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LIQUID TRANSFER MACHINE

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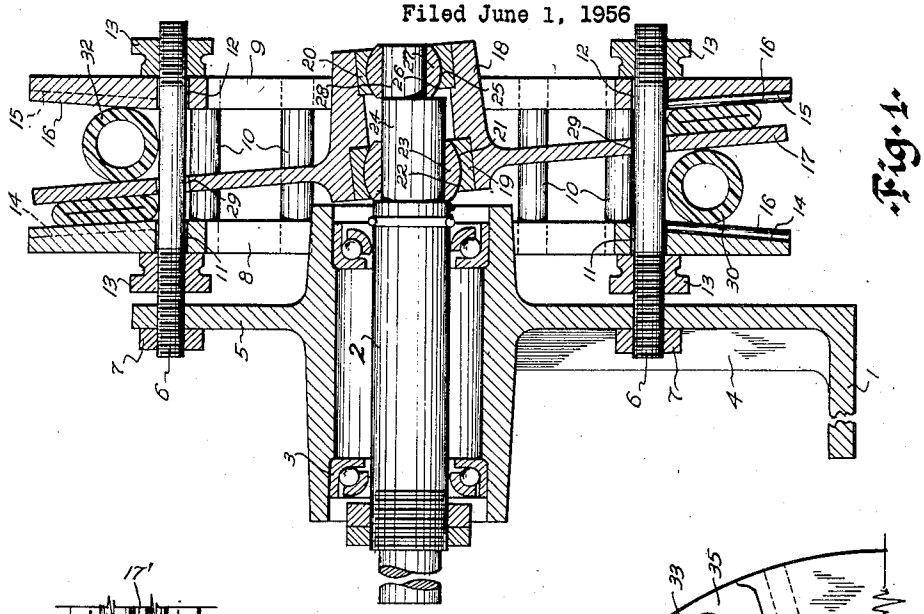


Fig. 1.

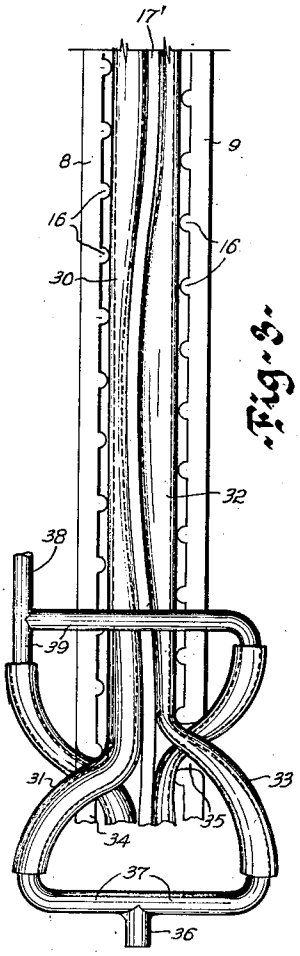


Fig. 3.

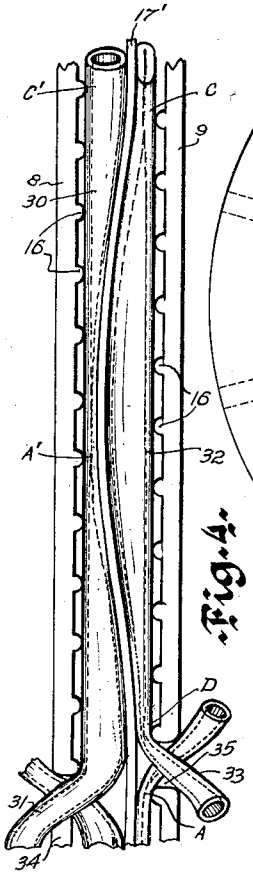


Fig. 4.

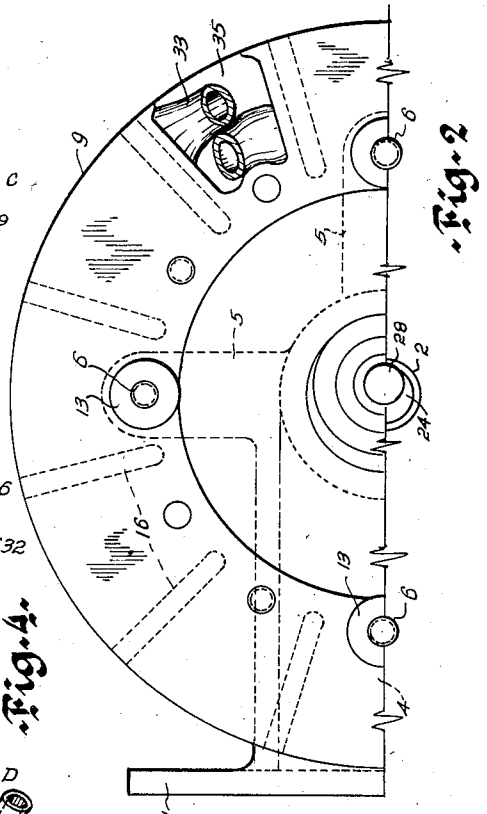


Fig. 2.

