July 29, 1947. C. F. WARREN 2,424,595

PUMPING MECHANISM

Filed March 13, 1944 3 Sheets-Sheet 1

Fig. 1.

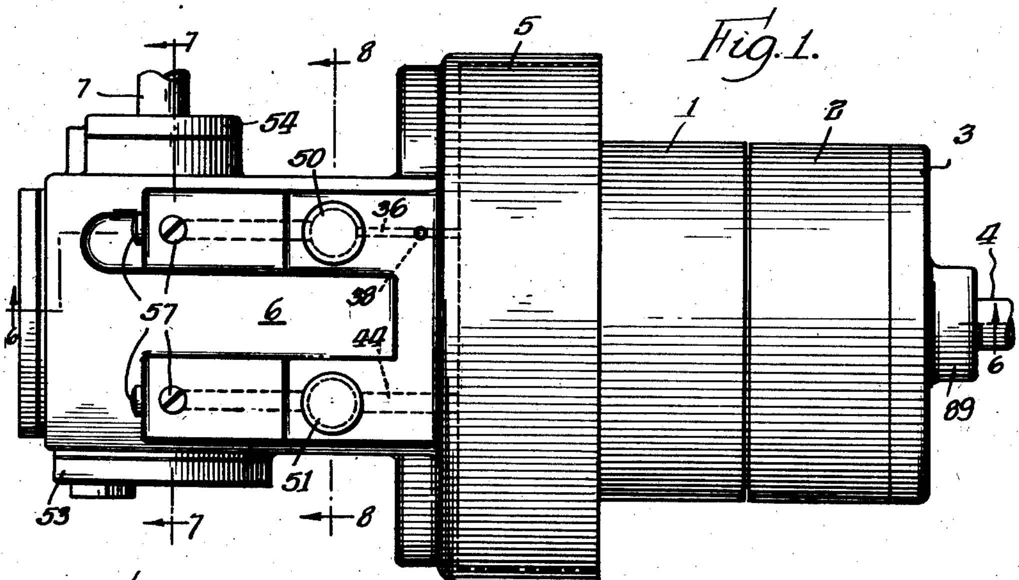


Fig. 2.

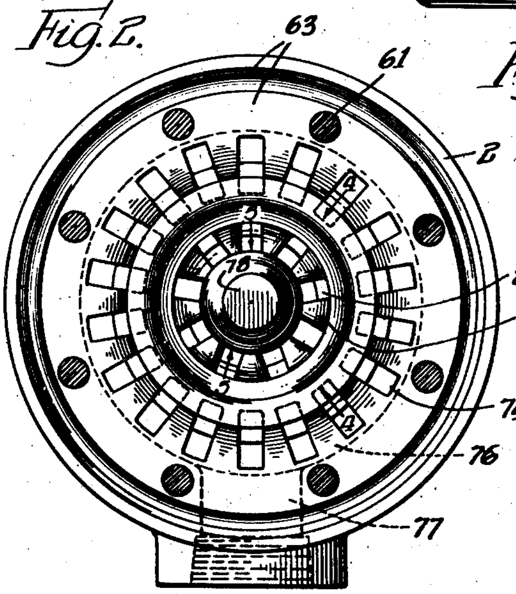


Fig. 3.

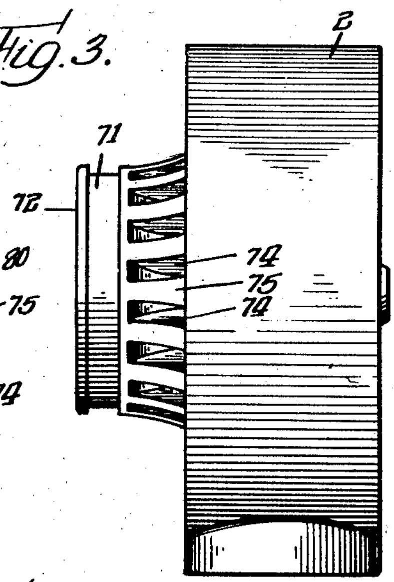


Fig. 4.

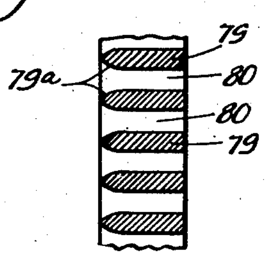
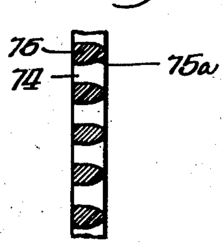


Fig. 5.



