Jan. 8, 1946.

J. MERCIER

2,392,754

PUMP

Filed March 7, 1942

5 Sheets-Sheet 1

FIG. 1

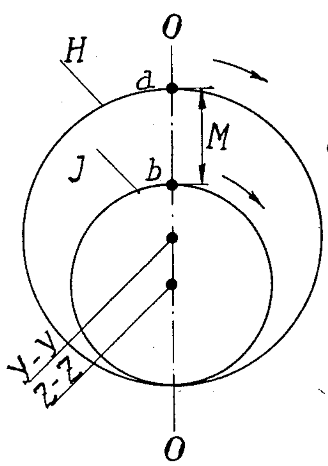

FIG. 2

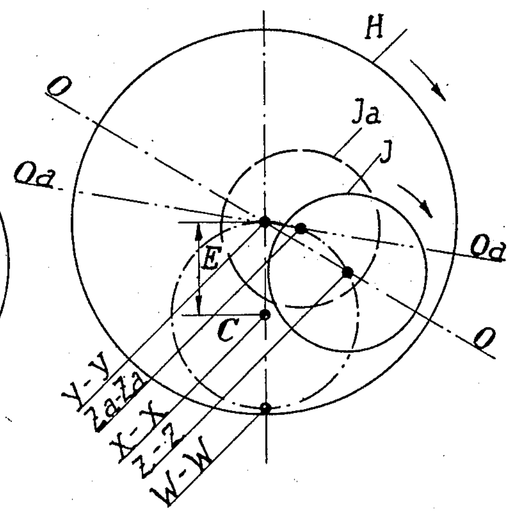

FIG. 6.

