

July 29, 1941.

J. M. WEYDELL

2,251,235

PUMP

Filed April 25, 1940

2 Sheets-Sheet 1

Fig. 1.

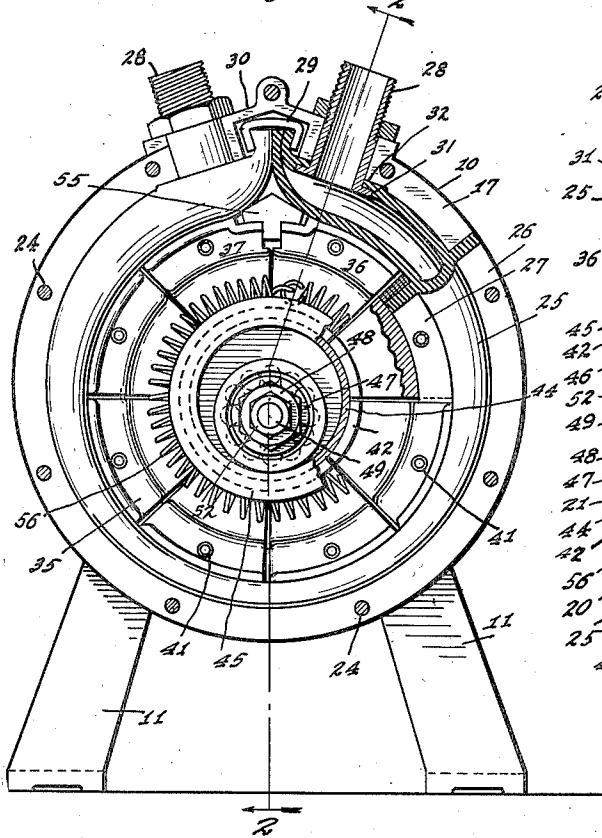


Fig. 2.

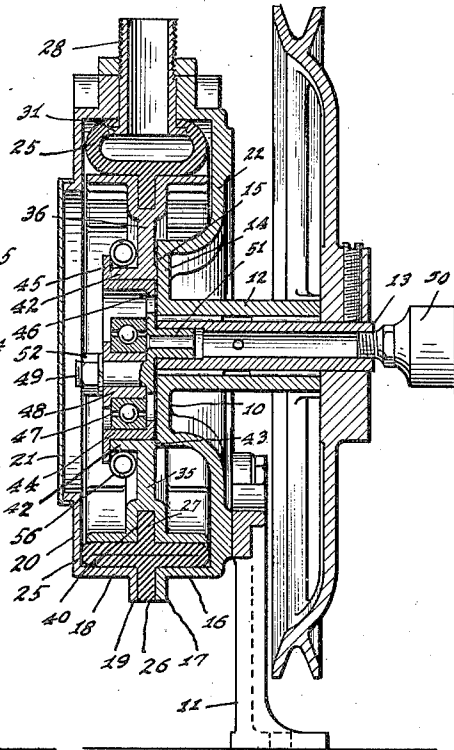


Fig. 3.

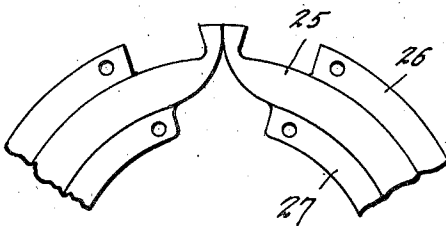
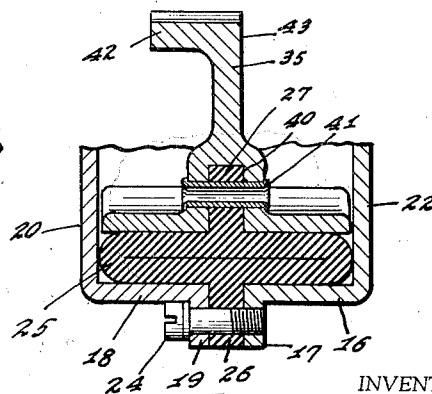


Fig. 4.



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Fig. 5.

