This invention relates to reversible rotary liquid pumps.

The object of the present invention is to provide in a liquid pumping apparatus of the reversible rotary pump type, a single automatically actuated valve for controlling the events of all the ports admitting and discharging liquid to and from the pump for maintaining a unidirectional flow of liquid to and from the apparatus with either direction of rotation of the pump.

While an apparatus as above set forth may be adaptable for many varied uses, it is especially applicable for pumping liquid through a closed system where the pump is driven by power means designed for reversal which would operate to reverse the direction of rotation of the pump.

An outstanding use for such an apparatus is for pumping lubricating oil to and from a machine such for instance as an engine, having a reversible characteristic, and which is advantageously coupled with the pump as a drive therefor to render the pump rotation reversible with reversal of the engine. The present principal known use for the apparatus is in connection with a Diesel engine such as a marine engine where reversal of the propeller shaft is an essential characteristic. The apparatus, as shown in the present instance in its preferred embodiment, is especially adapted for such use and it will be understood that the driven shaft of the pump is connected with a driving shaft forming part of the engine which driving shaft is reversible with reversal of the propeller shaft (either by reversal of the engine or otherwise, according to usual practice) and which in turn reverses the direction of rotation of the pump. When the apparatus is so used the lubricating oil ordinarily flows through a closed system containing a sump from which the liquid is drawn and to which the liquid returns for repeated use after it has made a lubricating cycle, and the present apparatus is designed for such a closed system, the pump being instrumental in circulating the liquid through the system which includes the apparatus of the present invention.

Referring to the drawings forming part of this application, Figure 1 is a plan view of the apparatus embodying the present invention, the discharge pipe being broken away; Figure 2 is a section on the line II—II of Figure 1, with various parts shown in full; Figure 3 is a view, similar to Figure 1, showing a modified apparatus having two pumping units, with the pipe connections removed; Figure 4 is a section on the line IV—IV of Figure 3, with various of the parts shown in full; Figure 5 is a section on the line V—V of Figure 1, with certain parts removed and other parts shown in full showing the valve in its uppermost position; Figure 6 is a view similar to Figure 5 showing the valve in its lowermost position; Figure 7 is a fragmental section on the line VII—VII of Figure 5, the valve being omitted; Figure 8 is a fragmental section on the line VIII—VIII of Figure 5, the valve and spring being omitted; Figure 9 is a section on the line IX—IX of Figure 8, the valve and springs being shown in valve intermediate position; Figure 10 is a section on the line X—X of Figure 3, parts being shown in full; and Figure 11, at the left, is an end view, and at the right, a section on the line XI—XI of Figure 2, with parts removed.

While the invention is not confined to any particular type of reversible rotary liquid pump it is shown in its preferred embodiment with a pump of the intermeshing gear type.

Figures 1 and 2 show the apparatus as involving but a single pump (best shown in Figures 2, 5 and 6) involving two interfitting gear wheels or pumping elements 1 and 2. The pump is housed within a casing, indicated generally by the reference numeral 3, which comprises a body portion 4 provided with a front integral wall 5 and a rear wall 6 detachable from the body portion. A gear casing, indicated generally by the reference numeral 7, is disposed adjacent the pump casing at the rear thereof, and is open at its front wall opposite the wall 5 and secured thereto by studs and bolts 8. The casing 7 is provided with a flanged top wall 9 for bolting the present apparatus to the engine or the like, with which the present apparatus is to be employed and in suitable association to a reversible part of such engine, etc., to effect driving of the pump. To this end the shaft of a gear wheel 10 is mounted in blocks 11 secured to the top wall 9, the wheel extending downwardly into the casing 7 through an opening in the top wall. This wheel is for engagement with another gear wheel which is mounted on a shaft and which forms part of and is reversible with the engine (not shown) with which the present apparatus is employed.

The pump gear wheel 1 is integrally formed on a shaft 12 mounted in through openings provided in the walls 5 and 6, the shaft extending into the casing 7 and having secured thereon a gear wheel 13 which is in mesh with the gear wheel 10 to be driven thereby for driving the pump, the pump gear wheel 1 serving as a drive for the intermeshing pump gear wheel 2. The gear wheel 2 is mounted on a shaft 14 carried in
a through opening provided in the wall 5 and in an opening in the wall 6 that extends but part way through this wall. A plate 15 is disposed in engagement with the outer face of the wall 5. The wall 6, body portion 4 and plate 15 are secured together by bolts 16.

The pump gear wheels 1 and 2 fit between the walls 5 and 6 with a working clearance and similarly have a working clearance with a transverse partition wall 17, forming part of the body portion 4, through which the bolts 16 pass. The outer wall 18 of the casing body portion 4 is arcuate from front to back and at its top and bottom is also arcuate from side to side, and the wall 11 is arcuate from side to side at its top and bottom where it engages respectively the gear wheels 1 and 2 and its front and rear ends are formed integral with the outer wall 18 and its front end with the front wall 5.

