Feb. 14, 1933.

G. E. T. EYSTON

1,897,190

ROTARY PUMP MACHINE

Filed April 21, 1931

6 Sheets-Sheet 1

Fig. 1

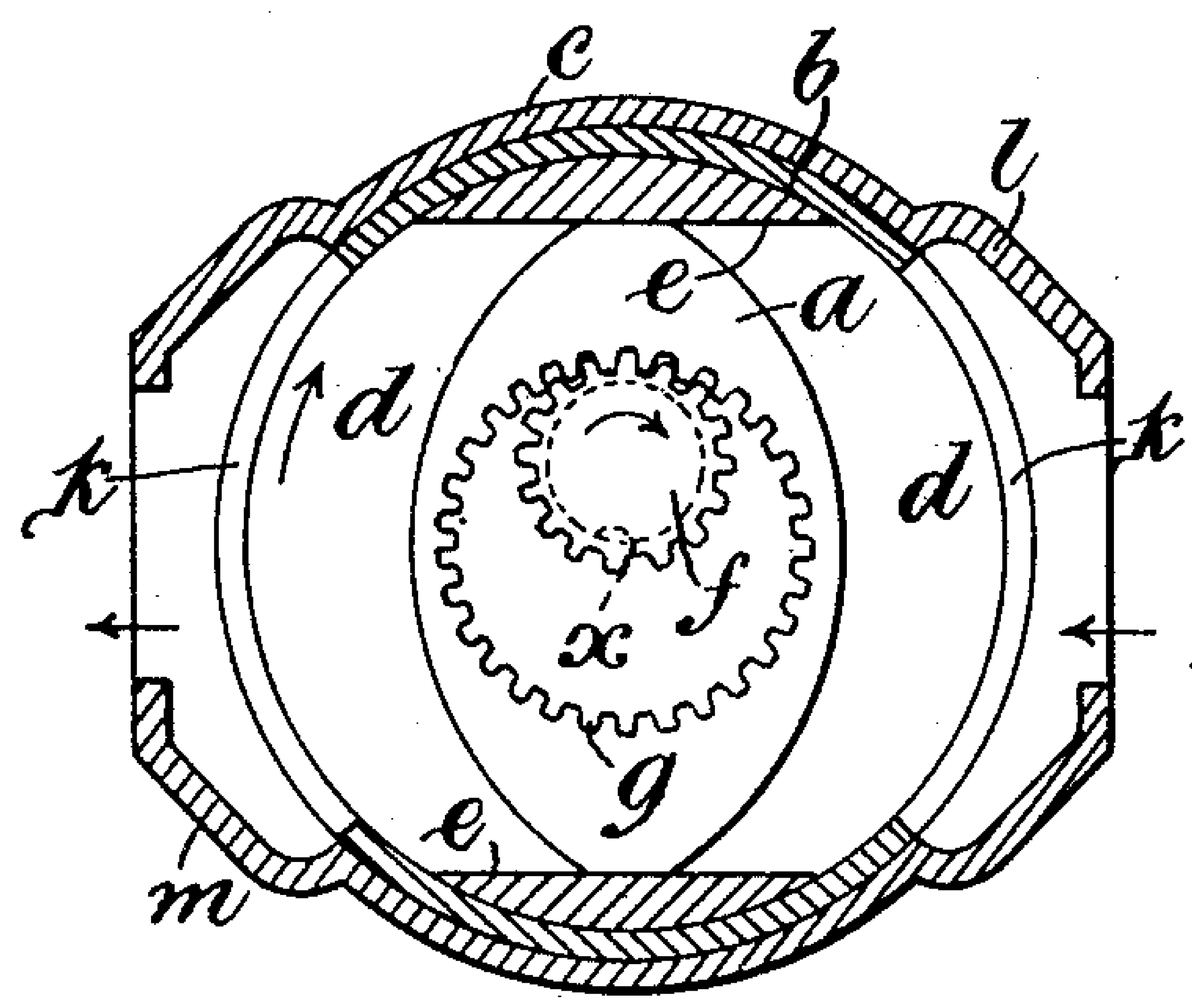


Fig. 2.

