H. C. BEHR.

PUMP AND SIMILAR APPARATUS.

APPLICATION FILED OCT. 25, 1919.

1,382,336.

Patented June 21, 1921.

3 SHEETS—SHEET 1.

Fig. 1.

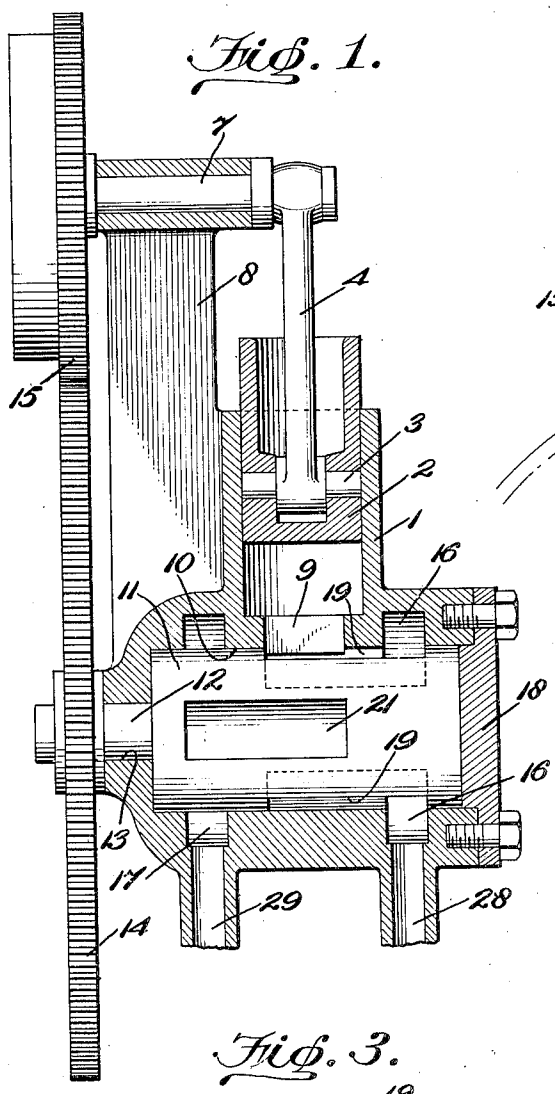


Fig. 2.

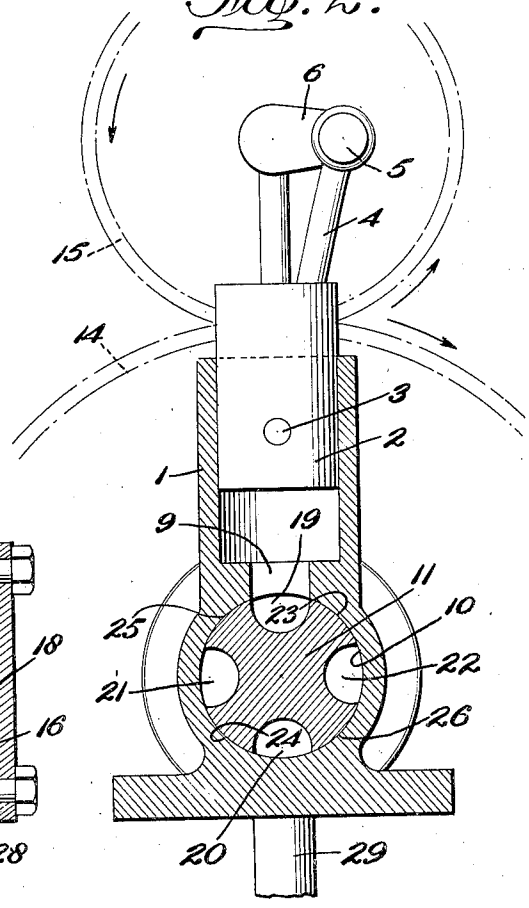


Fig. 3.

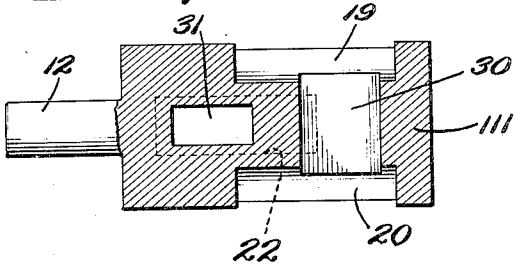
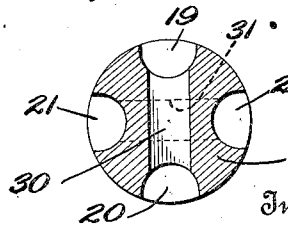


Fig. 4.



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3 SHEETS—SHEET 2.

Fig. 5.