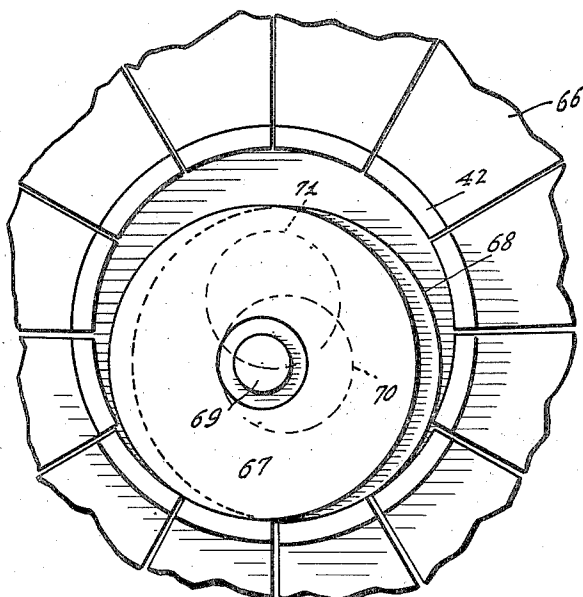


Fig. 7.

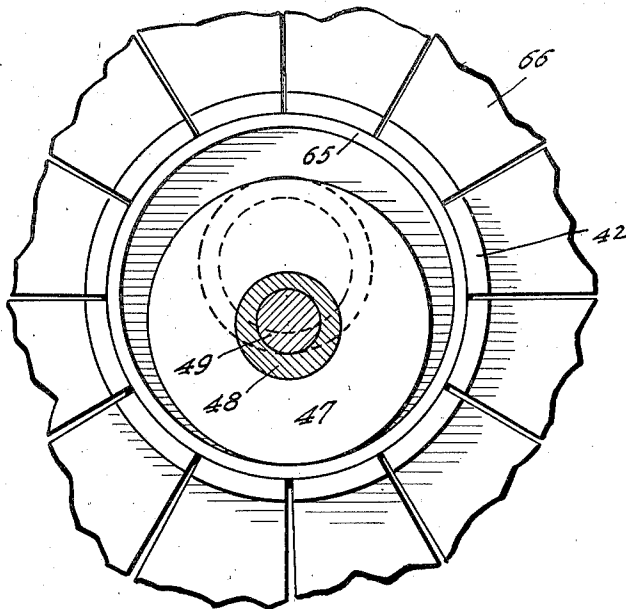


Fig. 6.

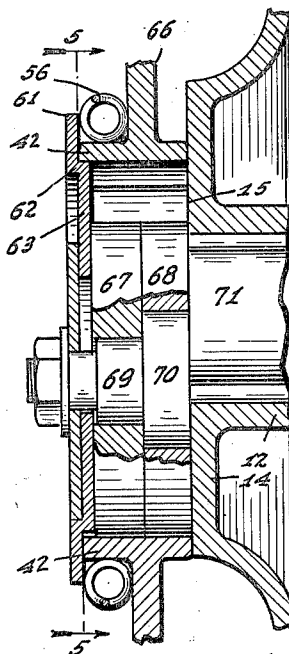
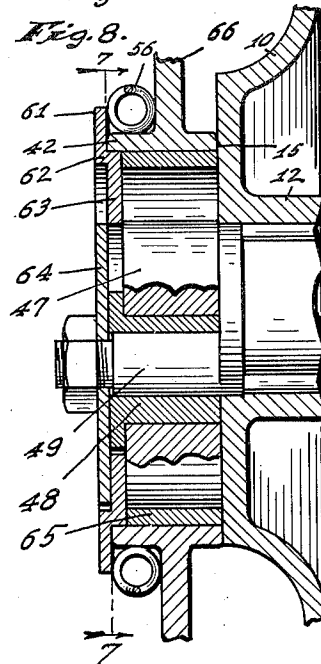


Fig. 8.



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Application April 25, 1940, Serial No. 331,522

23 Claims. (Cl. 103—149)

This invention relates to a pump of the type in which movement of fluid through an elastic tube is created by the progression therealong of means which squeezes the walls of the tube together.