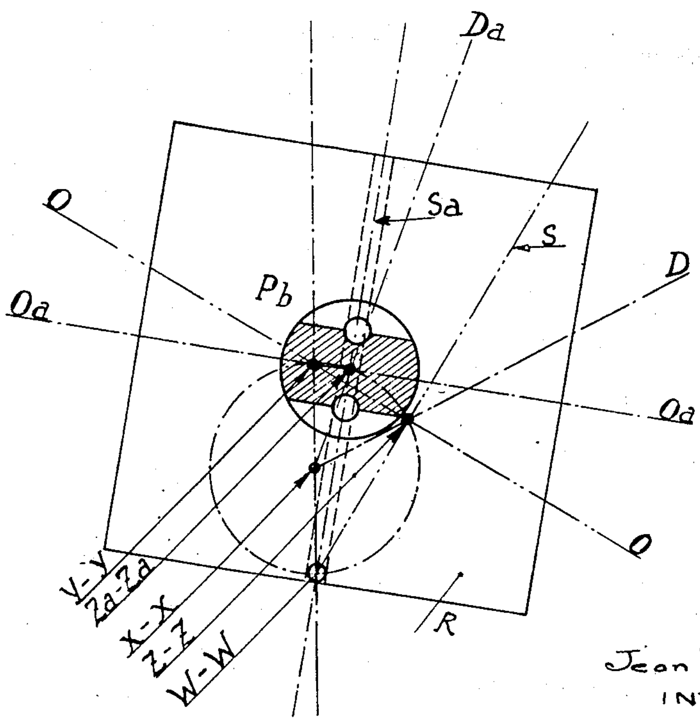

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FIG.3

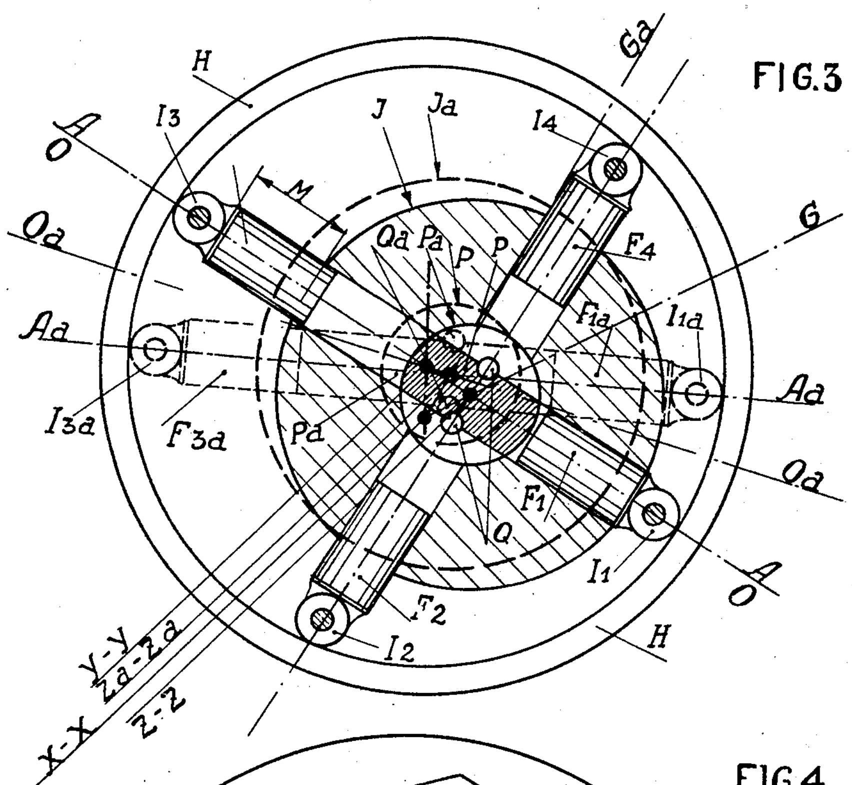

FIG.4

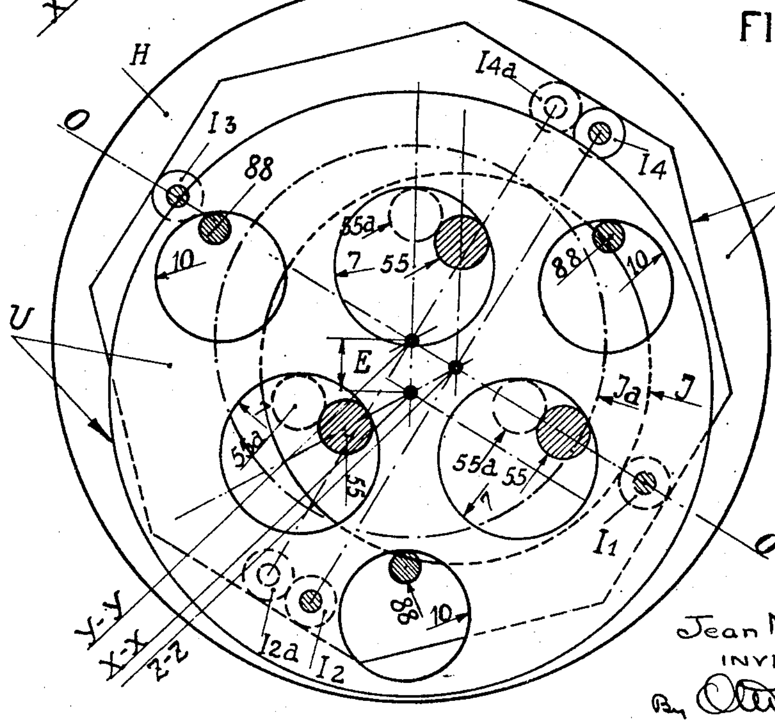

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FIG. 5

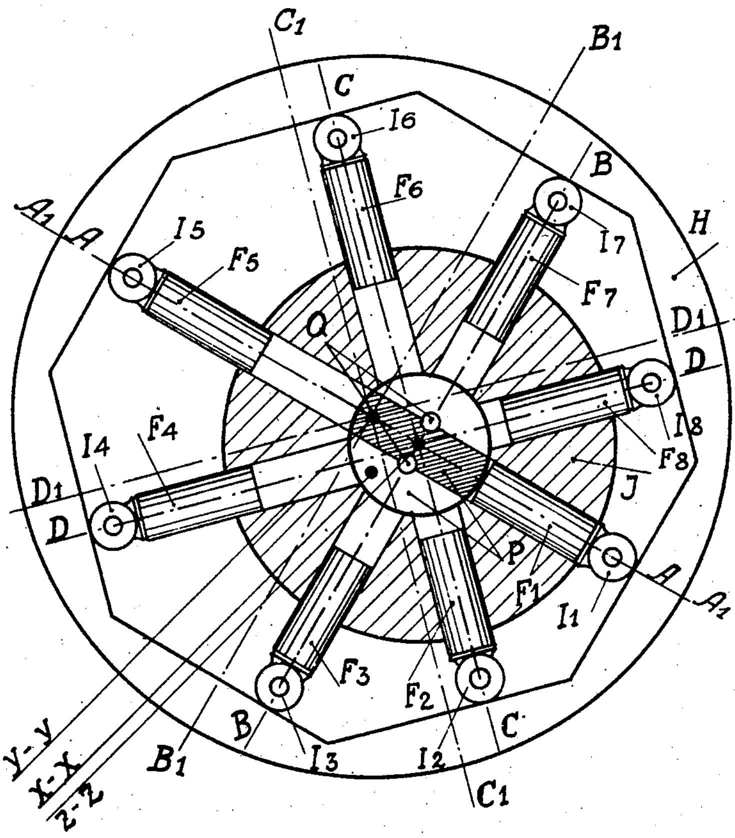


FIG. 11

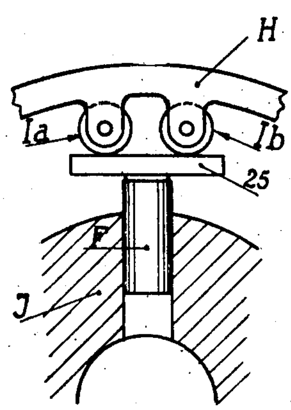
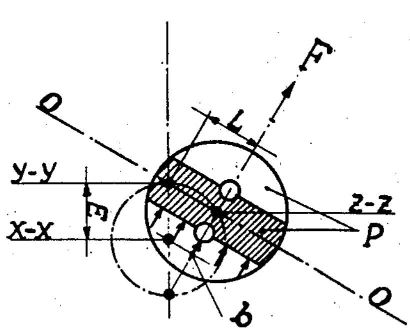


