

Jan. 17, 1967

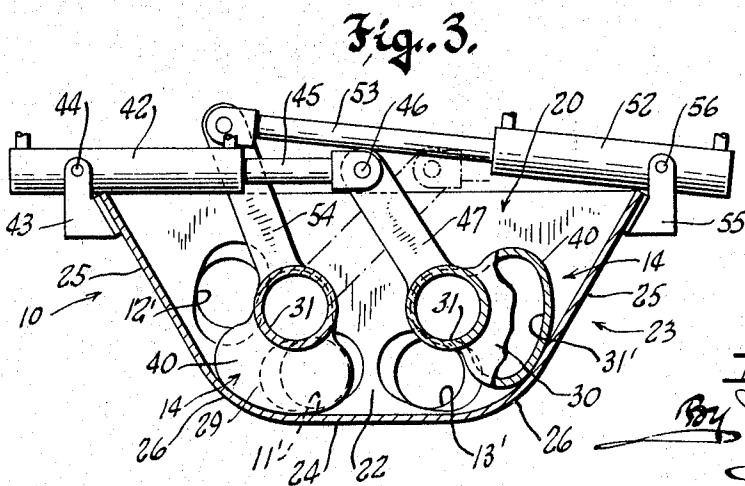
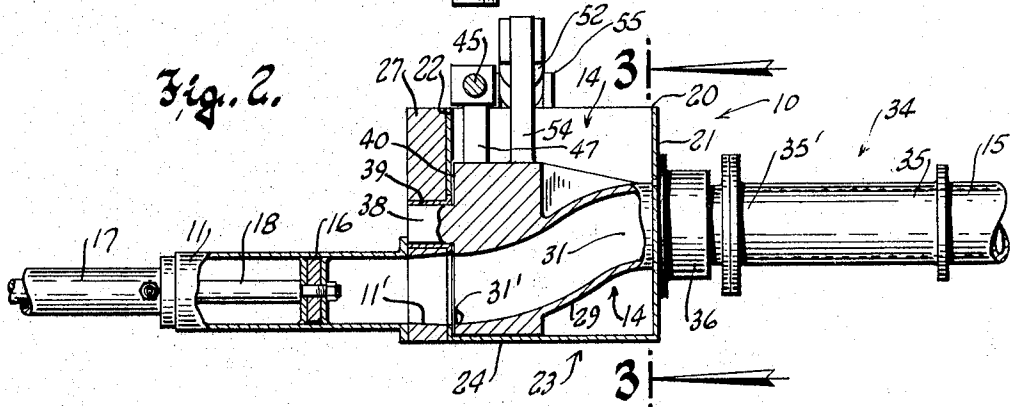
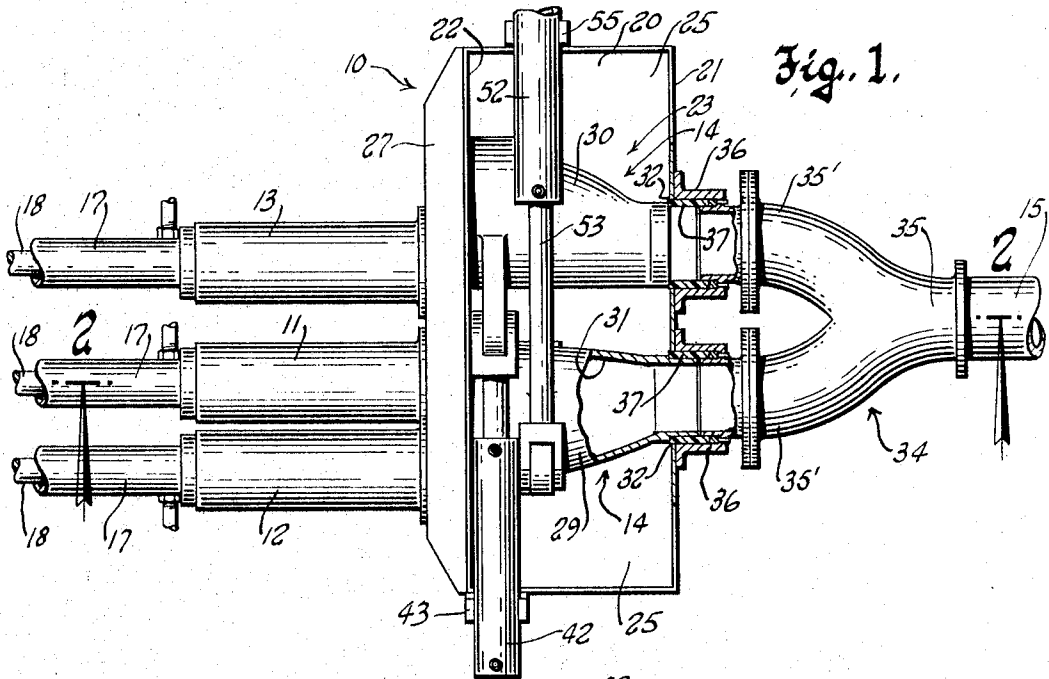
E. L. SHERROD