It is the object of the invention to improve the construction and the operation of such a pump, so that the construction will be simple and inexpensive and will not require the use of valves, and so that in operation the pumping action will be positive and the pump may be used either as a vacuum pump or as a pressure pump.

In accomplishing these objects, the pump is provided with a casing which has a cylindrical wall with radial walls at its edges. The flexible tube is laid against the radially inward surface of the cylindrical wall between the radial walls and the outer tube-wall is secured to that surface. Inlet and outlet conduits are arranged in communication with the flexible tube at its ends, and the tube is otherwise closed. The inner tube-wall is supported by and secured to a circumferential series of segmental shoes, which may be mounted together on a supporting ring. An eccentric moves the shoes successively against the flexible tube so that the tube is compressed over an area which progresses along the tube, and simultaneously the shoes diametrically opposite from the compressing shoes are pulled inwardly to open the tube portions with which they are associated. The inlet and outlet conduits are arranged generally radially of the casing in such position that their inner ends are closed by the compression of the tube walls. Such conduits are spaced closely enough together and the area of tube compression is made large enough to cause the periods during which the respective conduits are closed to overlap, so that the discharge conduit does not open until after the inlet conduit has been closed.

The accompanying drawings illustrate my invention. In the drawings: Fig. 1 is a vertical section of a pump embodying my invention, with the front half of the pump casing removed and with part of the flexible tube and of a shoe shown in section; Fig. 2 is a vertical section taken on the line 2—2 of Fig. 1, and showing the pump with the front half of the casing and the cover plate in place; Fig. 3 is a front elevation of a portion of the flexible tube; Fig. 4 is a fragmental section on the radial center line of one of the shoes; Figs. 5 and 6 are fragmental sections of a modification of the pump of Fig. 1 in which there are two eccentric rollers, Fig. 6 being taken on the line 6—6 of Fig. 5; and Figs. 7 and 8 are frag-

mental sections of another modification of the pump of Fig. 1 in which a single roller rolls against a free shoe-supporting ring, Fig. 8 being taken on the line 8—8 of Fig. 7.

5 The pump shown in the drawings has a generally cylindrical casing, conveniently made in two halves. The rear half 10 is arranged to be mounted on a suitable pedestal 11 and comprises a central bearing sleeve 12 to receive the main 10 shaft 13. A flange 14 at the front end of the sleeve 12 provides a planar surface 15 of considerable radial extent. Beyond such radial surface 15 the casing extends rearwardly to a radial web 22 which supports a cylindrical wall 16 with 15 a flange 17 at its front edge. The front half of the casing consists of a cylindrical wall 18 whose inner surface is concentric with the inner surface of the wall 16, and which carries at its rear edge a flange 19, and at its front edge a web 20 20 which extends inwardly but which is provided with a large central inspection opening closed by a suitable cover plate 21.

The flexible tube 25 is formed of oval cross-section with ribs 26 and 27 on the minor axis of 25 the oval. The outer rib 26 is adapted to be clamped between the flanges 17 and 19 of the casing halves by bolts 24, with the outer tube-wall against the cylindrical wall 16—18, and the width of the tube is such that it will be supported 30 in operation by the two radial webs 20 and 22. Near each end of the tube there is an opening for the reception of a nipple 28, and the ends of the tube are clamped together by means of a U-shaped clamp 29, the casing halves being suit- 35 ably formed to receive the nipples 28 and the clamp 29. The nipples 28 are circumferentially spaced only enough to leave room for the clamp 29 and the tube-ends which it embraces. The rib 26 of the flexible tube 25 is cut off so that its 40 ends will abut the conduits 28, and the space between the flanges 17 and 19 beyond the conduits 28 is filled by a suitable spacer 30. Flanges 31 at the inner ends of the nipples 28 clamp the edges of the conduit-receiving holes in the tube 45 25 against a flat in the cylindrical wall of the casing to seal its edges; the end faces on the flanges 31 being positioned to be engaged by the inner tube-wall when the tube 25 is collapsed, to close the nipples 28.