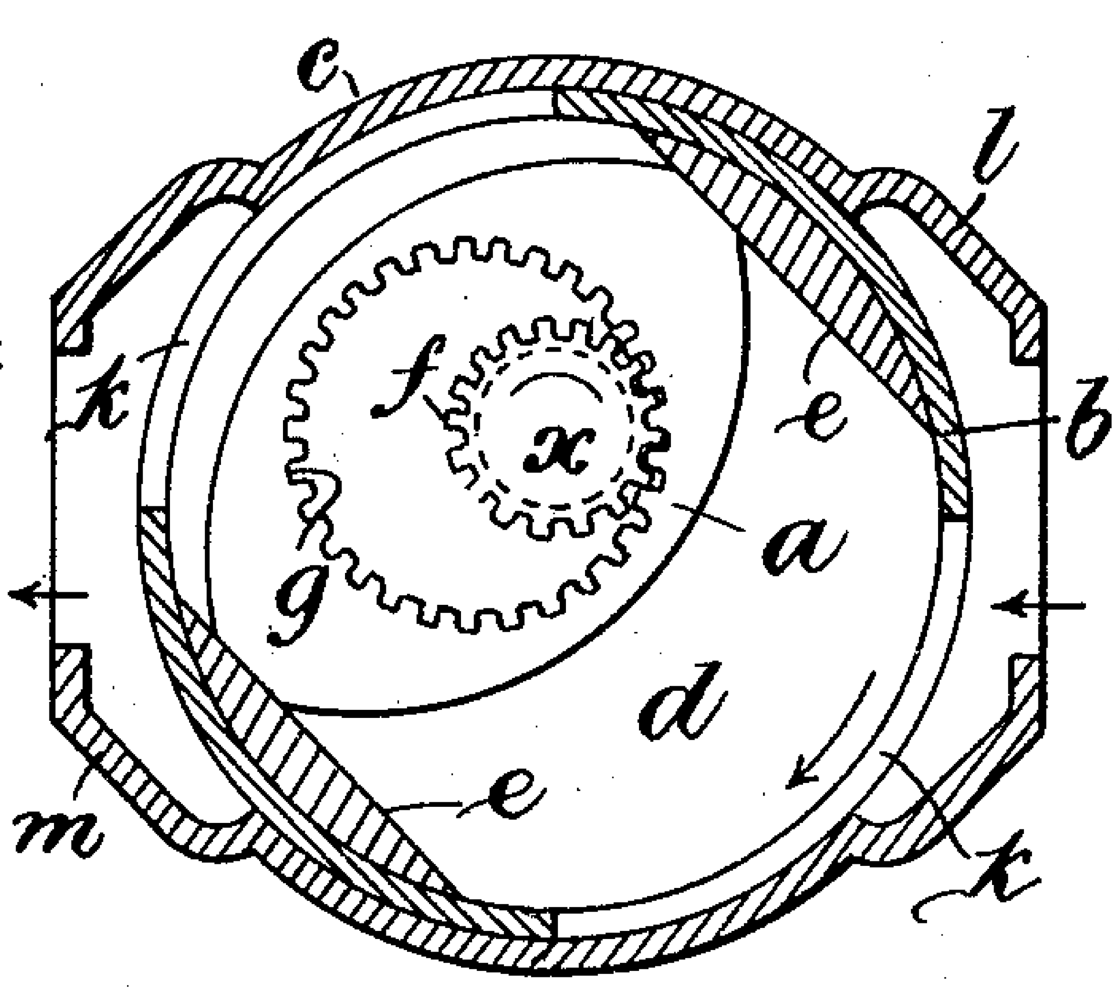
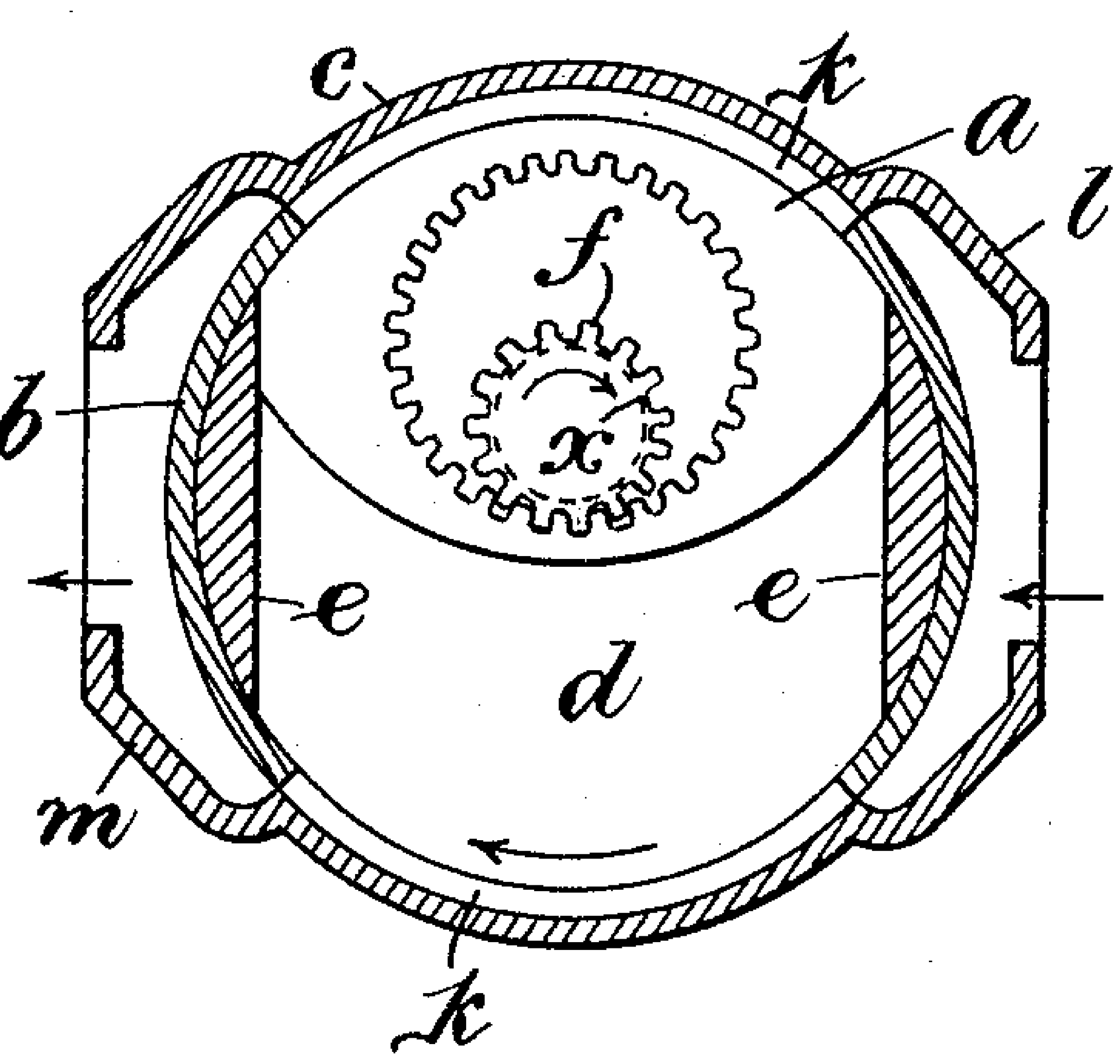


Fig. 3.



