July 30, 1963 P. E. MERCIER 3,099,223

PUMPS, MORE PARTICULARLY VOLUMETRIC PUMPS

Filed Aug. 8, 1961 4 Sheets-Sheet 1

FIG 1

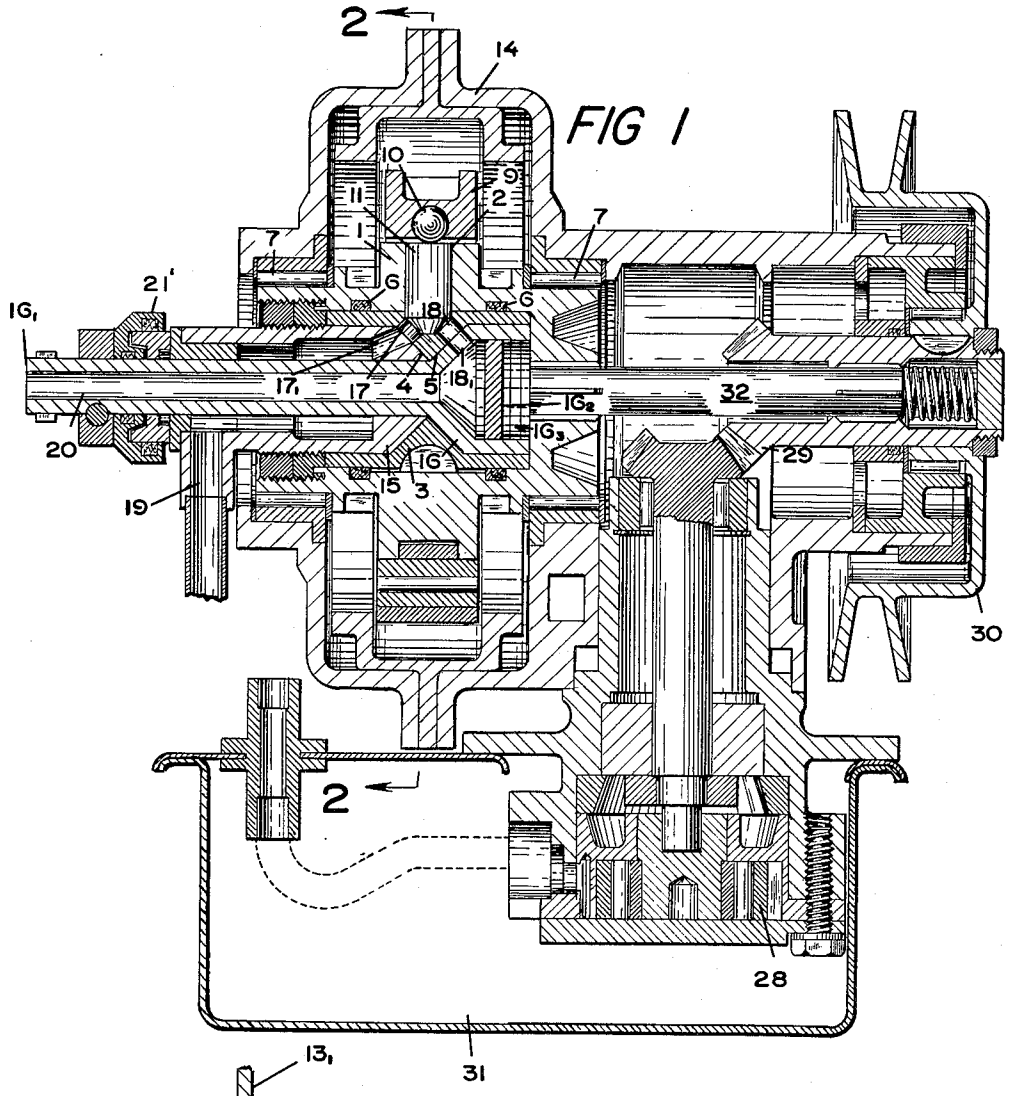
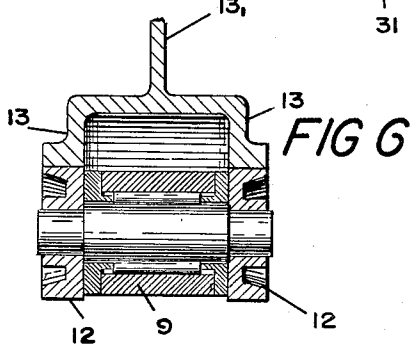