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LIQUID TRANSFER MACHINE

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3 Claims. (Cl. 103—149)

This invention relates to machines for transferring or pumping liquids and more particularly to machines of the resilient tube flexing type.

The use of resilient tubing as a pumping means has many advantages in the transfer of liquids. The easy removal of the pumping section for sterilization or replacement is of great importance in the medical field and wherever contamination must be prevented. Since the liquids do not come into contact with metal parts, particular attention to the corrosion characteristics of these parts is unnecessary and ordinary low cost materials of construction are satisfactory. As each cycle delivers a uniform volume the flow is metered and controlled by the frequency of the pulsing and the size of the tubing.

It is a general object of this invention to provide a liquid transfer machine of the tube flexing type of simplified construction and lower cost of manufacture. Another object is to provide such a machine which will permit the use of a wider range of resilient materials, which will reduce the power required to produce a given head, and which will efficiently transmit mixtures of liquids and solids of irregular shape and non-uniform size. Another object is to provide such a machine wherein the application of the pumping tubing thereto consists merely in a simple wrapping action without the necessity of dismantling the power mechanism. Another object is to provide a machine of reduced operating power and will operate to compensate irregularities in the wall thickness of the tubing. Still another object is to provide a machine wherein power is applied at a series of repetitive pressure areas with a single moving member. Another object is to provide a machine which will produce a given head within a pressure system by rapid deformation of a resilient tube forming a member of such pressure system. A further object is to provide a machine which will produce a continuous non-pulsing discharge from a resilient tube pumping means.

The invention broadly comprises a pair of resilient or flexible tubes each having a loop therein, means for feeding liquid to one end of each of said tubes, a pair of operatively fixed spaced plates between which the tube loops are arranged, a third plate tiltably mounted between said fixed plates and loops, and means for tilting said third plate to apply continuously advancing compressive pressure to a cross-section of each tube loop, and means for discharging pumped liquid from the other ends of said tubes.

Other objects, details and advantages will become apparent from the following description, with particular reference to the accompanying drawing, in which

Figure 1 is a sectional side elevation of a machine in accordance with the invention,

Figure 2 is a partial front elevation of the machine,

Figure 3 is a diagrammatic side elevation of the pumping tubes and pressure plates in one operating form of the invention, and

Figure 4 is a diagrammatic side elevation of the pumping tubes and pressure plates in another operating form of the invention.

In the drawing, 1 is a frame or support and 2 a shaft journalled in the bearing 3 carried by the support. The support includes a base arm 4 and a plurality of diametrically spaced arms 5 extending radially from the axis of shaft 2. A stud 6 has its threaded end fixed to each of arms 4 and 5 as by a nut 7. Mounted on studs 6 are a pair of annular plates 8 and 9 in fixed spaced relation to each other by means of a plurality of connecting pins 10. Each stud 6 extends through complementary openings 11 and 12 in the pair of plates, which are adjustably fixed on the studs as by adjusting nuts 13. It will be observed that the studs 6 are located closely adjacent the inner periphery of the plates 8 and 9. The interior face of each plate 8 and 9 radially beyond the studs 6 presents an outwardly inclined surface 14 and 15. Each surface 14 and 15 is provided with a plurality of radially disposed spaced ribs 16.

A disc or plate 17 is tiltably mounted between annular plates 8 and 9. As shown, plate 17 has a hub 18 provided with spaced bearings 19 and 20. Bearing 19 has a dished surface 21 in sliding engagement with a curved mating surface 22 on a bearing member 23 fixed to a reduced diameter portion 24 of shaft 2. Bearing 20 has a dished surface 25 in sliding engagement with a curved mating surface 26 on a bearing member 27 fixed to a crank or eccentric portion 28 of shaft 2 on the end of portion 24. It will be apparent that rotation of the shaft will cause eccentric 28 to impart continuously advancing tilting movement to plate 17, such movement being non-rotational and in a transverse direction.

Plate 17 is circular as shown and has a diameter approximately at least equal to that of the external diameter of plates 8 and 9. Plate 17 has a plurality of openings 29 through which the studs 6 loosely extend.