FIG. 7



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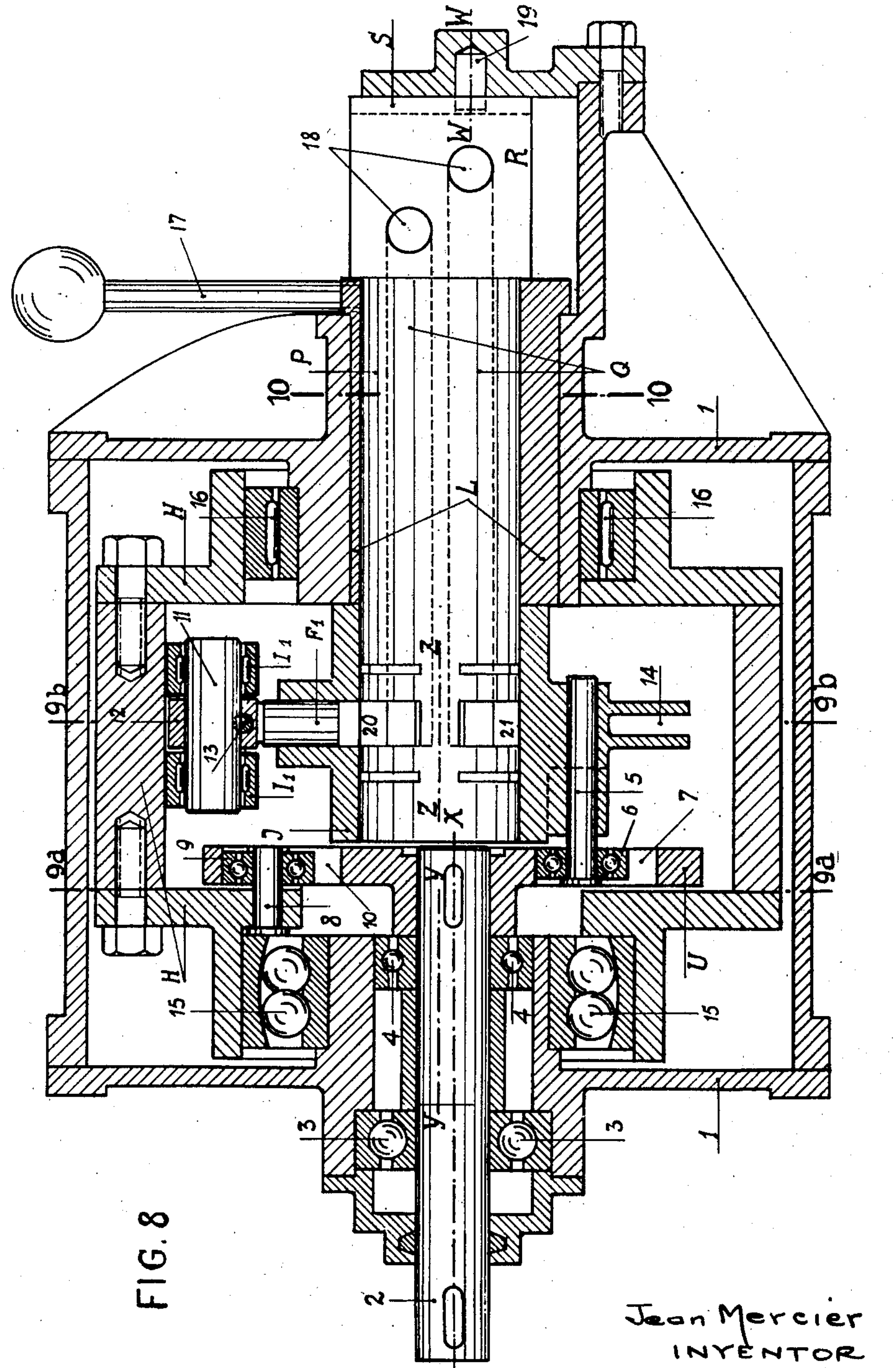

