Aug. 29, 1944. L. C. CHOUINGS 2,356,917

LIQUID PRESSURE ACTUATED PUMP

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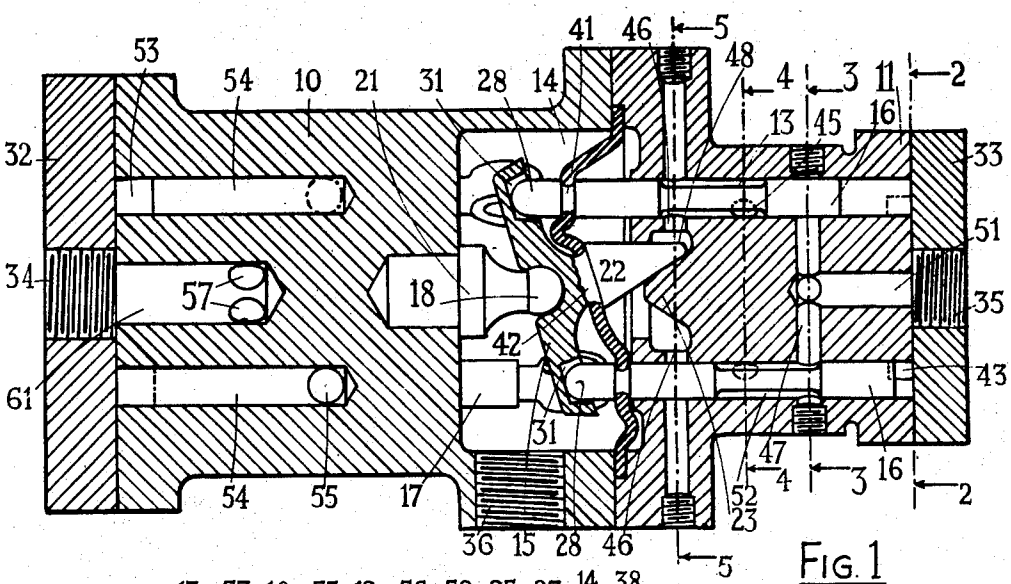