The partition wall 17 is provided with a large opening or passageway 19 extending from front to back at one side thereof (the left side as viewed in Fig. 1 and best seen in Figs. 5 and 6). A post 20 is disposed midway of this opening through which one of the bolts 16 passes for better securing the parts of the casing 23 together. At the side opposite the passageway 19 the top and bottom portions of the partition wall 17 are spaced to provide a large opening or passageway 21 comparable in size with the passageway 19 and extending laterally outwardly to form respectively walls 22 and 23 combining with the adjacent walls to provide a throat 24. The passageway 21 is provided with centrally disposed narrow ribs or supporting wall portions 25 (only one being shown) spaced to provide an opening 26 connecting the top and bottom portions of the passageway 21. At the inner ends of the wall portions 25, there is a post 27 similar to the post 20 through which one of the bolts 16 passes.

The passageways 21 and 19 are respectively for ingress and egress of the liquid to and from the pump when the pump is rotating in the direction as indicated by the arrows in Fig. 5, which, for convenience, will be termed "ahead" direction or rotation. And reversely the openings 19 and 21 are respectively for ingress and egress of the liquid to and from the pump when the pump is rotating in the opposite direction to that of Fig. 5, and as indicated by the arrows of Fig. 6, which, for convenience, will be termed "astern" direction or rotation. These terms "ahead" and "astern" are employed to correspond to the direction of rotation of a propeller shaft of a marine engine where the invention is especially applicable. However the manner of coupling the apparatus with the engine would, in practice, determine the direction of rotation of the pump, it only being necessary that the proper directional flow of the oil to and from the apparatus be effected.

The liquid is carried by the pump gear wheels from one opening or passageway to the other around the inner faces of the upper and lower portions of the partition wall 17. The liquid, as thus carried by the pump, travels in one direction for ahead movement and in the opposite direction for astern movement.

An important feature of the invention is that while the liquid is fed to the pump and discharged therein in opposite directions, requiring passing through the pump casing in opposite directions, one for ahead movement and the other for astern movement, nevertheless the flow of liquid to and from the apparatus is always in the same direction. This is a necessary requirement in a pump for pumping liquid through a lubricating system of a reversible engine or other apparatus, and this uni-flow direction of the liquid therefore must be maintained even though the engine or other machine to which the apparatus is applied is reversible.

The apparatus of the present invention further comprises a valve casing, indicated generally by the reference numeral 28, which casing comprises a body portion 29 having a wall 33 provided with an upper head 34 and a lower head 32, each studied to the wall 30. The wall 30 has an upper cylindrically-faced portion 33, a lower similar portion 34, an intermediate inner cylindrically-faced portion 35, a wall portion 36 disposed between the portions 33 and 35, spaced therefrom, and provided with an inner cylindrical face, and another wall portion 37 disposed between the portions 34 and 35, spaced therefrom and provided with an inner cylindrical face. The several inner cylindrical faces are in alignment and provide respectively a cylinder or chamber 38 for the piston valve, later to be described. The aforesaid spaces between the wall portions provide four ports as will later more fully appear.

The valve casing 28 and the pump casing 3 are shown as forming an integral structure. The former is shown disposed adjacent the latter at the side thereof containing the passageway 21. These two casings merge into a common wall portion in which are portions of the aforesaid four ports. The type of casing or casings forms no part of the present invention. For instance, the casings need not necessarily be made integral. They may be made separate and connected together in any suitable manner. Suffice it to say that the valve-controlled ports and various other features of the valve casing have communication with the pump casing even though this may be accomplished through an integral structure, a composite bolted structural wall or through structures involving piping connecting the various parts together. For this reason, regardless of the specific structure, the two casings may be considered as a single casing in the broad sense of the word. This casing is divided into two compartments by a portioned wall, one compartment housing the pump valve and the other compartment housing the piston valve.

The partition wall 17 divides the pump casing into an inner chamber 39 which contains the pump gear wheels and which opens to the passageway 21 affording communication with the valve casing and an outer chamber 40, the two chambers communicating through the passageway 19 for affording further communication of the inner chamber to the valve casing through the outer chamber, as will presently more fully appear. The outer chamber to this end is provided with an upper portion 41 and a lower portion 42.

To afford the aforesaid communications with the valve casing the wall portion 33 is formed integral with the upper portion of the pump casing outer wall 18 and the wall portion 35 is formed integral with the wall 22. Between the adjacent ends of the wall portions 33 and 35, the upper chamber portion 41 is open to provide an upper port a. In like manner the wall portion 35 is formed integral with the lower portion 36 of the pump casing outer wall 18 and the wall portion 37 is formed integral with the wall 23. Between the adjacent ends of the wall portions 34 and 37
the lower chamber portion 42 is open to provide a lower port b. The wall portion 35 is formed integral with the ribs or supporting wall portions 25. Between the adjacent ends of the wall portions 35 and 36 the passageway 21 is open to provide an upper intermediate port c. Likewise between the adjacent ends of the wall portions 35 and 36 the passageway 21 is open to provide a lower intermediate port d.