50 A circumferential series of shoes 35—37 bear against and support the inner tube-wall. These shoes are generally T-shaped in cross-section, and have a cylindrical outer face with a circumferentially extending slot in the center thereof for the reception of the inner rib 27 of the tube

25. The rib 27 is secured to each shoe 35—37, as by a single rivet 41 passing through aligned holes in the walls of the groove 40 and the rib 27 at the center of the shoe. The inner ends of each shoe has a foot 42, the heel portion of which provides a bearing surface 43 adapted to bear against the planar surface 15 on the rear half-casing. The feet 42 are of considerable axial extent and have a cylindrical bearing surface. In the pump of Fig. 1, the feet 42 fit against and are supported by the cylindrical surface of a cup 44, which is of Z-shaped cross-section so that it has an outer flange 45 which overlies the forward ends of the feet 42, and an inner flange 46 which lies behind the outer race of a ball bearing 47 that rolls on the inner surface of the cylindrical wall and is mounted on the crank arm 49 carried by the shaft 13. A flanged eccentric sleeve 48 interposed between the ball bearing 47 and the crank arm 49 permits adjustment of the overall eccentricity.

Conveniently, as shown in Fig. 2, the shaft 13 is a hollow shaft suitably threaded at one end for the reception of a grease cup 50 and drilled at the other end for the reception of a pressed fit of the shank 51 of the crank 49. The shank 51 is desirably drilled with a hole whose end is only slightly exposed beyond the outer surface of the inner ball race, and the shaft 13 has a radial hole intermediate its ends, so that the hollow shaft 13 may serve as a grease reservoir from which both the ball bearing 47 and the bearings for the shaft 13 may be lubricated, the grease being supplied from the grease cup 50.

The eccentric sleeve 48 between the inner ball race and the crank arm 49 is clamped in desired position on the crank arm 49 by the nut 52. Its front flange overlies the inner race of the ball bearing 47, and thus holds the outer race against the inner flange 46 of the cup so that the cup through its outer flange 45 holds the shoes in position with their bearing surfaces 43 against the planar surface 15. The grooves 40 which receive the inner ribs 27 of the tube 25 are so positioned with respect to the bearing surfaces 43 that they hold the two ribs 26 and 27 in radial alignment. In the pump of Figs. 1 and 2, this is accomplished by making the flange 17 co-planar with the planar surface 15, and the rear wall of the rib groove 40 co-planar with the bearing surfaces 43.

Desirably, there are a relatively large number of shoes 35—37, and I prefer to use as large a number as is conveniently practical consistent with economy of manufacture, eight shoes being shown in Figs. 1 and 2. The six shoes 35 are identical, and the other two shoes 36 and 37 which engage the ends of the tube 25 and which underlie the inlet and outlet conduits 28, have adjacent ends of both their outer faces and their radial surfaces cut away for the reception of a resilient filler block 55.

The shoes 35—37 are spaced slightly from each other and are yieldingly held against the cup 44 by means of a helical spring 56 which overlies the forwardly extending portions of their feet 42 and lies behind the outer edge of the cup-flange 45.

The throw of the crank 49 is sufficient to move the cup and its associated shoes out of concentricity with the casing sufficiently to completely collapse the flexible tube 25 and to squeeze the tube-walls together. The squeeze on the tube walls may be adjusted by turning the eccentric sleeve 48 on the crank 49 to prevent flow of the

fluid being pumped past the point of compression under the pressure at which the pump is to work. A greater working pressure on the fluid than that for which the squeeze is adjusted will tend to force fluid past the area of squeeze, to limit the working pressure in accordance with the squeeze adjustment and act as a relief for any greater pressure. Adjustment of the eccentric sleeve 48 will also increase or decrease the circumferential extent of the area over which the tubing walls are in engagement, and will likewise increase or decrease the period during which the tube walls are pressed against the respective flanges 31 to close the nipples 28, to change the time at which the discharge nipple opens with respect to the time at which the inlet nipple closes.