FIG 6



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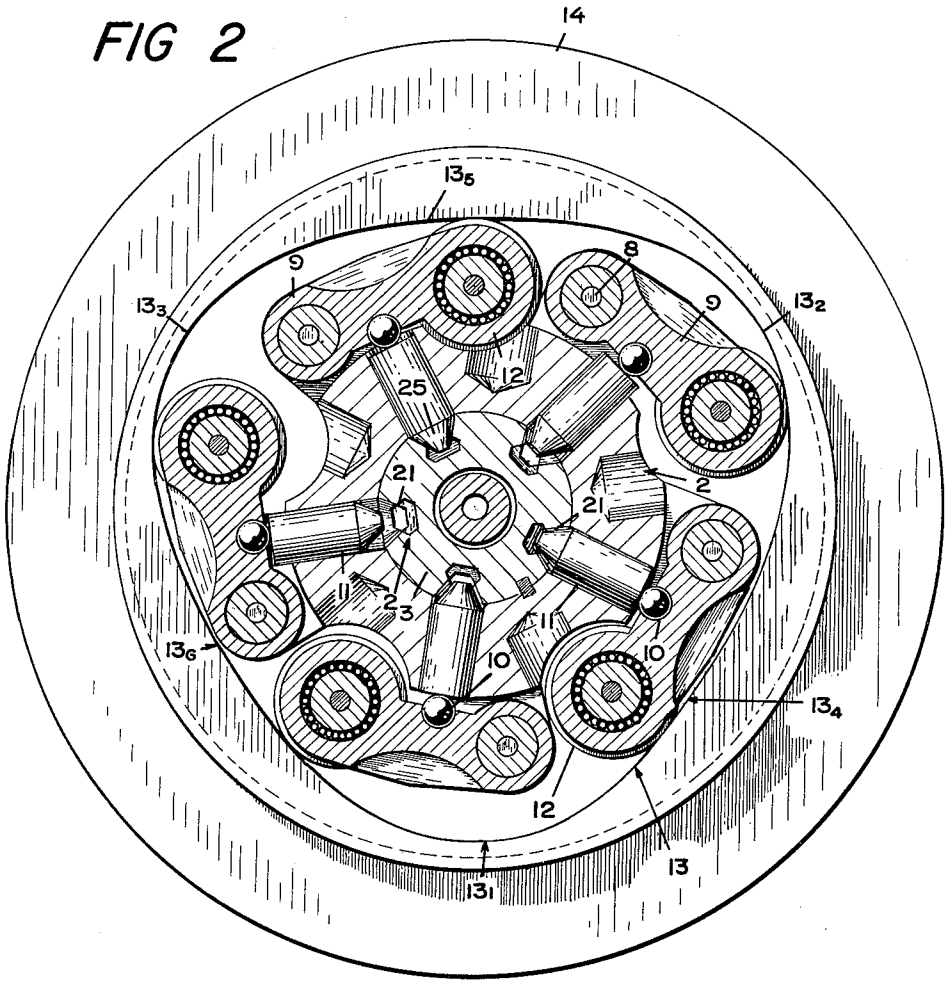
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July 30, 1963 P. E. MERCIER 3,099,223

