module title — PUMPS
module number — P2 011 2

TTE TRAINING LIMITED
MECHANICAL DEPARTMENT

POSITIVE DISPLACEMENT PUMPS

INTRODUCTION

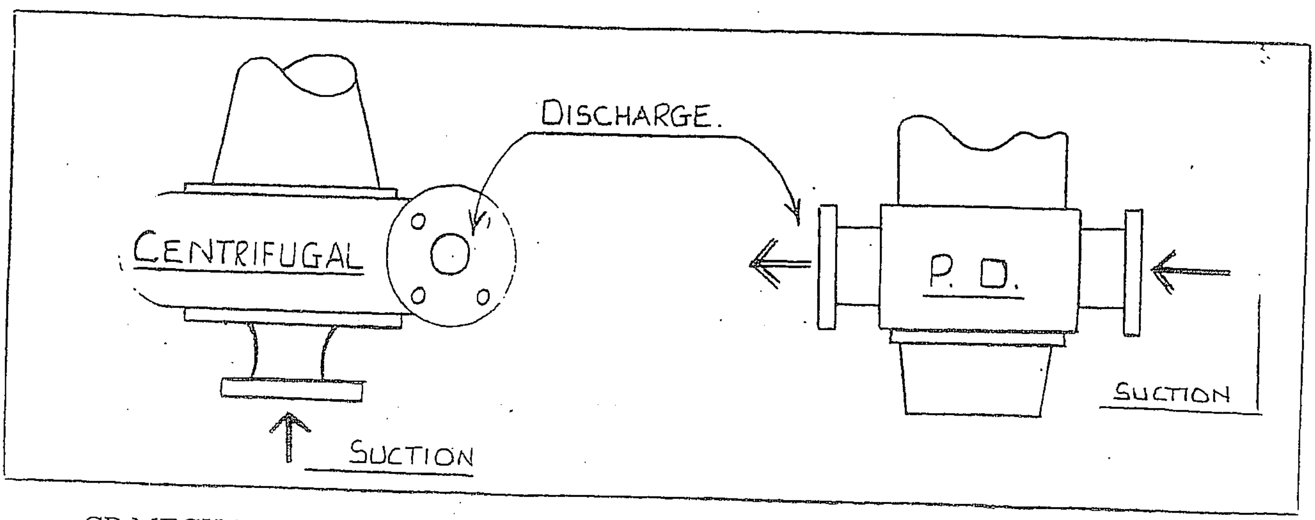
The correct preparation of the chemical solution is of vital importance. Not only must components of the solution be added in the correct proportions but they must also be well mixed so as to give uniform strength throughout. Because we cannot always rely on gravity to drop chemicals into reactors and mixing vessels, we need some other means of transferring chemicals around the plants.

For handling solids; fans, screw feeds and conveyers are generally used, for gases; compressors and fans and for fluids and solids in suspension, pumps are the conventional means of transfer. The two main types of pumps to be found on our plants are:-

CENTRIFUGAL PUMPS
POSITIVE DISPLACEMENT PUMPS (P D)

Whilst both types of pumps are very efficient and have their own individual advantages, they have distinct differences in their pumping actions. All centrifugal pumps work on the same principle that is using an impeller to create a centrifugal force inside the volute casing, which forces the product out through the discharge pipe work. Although very efficient, this type of pumping action creates a lot of turbulence, which is not always suitable for chemical reactions.

A P D pump however has a much more steady and controlled pumping action. Instead of entering through the front of the pump and leaving at 90° through the side, the product usually passes through a P D pump in a straight flow and at a controlled rate. The difference between the two types of pumps can be seen in Fig. 1.



PUMPING PRINCIPLE

Before looking at individual working principles of P D pumps of different types, let us first look at the basic principle they all adhere to. If we look at the example of spectators entering a football ground through a turnstile; only one person may pass through at any one time, the turnstile holding the rest back until he has paid his entrance fee and passed through. The turnstile not only counts spectators in, but acts like a non-return valve, allowing nobody to pass back out again. So the spectators enter into the paddock at a steady flow, the same amount each time passing through.

If, as in Figure 2, the paddock has a limit of 5000 spectators, then when this amount has entered, the turnstile should be closed, even if it means leaving another 1500 outside. Even if this extra amount could fit in, the paddock would become too tightly packed and unsafe, possibly resulting in an accident.

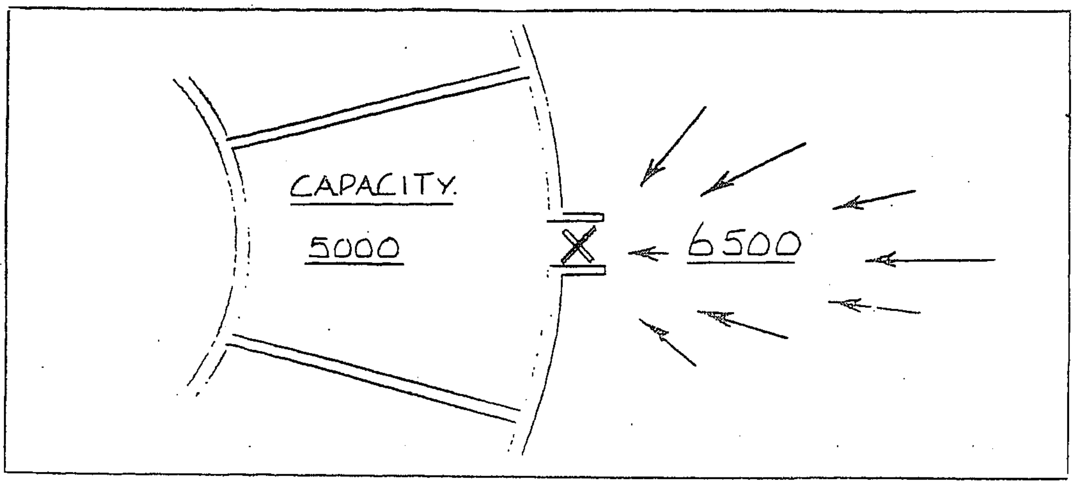


Figure 2.

If, as sometimes happens, the game starts before all the spectators are in, there is an immediate surge forward to try to gain access a little quicker, but as the flow of spectators is governed by the turnstile, which will only allow one person at a time, the rate of entry remains the same. The only way to speed things up would be to increase the speed of the turnstile.

This is basically how a P D pump operates, by allowing the same amount of product through each time at a set rate. The rate of flow may be increased by increasing the speed of the pump. The pumping action is achieved by allowing the pumping chamber to fill with product and displacing this product out through the discharge side. This can be done by using various techniques such as rotary lobes or reciprocating pistons etc., (this will be covered with individual pumps) so ensuring the same amount of product is passed through each time. A much more gentle action is used in pumping the chemicals through a P D pump, loading to a lot less turbulence and churning of our product.

Each individual pump has its own way of stopping the product passing back into the suction, some use non-return valves, others use small clearances around the pumping parts. In each case the result is the same as the turnstile, the product can only flow in one direction.

P D Pumps have no respect for vessel capacities, blocked pipe work or even wrongly shut valves. As in the case of the over packed paddock at the football match, a P D pump will continue to pass product through until a dangerously high pressure is reached. The result will be, if not checked, that the weakest part of the system will rupture. To ensure this cannot happen, all P D pumps should be fitted with a relief system. Some pumps have them fitted as an integral part of the body; if this is not the case then a relief line and valve should be fitted as shown in Figure 3.

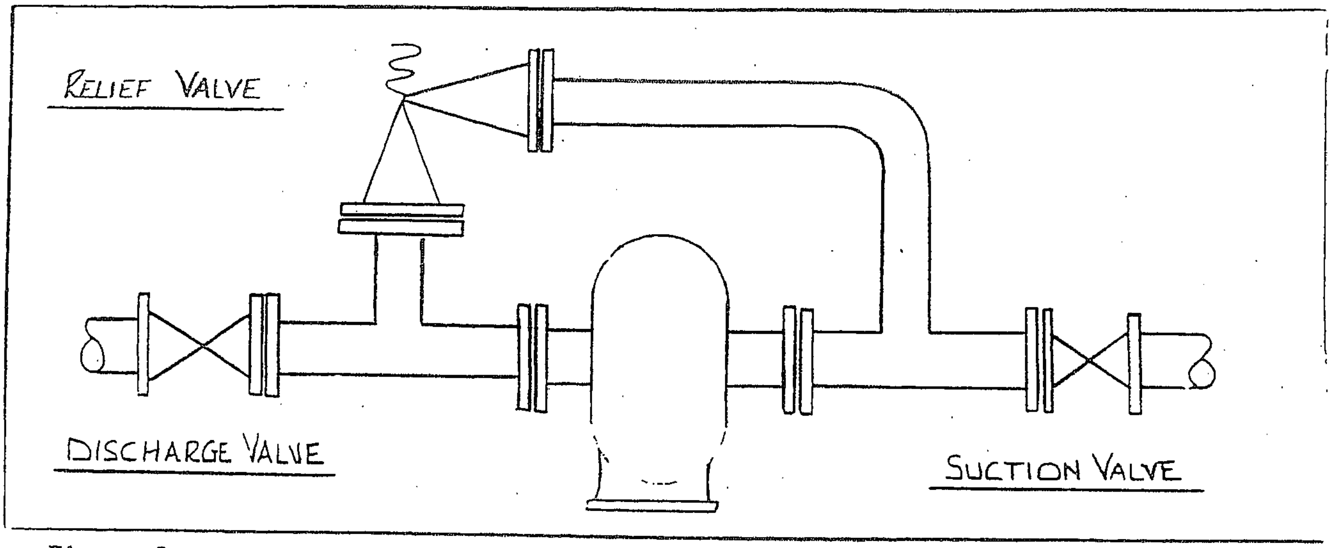
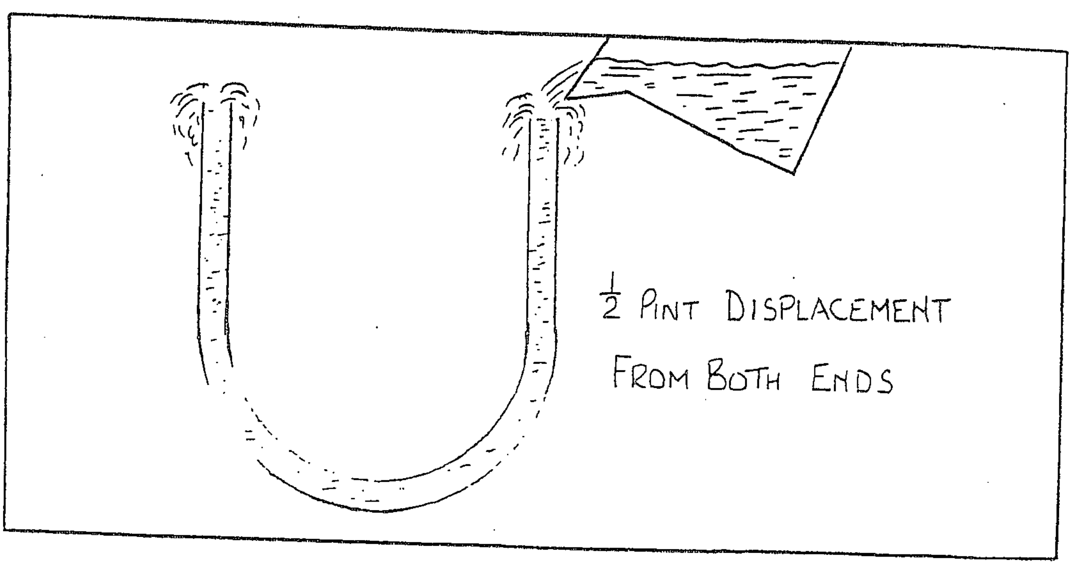


Figure 3

Whichever method is used, the result is the same, product is relieved from the delivery side back into the suction. To look at basic principles of positive displacement we can see in Figure 4 a glass "U" tube, filled to the brim with water. If we carefully add another ½ pint of water to this, we will displace a ½ pint of water from the tube, usually out of both sides. So what was poured in came back out.