These four ports a, b, c and d provide the aforesaid communications between the pump chambers 39 and 40 and the valve casing and are controlled by a single valve later to be described.

The wall 30 is enlarged from the upper edge of the port a to the lower edge of the port c circumferentially by the wall portion 43 providing a space or chamber 44 exterior to the valve cylinder 38 within the valve casing. The chamber 44 is divided by diametrically opposite wall portions into two parts, as will later appear, and the inner part is divided into upper and lower sections by the wall 22. These sections are open to the valve cylinder through the ports a and b, which extend to the just-mentioned opposite wall portions and, are, exteriorly of the valve cylinder, open, the upper section to the chamber portion 41 and the lower section to the passageway 21 at the upper part thereof. Similarly the wall 30 is enlarged from the upper edge of the port d to the lower edge of the port b circumferentially by the wall portion 45 providing a space or chamber 46 exterior to the valve cylinder 38 within the valve casing. The chamber 46 is divided by diametrically opposite wall portions into two parts, as will later appear, and the inner part is divided into upper and lower sections by the wall 23. These sections are open to the valve cylinder through the ports d and b, which extend to the just-mentioned opposite wall portions and, are exteriorly of the valve cylinder, open, the lower section to the chamber portion 42 and the upper section to the passageway 21 at the lower part thereof.

The wall portions 43 and 45 (best shown in Figs. 7 and 8) at the back of the valve casing turn inwardly to provide respectively wall portions 47 and 48 which connect respectively with the wall portions 43 and 45 and extend from the lower edge of the wall portion 33 to the upper edge of the wall portion 34, extending inwardly between the ports to form part of the valve cylinder.

At the front of the valve casing and opposite the wall portions 41 and 48 the wall 30 is thickened from top to bottom to provide a solid portion 49 which extends outwardly from the portions 33, 35 and 34, and which extends inwardly from the portions 43 and 45 connecting these two portions 43 and 45 respectively with the portions 36 and 37, and which extends respectively across the ports a — c and d — b to the inner face of the valve cylinder to form parts thereof. The solid portion 49 in its passageway through the valve and the ribs as shown provides respective wall portions 50 and 51, similar to the wall portions 47 and 48. The wall portions 47 and 50 divide the chamber 44 into an inner portion 52 at the side of the valve cylinder adjacent the pump casing, and an outer portion 53 at the opposite side of the valve cylinder. Likewise the wall portions 48 and 51 divide the chamber 46 into an inner portion 54 at the side of the valve cylinder adjacent the pump casing, and an outer portion 55 at the opposite side of the valve cylinder.

The outer portion 55 is provided with an inlet or suction opening 56, flanged to engage the flange of a pipe coupling 57, and the coupling 57 is flanged at its opposite end to engage the flange of a pipe 58 which is provided with a check valve 59. The check valve is not required for the proper functioning of the apparatus but is desirable to prevent flow from the valve casing through the inlet or suction opening in case the apparatus should temporarily fail to function, as will later more fully appear. The outer portion 53 is provided with an outlet or discharge opening 60, flanged to engage the flange of a pipe coupling 61, and the coupling 61 is flanged at its opposite end (not shown) to receive the flange of a pipe (not shown). The respective engaging flanges are bolted together in the usual manner. By a different setting of the valve casing heads 31 and 32 from that shown in the drawings the opening 56 will serve as the inlet or suction opening and the opening 56 will then serve as the outlet or discharge opening, as will later more fully appear. With such a change the check valve 59, if employed, will obviously be placed in the other pipe.

It will be understood that the couplings and pipes leading from the inlet and outlet openings of the valve casing, as well as the apparatus, are included in the flow circuit leading to and from the Diesel engine or other machine, or more properly that portion thereof that is to be lubricated. The flow circuit will usually include a sump for containing the supply of lubricating oil and the inlet opening 56 will be connected through piping therefrom to the sump and the lubricating oil therein whereby the pump is supplied with lubricating oil flowing from the sump through the piping to the inlet opening 56 and thence from the valve casing to the pump casing.

The outlet opening 60 will be connected through piping therefrom to the part of the engine or other machine to be lubricated and other piping forming part of the flow circuit will lead therefrom to return the lubricating liquid that has been used to the sump. Obviously this part of the piping need not enter the liquid in the sump. It may terminate above the level of the liquid in the sump, it only being necessary that it discharge into the sump, and to this extent in such event the flow circuit would not be strictly closed. This however, is not a part of the present invention and only illustrates a possible use thereof. Furthermore it is not intended to limit the apparatus solely for pumping lubricating oil. It may have other uses.