FIG. 1

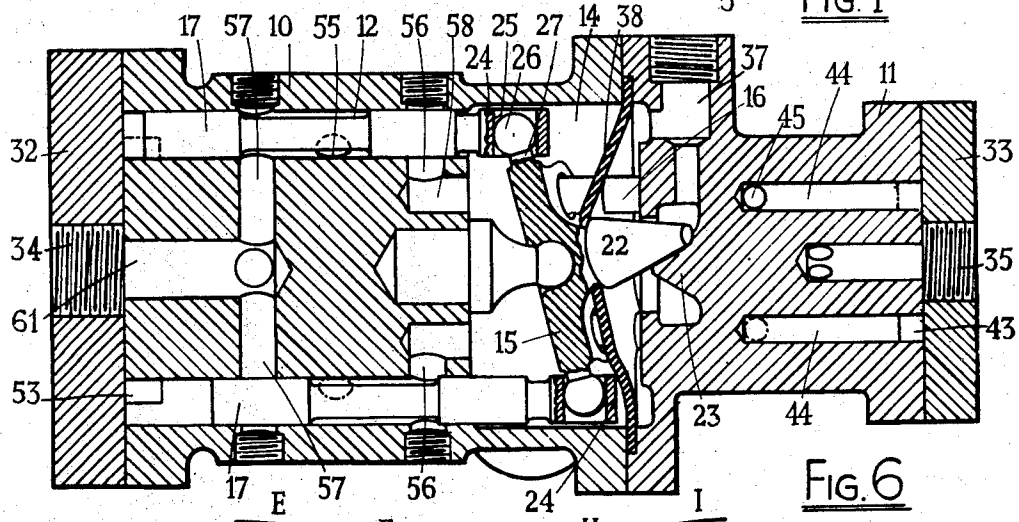


FIG. 6

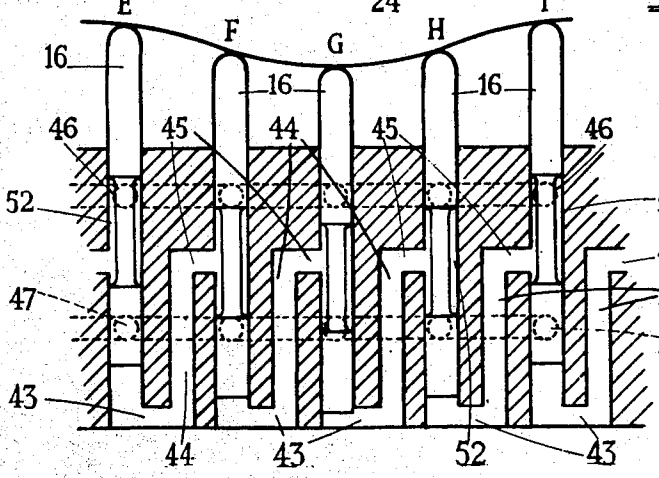


FIG. 8

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FIG. 2

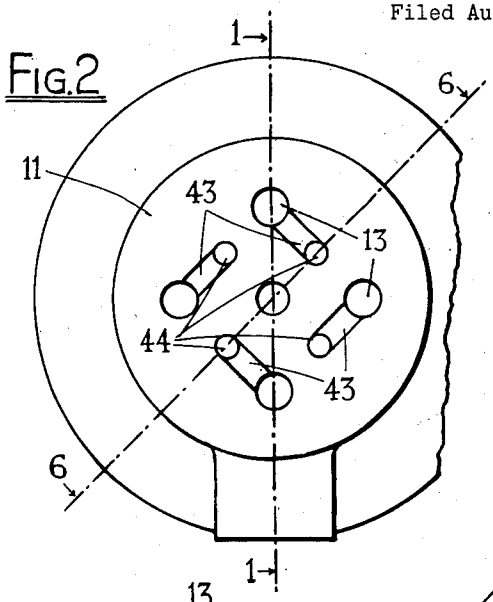


FIG. 3

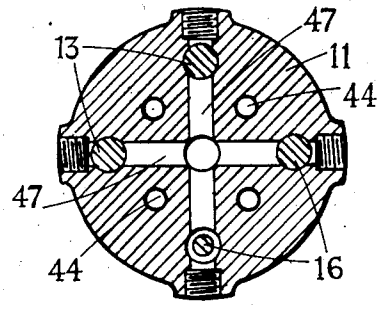
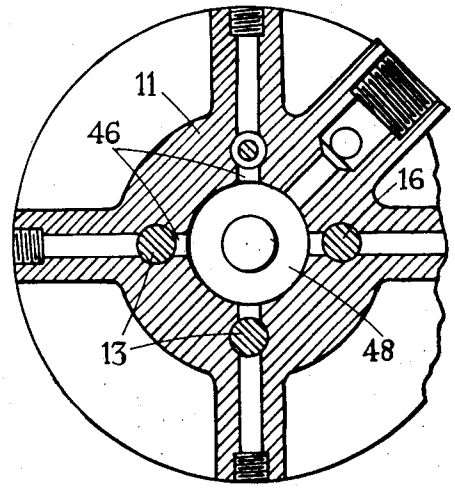


FIG. 5



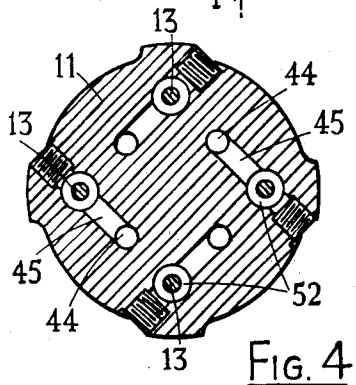
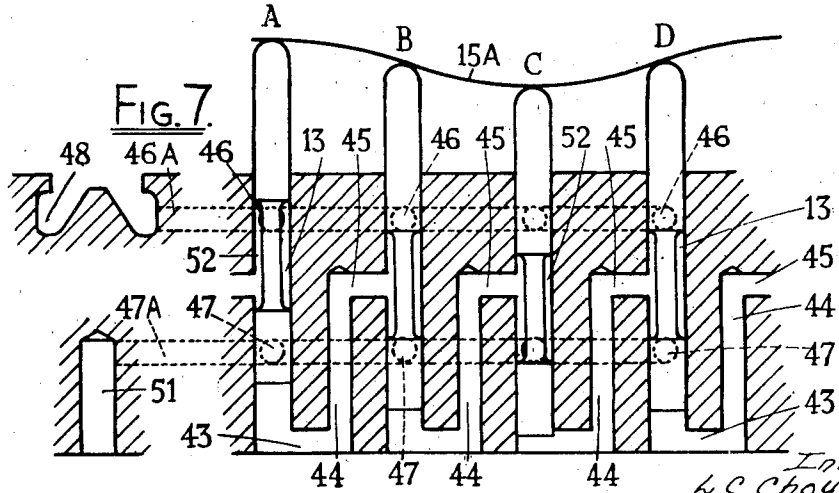