Figur

If we could fit a non-return valve to the inlet of our "U" tube, as in Figure 5, and pour in ½ pint of water, although we would still displace a ½ pint of water from the tube, it would be a controlled flow out of the open end. This is basically how a P D pump operates, and is shown in Figure 5.

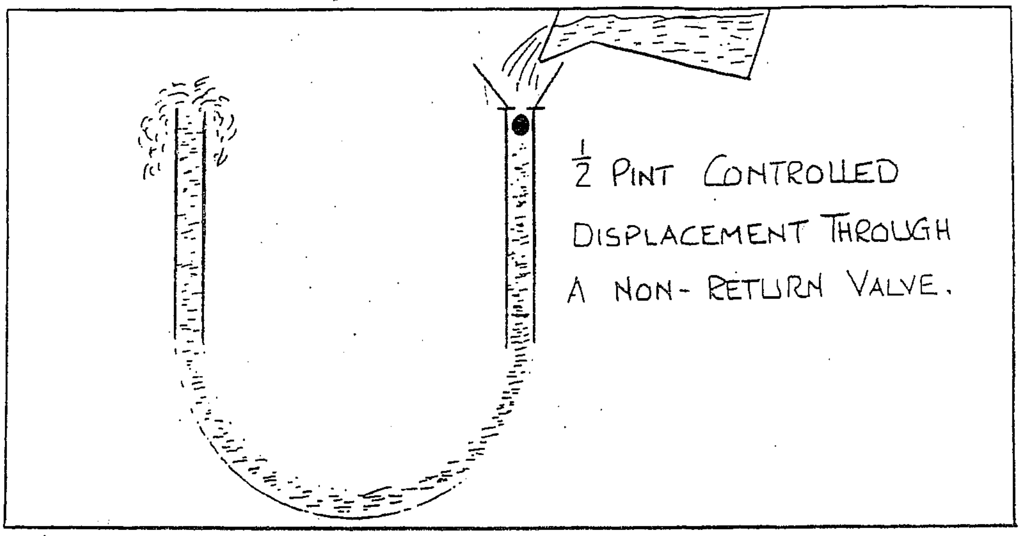


Figure 5

The advantages of using a P D pump are:-

(a) The fluid is pushed through the pump rather than whirled by an impeller.

(b) The flow is roughly proportional to the speed. (The discrepancy arises from slippage within the pump which in turn is dependent on pressure and viscosity.)

(c) They can handle fluids with a wide range of viscosities.

(d) They normally operate at low speeds.

The disadvantages are:-

(a) The nature of flow can be pulsating, which may give rise to piping vibration, waterhammer and noise.

(b) A built in relief valve or a bypass is essential, otherwise severe damage will result when operating against a blocked pipe or closed discharge valve.

POSITIVE DISPLACEMENT PUMPS

Positive Displacement pumps can be divided into the following types:

(a) ROTARY

(b) RECIPROCATING

(c) PERISTALTIC

ROTARY P D PUMPS

The rotary P D pumps employ rotors or similar impelling devices (screws, lobes, gears or vanes) that rotate within a casing with close clearances (radially and axially) to minimize slippage.

The basic types of ROTARY PUMPS are:

(a) SCREW PUMPS

(b) GEAR AND LOBE TYPE PUMPS

(c) VANE TYPE PUMPS

(d) ROTARY PISTON TYPE

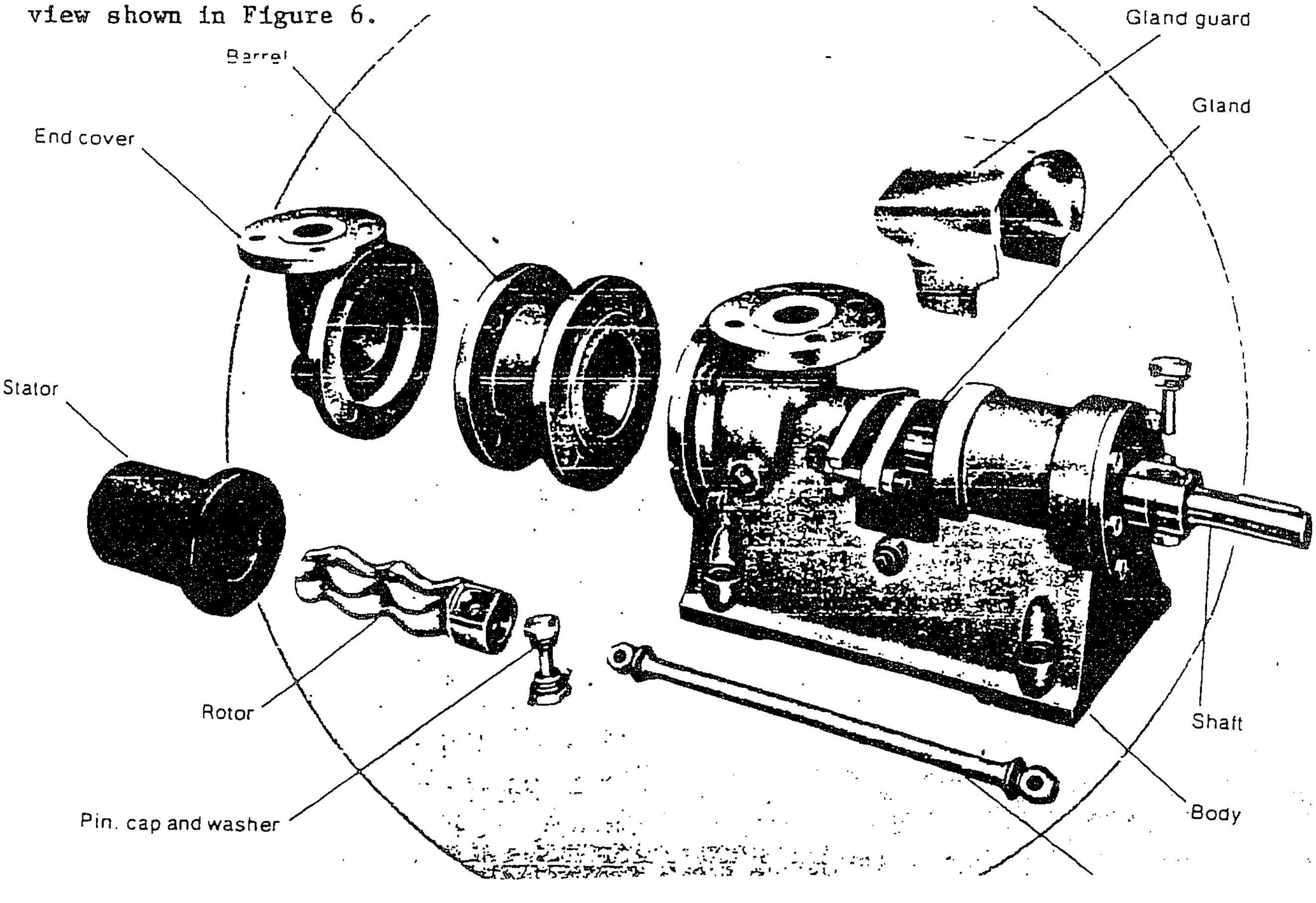
(a) SCREW PUMPS

All screw pumps consist of one or more screws which rotate in a casing and are broadly split into single, twin and triple screw designs. They all have the P D characteristics with constant flow at constant speed. Generated head is only limited by the power available and the mechanical strength of the unit.

SINGLE SCREW

The most common single screw pump in general use is the MONO PUMP. The pump consists of a single rounded profile screw or rotor which rotates in a generally flexible stator. The rotor extends through a gland and bearing at the suction end to form the drive shaft.

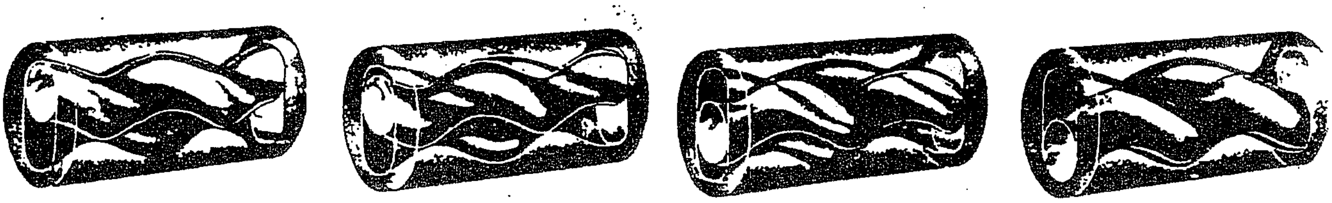
The main components of a standard Mono pump can be seen in the exploded view shown in Figure 6.



PUMPING PRINCIPLE

The main pumping elements consist essentially of a resilient stator (usually rubber) in the form of a double internal helix, and a single helical rotor which rotates within the stator with a slightly eccentric motion. The rotor is of constant circular cross section, the centres of the sections forming a helix which is eccentric to the rotor axis. The pitch of the stator is twice that of the rotor and the two engage in such a fashion that the rotor section traverse the stator aperture. The rotor maintains a positive seal along the length of the stator, and this seal progresses continuously through the pump, giving uniform positive displacement.