The liquid is pumped, when the pump is in operation, to maintain a continuous flow or circulation of the liquid through the system during the operation of the engine or other machine. The pump pumps the liquid from the valve casing. The pump pumps the liquid to produce the flow and the piston valve cooperating with the parts a, b, c and d operates to maintain a unidirectional flow always through the inlet opening 56 to the pump casing and out of the pump casing to the outlet opening 60. While the pump maintains the flow it will be understood that part of this flow will be by gravity, depending upon the relative heights of the various parts included in the flow system.

In the case of a marine Diesel engine, for illustration, in addition to supplying lubricating oil to the engine it is usually desirable to also supply lubricating oil to the clutch between the
engine and its driven machinery. It is preferable to employ a separate pump for each of these purposes, and therefore the invention is not limited to a single pump and valve unit but may include other units according to the use to be made of the invention. Therefore according to the above illustration two units would be employed, one for the engine and the other for the clutch, and Figs. 3, 4 and 10 illustrate a modification of the invention covering two units which will later be described.

Returning to the single unit embodiment, the piston valve is indicated generally by the reference numeral 62. It is of somewhat skeleton formation and has a cylindrical broken outer face 63 which engages the face of the cylinder 38 to provide a sliding fit in an axial direction therein with for control of the ports a, b, c and d.

In the present instance the valve is provided for three adjustments, that is to say three positions, namely an upper position, shown in Fig. 5, opening the ports d and a, and closing the ports b and c, a lower position, shown in Fig. 6, opening the ports b and c, and closing the ports d and a, and an intermediate position, shown in Fig. 9 but best shown in Fig. 10, (of the two unit embodiment), closing all the four ports.

The valve 62 is preferably an integral structure. It comprises a middle body portion 64, which supports three sections or portions 65, 66 and 67, each providing a portion of the valve cylindrical outer face 63. The portion 65 is in the form of a hollow cylinder open at its upper end and closed at its lower end by the wall 68 integrally formed with the body portion 64 at the upper end thereof. This portion 65 has an outer cylindrical face 68 which outlines the port a. The portion 66 is similar to the portion 65 but reversed in direction thereby being open at its lower end and closed at its upper end by the wall 70 integrally formed with the body portion 64 at the lower end thereof. This portion 66 has an outer cylindrical face 70 which controls the port b. The portion 67 is disposed centrally between the portions 65 and 66 and is integrally connected to the body portion 64 through the centrally disposed hub 72. This portion 67 has an outer cylindrical face 72 which controls the ports c and d.

The ports a, b, c and d, which are valve cylinder ports connecting the cylinder with the pump casing and preferably are of the same length or height and are preferably of the same width, the width being large in comparison to the length to provide large port openings. The ports a and c terminate at the wall portions 48 and 51 (see Fig. 8 for the port b). The ports thus extend substantially half way around the valve cylinder and have spaced therefrom the inner portion of the wall 43 (for ports a and c) which merges into the pump casing and the other portion of the wall 45 (for ports b and d) which likewise merges into the pump casing. The aforesaid merging is more properly into the common wall portion between the pump and valve casings. From the foregoing it will be seen that the chamber intermediate portions 52 and 54 are exterior to and extend half way around the valve cylinder and their sections are adjacent respectively to the ports a—c and d—b. The chamber outer portions 53 and 55 are exterior to and extend half way around the valve cylinder and are adjacent respectively to other valve cylinder ports a—c and d—b, these ports a', c', d' and b' being transversely oppositely disposed respectively to the ports a, c, d and b. Thus the liquid can only reach the pump from the inlet opening 56 and can only reach the discharge opening 60 through the valve.

The lower end of the portion 65 is spaced from the upper end of the portion 67 to provide a valve port e, and likewise the upper end of the portion 66 is spaced from the lower end of the portion 67 to provide a valve port f. Thus the valve has two ports preferably of a length or height equal to the ports a, b, c and d but extending entirely around the valve.

The body portion 64 is made relatively small in cross section and the hub 72 is made relatively thin providing a skeleton formation for the valve whereby a valve chamber 74 extending entirely around the valve is provided for the valve port e, and another valve chamber 78 likewise extending entirely around the valve is provided for the valve port f.

The valve port f, when the valve has been adjusted to raised position as shown in Fig. 5, opens the port d to the inlet or suction opening 56, the cylindrical face 11 at the same time closing the port c. When the valve port e opens the port a to the outlet or discharge opening 60, the cylindrical face 13 at the same time closing the port d. In like position in this position of the valve, the valve port e opens the port c to the outlet or discharge opening 70, the cylindrical face 69 at the same time closing the port a. Thus it will be noted that during these two adjustments the valve ports e and f are always active but only two of the ports a, b, c and d are open for these two valve adjustments.