FIG. 4

FIG. 7.



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UNITED STATES PATENT OFFICE

2,356,917

LIQUID PRESSURE ACTUATED PUMP

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Application August 21, 1941, Serial No. 407,790
In Great Britain May 2, 1940

6 Claims. (Cl. 103—49)

This invention relates to liquid pressure actuated pumps primarily intended to act as liquid pressure transformers, that is to produce a flow of liquid at a chosen pressure by the action of a greater or less flow of separate liquid at a less or greater pressure.

One object of the invention is to provide a liquid pressure motor-pump combination or transformer having no rotary parts. Another object is to provide a liquid pressure transformer having pump and motor cylinders each in circumferential array about an axis and in which the movement of each plunger controls the admission of liquid to and the escape of liquid from the cylinder containing another plunger of the same series.

The invention is hereinafter described with reference to the accompanying drawings, in which—

Figure 1 is a longitudinal section of one form of liquid pressure actuated pump according to the invention, the section being taken on the line 1—1 of Figure 2;

Figure 2 is an end view of the motor portion of the pump with the end plate removed, the view being taken on the line 2—2 of Figure 1;

Figures 3, 4 and 5 are cross-sections of the motor portion of the pump, taken respectively on the lines 3—3, 4—4 and 5—5 of Figure 1;

Figure 6 is a longitudinal section of the pump on the line 6—6 of Figure 2;

Figure 7 is a development, in somewhat diagrammatic form, of the pitch circle of the motor plungers; and

Figure 8 is a similar development of the pitch circle of the motor plungers in a modified form of pump.

Referring to the drawings, the pump body comprises two cylinder blocks, one of which, 10, contains the pump cylinders, whilst the other, 11, contains the motor cylinders, each group of cylinders being parallel to and in circumferential array about a central axis. The two cylinder blocks are secured together with their axes in line. In the arrangement shown in Figures 1 and 2 the pump and motor have each four cylinders formed by bores in the respective cylinder blocks, the pump cylinder bores being indicated at 12 and the motor cylinder bores at 13. A cavity 14 between the two cylinder blocks 10 and 11 provides accommodation for a disk 15 by which the movement of the motor plungers 16 is communicated to the pump plungers 17, the disk 15 being mounted for universal tilting movement on a ball head 18 formed on a pillar 21 mounted in the pump cylinder body 10, and being guided by cooperating conical projections 22 and 23 on the disk and motor cylinder block respectively. The pump cylinder bores 12 are spaced equi-distantly about their pitch circle, and the motor cylinder bores 13 are also spaced equi-distantly about their pitch circle, the two cylinder blocks being so arranged that the motor cylinder bores 13 are angularly displaced through 45° with respect to the pump cylinder bores 12, and are thus midway between the respective adjacent pairs of the latter.

The pitch circle of the pump cylinder bores 12 is greater in diameter than the pitch circle of the motor cylinder bores 13, and the bores 12 are themselves larger than the bores 13. The stroke of the pump plungers is, therefore, greater than the stroke of the motor plungers, and both the bore and stroke of the pump being greater than those of the motor, the unit acts as a liquid pressure transformer, the liquid delivered by the pump being greater in quantity and lower in pressure than that supplied to the motor.