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ROTARY PUMP MACHINE

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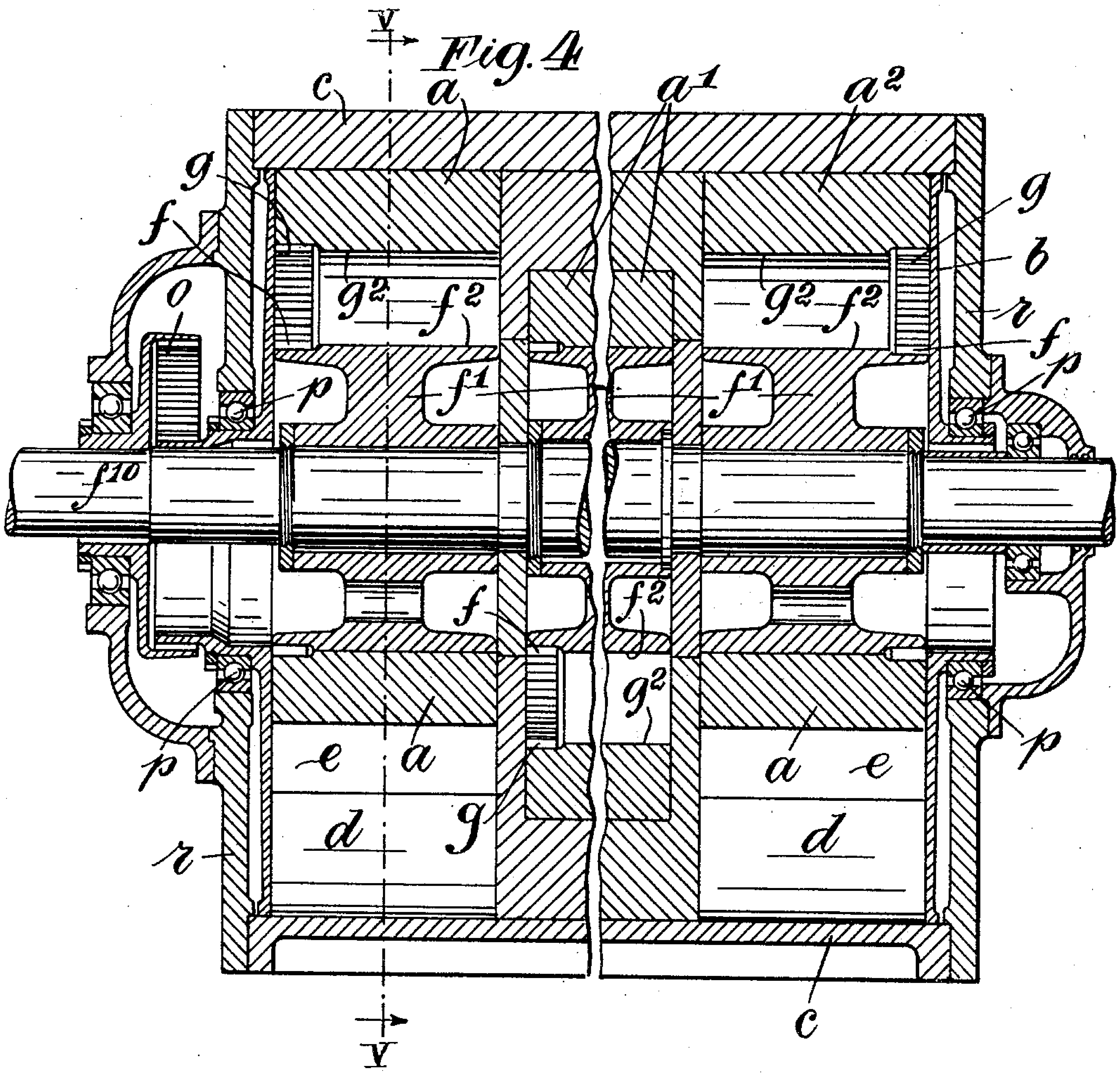

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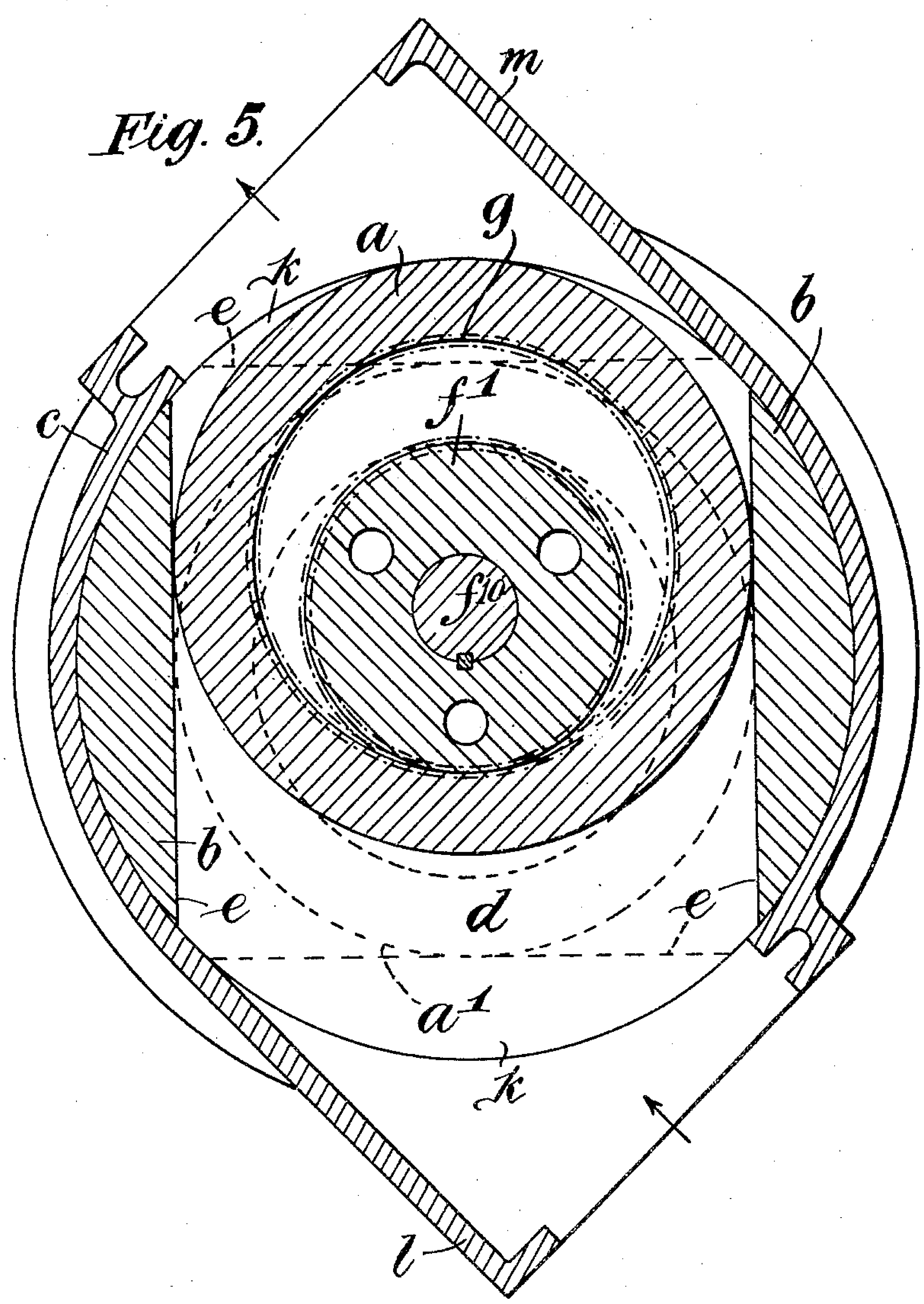
Fig. 5.