In operation of the pump of Figs. 1 and 2, rotation of the crank shaft 13—49 rolls the outer ball-race around the inner surface of the cup 44 to move that cup, desirably with little rotation, in a circular orbit around the axis of the shaft 13. This movement carries the shoes 35—37 progressively and successively outward toward the casing at one progressing circumferential portion of the cup 44 and inwardly away from the casing at the opposite circumferential portion of the cup 44. Thus about half of the shoes are moving outwardly and half are moving inwardly at all times. Those which are moving outwardly are moving to compress the tube 25 to force any fluid therein in the direction of rotation. The last of the outwardly-moving shoes completely collapses the tube and squeezes its walls together, to an extent depending on the adjustment of the eccentric sleeve 48, to seal the tube at that point against flow of any fluid in the tube in a direction opposite to that of rotation.

The shoes which are moving in an inward direction are held against the cup by the helical spring 56 and positively pull the tube to open position, to draw into the associated portion of the tube a supply of fluid through the inlet conduit 28.

I have found that with my segmental shoe construction the severe tendency which would otherwise be created to move the inner wall of the tube 25 circumferentially with respect to the outer wall is greatly reduced, to within a practical limit for long and satisfactory operation. I believe the explanation for this is as follows.

During the simultaneous movement of all the shoes they tend to move in a circular orbit, and the group of shoes tends to rotate in a direction opposite to that of the crank shaft. By reason of their separation and the elasticity of the rib 27 and spring 54 through which they are interconnected, they are permitted to move in a circumferential direction with respect to each other and to the cup 44, to change the clearance space between them. The relative circumferential movement thus provided changes the shape of the orbit through which they move, to decrease the circumferential component of their movement relative to the pump casing. Moreover, by this movement relative to each other, they move apart during their outward movement and are spaced apart when they approach and pass through the period during which they squeeze the tube-walls together. This is believed to give them a greater effective circumferential length substantially equal to the circumferential length of the path against which the shoes as a group roll, which permits the group of shoes to avoid any backward rotation with respect to the pump casing and thus to avoid rubbing the tube-walls against

each other and to substantially reduce the circumferential pull on the inner tube wall.

It is to be noted that the cup 44 performs two distinct and separable functions: first, it acts as a backing support for the several shoes and prevents their movement inwardly to a position in which they rub together and might become wedged together; second, it serves to transmit the force from the rolling ball-race 47 to the shoes and presents a smooth surface for such race to roll on.

In the pump of Figs. 7 and 8, these two functions are separately performed. The shoe-support is provided by a ring formed with an outer flange 61 overlying the ends of the feet 42, a short axial wall 62 against which the feet 42 are held by the spring 56, and an inner annular wall 63 by which the ring is held in place. The wall 63 has a central opening large enough to avoid interference with the crank 49, or the flange of the sleeve 48 carried thereby, during its revolution, and is engaged and held rearward by a large washer 64 carried by the crank 49 behind the nut at its end. The eccentric roller 47 rolls against a free race 65 which is of substantially the same outside diameter as the wall 62 of the shoe-supporting ring and is free to move circumferentially with respect to the shoes and to the shoe support. If desired the race 65 may be the outer ball race of a ball bearing mounted on a crank 49 of suitable throw to give the desired shoe movement.

The pump has no separate valves, for the inner ends of the inlet and outlet conduits 28 are arranged to be closed by the pressing of the inner wall of the tube 25 against such inner ends. Desirably, the arrangement is such that the inlet conduit will be closed before the discharge conduits opens, so that there will be no loss of either pressure or vacuum by any reverse flow through the tube. To this end in the pump of Figs. 1 and 2, the inlet and outlet conduits 28, although disposed in a generally radial direction, are not precisely radial. Instead, they are inclined away from each other so that their center lines cross at a point spaced toward them from the axis of the shaft 13. This spacing is equal to about half the throw of the crank, and is located in Fig. 1 at the apex of the angle in the section line 2—2. Because of this inclination of the conduits 28 the inner wall of the tube 25 does not leave the rearward edge (in the direction of rotation) of the discharge opening to unseal that discharge opening until after the portion of the inner wall which is associated with the inlet conduit is pressed against the forward edge of such inlet conduit to complete the closing of that inlet conduit.