FIG. 8

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FIG. 10

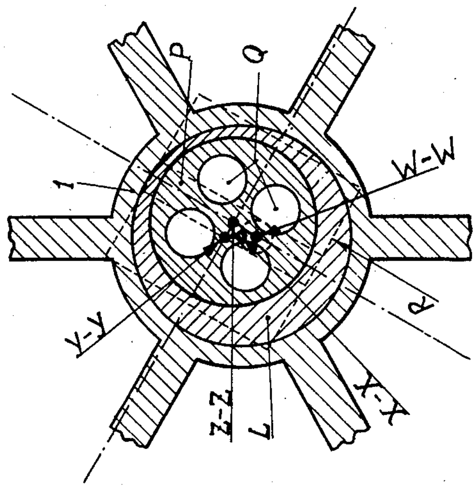
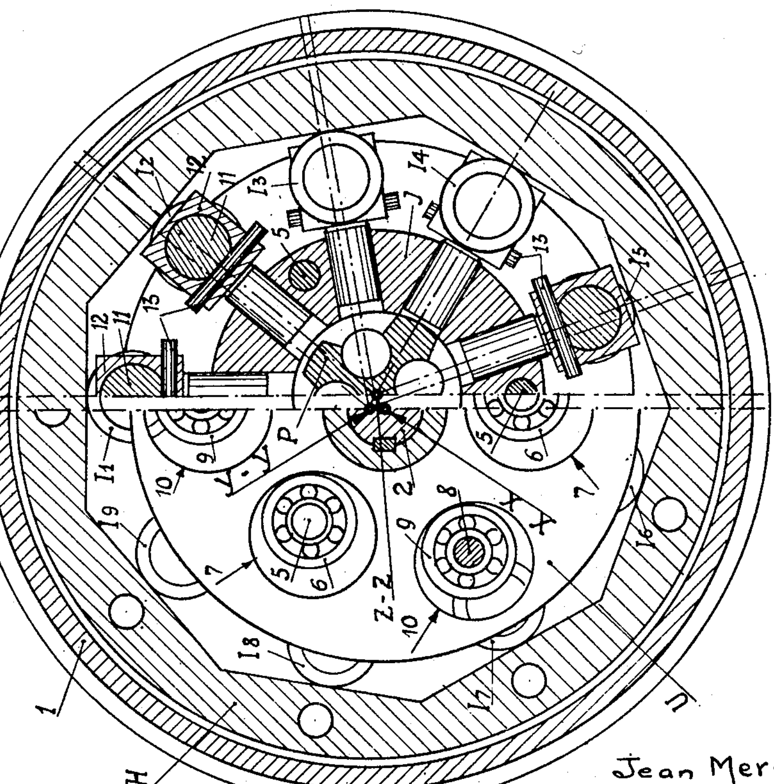


FIG. 9



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Patented Jan. 8, 1946 **2,392,754**

UNITED STATES PATENT OFFICE

2,392,754

PUMP

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Application March 7, 1942, Serial No. 433,725
In France March 13, 1941

8 Claims. (Cl. 103—161)

The present invention relates to rotary apparatus such as pumps, motors, compressors and the like, including two parts rotatable about two parallel axes, respectively, and in which one of the parts, carrying sliding elements, and forming for instance a cylinder block, cooperates with the other, the latter forming for instance a ring which, due to the fact that it turns about an axis different from that of the first part, produces a relative displacement of said sliding pieces, for instance of pistons in the cylinders of said block. The rate of delivery of the pump depends upon the distance between the two axes.

Heretofore, in apparatus of this kind, the rotation of one of the two rotary parts was transmitted thereto from the other part through the intermediate of the pistons or equivalent elements, which involved considerable friction between the pistons and the cylinders.

According to a feature of the present invention, both of the rotary parts, such as for instance the cylinder block and the ring above mentioned, are driven at the same speed so that the pistons or equivalent elements have no action whatever in the transmission of the rotation. Thus, both rotary parts may be driven from a common driving shaft, through suitable transmissions.

In order to reduce fractional stresses to a minimum, the pistons or equivalent elements and the ring which controls their sliding movements in the cylinder block cooperate by means of rollers or the like.

Preferably, such rollers are carried by the pistons or equivalent members and the ring is provided with flat plane faces along which said rollers run, respectively. As these faces are always perpendicular to the axes of the respective pistons, all oblique stresses are eliminated and friction is reduced to a minimum.

A particular object of the present invention is to provide a variable flow pump of the type above described. In such a pump, in order to vary the flow, it is necessary to vary the distance between the respective axes of the two rotary parts while keeping them driven at the same angular velocity.

With this object in view, according to a feature of the present invention, the axes of the two rotary parts, i. e., for instance of an inner cylinder block and of an outer ring, are both movable about a third axis parallel to them and fixed in space.

According to another feature of the present invention, the transmission between at least one of the two rotary parts and the means for driving said part (for instance a driving shaft) is such that the movement of the axis of the driven part about the above mentioned third axis does not involve any rotation of said part about its own axis, so that the cylinders may remain always perpendicular to the corresponding flat faces of the ring. In other words, when one of the rotary parts of the pump has its axis displaced about the third mentioned axis, said part must carry out a strictly translatory displacement.

In view of the fact that the axis of the cylinder block is displaced, relatively to the axis of the ring, by movement about a third, fixed axis, the plane of symmetry of the system, which passes through both of these two first mentioned axes, is also displaced with respect to the third axis.