The illustration shows four consecutive positions of the rotor as it makes one half turn (shown by arrow in the stator). Th progressive passage formed by the engagement of the rotor and stator helixes, and the combined axial and rotational thrust of the rotor scroll through the stator will be seen.



APPLICATIONS

This type of pump is made to British Standard Metric specifications and are designated as M D or M H range models. Examples of these can be seen in Figure 7.

Examples of MD & MH range construction

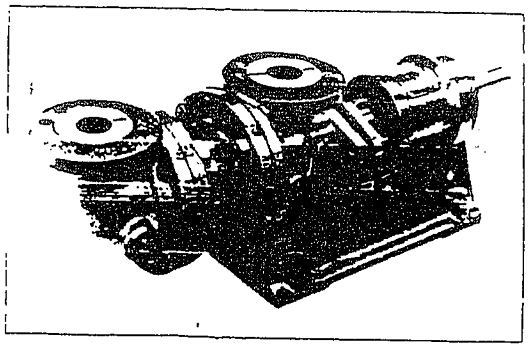


Fig 1 Typical of MD30, MD40, MD60, MD70, MD80

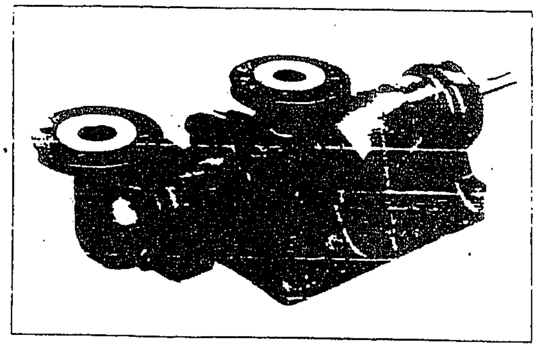
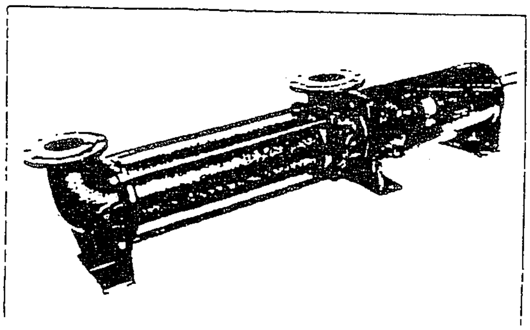
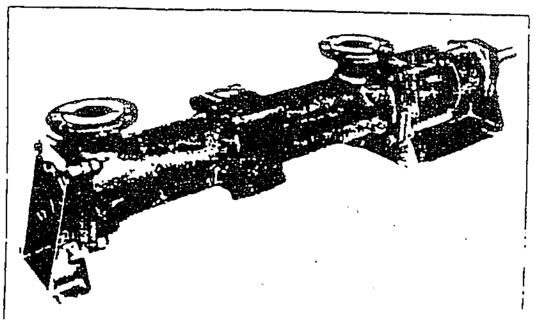


Fig 2 Typical of MH30, MH40, MH60





The M O and M W range of pumps are used for a wide variety of pumping and transfer duties. They are efficient at handling anything from abrasive slurries, aggressive or reactive chemicals to viscous liquids, oils or suspensions at high temperatures.

They will also gently transfer delicate and shear sensitive products such as latex, thixotropic products and solids in suspension with minimum agitation and aeration.

M D RANGE

Among a wide variety of applications M D pumps are to be found pumping highly abrasive slurries such as water containing granite chips and other similarly demanding duties such as de-watering sand; whilst in the paper manufacturing industry, these versatile pumps are used to transfer starch slurry at temperatures up to 95^{o}C. Other typical applications include the pumping of detergents, farm wastes and tannery effluent sludges.

M H RANGE

Constructed with stainless steel product contact parts, M H pumps are used wherever extended resistance to corrosive duty conditions is required, or in the pre-production transfer of food-stuffs. These pumps fulfil a wide range of duties from the pumping of gels and creams in the pharmaceutical industry, to the transfer of synthetic fibres. M H pumps are also widely used for bulk handling of fruit pulps and peel, sugar solutions, and in the brewing industry, for the pumping of beer and priming sugar.

We can see from this the wide variety of pumping duties these pumps will handle, from extremely abrasive products (containing chips of granite) to a variety of duties in the food industry, where in some cases they are used to transfer Baked Beans and whole fish without damage.

In the table below can be seen the standard materials available for Rotors and Stators. The best combination of these may be chosen in conjunction with M D or M H pumps to suit operating conditions of temperature corrosion and abrasion, for the majority of applications. If in any doubt about the compatibility of Rotor, Stator and product, the manufacturer should be consulted.

Stator materials	
resilient:	Natural rubber Nitrile rubber Hypalon* Urethane Viton*
non-resilient:	Cast iron Ferobestos Tufnol

* Dupont Ltd. materials

Rotating parts materials: (Designations in accordance with British Standard 970)	
905 M31R 220 MO7	Nitralloy rotor and hard chrome plated mild steel shaft
316 S16 220 MO7	Hard chrome plated stainless steel rotor and hard chrome plated mild steel shaft
BS4659. BD3 220 MO7	Tool steel, hard chrome plated rotor and hard chrome plated mild steel shaft
316 S16	Stainless steel rotor and shaft (unplated)
316 S16 316 S16	Hard chrome plated stainless steel rotor and hard chrome plated stainless steel shaft

PUMP OPERATION

The pump must never be run dry, even for a few revolutions or the stator will be immediately damaged. Pumps must be filled with liquid before running. Filling plugs are provided for this purpose. This initial filling is not for priming purposes, as these pumps are self priming, but to provide the necessary lubrication of the stator until the pump primes itself.

The pump normally retains sufficient liquid to provide start up lubrication, but if it has been standing for sometime, moved to a new location or dismantled for maintenance, it must be filled with liquid and given a few turns by hand before starting.

The pump is normally somewhat stiff to turn by hand on account of the close fit of the rubber stator, but this stiffness disappears when the pump is running against pressure.

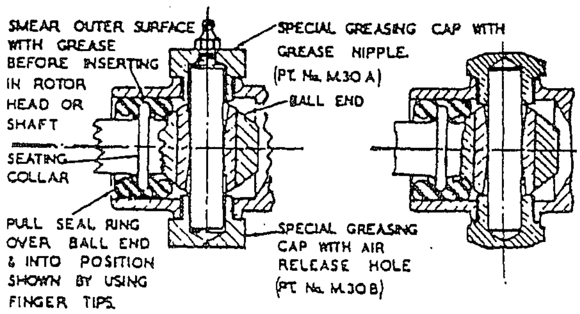
ROTATION

Pumps are normally arranged for counter-clockwise rotation (facing the driving end) which results in the branch nearer the driving end being the suction. They can run in the other direction if required, essential where there should be no risk of aeration. If this is the case then any relief system should be altered to be compatible with the new direction of flow. Also in some cases it may be necessary to reverse the Barrel, Barrel gasket and stator.

DRIVE

The drive for the "Rotor" is transmitted to the hollow pump shaft, by means of a coupling rod, connected by two universal joints and protected by rubber seal rings to prevent solids reaching the pins. Details of this can be seen in Figure 8.

Greasing assembly for D70, D72 and D80 Pumps



Operating assembly for D70, D72 and D80 Pumps

FIG 8

Apart from the portion of the shaft which rotates inside the stuffing box, these components of the pump will experience a lot of work and may wear. Usually these parts are small and inexpensive.

It is recommended that the rubber rings are not stretched, or fitted with the aid of tools, also they should not be lubricated before fitting to the coupling rod. The outer surface of the ring can be lubricated after fitting to the coupling rod, to ease the assembly of the pump.

These rings can fail and allow product to pass through the hollow shaft. It is therefore possible to find product leaking from the coupling guard.

MAINTENANCE

In normal running conditions, there is little to go wrong with these pumps, the main components experiencing wear being:-

(a) RUBBER STATOR

(b) UNIVERSAL JOINTS

(c) HOLLOW SHAFT (SEALING AREA)

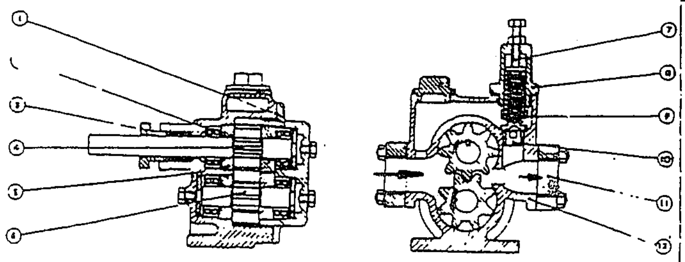
(d) GLAND PACKING

The bearings, provided they are correctly lubricated, should give a normal running life, providing any gland leakage is attended too quickly and not allowed to splash into the bearing cap.

(b) GEAR AND LOBE TYPE PUMPS

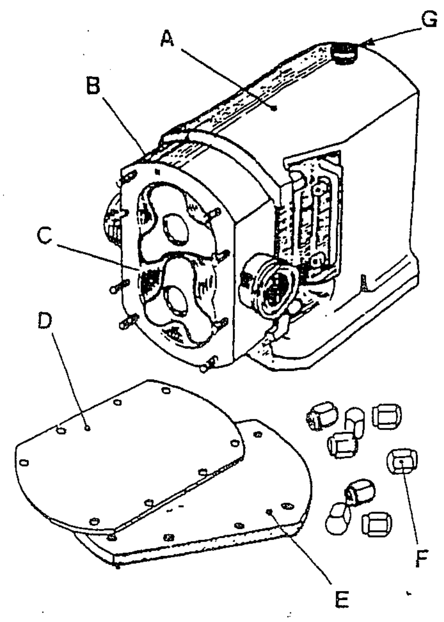
These pumps consist of two gears (or lobes) intermeshing and rotating in opposite directions to each other. The driving gear can drive the idler gear either directly or via an external timing gearbox. Use of either drive depends on the nature of the fluid being pumped (i.e. if lubricant and clean, use the former, if not, or the fluid contains limited amounts of solids in suspension, then the externally timed gears must be used).

Examples of geared and lobed pumps can be seen in Figure 1.



1. Back cover.
2. Ball bearings.
3. Gland.
4. Driving spindle and gear.
5. Distance pieces.
6. Driven spindle and gear.
7. Adjusting screw.
8. Spring box.
9. Spring.
10. Relief valve.
11. Delivery flange.
12. Pump body.

GEAR TYPE PUMP



A - Gear housing

B - Rotor case

C - Rotors

D - PTFE (Teflon) cover jo

E - Front cover (std)

F - Dome nuts

G - Oil filler plug

IMPORTANT!

DO NOT FORGET TO FILL OIL GEAR HOUSING BEFORE STARTI!