This inclination of the nipples 28 has a further function. When the point at which the tube 25 is closed approaches the discharge conduit, pressure will be built up at the discharge end of the tube and will tend to force the fluid in the tube past the discharge conduit and into the small portion of the tube which lies therebeyond. But the slight inclination of the discharge nipple 28 places its forward edge slightly farther from the center of the casing than its rearward edge, and delays the final closing of the discharge nipple to permit fluid which has been forced past the nipple to escape back through that discharge nipple. This final discharge of the last portion of fluid in the tube 25 is assisted by the use of the resilient filler block 55, which by reason of its raised central portion tends to progressively squeeze the tube together from its end rearward-

ly. Thus, during the final portion of the discharge action the tube is squeezed together simultaneously from both ahead and behind the discharge nipple. Similarly, as compression of the tube at the inlet end thereof starts, the filler block 55 first presses together the walls of the tube which lie between the closed end thereof and the inlet nipple 28.

Where it is not conveniently practical to obtain the desired overlap of the closings of the discharge and inlet openings by the arrangement just described, as where the nipples 28 must be spaced apart a distance such that the desired or obtainable circumferential length of the area of squeeze contact of the tube-walls will not cover both nipples 28 simultaneously, and where the slight inclination of the nipples will not overcome the deficiency; the result may be obtained by the modified arrangement shown in Figs. 5 and 6.

The pump shown in Figs. 5 and 6 has a casing like that of Figs. 1 and 2 save that the planar surface 15 is positioned somewhat rearwardly from its position in Figs. 1 and 2, and the feet 42 on the shoe segments 66, are of correspondingly greater axial extent, to provide space for two rollers 67 and 68 in place of the single roller of the modifications of Figs. 1-2 and 7-8. The two rollers 67 and 68 are shown for simplicity as plain rollers, although in actual practice suitable anti-friction bearings should be provided. The rear roller 68 is mounted on a large eccentric journal 70 carried by the main shaft 71, and has an axial extent of about half the axial width of the feet 42 and behind the central plane of the shoes 66. The front roller 67 is mounted on an eccentric 69 which is smaller than the eccentric 70 and is carried thereby wholly within the circumference of the eccentric 70. The eccentricity of the eccentric 69 is the same as that of the eccentric 70 but its axis is angularly displaced from the axis of the eccentric 70 about the axis of the main shaft 71 so that the point of contact of the rollers 67 and 68 are correspondingly displaced from each other circumferentially of the inner face of the feet 42 of the shoes 66.

In this two roller modification the rollers roll against the inner faces of the feet 42, without the intervening race 65 or cup 44. The shoes are supported, however, by a ring 61-63 and held against such ring by a spring 56 or by a loosely fitting solid ring (not shown) so that they tend to move in the same way as in other modifications, to cause simultaneous closing of the flexible tube at one side and opening of the tube at the other side. This action is modified, however, by slight movement of the shoes engaged by the rollers 67 and 68 away from the wall 62 of the supporting ring, and the tension of the spring 56 (or size of the loosely fitting solid ring) is adjusted to permit such separation. The separation of the shoes from the ring 61-63 which is desirably permitted is only sufficient to allow the rollers to have some independent action on the shoes, to create two angularly displaced points of pressure at the area over which the tube-walls are squeezed together. The squeeze area is thereby extended in circumferential length, to cover both the inlet and the outlet ports of the pump.

While this two-roller arrangement does not provide a continuous smooth surface for the rollers to engage, the variations from smoothness are minimized by the use of the ring 61-63

and the spring 56 or other means to hold the shoes against excessive separation therefrom; and the effect of such variations on operations is further minimized by the use of large rollers 67 and 68 displaced only sufficiently to provide the desired extension of the squeeze area.

It will be noted that the tube 25 is supported on all four sides—on its outer side by the cylindrical wall of the casing, on its inner side by the shoes 35—37, and at its front and rear by the radial walls of the casing. By reason of this full support for the tube 25 the pressure at which the pump may work is increased well beyond what would be possible if the pressure was held only by the strength of the elastic tube.

The pump may operate in either direction and may be used either as a pressure pump or as a vacuum pump. It may be adapted for use with a wide variety of materials. Its flexible tube 25 may be made of rubber or of any other desirable material which is resistant to any corrosive action of the material to be pumped. Similarly, the nipples 28 may be made of a material which is resistant to attack by the fluid it is desired to pump. Thus, by making the tube 25 and nipples 28 of suitable material, the pump may be used for liquids, such as water, acids, oils, gasoline, etc., or for gases.

