Oct. 5, 1948. L. E. TOPHAM 2,450,570

VARIABLE DISPLACEMENT PUMP

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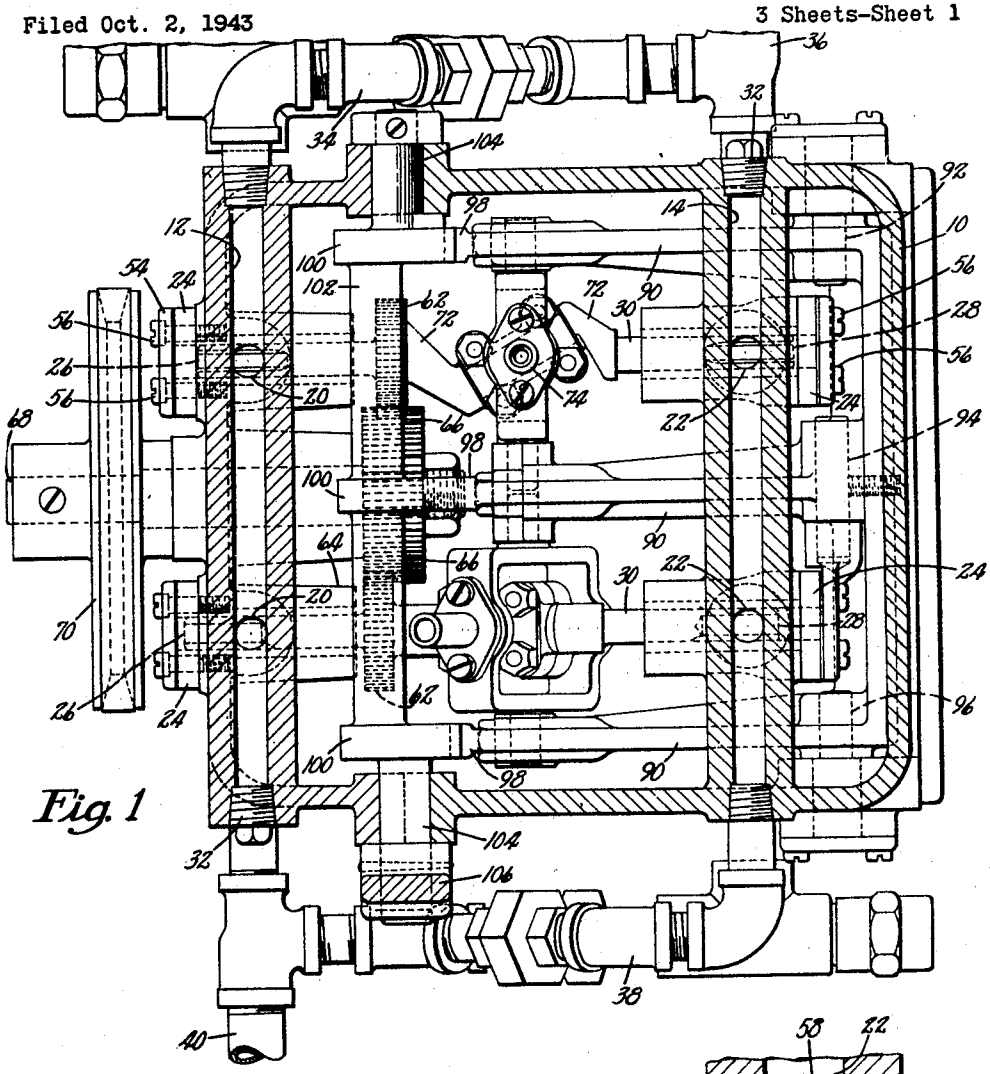