A loop 30 of a tube 31 is disposed around studs 6 between plate 8 and tilting plate 17 and a loop 32 of a second tube 33 is disposed around studs 6 between plate 9 and tilting plate 17.

The end portions of tube 31 extend through an opening 34 in plate 8 and the end portions of tube 33 extend through an opening 35 in plate 9. An inlet conduit 36 for material to be pumped has branches 37 connected to one of the ends of tube 31 and one of the ends of tube 33. An outlet conduit 38 has branches 39 connected to the other of the ends of tube 31 and the other of the ends of tube 33.

In operation, rotation of shaft 2 will result in oscillation of hub 18 and plate 17 about the axis of the shaft by reason of the eccentric 28. In other words, the peripheral portion of plate 17 will reciprocate between annular plates 8 and 9, such reciprocation taking place in a circular path about the axis of shaft 2. Thus, the peripheral portion of plate 17 will apply an advancing compressive action on each loop 30 and 32 interposed between plate 17 and operatively fixed plates 8 and 9. It will be apparent that the correspondingly compressed or uncompressed portions of tubes 30 and 32 will be spaced 180° from each other. It will also be apparent that movement of the peripheral portion of plate 17 across a tube diameter will occur without any surface motion whatever at the points of contact. The ribs 16 provide radial lines of contact to ensure effective compressive closing action of the tube walls.

As previously indicated, the pair of annular plates 8 and 9 may be axially adjusted with respect to oscillating plate 17 for various types of pumping requirements. As shown in Figure 1, plates 8 and 9 are so positioned that a portion of loop 32 is completely collapsed or closed while a portion spaced 180° therefrom is fully open.

Similarly, a corresponding portion of loop **30** spaced 180° from a collapsed portion of loop **32** is completely closed while a corresponding portion is fully open. This arrangement of the pump is diagrammatically illustrated in Figure 4 wherein **17'** represents the oscillating path of plate **17**. Referring to Figure 4, it will be observed that with shaft 2 rotating in a clockwise direction, and considering loop **32** only, one revolution of the shaft will collapse portion A, which, as shown, is located adjacent the outlet end of the loop, and also portion C. Portion D, adjacent the inlet end of the loop is just closing and the liquid held between A and C is being moved towards C and at the same time being trapped by the closing of D. However, at the same time, plate **17** is is moving away from A and C and the liquid therebetween can flow toward and past A to the discharge end. Likewise, plate **17** is moving towards the succeeding portion E of loop **32** and will close the loop at this point as it opens the loop at D. As this action progresses, the release of pressure on D and succeeding portions permits the tube to approach its circular form. This creates a reduced pressure zone behind the areas of contact. It, therefore, follows that rotation of the shaft causes a volume of liquid to be accepted equal to that portion confined between pressure points A and C for each revolution and that the total volume delivered in a given time is equal to the unit volume times the revolutions in such given time. It is also apparent that the delivery of liquid by loop **32** will be of pulsating nature.

Now, considering loop **30**, it will be seen that plate **17** has sealed it at portion A' and that a low pressure zone exists between A' and inlet end of loop **30**. Likewise a high pressure zone exists between A' and C' and liquid will be pushed through the outlet end of loop **30** as the shaft rotates. Since plate **17** at C' is at a point of maximum recession the rate of discharge is also at a maximum while loop **32** at the same instant is at a point of minimum discharge through its outlet. Considering any other instantaneous position of the tube loops, it will be seen that although each tube produces a pulsing delivery of liquid, the pulses of both tubes add to produce a continuous uniform rate of flow through the interconnected inlet and discharge ends of the tubes.

Figure 3 illustrates a different setting of plates **8** and **9** with respect to plate **17** whereby loops **30** and **32** are not completely collapsed at any portions thereof at any time. The pressure created by the approaching portions of plate **17** and plates **8** and **9** applies a squeezing action on the liquid in such section of the loops and urges the liquid ahead of this squeezing area while the receding portions of plate **17** and plates **8** and **9** permit the tube loops to regain progressively their maximum cross-sectional area and cause a suction zone. Although these pressure and suction zones are not completely separated, as in Figure 3, a pressure head is developed on the liquid equal to that necessary to overcome the friction head through the orifice formed by the tube at the point of maximum closure.

It is, therefore, apparent that at a given speed of shaft rotation a given head can be produced by adjustment of plates **8** and **9**.