I claim as my invention:

1. A pump, comprising a casing having a cylindrical inner wall, a flexible tube lying against said casing wall, means securing the outer tube-wall against said casing wall; a circumferential series of individual shoes bearing against the inner tube-wall and secured thereto, means to successively move said shoes to compress said tube and simultaneously move the diametrically opposite shoes to open said tube, and inlet and discharge ports communicating with said tube at its ends.

2. A pump, comprising a casing having a cylindrical inner wall, a flexible tube lying against said casing wall, means securing the outer tube-wall against said casing wall; a longitudinal rib on the inner tube-wall extending radially inward with respect to the casing, and a circumferential series of shoes bearing against the inner tube-wall, embracing said rib, and secured thereto, means to successively move said shoes to compress said tube, and inlet and discharge ports communicating with said tube at its ends.

3. A pump, comprising a casing having a cylindrical inner wall, a flexible tube lying against said casing wall, a rib on the outer tube-wall secured in said casing behind the cylindrical surface thereof; a longitudinal rib on the inner tube-wall extending radially inward with respect to the casing, and a circumferential series of shoes bearing against the inner tube-wall, embracing said rib, and secured thereto, means to successively move said shoes to compress said tube, and inlet and discharge ports communicating with said tube at its ends.

4. A pump, comprising a casing having a cylindrical inner wall, a flexible tube lying against said casing wall, means securing the outer tube-wall against said casing wall; a longitudinal rib on the inner tube-wall extending radially inward with respect to the casing, a circumferential series of shoes bearing against the inner tube-wall, said shoes having means embracing said rib and being individually secured to said rib adjacent to their radial center lines, means to successive-

ly move said shoes to compress said tube, and inlet and discharge ports communicating with said tube at its ends.

5. A pump, comprising a casing having a cylindrical inner wall, a flexible tube lying against said casing wall, means securing the outer tube-wall against said casing wall; a circumferential series of shoes bearing against the inner tube-wall and individually secured thereto adjacent to their radial center lines, said shoes being spaced to provide clearance between them, a backing ring for said shoes, and bearing surfaces on said shoes, means to successively move said shoes to compress said tube, and inlet and discharge ports communicating with said tube at its ends.

6. A pump, comprising a casing having a cylindrical inner wall, a flexible tube lying against said casing wall, means securing the outer tube-wall against said casing wall; a circumferential series of shoes bearing against the inner tube-wall and individually secured thereto adjacent to their radial center lines, said shoes being spaced to provide clearance between them, a backing ring for said shoes, and bearing surfaces on said shoes, means for holding said shoes against said backing ring and means for moving said backing ring eccentrically to successively move said shoes to compress said tube and simultaneously move the diametrically opposite shoes to open said tube, and inlet and discharge ports communicating with said tube at its ends.

7. A pump, comprising a casing having a cylindrical inner wall, a flexible tube lying against said casing wall, means securing the outer tube-wall against said casing wall, a circumferential series of shoes bearing against the inner tube-wall and individually secured thereto adjacent to their radial center lines, said shoes being spaced to provide clearance between them, a backing ring for said shoes, and bearing surfaces on said shoes, and an elastic ring holding said shoes against said backing ring, means to successively move said shoes to compress said tube and simultaneously move the diametrically opposite shoes to open said tube, and inlet and discharge ports communicating with said tube at its ends.

8. The pump as defined in claim 5 in which the backing ring forms a race in engagement with said bearing surfaces and the shoe moving means comprises an eccentric operating on said race.

9. The pump as defined in claim 5 in which there is a race fitting against said bearing surfaces and said shoe moving means comprises an eccentric operating on said race.

10. The pump as defined in claim 5 in which said shoe moving means comprises a plurality of angularly spaced eccentric rollers rolling against said bearing surfaces of the shoes, and means for limiting separation of said shoes from the backing ring.

11. A pump as defined in claim 1, in which the inlet and discharge ports are formed by conduits extending generally radially of the casing and are positioned to be closed by movement of the inner tube-wall against their ends.