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ROTARY PUMP MACHINE

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Fig. 6.

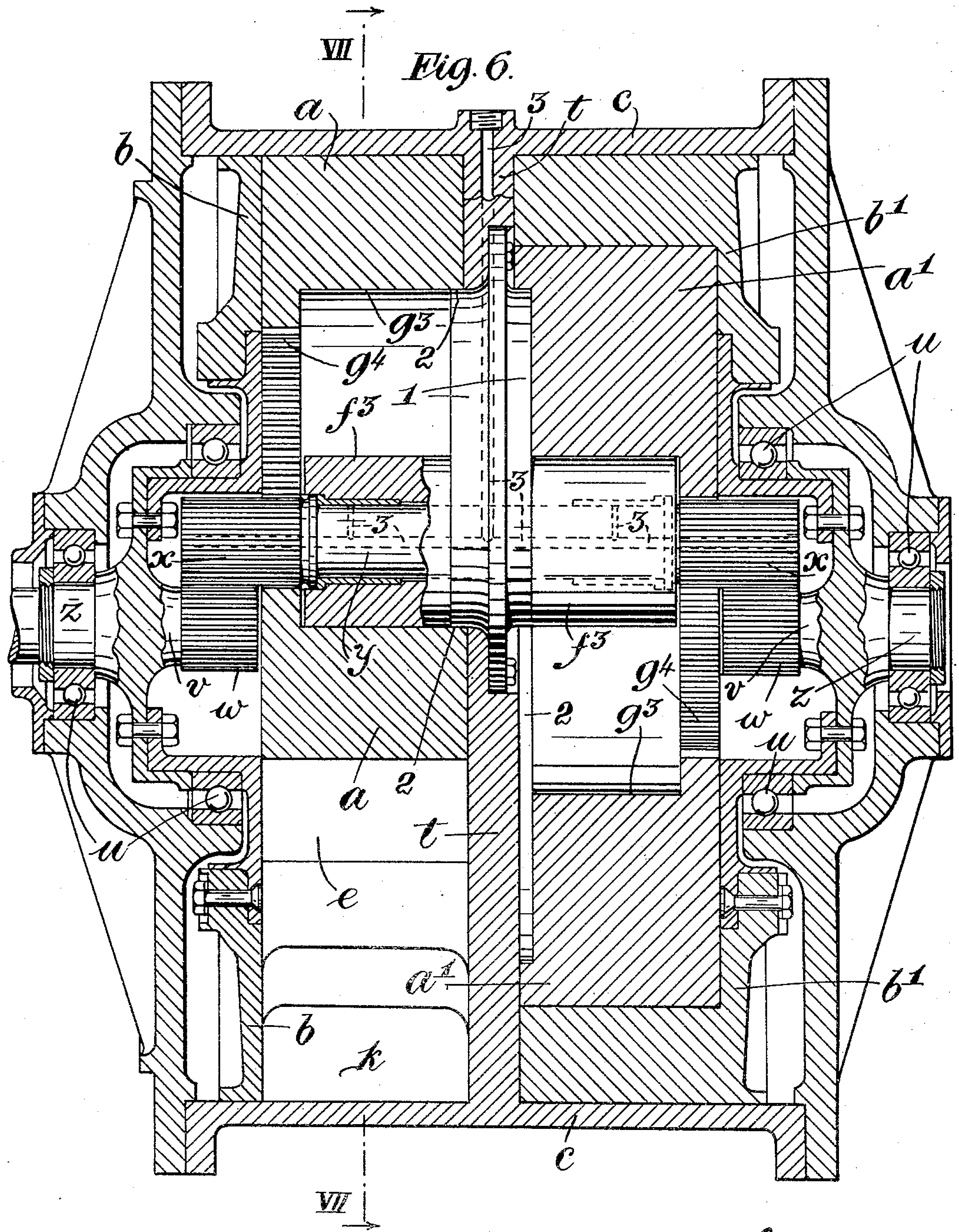

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