PUMPS, MORE PARTICULARLY VOLUMETRIC PUMPS

Filed Aug. 8, 1961 4 Sheets-Sheet 2

FIG 2



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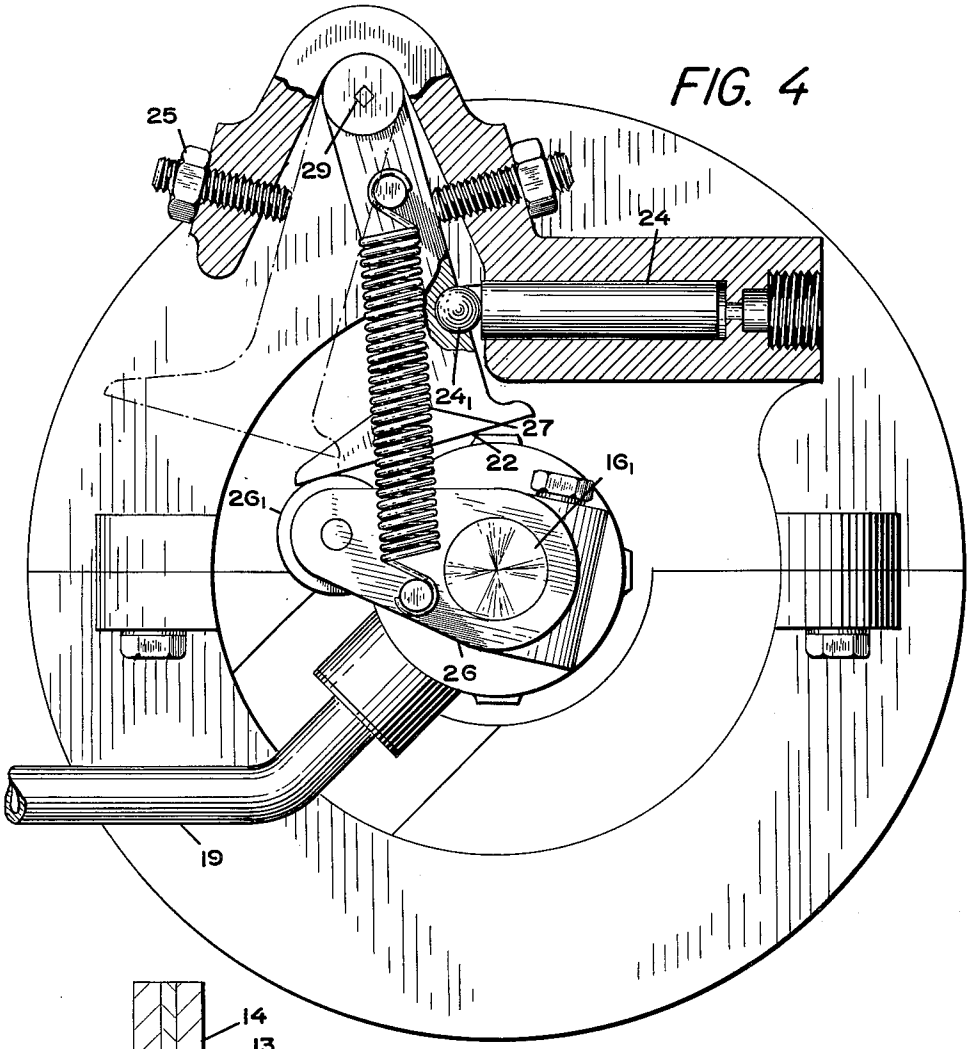
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PUMPS, MORE PARTICULARLY VOLUMETRIC PUMPS