Fig. 1

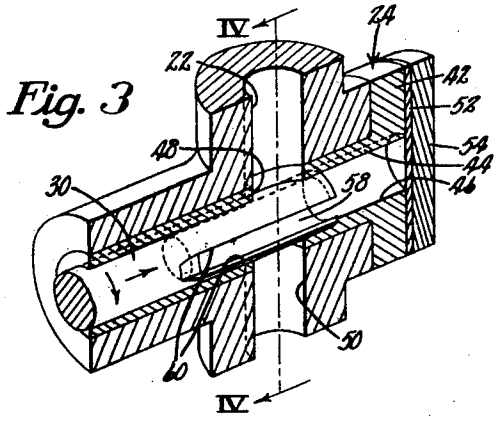



Fig. 3

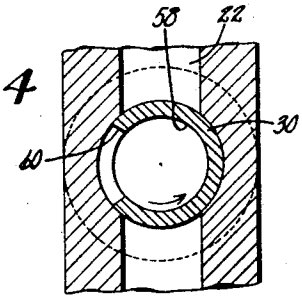



Fig. 4

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Fig. 2

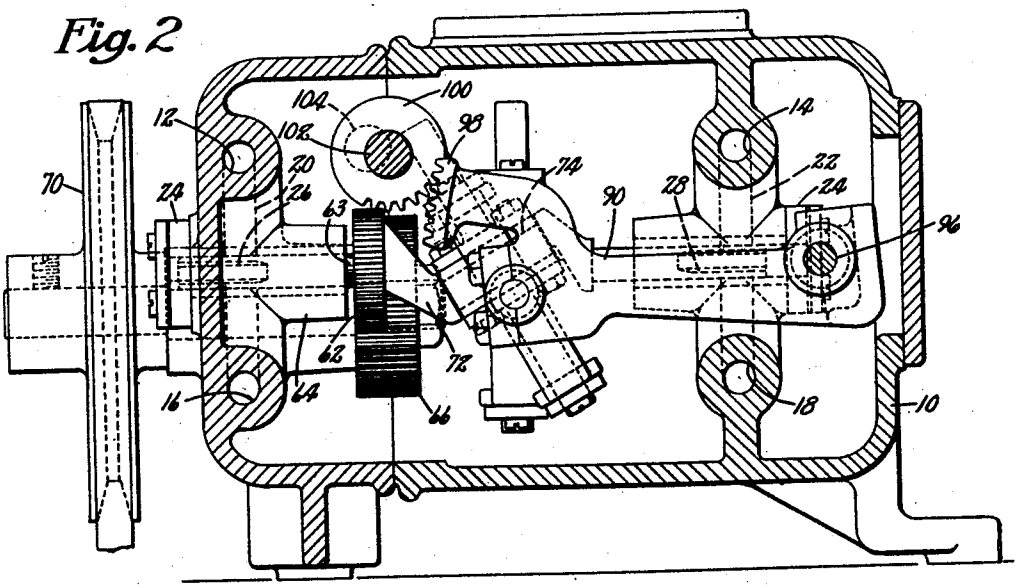



Fig. 5

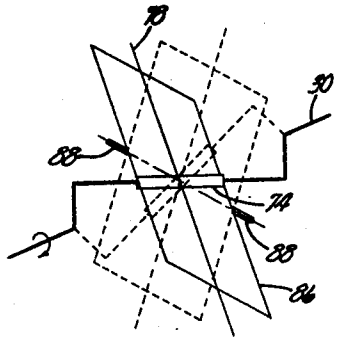
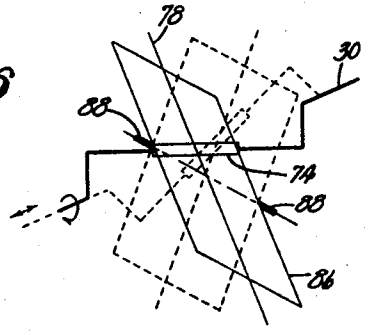



Fig. 6




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Fig.7.

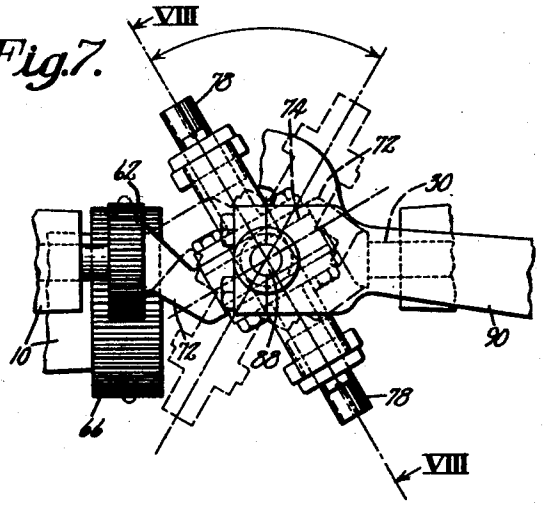



Fig.8.

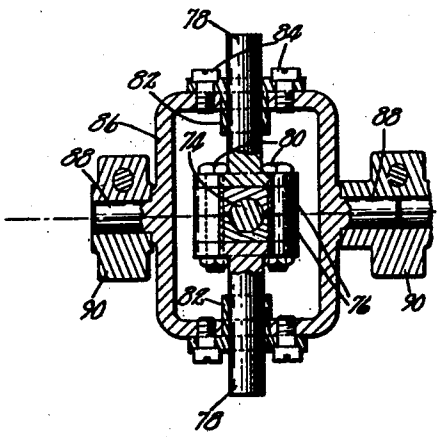



Fig.9.