As, on the other hand, the distributor of the pump is mounted in the cylinder block, the movement of the cylinder block produces a displacement of the plane of symmetry of said distributor which no longer coincides with the plane of symmetry of the system. It will readily be understood that this will involve a serious disturbance in the working of the pump.

In order to obviate this drawback, according to still another feature of the present invention, I provide means for automatically correcting the position of the plane of symmetry of the distributor with respect to the position of the plane of symmetry of the whole system. In this way, all the elements remain in the same relative position, as if the displacement of the axis of the cylinder block with respect to the axis of the outer ring took place along a straight line.

Other features of the present invention will appear from the following detailed description of some specific embodiments thereof.

Preferred embodiments of the present invention will be hereinafter described, with reference to the accompanying drawings, given merely by way of example, and in which:

Figs. 1 and 2 are two explanatory views illustrating the principle of the machines with which the invention is concerned;

Fig. 3 is a diagrammatical view illustrating the conditions to be complied with for ensuring a normal working of the pump according to the invention;

Fig. 4 shows the transmission means between the driving member on the one hand and the cylinder block and the ring on the other hand;

Fig. 5 is a diagrammatical view of a pump made according to the invention;

Fig. 6 is an explanatory view showing how the position of the distributor is adjusted;

Fig. 7 is a detail view intended to show that the pump is of the self regulating type;

Fig. 8 is a longitudinal vertical section of an embodiment of the pump made according to the invention;

Fig. 9 is a vertical cross-section of the pump of Fig. 8, the left hand side being a section on the line 9a—9a of Fig. 8 and the right hand side on the line 9b—9b of the same Fig. 8;

Fig. 10 is a vertical section on the line 10—10 of Fig. 8;

Fig. 11 is a partial vertical section of a modification.

Referring first to Fig. 1, *a* is a point which turns about an axis Y—Y and *b* is a point which turns, with the same angular velocity, about axis Z—Z. It is shown that the distance between *a* and *b* varies, as these two points turn about their respective axes, from the maximum value M to zero. Many devices are known which are based on this principle, i. e., the rotation of two parts H and J about special, parallel axes Y—Y and Z—Z.

The centers of rotation Y—Y and Z—Z are located on a line O—O which constitutes the axis of symmetry of the system. If the center of rotation of part J is moved along axis O—O so as to reduce its distance from the center of rotation of system H, the value of M is reduced, and finally becomes constant when the two centers are in coincidence. This property has been utilized for varying the flow of a pump made in accordance with the principle above stated, this flow varying from a maximum value, proportional to M, down to zero.

According to a characteristic of the present invention, the variation of flow is obtained, not by a rectilinear relative displacement of the centers of parts H and J, but by a relative displacement along a circular arc having its center fixed in space, at C in Fig. 2 (this point being the intersection, with the plane of the figure, of an axis X—X parallel to Y—Y and Z—Z).

However, when the angle Y—Y, C, Z—Z varies for instance to the value Y—Y, C, Z*a*—Z*a*, part J comes into position J*a*, shown in dot and dash lines in Fig. 2. The axis of symmetry of parts R and J then passes from the position shown at O—O into the position O*a*—O*a*. Such a displacement of the axis of symmetry of the parts modifies the position of the elements of part J with respect to this axis of symmetry. In order to correct the position of the elements of this part J with respect to the axis of symmetry (in particular, in the case of a hydraulic apparatus, in order to bring back the distributor into proper position with respect to the cylinder block), I provide the system with any suitable kinematic connection, such as a complementary fixed axis W—W, capable of creating the necessary mechanical conditions. This axis (which is shown by a point in Fig. 2) is disposed on the circle along which axis Z—Z is displaceable, at the intersection of this circle with diameter C, Y—Y. This constitutes a characteristic feature of the invention.

In Fig. 3, I have diagrammatically shown a pump of the type with which the invention is concerned, so as to illustrate the conditions under which the apparatus is called upon to work.

In this figure X—X shows the axis fixed in space. The axis Y—Y about which ring H is rotatable is fixed with respect to X—X.

Axis Z—Z, which is the axis of rotation of the cylinder block J, can be displaced parallel to itself along a circular arm about axis X—X. Pistons F_1, F_2, F_3, F_4, carry rollers I_1, I_2, I_3, I_4 which run upon ring M. These pistons are radially slidable with a reciprocating movement in the cylinder block, their movement toward the axis Z—Z being produced by the action of ring H on their rollers. This movement toward the center corresponds to the delivery of the pump. The displacement of the pistons away from the center is produced by centrifugal force and causes liquid to be drawn into the cylinders. The stroke of the piston is shown at M.

In the position shown in full lines in Fig. 3, the axis of symmetry O—O passes through the centers of rotation Y—Y and Z—Z coincides with the axis of pistons F_1, F_3, designated by A—A. The distributor is shown at P.