Filed Aug. 8, 1961 4 Sheets-Sheet 3

FIG. 4



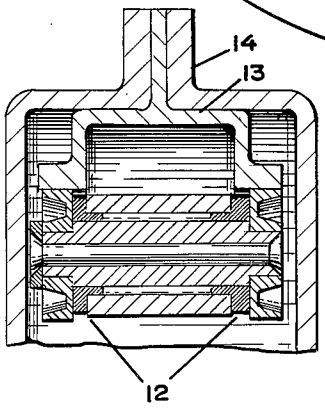


FIG 3

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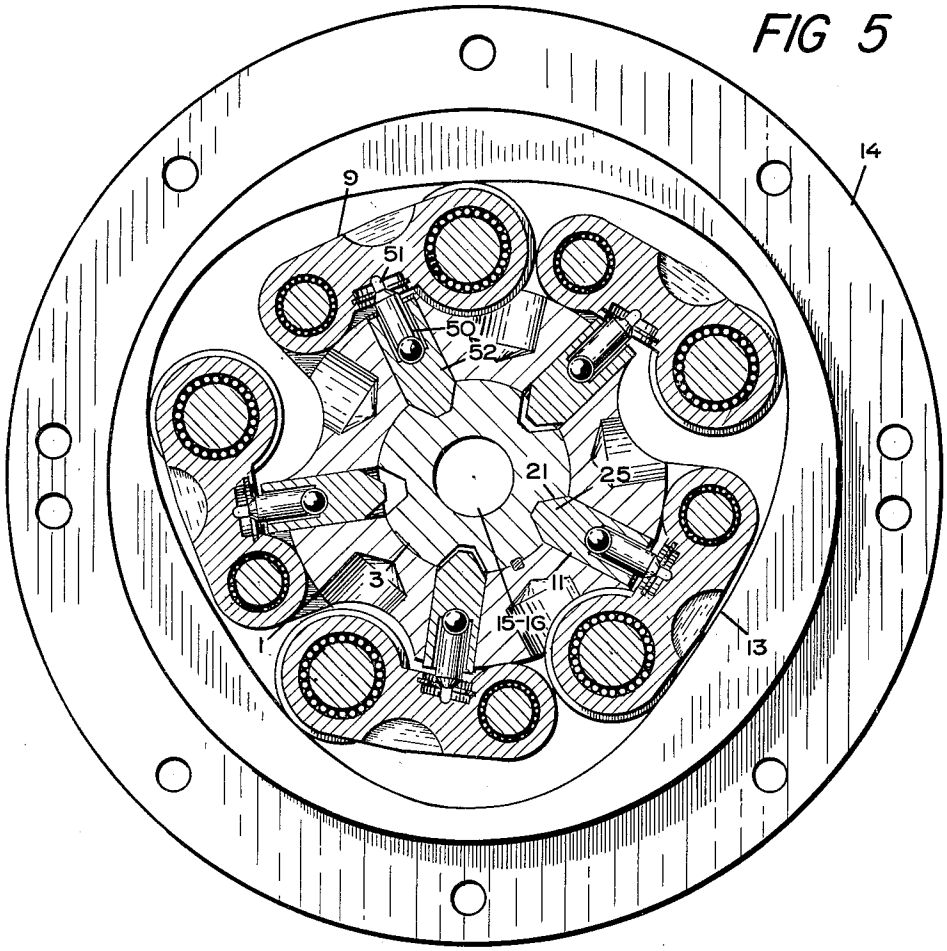
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July 30, 1963 P. E. MERCIER 3,099,223

PUMPS, MORE PARTICULARLY VOLUMETRIC PUMPS

Filed Aug. 8, 1961 4 Sheets-Sheet 4

FIG 5



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3,099,223

PUMPS, MORE PARTICULARLY VOLUMETRIC PUMPS

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Filed Aug. 8, 1961, Ser. No. 130,055
1 Claim. (Cl. 103—161)

This application is a continuation-in-part of application Serial No. 502,123, filed April 18, 1955, now abandoned.

This invention relates to a volumetric pump capable of operating as a high pressure pump or as a motor. The pump comprises a central body having a plurality of radially extending cylinders in which reciprocating pistons are located.

The alternating movement of the pistons is controlled by a cam outside of the cylinders.

The cylinders communicate through inlet and discharge openings with a distributor mounted in the axis of the pump body.

Pumps of this kind are already known comprising two piston strokes per revolution. The alternating movement of the pistons is controlled by a cam; said pistons being, by means of rollers, directly in contact with the cam. These machines comprise, for cancelling the reactions of axes, an even number of pistons whose actions on the axis are annulled in pairs.