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PUMPING MECHANISM

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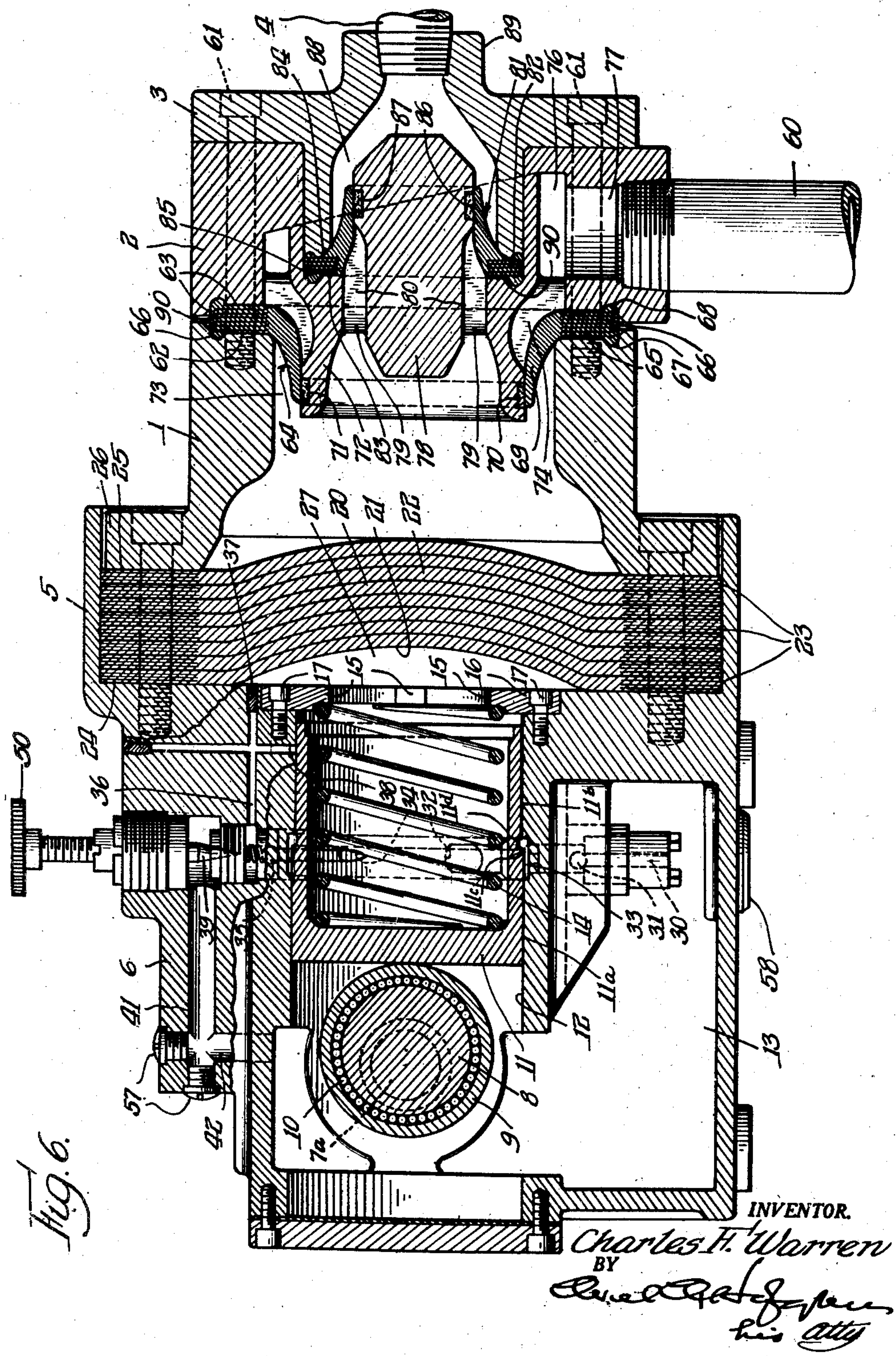

Fig. 6.