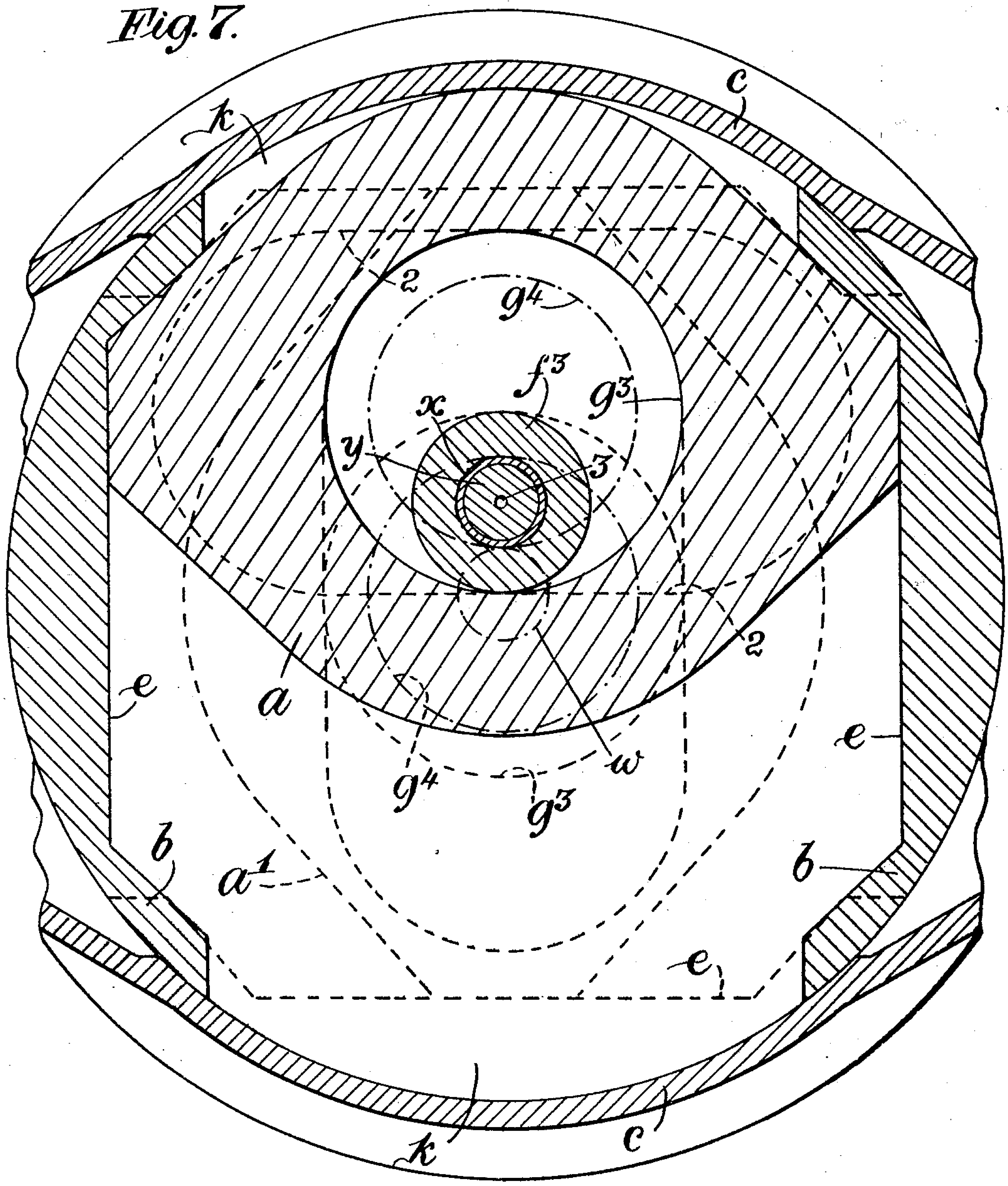
Fig. 7.



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ROTARY PUMP MACHINE

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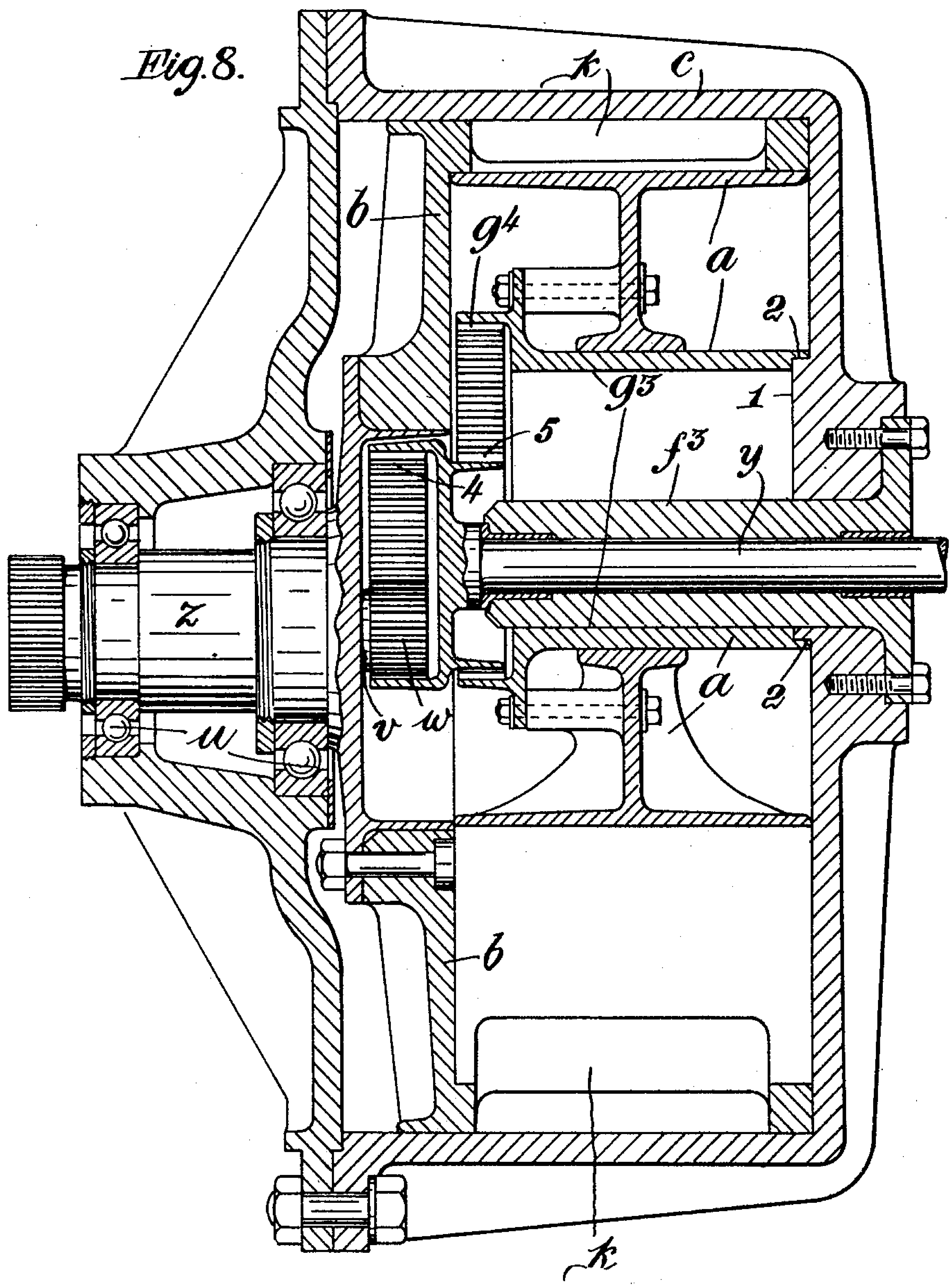
Fig. 8.