The pump plungers 17 are formed at their ends co-operating with the disk with enlarged heads 24 in which are formed transverse bores 25 to receive ball heads 26 formed on stems 27 projecting from the disk 15, the plungers being thus compelled to follow the movement of the disk in both directions, and the ball heads 26 sliding in the bores 25 to compensate for the slight change of the radial distance from the axis of the pump to the centres of the ball heads due to the oblique position of the disk. The motor plungers 16 have hemi-spherical ends 28 entering cavities 31 in the disk, the cavities having flat end surfaces parallel to the plane of the disk, such end surfaces being of slightly larger radius than the plunger ends to allow for the effect mentioned above in connection with the pump plungers. No springs are provided to return either set of plungers, the pump plungers being positively connected to the disk so as to be moved in both directions thereby, whilst the motor plungers which are unconnected to the disk and are merely in engagement therewith, are held against the disk by the liquid pressure during their pressure strokes.

The outer ends of the pump and motor cylinder bores are closed by end plates 32 and 33 respectively, the former end plate 32 having in its centre the pump delivery connection 34, whilst the latter end plate 33 has at its centre the motor inlet connection 35. The inlet connection 36 for the pump, and the exhaust connection 37 for the motor are connected to the cavity 14 in which the disk 15 is mounted, the cavity being separated into

two chambers to isolate the two fluids one from the other by a diaphragm 38 clamped at its edge between the two cylinder blocks 10 and 11. The motor plungers 16 and the conical projection 22 on the disk pass through apertures in the diaphragm, the plungers 16 being grooved circumferentially at 41 to receive the edges of corresponding holes in the diaphragm, the holes being smaller than the diameter of the plungers. The diaphragm is also provided with a central hole slightly smaller than the neck 42 of the conical projection 22 and is stretched into place thereon.

The pump and motor units are arranged substantially identically as regards the valves controlling the inlet and outlet of liquid to the cylinders, and consequently only the motor unit will be described in detail. Each plunger itself forms the controlling valve for one of the plungers next adjacent thereto, the controlling plunger being formed with an annular recess to connect a transfer passage leading to the pressure space in the cylinder bore of the controlled plunger with either an inlet or an outlet passage.

The motor unit only is illustrated in detail in the drawings, it being considered that the description of that unit will make it perfectly clear how both motor and pump units work. Figures 2, 3, 4 and 5 are transverse sections of the motor unit taken through the various ports and passages, and Figure 7 is a development of the pitch circle of the motor cylinder bores, showing the connections of the several passages. From Figure 7 it will be seen that a passage 43 leads from the outer end of each bore 13 and is connected by an axially directed passage 44 to a further passage 45 leading into the next bore 13 intermediate the ends of the latter. Equidistantly spaced on each side of the passage 45 are ports leading to radial passages 46 and 47, the passages 46 leading to a recess 48 around the conical projection 23, and the passages 47 leading to a central axial passage 51 leading from the inlet connection 35. The length of the annular recess 52 in each plunger is equal to the distance between the passages 46 and 47, and the recess 52 is so positioned on the plunger that, when the latter is in its mid position, the two passages 46 and 47 are just closed. Thus each plunger is formed with a recess 52 constantly open to a transfer passage 43, 44, 45 leading to the cylinder for which that plunger acts as a valve, and connecting said transfer passage alternately to an inlet 47 and an outlet 46 as the plunger reciprocates.

The pump unit also has passages 53 leading from the outer ends of the plunger bores 12, and connected by axially directed passages 54 to further passages 55 leading into adjacent bores intermediate their ends, and passages 56 and 57 entering the bores 12 on opposite sides of the passages 55 connect respectively with suction passages 58 opening from the cavity 14, and with a delivery passage 61 opening to the delivery connection 34.