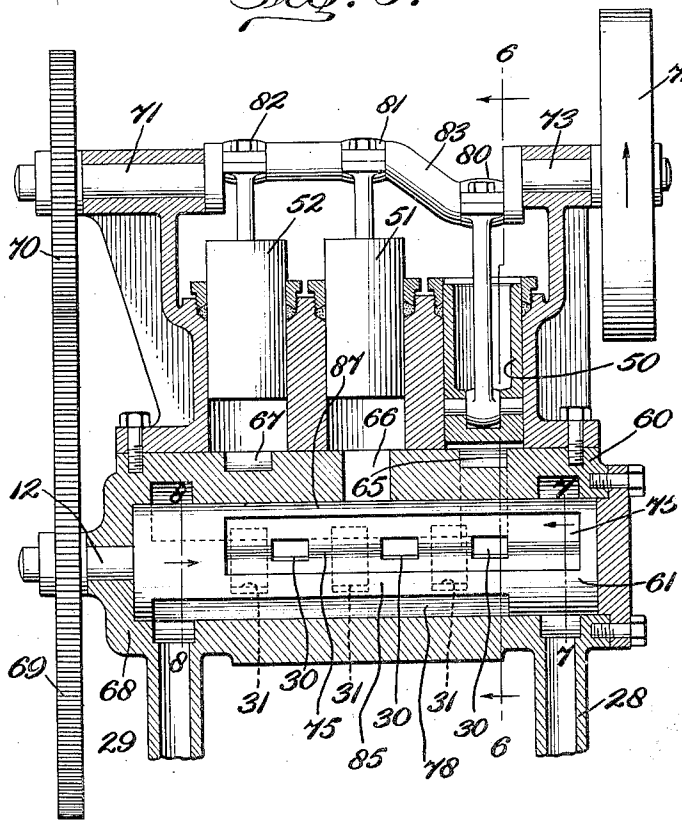


Fig. 6.

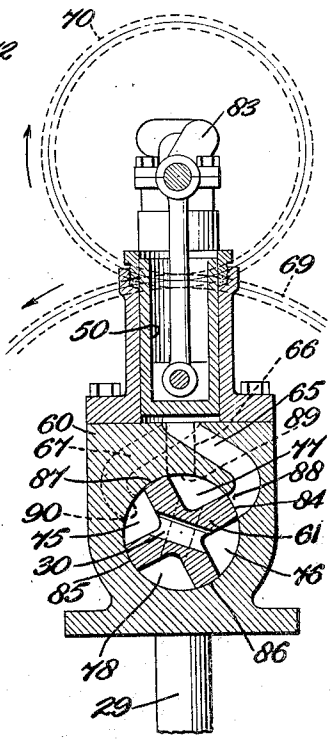


Fig. 7.

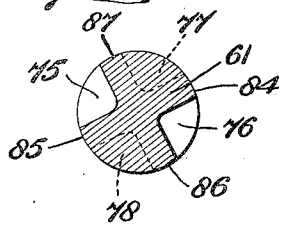
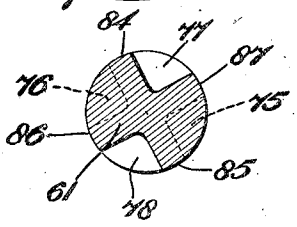


Fig. 8.



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3 SHEETS—SHEET 3.

Fig. 9.

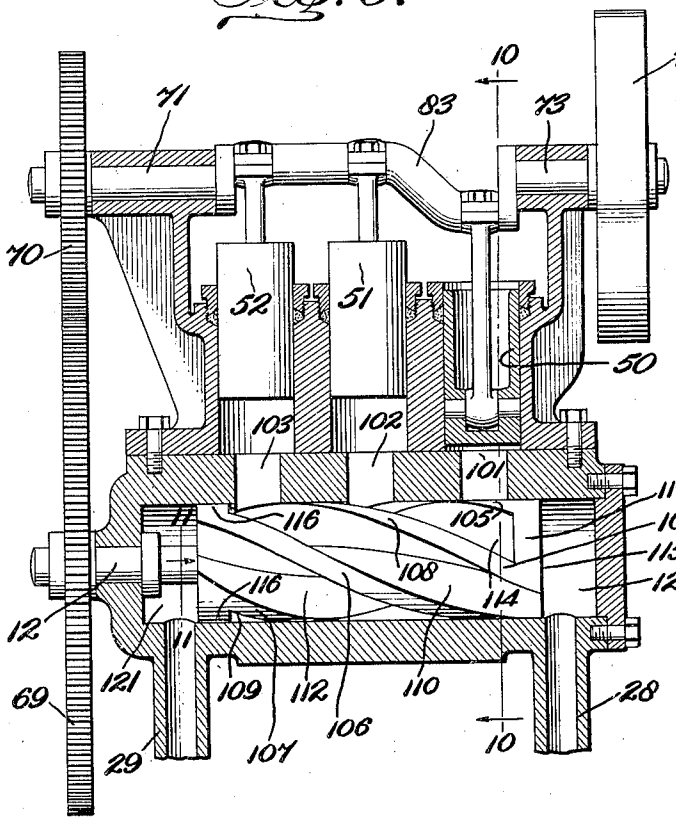


Fig. 10.