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UNITED STATES PATENT OFFICE

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ROTARY PUMP MACHINE

Application filed April 21, 1931, Serial No. 531,763, and in Great Britain April 22, 1930.

This invention comprises improvements in and connected with rotary pump and like machines of the kind comprising a piston body mounted within an outer rotary cylinder or working chamber and adapted, while revolving with the latter, to partake of a reciprocatory motion back and forth across the space of the cylinder or in the working chamber.

The object of the invention is to obtain more efficient control of the working parts in machines of this nature and particularly to obtain improved drive and to take up centrifugal effects on the piston with minimum of friction so that the piston parts may be of robust construction.

According to this invention, the piston body is placed under control of parts having rolling contact engagement with each other, the piston rolling bodily with one of these parts, and drive of the piston is effected by rotating one of the rolling contact parts about its own axis. The rolling contact parts may comprise a circular gear surface which is mounted rotatably in the machine and a centric circular gear surface on the piston, the diameters of these surfaces being so related that on rotating the first one it may, by engagement with the circular gear surface of the piston, positively reciprocate the latter in the outer cylinder or working chamber. If desired, both the piston and the outer rotary cylinder or working chamber may have drive applied to them so that reactionary pressure between the piston and the sides of the working or pumping space is reduced or eliminated. In this way improved operation of the machine is obtained and smoother working of the piston ensues, greatly reducing friction.

For the purpose of enabling the invention to be readily understood, reference is directed to the accompanying drawings in which:

Figures 1, 2 and 3 are cross-sections of a rotary pump machine construction according to these improvements, with the piston and cylinder shown in successive rotatory positions.

Figure 4 is a longitudinal section of a modified construction.

Figure 5 is a cross-section on the line V—V of Figure 4.

Figure 6 is a longitudinal section illustrating another modification.

Figure 7 is a cross-section on the line VII—VII of Figure 6, and

Figure 8 shows another modification in longitudinal section.

The machines illustrated in the drawings are of the same general nature as those described in the specification accompanying my patent application Serial No. 463,113, filed June 23, 1930, in that they comprise a rolling contact form of control for the reciprocatory piston.

In Figures 1 to 3, *c* is the outer casing of the machine, *b* a revoluble cylinder or drum mounted to revolve in the outer casing, and *d* the pumping space or working chamber of the machine formed in the cylinder *b*. The working chamber is bounded on two sides by flats *e* for travel of a piston *a* to and fro and *k* are ports at the ends of the chamber, which co-operate with fluid-inlet and delivery connections *l*, *m* of the outer casing. The flats or the piston tips may be fitted with spring pressed packing pads or strips to maintain a seal. The rolling contact control of the piston is effected by the circular gear *f* mounted eccentrically in the casing *c* and an internal gear surface *g* on the piston, and as the machine rotates the surface *g* rolls cycloidally with the piston round the gear *f* in a manner similar to that described and illustrated in the specification of my said patent application. In the drawings of such patent application, the member *f* was shown normally stationary but according to the present case, in Figures 1 to 3, this member *f* is mounted rotatably in the casing *c* and is formed as a toothed gear adapted to be rotated about its own centre. Thus, in revolving, the gear *f* is adapted to reciprocate the piston through the internal gear *g* and the piston in turn may rotate the cylinder *b* owing to its engagement with the flats *e*. The surfaces *f* and *g* may be geared together by toothed formations or otherwise to produce the drive and whether the teeth extend along the whole length or only part of the length of these parts, it will be clear that there will be a cycloidal roll of the surface g about the surface f as is shown by the progressive position of these parts in Figures 1 to 3; the dot-and-dash pitch lines indicate toothed surfaces f and g in Figures 2 and 3. In the operation of the machine, at higher speeds the centrifugal force is operative on the piston to maintain its reciprocatory movements under control of the co-acting surfaces f, g, and any tendency of the piston to slip and fall out of position when the machine comes to rest or at starting, may be prevented in suitable manner, as by the provision shown in Figures 6 and 7, wherein the parts 1, 2, effectively prevent slip and fall of the piston and also eliminate possibility of dead-centre stoppages.