These machines have the disadvantage of maintaining a resistant or motor torque irregularity (pump or motor receiver) equivalent to that obtained with a half number of pistons. For example, in a six-cylinder machine, the torque irregularity is equivalent to a three-cylinder machine.

Actually, if we take a cam with two pairs of hollows connected by intercalary arcs with a slight curvature (elliptical or pseudo-elliptical cam) and acting on pistons whose number is a multiple of even numbers of hollows and with a slight curvature of the cam, the dead-centers corresponding to the divergent or extension movement towards the exterior of the pistons and their driving rollers is situated in the vicinity of points of decided curvature arcs farthest removed from the center of the pump. The dead-centers of the pistons towards the center of the pump are situated in the vicinity of points of mean slight curvature arcs nearest to the centre of the pump.

In an arrangement of this kind, as the number of pistons is even, two pistons diametrically opposed in the pump body follow identical cycles. At each dead center, symmetrical stresses are developed by the diametrically opposed pistons, there is no reaction of the pump body on the bearings when passing these dead centers; but from the point of view of regularity of the torque transmitted or received by the machine (operating as a motor or generator), everything occurs as if the number of pistons was reduced by half. This coefficient of regularity is thus very poor with regard to the number of pistons utilized, and the vibrations resulting therefrom are prejudiciable to the output of the assembly.

Let us now take the case of a cam comprising three hollows connected to each other by slight curvature arcs and comprising a number of pistons equal or the multiple of three. The outward and return number of each piston per revolution of the machine is thus three.

In these conditions, there is a good equilibrium between each group of three pistons arranged at 120 degrees to each other in the pump body. Thus, no reaction appears of the axis of the pump body on its bearings, but on the other hand, the irregularity coefficient of the torque will be very bad.

The present invention has more particularly the purpose of obviating this disadvantage and producing a machine in which the resistant or motor torque, is relatively regular, while reducing the reactions of the axes.

A machine enabling the preceding objects to be attained, has the characteristics which result from the description hereafter, and in particular, the attached claim.

A machine according to the invention operating, as an example, as a volumetric pump, is shown in the attached drawings, in which:

FIG. 1 is an axial sectional view of the pump assembly;

FIG. 2 is a sectional view of the pump taken along the section line II—II of FIG. 1;

FIG. 3 is a partial sectional view of a roller holder taken thru the axis of one of the rollers;

FIG. 4 is a sectional view of a pressure adjusting device for the delivery at the corresponding distributor position;

FIG. 5 is a vertical sectional view of a modification of the pump, and,

FIG. 6 is a partial sectional view showing the arrangement of the rollers upon the levers operating the pistons of the pump.

Referring to the drawings, the pump comprises a central body 1 having radially extending cylinders 2 which are preferably of an uneven number for each machine. The central body 1 has a centrally located cavity in which a core 3 provided with recesses 21 is located. The core 3 is so adjusted that the recesses 21 constitute the inner ends of the cylinders 2.

The core 3 is also provided with tapered surfaces 4 and 5 which act as bearing points for two distributor members 15 and 16. The entire assembly is mounted in the axis of the pump body. At each side of the core 3 fluid tight rings 6 are provided to prevent leakage between the core 3 and the central body 1.

The body 1 is supported upon bearings 7 located on each side of a plane containing the longitudinal axes of the cylinders. The body 1 is also provided with axles 8 located near its periphery which are parallel to the axles of the bearings around which the levers 9 upon which rollers are mounted oscillate. The oscillation of the levers 9 causes a reciprocation of the pistons 11 by means of ball bearing push rods or the like.

The use of the ball bearing push rods 10 practically eliminates any lateral stresses of the pistons in their respective cylinders and consequently reduces overheating and wear.