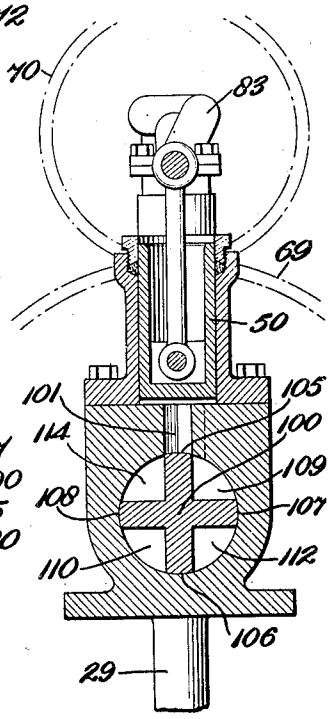


Fig. 11.

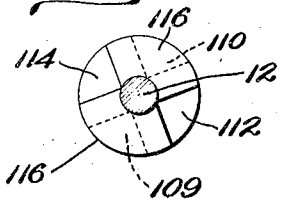
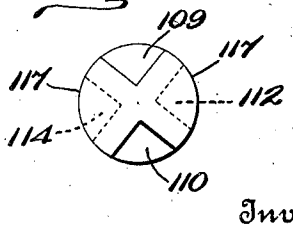


Fig. 12.



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PUMP AND SIMILAR APPARATUS.

1,382,336. Specification of Letters Patent. Patented June 21, 1921.

Application filed October 25, 1919. Serial No. 333,202.

To all whom it may concern:

Be it known that I, HANS C. BEHR, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Pumps and Similar Apparatus; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to pumps and similar apparatus in which the pistons are operated by cranks, and particularly to such machines as have a number of single acting cylinders in a row and are commercially known as multiplex pumps.

One of the main objects of the invention is to make such apparatus suitable for operation at higher speeds than are now practicable, so that a smaller and therefore a cheaper mechanism may be used. Another object is to adapt these mechanisms to the handling of thick and viscous liquids; and a still further object is to reduce friction and wear of the apparatus, especially when used at higher pressures.

With these and other objects in view the invention consists in the details of construction and combinations of parts involving an application of a balanced rotary valve of a special design to such machines, and which is positively operated by mechanism from the crank shaft, all as will be more fully hereinafter disclosed and particularly pointed out in the claims.

For simplicity of description in what follows, the inventive idea will be disclosed mainly in connection with pumps.

Referring to the accompanying drawings, forming a part of this specification, in which like numerals designate like parts in all the views:—

Figure 1 is a vertical sectional view, partly in elevation, of a pump made according to this invention;

Fig. 2 is a transverse sectional view of the pump shown in Fig. 1;

Figs. 3 and 4 are respectively longitudinal and transverse sectional views of a modified form of the valve shown in Figs. 1 and 2;

Fig. 5 is a longitudinal vertical sectional view, partly in elevation, of a triplex pump having a valve operating according to this invention;

Fig. 6 is a transverse sectional view of the pump and valve shown in Fig. 5, taken on the line 6—6 of the said figure, certain of the parts being omitted;

Figs. 7 and 8 are transverse sectional views of the valve shown in Fig. 5, taken respectively on the lines 7—7 and 8—8 of the said figure;

Fig. 9 is a view similar to Fig. 5, illustrating a somewhat modified form of valve plug;

Fig. 10 is a transverse sectional view, taken on the line 10—10 of Fig. 9, looking in the direction of the arrows, certain of the parts being indicated in broken lines;

Fig. 11 is a sectional elevational view of the valve plug shown in Fig. 9, taken on the line 11—11 of the said figure; and

Fig. 12 is an end elevational view of the said valve plug, as seen from the right in Fig. 9.

1 indicates any suitable cylinder, provided with a plunger or piston 2, coupled by the pin 3 and connecting rod 4 to the crank pin 5 on the crank 6. 7 represents a crank shaft, mounted in the bearing frame 8 rigid with the cylinder 1, which cylinder is provided with the port 9, communicating with the valve chest 10, as shown. 11 indicates a valve of any suitable form fitting fluid-tight in said valve chest, after the manner of a plug cock or valve. The stem 12 of the valve 11 also fits fluid-tight in the end 13 of the valve chest 10, and carries on its projecting end the gear 14, meshing with the gear 15 fixed to the crank shaft 7, all as will be clear from the drawings. The gear 14 in Fig. 1, is twice the diameter of the gear 15, so that the crank shaft 7 makes two revolutions for one revolution of the valve 11.