According to the invention, in order to vary the flow of the pump, axis Z—Z is displaced about axis X—X. As a consequence of this displacement, the stroke of the pistons is reduced, since the centers of rotation of Z—Z and Y—Y are brought nearer to each other.

In Fig. 3, I have shown in broken lines at J*a* the position of the cylinder block after this displacement.

It should be noted, however, that if the whole of the cylinder block were caused to turn about axis X—X in order to vary the flow of the pump, the drive could not operate properly for the following reasons:

First, the axis A—A of the pistons would come into the position A*a*—A*a*, shown in broken lines in Fig. 3 due to the considerable angular displacement of the pistons, as shown by the drawing.

Second, the distributor P, mounted in the body of the cylinder block, would assume position P*a*, following exactly the movement of the cylinder block. In this new position, the axis of symmetry of the distributor would be displaced with respect to the axis of symmetry O—O of the system. This would cause serious disturbances in the operation of the pump since axis O—O must not be considered merely from the geometrical point of view but also from the point of view of the working of the pump. As a matter of fact, the position of this axis determines, on the one hand, the suction of the pump, and, on the other hand, its delivery.

Furthermore, with a construction such as that illustrated by Fig. 3, and even with ring H rotated about its axis with the same speed of revolution as cylinder block J about its axis, rollers I_1, I_2, I_3, I_4 would be subjected to oblique stresses from the inner wall of said ring.

The present invention makes it possible to avoid these disadvantages.

Fig. 4 shows how this result is obtained, with respect to two of the disadvantages above mentioned. In this figure motion is transmited to cylinder block J on the one hand and ring H on the other hand, in such a manner that the two parts H and J are driven at exactly the same angular speed and the adjustments necessary to vary the flow of the pump are made in such a way, that, when axis Z—Z is caused to turn about X—X, all the points of cylinder block J are displaced parallel to each other, that is to say this cylinder block moves with a translatory motion.

Moreover, Fig. 4 shows an arrangement in which the exertion of oblique stresses by the outer ring on the pistons is wholly eliminated.

In this device, a disc U is keyed to a driving shaft and transmits the movement thereof on the one hand to the outer ring H and, on the other hand, to the cylinder block J. The transmission is effected as follows:

The disc U is provided with two series of circular holes. Three of these holes 7 equidistant from the center X—X of the disc serve for the drive of the cylinder block J. Three other holes 10 also equidistant from axis X—X, serve for the drive of the outer ring H. The cylinder block carries fingers 55 engaged in holes 7, while the ring carries fingers 88 engaged in holes 10.

The difference between the diameter of each circular hole 7 and the diameter of the corresponding finger 55 is equal to twice the eccentricity of the cylinder block, that is to say twice the distance between axis Z—Z and axis X—X, or 2E.

The distance between axis Y—Y and axis X—X being also equal to E, the difference between the diameter of each hole 10 and the diameter of the corresponding finger 88 is also equal to 2E.

Thus, each of the two essential parts of the pump, to wit the cylinder block and the outer ring, is coupled with the driving disc U in such manner that its axis can be displaced along the arc of a circle about the axis of said disc without, in the course of such displacement, said cylinder block or said ring being rotated about its own axis, that is to say each displaced part carries out a translatory movement.

Of course, the arrangement above described, including circular holes and fingers engaged in said holes, could be replaced by any other transmission giving the result above set forth.

In actual practice, it has been found that, since it suffices to displace axes Y—Y and Z—Z relatively to each other by rotation about axis X—X, it is simpler to leave one of the two first mentioned axes, for instance Y—Y in fixed position with respect to X—X and to displace only axis Z—Z about X—X.

In this case, as shown by Fig. 4, fingers 88 always remain in the same positions with respect to the corresponding circular holes 7, while fingers 55 may ocupy any position, in tangential contact with the wall of the corresponding circular holes 10, between the positions 55a shown in broken lines (which correspond to a flow equal to zero) and the positions 55 shown in solid lines, which are supposed, for instance, to correspond to the maximum distance between axes Z—Z and Y—Y and therefore to the maximum flow.

According to another feature of the invention illustrated in Fig. 4, the inner wall of ring H, on which the rollers I_1—I_4 run, is of polygonal section, the number of sides of the polygon being eoual to the number of pistons and such sides being perpendicular to the axis of one of said pistons. As ring H and cylinder block J turn exactly at the same speed about their respective parallel axes Y—Y and Z—Z, this perpendicularity of the sides of the polygon with respect to the corresponding piston axes is preserved constantly and no oblique force is exerted by ring H on the pistons. Friction is thus reduced to a minimum.

Of course, in view of the fact that the cylinder block moves with a translatory motion when its axis Z—Z is caused to rotate about X—X in order to modify the flow of the pump, such a variation also leaves the piston axes still perpendicular to the corresponding sides of the polygonal inner wall of ring H.