Unlike centrifugal pumps, in which the head produced is the result of continuous application of centrifugal force requiring a large power input, the present invention avoids the use of centrifugal force to develop head and requires only a small fraction of the power to develop the same head. Moreover, since centrifugal pumps generate the head by high velocity imparted to the liquid or slurry in the pump casing, the same centrifugal force segregates the heavier materials, which, if of a solid or sticky nature tend to seal off the discharge. The device of the present invention imposes no centrifugal action on the material being handled and thus there is no segregation of components of differing specific gravity.

Operation of the device in the setting shown in Figure 3 is of some additional advantage in prolonging the life of the tubing employed due to partial rather than complete collapsing of the tube.

The head developed at any given speed can be readily varied without interrupting the pumping operation by simple adjustment of the nuts **13**. In this manner, the plates **8** and **9** may be adjusted relatively to plate **17** to generate any head from, say, 1 to 90 feet.

Furthermore, it has been found that closing of a resilient pumping tube at spaced intervals rather than continuously, as heretofore proposed, permits positive displacement even though strands of material under handling are pinched between the tube walls at pressure points. At the instant of sealing, the distance travelled by solids in the pumped material to prevent pinching is very short, being just to each side of the pressure point into the spaces where the tube is not closed. The absence of material pinching is of vital importance, for instance, in the pumping of whole blood where damage to cells must be kept to a minimum.

The pump of the present invention may be of small size capable of operating with small tubes of one eighth inch in outside diameter. Such a machine may have a capacity of one cubic centimeter per revolution and a continuous uniform delivery when operated at one revolution per hour. This small continuous delivery is extremely useful for certain purposes. Orifices usually employed to meter such a flow are so small that they are easily blocked by very small cells or solids. Since no fixed orifices or valves are used in the device of the present invention, such cells or solids do interfere with continuous operation. This makes practicable the continuous infusion of biological liquids at lower rates than has heretofore been possible. Since the orifice formed in the pump of this invention, by adjustment of the pressure plates whereby the tube is not completely closed, is a continuously moving one, any particles which lodge therein are immediately released as the pressure point is moved away.

The simple feature of using the orifice formed by a deformed tube to regulate the pressure developed by cyclic deformation of the same tube is a most important feature of the present invention.

The following comparative table of delivered volume of liquid and tube sizes is given by way of example:

Tube Sizes	Volume/Revolution, Approximate, cc.
I.D. O.D.	
1/8 x 3/32	2.7
5/16 x 5/64	6.2
1/4 x 3/32	11
5/16 x 5/64	17
3/8 x 3/32	26
7/16 x 7/64	33

I claim:

1. A liquid transfer machine comprising a frame, a driven shaft journalled therein, a pair of annular plates fixed together in spaced relation to each other, said plates being axially adjustably fixed to said frame in coaxial relation to said shaft, a third plate having a hub tiltably mounted on said shaft and a peripheral portion disposed between said annular plates, said shaft having an eccentric portion engaging said hub to impart tilting movement to said hub and third plate on revolution of said shaft, a pair of flexible tubes each having a loop disposed between the peripheral portion of said third plate and one of said annular plates, each said annular plate having on the inner surface thereof a plurality of radially extending ribs engaging one of said tube loops, said third plate compressing said tube loop against said ribs on tilting movement thereof, means for feeding liquid to one end of each of said tubes, and means for discharging liquid from the other end of each of said tubes.

2. A liquid transfer machine comprising a frame, a driven shaft journalled therein, a pair of annular plates fixed in spaced relation to each other, said plates being fixed to said frame in coaxial relation to said shaft, a third plate tiltably mounted on said shaft and having a peripheral portion disposed between said annular plates, an eccentric carried by said shaft for imparting tilting movement to said third plate on revolution of said shaft, a pair of flexible tubes each having a loop disposed between the peripheral portion of said third plate and one of said annular plates, each said annular plate having on the inner surface thereof a plurality of radially extending ribs for engagement with one of said tube loops, means for feeding liquid to one end of each of said tubes, and means for discharging liquid from the other end of each of said tubes.

3. A liquid transfer machine comprising a frame, a driven shaft journalled therein, a pair of annular members fixed to said frame in spaced relation to each other and in coaxial relation to said shaft, each said member having

a series of uniformly spaced radially extending ribs, the outer surfaces of said ribs of each member being coplanar, a plane plate tiltably mounted on said shaft and having a peripheral portion disposed between and in spaced relation to said annular members, eccentric means for imparting tilting movement to said plate on revolution of said shaft, a pair of flexible tubes each having a loop disposed between the peripheral portion of said plate and one of said annular members for engagement of said ribs therewith, means for feeding liquid to one end of each of said tubes, and means for discharging liquid from the other end of each of said tubes.

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