In the longitudinal sectional views (Figures 1 and 2) of the pump, the cross-passages between the plunger bores 12, 13 and the various longitudinal passages have been indicated, those which extend rearwardly from the section plane being shown in full lines, and those which extend forwardly from the section plane in chain-dotted lines. The action of the plungers is described with reference to Figure 7, representing the motor unit, and in which the disk 15 has been indicated by a development of the line 15A joining the points of contact of the plungers therewith. Liquid under pressure is being fed to the inlet 35, and flows by way of the passage 51 into the radial passages 47, the connection being indicated by the dotted passage 47A. The plungers in Figure 7 have been lettered A, B, C and D, and it will be seen that passage 47 in the bore of plunger C is the only one that is not closed. Liquid, therefore, flows into the recess 52 of plunger C, and through passages 45, 44 and 43 into the pressure space in the bore of plunger B, forcing this plunger inwardly. The part of the disk engaged by the plunger B is thus urged away from the motor cylinder block 11, and the diametrically opposite part, engaging plunger D, is moved towards the same cylinder block. The plunger D is thus moved outwardly (downwardly in Figure 7) to uncover the passage 47 in its bore and feed pressure liquid to the pressure space in the bore of plunger C. The liquid expelled from the pressure space in the bore of plunger D as it moves down flows through passages 43, 44 and 45 to the annular recess 52 in plunger A, and so through passage 46 to the recess 44, and the exhaust connection 37. The connection of the passages 46 to the recess 48 is indicated by the dotted passage 46A. The movement of the disk is causing the plunger A to move outwardly (downwardly in Figure 7) and the passage 46 is thus being gradually closed, reaching its fully closed position when plunger D reaches the extreme outward end of its stroke. As soon as the exhaust passage 46 controlled by plunger A is fully closed, the inlet passage 47 controlled by the same plunger begins to open, and the plunger D commences to move inwardly under the pressure. It is thus apparent that the plungers move inwardly consecutively, in the order, commencing with the plunger first referred to above—B, C, D, A. The line of maximum inclination of the disk, therefore, travels round in a circle, that is, the disk performs a movement of nutation about the common axis of the two cylinder blocks, and the pump plungers are reciprocated in their cylinders, the suction and delivery of liquid being controlled in the same manner as the pressure and exhaust of liquid in the motor.

The projection 22 on the disk 15 may be of other than true conical form, being for example substantially elliptical in cross-section, so that the angle of inclination of the disk varies slightly as it changes its position, thus modifying the relation between the speed of movement of the pump plungers and the rate of travel of the projection 22 around the projection 23.

More than four plungers may be employed in either the motor or the pump, or both, the number of plungers being $4n$ where n is any whole number and each plunger serving as valve to nth plunger on one side of it. There are thus n groups of plungers, each group in itself resembling the arrangement described above, and the plunger of each group being arranged between the plungers of the other or others. Thus in an arrangement employing eight ($2n$) plungers, each plunger acts as the valve for the plunger next but one to it.

A number of plungers greater than four, but not a multiple of four may be employed, each plunger acting as valve for the plunger next adjacent thereto. In this case the adjacent plungers are out of phase by less than one half of their total stroke, and the inlet and exhaust periods cannot correspond exactly each with one half of the plunger movement. Figure 8 is a development of an arrangement having five plungers, lettered respectively E, F, G, H and I, the inlet, exhaust,

and transfer passages being numbered to correspond with those in Figure 7. It will be seen that, compared with the four cylinder arrangement, the annular recess **52** in each plunger has been displaced towards the disk, so that the inlet passages **47** do not commence to open until the controlling plungers have completed more than half of their outward strokes, and close again before the plungers have completed half of their inward strokes, the exhaust passages **46** remaining open for the whole of the time during which the inlet passages are closed. In Figure 8 the plunger G has just reached the outer end of its stroke, and is about to move inwardly, and the plunger H is about to uncover the inlet passage **47**. The plunger E has not yet completed its inward stroke, but the plunger F, which controls the connections to the cylinder of plunger E, has just closed the inlet passage **47**, and is about to open the exhaust passage **46**. The plungers are not, therefore, acted on by the pressure during their full strokes.

The pump plungers may be equal in number to the motor plungers, or there may be more or less of them, according to the relative capacities required for the pump and motor.

The valves for controlling the admission of liquid to the motor and pump cylinders, and its exhaust therefrom, may be separate from the motor and pump plungers, being for example separate axially moving plungers acting in the manner fully described herein, and actuated by connection with the swashplate. As a further modification, the flow of liquid may be controlled by rotary distributors driven in any convenient manner.