The valve chest 10 is provided at one end with the annular inlet chamber 16, and at the other end with the annular outlet chamber 17, which encircle the valve 11, as shown. A removable bonnet 18 closes the open end of valve chest 10, and permits the insertion and withdrawal of the valve 11. The valve 11 is provided with two oppositely disposed inlet passages 19 and 20, both overlapping and at all times communicating at their outer ends with the inlet chamber 16, while their inner ends are adapted to overlap and communicate intermittently with the cylinder port 9, as the valve 11 rotates.

Intermediate to said inlet passages 19 and 20 are the outlet passages 21 and 22, both communicating intermittently with the cyl-

inder port 9, as the valve 11 rotates, and overlapping and at all times communicating with the outlet chamber 17. The valve faces 23, 24, 25 and 26, separating the said passages 19, 20, 21 and 22 are of sufficient width to intermittently close the cylinder port 9. It is therefore obvious that on rotation of the valve 11, the inlet passages 19 and 20 will alternate with the outlet passages 20 and 21 in coming into communication with the port 9, and thus effect the reception and discharge of the material being handled.

In Figs. 1 and 2, the piston 2 is shown as having completed about half its upstroke while the crank 6 has described an angle of 90°. When the crank 6 was at its lower dead point, the piston 2 was at its lowest position and the port 9 was closed off by the valve face 23. As soon as the piston begins to be moved by the crank 6, turning in the direction of the arrow, the valve 11 is rotated in the opposite or clockwise direction, as seen in Fig. 2, by the gears 14 and 15, thereby bringing the inlet passage 19 into communication with port 9, and space beneath the piston 2, so that fluid will be drawn after the said piston, in its upward movement, through port 9, inlet passage 19, inlet chamber 16, and inlet pipe 28, leading to said chamber. When the crank 6 is at midstroke, having rotated through 90° as shown in Figs. 1 and 2, the valve 11 will have rotated through 45°, and the inlet passage 19 is central below the port 9 as illustrated. On further rotation of the crank in the said direction, through a further 90°, *i. e.*, when the piston 2 has reached the upper end of its stroke, the valve 11 will have rotated through a further 45°, and the valve face 25 will have closed off the port 9. As the crank 6 rotates still farther in the same direction, the piston 2 will begin to descend, while at the same time valve face 25, will begin to uncover port 9, and bring it into communication with outlet passage 21. The piston 2, during its downward movement will now expel the fluid through port 9, outlet passage 21, outlet chamber 17, and outlet pipe 29, leading from said chamber. After the piston 2 has completed its entire downstroke, the crank 6 will have passed through an angle of 180° from its highest position, the valve 11 will have rotated through an angle of 90° and its face 24 will have closed the port 9. The crank 6 has now made a complete revolution from its lowest position, while valve 11 has made half a revolution. As crank 6 continues to rotate, the piston 2 again rises, while valve face 24 in rotation moves off and uncovers port 9, placing the latter into communication with inlet passage 20 during the upstroke of piston 2, which then draws fluid through port 9, inlet passage 20, inlet chamber 16, and inlet pipe 28. When piston 2 has again reached the extreme upper end of its stroke and crank 6 has passed through another 180°, valve 11 will have passed through 90° more and valve face 26 will have closed off port 9.

When piston 2 begins to descend a second time, valve face 26 will move off port 9, thus putting it into communication with outlet passage 22, and as the said piston moves downward it will likewise expel the fluid through port 9, outlet passage 22, outlet chamber 17, and outlet pipe 29. When piston 2 again arrives at its extreme lower position, the valve face 23 will again cover part 9, and a full revolution and cycle of operations of valve 11 will have been completed, while the crank 6 and piston 2 have completed two full cycles of operation.

It will be obvious that by having the inlet and outlet passages 19, 20, 21 and 22 equally spaced circumferentially, terminating at corresponding points of the valve 11 longitudinally, and otherwise disposed as shown, the said valve will be in perfect equilibrium as to the inlet and outlet pressures acting radially upon it. This constitutes an important feature of my invention, and it may be applied to any plurality of inlet passages combined with a corresponding number of outlet passages, as long as the said inlet passages are of equal size and said outlet passages are also of equal size and all symmetrically disposed around the body of the said valve. A valve having a greater number of passages must, however, revolve slower than a valve having a lesser number of passages. Thus a valve having three inlet passages must make only one third of a revolution for one of the crank shaft, while a valve having two inlet passages makes one half a revolution for one of the crank shafts.