In each valve adjustment the liquid from the inlet or suction opening 56 to reach the pump casing must pass through valve chamber 75 and likewise the liquid to enter the outlet or discharge opening 60 must pass through valve chamber 77. This is necessary on account of the wall portions 48 and 51 dividing the chamber 46 into the two portions 44 and 45, and the wall portions 47 and 50 dividing the chamber 44 into the two portions 42 and 43. In order to ensure the liquid to get to one side of the valve casing to the other must pass through the valve chambers.

It will thus be seen from the foregoing that for the rotation of the pump gear wheels as shown by the arrows in Fig. 5, which has been previously considered rotation for ahead movement, the valve is in raised position. The liquid enters the port d and travels through the passageway 21 toward the left side of the pump. It is discharged by the pump through the passageway 19 and travels through the portion 41 to the port a.

It will further be seen that for the opposite rotation of the pump gear wheels as shown by the arrows in Fig. 6, which has been previously considered rotation for astern movement, the valve is in lowered position. The liquid enters the port b, travels through the portion 42, and from the portion 42 travels through the passageway 19 toward the right side of the pump. It is discharged by the pump through the passageway 21 to the port c.
From the foregoing it will be seen that for either rotation of the pump gear wheels the liquid enters the apparatus through the inlet or suction opening 56 and leaves the apparatus through the outlet or discharge opening 60. The only difference between ahead and astern movements is that for ahead movement the liquid enters the pump from the right side thereof and that the ports d and c are the active ports, and that for astern movement the liquid enters the pump from the left side thereof and that the ports b and c are the active ports. Furthermore the valve ports f connects the pump casing with the inlet or suction opening 56 at both positions of the valve, and similarly at both positions of the valve the valve port e connects the pump casing with the outlet or discharge opening 60.

While the aforesaid valve and various ports are set forth in the preferred embodiment of the invention, it will be understood that the invention from a broad aspect is not thus limited, but that other types of valves and arrangements and number of ports may be used, suitable to attain the aforesaid object.

The piston valve 62 cooperates with the valve casing 25 to provide an upper fluid chamber 76 of variable capacity, and a lower fluid chamber 71 also of variable capacity. Within the chamber 76 is a compressible coil spring 76 abutting at its upper end the head 41 and at its lower end the wall 68. A similar spring 79 is disposed within the chamber 71 abutting at its lower end the head 52 and at its upper end the wall 70. These springs serve to stabilize or steady the adjusting elements of the piston valve but are primarily for returning the piston valve from either of its raised or lowered active positions, which are its extreme positions, to its aforesaid intermediate inactive position as shown in Fig. 9, in which position all the ports are closed, as best shown in Fig. 10, the ports being provided with a suitable amount of overlap in this position of the piston valve as clearly shown in Fig. 10. In this intermediate position of the valve the springs are but slightly compressed but sufficiently so to insure the maintenance of the piston valve in this all-port-closed position.

The piston valve is automatically actuated from its intermediate position to either of its extreme positions and held in these extreme positions by the pressure due to the rotation of the pump. Before describing the structural features and their manner of operation to accomplish this it should be noted that in the upper position of the piston valve, as shown in Fig. 5, the upper spring 78 is further compressed and that the lower spring 79 is slightly expanded, this slight expansion being due to its slight compression when the piston valve is in its intermediate position. In similar manner when the piston valve is in its lowered position the lower spring 79 is further compressed and the upper spring is slightly expanded.

As is obvious, when there is no liquid pressure in the apparatus the energy of the further compressed springs 78 and 79 (and 76 and 79 for the respective positions of the piston valve) will operate to automatically return the piston valve to its intermediate position. This occurs when the rotation of the pump ceases. Therefore when the pump is at rest the piston valve is always in its all-port-closed position. Accordingly when the pump starts to rotate the piston valve is initially at all-port-closed position, and it will be adjusted automatically by fluid pressure due to the operation of the pump, the direction of the piston valve's movement being dependent upon the direction of rotation of the pump gear wheels, as will later be explained. Also, as will later be explained, upon reversal of the rotation of the pump the piston valve will automatically move from its then adjusted extreme position to its intermediate all-port-closed position, resembling its movement when the pump comes to rest, and from this intermediate position it will immediately move to its opposite extreme position responsive to the reversal of the rotation of the pump.

On the lower end of the wall portion 56 within the inner portion 52 of the chamber 44 and between the wall portions 47 and 50, that is to say on the pump side of the valve casing, is an outwardly directed transverse wall portion 58 of the wall 22 and which divides the portion 52 into two parts, thereby separating ports a and c. At the upper end of the wall portion 37 is a similar wall portion 51 of the wall 23 which divides the portion 54 into two parts, thereby separating ports b and d. The ports b and d are not separated nor are the ports a' and c' separated. This is because the portions 55 and 53 are merely chambers respectively for the inlet opening 56 and the outlet opening 60, the former opening supplying liquid to either the port b or d, depending upon the position of the piston valve, and the latter simultaneously receiving liquid respectively from the port c or a.