Springs may be provided to retain the motor plungers in contact with the disk, or they may be so connected thereto as to follow the movement at the disk on both the pressure and exhaust strokes.

The pump and motor cylinders may be formed in a common cylinder block having the disk mounted at one end, the pump cylinders being on a different pitch circle from the motor cylinders or being arranged alternately with the motor cylinders on a common pitch circle. The angle of the disk may be controlled by a crank instead of by the co-operating projections described herein.

What I claim is:

1. A liquid pressure actuated pump comprising, a plurality of pump cylinders in circumferential array about an axis, plungers operating in the cylinders, a plurality of motor cylinders separate from said pump cylinders and in circumferential array about the same axis, plungers operating in the motor cylinders, and a disk mounted for universal tilting movement, each plunger of each set being in direct engagement with the disk which is urged by the motor plungers to perform a movement of nutation about the common axis of the two groups of cylinders, each of said pump plungers forming a valve to control the admission of liquid to, and the escape of liquid from the cylinder of another pump plunger.

2. A liquid pressure actuated pump comprising, a plurality of pump cylinders in circumferential array about an axis, plungers operating in the cylinders, a plurality of motor cylinders separate from said pump cylinders and in circumferential array about the same axis, plungers operating in the motor cylinders, and a disk mounted for universal tilting movement, each plunger of each set being in direct engagement with the disk which is urged by the motor plungers to perform a movement of nutation about the common axis of the two groups of cylinders, each of said motor plungers forming a valve to control the admission of liquid to, and the escape of liquid from the cylinder of another motor plunger.

3. A liquid pressure actuated pump comprising, a pump cylinder block, a plurality of cylinders in said pump cylinder block in circumferential array about an axis, plungers operating in the cylinders, a motor cylinder block, a plurality of cylinders in said motor cylinder block in circumferential array about an axis, plungers operating in said motor cylinders, means for securing said cylinder blocks together in fixed angular relation and with their axes in alignment, a sleeve-like spacing member defining a cavity between said cylinder blocks, a disk in said cavity, and a fixed support on which said disk is mounted for universal tilting movement, each plunger of each series being in direct engagement with said disk, which is urged by the motor plungers to perform a movement of nutation about the common axis of the two cylinder blocks.

4. A liquid pressure actuated pump, according to claim 3, wherein a flexible diaphragm divides the cavity into two chambers, one connected to the inlet side of the pump, and the other to the exhaust side of the motor.

5. A liquid pressure actuated pump comprising, a pump cylinder block, a plurality of cylinders in said pump cylinder block in circumferential array about an axis, plungers operating in the cylinders, a motor cylinder block, a plurality of cylinders in said motor cylinder block in circumferential array about an axis, plungers operating in said motor cylinders, means for securing said cylinder blocks together with their axes in alignment, a sleeve-like spacing member defining a cavity between said cylinder blocks, a ball-headed post mounted on one of the cylinder blocks and projecting into said cavity, said post being co-axial with the cylinder blocks, a disk mounted for universal movement on said post, a frusto-conical projection on said disk, a second frusto-conical projection extending axially from the other cylinder block, each plunger of each series being in direct engagement with said disk, which is urged by the motor plungers to perform a movement of nutation about the common axis of the two cylinder blocks, the inclination of the disk being governed by the engagement of the two conical projections.

6. A liquid pressure actuated pump comprising two cylinder blocks, means connecting the two cylinder blocks and inhibiting relative rotation thereof, a plurality of pump cylinders formed in one of the cylinder blocks in circumferential array about an axis, plungers operating in the cylinders, a plurality of motor cylinders formed in the other cylinder block in circumferential array about the same axis, plungers operating in the motor cylinders, a disk in direct engagement with each plunger of each set, and a support fixed with respect to the cylinder blocks on which said disk is mounted for universal tilting movement about the common axis of the cylinder blocks, the said disk being urged by the motor plungers to perform a movement of nutation about the common axis of the two groups of cylinders.

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