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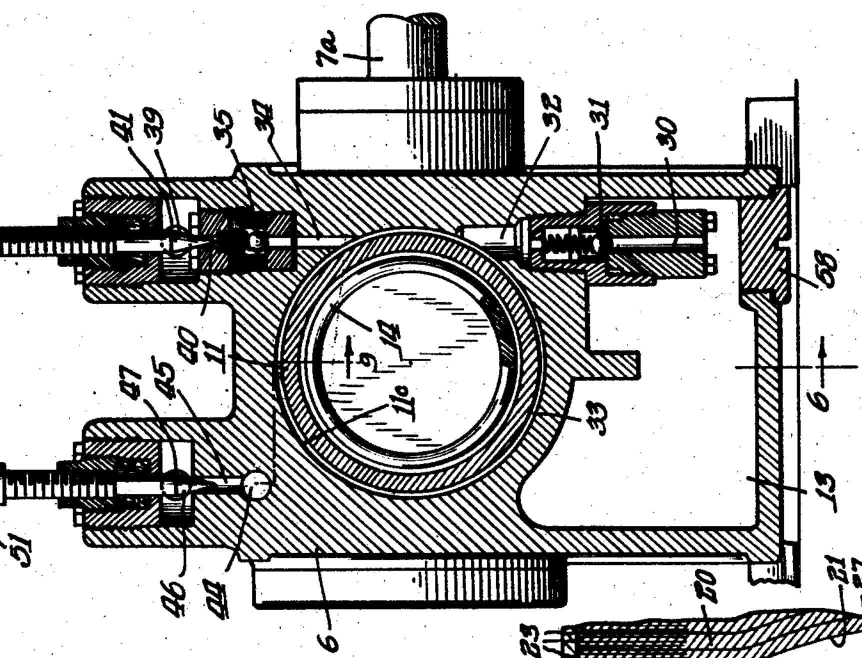

Fig. 8.

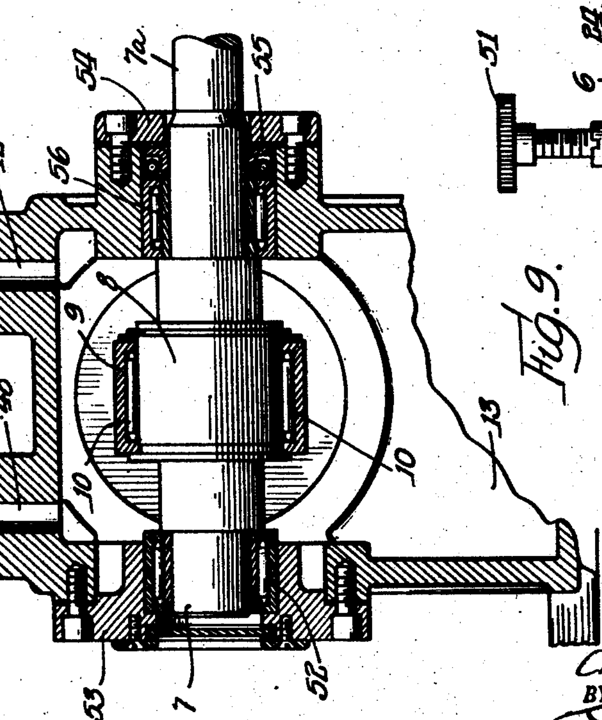

Fig. 7.

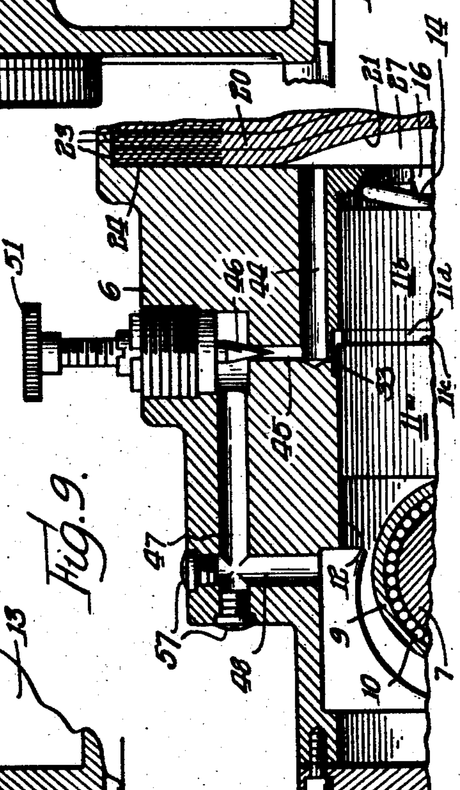

Fig. 9.

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UNITED STATES PATENT OFFICE

2,424,595

PUMPING MECHANISM

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Application March 13, 1944, Serial No. 526,188

12 Claims. (Cl. 103—44)

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This invention relates to a pumping mechanism include driving means therefor, especially designed to employ a diaphragm as the movable element of the pump and to displace the diaphragm through the medium of a liquid column as the means by which motion is communicated to the diaphragm.

One object of the invention is to provide a new and improved pumping mechanism including hydraulic actuating means.