A little consideration will show that by reversing the direction of rotation, the direction of the flow of fluid through valve 11 will also be reversed, pipe 29, chamber 17, and passages 21 and 22 becoming the inlet members, while passages 19 and 20, chamber 16, and pipe 28, become the outlet members for the fluid.

It is further obvious as in the case of any crank driven pump having positively operated valves, that if the inlet pressure is greater than the outlet pressure, the apparatus shown in Figs. 1 and 2 may act as a motor instead of as a pump, the piston in such case being propelled by the fluid instead of drawing said fluid after it.

In the modified form of valve 111, shown in Figs. 3 and 4, I have provided the transverse passages 30 and 31, respectively, connecting the inlet passages 19 and 20, and the outlet passages 21 and 22. Thus when one of the inlet passages such as 19, is in communication with cylinder port 9, the other inlet passage 20 will also be in communica-

tion with said port 9 through the transverse passage 30; so by making said passage 30 of sufficient size, one portion of the fluid passing port 9 may be made to pass through the inlet passage such as 19, adjacent to it, while the other part of said fluid reaches said port through the other inlet passage such as 20, and the said transverse passage 30. The same conditions will be brought about by the transverse passage 31, connecting the outlet passages 21 and 22. Both the pairs of inlet and the outlet passages 19, 20, 21 and 22 can therefore be made of less cross sectional area, by connecting them in the manner shown through the transverse passages 30 and 31, for a given velocity of the fluid through apparatus, than when such transverse passages are absent. The modified construction shown, in other words, provides a more advantageous utilization of the fluid transmitting capacity of the valve 111.

A single cylinder apparatus is, however, not as well adapted for motors and pumps as is a multi-cylinder apparatus, owing to the uneven and intermittent rate of flow through the conduits leading to and from the apparatus. My invention is, therefore, more especially suited to multi-cylinder apparatus, such as will now be described.

In Fig. 5 is shown a pump with three single acting cylinders 50, 51 and 52, driven by cranks spaced at equal angles of 120°, a type of pump commercially known as a triplex pump. The valve chest 60 is here shown made in a separate piece from the cylinders 50, 51, and 52 to which it is secured by screw bolts as shown. This arrangement often enables an easier construction and also an adaptability of the valve 61 to existing pumps.

As will be seen in the figures, the valve chest 60 extends along the row of cylinders with which it communicates by means of the ports 65, 66 and 67, through the body of the valve chest.

As in the case of Fig. 1, the valve 61 is provided with the stem 12, extending fluid tight through the end 68 of valve chest, and the projecting end of said stem 12 has fixed on it the gear 69, which is driven by gear 70 fixed on the end 71 of the crank shaft, which is rotated by the pulley 72, fixed on its other end 73. The gear 69 is twice the size of gear 70 so that the crank shaft makes two revolutions for one made by the valve 61, which latter has two inlet passages 75 and 76, and two outlet passages 77 and 78, as in the case illustrated in Figs. 1 and 2. Since the pistons are operated from the cranks 80, 81 and 82, at a phase difference of 120°, the ends of the piston strokes, at which the change from inlet to outlet conditions, and vice-versa, takes place, will also succeed each other by the same phase difference. And since as pointed out, the valve 61 makes only half a revolution, while the crank shaft 83 makes a complete revolution, the said valve 61 will revolve only 60° while the crank shaft 83 revolves 120°. If, therefore, the edges of the valve faces 84, 85, 86 and 87 of valve 61 are parallel to the axis of said valve as in Fig. 5, the entrances 88, 89 and 90 of the cylinder ports 65, 66 and 67 leading respectively to cylinders 50, 51 and 52, will also have to be spaced circumferentially on the said bore of the valve chest at angles of 60° in order to insure that the said ports will be opened and closed by the valve, in proper succession. Thus, if the piston 50 is just starting on its upward or intake stroke by rotation of the crank shaft 85 in a clockwise direction, as seen in Fig. 6, or in the direction indicated by the arrow in Fig. 5, the valve face 84 will be just beginning to uncover the entrance 88 of the corresponding cylinder port 65. The entrance 89 of port 66 being as pointed out, 60° ahead of entrance 88 of port 65, valve 61 must rotate 60° in a counter clockwise direction as seen in Fig. 6, in order that its valve face 84 may cover the entrance 89 to said port 66. The crank shaft 83 will in the meantime have rotated through an angle of 120°, bringing crank 81 and piston 51 to their lowest positions in readiness for beginning their upstroke.

A further rotation of valve 61, through 60°, with a corresponding rotation of crank shaft 83, through 120°, brings valve face 84 over the entrance 90 of the third port 67, the piston 52 of which will then be in its lowest position ready to begin its upstroke.