When the pump operates as a pump the pistons 11 travel inwardly during the delivery period and outwardly when liquid is suctioned into the cylinders. When the pump operates as a hydraulic motor liquid under pressure is admitted into the cylinders when the pistons travel outwardly while the discharge of the liquid to the tank 31 takes place upon the reverse movement of the pistons.

The rollers 12 mounted upon the levers 9 roll inside a cam 13 mounted upon the casing 14 in which the body 1 is mounted and the central body has a relative movement with respect to such cam and casing. The cam 13 is in the form of a ring having hollows and small curvature parts in between the interior surface thereof which control the displacement of the pistons by the rollers 12 rolling thereon. The cam 13 may be a single cam or comprise a double cam. A single cam comprises a single ring which is located in the plane of symmetry of the cylinders while a double cam comprises two rings located alongside of one another wherein each ring is located at opposite sides of the plane of symmetry of the cylinders.

As shown in FIGURE 2, the cam 13 has a three-cusped shape. On the internal face of the cam 13 we see the parts farthest removed from its center of symmetry, which have the most acute curvatures, and, intercalated between

the latter, the parts with a less pronounced curvature which are nearest to said center of symmetry.

The cam 13 as shown in FIG. 3 has the shape of a double internal runway and as appears from FIG. 2 it has the small curvature parts 13_4, 13_5 and 13_6 and the hollows 13_1, 13_2 and 13_3.

The curve characterizing the passage from one hollow to the next one or from one small curvature part to the next one occurs in uniform angular rotation. If there are 3 small curvature parts and 3 hollows for each complete revolution this passage from one hollow to the next one is equal to 120°.

Generally, should there be n bosses and n hollows, the curve is shown by the angular rotation of $2\pi/n$.

The distributor which is mounted at the axis of the pump is formed of two members 15 and 16. These members are respectively concerned with the intake and discharge of liquid when the pump operates as a pump. The members 15 and 16 have tapered portions bearing upon the tapered surfaces 4 and 5 of the central core 3. The core 3 has ports 17 and 18 therein and by means of corresponding ports 17_1 and 18_1 carried by the distributor members 15 and 16 the cylinders communicate alternatively with the intake pipe 19 and the discharge pipe 20.

In FIGURE 1, the ports 17, 17_1, 18 and 18_1 are shown for clarity in the case of the cylinder 2, of this figure as being in simultaneous coincidence although such coincidence does not happen in fact.

The recesses 21 forming the ends of the cylinders 2 as well as the corresponding ends of the pistons 11 have a tapered shape with the apex thereof turned towards the axis of the body 1 which on one hand reduces the distance covered by the liquid through the ports 17 and 18 of the distribution and on the other hand reduces the volume at the end of the compression to its smallest possible value.

The members 15 and 16 of the distributor are held against the surfaces 4 and 5 by the discharge pressure of the pump. The adjustment of play and the take-up for wear and expansion are therefore automatically obtained by the relative movement of the two distributor members. For this purpose the member 16 has a cylindrical extension 16_1 forming a center tube which is located inside the other member 15. The tube 16_1 and the member 15, form an annular chamber 21' in which the delivery pressure is exerted tending to bring the members 16 and 15 by suitable pressure to bear upon the surfaces 4 and 5. The chocking of the members 16 and 15 which are individually assigned to high and low pressure can be done independently of one another so as to insure the best filling of the cylinders and the optimum reduction of compressibility effects.

A partition 16_2 bearing on the auxiliary stop 16_3 carried by the distributor 16 in the vicinity of its flared-out terminal part, forms the volume occupied by the liquid under pressure in this part of the distributor and any leak is prevented by the fluid tight packing of the partition 16_2.

The ports 17_1 and 18_1 provided upon the members 15 and 16 for the intake of liquid and the delivery thereof outside of the cylinders 2 are uniformly distributed over the periphery of each of the members 15 and 16 in a number equal to the number of bosses or hollows encountered in a complete revolution.