Another object of the invention is to provide a pumping device in which a pumping chamber is provided with a movable wall of flexible material and a reciprocatory piston is operatively connected with such wall through the medium of a confined quantity of fluid, pre-loaded to a desired pressure and pre-stretching the movable wall so that each reciprocation of the piston produces a corresponding vibration of the diaphragm, enlarging and then reducing the volume of the pumping chamber.

It is also an object of the invention to provide an actuating mechanism for a diaphragm pump in which a reciprocating piston is arranged to transmit its movement to the diaphragm through a confined column of liquid, and the motion of the piston is also utilized in a structure comprising a make-up pump for replacing leakage of the fluid and maintaining it at a predetermined pressure with a resultant predetermined tension on the movable wall.

The invention is also concerned with the provision of check valves of a novel type in which a ring of flexible elastic material is made of radially tapering thickness, and is mounted with its thicker edge clamped in fixed position and with its thinner portion formed out of the plane of the thicker portion for seating engagement against an annular surface.

It is also an object of the invention to arrange such a valve member with its thinner flexilbe portion extending across an annular passage for the fluid so that the flow in one direction tends to force the thin portion of the valve member off its annular seat while flow in the opposite direction tends to wedge it more tightly into seating relation.

Other objects and advantages of the invention will appear from the following description taken in connection with the drawings in which:

Fig. 1 is a top plan view of a pumping mechanism embodying this invention.

Fig. 2 is a transverse sectional view taken substantially as indicated at line 2—2 on Fig. 1, but on a larger scale, and with the valves omitted.

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Fig. 3 is a side elevation of the valve section of the pump disassembled from the remaining parts of the mechanism.

Fig. 4 is a detail section taken as indicated at line 4—4 on Fig. 2.

Fig. 5 is a detail section taken as indicated at line 5—5 on Fig. 2.

Fig. 6 is a longitudinal vertical section of the pumping mechanism taken substantially as indicated at line 6—6 on Fig. 1, and on the same scale as Figs. 2 and 3, but with a portion of the view taken as a section at the line 6—6 on Fig. 8.

Fig. 7 is a fragmentary transverse section taken as indicated at line 7—7 on Fig. 1.

Fig. 8 is a transverse vertical section taken as indicated at line 8—8 on Fig. 1.

Fig. 9 is a fragmentary vertical section taken as indicated at line 9—9 on Fig. 8.

While the invention is susceptible of various modifications and alternative constructions, the embodiments shown in the drawings and described hereinafter are by way of preferred illustration only, and it is not intended that the invention be limited thereto or thereby, but it is the intention to cover all modifications and alternative constructions falling within the scope of the invention as defined by the claims.

The pumping mechanism which is the subject of this invention is applicable to a wide variety of uses, and is compactly designed so that, when desired, it may be portably mounted. Fig. 1 indicates the external appearance of the unit as assembled, with the pumping chamber 1 and valve chamber 2 connected in axial alignment, and provided with an end wall or cover plate 3 into which an outlet or discharge pipe 4 is coupled. The portion 5 of the casing encloses the working diaphragm of the pumping chamber with the pump chamber 1 and valve chamber 2 arranged at one side of the diaphragm, and with the actuating mechanism enclosed in a housing 6 which, as shown, is integral with the part 5. A rotary driving shaft 7 is journaled in the housing 6, and mechanism for converting the rotary motion of the shaft 7 into vibratory motion of the diaphragm is contained within the housing 6.

By reference to Fig. 6 it will be seen that the shaft 7 includes an eccentric portion 8 on which there is rotatably carried a ring 9 with needle rolls 10 interposed to reduce friction between the eccentric 8 and the ring 9. Said ring 9 bears against the end wall of a piston 11 which is mounted for reciprocation within a cylinder 12 formed in the housing 6. The lower portion of the housing constitutes a crank case 13 serving as a reservoir for oil or similar fluid which is employed as the hydraulic medium for transmitting motion from the piston 11 to the diaphragm of the pump.

The piston is yieldingly urged toward and maintained in contact with the ring 9 by means of a spring 14 which is pocketed within the hollow piston 11. One end of the spring 14 is seated against the end wall of the piston 11 while the opposite end is supported by lugs 15 projecting inwardly from a ring 16 which is secured, as by screws 17, at the outer end of the cylinder 12. Thus, as the shaft 7 revolves, the eccentric 8, with the anti-friction ring 9 interposed, cooperates with the spring 14 to reciprocate the piston 11 in the cylinder 12. The eccentricity is relatively small so as to give the piston a short stroke, suitable for high speed operation.