Fig. 5 shows diagrammatically an example in which a cylinder block carrying eight pistons cooperates with a ring H the inner wall of which is of octagonal cross section. This view shows how the rollers carried by the pistons run along the sides of the polygon. In this view, lines A_1—A_1, B_1—B_1, C_1—C_1, D_1—D_1 are perpendiculars to the sides of the octagon passing through the center of ring H; A—A, B—B, C—C, D—D are the axes of the piston. It is clear that A—A remains always parallel to A_1—A_1, B—B to B_1—B_1, C—C to C_1—C_1, and so on.

Fig. 5 also shows that the distributor P is disposed in such manner that its axis of symmetry coincides with the axis of symmetry of the system including parts H and J. This position corresponds to symmetry of the pump: three of the pistons are, in this position on the suction side, and three on the delivery side.

Fig. 6 shows in what manner the distributor is kept, according to the invention, always in the plane of symmetry of the system. In this example, the end face R of the distributor is provided with a groove S. On the other hand, I provide a pin in fixed position carried by the frame of the pump and extending along axis W—W. This axis W—W is located on the circumference along which axis Z—Z is movable, at the point where this circumference is intersected by diameter Y—Y, X—X.

When the cylinder block in which the distributor is mounted is displaced so that its axis turns about axis X—X, groove S is caused to slide on pin W—W, thus determining a rotation of the distributor with respect to the cylinder block which returns the plane of symmetry of the distributor to the proper relative position with respect to the axis of symmetry of the system including ring H and cylinder block J.

This results from the following calculation:

Angle Y—Y, Z—Z, W—W is equal to 90° and angle Y—Y, Za—Za, W—W is also equal to 90°, since both of these angles are inscribed in a semicircle. Therefore, angle O, Y—Y, Oa is equal to angle Z—Z, W—W, Za—Za, since the sides of these angles are respectively perpendicular to one another. It follows that the groove S of the distributor, and consequently the distributor itself, has turned through an angle equal to the angle through which the axis of symmetry of the system has turned so that the axis of symmetry of the distributor has assumed a position to coincide with the new position of the axis of symmetry of the entire system.

It is known that, when a pump absorbs a constant power, the pressure which acts on the distributor is inversely proportional to the flow. On the other hand, the flow is proportional to the eccentricity or distance between axes Y—Y and Z—Z, which will be designated by L. If F is the total pressure acting on the distributor, the product $F \times L$ is equal to a constant value, say K. The center of rotation of the distributor being at X—X, the value of the torque at this point is $F \times XXb$. Now, the distance X—X, b is equal to one half of L. Therefore, the torque is $F \times L/2$, that is to say K/2. It is constant: The pump is of the self-regulating type.

Figs. 8, 9 and 10 show an example of construction of a pump made according to the invention.

In these drawings, reference numeral 1 designates the frame of the apparatus, and 2 the driving shaft which transmits movement to the rotary parts of the pump. Reference characters 3 and 4 designate the bearings of this shaft. A disc U is keyed on shaft 2. In this disc are provided two series of circular holes. The first series includes three holes 7, disposed at the same distance from the axis X—X of the shaft, the centers of these holes being at 120° from one another.

The second series includes three holes 10. These holes are located at the same distance from axis X—X as the holes 7 with their centers at 120° from each other, the center of each hole 10 being spaced 60° from the centers of the two adjacent holes 7.

Holes 7 serve to transmit the movement of rotation of driving shaft 2 to the cylinder block J, which is provided for this purpose with three fingers 5 provided with suitable bearings for contacting the walls of the holes, for instance ball bearings 6 as shown.

Likewise, holes 10 serve to transmit the movement of the driving shaft to the outer ring H, which is provided, for this purpose, with three fingers 8, carrying ball bearings 9.

Ring H is mounted in the frame of the pump through bearings 15 and 16 and it turns about an axis Y—Y which is fixed with respect to said frame and extends at a distance E from X—X.

The pistons are slidable in corresponding bores provided in the cylinder block J. Z—Z is the axis of rotation of the cylinder block, inside which is mounted the distributor P, the axis of which is Z—Z. This axis Z—Z is movable with respect to axes X—X and Y—Y but its distance from the axis X—X is constant, equal to E, while the distance from axis Y—Y varies.

In Fig. 8, the flow of the pump is zero since axes Z—Z and Y—Y coincide.

Distributor P is mounted concentrically in a sleeve L which turns in the frame 1 about the axis X—X. This sleeve is fitted with a handlever 17, by means of which it can be turned about axis X—X so as to move axis Z—Z toward or away from Y—Y. When these two last mentioned axes are brought nearer to each other, the stroke of the pistons and therefore the flow of the pump are reduced, and vice-versa. When the two axes Z—Z and Y—Y coincide, the flow is zero.

Distributor P is provided with four channels Q, two of which serve for the suction of the liquid which passes through passages 20 into the cylinders and thence, through passages 21, into the delivery channels.