In the distributor, the member 15 is angularly fixed with regard to the cam 13 and the casing 14 by means of the tube 19. The member 16 is capable of limited angular displacement in order to allow compressibility effects at various pressures to be corrected since this member is fixed to the movable piece 26 by the extension 16_1 as shown in FIGURE 4. This correcting device comprises a cam 22 subjected to the action of an elastic member as for example a torsion bar 23 upon which the cam 22 is mounted. A push rod 24 receiving the delivery pressure acts upon the cam 22 so as to alter its angular position. The maximum displacement is limited by an adjustable stop 25. The cam 22 forms an abutment for a lever 26 carrying a roller which is fixed to the extension 16_1. The lever 26 drawn back by the spring 27 is controlled by the roller 26_1 rolling upon the cam 22 which is itself in equilibrium between the push rod 24 and the opposing torsion bar 23.

During working period the friction of the movable member 16 upon the core 3 tends to apply the roller 26_1 of the lever against the cam 22. At rest the spring 27 returns the roller 26_1 to the cam. The position of the cam 22 therefore being a function of the delivery pressure, it will be seen that the angular position of the movable member 16 automatically adjusts itself as a function of the differences between the delivery pressure and the intake pressure, the latter being fixed by a calibrated flap valve.

Instead of a single cam 22 with a spring two cams could be used instead for guiding the roller 26_1.

In view of the small value of the dead space the chocking of the distributor member assigned to low pressure is invariable with regard to the cam 13 carried by the casing 14 when the pump is operating as a generator.

Finally in this form the pump comprises preferably an auxiliary feed or boosting pump 28 driven by means of bevel gears 29 from a driving pulley 30. This pump comprises a calibrated flap valve for delivery which is not shown in the drawing for reasons of simplification.

The pump 28 takes the liquid from the tank 31 and injects it under pressure through the tube 19 into the low pressure member 15 of the distributor in order to prevent any cavitation when running at high speed or any risk of unpriming.

The operation of the pump is as follows: the central body 1 together with the pistons therein is rotated relative to the casing 14 and the cam 13 fixed to such casing and also relative to the distributor member 15 and 16. The rotation is obtained through the pulley 30 fixed to the shaft 32.

Upon rotation of the body 1 the rollers 12 of the levers 9 cooperating with the cam forces the pistons inwardly each time they pass over the second half length of a hollow part followed by the first half length of a small curvature part of the cam 13, taken in the direction of the displacement of the central body.

The pressure of the rollers 12 upon the cam 13 and the outward movement of the pistons is secured by centrifugal force if the central body is rotating or by the pressure of the booster pump 28 if the casing and the cam rotate with respect to a fixed central body. Finally in the case of a rotation of the central body and a substantial delivery pressure of the booster pump it will be the two above-mentioned effects that will be superposed for keeping the pistons in contact with the levers 9 and the pressure of the rollers 12 upon the cam 13.

In FIGURE 5 a further modification is shown which comprises a central body 1 having radially extending cylinders 2 whose ends extend into the core 3. Cooperating therewith is a similar distributor assembly comprising the members 15 and 16 as described above. In the cylinders 2, pistons reciprocate through push rods 50 under the action of levers 9 pivoted upon the body 1 having rollers 12 which are controlled by the double annular cam 13 shown in FIGURE 6. This cam comprises an extension 13_1 secured between the two parts of the pump casing.

According to the invention the body 1 comprises an odd number of radially extending cylinders 2, five being shown in FIGURE 5. The body cooperates with an annular cam 13 which also has an odd number of small curvature parts and of hollows which number is different from that of the cylinders. In FIGURES 2 and 5 shown, such an arrangement is most efficacious for reducing the jerks during delivery and the disadvantages arising therefrom such as noise, loss of output, etc., by levelling the output while avoiding serious axis reactions owing to the large number of pulsations.

In a general manner, according to the invention, the machine comprises as great a number of pistons as possible, not having a common factor with the even number of hollows and small curvature parts, the arcs of the latter being preferably odd and at least equal to three.