The phases of operation for each cylinder considered separately are the same as those described for the single cylinder case illustrated by Figs. 1 and 2. Thus while the crank shaft 83 revolves 180° in its upstroke to bring any one of the pistons from the beginning of its intake stroke to the beginning of its expulsion stroke, the valve 61 revolves through half that amount, or 90°, during which period the cylinder in question will be in communication with one of the inlet passages 75 and 76. During its downstroke, the crank shaft 83 revolves through another 180°, and valve 61 through another 90°, during which period the said cylinder will be in communication with one of the outlet passages 77 or 78. For the next 180° through which the crank shaft revolves, the piston is again on its upstroke, and the valve 61 has made another 90°, during which period the opposite inlet passage is in communication with the cylinder port. Another 180° turn of the crank shaft causes the second expulsion stroke of the piston, while the valve 61 in turning through 90° completes one revolution and brings it back to its first position relative to the cylinder port in question. The process as de-

scribed is the same for each one of the said cylinders, and they succeed each other by a phase difference of 120°, for a triplex pump, all as will be clear to those skilled in the art.

Obviously for a pump having more or fewer cylinders than a triplex pump, the phase difference of the cylinder strokes would also be different, and the angles according to which the entrance of the cylinder ports must be spaced around the bore of the valve chest would correspondingly be different. Thus for a quintuplex pump having five cylinders, the cranks would be spaced at angles of 72° and if the valve 61 had two inlet and two outlet passages and making one revolution for two of the crank shafts as in the case of Fig. 6, the entrance of the ports in the bore of the valve chest would be spaced at angles of one half of 72° or 36°. Expressing the matter comprehensively: In order to perform this phase of port control of the cylinders in proper succession, the valve must rotate through an angle equal to 360°, divided by the product of the number of cylinders, and the number of inlet passages in the valve all as is obvious upon inspection. For the sake of brevity in what follows, this angle through which the valve rotates will be designated "the valve rotation angle." For a straight faced valve as in Fig. 6, the ports would have to be displaced by an amount equal to the valve rotation angle ahead of the advancing valve faces.

In the construction of Figs. 5 and 6, as in the case of the valve illustrated in Figs. 3 and 4, the inlet passages 75 and 76 of valve 61 are connected by the three transverse passages 30, and the outlet passages 77 and 78 are similarly connected by three transverse passages 31, thus securing the advantage of a simultaneous inlet and outlet flow through two passages instead of only one, as disclosed in the case of the valve 111, shown in Figs. 3 and 4.

In the still further modified form of the invention shown in Figs. 9 to 12, the valve 100 likewise makes only one revolution for two of the crank shafts 83, the gears 69 and 70, being in the ratio of two to one. With the three cylinders the phases of the piston strokes differ again by 120° corresponding to 60° of valve rotation. The cylinder ports 101, 102, 103 are in this case placed in a straight row parallel to the axis of the valve 100, which provides a shorter and more direct course for the fluid than in the case of Figs. 5 and 6. The faces 105, 106, 107, 108 and passages 109, 110, 112 and 114 in said valve must therefore be displaced circumferentially by the valve rotation angle of 60° as previously defined, from one cylinder port to the next succeeding one in a direction opposite to that of the rotation of the valve as seen from its inlet end. In other words, the faces and passages in the body of the valve where they pass over the cylinder ports 101, 102, and 103 must be on helices having a 60° twist from port to port as shown in Fig. 9.

The inlet passages 109 and 110 formed between the said helices are open at the inlet end 115 of valve 100, and are closed off at the outlet end by the end walls 116, and the outlet passages 112 and 114, formed by said helices, are closed at the inlet end of valve 100 by the end walls 117, so that the said inlet passages are in continuous communication with the inlet chamber 120, and the said outlet passages are in continuous communication with the outlet chamber 121. These chambers 120 and 121 are in this case not formed around the ends of the valve, but are located adjacent to the said ends as appears in Fig. 9.

It is obvious that a number of constructions can be provided in which the entrances to the cylinder ports are displaced in the direction of rotation of the valve 100 by an amount less than the valve rotation angle, the required additional amount to complete said angle being provided by a distortion of the valve faces and passages in a direction opposite to the rotation of the valve. That is to say, in Figs. 5 and 6, the entrances to the cylinder ports have been displaced through a maximum displacement angle of 60° while the valve faces have not been distorted at all. In Figs. 9 and 10 on the other hand, the entrances to the cylinder ports have not been angularly displaced at all and the valve faces have been distorted through a maximum distortion angle of 60°. It is accordingly evident that a very large number of constructions could be devised in which the valve port entrances are displaced through a displacement angle less than the maximum, provided the valve faces are distorted in an opposite direction through a distortion angle such that the sum of the displacement and distortion angles will equal the said maximum displacement or distortion angles which are also equal to the valve rotation angle as above defined.

It will now be clear that in all the forms of the invention, I have provided a crank connected piston machine which may be single or double acting as desired, having a continuously and unidirectionally rotating valve which is positively operated from the crank shaft; that only a single valve plug is used to control both the inlet and outlet for all the cylinders of such a machine; that the said valve is perfectly balanced, and therefore less subject to wear than is one not so balanced; that such balancing is effected by providing a plurality of symmetrical inlet and outlet passages for the fluid passing through the machine; that by such

balancing the pump is made suitable for working at high pressures; that the cross sectional passage area of this valve may be utilized to good advantage by transversely connecting all the said inlet passages and by similarly connecting all the said outlet passages.

It is further obvious that in general, a machine equipped with such a valve may act on the fluid either as a pump or as a compressor, or that it may be driven by fluid under pressure as a motor. As a motor driven by a liquid, it may in some cases serve the purpose of a liquid meter. When used as a pump it will, by simply reversing the rotation, reverse the direction of the flow of fluid, so that the inlet becomes the discharge and the discharge the inlet. That the inlet and discharge flow will be axially and in one direction through the chamber of said valve for a given direction of rotation of the machine.

Owing to the absence of any reciprocating motion of the valve it will likewise be clear that there will be less shock and vibration in operation, than would be the case with reciprocating valves, like the ordinary lift, valve, or valves of the Corliss type, and that for this reason pumps or motors equipped with valves made in accordance with this invention are capable of continuously operating at higher speeds in practice, than are ordinary pumps or motors, and that a smaller and therefore cheaper machine can be used for a given purpose.

Especially is this the case when any of the forms of my invention are equipped with cross passages such as 30 and 31, for in such cases the fluid passes from the inlet through such passages into the cylinder, and the piston may be run at a much higher speed than is the case when said passages 30 and 31 are not employed. When the helical form of valve plug 100 is equipped with passages such as 30 and 31, the above mentioned advantages not only obtain, but in addition the liquid is less whirled during its passage through the valve than in the other forms.

When a uniformity of flow of the fluid is required it is preferred to provide the machine with not less than three cylinders for such a design falls in line with the common type of triplex pump made by nearly all pump builders, and therefore, crank shafts, the connecting rods, the plungers, etc., can in such case be purchased from manufacturers already equipped for their manufacture, and at once embodied in machines made according to this invention.

It is further obvious that thick or viscous liquids as well as liquids associated with small particles such as sugar carrying fluids, can be readily handled by this invention.

It is obvious that those skilled in the art may vary the details of construction as well as the arrangement of parts without departing from the spirit of the invention and therefore, I do not wish to be limited to the above disclosure except as may be required by the claims.

What I claim is:—

1. In an apparatus of the character described the combination of a cylinder provided with a port; a valve casing provided with inlet and discharge passages; a valve in said casing provided with a plurality of inlet and a plurality of discharge recesses separated by valve faces for controlling said port; a piston in said cylinder; connections between said valve and piston causing the speed of the one to bear a definite ratio to the speed of the other; and means comprising inlet and outlet chambers located in said valve casing with which said recesses are always in communication for admitting fluid to and for discharging it from said recesses, substantially as described.

2. In an apparatus of the class described the combination of a cylinder having a port; a valve casing having inlet and discharge passages; a valve in said casing provided with a plurality of inlet and a plurality of discharge recesses separated by valve faces for controlling said port; inlet means with which said inlet recesses are always in communication; outlet means with which said outlet recesses are always in communication; a piston in said cylinder; and connections between said valve and piston causing the former to move at a speed fixed in relation to the latter, substantially as described.

3. In an apparatus of the class described the combination of a cylinder having a port; a valve casing having inlet and discharge passages; a valve in said casing provided with a plurality of inlet and a plurality of discharge recesses separated by valve faces for controlling said port; said inlet recesses being symmetrically disposed around said valve and said outlet recesses being also symmetrically disposed around said valve so as to balance said valve; inlet means with which said inlet recesses are always in communication; outlet means with which said outlet recesses are always in communication; a piston in said cylinder; and connections between said valve and piston causing the former to move at a speed fixed in relation to the latter, substantially as described.

4. In an apparatus of the class described the combination of a cylinder having a port; a valve casing having inlet and discharge passages; a balanced valve in said casing provided with a plurality of inlet and a plurality of discharge recesses separated by valve faces for controlling said port; inlet means with which said inlet recesses are always in communication; outlet means with which said outlet recesses are always in communication; a piston in said cylinder; and

gear connections between said valve and piston causing the former to move at a speed fixed in relation to the latter, substantially as described.

5. In an apparatus of the class described the combination of a cylinder provided with a port; a valve casing having inlet and discharge passages; a valve in said casing provided with a plurality of inlet and a plurality of discharge recesses separated by valve faces for controlling said port; means for connecting a pair of said inlet recesses; means for connecting a pair of said outlet recesses; a piston in said cylinder; connections between said valve and piston causing the speed of the one to bear a definite ratio to the speed of the other; and means for admitting fluid to and for discharging it from said recesses, substantially as described.

6. In an apparatus of the character described the combination of a cylinder provided with a port; a valve casing having inlet and discharge passages; a balanced valve in said casing provided with a plurality of inlet and a plurality of discharge recesses separated by valve faces for controlling said port; a transverse passage through said valve for connecting a pair of said inlet recesses; a transverse passage through said valve for connecting a pair of said discharge recesses; a piston in said cylinder; connections between said valve and piston; causing the speed of the one to bear a definite ratio to the speed of the other; and means for admitting fluid to, and for discharging it from said recesses, substantially as described.

7. In an apparatus of the character described the combination of a plurality of cylinders each provided with a port; a valve casing having inlet and discharge passages; a balanced valve in said casing having a pair of oppositely disposed inlet recesses and a pair of oppositely disposed discharge recesses; said valve also provided with port controlling valve faces separating said recesses; inlet means with which said inlet recesses are always in communication; outlet means with which said discharge recesses are always in communication; and a piston in each cylinder adapted to suck in fluid through said inlet recesses and forcibly discharge it through said outlet recesses, substantially as described.

8. In an apparatus of the character described the combination of a plurality of cylinders each provided with a port; a balanced valve having a set of symmetrically disposed inlet recesses and a set of symmetrically disposed discharge recesses, said valve also provided with port controlling valve faces separating said recesses; means for connecting said inlet recesses with each other; means for connecting said discharge recesses with each other; inlet means with which said inlet recesses are always in communication; outlet means with which said discharge recesses are always in communication; and a piston in each cylinder adapted to suck in fluid through said inlet recesses and forcibly discharge it through said outlet recesses, substantially as described.

9. In an apparatus of the character described the combination of a plurality of cylinders each provided with a port; a balanced valve having a pair of oppositely disposed inlet recesses and a pair of oppositely disposed discharge recesses, said valve also provided with port controlling valve faces separating said recesses; a transverse passage through said valve for each port connecting said inlet recesses; a transverse passage through said valve for each port connecting said discharge recesses; inlet means with which said inlet recesses are always in communication; outlet means with which said discharge recesses are always in communication; and a piston in each cylinder adapted to suck in fluid through said inlet recesses and forcibly discharge it through said outlet recesses, substantially as described.

10. In an apparatus of the character described the combination of a plurality of cylinders each provided with a port; a valve casing having inlet and discharge passages; a balanced valve in said casing having a set of symmetrically and helically disposed inlet recesses and a set of symmetrically and helically disposed discharge recesses, said valve also provided with helically disposed port controlling valve faces separating said recesses; inlet means comprising an inlet chamber located in said casing with which said inlet recesses are always in communication; outlet means comprising an outlet chamber located in said casing with which said discharge recesses are always in communication; and a piston in each cylinder adapted to suck in fluid through said inlet recesses and forcibly discharge it through said outlet recesses, substantially as described.

11. In an apparatus of the character described the combination of a plurality of cylinders provided with ports having entrances angularly disposed relatively to each other; a valve casing having inlet and discharge passages; a valve member in said casing provided with a plurality of inlet and a plurality of outlet recesses separated by a plurality of valve faces for said port entrances; inlet means comprising an inlet chamber located in said casing with which said inlet recesses are always in communication; and outlet means comprising an outlet chamber located in said casing with which said outlet recesses are always in communication, substantially as described.

12. In an apparatus of the character described the combination of a plurality of cylinders provided with ports having entrances angularly disposed relatively to each other; a valve casing having inlet and discharge passages; a valve member in said casing provided with a plurality of inlet and a plurality of outlet recesses separated by a plurality of distorted valve faces for controlling said port entrances; inlet means comprising an inlet chamber located in said casing with which said inlet recesses are always in communication; and outlet means comprising an outlet chamber located in said casing with which said outlet recesses are always in communication, substantially as described.

13. In an apparatus of the character described the combination of a plurality of cylinders provided with ports having entrances angularly disposed relatively to each other; a valve casing having inlet and outlet passages; a valve member in said casing provided with a plurality of helically disposed inlet and a plurality of helically disposed outlet recesses separated by a plurality of helically distorted valve faces for controlling said port entrances; inlet means comprising an inlet chamber located in said casing with which said inlet recesses are always in communication; and outlet means comprising an outlet chamber located in said casing, with which said outlet recesses are always in communication, substantially as described.

In testimony whereof I affix my signature.

HANS C. BEHR.