As above described with reference to Fig. 6, the end of distributor P is provided, in its edge, with a groove S, which is engaged by a pin 19 mounted on the pump frame with its axis W—W so positioned as to restore the distributor to the desired position. The end portion R of the distributor is provided with two orifices 18—18, one for the inflow and the other for the outflow of the liquid.

The heads of the pistons are fitted with spindles 11 on which are mounted rollers, with the interposition of roller or ball bearings. The rollers run on the flat or plane surfaces of the inner wall of ring H. In order to prevent the spindles 11 from pivoting about the axis of pistons F, I provide cylindrical pins 13 engaged in slots 14 formed in suitable projections of the cylinder block.

In the embodiment of Fig. 11, the rollers, instead of being carried by the pistons, are carried by ring H. Each piston, such as F, is intended to cooperate with two rollers *Ia*, *Ib* bearing against an enlarged flat head 25 of said piston.

These two rollers *Ia*, *Ib* are so disposed that their common tangent is perpendicular to the axis of piston F and thus they are both applied against the surface of head 25, along which they run. In this case also the friction due to oblique stresses is greatly reduced.

Apparatus according to the invention can advantageously be used for many purposes and especially, as above described, as pumps.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of the present invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the spirit of the present invention as comprehended within the scope of the appended claims.

What I claim is:

1. An apparatus of the type described which comprises, in combination, a frame, two parts rotatable in said frame about two distinct parallel axes, respectively, radially slidable members in one of said parts, the other part including a surface adapted to cooperate with said members for controlling the sliding movement thereof in said first mentioned part, means, independent and exclusive of said slidable members, for rotating both of said parts at the same speed about their respective axes, at least one of said parts being so mounted in said frame that its axis can be displaced along a circular arc about a fixed axis parallel to the two first mentioned axes, so as to permit of varying the distance between the two first mentioned axes.

2. An apparatus of the type described which comprises, in combination, a frame, two parts rotatable in said frame about two distinct parallel axes, respectively, radially slidable members in one of said parts, the other part including a surface adapted to cooperate with said members for controlling the sliding movement thereof in said first mentioned part, means for movably supporting at least one of said parts in said frame so that its axis can be displaced along a circular arc about a fixed axis parallel to the two first mentioned axes so as to vary the distance of the two first mentioned axes to each other, a shaft journalled in said frame on said third mentioned axis, and independent transmission means between said shaft and each of said parts respectively, the transmission means between said shaft and the part having its axis movable in said frame being such that a displacement of said axis in said frame produces a mere translatory displacement of said part, the two transmission means being adapted to produce a rotation of both of the parts exactly at the same speed.

3. An apparatus of the type described which comprises, in combination, a frame, two parts rotatable in said frame about two distinct parallel axes, respectively, a number of members radially slidable in one of said parts, the other part including a polygonal surface the sides of which are perpendicular to said members, respectively, and in contact therewith, for controlling the sliding movement of said members in said first mentioned part, and means, independent of said slidable members, for rotating both of said parts at the same speed about their respective axes.

4. An apparatus of the type described which comprises, in combination, a frame, an inner cylinder block and an outer ring rotatable in said frame about two distinct parallel axes, respectively, radial pistons slidable in said cylinder block, the outer ring having an inner polygonal

wall the sides of which are perpendicular to the piston axes, respectively, rollers, carried by the outer ends of said pistons adapted to bear on said sides of the polygonal wall of the outer ring, and means, independent of said pistons, for rotating both said cylinder block and said outer ring, at the same speed about their respective axes.

5. An apparatus according to claim 3 in which at least one of said two parts is movably supported in said frame so that its axis can be displaced along a circular arc about a fixed third axis parallel to the two first mentioned axes so as to vary the distance between them, the means for rotating said last mentioned part being such that a displacement of said first mentioned axis in said frame produces a mere translatory displacement of the corresponding part.

6. An apparatus according to claim 4 in which at least one of the two parts, to wit, the cylinder block and the outer ring, is movably supported in said frame so that its axis can be displaced along a circular arc about a fixed third axis parallel to the two first mentioned axes so as to vary the distance between them, the means for rotating said part being such that a displacement of its axis in said frame produces a mere translatory displacement of said part.

7. An apparatus of the type described which comprises, in combination, a frame, two parts rotatable in said frame about two distinct parallel axes, respectively, radially slidable members in one of said parts, the other part including a surface adapted to cooperate with said members for controlling the sliding movement thereof in said first mentioned part, means for movably supporting said first mentioned part in said frame so that its axis can be displaced along a circular arc about a fixed third axis parallel to the two first mentioned axes, so as to permit of varying the distance between said two first mentioned axes, means for rotating both of said parts exactly at the same speed about their respective axes, a distributor in said first mentioned part coaxial therewith, and mechanical means interposed between said frame and said distributor for keeping the plane of symmetry of the distributor in coincidence with the plane passing through the two first mentioned axes.

8. An apparatus according to claim 7 further including means for moving the axis of said distributor about the third mentioned axis.

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