In order to obtain the rolling contact effect in Figures 1 to 3 it is essential to have appropriate relation between the diameters of the gears f and g. If the relative diameters of the gears g and f were of the value 2:1, the gear f would have to be stationary in order to obtain the rolling contact relation between these parts and the machine would have to be driven by rotating the drum b or the piston (of my patent application aforesaid). In Figures 1 to 3, therefore, wherein drive of the piston is to be effected by rotating the gear f, the diameter ratio must be greater or less than 2:1. The diameter of the gear is therefore made larger or smaller than half the diameter of the internal gear g. It is shown larger in the drawings and by rotating the gear f, rolling contact engagement between the same and the gear g can be achieved with effective operation of the piston and rotation of the cylinder b, the centre of the piston moving round the dotted circle x of which the radius is equal to the eccentricity of the gear f with respect to the central axis of the machine. There is a relation between the speeds of the gear f and the cylinder b as follows:—If r be the radius of the pitch circle of the teeth of the gear f and r' the radius of the dotted circle x, then the ratio of the speed of such gear to the speed of the cylinder b equals

$$\frac{r-r'}{r}$$

if r is greater than r' and

$$\frac{r'-r}{r}$$

if r is less than r'. The radius of the pitch circle of the internal gear g is equal to the sum of r and r'. It is to be noted that there is, of course, a rotary movement together of the gears f, g, but there is no slip so that the relative movement between them is purely a rolling contact engagement. The radii of the gears f, g would, of course, be selected to suit the particular speed ratio desired but it will be obvious from the above formulæ that if r is made greater than r', the speed of revolution of the gear g and thus of the cylinder will be greater than the speed of the gear f. If r be less than r', rolling contact will be maintained with the gear f rotating in the opposite direction to the cylinder b and gear g, the speeds being equal to each other or a fraction or a multiple one of the other depending on the relative values of r and r'.

By way of example, assume that the valve r' be equal to 1″ and the angular speed of the cylinder be required to be 1000 revolutions per minute, then example of pitch radii and corresponding speeds for the gear f have the values:—

Radius (r) of gear in inches	Angular speed of gear in R. P. M.
1.01	9.9
1.1	90.9
2	500
5	800
10	900
100	990
	Reverse rotation
0.9	111
0.75	333
0.66	500
0.5	1000
0.4	1500
0.3	2333
0.1	9000

If r equalled r' the speed of the gear f would be 0, thus demonstrating that the aforesaid 2:1 diameter ratio between the gear g and the gear f requires the latter to be stationary as described. For forward rotation of the gear f equal speeds of the cylinder and gear can only correspond with an infinity value for r but with reverse rotation of the gear f, equal speeds are obtained with r equal to $\frac{r'}{2}$. For lower values of r the speed increases indefinitely.

Theoretically, the diameter ratio between the gear g and the gear f may be any value greater or less than 2:1 but in practice, considerations of mechanical efficiency of the drive and lubrication would make the ratio of speeds between the gears best when of the order of approximately 10:1.

In Figures 4 and 5, the construction is of similar nature but there is a plurality of pistons a, a', a^2 which are cylindrical and the cylinder b also is driven by gearing o from the shaft f^{10} of the several gears f of the respective pistons. In some cases a cylindrical piston structure is advantageous because it is easy to construct and an independent drive of the cylinder is of much advantage, because it relieves the piston of reactionary pressure at the flats e and thus reduces friction. It is seen in Figures 4 and 5 that the gears f are formed on members f' keyed on the shaft f^{10}, but this is only to facilitate assembly because three pistons a, a', a^2 are used. If there were a smaller number of pistons, the gears f could be formed on the shaft f^{10}. The machine is shown in Figures 4 and 5 with the three pistons a, a', a^2 spaced apart angularly for balancing purposes. The middle piston a' would be made twice as long as each of the others a, a^2 so as to be heavy enough to balance the latter. The working chambers such as d for all the pistons are provided in the same cylinder b which is mounted in ball bearings p in the end covers r. The pistons, as before, have a rolling contact control, Figures 4 and 5 show, however, that the gears f, g, need only extend for part of the length of the parts f and a, a', a^2, so that the rolling contact engagement is partly over toothed surfaces, and partly over plain surfaces marked f^2, g^2. These plain surfaces f^2, g^2 would be equal in diameter to the pitch circles of the gears f, g and thus they enable the centrifugal pressure to be taken by the shaft f^{10} to the relief of the teeth of the gears. Floating crescent-shaped bushes or rollers may be inserted in the crescent space between the plain surfaces f^2, g^2 in the manner described in my patent application aforesaid, so as to eliminate slip should this tend to occur at low speeds, thereby relieving the teeth of lateral stresses. The teeth of the gears f, g and the gearing o may be constructed so that they do not come out of mesh in the event of the machine being used in the vertical position or when stationary under the action of gravity. There might, of course, be separate revoluble cylinders for each of the pistons in Figures 4 and 5 and separate gearings like the gearing o be provided for driving each of these cylinders. This separate cylinder idea may also be used in other constructions comprising a plurality of pistons and the separate cylinders would be freely mounted in cases where no direct drive by gearing such as o were used.

According to Figures 6 and 7 piston control is effected by rolling contact engagement of a surface on the piston with a stationary surface in the casing and piston drive is effected from the corresponding rotary cylinder. There are two pistons a, a' side by side and two rotary cylinders b, b' and the working chambers are separated by a central transverse partition t in the outer casing c. The pistons are lenticular but may be of other forms, and each has a plane circular surface g^3 adapted to have rolling contact engagement with the circular surface of an internal stub f^3 fixed to the partition t of the casing, the diameter ratios of the two surfaces being 2:1 respectively. The rotary cylinders b, b' are mounted by shaft parts z in spaced anti-friction bearings u in the end covers of the casing and have internally projecting axial parts v with gears w, adapted to engage with gears x of the same diameter on the ends of a gear shaft y extending centrally through the cam parts f^3 of the two pistons. Drive is applied to the shaft z of one of the rotary cylinders b, b' and this effects drive of the other through the gear shaft y, but separate drive may be applied to each side of the machine if desired. The pistons have gear surfaces g^4 at the outer ends and these mesh with the external gears x on the gear shaft y, the gear ratio being, say 3:1. In this machine, the gears x on the shaft y are of less diameter than (e. g. half the diameter of) the stubs f^3 so that the pistons a, a' revolve in reverse direction to such gears. The latter, however, are geared to the rotary cylinders through the gears w so that actually the latter and the pistons revolve in the same direction. The gear surfaces g^4 roll cycloidally round the gears x in a similar manner to which the surfaces g^3 roll round the stubs f^3 as will be readily understood but, at the same time, the gears w, x effect positive drive of the pistons. In order to prevent the pistons from slipping and from dropping under the action of gravity when the machine is stationary, the central partition is fitted with eccentric parts 1 engaged with parallel surfaces 2 of the pistons. Lubrication of the gears and appurtenant rotary parts is effected in simple manner by ducts 3 in the central partition t and the gear shaft y.