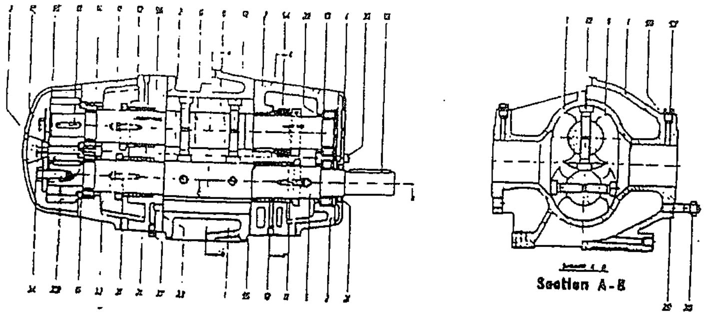
Figure 1

On lobe pumps, the number of lobes can vary to suit the duty. Generally the dirtier the fluid (heavy slurries) the fewer is the number of lobes.

Like all P D pumps, rotary lobe and gear pumps require a relief valve. This is usually an integral part of the pump.

The number of glands can vary from one to four, depending on the type of pump and the fluid handled. This can be in the form of a packed gland, or mechanical seals, again depending on the duty for which the pump is to be used on.

An example of this can be seen in Figure 2, which shows a LEDERLE PUMP of the KRM, KRM range, ROTARY LOBE TYPE.



Sectional Drawing and Spare Parts List

Model KR Rotary Piston Pump

1 Casing
2 Bearing support
3 Gear box
4 End plate
5 Drive shaft
6 Driven shaft
9 Lobed cam
10 Lobe screw
11 Stuffing box
12 Sealing liquid ring
13 Cyl. roller bearing
14 Grooved ball bearing
15 Int. circlip
16 Gear wheel
17 Gear wheel lock plate
18 Gear wheel fitting key
19 Coupling fitting key
20 Seal
21 Splash ring
23 Seal
24 Packing ring
25 Forced lubricating point
26 Cover cap
27 Stud bolt
28 Hex. nut
29 Stud bolt
30 Hex. nut
31 Stud bolt
32 Hex. nut
33 Hex. screw
34 Hex. socket head screw
35 Hex. socket head screw
37 Screw plug
38 Seal
40 End plug
41 Core plug
42 Knee
43 Nipple

Models with mechanical seal

54 Mechanical seal
54a Sleeve (start)
54b Seal ring
54c Seal ring casing
54d O-ring
54e Springs
54f Lock ring
54g Grooved dowel pin
54h Hex. nut
54i Hex. socket head screw

Vacuum design

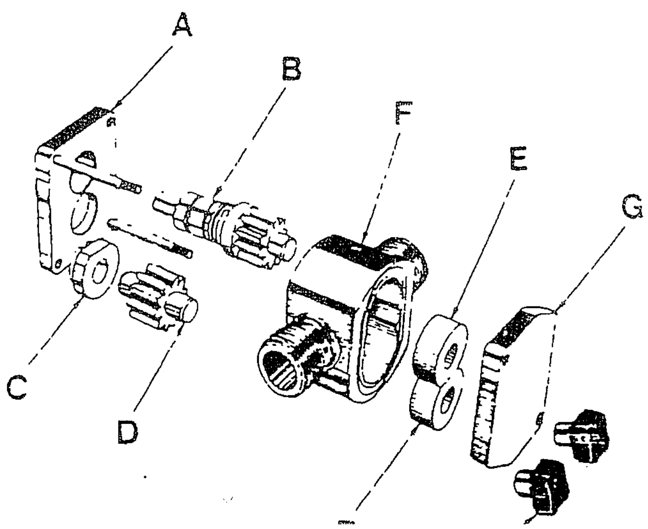
55 Combination seal
55a Seal ring
55b Seal
55c O-ring
55d Disk spring
55e Cyl. pin
56 Pocket ring seal
56a Nut ring
56b Supporting ring
56c Disk spring

Figure 2

These pumps make use of a double, back to back mechanical seal, mounted on sleeves to protect the shaft. The seal assembly can be pressure tested in the housing, prior to being fitted onto the pump. In this way it can be seen if there are any leaks on either the front or back seals.

Other types of Rotary Lobe pumps found in industry are:

STAINLESS STEEL PUMPS
and
IBEX PUMPS



A - Back plate
B - Drive shaft assembly
C - Rear bush (lay shaft)
D - Lay shaft
E - Front bushes
F - Body
G - Front cover
H - Hand nuts

Another type of P D Rotary Lobe Pump is made by the STOTHERT & PITT Company, where one rotor, the male, is keyed to the shaft, whilst the female rotor is supported by the pump body and surrounds the male, or inner rotor. There are two types, one for HIGH VISCOSITY FLUIDS, called the SEVEN EIGHT TYPE.

THREE FOUR TYPE

This refers to the number of lobes on each rotor:-

THREE ON THE INNER AND FOUR ON THE OUTER

An example of the THREE FOUR TYPE can be seen in Figure 3, along with the main parts and working principles.

SEVEN EIGHT TYPE

This again refers to the number of lobes on each rotor:

SEVEN ON THE INNER AND EIGHT ON THE OUTER

An example of the SEVEN EIGHT TYPE can be seen in Figure 4, along with the main parts and working principles.

INSTALLATION AND OPERATION

Piping to and from the pump must be thoroughly clean before use as any abrasive or hard particles which enter the pump will cause severe damage. Sharp bends and sudden changes in pipe diameters should be avoided, also the pipe work should be adequately supported.

Some pumps are fitted with heating or cooling jackets, if this is the case, the feed to the jacket should be opened prior to starting the pump and allowed sufficient time to reach the desired temperature before starting the pump.

PUMP START UP

Prior to start-up the following points must be observed:

(a) Check lubrication as well as sealing liquid pressure.

(b) Prime the pump with a small volume of liquid to be pumped as the pump is not self-priming when dry.

(c) All pump shut off valves in the suction and delivery lines must be open.

(d) Check temperature of pumps provided with heating jackets.

FIG. 3

THREE-FOUR TYPE FOR HIGH VISCOSITY FLUIDS

The principal parts of the Pump are Body, Body Liner, Gland and Inspection Covers, Inner Rotor keyed to shaft and Outer Rotor.

The Inner Rotor is held in position by its bearings in the Pump Covers, whilst the Outer Rotor is supported by the Pump Body and Covers. The centres of the two Rotors are eccentric one to the other.

Figs. A, B, C and D illustrate the Rotors in sequence of positions during one revolution. Reference to Fig. A shows the lobe 1 of the Inner Rotor completely filling a recess of the Outer Rotor and by following the numbers in sequence in the successive Figs. A, B, C and D, it may be seen how this lobe during a complete revolution moves forward to the next recess in the Outer Rotor, creating while so doing a pocket of gradually increasing capacity up to the position 9, Fig. A and from there onwards to 16, Fig. D, gradually decreasing until the pocket is again filled by the next lobe as in 1, Fig. A.

The fluid is drawn into the pump through ports of the Outer Rotor while the pocket is increasing and forced out of the opposite side of the Pump during the last half revolution when the pocket is decreasing.

Figs. E, F and G illustrate the construction of the Body Liner, Outer Rotor and Inner Rotor. The Outer Rotor has four ports which are open to the chamber of both the suction and delivery side of the Pump during rotation. These ports are closed momentarily by a facing at both top and bottom of the Pump Body in order to effect the cut-off between the suction and delivery of the pump.

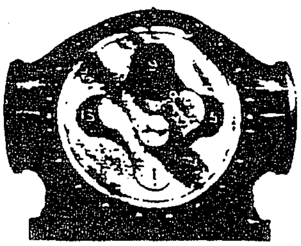


Fig. A

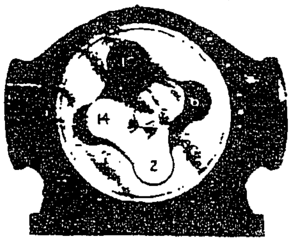


Fig. B

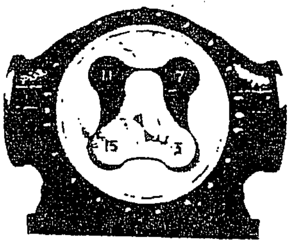


Fig. C

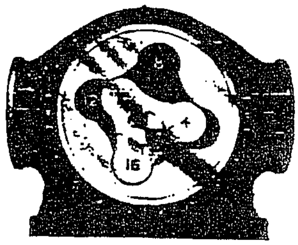


Fig. D

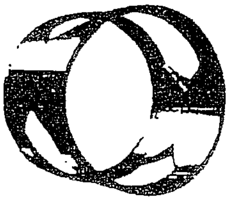


Fig. E

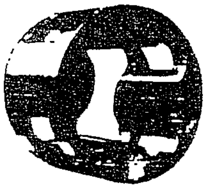


Fig. F

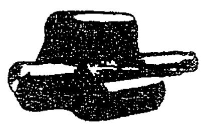


Fig. G

CAPACITY CONTROL

Capacity Control - increased or decreased discharge can be obtained by speed variation, approximately proportional to the pumping speed.

Consequently, there are two drive versions:-

(a) VARIABLE SPEED = Capacity control by varying the pumping speed, at constant pump discharge pressure.

See Figure 5.

Lobe pumps are not permitted to operate against a closed discharge line isolation valve, as the max permissible pressure will be exceeded, which will result in damage to the pump, or jamming.

(b) CONSTANT SPEED = Capacity control by slide valve and bypass.

LEDERLE INSTALLATI

(VARIABLE SPE
CONTROL)

A MOTOR
B BELT DRIVE (TIMING)
C VARIABLE SPEED GEARBOX
D REDUCTION GEARBOX
E COUPLING
F PUMP
G STROKE ARM
H PNEUNMATIC ADJUSTMENT

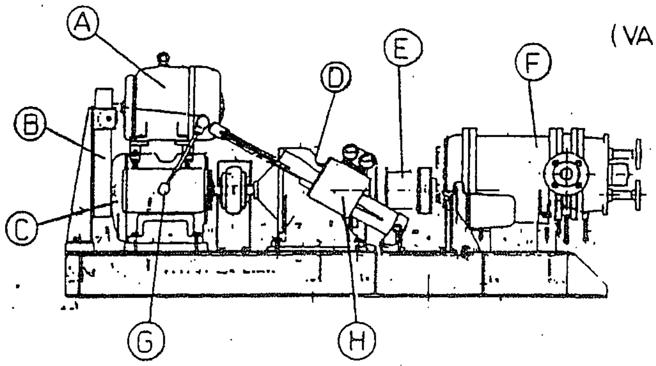


FIG 5

PUMPING SPEED

The optimum pumping speed is selected for all lobe pump applications. The size of the pump to be chosen is determined by the capacity and by the permissible pumping speed, which depends on the viscosity of the liquid to be pumped. The pumping speed must be low enough to permit the liquid to flow into the pump without starving. Obviously, lobe pumps are also suitable for handling low viscosity liquid. The inevitable gap losses can be compensated for by increasing the pumping speed.