3,298,322

PUMP FOR SEMI-FLUID MATERIALS

Filed April 20, 1966

5 Sheets-Sheet 1



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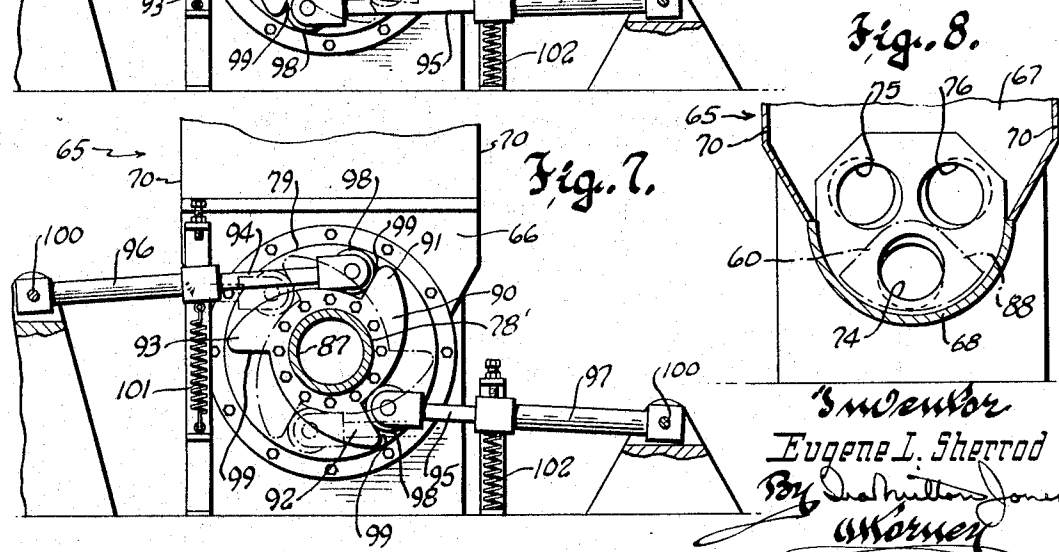
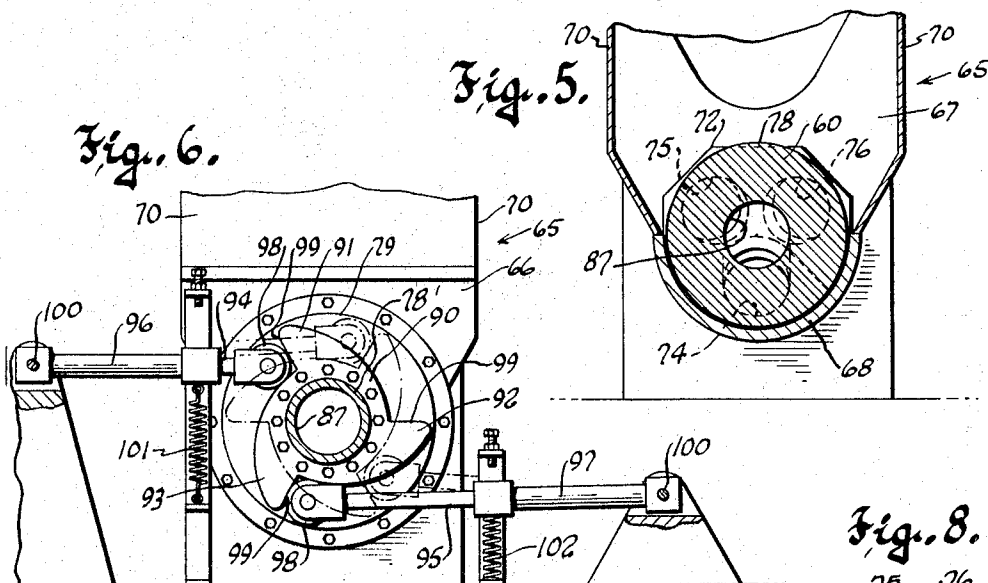
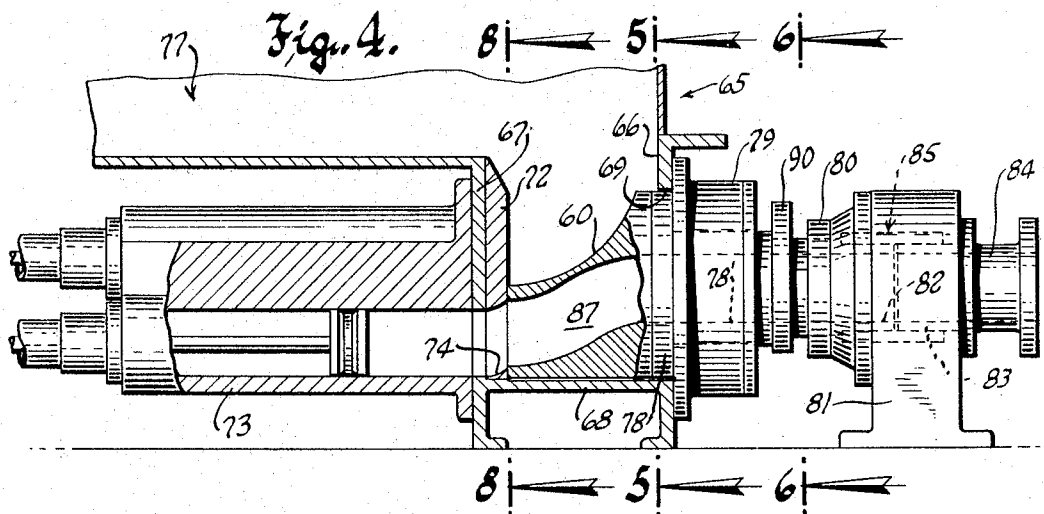
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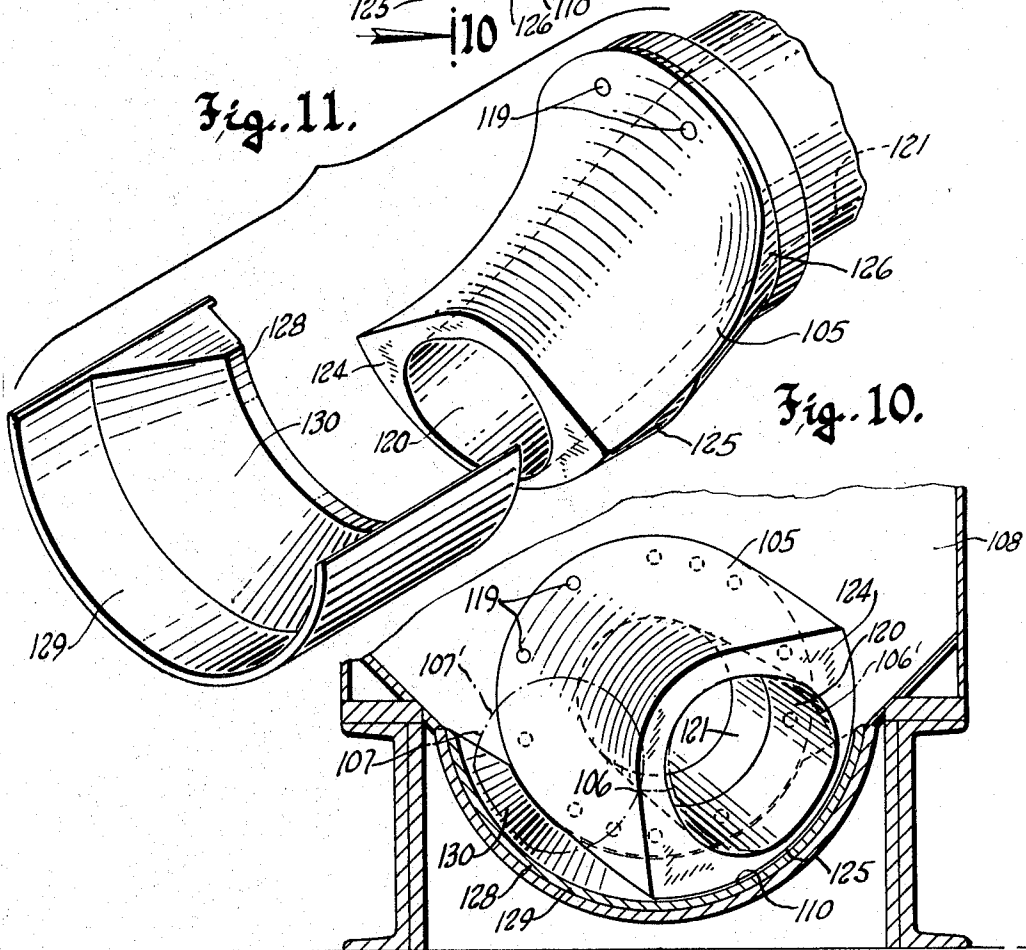
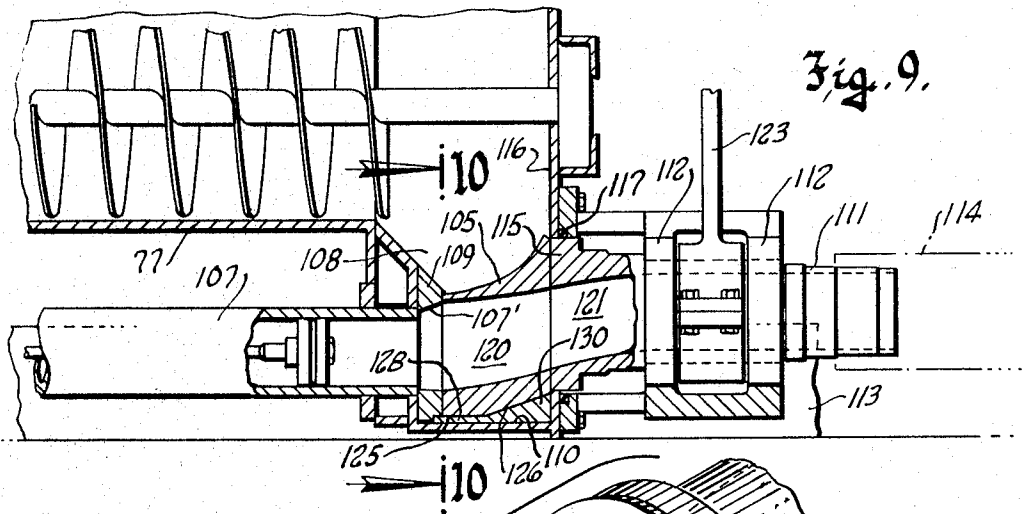
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PUMP FOR SEMI-FLUID MATERIALS

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5 Sheets-Sheet 3



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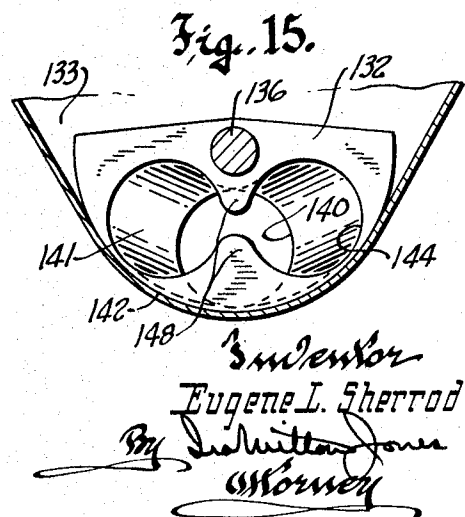
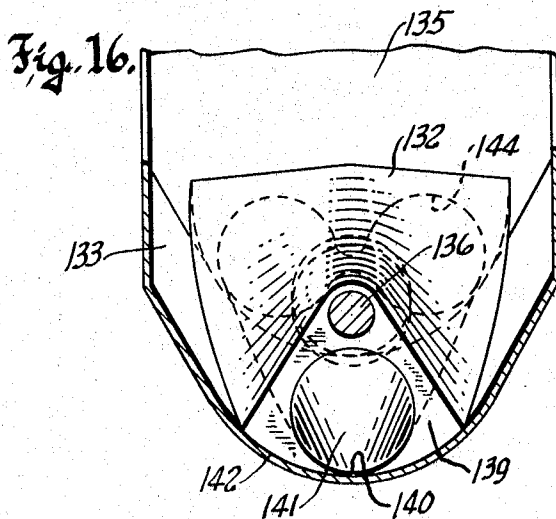
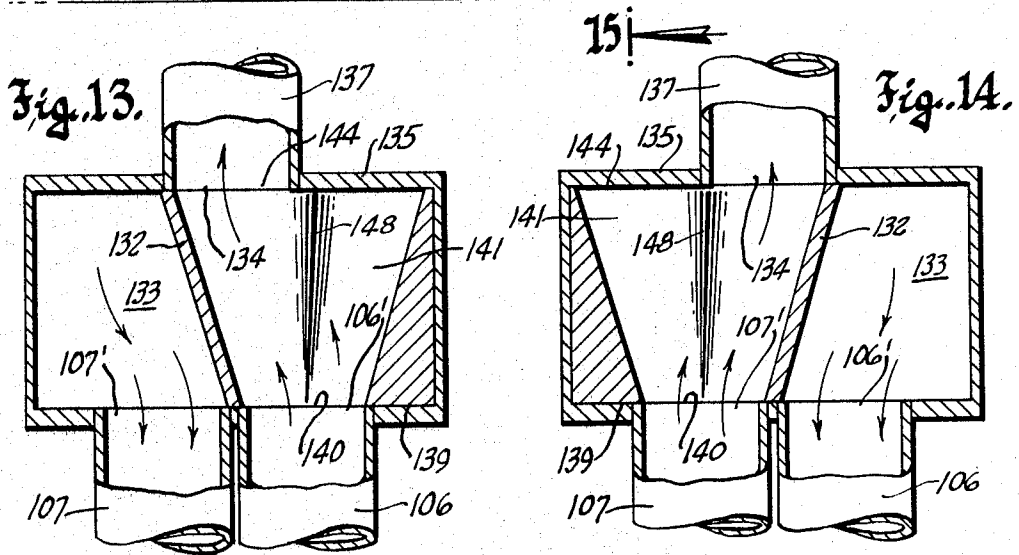
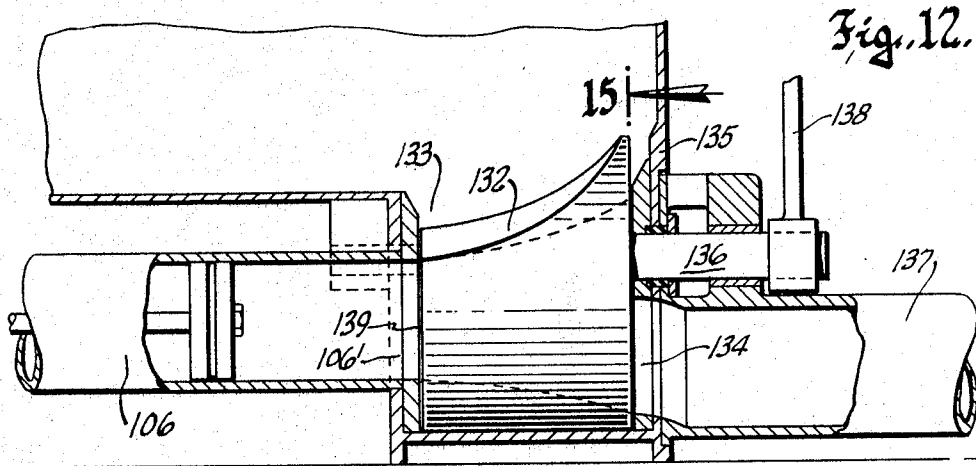
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PUMP FOR SEMI-FLUID MATERIALS

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5 Sheets-Sheet 4



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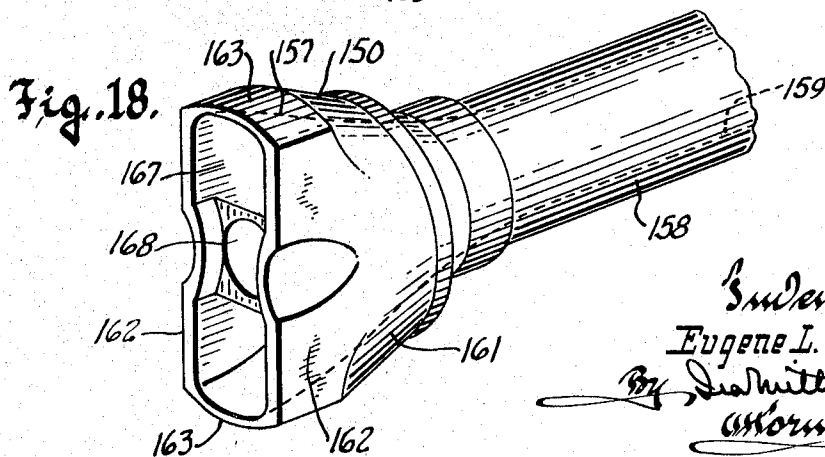
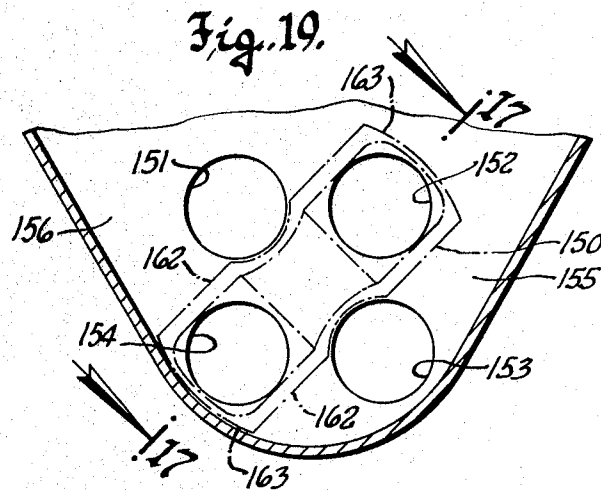
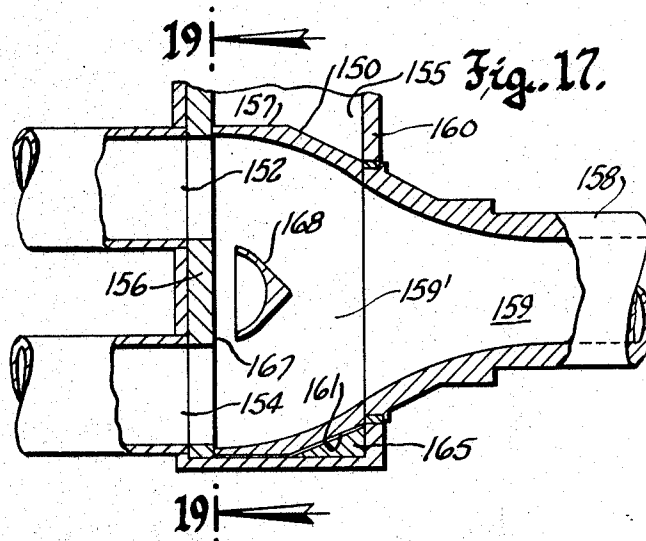
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PUMP FOR SEMI-FLUID MATERIALS

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5 Sheets-Sheet 5



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3,298,322

PUMP FOR SEMI-FLUID MATERIALS

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Filed Apr. 20, 1966, Ser. No. 549,746
12 Claims. (Cl. 103—170)

This application is a continuation-in-part of my co-pending application Serial No. 322,299, filed November 8, 1963; and the invention herein disclosed relates to positive displacement pumps and has more particular reference to improvements in valve mechanism for pumps of the type which are designed to handle materials or products that are semi-liquid in nature and have poor flow characteristics, such as freshly mixed concrete.

A pump especially well suited for the above purpose is disclosed in my Patent No. 3,068,806 issued December 18, 1962. It features a number of closely grouped pumping cylinders having ports that are charged from a common feed chamber and through which the product is discharged to a common delivery line. A piston in each cylinder is moved in a charging direction to induct the product being pumped into its cylinder from the feed chamber while the cylinder is closed off from the delivery line, and the piston is moved in the opposite direction to discharge the product to the delivery line while the cylinder is closed off from the feed chamber.

All such pumps, of course, require valve means to control communication of the pumping cylinders with both the feed chambers and the delivery line; and it will also be appreciated that valve and piston movements have to be synchronized to insure communication between the feed chamber and each cylinder on the charging stroke of its piston, and similarly to assure communication between the delivery line and each cylinder on the discharging stroke of its piston.

The valve mechanism ordinarily provided for semi-fluid pumps in the past, and especially for concrete pumps, left much to be desired. They were objectionable for many reasons but primarily because of the multiplicity of valves employed therein. In the simpler pumps, one valve was provided for each pumping cylinder; while in more complicated pumps, it was not unusual to provide separate charging and discharge valves for each pumping cylinder. Moreover, the valve mechanism employed in the past were often quite complicated and not always reliable in operation.

In addition, it was also very difficult to provide the valve mechanisms heretofore in use with the necessary pressure seals, without involving the use of two or more seals per valve. Frequently, these seals had to be applied to objectionably large diameter surfaces of the valves, due to their peculiar natures.

With these objections in mind, it is a primary purpose of this invention to provide a semi-fluid pump of the character described with valve mechanism which overcomes the disadvantages noted, and which is relatively simple in construction and efficient in operation.

More specifically, it is an object of this invention to provide a semi-fluid pump with valve mechanism of improved construction, wherein both charging and discharging of one or a plurality of pumping cylinders can be selectively controlled in the manner described by a single valve unit having but one delivery passage formed therein and common to all the pumping cylinders.

Still another object of this invention resides in the provision of a semi-fluid pump of the character described with valve mechanism that comprises a single rotatable valve member capable of serving a number of pumping cylinders and which requires but one pressure seal, at its junction with the delivery line of the pump,

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to effectively preclude leakage of the more liquid constituents of freshly mixed concrete and the like; and which moreover will be more or less self cleaning in operation.

In this latter respect, it is a purpose of this invention to provide an improved valve mechanism for concrete pumps and the like, which valve mechanism comprises a single rotary valve having a curved bottom surface that more or less nests in a feed or valve chamber having a bottom portion with a matingly curved surface, and wherein said curved surfaces are uniformly contiguous throughout an angle of substantial magnitude so as to prevent solids in the product in the valve chamber from becoming wedged between the bottom of the valve and the chamber wall therebeneath, or from accumulating on the walls of the chamber in a manner such as could interfere with proper operation of the valve.

More specifically, it is a purpose of this invention to provide an improved valve having other surfaces that are cooperable with walls of the chamber in which the valve operates to guide the product to be pumped toward the cylinder port or ports being charged from the valve chamber.

A further object of this invention resides in the provision of improved valve mechanism for multi-cylinder semi-fluid pumps of the type embodying the principles of my aforesaid Patent No. 3,068,806, which valve mechanism comprises a single rotatable valve element that serves to control charging and discharging of all of the pumping cylinders and is movable to a discharge position with respect to each cylinder, in turn, at which its simultaneously effects direct communication between the feed chamber and two other cylinders to enable them to be charged while one of the cylinders is discharging to the delivery line through the delivery passage in the valve element.

With these and other objects in view which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate several complete examples of the physical embodiments of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

FIGURE 1 is a plan view of a three cylinder semi-fluid pump embodying valve mechanism of this invention;

FIGURE 2 is a sectional view taken through FIGURE 1 along the line 2—2, parts thereof being shown in elevation;

FIGURE 3 is a cross section view taken through FIGURE 2 along the plane of line 3—3;

FIGURE 4 is a view partially in elevation and partially in section illustrating another three cylinder semi-fluid pump embodying valve mechanism of this invention;

FIGURE 5 is a cross sectional view taken through FIGURE 4 on the plane of line 5—5;

FIGURE 6 is another cross sectional view taken through FIGURE 4 on the plane of line 6—6;

FIGURE 7 is a view similar to FIGURE 6 showing the parts in another position of operation;

FIGURE 8 is a cross sectional view taken through FIGURE 4 on the plane of line 8—8, more or less diagrammatically showing the manner in which the valve element governs the three cylinder ports of the pump;

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FIGURE 9 is a sectional view similar to FIGURE 2 but illustrating a two cylinder pump embodying valve mechanism of this invention;

FIGURE 10 is a cross sectional view taken on the plane of the line 10—10 in FIGURE 9;

FIGURE 11 is a group perspective view of the valve seen in FIGURE 9, and showing its relationship to a liner for the bottom of the valve chamber;

FIGURE 12 is a sectional view similar to FIGURE 9 but showing still another valve mechanism of the invention incorporated in a two cylinder pump;

FIGURES 13 and 14 are more or less diagrammatic views showing the valve of FIGURE 12 in each of its two operating positions;

FIGURE 15 is a cross sectional view through the valve chamber, taken on the line 15—15 of FIGURE 12 and showing the valve in an intermediate position;

FIGURE 16 is a cross sectional view of the valve chamber showing the valve in perspective therein and as viewed from its rear;

FIGURE 17 is a sectional view through the valve chamber of a four cylinder pump showing still another type of valve suitable for use therein, said view being taken on the line 17—17 of FIGURE 19;

FIGURE 18 is a perspective of the valve seen in FIGURE 17, viewing the same from its rear; and

FIGURE 19 is a cross sectional view of the valve chamber, looking rearwardly therein, and taken on the line 19—19 of FIGURE 17.

Referring now more particularly to the accompanying drawings, in which like reference characters have been applied to like parts throughout the views, the numeral 10 in FIGURE 1 generally designates the feed chamber of a semi-fluid pump comprising three pumping cylinders 11, 12 and 13. The cylinders are arranged to receive the material or product to be pumped from the interior of the feed chamber under the control of valve mechanism 14 of this invention, which valve mechanism is mounted in the feed chamber and also serves to conduct material discharged from the pumping cylinders to a delivery line 15 common to the cylinders.

As is customary, the piston 16 in each pumping cylinder is reciprocated by power means which, in the present case, is illustrated as comprising hydraulic cylinders 17, one for each pumping cylinder, having a piston rod 18 connected with the piston 16 of the pumping cylinder in the manner illustrated best in FIGURE 2. These operating or driving cylinders 17 are all of the double acting variety, and their operation may be timed and synchronized with that of the valve mechanism in the manner disclosed in my aforesaid Patent No. 3,068,806.

The feed chamber 10, which also serves as the valve chamber, comprises a receptacle having an open top providing an inlet 20, opposite flat upright walls 21 and 22 at the front and back of the receptacle, respectively, and a bottom wall generally designated 23, having a substantially flat center section 24 and upwardly and outwardly convergent end sections 25 joined to the bottom section by outwardly convex or rounded bottom wall sections 26.

As shown, the back wall 22 of the feed chamber may be substantially reinforced by a heavy plate 27 to which the forward ends of the pumping cylinders 11, 12 and 13 are secured; and holes 11', 12' and 13' in the rear wall and reinforcement provide pump or cylinder ports that register with the open front ends of the cylinders 11, 12 and 13, respectively.

Primarily to illustrate the versatility of the valve mechanism 14 of this invention, it has here been shown as comprised of two valve members or units 29 and 30, each mounted in the feed chamber and extending across the space between its front and back walls 21 and 22. As will be described at greater length hereinafter, the valve member 29 serves two of the pumping cylinders

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11 and 12, while the third pumping cylinder is served by the valve member 30.

Each of the valve members has a delivery passage 31 extending fore and aft therethrough, which passage has a recurved or shallow S-shaped bend in it. The forward or outlet ends of the delivery passages 31 of the valve members register with delivery ports 32 in the front wall 21 of the feed chamber located substantially on the axes of curvature of the two rounded bottom wall sections 26 of the feed chamber. A Y-shaped duct 34, sometimes referred to as a "Siamese" pipe, has a stem 35 that joins with the delivery line 15 and opposite branches 35' which extend rearwardly from its stem and are connected with the front wall of the feed chamber by flanged couplings 36, in register with the delivery ports 32.

It is a feature of this invention that each of the valve members 29 and 30 is mounted in the feed chamber and supported for rotation about the axis of its delivery port 32, with the forward or outlet end of its delivery passage 31 coaxial with the delivery port and at all times in register therewith.

In the pump shown, each of the valve members has a slightly reduced cylindrical forward end portion that projects through its delivery port 32 and is journaled in a bearing sleeve 37 located partly in the delivery port and partly in the adjacent coupling 36. This sleeve also provides a pressure seal that extends forwardly past the end of its valve member into the coupling 36 to prevent leakage of material being pumped from the joint between the valve member and its coupling. A trunion 38 on the rear end portion of each valve member, coaxial with its bearing 37, is received in a bearing 39 in the rear wall and reinforcement 27 of the chamber, as best seen in FIGURE 2. The fore and aft bearings for the valve members thus cooperate to support the valve members for rotary motion about fixed parallel axes that have been shown as lying in a common horizontal plane.

As also seen in FIGURE 2, the forward or outlet end of the delivery passage 31 in each of the valve members is coaxial with both the front and rear bearings for the valve member, but the rear or inlet end of the delivery passage 31 is offset radially a distance from the axis of rotation of the valve member due to the recurved shape of the passage. Hence, the inlet end of the discharge passage in each valve unit travels in an orbit that is concentric to the axis about which the valve rotates.

The rear portion 40 of each valve element is flatwise contiguous to the inner surface of the rear wall 22 of the feed chamber, and it is widened along its orbit of travel, as seen best in FIGURE 3. The valves are also shaped to have surfaces that are concentric to the axes about which they rotate, and which surfaces are contiguous to the curved corner sections 26 of the feed chamber throughout an angle of substantial magnitude so as to prevent all but the smallest solid particles (sand or the like) from becoming wedged between the undersides of the valves and the curved bottom surfaces of the feed chamber. The delivery passage 31 in each valve element is also progressively widened in the direction of orbital travel of its rear portion, toward the mouth 31' of the delivery passage.

Each valve element is oscillatable back and forth through an arc of about 65°, between a first operating position at which its wider rear end portion is below the valve axis, or adjacent to the flat bottom wall portion 24 of the feed chamber, and a second operating position at which said wider rear portion of the valve element is disposed laterally alongside the valve axis, between the latter and the adjacent upwardly convergent end wall 25 of the feed chamber. The cylinder ports 11' and 13' are located nearly directly beneath the axes of the valve elements 29 and 30, respectively, to be covered by the wider rear portions of the valve elements when both are in their first operating positions described, and at which positions the

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wide mouths of the valve elements are in register with the cylinder ports 11' and 13'.

FIGURE 3 shows the valve element 29 in its first operating position, and valve element 30 in its second operating position.

Hence, the valve element 29 is in a delivery position with respect to the cylinder port 11', at which it conducts material discharging from cylinder 11 through the delivery port 32 to the delivery line 15. The valve element 30, however, is in a charging position with respect to its cylinder port 13', permitting direct communication of cylinder 13 with the interior of the feed chamber.

In this position of the valve element 29, its wider rear portion lies entirely below the cylinder port 12', which is located laterally of the axis of valve element 29, between said axis and the adjacent upwardly convergent end wall 25 of the feed chamber. Accordingly, whenever the valve element is in a delivery position with respect to the cylinder port 11', as shown in FIGURE 3, it is in a charging position with respect to its other cylinder port 12'. Conversely, when the valve element is swung clockwise as viewed in FIGURE 3 to its second operating position, corresponding to the position of valve element 30 and covering cylinder port 12', it is then in a delivery position with respect to cylinder 12 and in a charging position with respect to cylinder 11.

With the arrangement described, of course, the cylinder ports are offset from the axes of rotation of their respective valve elements a distance equal to the radial offset between the inlet and outlet ends of the recurved cylinder ports may be widened or flared at diametrically opposite sides, in the direction of orbital travel of the valve elements, and forwardly toward the feed chamber, so as to more or less match the shape of the inlet ends of the delivery passages in the valve elements.

In operation, when the valve element 30 is in its charging position seen in FIGURE 3, the product to be pumped is inducted into the cylinder 13 from the interior of the feed chamber during the charging stroke of the piston 16 in said cylinder, inasmuch as the cylinder port 13' is then in direct communication with the interior of the feed chamber. At the completion of the charging stroke of the piston, the valve member 30 is rotated in the clockwise direction as seen in FIGURE 3, to bring the mouth of its delivery passage into register with the cylinder port 13' to close it off from the interior of the feed chamber and to then communicate it with the delivery port 32 in the forward wall of the feed chamber. Thereafter the piston 16 in the pumping cylinder 13 can begin its discharge stroke during which it travels forwardly in its cylinder to expel material forwardly through the cylinder port 13' and the delivery passage 31 to the delivery line 15.

Power means is provided to oscillate the valve element 30 between its charging and discharging positions described. As shown, such power means may comprise a double acting fluid pressure cylinder 42 carried by a bracket 43 mounted on the end wall of the feed chamber remote from the valve member 30, and having the cylinder pivotally connected thereto as at 44 for rocking motion about a fore and aft extending horizontal axis. The piston rod 45 of the cylinder has its forward end connected by a pin 46 with an upstanding arm 47 joined to the top portion of the valve element 30 so that extension of the piston rod from its position seen in FIGURE 3 rocks the valve element from its charging position shown to its discharging position covering the cylinder port 13'.

Subsequent retraction of the piston rod returns the valve element 30 to its charging position shown.

The valve mechanism described is unique inasmuch as it lies entirely to one side of the cylinder port 13' when in its charging position, so that the product to be pumped can flow freely from the interior of the feed chamber for induction into the pumping cylinder 13 on the charging stroke of its piston. Also in this charging position, the rear wall 22 of the feed chamber closes the mouth of

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the delivery passage 31 in the valve element, to prevent back flow of material into the feed chamber from the delivery line 15. In the discharging or delivery position of the valve element 30, its recurved delivery passage 31 smoothly conducts the material expelled from the cylinder 13 on the discharge stroke of its piston, to the delivery port and ultimately the delivery line 15, with a minimum of resistance to flow due to the gentle curvature of the delivery passage 31.

The other valve element 29 is a mirror image of the valve element 30, and as seen in FIGURE 3 is arranged symmetrically therewith about a median vertical plane of the feed chamber normal to its flat front and rear walls 21 and 22, respectively. The valve element 29, however, serves two pumping cylinders, namely the cylinders 11 and 12. In each of its operating positions, it is in discharging relation with respect to one of its cylinder ports and at the same time in charging relation with respect to its other cylinder port.

During operation of the pump, the valve member 29, in its position seen in FIGURE 3, conducts material discharging from the pumping cylinder 11 to the delivery line while at the same time allowing material from the feed chamber to be inducted into the pumping cylinder 12 through its cylinder port 12'. For this purpose, of course, the pistons in the two cylinders 11 and 12 can be operated such that they move in opposite directions.

A second fluid pressure operated cylinder 52 is provided to impart oscillatory motion to the valve element 29 between its two operating positions described. Its piston rod 53 is connected with an upstanding arm 54 on the valve element 29 corresponding to the arm 47 of the valve element 30. In this case, however, the cylinder 52 is mounted on a bracket 55 carried by the opposite end wall of the feed chamber, for up and down rocking motion about the axis of a pin 56 in the bracket.

FIGURE 3 shows the piston rod 53 of cylinder 52 extended, with the valve element 30 at its limit of counterclockwise motion. When the piston rod 53 is retracted, it imparts clockwise rocking motion to the valve element to carry it through an angle of approximately 65° to its second operating position covering the cylinder port 12' and uncovering the cylinder port 11'.

It will be apparent, of course, that the operation of the pumping cylinders and the valve operating cylinders can be so synchronized that as soon as each pumping cylinder is fully charged, the valve element for that cylinder will be moved to a delivery position with respect to the charged cylinder, ready to conduct to the delivery line material expelled from the cylinder by forward travel of its piston.

If desired, the pistons in the pumping cylinders 11, 12 and 13 can be driven with the differential rates disclosed in my aforesaid Patent No. 3,068,806, namely with each piston driven at the same optimum charging speed and at a discharging speed which is twice that of charging; and with two pistons moving rearwardly at the same time through different fractions of their charging strokes while the third piston is driven forwardly at higher speed in its discharge stroke.

From the description thus far it will be readily apparent that a fourth pumping cylinder could very well be incorporated in the apparatus shown in FIGURES 1 through 3 to be served by the valve element 30 in the same way as the pumping cylinder 12 is served by the valve element 29. The cylinder port (not shown) of the fourth cylinder would, of course, open through the rear wall of the feed chamber in symmetrical relationship to the cylinder port 12'.

Thus, one of the features of the valve mechanism described is that the same valve element may be employed in either a single or a double cylinder pump, and that a pair of right and left valve elements 29 and 30 may be employed in either a three cylinder or a four cylinder pump.

FIGURES 4 through 8 disclose a modified form of pumping apparatus in which a single valve member 60, like that previously described, is operable to serve three pumping cylinders. The valve member 60 is in this case also mounted within a feed or valve chamber 65 having flat upright front and rear walls 66 and 67, respectively, a semi-circular bottom wall 68 which is concentric to the axis of a delivery port 69 in the front wall 66, and more or less upright side walls 70, the lower portions of which converge toward their junctions with the curved bottom wall 68.

The valve member 60 has a cylindrically surfaced exterior that is contiguous to the inner surface of the curved bottom wall 68, and it has a rear portion which is flatwise contiguous to a port adaptor or wear plate 72 that is secured to the rear wall 67 at the inside of the feed chamber.

A cylinder unit 73 which is bored to provide three pumping cylinders is fastened to the rear wall 67 of the feed chamber, and the front end portions of the cylinders register with cylinder ports 74, 75 and 76 in the wear plate and rear wall of the feed chamber. These cylinder ports are arranged in angularly equispaced relationship about the axis of the delivery port 69 and spaced equal radial distances therefrom.

The open top of the feed chamber is here shown communicated with the forward end portion of a trough, generally designated 77, in which a screw or the like, not shown, may be provided to propel the product to be pumped forwardly into the feed chamber.

The valve member 60 has what may be termed a cylindrical hub portion 78 that is freely rotatably received in the delivery port 69, and a reduced tubular portion 78' that projects forwardly through a pair of outboard bearings 79 and 80 to cooperate therewith in mounting the valve member coaxially of the delivery port 69. The bearing 79 is secured to the outer side of the front wall 66 of the feed chamber, while the bearing 80 is carried by a bearing supporting member or pedestal 81. The pedestal is bored to receive the forward end 82 of the tubular portion 78' and to also receive a tubular rear portion 83 on an attaching flange 84 that is secured to the front of the pedestal and provides for attachment of a delivery line (not shown) to the pumping apparatus.

The pedestal 81, in addition to providing a forward bearing for the valve member, also contains the single high pressure seal, generally designated 85, that is needed to seal the joint between the forward end of the valve member and the delivery line coupling 84.

The valve member 60 also has a delivery passage 87 extending fore and aft therethrough, with its forward end portion gently merging into the tubular forward extension of the valve member. Its inlet or rear end portion is the same diameter as the forward end portion and opens through the rear part of the valve member that sweeps across the inner surface of the wear and port adaptor plate 72. This delivery passage 87 is similarly recurved so that its rear end portion or mouth is radially offset from the axis of rotation of the valve a distance corresponding to the radial distances between said axis and the cylinder ports 74, 75 and 76.

Hence, in each of three angular positions equispaced from one another and at which the rear or inlet end portion of the delivery passage 87 registers with a different one of the cylinder ports, the material in the pumping cylinder associated with said port may be discharged forwardly through the delivery passage 87 in the valve member and out through the tubular forward extension 78' to the delivery line. During such discharge of each pumping cylinder, the two remaining cylinders can be charging, and for this purpose, the rear end portion of the valve member is sector shaped and large enough to cover only one cylinder port at a time. Preferably, its shape and size is such as indicated in the FIGURE 8 diagram by the broken line 88.

This diagram also shows the arrangement of cylinder ports 74, 75 and 76 in the wear or port adaptor plate 72, looking at the latter from inside the feed chamber. As therein seen, the cylinder ports are round and the sector shaped rear end portion 88 of the valve member is of a size to cover the port 74 when the valve member is in its discharging position communicating the associated cylinder with the delivery line. In that position, the valve member leaves the other two ports 75 and 76 open and in direct charging communication with the interior of the feed chamber.

When the valve member is rotated about its axis through an angle of 120° in the clockwise direction as viewed in FIGURE 8, it covers the cylinder port 75 to communicate its associated cylinder with the delivery line and leaves the cylinder ports 74 and 76 uncovered and in direct communication with the interior of the feed chamber so that the latter may be charged while the cylinder associated with the port 75 discharges.

Similarly, rotation of the valve member through another 120° of rotation in the clockwise direction brings it to its third operating position covering the port 76 to enable the cylinder associated therewith to be discharged to the delivery line while the ports 74 and 75 are uncovered and in direct charging communication with the interior of the feed chamber, so that the cylinders associated with the ports 74 and 75 may be charged while the cylinder associated with the port 76 is discharging.

The valve member 60 is adapted to be intermittently driven in one direction about its axis of rotation, to each of its operating positions. A ratchet 90, fixed to the exterior of the tubular forward extension 78' of the valve member, at a location between the two outboard bearings 79 and 80, is provided for that purpose. The ratchet has three lobes 91, 92 and 93 which are adapted to be acted upon by a pair of actuators 94 and 95 to effect the desired intermittent advance of the valve member. These actuators comprise the piston rods of fluid pressure cylinders 96 and 97, each of which carries a roller 98 on its outer end for engagement with radially disposed working faces 99 on the ratchet lobes to effect clockwise rotation thereof, as viewed in FIGURES 6 and 7, in consequence of extension of the piston rods 94 and 95.

The cylinders 96 and 97 are operated in opposite phase relationship, so that with the parts in their positions seen in FIGURE 6, extension of the piston rod 94 by its cylinder can take place simultaneously with retraction of the piston rod 95. When that occurs, the roller 98 on the piston rod 94 pushes against the working face of the lobe 91 to rotate the ratchet and the valve member clockwise through an angle of 60°, while the lobe 92 is carried down to a position ahead of the roller on the then retracted piston rod 95 of the cylinder 97. FIGURE 7 shows the positions of the ratchet and piston rods after such actuation of the ratchet. The piston rod 94 may now be retracted while the piston rod 95 is extended so that the roller on rod 95 pushes against the working face of lobe 92 to cause the ratchet to be rotated another 60° in the clockwise direction, and thus complete the movement of the valve member through the 120° increment necessary to shift it from one operating position to the next.

The two cylinders 96 and 97 are mounted at opposite sides of the forwardly extending tubular part of the valve member, both cylinders being mounted on pivotal supports 100 at their outer ends, so that they can rock up and down as the rollers on their piston rods ride over the lobes to operating positions confronting the working faces of the lobes.

As indicated in FIGURE 7, the cylinder 96 is yieldingly biased in a downward direction by a tension spring 101, while the cylinder 94 is yieldingly urged upwardly by an expansion spring 102.

It will be noted that with the pumping apparatus disclosed in FIGURES 4 through 8, the valve member is

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rotated in only one direction to its successive operating positions, by mechanism that is located entirely outside the feed chamber.

FIGURE 9 illustrates a two cylinder pump equipped with a slightly different form of valve 105 embodying this invention. The two cylinders 106 and 107 are shown mounted horizontally one beside the other and beneath the trough 77 that opens forwardly into the open top of the feed or valve chamber 108. The front ends of the cylinders open to the interior of the valve chamber through cylinder ports 106' and 107' in a wear plate 109 secured to the upright rear wall of the chamber. The cylinder ports are located slightly below but equal radial distances from the fore and aft axis of the substantially semi-cylindrical bottom 110 of the valve chamber.

In this case, the pump is provided with a delivery tube 111 which is supported in bearings 112 for rotary motion about the axis of the semi-cylindrical bottom 110 of the valve chamber. These bearings are carried by opposite rails 113 that provide the base frame of the pump.

The forward end of the delivery tube is adapted to be coupled to a delivery line indicated at 114. Its rear end 115 is enlarged and cylindrical in shape, and it is rotatably received in a hole in the upright front wall 116 of the valve chamber. A seal device 117 supported from the bearing structure 112 prevents liquid materials in the product contained in the valve chamber from leaking out of the chamber around the exterior of the cylindrical rear end of the delivery tube 111.

While the valve 105 can be made an integral part of the tube 111, it has here been shown as comprising a separate unit having a fore and aft dimension slightly less than the spacing between the inner surface of the wear plate 109 and of the front wall 116 of the valve chamber. It is secured to the cylindrical rear end of the delivery tube, as by screws 119, thus giving the advantage that it can be detached therefrom and removed from the valve chamber through the open top thereof, for replacement whenever necessary.

Only the rear part 120 of the delivery passage is formed in the valve 105. The front part 121 of the delivery passage is provided by the delivery tube 111, and it is curved slightly in a direction opposite the curvature of the rear part 120 of the passage.

As in the embodiment of the invention shown in FIGURE 4, the forward end of the valve 105 could be cylindrical, and it could also have a cylindrical surface of substantial area on its underside extending across the space between the front and rear walls of the valve chamber in contiguous relation to the semi-cylindrical bottom of the chamber. As here shown, however, the valve 105 has been made as light in weight as possible to make it easier for drive mechanism not shown but connected to a lever 123 fixed to the delivery tube 111, to swing the valve back and forth between its two operating positions. For this purpose, the top of the valve is formed to resemble the inside surface of a section of V-pulley in that it has a concave appearance when viewed from the side, and a more or less gabled appearance when viewed from its sector-like rear end 124. The rear of the valve is thus much smaller than its front at the junction thereof with the rear of the delivery tube 111. As seen best in FIGURES 10 and 11, the underside of the valve at its rear has a cylindrical surface 125 which extends axially nearly halfway to its front and through an angle of substantial magnitude. The bottom and sides of the valve at the front portion thereof are formed with a forwardly convergent frusto-conical surface 126. All of the surfaces 125 and 126, however, are concentric to the axis of the semi-cylindrical bottom portion 110 of the valve chamber. At its extreme front, the frusto-conical surface on the valve extends continuously around its exterior.

Since the surfaces 125 and 126 on the underside of the valve are spaced a distance from the inner surface

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of the cylindrical bottom portion of the chamber in which the valve operates, a liner 128 is secured in the bottom portion of the chamber to take up all but a very small clearance space beneath the valve. The liner has a thin cylindrical rear portion 129 over which the cylindrically surfaced rear of the valve sweeps, and a forwardly convergent frusto-conical front portion 130 over which the similarly shaped front portion of the valve sweeps, in substantially close proximity thereto.

As can be appreciated from FIGURE 10, the cylindrical surface on the gabled rear portion of the valve extends for an angle of somewhat more than 90°, while the mating surface on the liner extends for an angle of nearly 180°.

In the position of the valve seen in FIGURE 10, the sector-like rear of the valve covers the cylinder port 106' to conduct the product expelled from its cylinder to the delivery tube on the discharge stroke of the piston in said cylinder. In this position, the valve leaves the other cylinder port 107' open to the interior of the valve or feed chamber so that the product in the latter can be inducted into the cylinder 107 during the retraction stroke of its piston. Note that the side surface of the valve which is uppermost, in this position thereof, slants downwardly toward the port 107' to guide concrete or other material in the chamber thereto, while the other side surface of the valve is nearly vertical and clears the port 107'. Also, both of these gabled side surfaces define sharp corners at their junctions with the curved underside of the valve, so that the leading corner will act to plow concrete or other material off the surface of the liner as the valve is moved from one operating position to the other.

The liner, of course, actually defines the bottom and side surfaces of the valve chamber over which the valve moves during operation of the pump. Note also that the valve is shaped to cooperate with the valve chamber in a way that eliminates all pockets in which concrete or other material may accumulate and seriously interfere with valve motion. All surfaces on the valve and the feed or valve chamber are so sloped that concrete or the like will be guided toward either cylinder port uncovered by the sector-like rear end portion of the valve as it is moved from one operating position thereof to the other.

FIGURE 12 shows another embodiment of a two cylinder pump which differs from that last described mainly in that its valve 132 is mounted in the feed or valve chamber 133 for back and forth swinging motion about an axis spaced a distance above a circular delivery port 134 in the front wall 135 of the chamber. For this purpose, the valve is mounted on the rear of a shaft 136 suitably journaled for rotation on a fixed axis normal to the upright front and rear walls of the feed chamber, with the shaft located just above a stationary delivery tube 137 that has its rear end in communication with the delivery port 134. The shaft, of course, extends through a suitably sealed hole in the front wall of the chamber, and an operating lever 138 affixed to its forward end is adapted to be operatively connected with the drive means (not shown) for swinging the valve back and forth between its two operating positions.

The valve 132 also has a substantially small sector-like rear end 139 through which the mouth 140 of a delivery passage 141 in the valve opens. The underside of the valve has a cylindrical surface 142 which is concentric to the axis about which the valve swings, and which extends for the entire axial length of the valve. As before the valve nests in the bottom portion of the feed chamber with its cylindrical underside contiguous to the curved inner surface of the chamber, which is curved to more or less mate with the cylindrical surface on the valve.

The valve widens progressively toward its forward end, which is substantially semi-cylindrical in shape as best seen in FIGURES 15 and 16. Its delivery passage 141 also widens progressively forwardly from its more or less

circular mouth 140, to terminate in a bean-slot type of outlet 144 at the front end of the valve.

The cylinders 106 and 107 have ports 106' and 107', respectively, which open forwardly into the feed or valve chamber at locations below but spaced equal radial distances from the axis of rotary movement of the valve, and equal distances to opposite sides of a vertical plane containing the axis about which the valve swings. The delivery port 134 is located on said plane, and spaced from the valve axis the same distance as the cylinder ports. Because of this relationship between the cylinder ports and the delivery port, the rounded ends of the bean-slot outlet 144 for the delivery passage in the valve can be said to be coaxial with the cylinder ports when the valve is in an intermediate position such as seen in FIGURES 15 and 16, midway between its two operating positions. It is for this reason that first one end portion and then the other of the bean-slot outlet 144 of the delivery passage will be carried into register with the delivery port 134 upon swinging of the valve from a first operating position at which the mouth 140 of its passage registers with one cylinder port 106' (FIGURE 13) to its second operating position at which the mouth 140 of its passage registers with the other cylinder port 107' (FIGURE 14). In other words, the delivery passage 141 in the valve will be in communication with the delivery port 134 at all times, while the mouth of the delivery passage is selectively communicable with the cylinder ports.

FIGURE 13 more or less diagrammatically illustrates the valve in a first operating position at which its delivery passage conducts material expelled from the cylinder 106 to the delivery tube 137 while the cylinder port 107' is open to the interior of the valve chamber for charging of its cylinder. FIGURE 14 similarly shows the valve in its second operating position at which the cylinder 106 can be charged while the cylinder 107 discharges to the delivery tube through the delivery passage in the valve.

If desired, the delivery passage 141 in the valve can be formed with centrally located opposing upper and lower ridges 148 that extend axially of the valve and assist in channeling material passing through the delivery passage into the delivery port in either position of the valve. These ridges have maximum height at the forward end of the valve, but they progressively decrease in height toward the rear of the passage so as to avoid having any flow obstructing effect on the material entering the delivery passage.

While the valve 132 has been shown as having a delivery passage that is wide enough at its forward end to remain in communication with the delivery port 134 in both operating positions of the valve, it will be appreciated that the delivery port 134 could be widened to cooperate with a straight through delivery passage of more or less uniform diameter in the valve to achieve the same purpose of continuous communication with the delivery passage. Alternatively, a straight through delivery passage of uniform diameter could cooperate with two spaced apart delivery ports in the front wall of the feed chamber, in which case the delivery ports would be connected with a delivery line by a "Siamese" pipe of small span. In either case, the valve, of course, would still have to have a front end portion large enough to cover the wider delivery port or ports and close off the same from communication with the interior of the feed chamber in all positions of the valve.

The embodiment of the invention shown in FIGURES 17 to 19 provides a valve 150 for a pump having cylinder ports 151, 152, 153 and 154, one for each of four pump cylinders, only two of which can be seen in FIGURE 17. The cylinder ports open forwardly into the feed or valve chamber 155 through its upright rear wall 156, and they are grouped about a common center, being equispaced therefrom and from one another, with two ports horizontally opposite one another above the center and the other two below the center and the ports thereabove.

This grouping of the cylinder ports is best seen in FIGURE 19.

The valve 150 is somewhat like that seen in the FIGURE 9 embodiment of the invention in that it comprises a rear portion 157 which is located within the feed or valve chamber, and a delivery tube 158 to which the valve is bolted and which thus rotates with the valve. The delivery tube is rotarily supported, as by the same bearing structure shown in FIGURE 9, with its passage 159 on an axis passing through the center about which the cylinder ports are grouped. The cylindrical rear end of the delivery tube is received in a suitable sealed opening in the front wall 160 of the feed chamber and abuts the forwardly convergent frusto-conical front end 161 of the inner valve 157 to which it can be secured by screws not shown.

The rear end portion of the inner valve 157 has a substantially rectangular shape, as seen in FIGURE 18, with substantially flat sides 162 and rounded ends 163 that provide cylindrical surfaces concentric to the axis of the delivery tube 158. These cylindrical surfaces on the valve are again contiguous to the semi-cylindrical bottom portion of the feed chamber, while the frusto-conical portion 161 of the valve has its undersurface contiguous to that of a liner 165 in the forward bottom portion of the feed chamber.

The substantially rectangular rear end of the valve is adapted to cover a different pair of diametrically opposite cylinder ports in each operating position of the valve. The mouth 167 of its discharge passage 159' is widened in the direction of the long dimension of the rectangle so as to communicate both ports of either pair covered thereby with the delivery tube 158.

As seen in FIGURE 19, the valve 150, in a first operating position, covers the cylinder ports 152 and 154 and leaves the other two ports open for charging. While forming no part of this invention, it is contemplated that only one of the two cylinders whose ports are thus covered by the rear of the valve will have its piston driven in the discharge direction while the other remains idle.

The valve drive mechanism, not shown, is adapted to rock the valve back and forth between two operating positions. Thus, when the valve is swung 90° in the counterclockwise direction from its position seen in FIGURE 19, it leaves the ports 152 and 154 open to the interior of the feed chamber and covers the ports 151 and 153, thereby communicating the latter with the delivery tube.

If desired, the outwardly and rearwardly flared delivery passage in the inner valve 157 may be provided with a flow divider 168, which tends to divide the mouth thereof into separate passages at opposite sides of the valve axis.

From the foregoing description, together with the accompanying drawings, it will be apparent to those skilled in the art that this invention provides in a pump, for concrete and other semi-fluid materials, an improved valve mechanism that is highly efficient in operation, and which further readily lends itself to use in pumps having one, two, or a number of pumping cylinders.

What is claimed as my invention is:

1. In a positive displacement pump of the type having a pair of pump cylinders open at one end to provide for induction of material to be pumped into the cylinders during the retraction strokes of their pistons and to provide for discharge of the material from the cylinders during the extension strokes of their pistons, and further having means to drive the pistons back and forth in their cylinders in opposite phase relationship:

- (A) fixed wall means defining a feed chamber having
- (1) spaced apart upright front and rear wall portions connected by bottom and side wall portions,
 - (2) an inlet which opens into its upper portion to admit to the feed chamber material to be pumped,

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- (3) a delivery port opening through said front wall portion, and
- (4) a pair of cylinder ports opening through said rear wall portion, one for each pump cylinder and communicating with the open end thereof;
- (B) a valve mounted in the feed chamber for rotary motion about an axis fixed with respect thereto and normal to said front and rear wall portions thereof, said valve extending substantially entirely across the space between the front and rear wall portions and having
- (1) a rear portion operable upon rotary movement of the valve from one operating position thereof to another to cover and close off first one and then the other of the cylinder ports from the interior of the valve chamber;
 - (2) means on the front of the valve to at all times close off the delivery port from the interior of the valve chamber, and
 - (3) passage means extending fore and aft through the valve and opening through said rear portion thereof, to communicate the delivery port with whichever cylinder port is covered by said rear portion of the valve; and
- (C) mating curved surfaces on the underside of the valve and the bottom portion of the chamber, said surfaces being concentric to the valve axis and being uniformly contiguous throughout an angle of substantial magnitude so as to preclude solids in the material contained in the valve chamber from becoming wedged between the underside of the valve and the bottom portion of the chamber or tending to build up on the valve or its chamber during rotary motion of the valve from one of its operating positions to another, and prevent the accumulation of material on any wall portion of the feed chamber or the valve that would tend to interfere with said motion of the valve.
2. The positive displacement pump of claim 1, further characterized by:
- side surfaces on the valve joining its curved surface and forming therewith abrupt edges which sweep across the curved surface of the bottom of the feed chamber to plow all but the smallest sized materials in the feed chamber off the surface of the bottom wall about to be covered by the valve as the valve moves from one operating position to another.
3. The positive displacement pump of claim 1, further characterized by the fact that
- said mating curved surfaces are uniformly spaced from the axis of the valve.
4. The positive displacement pump of claim 3, further characterized by the fact that
- said mating curved surfaces extend for the full axial length of the valve.
5. The positive displacement pump of claim 4, further characterized by the fact that
- the front end portion of the valve is cylindrical and said curved surface of the valve is a continuation of the cylindrical surface at the front end portion thereof.
6. The positive displacement pump of claim 5, further characterized by the fact that
- the rear end portion of the valve has a sector-shaped cross section.
7. In a positive displacement pump of the type having pump cylinders open at one end to provide for induction of material to be pumped into the cylinder during the retraction strokes of their pistons and to provide for discharge of the material from the cylinders during the extension strokes of their pistons, and further having means to drive the pistons back and forth in their cylinders:
- (A) fixed wall means defining a feed chamber adapted to receive material to be pumped and having

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- (1) an upright front wall portion with a delivery port therethrough,
 - (2) an upright rear wall portion with at least three equispaced cylinder ports therethrough arranged in a circle concentric to the axis of the delivery port, and
 - (3) bottom and side walls connecting the front and rear wall portions,
 - the bottom wall being substantially semi-cylindrical and concentric to said axis;
- (B) a rotary valve in the bottom portion of the feed chamber confined between its front and rear wall portions and constrained to turn about said axis of the delivery port to each of as many operating positions as there are cylinder ports, said valve having
- (1) a cylindrical front end portion at all times closing off the delivery port from the interior of the feed chamber, and
 - (2) a sector-shaped rear end portion in sliding engagement with the rear wall portion of the feed chamber and of a size to cover only one of the cylinder ports and which,
 - in each of the operating positions of the valve, closes off a different one of said cylinder ports from communication with the interior of the feed chamber, while leaving the others open to the interior of the feed chamber to permit their respective cylinders to be simultaneously filled by retraction of the pistons therein; and
 - (3) passage means extending fore and aft through the valve,
 - the front end of said passage means being coaxial with and at all times communicating with the delivery port, and the rear end of said passage means opening through the rear end of the valve to align with whichever cylinder port is covered by the rear end portion of the valve and thereby communicate the same with delivery port,
 - the curved surface of the cylindrical front end portion of the valve and the curved surface of the sector-shaped rear end portion thereof being continuations of one another and having a radius only slightly smaller than that of the inner surface of the semi-cylindrical bottom wall of the feed chamber,
 - so that as the valve turns from one position to another its curved surface moves across the bottom of the feed chamber in uniformly close contiguity therewith, and
- (C) power means operatively connected with the valve to impart torque to the same to turn the valve from one operating position to another.
8. The positive displacement pump of claim 7, wherein the power means imparts only unidirectional torque to the valve, so that the valve always turns in the same direction as it moves from one operating position to another.
9. In a positive displacement pump of the type having a pair of pump cylinders open at one end to provide for induction of material to be pumped into the cylinders during the retraction strokes of their pistons and to provide for discharge of the material from the cylinders during the extension strokes of their pistons, and further having means to drive the pistons back and forth in their cylinders:
- (A) fixed wall means defining a feed chamber having
- (1) spaced apart upright front and rear wall portions connected by bottom and side wall portions,
 - (2) an inlet which opens into its upper portion to admit to the feed chamber material to be pumped, and

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- (3) a pair of cylinder ports opening through said rear wall portion, one for each pump cylinder and communicating with the open end thereof;
- (B) a valve mounted in the feed chamber for rotary motion about an axis fixed with respect thereto and normal to said front and rear wall portions thereof, said valve extending substantially entirely across the space between the front and rear wall portions and having
- (1) a rear portion operable upon rotary movement of the valve from one operating position to another to cover and close off first one and then the other of the cylinder ports from the interior of the valve chamber, and
 - (2) passage means extending fore and aft in the valve and opening through said rear portion thereof to communicate with whichever one of said cylinder ports is covered by said rear portion of the valve;
- (C) a tube carried by the feed chamber and extending forwardly therefrom, said tube providing a delivery passage having a mouth at its rear at all times connected with said passage means in the valve through an opening in the upright front wall portion of the chamber and being closed off from the interior of the feed chamber by the valve; and
- (D) mating curved surfaces on the underside of the valve and the bottom portion of the chamber, concentric to the valve axis and uniformly contiguous throughout an angle of substantial magnitude.
10. The positive displacement pump of claim 9, wherein said cylinder ports are located below the valve axis and equal distances to opposite sides of a vertical plane containing said axis, and wherein the mouth of the delivery tube is coaxial with the valve.
11. The positive displacement pump of claim 9, wherein the valve is mounted for rotary movement about an axis spaced a distance above the mouth of the delivery pas-

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sage and above the cylinder ports but spaced equal radial distances therefrom, and wherein the passage means in the valve widens progressively toward the front of the valve so as to be in communication with the mouth of the delivery passage in both operating positions of the valve.

12. The positive displacement pump of claim 9, wherein the axis of the valve is coaxial with the mouth of the delivery passage, wherein the pump comprises a second pair of pump cylinders each having a cylinder port opening through the rear wall portion of the chamber, the ports being arranged in diametrically opposite pairs and all located equal distances from the valve axis, wherein the valve has a substantially narrow rectangular rear portion operable upon rotary movement of the valve from said one operating position thereof to its other operating position to cover and close off first one pair and then the other pair of cylinder ports from the interior of the chamber so that a pair of cylinder ports will be open to the chamber interior in either position of the valve, and wherein said passage means in the valve is widened in the direction of the long dimension of said rectangular rear portion thereof so as to simultaneously communicate both cylinder ports covered thereby with the delivery passage.

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