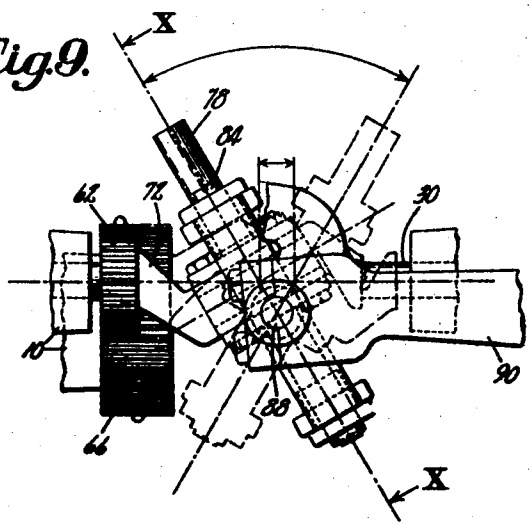
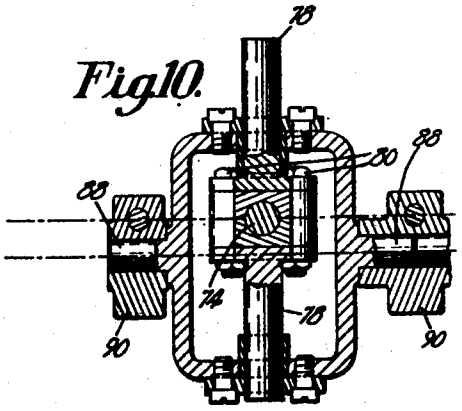



Fig.10.




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# UNITED STATES PATENT OFFICE

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## VARIABLE DISPLACEMENT PUMP

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Application October 2, 1943, Serial No. 504,755

3 Claims. (Cl. 103—38)

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This invention relates to pumps and is herein illustrated as embodied in a variable displacement pump.

It is an object of the invention to provide an improved pump having mechanism for readily facilitating the variation of flow of fluid through the pump from zero to maximum in either direction.

To this end and as illustrated, the invention provides a rotatable piston mounted for reciprocation in a chamber having fluid intake and exhaust ports, the end of the piston constituting a valve having a port operable successively during rotation of the piston to connect the intake and exhaust ports with the chamber. Preferably, and as illustrated, use is made of a plurality of pistons and chambers, the amount of discharge being varied by varying the length of stroke of the pistons. Preferably, too, the direction of flow of the fluid is reversed when desired by shifting the pistons longitudinally of the chambers, so that the intake and exhaust portions of the cycle of the two pistons are interchanged, that is, shifted in phase by 180°.

These and other features of the invention are disclosed in the following specification and in the accompanying drawings, and are pointed out in the claims.

In the drawings,

Fig. 1 is a plan view, partly in section, of a pump constructed in accordance with one embodiment of my invention;

Fig. 2 is a vertical cross sectional view of the mechanism shown in Fig. 1;

Fig. 3 is a longitudinal cross sectional view, on an enlarged scale, through one of the pump cylinders;

Fig. 4 is a transverse cross sectional view, on an enlarged scale, taken along line IV—IV of Fig. 3;

Figs. 5 and 6 are diagrammatic views illustrating the operation of the mechanism;

Fig. 7 is a side view, partly in section, of the mechanism for varying the stroke of the pump;

Fig. 8 is a cross sectional view taken along line VIII—VIII of Fig. 7;

Fig. 9 is a side view, partly in section, of the mechanism shown in Fig. 7 after operation of the manual control means; and

Fig. 10 is a cross sectional view taken along line X—X of Fig. 9.

The pump mechanism may comprise any suitable number of pump units, each including two pump cylinders having pistons positioned therein and a single piston rod or shaft connecting the

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pistons. Figs. 1 and 2 show a housing 10, having therein two of such units. Preferably, the housing is a casting having four parallel fluid passages 12, 14, 16 and 18 extending transversely thereof, the passages 12 and 14 being located directly above the passages 16 and 18, respectively. The passages 12 and 16 are connected by two vertically extending passages 20, and the passages 14 and 18 are similarly connected by vertical passages 22. Each of the vertical passages is provided with a pump cylinder 24 extending in a horizontal direction, the cylinders on opposite sides of the central portion of the housing being in alinement with each other. In each pair of alined cylinders are located pistons 26 and 28, which are joined by a single connecting rod or shaft 30.