ROUTINE MAINTENANCE

If correct installation and operation procedures are applied, there is little to go wrong on these pumps, generally being of a sturdy design.

A periodic check on the lubrication levels, (once a week) will ensure long life for the bearings and timing gears.

If the pumps are fitted with packed glands, these should be inspected regularly and any leaks discovered should be controlled by either nipping the gland or repacking.

On pumps fitted with mechanical seals, the level of the sealing fluid needs regular inspection. If the level of fluid is found to be dropping, this could indicate a seal failure which should be corrected before the product can escape and contaminate the rest of the pump.

FIG 4.

SEVEN-EIGHT TYPE FOR LOW VISCOSITY FLUIDS

The principal parts of the pump are Body, Body Liner, Gland and Inspection Covers, Inner Rotor keyed to Shaft and Outer Rotor.

As will be seen from the accompanying illustrations the assembly is similar to that of the Three-Four Type.

Displacement is effected by any one lobe of the inner rotor moving forward over one lobe of the outer rotor during one revolution of the shaft and the action is therefore of the same character as that of the Three-Four Type.

No attempt is made here to number the successive positions of the rotors, as it is felt the action will be readily apparent from the description of the Three-Four Type.

The features of both are very similar, the main difference being the number of engaging lobes.

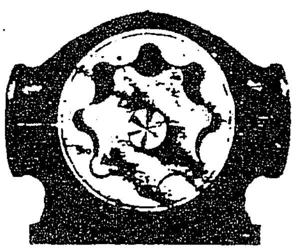


Fig. A

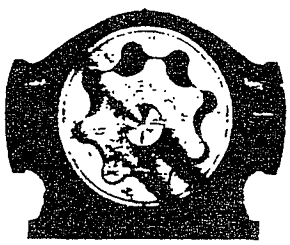


Fig. B

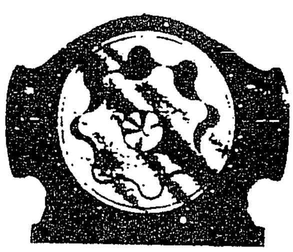


Fig. C

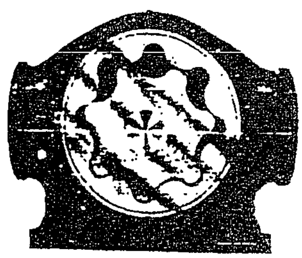


Fig. D

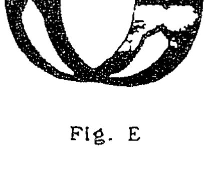


Fig. E

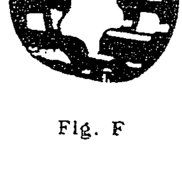


Fig. F

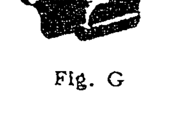
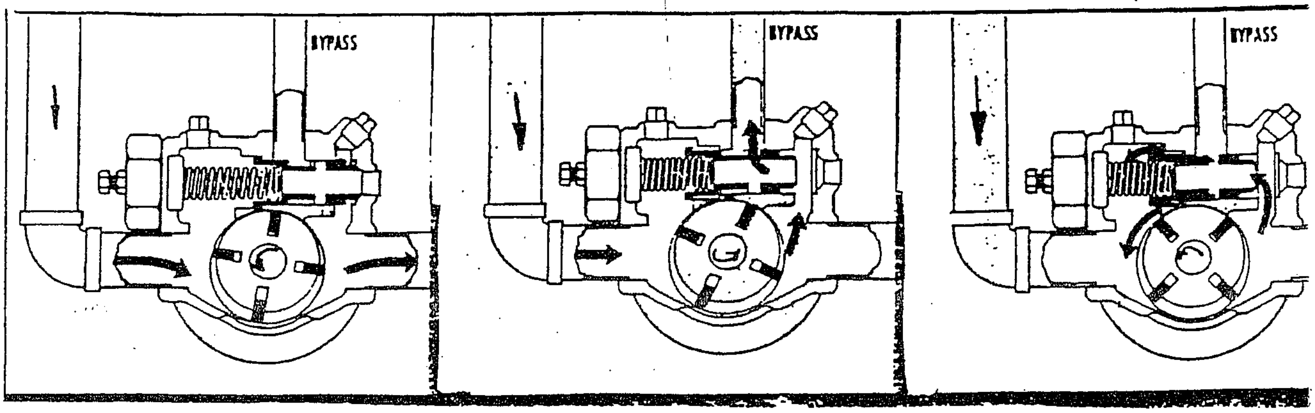


Fig. G

(c) VANE TYPE P D PUMPS

The rotor, which carries the vanes mounted in axial slots, is mounted eccentric to the casing. This arrangement provides pockets of variable volumes depending on their angular position, the smaller being near the suction and discharge port. See Figure 1.



The vanes are either spring loaded against the casing or are of a solid piece which passes through the slotted shaft, relying on centrifugal force to throw them out.

Pumps with flexible vanes (elastomers) are available for various duties but they have limited available differential pressures (3.5 bars gauge - 50 psig) and temperature, and on dry running they generate excessive heat causing severe damage and seizure.

For high differential pressure, double acting pumps are used (oval or elliptical casing), and their use is generally confined to hydraulic duties.

Some sliding vane pumps have a variable eccentric feature built into their design. This is to accommodate variable flows at constant pressures (e.g. fuel oil pumps).

As the pump relies on continuous sliding/rubbing action of the vanes against the casing and slots in the rotor, the pumped fluid must have some lubricating qualities for satisfactory operation. However, the use of modern plastics has helped to reduce the problem to a certain extent.

It is advisable that fluids containing solids in suspension should not be pumped with sliding vane pumps.

Range of flow rates - up to 300 m^3/h.

(d) ROTARY PISTON PUMPS

The basic concept of the above pump relies on the rotary motion of either rotor or body imparting a reciprocating (or oscillating) motion to the pumping pistons or plungers. Fluids pumped must be clean and have lubricating qualities.

These pumps can be divided into the following types:

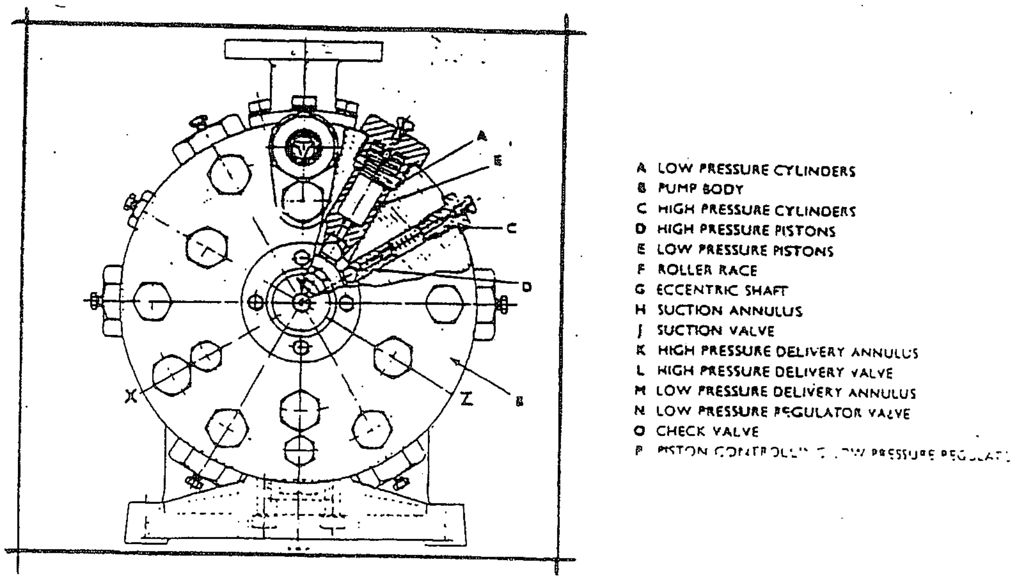
(a) RADIAL PISTON

(b) AXIAL PISTON

(c) ORBITAL PISTON

(a) RADIAL PISTON

The main use for these pumps, which deliver low to medium range pressures, 20 to 120 bar, is the hydraulics field. The radial plungers are housed in cylinders carried on the rotor which is mounted eccentric to the casing Figure 1.



In some cases the casing eccentricity can be varied to give a variable flow. These pumps should be used on clean filtered fluids to avoid damage to valves and tight clearance.

Shaft sealing is achieved by use of a lip seal, as the main sealing is obtained by close side clearances within the pump.

(b) AXIAL PISTON PUMP

The cylinders/plungers and drive shaft are parallel, and the reciprocating motion is generated by a tilted swash plate or cam shaped drive plate. The capacity can be varied from zero to maximum rated throughout by varying the angle of tilt which can be done automatically to maintain a constant delivery pressure in the system.

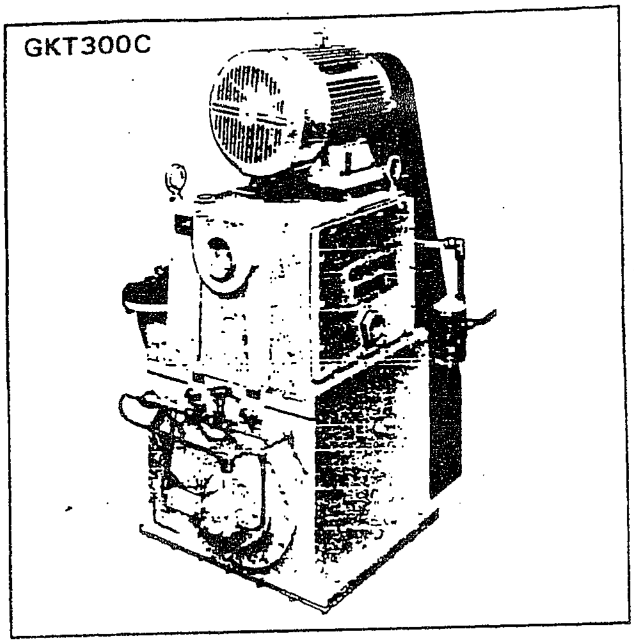
This pump is also confined to hydraulic systems where medium to high (120 to 190 bar) pressures are required. Again filtered, clean fluids should be pumped as fine tolerances are used.

(c) ORBITAL PUMPS

The piston or cam rotates eccentrically within the casing such that only one point of rolling contact is established between the piston and the casing. The motion generates a sweeping action ahead of the point of contact, similar to the vane action in the sliding vane pump.

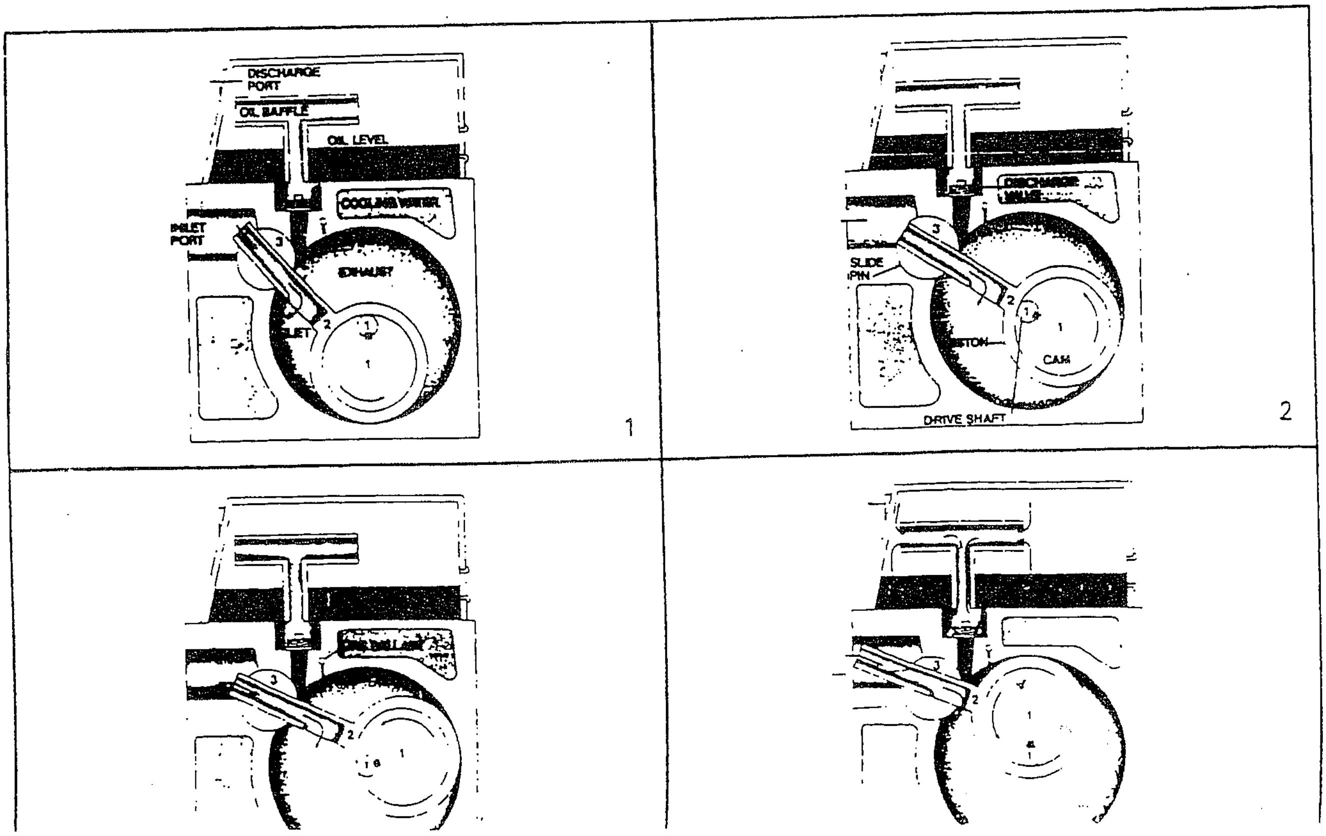
Suction and discharge ports are separated by a vane which is loaded to maintain contact with the piston at all times. Alternative designs incorporate a sliding lip to perform the same function.

An example of this type of pump is the KINNEY VAC PUMP.



Description

The Kinney® high vacuum rotary piston pumps consist of three working parts: (1) the shaft with eccentric cam keyed on; (2) the rotary piston with hollow extension cast integral which slides up and down freely in (3) the slide pin.



This hollow extension of the piston provides two distinctive and sound features. (A) Being cast integral with the piston eliminates the weakness of any joint which would be necessary to connect these two vital parts of a piston. (B) This integral hollow extension has openings cut on the inlet side to provide a large and direct inlet port opening for gases to diffuse into the cylinder when the inlet port is uncovered. This inlet is relatively large to assure maximum admittance or conductance speed of the pump itself – a feature so necessary in high vacuum service.

An individual analysis of the inlet stroke of a Kinney® pump follows: Starting at the top of a stroke of a simplex pump the inlet port is closed because it is covered by the slide pin. As the shaft revolves the cam pulls the piston downward and creates a differential in pressure. Through the new uncovered inlet port the gases diffuse into the cylinder space which is rapidly being created by this cam and piston action.

Just as the piston returns to the end of its stroke, the inlet ports are mechanically closed off again by being covered up by the slide pin. This provides a positively operated inlet port; thus no pressure differential is required to open and close the port. The discharge action as can be seen overleaf is a concurrent process. At the very end of the stroke all of the air or gas has been expelled and followed by the wave of sealing oil. The air and oil mixture passing through the spring loaded discharge valve is expelled throu' the discharge pipe and into the overhead separato tank. Here the large diameter tank slows down the velocity of the air-oil mixture and provides the time necessary for the efficient separation of the air-oil mixture. The oil drops back into the storage space outside of the vertical discharge pipe, awaiting return to the pump.

Throughout the operating cycle the outside diameter of the piston is always tangent to, but not in contact with, the cylinder wall. At the moving point of tangency an effective oil seal is built up ahead of the piston which, in addition to the film of oil between the ends of the piston and cam and face of heads, as well as in the slide pin clearances, prevents leakage from the compression to the vacuum side. Re-expansion is reduced to a minimum – a condition essential for low ultimate pressure, fast pumping speed and quick recovery time over the compl range of pressures required.

Water or Air Cooled

The complete range of rotary piston pumps can be supplied air cooled if requested. This offers the distinct advantage of mobility and eliminates the need for water cooling pipework to and from the pump.

Gas Ballast

All oil sealed pumps produced by Graham are fitted with a gas ballast facility as standard. This enables the pumps to handle a limited amount of water vapour without contaminating the sealing oil.

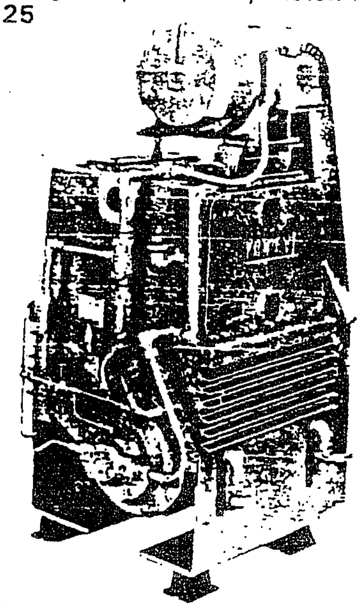
Atmospheric air is admitted through the gas ballast valve on the compression side of the rotor boosting the pressure of the mixture so that the compression applied to the water vapour is far less than would be required to open the discharge valve. The pressure to which the water vapour content is compressed is also less than that where it would condense and therefore passes through the discharge as vapour.

The limiting factors are that the pump should be at a temperature of 70 – 80°C, the partial pressure of the water vapour at inlet should not exceed 40m bar and the amount of air admitted through the gas ballast valve should be 10% of the pumps capacity.

A thermostat valve should be fitted to the cooling water outlet to ensure operation at the correct temperature.

With gas ballast in operation the ultimate pressure expected on a single stage oil sealed mechanical vacuum pump should be better than 1.33 m.bar.

Double Stage Triplex Rotary Piston Pump GKTC225



RECIPROCATING PUMPS

Reciprocating pumps, which include METERING pumps have a simple working action. The working principle consists of a piston or ram, sliding within a cylinder, with delivery of the product being on the forward stroke of the ram. Due to the nature of the pumping action, SUCTION and DELIVERY valves are necessary. These are in the form of NON-RETURN VALVES.

The flow is pulsating, especially on single piston designs, but their pulsations can be minimized by using multi piston designs or surge chambers.

A typical RAM type pump can be seen in Figure 1 with a simple cone type non-return valve.

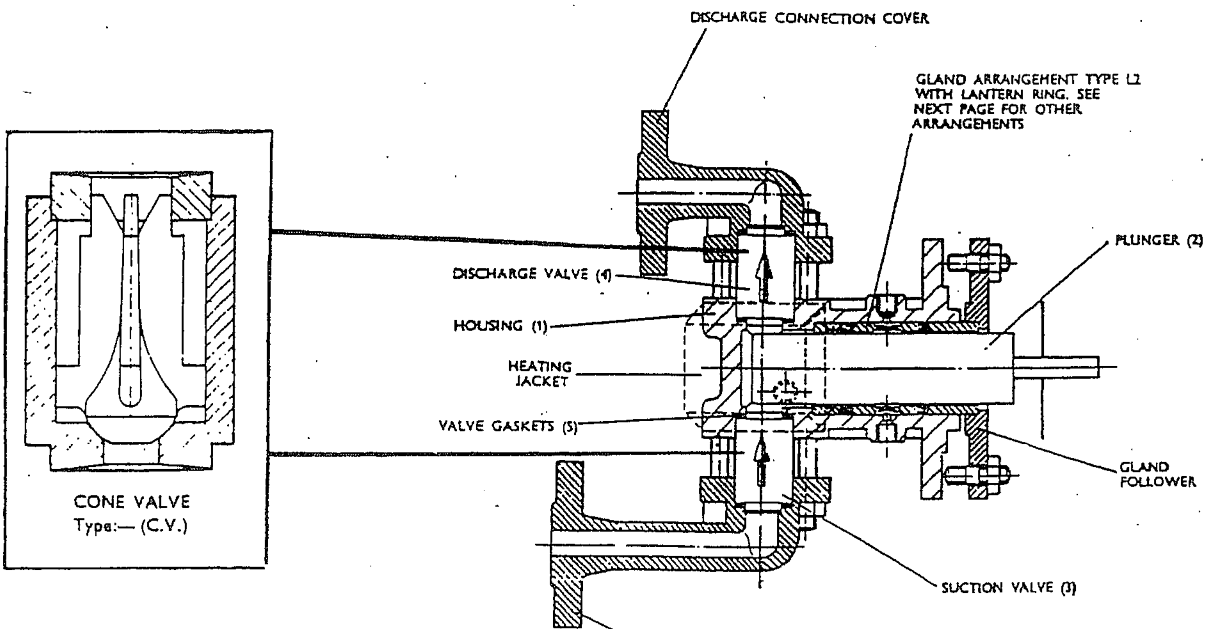


FIG 1

Another type of valve used is the "BALL TYPE", shown in Figure 2, these can be single, double or even triple ball valves.

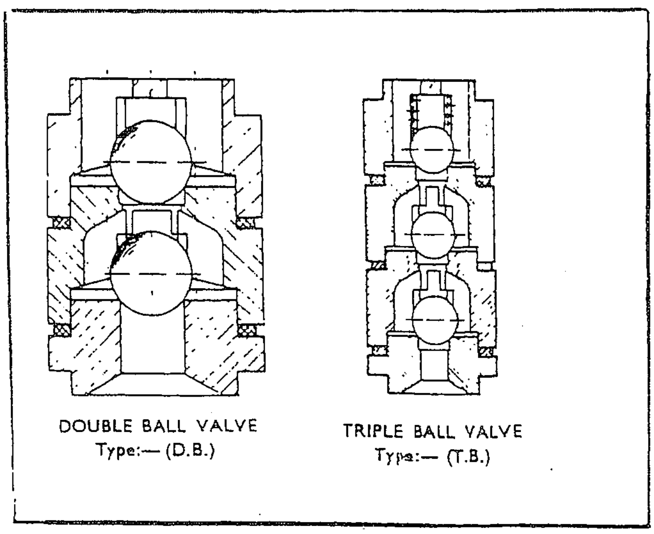


FIG 2

Metering pumps incorporate the following features:

(a) They can administer an exact and repetitive predetermined quantity of fluid (within ± 1% of the setting).

(b) The quantities pumped are usually small.

(c) They can deliver a quantity which is proportional to the main flow rate, or any other system parameter, (e.g. temperature, P H chemical analysis, density etc).

(d) The flow rate can be adjusted either when the pump is in operation or at rest.

(e) As P D pumps, they must not be operated against a closed discharge so a relief valve should be fitted into the discharge line to relieve back into the suction.

(f) A positive pressure must be applied to the discharge valves to allow a proper seating and therefore proper operation.

(g) To improve accuracy, valves may be duplicated or triplicated.

(h) When metering fluids with solids in suspension, soft value seating are required.

(i) Capacity can be varied by altering the stroke length of the ram. This is accomplished by either varying the fulcrum of the actuating lever, or by varying the eccentricity of the actuating cam. Alternatively, capacity can be varied by varying the speed of the pump.

(j) Pump stroke can be varied manually or automatically and be remotely actuated to meet the process parameter specification.

(k) The pump speed is usually low (max 200 rpm), therefore the speed is reduced by the use of a worm and wheel in the gear box. This work and wheel also transforms the drive from ROTARY to RECIPROCATING with the aid of the eccentric actuating cam.

The two main types of metering pumps are the:-

(a) RAM or PLUNGER PUMP

and the

(b) DIAPHRAGM PUMP

Both pumps operate on the same working principles, i.e.:

Reciprocating piston, operated from a motor via a worm and wheel through an eccentric cam. The piston pumping the fluid through suction and delivery non-return valves.

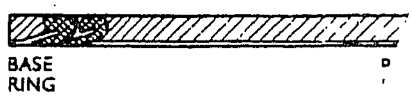
The main difference between the two pumps is, in the RAM or PLUNGER type pump, the piston is actually immersed in the pumping fluid or product, while the DIAPHRAGM pump has the piston immersed in oil, isolated from the product.

RAM OR PLUNGER PUMPS

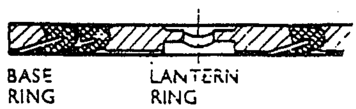
The RAM PUMPS are robust and simple in construction. However, the need for a stuffing box to reduce or eliminate gland leakage is one of their major drawbacks. Not only is the gland leakage often unacceptable from safety, hazards, spillage and loss of product points of view, but it can drastically affect metering accuracy and repeatability due to the leakage flow being inconsistent. It can be a high proportion - if not higher, than the quantity pumped.

There are a variety of gland assemblies which can be used in the stuffing box. A selection can be seen below.

L1

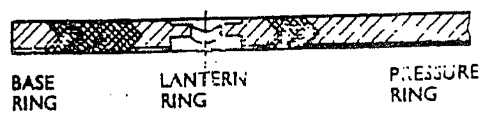


L2

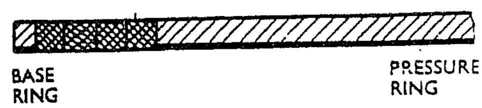


V1

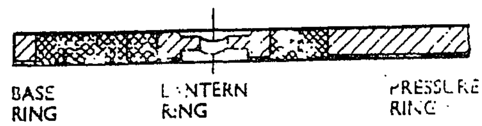
V2



P1



P2



INSTRUCTIONS FOR ADJUSTING STUFFING BOXES

L1 and L2

The gland should be tightened as lightly as possible. Manual tightening, without using a tool, will suffice to ensure sealing of plunger packing.

Where two studs are provided for mounting the gland follower, these must be tightened uniformly taking care not to overtighten.

V1 and V2

When the pump is started up loosen the gland and allow stuffing box to drip for a short period; subsequently slowly tighten the gland until no further leakage occurs.

The above procedure should be repeated after each prolonged shut-down. The tool supplied may be necessary to tighten the stuffing box but not more than a gentle pressure is required.

P1 and P2

This gland must be tightened firmly until no leakage occurs. The correct size spanner should be used to tighten the stuffing box.

IN GENERAL

IF IT IS NO LONGER POSSIBLE TO STOP LEAKAGE BY THE PROPOSED PROCEDURES, PACKING RINGS ARE WORN OUT AND MUST BE REPLACED. IF THE PLUNGER IS BADLY SCORED IT SHOULD ALSO BE REPLACED

LANTERN RINGS

Some liquids require a lantern ring to be incorporated into the pumpheads. In order to reduce the wear on the plunger and seals compatible liquids can be used to lubricate and purge. Similarly, leakage of corrosive liquid and vapour from the glands to the surrounding atmosphere can be piped to drain or a sump.

Toxic liquids or vapours can be sealed or piped to safe areas. Steam or water can be used for cleaning and sterilizing or sealing atmospheric dirt from the liquid being pumped.

Examples:-

(a) Sugar solutions require water sealed lantern rings.

(b) Sodium Hydroxide or other solutions which tend to crystallize in the gland can be purged.

(c) Acids pumped under high pressure which would produce corrosive vapours if leakage occurs can be piped to drain or purged away with compatible liquid.

(d) Higher pressure applications will require oil lubrication of the seals.

Some duties require pumpheads of HARD PVC or CERAMIC construction. If this is the case the caution should be exercised when tightening glands. This applies to all gland arrangements.

DIAPHRAGM PUMPS

These pumps work on the same principles as the PLUNGER TYPE PUMP, except that the pumping action is achieved by means of a diaphragm, which isolates the piston from the product. These pumps can be sub-divided into two types:

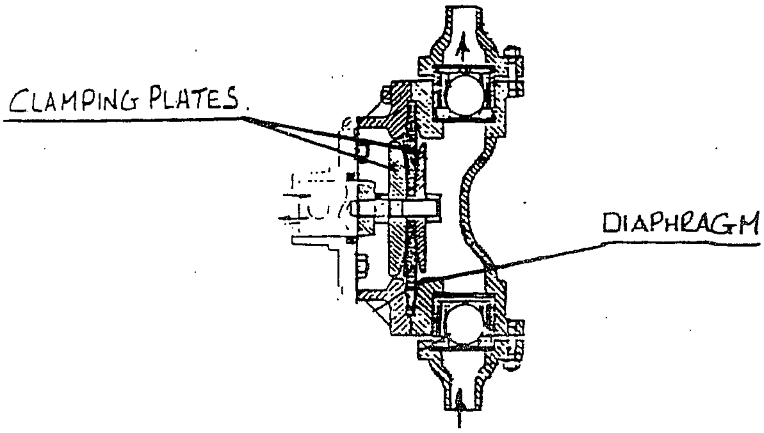
DIAPHRAGM PUMPS

MECHANICAL DIAPHRAGM

HYDRAULIC DIAPHRAGM

MECHANICAL DIAPHRAGM PUMPS

In this type of pump the oscillating action of the flexible diaphragm is achieved by direct mechanical drive, i.e. the ram is fastened directly onto the diaphragm which can be seen in the sketch.



Mechanical diaphragm pumps are normally used in dosing duties where accurate metering is not required and as the loads on the diaphragm are not balanced, operating pressure is limited to 6 bar (84 psig) depending on size.

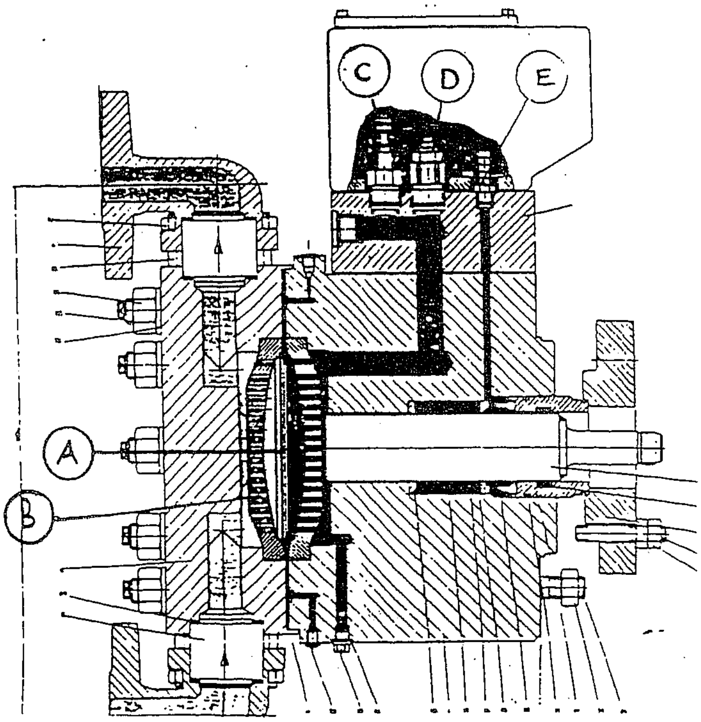
As no fluid comes into contact with the plunger, there is no need for any gland sealing arrangements.

HYDRAULIC DIAPHRAGM PUMPS

The diaphragm is actuated by oil which is displaced by the ram. This feature offers a completely balanced diaphragm loading, which means high pressures can be achieved.