The modification shown by Figure 8 comprises a single cylinder b and built-up piston a of cylindrical or lenticular form, but instead of external gears for driving the gear shaft y as in Figures 6 and 7 the external gear w on the axial projection v of the rotary cylinder meshes with a double gear on the gear shaft y, one side of this double gear being internally toothed as at 4 to engage the gear w and the other side being externally toothed as at 5 to engage the internal gear g^4 of the piston. The stub f^3 is fixed in one end cover of the machine and the cylinder b is mounted by a shaft z in spaced anti-friction bearings u in the other end cover, and the first mentioned end cover has an eccentric part 1 engaging parallel surfaces 2 of the piston as before to prevent the latter from slipping and from falling out of position when the machine comes to rest. The cylinder gear w drives the double gear forwardly in this case and therefore the external gear part 5 of the double gear is made greater in diameter than the stub f^3. Means other than the eccentric part 1 on the end cover or partition of the casing may be adopted in this and the other modifications for preventing fall of the piston or pistons when stationary, such as a floating crescent-shaped bush or roller as described in connection with Figures 4 and 5.

I claim:—

1. Rotary pump or like machine comprising an outer casing, a rotary working chamber in said casing, a piston operative in said working chamber, a circular surface on the piston and a circular surface mounted eccentrically in said casing, said surfaces being adapted to have rolling contact engagement with each other to control movement of the piston in said working chamber, an axial drive shaft for said rotary working chamber and a gear drive between said shaft and said piston.

2. Rotary pump or like machine comprising an outer casing, a rotary cylinder, mounted in said casing and formed with a transverse working chamber, a piston operative in said working chamber, an internally circular surface on the piston and a cooperative externally circular surface mounted eccentrically and stationarily in said casing, said surfaces being adapted to have rolling contact engagement with each other to control movement of said piston in said working chamber, a drive shaft fixed to said cylinder, a gear shaft mounted co-axially with said externally circular surface, a gear drive between said shafts and an internal gear drive between the gear shaft and said piston.

3. A rotary pump or like machine comprising a revoluble working chamber, a piston adapted to reciprocate in and revolve with said chamber, a curved gear surface disposed on and non-rotatably fixed with respect to said piston, a companion curved gear surface disposed in the machine and engaged in continuous cycloidally rolling fashion by said gear surface of said piston as the latter revolves with said working chamber, and means for imparting rotation to said piston through said gear surfaces.

4. A rotary pump or like machine comprising a revoluble working chamber, a piston adapted to reciprocate in and revolve with said chamber, a circular gear surface disposed on and non-rotatably fixed with respect to said piston, a second circular gear surface disposed revolubly in the machine and engaged in continuous cycloidally rolling fashion by said gear surface of said piston as the latter revolves with said working chamber, and means for rotating said second circular gear surface to effect rotation of said piston.

5. A rotary pump or like machine comprising a revoluble working chamber, a piston adapted to reciprocate in and revolve with said chamber, an internally circular gear surface disposed on and non-rotatably fixed with respect to said piston, an externally circular gear surface mounted in the machine and engaged in continuous cycloidally rolling fashion by said internally circular gear surface of the piston as the latter revolves with said working chamber, and means for rotating said externally circular gear surface to effect rotation of said piston.

6. A rotary pump or like machine comprising a revoluble working chamber, a piston adapted to reciprocate in said chamber as the latter revolves, a plain circular surface and a toothed circular surface disposed on and non-rotatably fixed with respect to said piston, a plain circular surface and a toothed circular surface disposed in the casing of the machine, and engaged in cycloidally rolling fashion with the first-mentioned surfaces as the piston revolves with said working chamber, and means for imparting rotation to said piston through said toothed surfaces.

7. A rotary pump or like machine in accordance with claim 6, in which the plain circular surface in the casing of the machine is a non-rotatably fixed surface.

8. A rotary pump or like machine comprising a revoluble working chamber, a piston adapted to reciprocate in and revolve with said chamber, a circular gear surface disposed on and non-rotatably fixed with respect to said piston, a companion circular gear surface disposed eccentrically in the machine and engaged in continuous cycloidally rolling fashion by said circular gear surface of said piston as the latter revolves with said working chamber, means for imparting rotation to said piston and working chamber through said gear surfaces and additional means for driving said revoluble working chamber.

9. A rotary pump or like machine comprising an outer casing, a cylinder, with a transverse working space, mounted to revolve in said casing, a piston mounted to reciprocate in said space from side to side of said cylinder, an internal gear surface of circular contour formed centrically within and non-rotatably fixed with respect to said piston, a revoluble circular gear surface disposed eccentrically in said casing and engaged in continuous cycloidally rolling contact by said circular gear surface of said piston as the latter revolves with said cylinder and means for imparting rotation to said piston through said gear surfaces.

10. A rotary pump or like machine comprising a revoluble working chamber, a piston adapted to reciprocate in and revolve with said chamber, a curved gear surface disposed on and fixed with respect to said piston, a companion curved gear surface disposed in the machine and engaged in continuous cycloidally rolling contact by said curved gear surface of said piston as the latter revolves with said working chamber, means for imparting rotation to said piston through said gear surfaces and means operative to prevent said piston from falling and thereby prevent possible dead-centre stoppages at slow speeds or at starting.

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