One end of each of the passages 12, 14, 16 and 18 is closed by a plug 32. The passage 12 is connected with the passage 18 by pipe connections 34 leading to fluid pipe 36. Passages 14 and 16 are likewise connected together by pipe connections 38, which lead to a fluid pipe 40. Either of the fluid pipes may serve as an intake or a discharge pipe for supplying to or discharging from the pump cylinders the fluid set in motion by the operation of the pistons.

Each of the cylinders 24 comprises a plug 42 (Fig. 3) having a reduced bearing portion 44 extending transversely of the vertical passages 20 or 22, and has a machined bore 46 provided with two ports 48 and 50 in alinement with the vertical passages. The ends of the cylinders are closed by packing 52 held in position by washers 54 and bolts 56.

The end portion of each piston constitutes a valve for controlling the direction of flow of the fluid relatively to the pump cylinders. As shown in Fig. 3, the end of each piston is provided with a cylindrical open-ended chamber 58, extending axially of the piston and having a narrow elongated slot or valve port 60 cut in its side wall. The wall of the chamber acts to prevent flow of fluid through the vertical passage (20 or 22), except when the slot 60 is alined with one or the other of the ports 48 or 50.

As will be hereinafter described, each piston is arranged for reciprocation in its cylinder and for continuous rotation about its axis. In the position shown in Fig. 3, with the piston moving to the right and rotating in a clockwise direction, as indicated by the arrows, it will be noted that the valve port 60 is about to be alined with the port 50, with the result that fluid in the cylinder will be forced out through the port. Upon further rotation of the cylinder, during which the

piston is moved toward the left in Fig. 3, the slot will become alined with the port 48 and, if fluid is supplied thereto, it will pass by suction into the cylinder ready for ejection upon the next compression stroke of the piston. As shown in the upper portion of Fig. 1, the pump unit is in position with the piston at the right side of the figure on the compression stroke, during which fluid is forced out of the cylinder and discharged into the fluid pipe 38, while at the same time the piston at the left side of the figure is on the suction stroke and will receive fluid from the fluid pipe 34.

In order to rotate the shafts 30 with their associated pistons, each shaft is provided with a pinion 62 mounted on a shaft 63 in bearings 64 in the housing and meshing with a gear 66 mounted upon a shaft 68 carried by the housing and arranged to be driven by a pulley 70.

The mechanism by which the pistons are reciprocated when desired will now be described. Each shaft 30 is provided, midway between the pistons, with two offset portions 72 extending at an angle of approximately 30° to the axis of the shaft, and having between them a cylindrical member or crank 74, best shown in Figs. 7, 8, 9 and 10. Surrounding the crank are two bearing members 76, from which extend in opposite directions pivots 78, the pivots and bearings being secured in position by bolts 80. The pivots are in turn mounted in bearings 82 secured by screws 84 to a gimbal 86. Each of the gimbals is provided with trunnions 88 extending at right angles to the axis of the pivots, the trunnions being mounted, as shown in Fig. 1, in levers 90 which are mounted on pivots 92, 94 and 96 on the housing. The position of the trunnions can be shifted in a heightwise direction by means of racks 98 on the levers 90 and meshing with gear segments 100 secured to a bracket 102 pivotally mounted upon the housing. The bracket is carried by pins 104 in the housing, and is mounted with its axis eccentric to the axes of the pins, with the result that, upon rotation of the pins by a lever 106, the racks 98 will be rotated and moved outwardly, thus effecting rotation of the levers 90 about their pivots and resulting in the raising or lowering of the trunnions 88. Thus, the member 74 during rotation constitutes a conical crank, the position of the apex of the cone of which is variable. This construction is such that, upon rotation of the piston rods, the cranks will rotate, effecting an oscillating movement of the pivots 78 about the axes of the trunnions.

If the trunnions are positioned with their axes intersecting the main axis of the shaft 30, as shown in Figs. 7 and 8, the gimbal with its pivots will oscillate back and forth through an angle of about 60° without effecting any reciprocating movement of the shaft. However, if the lever 106 is moved in such a way as to position the trunnions below the main axis of the shaft, as shown in Figs. 9 and 10, upon rotation of the shaft, the gimbal will oscillate about the axis of the trunnions, then positioned below the main axis of the shaft, with the result that a longitudinal reciprocating movement is imparted to the shaft and to the piston rods. The amount of the movement of the shaft corresponding to the stroke of the pistons will vary, depending upon the position of the trunnions relatively to the axis of the shaft, the stroke being increased as the distance between the two axes increases.

Figs. 5 and 6 illustrate diagrammatically the variation in movement of the shaft for different adjustments of the gimbal 86. In Fig. 5, the gimbal is indicated in the position in which the axis of its trunnions 88 intersect the axis of the shaft 30. After rotation of the shaft through 180°, the parts will assume the positions indicated in dotted lines. It is to be noted that the pivots 78 have oscillated about the axes of the trunnions through an angle of about 60°, and that no reciprocating movement of the shaft has taken place.