The portions 55 and 53 are however separated by the wall portion 41 and the branches of the wall portions 45 and 43 extending therefrom, the branch of the wall portion 45 extending to the walls 48 and 51 and the branch of the wall portion 43 extending to the walls 47 and 50. The ports c and d are not separated, that is to say they are always in communication exterior to the piston valve.

The movement of the piston valve from its all-port-closed position to its extreme positions is dependent upon the liquid pressure produced by the rotating pump, and which of these extreme positions it will assume is dependent upon the direction of rotation of the pump.

The following means are provided to effect accomplishment of these valve movements. The solid portion 42 is provided on and a portion 82 extending from end to end thereof is provided therein. A transverse passageway 83 divides the bore 82 into an upper passageway 84 and a lower passageway 85, both opening into passageway 85. The heads 31 and 32, as aforesaid, are designed for two settings, one rendering the passageway 84 active and the other rendering the passageway 85 active, as will later more fully appear. The drawings show the passageway 84 active and the passageway 85 dead. The foregoing description of the apparatus however equally applies as to structural features whichever passageway 84 or 85 is the active one, but the direction of flow to and from the apparatus is reversed with reversal of the passageways.

The passageway 82 opens into the lower part of the chamber portion 52 and connects it with passageway 84 (see Fig. 7) thereby affording communication at all times between the passageway 84 and the passageway 21.

At the back of the pump and valve casings where they are integrally formed in providing a single casing as aforesaid the wall is made sufficiently thick to provide for a lower passageway 88 and an upper passageway 87 to be formed
therein. The same remarks here apply as have been previously made regarding the heads 31 and 32 except that in the present setting of the heads 31 and 32 the passageway 85 is the active passageway and the passageway 87 is dead. The passageway 86 at its upper end has a mouth 88 opening into the lower part of the chamber portion 84 thereby affording communication at all times between the passageways 86 and the lower portion 42 of the chamber 40. Similarly the passageway 87 at its lower end is provided with a mouth 89 opening into the upper part of the chamber portion 85 thereby affording communication at all times between the passageways 87 and the upper portion 41 of the chamber 40.

The head 31 is provided with a circular flange 90 against which the piston valve seats when in its raised position and the head 32 has a similar flange 91 against which the piston valve seats when in its lowered position. The head 31 is provided with a recess 92 registering with the chamber 76 and passageway 84 thereby bringing the upper fluid chamber 76 into communication with the passageway 84. The head 32 has a similar recess 93 affording communication between the chamber 77 and passageway 86. The passageway 85 is closed at its lower end by the head 32 and the passageway 87 is closed at its upper end by the head 31. The passageways 85 and 87 are thus rendered inactive.

The operation of the apparatus is as follows:

When the pump is at rest the liquid in the apparatus is under atmospheric pressure; at least there is no differential pressure of the liquid filling the several parts of the apparatus and the piston valve is in its port-closed position as shown in Figs. 9 and 10. If the pump is rotated from this position of rest in the direction shown by the arrows in Fig. 5 (ahead movement), the inlet opening 56 and the outlet opening 60 being closed, the pump will operate to draw the liquid from the chamber 18 through the parts 92, 84, 83, 52 (at the lower part thereof) and 21. It will at the same time force the liquid to the chamber 77 through the parts 19, 82, 84 (at the lower part thereof), 86, 85 and 87. The differential liquid pressure on the opposite sides of the piston valve, the predominating pressure being in the chamber 77. The piston valve will begin its upward movement and initially open the ports a and d. At this point the pump will begin to take liquid from the inlet opening 56 and discharge it through the outlet opening 60. The valve will continue its movement upward to its extreme position fully opening the ports a and d, the ports c and b remaining closed. The piston valve will remain in this position for the reason that the differential pressure is maintained during this ahead movement. This differential liquid pressure compresses the spring 78, the spring 79 being substantially neutral. When the pump is stopped the differential pressure ceases, that is to say the liquid pressure in the apparatus is reduced to atmospheric pressure or to uniform pressure at least insomuch as its action on the piston valve is concerned. The spring 78 thereupon reacts and consequently the piston valve is lowered to its intermediate or all-port-closed position. The spring then acts to yieldingly resist valve movement from this position.

If the pump is rotated from this position of port-closed position shown by the arrows in Fig. 6 (astern movement), the pump will operate to draw the liquid from the chamber 77 and discharge it into the chamber 76 through the same parts respectively as previously mentioned but in the reverse order. The operation of the piston valve in its down stroke movement and its return to all-port-closed position when the pump stops, is similar to that previously described with reference to Fig. 5.