12. A pump as defined in claim 1, in which the inlet and discharge ports are formed by conduits extending generally radially of the casing and are positioned to be closed by movement of the inner tube-wall against their ends, the end surface of at least one of said conduits being inclined from tangential with respect to the casing, whereby the time of opening of the dis-

charge conduit is delayed with respect to the time of closing the inlet conduit.

13. A pump, comprising a casing having a cylindrical inner wall, an elastic tube lying against said wall and secured thereto, inlet and discharge ports communicating with said tube, a segmented annular structure engaging the inner tube-wall, means securing the segments of said structure individually to said inner tube-wall, means for holding said segments in annular relationship and permitting limited circumferential relative movement between them, and a rotatable eccentric acting progressively on said structure to simultaneously close a portion of said tube and open another portion of said tube.

14. A pump, comprising a casing having a cylindrical inner wall, an elastic tube lying against said wall and secured against circumferential movement with respect thereto, inlet and discharge ports communicating with said tube, a segmented annular structure engaging the inner tube-wall, means for holding said segments in annular relationship and permitting limited circumferential relative movement between them, and an eccentric acting on said structure to simultaneously close a portion of said tube and permit the diametrically opposite portion of said tube to open.

15. A pump, comprising a casing having a cylindrical inner wall, an elastic tube lying against said wall and secured thereto, inlet and discharge ports communicating with said tube, a segmented annular structure engaging the inner tube-wall, an elastic reinforcement carried by said inner tube-wall to which the segments of said annular structure are individually secured whereby circumferential stretching of said reinforcement separates said segments, and a rotatable eccentric acting progressively on said structure to simultaneously close a portion of said tube and open another portion of said tube.

16. A pump, comprising a cylindrical wall, an elastic tube having one tube-wall in engagement with and secured to said cylindrical wall, ports in communication with said tube, a ring, a series of individual shoes circumferentially movable on said ring and extending therefrom into engagement with the other tube-wall and secured thereto, and eccentric means acting progressively on said ring and shoe structure to close a portion of said tube and simultaneously open another portion of the tube.

17. A pump, comprising a casing having a cylindrical inner wall, an elastic tube lying against said wall and secured thereto, inlet and discharge

ports communicating with said tube, an annular series of shoes engaging and individually secured to the inner tube-wall, said annular series of shoes having a normal circumference smaller than the circumference of a inner tube-wall when said tube is collapsed, said shoes being yieldingly interconnected and separable from each other at their periphery an aggregate distance substantially equal to the difference between said circumferences and a rotatable eccentric acting progressively on said annular series of shoes.

18. A pump, comprising a casing having a cylindrical wall, an elastic tube lying against said cylindrical wall, an inlet and an outlet port communicating with said tubes, tube-supporting radial walls at the edges of said cylindrical wall, an annular series of individual shoes bearing against the free wall of said tube in supporting relationship thereto, and means for moving said shoes successively to compress said tube.

19. A pump as defined in claim 13 with the addition of tube-supporting radial walls at the edges of said cylindrical wall.

20. A pump, comprising a casing having a cylindrical inner wall, a flexible tube lying against said casing wall, means securing the outer tube-wall against said casing wall; a circumferential series of individual shoes bearing against the inner tube-wall and secured thereto, means to successively move said shoes to compress said tube and simultaneously move other shoes to open said tube, and inlet and discharge ports communicating with said tube at its ends.

21. A pump as defined in claim 20 with the addition of tube-supporting radial walls at the edges of said cylindrical wall.

22. A pump, comprising a cylindrical wall, an elastic tube extending circumferentially against said wall, inlet and outlet ports for said tube, an annular series of separable shoes positioned against said tube on the opposite side thereof from said cylindrical wall, and a rotatable eccentric acting progressively on said shoes to cause them to close said tube.

23. A pump, comprising a cylindrical wall, an elastic tube extending circumferentially against said wall, inlet and outlet ports for said tube, an annular series of separable shoes positioned against said tube on the opposite side thereof from said cylindrical wall, and a plurality of rotatable eccentrics acting progressively at circumferentially spaced points on said series of shoes to cause said shoes to close the tube.

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