In Fig. 6, the gimbal is indicated in position with its trunnions below the axis of the shaft 30. After 180° of rotation of the shaft, the parts are in the positions indicated in dotted lines. In this instance the gimbal has also moved through an angle of about 60°, but a longitudinal movement has been imparted to the shaft.

It is to be noted that the lever 106 can be moved during the operation of the mechanism to vary the length of the stroke of the pistons, the movement of the lever in itself resulting in a longitudinal movement of the pistons to the right or to the left, independently of the drive of the mechanism. If, instead of moving the lever in a direction to lower the trunnions, the lever is moved to raise them above the main axis of the pistons, the pistons are moved to the left, with the result that the action of the pump is reversed. That is, what was the intake now becomes the discharge side of the pump, and vice versa. Thus, the position of the parts shown in Fig. 3 is 180° out of phase with the position the parts would occupy if the trunnions were moved to a point an equal distance from the main axis of the shaft. Thus, the mechanism provides means for facilitating the operation of the pump at different discharge capacities, and also provides for reversing the direction of flow of fluid through the pump. In other words, the fluid can be caused to flow through the pump in either direction at capacities varying from zero to a maximum. In view of the fact that the parts are rotated continuously during the operation of the pump, even when the discharge is zero, the static friction is reduced to a minimum.

It will be noticed that the two pump units shown in Fig. 1 are 90° out of phase. That is, the compression stroke of the unit in the lower part of the figure will take place one-quarter of a cycle after the operation of the unit shown in the upper portion of the figure, other parts of the operation being in the same relation. This contributes to the smoothness of operation of the pump tending to balance the force acting and to cause a smooth discharge of fluid.

Having described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. A pump comprising a pump cylinder, fluid passages extending from the side walls of the cylinder, a crank shaft, a piston carried at the end of the crank shaft and being positioned in the cylinder between the fluid passages, the piston having an open-ended chamber extending longitudinally of the pump cylinder and an elongated valve port extending through the side wall of the chamber, means for continuously rotating the crank shaft and piston, a crank on the crank shaft, means operable from the crank itself to effect reciprocation of the shaft and piston whereby the valve port is successively brought into alinement with the fluid passages during reciprocatory and rotary movements of the piston and means associated with the crank for varying the length of stroke of the piston.

2. A pump comprising two pump cylinders, a crank shaft extending between the cylinders, pistons on the ends of the shaft and positioned within the cylinders, fluid passages extending from each of the cylinders upon opposite sides of each of the pistons, each of the pistons having an open-ended chamber therein and a valve port extending through the side wall of the chamber, means for continuously rotating the crank shaft to present each of the valves successively in alinement with the fluid passages in its cylinder, fluid supply means connected to the several fluid passages, means for reciprocating the crank shaft during rotation thereof thereby to effect fluid discharge from one of the cylinders and fluid intake into the other cylinder during each cycle of operation, and means for varying the amount of reciprocating movement of the crank shaft thereby to vary the amount of fluid intake and discharge from zero to a maximum.

3. A pump comprising a housing having two fluid passages extending in parallel relation, a pump cylinder located in each of the passages and extending transversely thereof, the cylinders being in alinement with each other, a crank shaft extending between the cylinders, pistons located upon the ends of the crank shaft, fluid connections extending between the upper end of one of the passages and from the lower end of the other of the passages, a fluid line leading to the connections, a plurality of ports in each of the cylinders communicating with the passages, a valve carried by each of the pistons and comprising a hollow member located in a cylinder, a port extending through the wall of the hollow member, means for reciprocating the pistons, and means for continuously rotating the pistons during their reciprocating movement thereby successively to present the valve in alinement with the ports.



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## REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 1,106,326 | Winton | Aug. 4, 1914 |
| 1,244,160 | Anderson | Oct. 23, 1917 |
| 1,312,962 | Dourte | Aug. 12, 1919 |
| 1,326,889 | Anderson | Dec. 30, 1919 |
| 1,389,547 | Eger | Aug. 30, 1921 |
| 1,501,758 | Dress | July 15, 1924 |
| 1,694,834 | Sinclair | Dec. 11, 1928 |
| 1,868,498 | Gruman | July 26, 1932 |
| 2,101,377 | Sassen | Aug. 6, 1935 |
| 2,070,203 | Gregg | Feb. 9, 1937 |
| 2,104,590 | Hill | Jan. 4, 1938 |
| 2,181,234 | Hawes | Nov. 28, 1939 |