When the rotation of the pump is reversed, say for instance from its rotation as shown by the arrows in Fig. 5 to its rotation as shown by the arrows in Fig. 6, the piston valve (which is then in its raised position) immediately moves to its intermediate all-port-closed position, and from this intermediate position moves to its opposite extreme position as shown in Fig. 6 in the manner previously described. Thus the apparatus in both extreme positions of the piston valve takes the liquid from the inlet or suction opening and discharges it through the outlet or discharge opening thereby insuring a uni-directional flow of the liquid from the apparatus through the system for either direction of rotation of the pump. In the extreme position of the piston valve shown in Fig. 5, the liquid enters the pump inner chamber 39 and the pump from the right side thereof, and in the extreme position of the piston valve as shown in Fig. 6, the liquid enters the pump inner chamber 39 and the pump from the left side thereof.

If the head 31 is turned about its axis to bring the recess 92 in register with the passageway 87 thereby simultaneously blocking off the passageway 84, and the head 32 is similarly turned to register the recess 93 with the passageway 85 thereby simultaneously blocking off the passageway 86, the operation is similar to that already described but the movement of the piston valve is reversed. The opening 60 will then be the inlet or suction opening and the opening 56 will be the outlet or discharge opening. Consequently the flow through the system from and to the apparatus will be in the reverse direction.

To insure proper setting of the heads 31 and 32 they are made of a shape more or less triangular and seat upon a similarly shaped face of the pump casing. They are secured to the casing by studs 44 uniformly spaced, two studs being provided for each side of the triangle.

The recess in the head (82 or 85) to which the valve may be admitted from the opening 85 is denoted the outlet face of the head by an indicator, which in the present instance is an arrow 45, cast or otherwise marked on the head.

The recesses are disposed opposite one of the five vertexes of the triangle of the heads and one of the vertexes of the triangle of the seats is disposed at the front of the apparatus in register with the bore 82 (passageways 84 and 85). The passageways 85 and 87, which are in alignment, are disposed at 120° from the bore 82, that is to say they are disposed at another of the vertexes of the seats.

As shown in Fig. 1, the indicator 45 (full lines) on the head 31 points toward the recess 92, and the indicator 45 (dotted lines) on the head 32 points toward the recess 93. This is the setting of the heads for the operation of the apparatus as shown in Figs. 5 and 6. To move the heads to their other settings all that is necessary is to rotate the head 31 120° in a clockwise direction as viewed in Fig. 1, and the head 32 120° in the reverse direction, the heads of course being first freed from and finally secured to their respective seats. This provides a simple and ready means of selecting which of the openings 56 or 60 shall
be the inlet or suction opening and the other the outlet or discharge opening, no other changes in the apparatus being required for this, except changing the check valve 99 (if employed) to the other pipe, as already mentioned. The head adjustment may be of particular advantage where more than one pumping unit is employed, that is to say where more than one flow circuit is handled by the apparatus, as it provides for a selection of flow to and from the apparatus for each pumping unit even though the pumps of the units are driven by the same shaft and consequently in the same direction.

Figs. 3, 4 and 10 show such a multiple unit apparatus. While in this embodiment only two pumping units are employed it will be understood that it is contemplated as within the invention to use other units where desired. This may be done, as will be seen, in an obvious manner without changing the basic principle or operation. There are but few structural differences between the single pumping unit apparatus and multiple pumping unit apparatus. Therefore where reference is made to similar parts similar numerals are employed with accents added. It is therefore deemed unnecessary, as it would be a mere repetition to describe the operation or structure except as to the structural differences.

Where two pumping units are employed they are placed side by side, one unit being disposed outwardly of the other, and the inwardly disposed unit being adjacent the gear casing. Bolts 169 are employed similar to the bolts 16 but longer for holding the plate 161, pump casings and gear casings together.

The pumping units are separate from each other except as to the pump gear wheel shafts, which are common to both units, and one plate 161 serves for both units, the inner unit requiring no separate plate as is obvious. This brings the rear face of the outer pump casing into engagement with the front face of the inner pump casing. The front wall 5' of the inner pump casing thus serves as the rear wall for the outer pump casing similar to the wall 6' which serves as the rear wall for the inner pump casing. The pump gear wheel 96 of the inner pumping unit has its integral shaft 97 extending through the pump casing of the outer pumping unit and journaled into its wall 5'. The pump gear wheel 96 of the outer pumping unit is journaled on the shaft 97. The pump gear wheel 99 of the inner pumping unit is driven by the gear wheel 96 and the pump gear wheel 100 of the outer pumping unit is driven by the gear wheel 99. Gear wheels 99 and 100 are freely mounted on a common shaft 101 which extends through both pump casings being mounted at its inner end in the wall 6' and at its outer end in the wall 5' of the outer pumping unit and passing through the wall 5' of the inner pumping unit. It will thus be seen that the pumps of the pumping units are driven by a single gear wheel 13'. They therefore rotate in the same direction and are reversed simultaneously when the gear wheel 13 is reversed.