To ensure accuracy and repeatability the hydraulic chamber behind the diaphragm must at all times be kept free from air or vapour. This is achieved by fitting "SNIFTING VALVES" which immediately replace any oil losses through the ram gland, or through the pressure relief valve on the oil circuit.

A DIAPHRAGM
B SUPPORT PLATES
C SPILL VALVE
d VENT VALVE
e SNIFTING VALVE



Normal operation and accuracy will be impaired when operating near the boiling point of the hydraulic fluid.

A supporting disc is required to limit the stroke of the diaphragm to prevent rupture due to surges in the operating pressure. This arrangement limits single diaphragm pumps to clean liquids where lodging of suspended solids in the disc and eventual damage to the diaphragm cannot occur.

Hydraulically operated pumps can be operated remotely from the actuating mechanism and drive via a pneumatic pressure line.

SEALING

To improve gland performance, the ram must be guided with suitable bush bearings and have a hardened surface to reduce wear. Lip seals (CHEVRON PACKING) are preferred to soft packing as they are automatic in action and do not require as much attention as soft packing does.

Diaphragm pumps can be used to eliminate leakage completely. However, they are more expensive than ram pumps and their use must be justified by either safety aspects or by process aspects, e.g. metering accuracy or loss of product.

INSTALLATION & OPERATION

(a) Pipes with sharp bends should be avoided as the pulsating action of the pumps could result in a vibration problem similar to water hammer.

(b) Pipes must be adequately supported, especially with non-metallic pumps, to minimize distortion and allow proper valve seating.

(c) Adequate access for priming and routine maintenance must be provided.

(d) For reliable metering operation, adequate NON POSITIVE SUCTION HEAD (NPSH) must be provided. The NPSH requirements of metering pumps are in general low, as the flow rates are small and speed of the pump is low. Aerated fluids cannot be metered reliably.

PERISTALTIC PUMPS

The basic design of the PERISTALTIC pump relies on a flexible tubing diaphragm (rubber or nylon) is moved axially along the tube, thereby conveying the fluid ahead of the squeeze within the tube. The squeezing action can be generated hydraulically or mechanically.

HYDRAULIC PERISTALTIC PUMPS

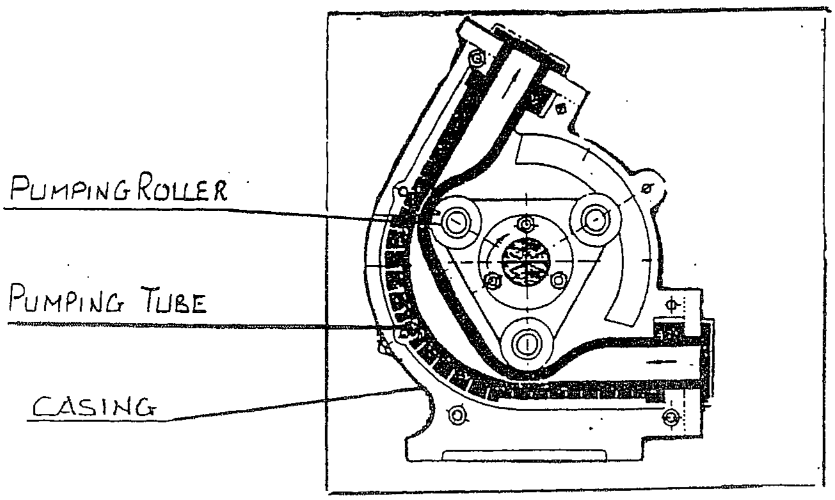
On hydraulically squeezed pumps (Figure 1), the pumping tube is surrounded by the hydraulic working fluid. The pressure in the fluid is varied by a mechanical piston or a pneumatic diaphragm. This motion imparts a squeezing and relaxing action on the pumping tube. With suitable valve arrangements, similar to those in metering pumps, the fluid is conveyed to the desired point.

The nature of flow is pulsating and damping chambers are desirable, especially when long runs are used.

Pumps will deliver up to 14m^3/hr at pressures up to 100 psi (6.9 bar).

MECHANICAL PERISTALTIC PUMPS

On mechanical squeeze pumps the pumping tube is trapped between the pump casing and one or more rollers running along the tube (Figure 2). As can be seen from the sketch, as the rollers rotate, the tube is squeezed and the product pushed along the tube from the suction to the discharge.

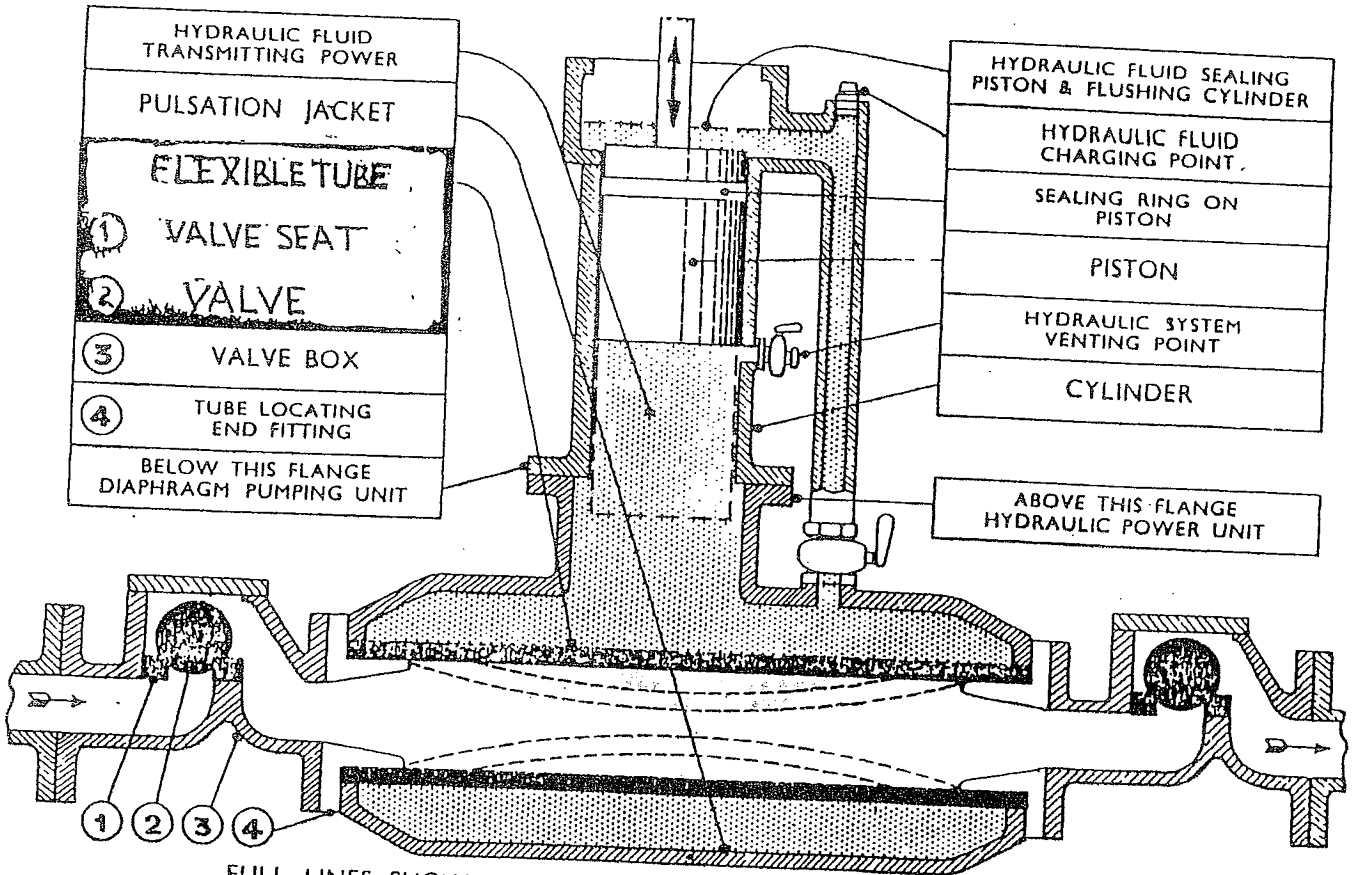


From the construction, it is obvious that peristaltic pumps are of the glandless design, and of low flow rates and low pressures to give satisfactory pumping tube life.

These pumps are generally found in laboratories where duties are not severe and usually a greater degree of supervision is available.

APPLICATIONS

By careful selection of materials for the pumping tube and valves, these pumps are capable of handling a variety of products.



FULL LINES SHOW PISTON AND DIAPHRAGM ON SUCTION STROKE
DOTTED LINES SHOW PISTON AND DIAPHRAGM ON PRESSURE STROKE

Fig.1 Hydraulic Peristaltic Pump.

P.T.F.E.

CORROSIVES:	Both hot and cold (all acids, liquid bromine, chlorinated compounds etc.)
SOLVENTS, EXPLOSIVES:	On pneumatically operated hydraulic pumps there is no danger from sparks.
ULTRA PURE LIQUIDS:	No contact or contamination with atmosphere.
PHARMACEUTICAL:	Fermentation broths, Antibiotics, Penicillin, Vitamins etc. (Pumps can be easily sterilized).

VITON OR HYPALON PUMPS

Liquids with abrasive solids in suspension (slurries, crystalline products etc.)

Special design for nuclear applications.

INSTALLATION

(a) The pump should be mounted as close as practical to the source of supply.

(b) On pneumatic systems, a pressure regulator should be used on the air supply to limit the air pressure between 0.5 and 3 bar over the pump total head. This will save air and prevent vibration.

(c) An air filter is advisable to protect the pressure regulator and air valve from pipe scale.

(d) A relief valve should be fitted into the system.

P D PUMP INSTALLATIONS (EXAMPLES)

PUMP TYPE	DUTIES	LOCATION
GEAR PUMPS	FUEL OILS, SECHEURS LUBRICATION FOR REFRIGERATION SETS RUBBER SOLUTION ACRTONS TANKER OFF-LOADING	WALLERSCOTE WORKS CK & RSV WORKS ALLOPRENE (WIDNES)
LOBE PUMPS	SODIUM AMMONIA TRANSFER BIPYRIDIL DISCHARGE FROM STILL	PARAQUAT (WIDNES)
VANE PUMPS	LIQUEFIED PROPYLENE ARCTONS TANKER OFF-LOADING	CTC ROCKSAVAGE WORKS
SINGLE SCREW (MONO)	VARIOUS SLURRIES	ALKALI WORKS
TWIN & TRIPLE SCREW	FUEL OIL	POWER STATIONS
ORBITAL PISTON	DIGLYME STILL VAC PUMP	PARAQUAT
PERISTALTIC (HYDRAULIC)	D N T	BURN HALL