Directly opposite the open end of the piston 11 is the multiple diaphragm 20, which may be composed mainly of sheets of rubber, but in which the layer 21 adjacent the cylinder 11 is preferably Neoprene or similar oil-resisting, synthetic material, since it is the intention to employ a quantity of oil confined between the cylinder 11 and the diaphragm 20 for actuating the latter. If the pump is to handle oil or other fluid which would attack natural or synthetic rubber, the outer layer 22 may also be of Neoprene or like material. It may be understood that the several layers of the diaphragm 20 are preferably of circular outline, and, as indicated in Fig. 6, each layer has embedded in its marginal portion a plurality of rings of reinforcing fabric, as seen at 23 in Fig. 6. These rings are spaced apart at substantially uniform intervals, and thus serve to limit the compressibility of the annular portions of the flexible diaphragm layers when the diaphragms are clamped in position between the shoulder 24 of the casing 5 and the shoulder 25 on a flange 26 of the pump chamber 1. The portion of the housing designated as 5 in Figs. 1 and 6 is a thin annular wall which encloses the edges of the diaphragms and telescopes over the flange 26 to give the assembly a neat external appearance, and prevent the radial expansion of the diaphragm when under high pressure.

Necessarily, for proper operation, the diaphragm layers are initially bulged away from the piston 11, forming a space 27, as seen in Fig. 6. These layers are nested together, as seen in Fig. 6. For diaphragms of ten to twelve inches in diameter, it is found satisfactory to make each layer about one-quarter of an inch thick, and by experiment it has been found that an assemby of eight layers is somewhat more efficient than a lesser number, whereas an increase in the number of layers above eight does not appear to improve the operation. With the proportions indicated, and when under pre-tension the diaphragm responds promptly and sensitively to the pulsations produced by reciprocation of the piston 11, and operates effectively to create alternate suction and pressure in the pumping chamber 1 for moving liquid therethrough.

The oil or like fluid which is employed for transmitting movement from the piston 11 to the diaphragm 20 is arranged to be derived in the present construction from the reservoir 13 by way of an intake passage 30 leading past a check valve 31 and through a duct 32 which intersects an annular chamber 33 formed in the wall of the cylinder 12 so as to encircle the piston 11 therein. Preferably, the rear portion 11^a of the piston is made of slightly larger diameter than the forward portion 11^b, and the shoulder 11^c, which marks the forward end of the larger portion 11^a, is positioned to reciprocate within the annular chamber 33 so that the piston will operate as a make-up pump. If desired, this shoulder may be more sharply defined by forming an annular groove 11^d in the piston 11, with the shoulder 11^c as one wall of the groove. Thus, as the piston reciprocates, the portion 11^a, moving rearwardly (that is, to the left of the structure, as seen in Fig. 6), enlarges the capacity of the annular chamber 33, causing oil to be sucked into it by way of the check valve 31 and passage 32. Then on the return stroke, the larger part 11^a of the piston displaces a portion of the oil in the annular space 33, forcing it upwardly through the duct 34 and past the check valve 35 into a feed passage 36, as will be clear by reference to Fig. 8. As indicated in Fig. 6, the duct or feed passage 36 extends horizontally in the casting of the housing 6, and the end of the passage is closed by a threaded plug 37. A vertical passage 38 intersects the passage 36 and leads into the cylinder 12 near its forward end (the right-hand end in Fig. 6) at a point at which said passage 38 will be uncovered by the forward end of the piston 11 when it is fully withdrawn to the extreme end of its movement toward the driving shaft 7. Thus the oil in the outlet or feed passage 34, 36, 38 can only enter the space 27 between the piston and the diaphragm during this brief interval while the piston is reversing its direction of travel, and until the oil is thus released its pressure is relieved by escape past a needle valve 39 which controls a relief port 40 just above the check valve 35 and horizontal passage 36. The fluid escaping by way of the port 40 travels through a passage 41, 42 which discharges into the crank case 13 and thus returns the oil to the supply reservoir therein.

Obviously, if the space between the diaphragm layer 21 and the end wall of the piston 11 is already filled with oil with adjustments made to provide a given working pressure and given pre-tension on the diaphragm, there will be no flow from the passage 38 into the space, even when said passage 38 is uncovered by the piston 11, and at such times substantially the entire quantity of oil pumped from the annular chamber 33 will be returned to the reservoir in the crank case 13. However, I have found it advantageous to replenish the oil confined between the piston and the diaphragm continuously while maintaining it in pre-loaded condition under the desired pressure. This continual change is accomplished by way of the escape passage 44 which leads horizontally from the space adjacent the diaphragm 21 to a connecting vertical passage 45 controlled by a needle valve 46 past which it discharges into a return passage 47, 48, spilling into the crank case 13 and returning a portion of the oil to the reservoir therein. This return flow of the oil to the reservoir, is permitted at a rate depending upon the adjustment of the needle valve 46 which may be set for a given working pressure and given pre-tension of the diaphragm; and this return flow allows some oil to be added by way of the passage 38 at the end of each piston stroke to replace the oil thus released. Thus, by adjustment of the knob 50 of the needle valve 39 and the knob 51 of the needle valve 46, the quantity supplied by the make-up piston 11a working in the annular chamber 33, may be balanced against the quantity released through the passages 44, 45, 47 and 48, and a given working pressure may thus be maintained. The adjustability of the valves 39 and 46 makes it possible to take into account any leakage which may occur past the piston 11, the effect of such leakage, of course, being added to the quantity of oil released by way of the needle valve 46.

As shown in Fig. 7, the crank-shaft 7 terminates at one end within the housing, where it is carried on needle bearings 52 mounted in a removable cover plate 53. The other end of the shaft extends at 7a for connection with any suitable driving motor, projecting through an opening in a cover plate 54 which encloses suitable packing means 55 just beyond the needle rolls 56 on which this end of the shaft is mounted. As a convenient design for manufacture, the passages 41 and 42, and also passages 47 and 48, are shown drilled through from the outer surface of the cast housing 6, and these passages are plugged at the outer ends with screw plugs 57. Any one of these plugs may be removed for the purpose of adding fresh oil to the crank case reservoir 13, and a screw plug 58 in the bottom of the crank case may be removed for draining the oil and flushing out the mechanism when required.

The pump chamber 1, into which liquid is drawn from the inlet pipe 60, and from which it is expelled through the outlet pipe 4, has connected to its outer end the annular valve chamber 2 and the front wall or cover plate 3. Countersunk cap screws 61 extend through the cover plate 3 and through the valve chamber 2 into threaded openings in the end wall of the pump chamber 1 to hold these parts in assembled relation. The end wall 62 of the chamber 1 and the opposing end wall 63 of the valve chamber 2 function as clamping jaws to secure an annular valve member of rubber or similar resilient material shown at 64. The thicker body portion 65 of this valve member is gripped between the faces 62 and 63, and the extreme marginal portion 66 is made slightly wider than the remainder of the body and is accommodated in annular grooves 67 and 68 formed in these faces 62 and 63 respectively. The inner annular portion 69 of the valve member 64 is of tapering cross-section and is formed so as to extend substantially at right angles to the body portion 65. The inner margin of the valve member thus encompasses and seats against the annular valve seat 70 which, as seen in Fig. 6, is supported in a groove 71 formed in the inner cylindrical portion 72 of the valve chamber 2. This inner portion extends rearwardly (to the left in Fig. 6) from the transverse end wall of the chamber 2, and is spaced within the chamber so as to provide an annular passage 73 across which the valve 64 extends when it contacts with the seat 70. This passage 73 connects with a series of grooves or channels 74 which alternate with intervening ribs 75 against which the resilient valve member 64 is supported. The channels 74 connect with an annular manifold 76 which has an inlet 77 leading from the lower side of said manifold and provided with threads for connection of the pipe 60 thereto. As shown, the manifold 76 is of tapered cross-section to insure distribution of the incoming fluid to the several channels 74. Thus, as the diaphragm 20 recedes from the annular mouth 73, and reduces the pressure on the outer annular face of the portion of the valve member 64 which is seated at 70, this thin edge of

the valve is expanded and unseated, and the liquid in the pipe 60 is drawn past the valve into the pumping chamber 1.

Within the inner cylindrical portion 72 of the valve chamber 2 a core 78 is supported by integral ribs 79 spaced at intervals circumferentially of the core 78 and providing channels 80 between them. These channels are closed normally by an annular valve member 81 of rubber or like resilient material, having a body portion 82 which is clamped between a shoulder 83 at the outer end of the cylinder 72 and a shoulder 84 formed on the central portion of the cover plate 3 which telescopes within the outer end wall of the chamber 2. A thickened marginal portion 85 of the valve member is accommodated in grooves adjacent these clamping faces, as seen in Fig. 6, to insure anchorage and retention of the valve in this position, and the inner annular portion of the valve member is tapered to a minimum thickness and formed at right angles to the anchored body portion 82 so as to engage an annular seat 86 lodged in a groove 87 in the core member 78. Around this end of the core, and immediately around the thinner portion of the valve member 81, an annular passage 88 is formed between the core 78 and a bore in the cover plate 3, and this passage tapers to a central outlet in a hub 89 which is threaded for connection with the outlet pipe 4.

The portions of the valve members 64 and 81 which are compressively gripped between shoulders of the structure for anchoring them in position are preferably reinforced by intermolded rings of fabric, indicated at 90, so as to somewhat limit compressibility of these portions of the valve members and permit them to be firmly clamped in place when the parts 1, 2 and 3 are assembled and secured by the clamping screws 61.

To facilitate the flow of the liquid through the channels 74 and 80, the ends of the intervening ribs 75 and 79 are tapered or streamlined, as indicated in Figs. 4 and 5. Thus, the tapered end portions 79a confront the flow of liquid as it enters passages 80 between the ribs 79 and the tapered ends 75a of the ribs 75 direct the flow into the intervening passages 74.

Because the relief passages 44, 45, 47, 48 is constantly open though restricted in flow capacity by the adjustment of the needle valve 46, there will be some fluid expelled from the space 27 between the piston and the diaphragm during each working stroke. However, any liquid so dispelled is so rapidly replaced on each make-up pump stroke that there is, in effect, no loss and a constant mean pressure is maintained as desired by the adjustment of needle valve 39 which determines the pressure under which the fluid is supplied to the space 27, and thus becomes the controlling factor in providing the proper degree of pre-loading or pre-tension on the diaphragm.

It may be pointed out that the pre-tension of the diaphragm 20 serves a dual purpose. It acts through the maintained fluid pressure to hold the piston 11 hard against the actuating eccentric 8, and at the same time the latent energy in the resilient diaphragm, which is created by putting the diaphragm under pre-stress, serves as the sole pulling factor to create the vacuum necessary for pumping liquid from the inlet pipe 60 into the pump chamber 1.

I claim as my invention:

1. A pumping mechanism comprising a pump chamber with valve-controlled intake and dis-

charge ports and an elastic diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston mounted for reciprocation therein, a column of liquid under pressure confined between said piston and said diaphragm and acting to bulge the diaphragm toward the pump chamber, and means operative to reciprocate the piston at high speed, said elastic diaphragm being of appreciable thickness whereby variation in the pressure of the liquid column operates to modify the curvature of the diaphragm and to vary the effective displacement area thereof presented in the pump chamber, said diaphragm having a bulge toward the pump chamber at all times including when the piston is at the end of its suction stroke.

2. In a pumping mechanism comprising a pump chamber with valve intake and discharge ports and a resilient diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston therein, means to reciprocate said piston, and means confining a column of liquid under a pre-determined initial load between the piston and diaphragm to induce a definite pre-stretch on the latter and to reciprocate said diaphragm in direct positive response to the piston movement, thereby enabling the piston, the fluid, and the diaphragm to operate as a mass unit, and means to vary the pre-determined initial load and pre-stretch of the diaphragm in a manner to alter the spherical area of the diaphragm in the pumping chamber and thus vary its effective displacement therein so as to vary the volume of liquid being pumped, said diaphragm having a bulge toward the pump chamber at all times including when the piston is at the end of its suction stroke.

3. A pumping mechanism comprising a pump chamber with valve-controlled intake and discharge ports and a resilient diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston therein, means to reciprocate said piston, and means confining a column of liquid under a predetermined initial load between the piston and the diaphragm to induce a definite pre-tension on the latter and to reciprocate said diaphragm in direct positive response to the piston movement, said piston having a larger portion and a smaller portion with a shoulder at the junction of said portions and the cylinder having an annular chamber in which said shoulder is reciprocated by the piston movement to operate as a make-up pump, a supply of liquid, a supply passage leading therefrom to said annular chamber, and a delivery passage leading from said chamber to the column confined between the piston and the diaphragm, said delivery passage being normally closed by the piston and opened by movement of said piston at the end of its stroke away from the diaphragm, together with check valves in the supply and delivery passages.

4. A pumping mechanism comprising a pump chamber with valve-controlled intake and discharge ports and a resilient diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston therein, means to reciprocate said piston, and means confining a column of liquid under a predetermined initial load between the piston and the diaphragm to induce a definite pre-tension on the latter and to reciprocate said diaphragm in direct positive response to the piston movement, a constantly open, resricted relief passage leading from said column, and make-up means operating at least once during each reciprocation of the piston to replace liquid released through said relief passage.