These hollows and these small curvature parts follow one another continuously. Owing to the fact that the oscillation point of the roller-holder levers controlling the movement of the pistons is placed outside the application points of the levers on the annular cam and on the pistons, the driving point of the piston being between the oscillation point and the roller rolling on the cam allows by reducing the cross reactions acting on the pistons, to increase the delivery pressure for one and the same limit load of the rollers rolling on the cams and this limit load of the rollers is appreciably greater when the rollers roll inside a hollow crown, than when they roll outside of a convex cam.

This reduction is the more necessary as the hollows of the cam are connected to each other by a slightly curved surface forming steep slopes on either side of their middle.

The middle point of the small curvature arcs of the cam actually corresponds to the extreme positions of the pistons towards the center of the central body carrying the cylinders. Likewise, the middle point of a hollow of the cam corresponds to a dead point towards the exterior for the piston whose roller passes by said point.

The fact that the number of pistons has no common factor with the even number of hollows and the slightly curved part, enables good torque regularity and slight reactions on the axis of the central body. Finally, according to the invention, we have, by the combination of the above-mentioned elements, a machine with a good torque regularity, while having very slight cross reactions on the pistons, and slight reactions on the bearings of the central body.

Actually, if we refer to the example taken in the preface in which the cam comprises three hollows connected to each other by slight curvature arcs and a number of pistons equal to or the multiple of three, we saw that the coefficient of the torque irregularity was considerable.

If we take the machine according to the invention with a cam with three hollows connected to each other by slight curvature arcs and with five cylinders, we see that there are fifteen outward and return cycles of the piston per revolution. The torque irregularity coefficient is thus that of a pump with one cycle per revolution and per cylinder, provided with 15 cylinders.

In this machine, when a piston passes by a dead point there is a piston which is about $\frac{1}{30}$ of a revolution in front of its dead point corresponding to another piston $\frac{1}{30}$ of a revolution behind its corresponding dead point. in these conditions, we see that the reactions of the axis of the pump body on its bearings are variable, bot not very considerable.

Any known factor, in the case of a similar arrangement with a larger number of pistons and hollows in the cam would introduce a synchronism in the reactions of the pistons harmful to the regularity of running, the degree of irregularity being multiplied by said known factor.

Furthermore, in the example shown, the pistons 11 are driven by push rods 50 which bear against the control levers 9 by a knife joint 51. At the other end these push rods bear on the pistons by means of a ball 52. This assembly reduces the lateral stresses on the cylinders and consequently the wear involved. Furthermore it would be advantageous for the purpose of reducing friction to mount the rollers 12 upon ball or needle bearings.

It is thought that the invention and its advantages will be understood from the foregoing description and it is apparent that various changes may be made in the form, construction and arrangement of the parts without departing from the spirit and scope of the invention or sacrificing its material advantages, the forms hereinbefore described and illustrated in the drawings being merely preferred embodiments thereof.

What I claim is:

In a volumetric pump capable of operating as a generator of fluid under pressure or as a motor using the fluid under pressure, the combination comprising a casing, a pump body having a plurality of radial cylinders rotatively mounted on said casing, a distributor mounted coaxially with said body having inlet and discharge orifices communicating with said cylinders, a ring cam having a plurality of hollows and arc portions with a slight curvature continuously alternately connecting said hollows, a reciprocating piston in each cylinder, the number of said pistons not having a common factor with the number of said hollows and said arc portions, a lever cooperating with each of said pistons having at one end thereof an axis of oscillation on said body, a roller on each lever located at the other end of said lever cooperating with said cam and an articulated rod between each piston and its corresponding lever located between the axis of oscillation of a lever and the roller upon such lever, said rod having a ball contacting said piston at one end and a knife edge at the other end contacting said lever.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,099,223 July 30, 1963

Pierre Ernest Mercier

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the heading to the printed specification, between lines 7 and 8, insert the following:

Claims priority, application France Apr. 17, 1954

Signed and sealed this 8th day of September 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents