFT OFF DEVICE: Prior to the initial start-up of the pump insure that the balance disks are in proper position (rotor all the way to the suction end) and properly lubricated (rotate pump shaft with rotor in proper position with no axial force on rotor). Future start ups of the pump may be done with out setting up the disks.

Make sure that there is a flow in the pipes supplying the external sealing liquid, cooling water for the shaft seal, and lube oil. Do not switch on driver until then.

After switching on the driver, immediately observe pressure gauges. If the discharge pressure does not rise continuously as the speed increases, stop the pump, insure no damage has occurred, and vent once more, carefully.

Once the pump has been brought up to working speed, open the regulating valve in the discharge line (SLOWLY) until the required service duty is reached.

Operation against closed regulating valve in the discharge line, without pumping through the recirculating by-pass or the manual recirculating line, will lead to *DESTRUCTION* of the pump. This condition must be avoided.

The pump may operate for hours with the recirculating by-pass and/or the manual recirculating line open.

Check oil pressure and flow to pressure feed lubricated bearings and adjust them, if necessary. Normal oil pressure for the pump bearings: approximately 7 to 12 psi, with 22 psi max (.5 to .8 bar, 1.5 bar max.).

For running-in the packing, lightly tighten gland, even if the leakage is greater than normal. After a running-in period the gland should be tightened evenly until there is only slight leakage from the stuffing box. This should be done gradually to give the packing time to run in after each adjustment.

Any necessary changes of the operating flow may be effected only with the regulating valve in the discharge line.

Particular care should be taken

- that the driver does not overload if the density of the liquid handled is greater than that originally assumed, or the rated flow rate is exceeded.

- that in the case of larger flow rates the available suction head is still sufficient or, alternatively, that the suction lift to be overcome by the pump is not too high, as otherwise damage due to cavitation will occur.

- keep in mind that when the flow rate is more than 1.25 times the flow rate at best efficiency point, the balance device may be damaged.

When starting up automatically operated plants, all isolating valves, including the discharge gate valve, must be kept open.

Only after checking of the pump pressures, the shaft seals, the bearings, the by-pass, etc. may the pump be used to deliver water to the system.

As long as the boiler has not reached its constant full pressure it is absolutely necessary to keep the "discharge pressure" under continuous observation when starting up and during operation.

If a meter for flow indication exists, this permits the same check. The maximum capacity allowed by Goulds must not be exceeded (1.25 times BEP).

In the starting phase of the boiler the discharge gate valve may have to be throttled to limit pump flow. If the pressure gauge indicates a fall in pressure, there is danger of the following:

1. Cavitation (capacity increases or, in the case of insufficient suction head, vaporization and cavitation takes place)

2. Failure of pump due to an excessive fall in pressure. The balance device will no longer function and the pump is liable to seize. Please observe the limit curve.

3. Exceeding the permissible pressure reduction in the feed water tank will cause vaporization corresponding to the particular flow rates. This can lead to cavitation damage, steam binding, and pump seizure.

When handling hot liquids we recommend re-checking the coupling alignment after the first start-up when the pump has reached operation temperature. If necessary, re-align the pump and/or the driver.

5.3 Stopping the Unit

When stopping the pump proceed, depending on the method of operation, as follows:

1. As long as the pump is started up against closed gate valve:

   Open manual recirculating line.
   Close discharge gate valve.
   Switch off driver.
   Shut off cooling water when pump temperature is less than 160 °F (70 °C).

2. With constant full boiler pressure:

   Stop driver, discharge gate valve may be left open.

   Shut off cooling water when pump temperature is less than 160 °F (70 °C).

   Shutting off the cooling water helps to save costs.

   Only when necessary, close shut-off valve in the feed line.

If there is danger of the pump freezing during prolonged shut-down periods (e.g. installation of the unit in the open air) the pump including its cooling chambers need to be drained.

5.4 Parallel Operation

Identical boiler feed pumps may work in parallel at all times, for the automatic by-pass protects the pump if the steam output of the boiler decreases markedly. If two pumps work in parallel, neither may be expected to do exactly 50% of the pumping; especially in the low capacity, front range of the pump curve. In this range even a small difference in the head capacity curves or in the speed of the drivers makes itself strongly felt. Unequal pumps or equal pumps with different hydraulic internal parts must be carefully checked as to their suitability for parallel operation against their head capacity curves. A base load pump running at constant speed may operate in parallel with a speed-controlled pump as long as the working pressure of the controlled pump corresponds to the service pressure of the uncontrolled pump.

5.5 Checking the NPSH

Both quotation and order data contain the particular design or working point at capacity Q, and the net positive suction head of the pump = NPSH required in feet (meters).

Checking the NPSH is done as follows: (Example: A boiler feed installation)

When measuring at a capacity, Q, with control pressure gauge at suction flange you obtain, at a temperature of 220 °F (105 °C), a gauge reading of 22 PSIA (1.52 Bar).

Properties of the boiler feed water are as follows:

- Specific gravity, SG, is 0.955 (density is 0.955 kg/dm^3)
- Saturated Vapor Pressure, Vp, is 17.19 PSIA (1.20 Bar Abs)

The NPSH is calculated as follows:

$$\text{feet of NPSH} = \left(\frac{Pgs+Pa-Vp}{SG}\right)\times 2.31+\frac{V^2}{2G}$$

$$\text{meters of NPSH} = \left(\frac{Pgs+Pa-Vp}{density}\right)\times 10.34+\frac{V^2}{2G}$$

Where, Pa is the local atmospheric pressure in PSIA (Bar Abs).

V is the flow velocity in ft/sec (m/sec).
G is the gravitational acceleration in ft/sec^2 (m/sec^2)

Assuming a 3" suction pipe and a flow of 140 GPM and one standard atmosphere as the local atmospheric pressure with V=13.4 ft/sec. (4.08 m/sec).

$$NPSH = \left(\frac{22+14.7-17.19}{.955}\right)\times 2.31+\frac{13.4^2}{2(32.17)} = 50\ ft.$$

$$NPSH = \left(\frac{1.52+1.01-1.20}{.955}\right)\times 10.34+\frac{4.1^2}{2(9.81)} = 15.25\ m.$$

The calculated NPSH must always be greater than the NPSH required by the pump to avoid cavitation and damage.

5.6 Checking the Total Head

The total head (= differential pressure) ie: 1015 PSI (70 bar) according to the data of the order results from the difference P2-P1. P1 is the pressure at the suction flange and P2 is the pressure at the discharge flange.

The total discharge head is P2. If the pressure is higher than guaranteed or than measured during performance test, the actual speed measured at the pump should be compared with that mentioned in the order documents.

Re-Starting

Before re-starting the pump, take care that the pump shaft is not rotating backwards. Starting with shaft rotating in opposite direction may lead to shaft damage.

6. Supervision and Maintenance

6.1 General

The pump must never be operated without liquid filling.

Even, smooth running of the pump rotor essential.

When delivering from a tank, the liquid level must always be well above the inlet opening of the feed line or the suction line.

The performance as indicated on the driver nameplate must not be exceeded.

When handling hot liquids pay attention to the flow of the cooling liquid to the shaft seal.

The cooling liquid flow should be adjusted so that the temperature rise of the cooling liquid does not exceed 27 °F (15 °C). Sudden changes in temperature of the liquid being pumped should be avoided.

6.2 Rise of Water Temperature in Pump

The losses in energy in the pump are converted into heat. At full speed the water heats up by 5 to 14 °F (3 to 5 °C), at low capacity even more, but hardly by more than 18 °F (10 °C). An excessive rise in temperature is avoided by the bypass system (compare subsection 4.2). The temperature at the suction and discharge flanges should be checked regularly and, if necessary, the values recorded.

6.3 Supervision and Maintenance of the Bearings

Grease lubricated rolling contact bearings
The bearing temperature must not exceed 175 °F (80 °C). In the case of residual thrust bearings, temperatures up to 220 °F (105 °C) max. may occur depending on the load and the ambient temperature.

Re-greasing (intervals)
Re-grease by means of a grease gun through the two grease nipples every 1500 operating hours. Residual thrust bearings, especially when running at temperatures exceeding 140 °F (60 °C), should be regreased every 400 to 600 operating hours. When regreasing there is a danger of impurities entering the bearing space. Take care that the grease container and the greasing devices are clean and that the lubricant does not become contaminated during the transfer procedure.

If the bearing temperature rises after regreasing, then there is too much grease in the bearing housing. Stop the pump and remove excess grease from the bearing covers after removing them.

After approximately 10,000 operating hours or two years of services, at the latest, the rolling contact bearings must be removed, thoroughly cleaned and replaced with a fresh grease filling. In the case of extremely unfavorable operating conditions such as dirty and wet operation or high ambient temperature the regreasing must be performed at considerably shorter intervals.

Grease rates/grease types
When greasing the rolling contact bearings the spaces of the bearings should always be entirely filled with grease. The housing space on both sides, however, should only be filled up to one third. If the bearings are over greased there is a danger of them running hot.

Use only high-quality lithium soap bearing grease which is resin and acid free and has a rust inhibiting effect.

We recommend to use lubricating grease NLGI consistency No. 3 (K3K DIN 51825.)

Grease Properties:

Consistency No.	3
Work penetration	220 - 250
usable temp. range	-4 to 248 °F (-20 to 120 °C)
Dropping point not below	338 °F (170 °C)

Oil lubricated bearings
When the pump is at rest, the oil level can be measured at the sight glass. The oil level must not exceed the mark of the sight glass (middle of the glass). In new bearings change the oil after about 200 hours, there after about once a year, if the bearing temperature is below 122 °F (50 °C) and there is no danger of contamination. When the bearing temperature is above 122 °F (50 °C) or there is a danger of contamination, the oil should be renewed about every six months.

Lubricating oil for rolling contact and sleeve bearings must meet the following requirements:

Extreme cleanliness, resistance to aging, good viscosity, temperature behavior, good water separating properties and protection against corrosion.

We recommend, depending on the operating temperature of the bearings and the speed of the pump, to use lubricating oils to the following table.

Lubricating Oil Requirements	Operating temp. of the bearings up to 176 °F (80 °C)		Operating temp. of the bearings above 176 °F (80 °C)	Ambient temp. 32 °F (0 °C)
	n up to 1500 rpm	n more than 1500 rpm		
ISO Grade	VG 68	VG 46	VG 100	VG 22
Approx. SSU @ 100° F	300	200	470	100
DIN 51517	C49	C36	C68	C25
Kinem. viscosity at 40° C (105° F) mm^2/sec	C68	C46	C100	C22
Neutralization Number mg KOH/g	0.15 maximum			
Ash % by weight (Oxide ash)	0.02 maximum			
Water content % by weight	0.1 maximum			
Suitable motor oil	SAE 20 / 20 W		SAE 30	SAE 10 W

Pressure feed lubricated bearings
The temperature of the lubricating oil at the entrance of the bearings should be 104 to 122 °F (40 to 50 °C). The bearing temperatures may be up to 104 °F

(40 °C) above ambient temperature but should not exceed the maximum allowable temperature of 176 °F (80 °C).

The pressure at the entrance of the bearings depends on the oil temperature, the clearances within the bearings and the losses in the pipelines. The following values, which are given for guidance only, are for warm oil as encountered during operation, measured at the bearing:

Normal oil pressure from 7 to 12 psi (.5 to .8 bar)
Max. oil pressure from 22 to 27 psi (1.5 to 1.8 bar)
Switch off pressure from 4 to 6 psi (.3 to .4 bar)

The qualities stated for the oil lubricated bearings also apply for sleeve bearings.

6.4 Shaft Seal (Stuffing Boxes)

For the purpose of servicing the stuffing boxes lock out the driver to prevent accidental starting, close the isolation valves, and bring the pump down to zero pressure.

Supervision and Maintenance of a Packed Stuffing Box:

It is essential that the stuffing boxes be properly packed. Be sure to use the packing which is the most suitable for the pumping liquid, i.e. for boiler feed water a graphite, non-asbestos, packing (without grease) or graphite/PTFE with a lubricant. The packing must not be inserted in one piece. The following arrangement has proved satisfactory: Insertion of single packing rings with cut ends; the innermost packing ring with 1/16 in. (2 mm) clearance between the ends, the following ring with, 1/32 (1 mm) clearance (2 rings for 4x5-9) and only the last two rings without clearance (Fig. 5). A worn packing must be removed completely and the sleeves must be perfectly smooth and free from scores.

It is strongly recommended that each packing ring be prepressed with a pressing device. Pre-pressed packing rings must be bent sideways and slipped over the shaft (See Fig. 6). When pushing them into place by means of the gland it is important that the cut ends be staggered (Fig. 7). The gland should be lightly tightened, as the packing is sufficiently compressed by the suction pressure. The stuffing box gland should project 3/16 to 5/16 in. (5 to 8 mm) into the stuffing box chamber. It is essential that liquid from the pump can leak outward along the shaft sleeve. There must be steady leakage, from slight to moderate, from the stuffing box. If a freshly packed stuffing boxes develops fumes, take back the gland slightly. It may be necessary to repack the box with new packing.

The gland should be tightened evenly, but not too tight. Excessive tightening will result in destruction of the packing and shaft sleeve.

After packing it must be possible to rotate the shaft by hand.

Supervision and Maintenance of the Mechanical Seal
The amount of the leakage from the mechanical seal depends on numerous parameters. A new seal will always have a greater leakage than a run-in one. Leakages of up to several thousand cubic centimeters per hour are to be found.

The life of a mechanical seal depends on various factors such as cleanliness of the liquid handled and its lubricating properties. Due to the diversity of operating conditions it is, however, not possible to give definite indications as to its life. The dry running of a mechanical seal, even for a few seconds, can cause seal damage and must be avoided.

Never operate the pump without liquid.

When replacing or changing the mechanical seal, check pump shaft for true running and check that the shaft sleeve surfaces are in perfect condition in the area of the mechanical seal.

6.5 Check of the Balance Disc

If the radial bearings are designed as grease lubricated rolling contact bearings, an indicating device is provided on the suction side bearing cover and on the pump shaft.

On all other bearing designs an indicator sleeve with a notch is screwed into the non-drive side bearing cover. A pin to the shaft enables the wear on the balance device to be easily monitored without dismantling.

During operation of the pump with a new balance device the wear indicator is on line. Movement of the shaft suggests wear on the balance device. It is necessary to continually observe the wear indicator. Displacement of the rotor by about 1/32 in. (1mm) necessitates a check and possibly the renewal of the balance device. If there is a lift-off device, the rotor is shifted to the discharge side by approximately 1/32 in. (1mm) in standstill position.

A significant criterion of control is provided by the pressure in the balance chamber. For particulars, please refer to subsection 4.4.

Variations in pressure, flow rate and temperature as compared with the previously measured values (always to be based on the same duty point and the same speed) suggest wear and deterioration. The balance device should then be checked.

6.6 Regulation

If the operating point of the pump is to be altered, regulation may only be effected on the discharge side of the pump or by speed variation. (Watch curve limit!)

WARNING:

DO NOT EXCEED 1.25 TIMES BEP OR OPERATE AT DISCHARGE PRESSURE BELOW 220 PSIA (15 Bar) PLUS SUCTION PRESSURE.

Never use gate valves in the suction line for regulating purposes. During regulation observe power input to driver, taking care that it does not overload. If the unit is variable speed (ie. turbine driven), the indicated maximum speed of the pump must under no circumstances be exceeded, there is danger of the suction head becoming inadequate and pump discharge ceasing. Also, the pump must not be operated at a speed were it will not generate at least 220 PSI (15 bar) differential pressure to prevent damage to the balance disk. Goulds must be informed of overspeeds e.g. for turbine over speed trip, tests, etc.

6.7 Check of Smooth Running

Care should be taken to ensure the pump runs smoothly at all times. In the case of vibration in the pump or driver, immediately determine the cause and remedy the trouble.

Alarm vibration levels: 0.25 in/sec (6mm/sec)

Shut down vibration levels: 0.4 in/sec (10mm/sec)

CAUTION: DO NOT OPERATE AN EXCESSIVELY VIBRATING PUMP.

6.8 Check in the Case of a Drop in Performance

Decrease in performance or complete failure of pump may have the following causes:

- Suction strainer clogged.
- Decreased speed of driver.
- Fall of manometric suction head (pump produces rattling sound if suction

head is too low).
- Improper assembly of pump.
- Wear of internal parts by long period of operation, or by contaminated or inadequately treated boiler feed water.

7. Disassembling and Re-Assembling

7.1 General

If the pump has been maintained and serviced carefully, breakdowns which necessitate the pump being dismantled should not occur. (see section 6 "Supervision and Maintenance").

If dismantling is required, however, the cause of the problem should be located before dismantling, if possible. When repair work or overhaul is involved, we recommend that you request the services of a Goulds engineer or send the pump to our PRO Shop for repair or rebuild to original specifications.

During pump repair all parts must be handled with greatest care.

Protect the shaft and the joint areas from damage. Since, after prolonged operating time it might be difficult to pull off the individual components from the shaft, we recommend to first employ a solvent. If this does not remedy the problem, the parts should be carefully and evenly warmed up. Avoid warming up the shaft. Place the parts on soft pads.

All parts must be carefully cleaned, checked for wear and, if necessary, reconditioned or replaced with new ones. It is imperative to check the shaft for true concentric rotation. Only genuine spare parts are to be used.

After assembly, the rotor must turn easily (by hand). Otherwise the bearings, couplings, shaft seal and wear rings may become prematurely damaged .

7.2 Disassembly

1. Uncouple driver and lock it out to prevent accidental starting.

2. Relieve pump of pressure, drain it, loosen the cooling and leakage water pipes, remove them as required. Disconnect the suction and the discharge piping and prop them.

3. When necessary, dismantle pump from bedplate, remove sheet-metal jacket and insulation mat, if any. Shaft sealing, bearings and balance device service does not require removal from bedplate.

4. Pull off coupling from pump shaft using the extractor or following warming

up to about 300 °F (150 °C).

5. Dismount bearing housings including bearings as well as stuffing box housings.

6. Unscrew shaft sleeve and pull off balance disc (if any) with extractor.

7. Remove counter-balance disc and shaft sleeve, or as the case may be, diaphragm sleeve and balance drum. The shaft sleeve or balance drum may also be removed after dismantling the discharge casing.

8. Unscrew tie bolts evenly and remove them.

9. Place supports beneath stage casings so they cannot fall down when discharge casing is being removed; dismantle discharge casing. Stage casings should be clamped together and then to the suction casing by means of clip bolts which are hooked onto the jacking ribs. This enables the discharge casing and the stage casing to be dismantled, one by one, without the other casing sections slipping out of their fits.

10. Unless already done (see point 7), dismantle shaft sleeve/balance drum; next take out over the shaft, one by one: impeller, stage casing; impeller, stage casing ... Tight fitting impellers can be easily removed if the shaft has been cooled down with dry ice and the impeller cautiously warmed up.

7.3 Assembly of Pump

The assembly is performed starting from the suction side. The same components for all the stages (the stage casings, impellers, diffusers) are numbered consecutively starting from the suction side. Attention must therefore be paid to the order of assembly.

Prior to assembly, the length "BL" of the individual stages, viz. the length of the stage casing and that of the impeller should be rechecked. Any difference in these lengths must be compensated for on the impeller hub, i.e. if the sealing faces of the stage casing are refinished, the length of the impeller hub must be machined to match the length of the stage casing after refinishing. Likewise, the width of the diffuser is to be reduced by the amount the stage casing has become shorter. Whenever possible, no more than .039 in (1mm) of metal should be removed per stage. This type of machining should be held to a minimum and only done by a highly qualified shop. Goulds PRO Shop is recommended.

Renew all O-rings.

In all cases the rotor is to be assembled and, while supporting it at the bearing points, checked for concentric rotation and balanced to ISO G.2.5. In assembling, care should be taken to ensure that the gap between the last stage impeller and the balance drum or pressure reducing shaft sleeve is set to .040 in. (1mm). The rotor must be checked for concentric rotation and then balanced. After that, take the rotor to pieces again up to (i.e. excluding) the suction shaft sleeve. Now begins the final pump assembly:

1. Stand suction casing on assembly table. For safety reasons it should be secured to table.

2. Push shaft from suction side through suction casing.

3. After inserting first key, slide first impeller onto shaft until it fits snugly against collar.

4. Measure dimension "A" on diffuser. (See Fig 8)

5. Push shaft with impeller in the axial direction until dimension B = A plus .080 in (2mm) (Fig. 8). This ensures that the discharge side impeller channel wall coincides with the discharge side diffuser channel wall. (as shown in Fig 8.)

   Measure dimension "C" and record.

6. Mount further parts in the sequence: stage casing complete with diffuser and O-ring, key, impeller etc. up to and including last stage impeller and shaft sleeve or balance drum.

   Note: When inserting the diffusers into the stage casings pay attention to the correct position of the anti-rotation pin in the hole of the guide vane.

7. Insert last stage diffuser and counter-balance disc or balance bushing into discharge casing with new O-rings, then mount discharge casing.

8. Install tie bolts, coat their threads with Molykote. Tighten nuts lightly and evenly till casings bear against each other. See that pump feet are flat and parallel to each other. Then tighten nuts firmly crosswise e.g. using a torque wrench to values shown:

	Torque	
Size	ft/lb	Nm
1½x2-6	95	130
2x2½-7	120	160
2½x3-7	120	160
3x4-8	165	225
4x5-9	200	270

9. If pump is fitted with the disc type balance device, push balance disc onto shaft and tighten it, or in the other case, tighten balance drum already in place with the discharge shaft sleeve firmly against shaft shoulder.

ONLY FOR BALANCE DISC DESIGN:

10. Shift rotor in the axial direction towards suction side until balance disc contacts the counter-balance disc.

11. Apply a ruler to the outside face of the suction casing and determine dimension "c" as under step 5. If dimension "c" is greater than that measured under point 5 (difference between the dimensions = c_1) the position of the rotor is towards the suction side. Correct position according to step 12. If dimension "c" is smaller than that measured under step 5 (difference between the dimensions = c_2), the position of the rotor is towards the discharge side. Correct it according to step 13.

12. If the measurement taken shows dimension c_1 (rotor towards the suction side), correct as follows:

    Dismount balance disc and reduce by amount c_1 the width of the disc on its inner face including the face which locates against the shaft shoulder, but not on the wear face. On size 4x5-9 take amount c_1 off the diaphragm shaft sleeve face which locates against the shaft shoulder. (See Figs. 9 + 10) Correct the length of the sleeve for the proper gap (0.40 in, 1mm) between the last stage impeller and the sleeve described in paragraph 7.3.

13. If the rotor position is towards the discharge side (dimension c_2), reduce the width of the balance disc by the amount c_2 on the wear face (see Fig. 9).

14. Assemble pump as under step 9. Check once more as described under steps 10 and 11. Dimension c must agree with dimension c as

determined by measurement under step 5.

ONLY FOR THE CASE OF BALANCE DRUM DESIGN:

10. Mount discharge side stuffing box housing (assemble stuffing box gland, deflector and insert circlip into the shaft groove. Pass spacer sleeve over the shaft and push it until it rests against the circlip. Screw on discharge side bearing housing. Insert spacer ring into the bearing housing. Put angular contact ball bearings (double-row or paired design; for paired angular contact ball bearings, arrangement as shown on section drawing) on rolling contact bearing sleeve. Mount them together on to the shaft and clamp them against the spacer sleeve by means of the bearing lock nut. Introduce spacer ring and mount non-drive side bearing cover. Between cover flange and bearing housing there should be a distance of at least the width of the gasket which is to be inserted later.

11. Apply a ruler to the outside face of the suction casing and determine dimension c as under point 5. If dimension "c" is greater than that measured under point 5 (difference between the dimensions = c_1) the position of the rotor is towards the suction side. This is always the case with new rotors, the spacer sleeve being oversized. Correct position. according to step 12. If dimension c is smaller than that measured under step 5 (difference between the dimensions = c_2), the position of the rotor is towards the discharge side. Correct it according to step 13.

12. If the measurement taken shows dimension c_1 (rotor position towards suction end), correct as follows:

    Remove rolling contact bearing with its sleeve and spacer sleeve. Reduce the length of the spacer sleeve on the face which locates against the rolling contact bearing by the measured difference c_1. (See Fig. 11).

13. If the rotor position is towards the discharge side (dimension c_2), a spacer sleeve longer by the measured difference c_2 is required or a corresponding shim between spacer sleeve and rolling contact bearing. (See Fig. 11).

FOR ROLLER BEARING DESIGN:

15. Screw on stuffing box housings, fit stuffing box glands loosely.

16. Fit deflectors, circlips and spacer rings on the shaft. Screw on bearing housing with the felt rings or radial joint rings inserted.

17. Mount rolling contact bearings, tighten shaft nuts and prevent them against loosening by means of lock-washers.

18. With grease lubrication: Mount bearing cover with felt ring and non-drive side bearing cover, each with a gasket, such that the flange comes to bear against the bearing housing and the outer ring of the roller bearing is clamped by the cover.

FOR SLEEVE BEARINGS:

15. Fit suction and discharge side stuffing box housings.

16. Pass stuffing box gland and deflectors over the shaft. Bolt on lower bearing housing half.

17. Insert bearing shells, labyrinth rings, and lubricating rings (if any). Bolt on upper bearing housing half.

18. Mount bearing cover, complete assembly of pump.

19. After assembly of the pump the rotor must be capable of being turned easily by hand and shifted by .071 to .138 in. (1.8 to 3.5 mm) maximum in the axial direction towards the discharge side (not in the case of balancing by means of a drum).

20. Place pump on bedplate and proceed as described in section 3.

7.4 Optional Lift-Off Device

IF THE RADIAL BEARINGS ARE ROLLER TYPE:

On the discharge side, contrary to sub-section 7.3 point 17, after putting in place the rolling contact bearing, screw on the intermediate ring including the gasket and insure it clamps the outer ring of the roller bearing. (see sub-section 7.3, point 18). Fasten the thrust bearing housing to the intermediate ring. Slip spacer sleeve over the shaft until it comes to bear against the inner ring of the radial roller bearing.

Adjustment in relation to the balance device:

Push rotor towards the suction side until the balance disc contacts the counter-balance disc. Determine dimension y (See Fig. 12). Dimension y reduced by dimension a (Table below Fig. 12) gives the required dimension x at the bearing carrier. Brand-new bearing carriers must be corrected to the required dimension x by re-machining the face where the springs push. For used parts the correction must be carried out by means of shiming between the thrust bearing of the lift-off device and the thrust bearing collar or, by placing shims of corresponding thickness between the thrust bearing housing and the springs or, by shortening the spacer sleeve.

Thickness of shiming or reduction in length of spacer sleeve = required dimension x - actual dimension x.

Shiming or Length Reduction = required x - actual x

Insert springs, place rolling contact bearing into bearing carrier and put both parts together on to the shaft and fasten them to the rotor by means of the bearing lock nut. Tighten lock nut. Mount non-drive side bearing cover. Now the rotor position must be shifted .040 in. (1mm) to the discharge side by the springs. If the shift deviates from the required dimension of .040 in. (1mm), correct at the non-drive side bearing cover as follows:

Actual dimension <.040 in. (1mm):	re-machining the surface towards the bearing collar
Actual dimension >.040 in. (1mm):	re-machining the surface towards the thrust bearing housing

IF THE RADIAL BEARINGS ARE OF THE SLEEVE BEARING TYPE:

Pump has been assembled as described in sub-section 7.3 up to and including point 17. Fit circlip to the shaft and screw on thrust bearing housing. Slip spacer sleeve over the shaft until it rests against the circlip.

Adjustment in relation to the balance device:

Same procedure as described under "IF THE RADIAL BEARINGS ARE OF THE ROLLER TYPE".

After completion of these operations check whether it is possible to rotate the shaft easily by hand. Thereafter the pump can be placed on the bedplate and mounted as described under 3, "ERECTING THE PUMP".

8. Spare Parts

When ordering spares, always state type, Goulds serial No., the year of manufacture, and indicate the item No. for the relevant sectional drawing. It is an imperative for service reliability to have a sufficient stock of readily available spares. It is advisable to keep on hand, in addition to a complete spare rotor, a few other wearable parts including:

(Depending on Pump Design:)

Balance disc
Counter-balance disc
Balance drum
Pressure reducing shaft sleeve for the balance device (i.e. the sleeve opposite the diaphragm bush, or the counter-balance disc, in discharge casing)
Shaft sleeves, suction and discharge side
Wear rings
Diffuser wear rings (if supplied)
Balance bushing in the discharge casing (for balance drum)
Rolling contact bearings
Sleeve bearings
O-rings
Felt seals
Radial shaft seal rings
Labyrinth rings
Packing or Mechanical seals

9. Drawings

9.1 Sectional drawing

9.2 List of components

9.3 List of connections

9.4 Outline drawing

The sectional drawing applying to each particular order is stated in the acknowledgement of order.

List of components and list of connections are matched to the sectional drawing.

The outline drawing will be prepared whenever an order is placed.

10. **Figures**

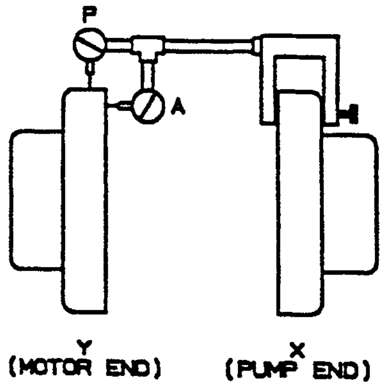


Figure 3

Tapered strainer

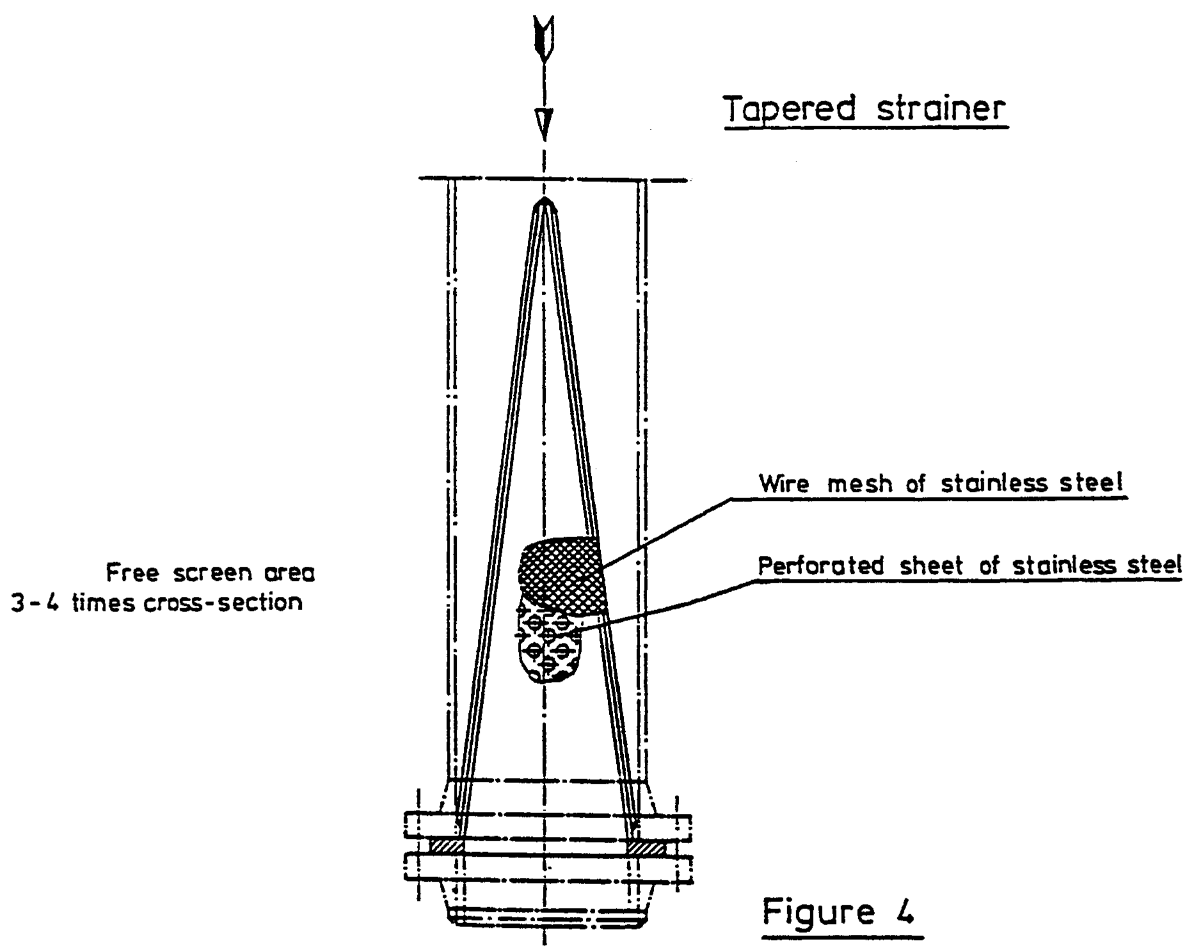


Figure 4

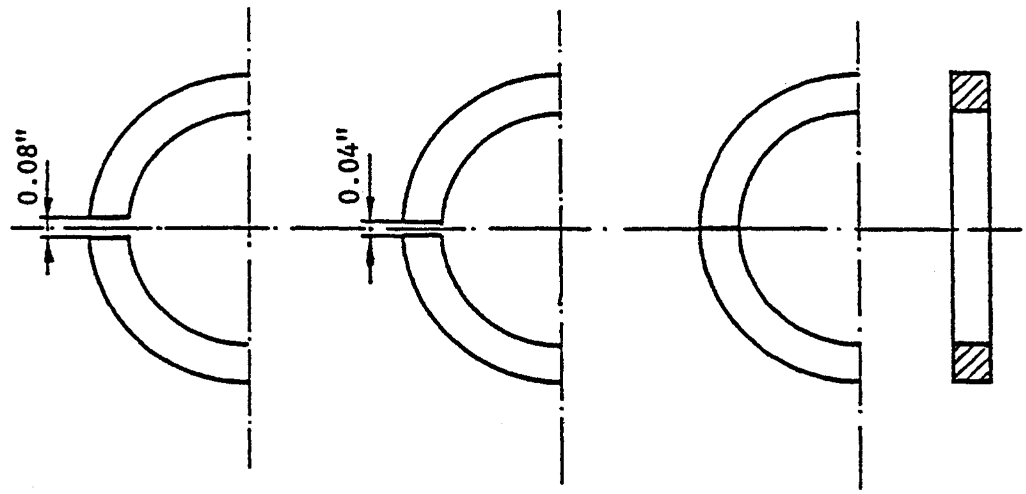


Figure 5

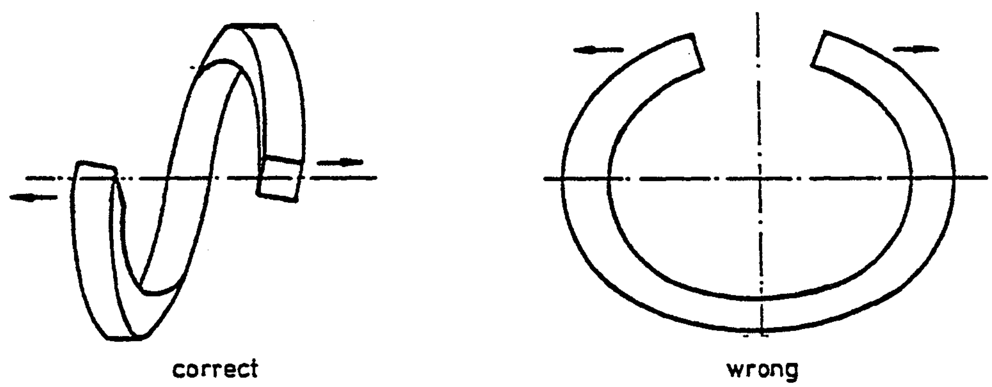


Figure 6

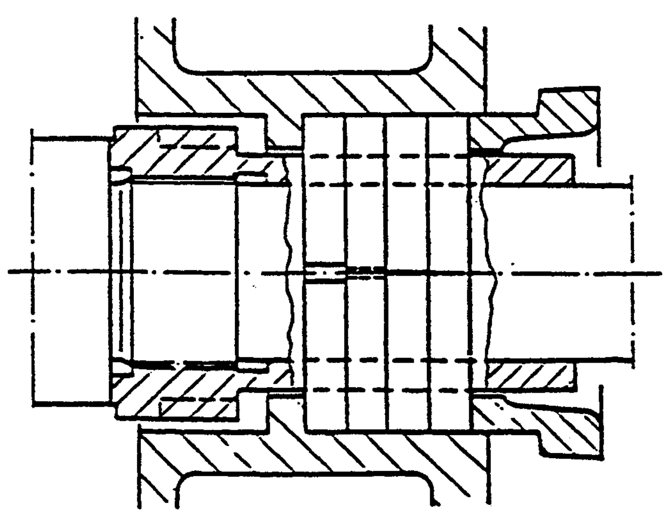


Figure 7

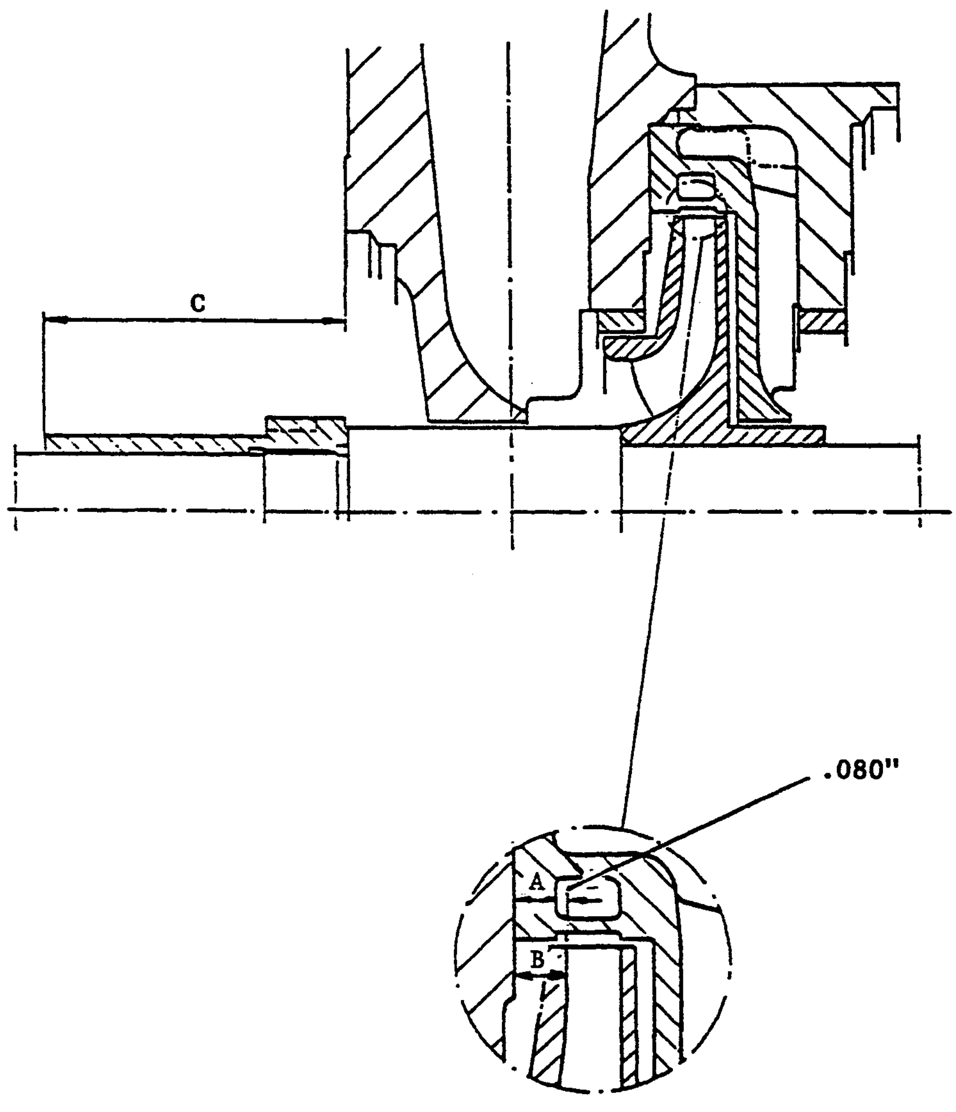


Figure 8

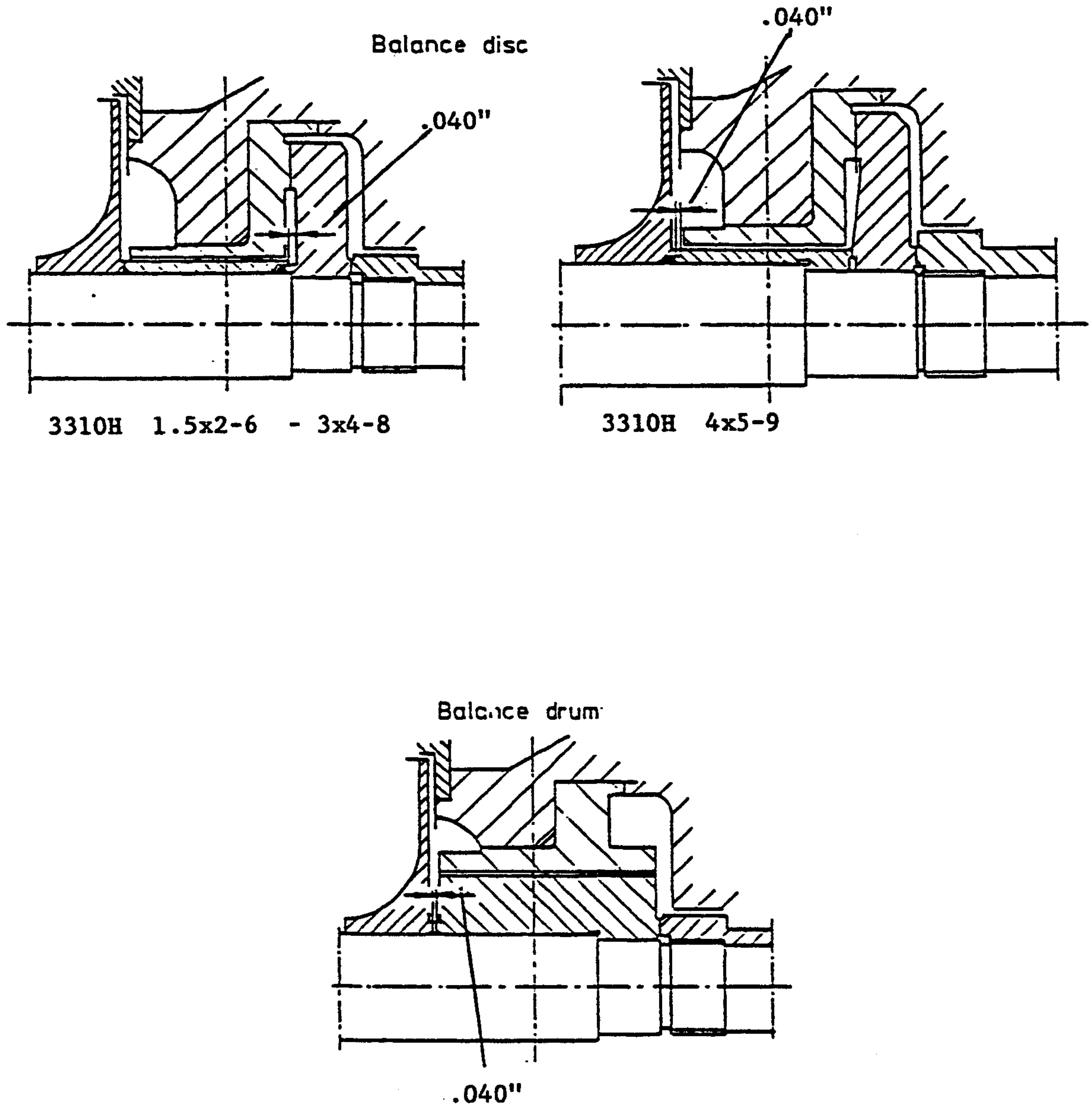
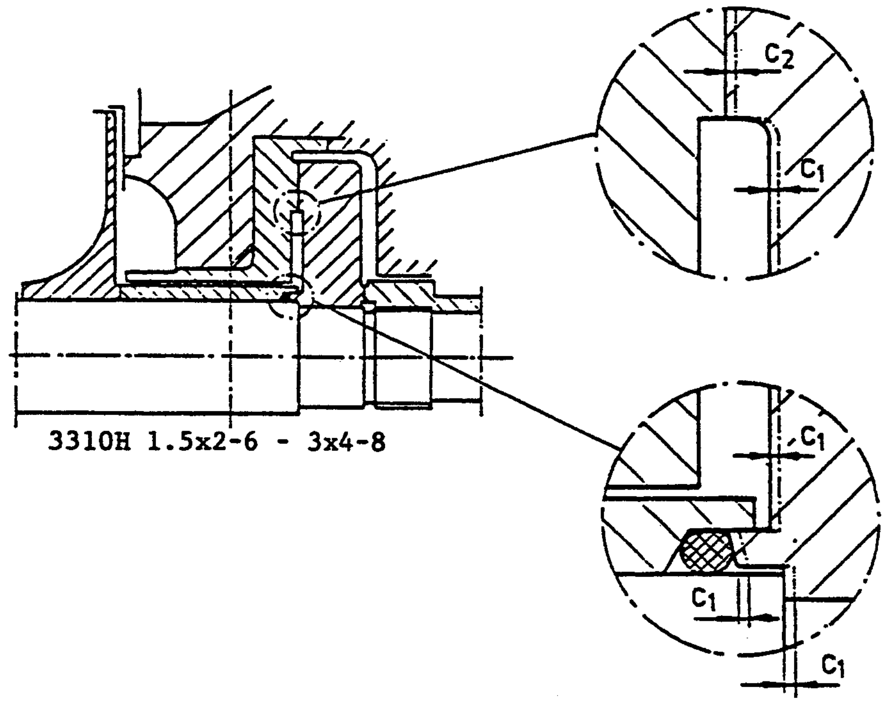
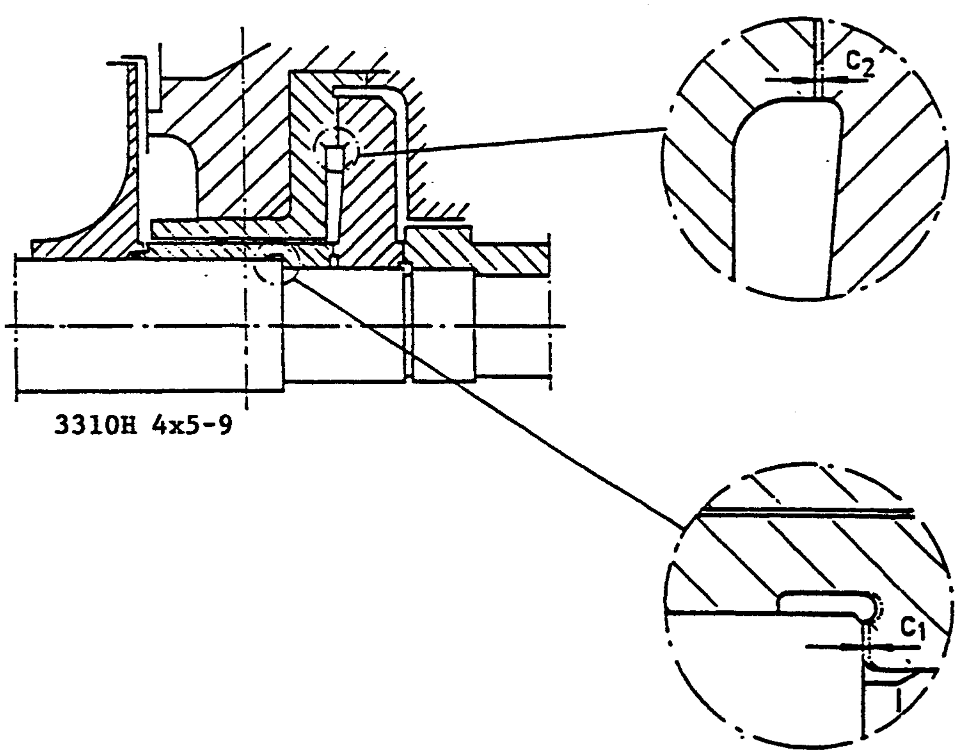

Balance disc
.040"
.040"
3310H 1.5x2-6 - 3x4-8
3310H 4x5-9
Balance drum
.040"

Figure 9



3310H 1.5x2-6 - 3x4-8



3310H 4x5-9

Figure 10

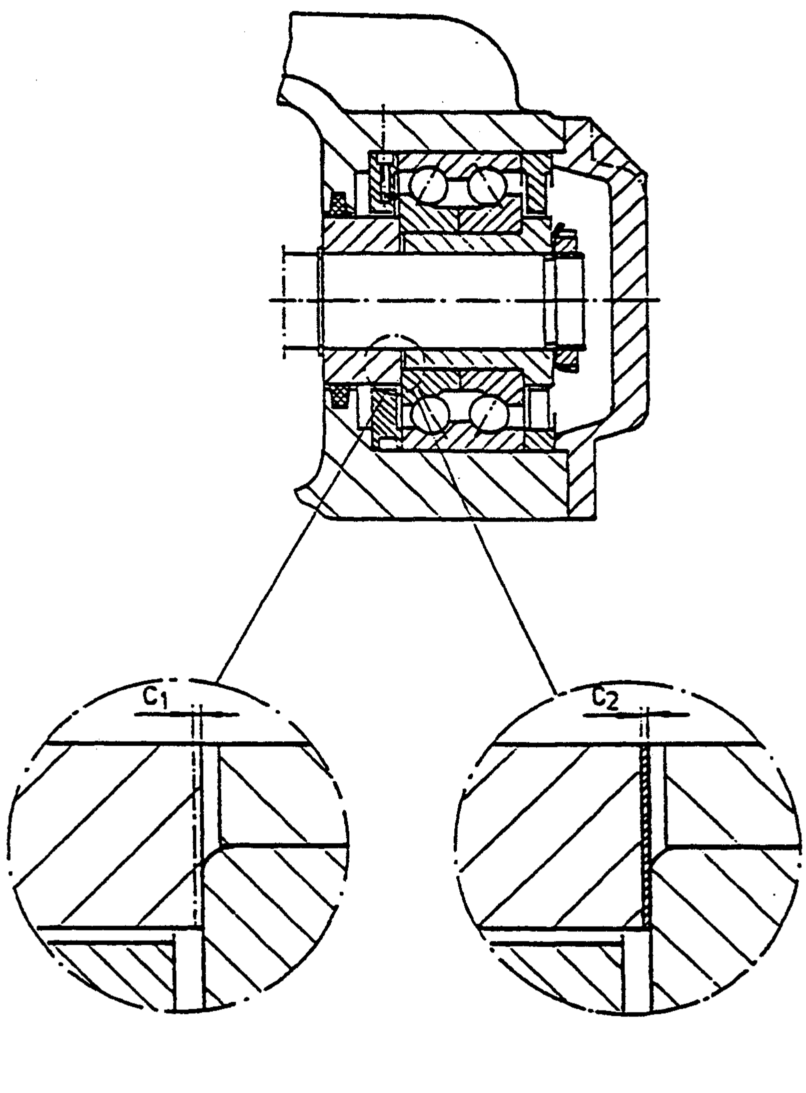
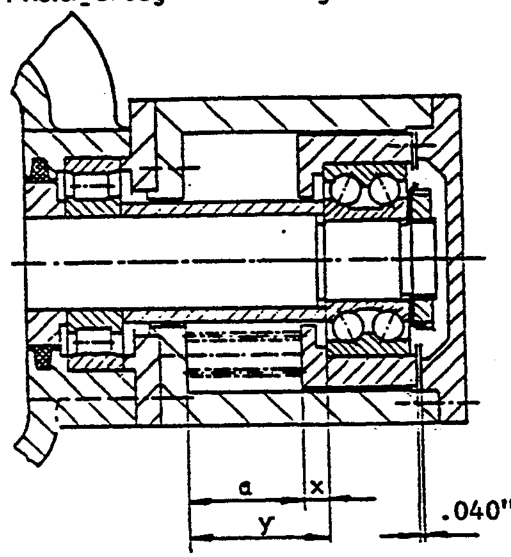


Figure 11

View: Rotor brought to bear against the balance device

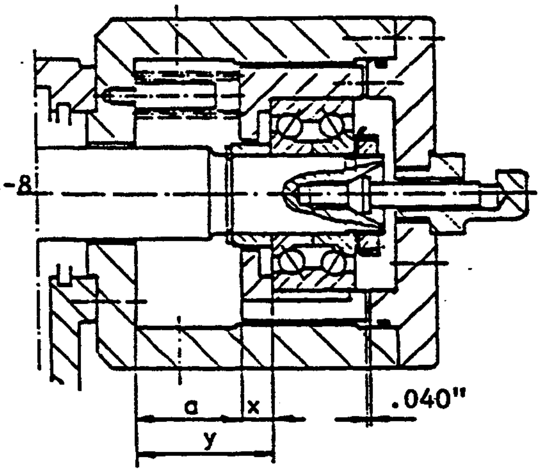


Model 3310H	Dimension A	
Pump Size	Inches	mm
1.5x2-6	1.555	39.5
2x2.5-7	1.476	37.5
2.5x3-7	1.535	39.0
3x4-8	1.476	37.5
4x5-9	1.496	38.0

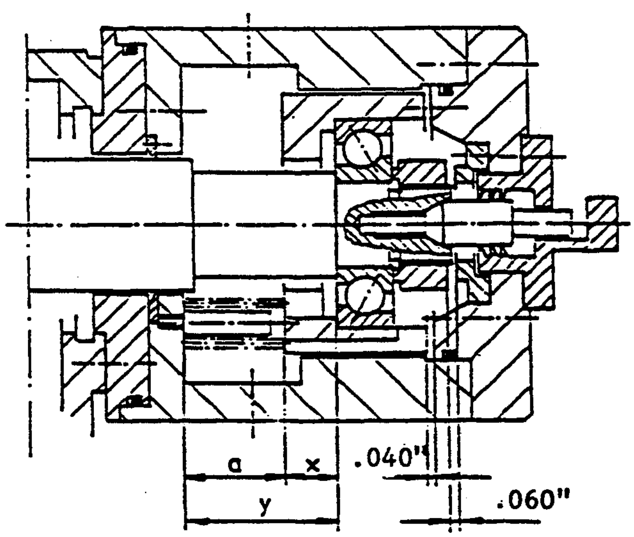
FIGURE 12

View: Rotor brought to bear against the balance device

3310H 1.5x2-6 - 3x4-8



3310H 4x5-9



Model 3310H	Dimension A	
Pump Size	Inches	mm
1.5x2-6	1.555	39.5
2x2.5-7	1.476	37.5
2.5x3-7	1.535	39.0
3x4-8	1.476	37.5
4x5-9	1.496	38.0

FIGURE 13