5. A pumping mechanism comprising a pump chamber with valve-controlled intake and discharge ports and a resilient diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston therein, means to reciprocate said piston, and means confining a column of liquid under a predetermined initial load between the piston and the diaphragm to induce a definite pre-tension on the latter and to reciprocate said diaphragm in direct positive response to the piston movement, said diaphragm comprising a plurality of layers of flexible and elastic sheet material superimposed with their marginal portions clamped between opposing annular faces of the pump structure and with their central portions normally bulging toward the pump chamber and away from said piston.

6. A pumping mechanism comprising a pump chamber with valve-controlled intake and discharge ports and a resilient diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston therein, means to reciprocate said piston, and means confining a column of liquid under a predetermined initial load between the piston and the diaphragm to induce a definite pre-tension on the latter and to reciprocate said diaphragm in direct positive response to the piston movement, said diaphragm comprising a plurality of layers of flexible and elastic sheet material superimposed with their marginal portions clamped between opposing annular faces of the pump structure, said marginal portions having spaced annular layers of fabric molded therein to limit their distortion under the clamping pressure.

7. A pumping mechanism comprising a pump chamber with valve-controlled intake and discharge ports and a resilient diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston therein, means to reciprocate said piston, means confining a column of liquid under a predetermined initial load between the piston and the diaphragm to maintain a definite pre-tension on the latter at the end of the suction stroke of the piston and to reciprocate said diaphragm in direct positive response to the piston movement, and make-up means operated by the piston movement to supply make-up liquid under relatively high pressure to said column of liquid to replace leakage from the column of liquid and maintain the preloading thereof and the pretension of the diaphragm.

8. A pumping mechanism comprising a pump chamber with valve-controlled intake and discharge ports and a resilient diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston therein, means to reciprocate said piston, means confining a column of liquid under a predetermined initial load between the piston and the diaphragm to maintain a definite pre-tension on the latter at the end of the suction stroke of the piston and to reciprocate said diaphragm in direct positive response to the piston movement, and make-up means operated by the piston movement to supply make-up liquid under relatively high pressure to said column of liquid and communicating with the column at the commencement of the piston stroke toward the diaphragm.

9. A pumping mechanism comprising a pump

chamber with valve-controlled intake and discharge ports and a resilient diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston therein, means to reciprocate said piston, means confining a column of liquid under a predetermined initial load between the piston and the diaphragm to maintain a definite pre-tension on the latter at the end of the suction stroke of the piston and to reciprocate said diaphragm in direct positive response to the piston movement, and make-up means operated by the piston movement to supply make-up liquid under relatively high pressure to said column of liquid and including an injector passage closed by the piston except at the end of its stroke away from the diaphragm.

10. A pumping mechanism comprising a pump chamber with valve-controlled intake and discharge ports and a resilient diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston therein, means to reciprocate said piston, means confining a column of liquid under a predetermined initial load between the piston and the diaphragm to maintain a definite pre-tension on the latter at the end of the suction stroke of the piston and to reciprocate said diaphragm in direct positive response to the piston movement, make-up means operated by the piston movement to supply make-up liquid under relatively high pressure to said column of liquid and including an injector passage controlled by the piston and a pressure relief port for said passage adjustable to determine the preloading pressure developed by said make-up means.

11. A pumping mechanism comprising a pump chamber with valve-controlled intake and discharge ports and a resilient diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston therein, means to reciprocate said piston, means confining a column of liquid under a predetermined initial load between the piston and the diaphragm to maintain a definite pre-tension on the latter at the end of the suction stroke of the piston and to reciprocate said diaphragm in direct positive response to the piston movement, make-up means operating continuously with the piston to provide liquid under relatively high pressure, means admitting such liquid to the said column intermittently and at least once during each reciprocation of the piston, and a relief passage leading from said column with means adjustable at will to vary the relief capacity of said pressure.

12. A pumping mechanism comprising a pump chamber with a valve-controlled intake and discharge ports and a resilient diaphragm constituting one wall of said chamber, together with actuating means including a cylinder, a piston therein, means to reciprocate said piston, means confining a column of liquid under a predetermined initial load between the piston and the diaphragm to maintain a definite pre-tension on the latter at the end of the suction stroke of the piston and to reciprocate said diaphragm in direct positive response to the piston movement, the stored energy of the pre-tensioned diaphragm providing the vacuum required for drawing liquid into the pump chamber, said stored energy within said diaphragm also acting to hold the fluid and the piston hard against the piston-reciprocating means, said diaphragm being prestretched in a direction toward the pump chamber at all times during the operation.

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