The apparatus of the present invention is particularly applicable to stranger and reliable as to operation. Nevertheless should the piston valve fail to move upon reversal of the pump, provision is made to meet such a failure either when the piston valve is in its raised position, as shown in Fig. 5, or in its lowered position, as shown in Fig. 6. A single illustration of such provision will suffice.

Consider for illustration the position of the piston valve as shown in Fig. 5. Upon reversal of the rotation of the pump gear wheels from that shown in Fig. 5 to that shown in Fig. 6, if the piston valve, on account of being stuck or for some other reason, fails to immediately move to its intermediate position preparatory to moving to its position shown in Fig. 6, the check valve 99 will serve to correct this and the piston valve will be forced to move from its position shown in Fig. 5 to its intermediate position. This is accomplished in the following manner: If the piston valve should remain in its position shown in Fig. 5 when the rotation of the pump is reversed the ports a and d would still be open and the pump would draw the liquid in the pump casing through port a and discharge it through port d. The check valve 99 prevents liquid being forced through the port d from passing into the pipe 58. Therefore a liquid pressure is provided in passageway 21 which is open to the chamber 76 through the parts as aforesaid, namely 83, 84 and 82. This liquid pressure therefore directly acts upon the piston valve at the wall 68 thereof and forces the piston valve to its intermediate or all-port-closed position, whereupon the action of the apparatus becomes normal moving the piston valve to its lowered position as shown in Fig. 6.

While there have been hereinbefore described approved embodiments of this invention, it will be understood that many and various changes and modifications in form, arrangement of parts and details of construction thereof may be made without departing from the spirit of the invention and that all such changes and modifications as fall within the scope of the appended claims are contemplated as a part of this invention.

The invention claimed and desired to be secured by Letters Patent is:

1. An apparatus for pumping liquids comprising a pump casing; a reversible rotary pump therein, one side of said pump being an inlet side for one direction of rotation and a discharge side for the other direction of rotation of said pump, and the other side of said pump simultaneously respectively being a discharge and an inlet side; a valve chamber; and a piston valve in said chamber providing with said valve at each end thereof a space for valve-operating liquid and said spaces being in communication with said casing, each at one of said sides of said pump to effect movement of said valve by pump-produced liquid pressure to one or the other of said sides of said pump and its adjacent intermediate port being inlet ports and the other ports being outlet ports, said chamber further having a valve for controlling the discharge of the valve and said valve having a port for controlling the discharge of the valve and said valve further having a port for controlling the opening of said inlet ports and opening transversely through said valve.
at either of said outlet port openings to said discharge orifice, said two valve ports being operatively independent of said two end spaces, said four chamber ports being suitably positioned in said chamber and said two valve ports being suitably positioned in said valve to effect opening of two alternately disposed chamber ports and closing of the other two chamber ports at one of said positions of said valve, and opening of the other two alternately disposed chamber ports and closing of the remaining two chamber ports at the other of said positions of said valve, whereby liquid admitted to said apparatus through said admission orifice will pass through said pump and discharge through said discharge orifice during both directions of rotation of said pump.

2. An apparatus for pumping liquids comprising a pump casing; a reversible rotary pump therein, one side of said pump being an inlet side for one direction of rotation and a discharge side for the other direction of rotation of said pump, and the other side of said pump simultaneously respectively being a discharge and an inlet side; a valve chamber; and a piston valve in said chamber axially movable to two opposite positions, said chamber providing with said valve at each end thereof a space for valve-operating liquid and said spaces being in communication with said casing, each at one of said sides of said pump to effect movement of said valve by pump-produced liquid pressure to one or the other of its said positions dependently responsive to the direction of rotation of said pump, said valve being moved in a direction from, and by the liquid in, the space in communication with the then discharge side of said pump, said chamber having four axially spaced consecutively arranged ports, the two end ports being in communication with said casing at one side of said pump and the two intermediate ports being in communication with said casing at the opposite side of said pump, one end port and its adjacent intermediate port being inlet ports and the other ports being outlet ports, said chamber further having an admission orifice transversely opposite said inlet ports and a discharge orifice transversely opposite said outlet ports, said valve having a port for controllably opening said inlet ports and opening transversely through said valve at either of said inlet port openings to said admission orifice, said valve further having another port for controllably opening said outlet ports and opening transversely through said valve at either of said outlet port openings to said discharge orifice, said two valve ports being operatively independent of said two end spaces and liquid-pressure balanced in an axial direction, rendering said valve movably un-affected by the liquid passing through said valve ports, said four chamber ports being suitably positioned in said chamber and said two valve ports being suitably positioned in said valve to effect opening of two alternately disposed chamber ports and closing of the other two chamber ports at one of said positions of said valve, and opening of the other two alternately disposed chamber ports and closing of the remaining two chamber ports at the other of said positions of said valve, whereby liquid admitted to said apparatus through said admission orifice will pass through said pump and discharge through said discharge orifice during both directions of rotation of said pump.

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