Jan. 9, 1945. R. STEVENSON 2,367,068

ROTARY PUMP

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Fig. 1.

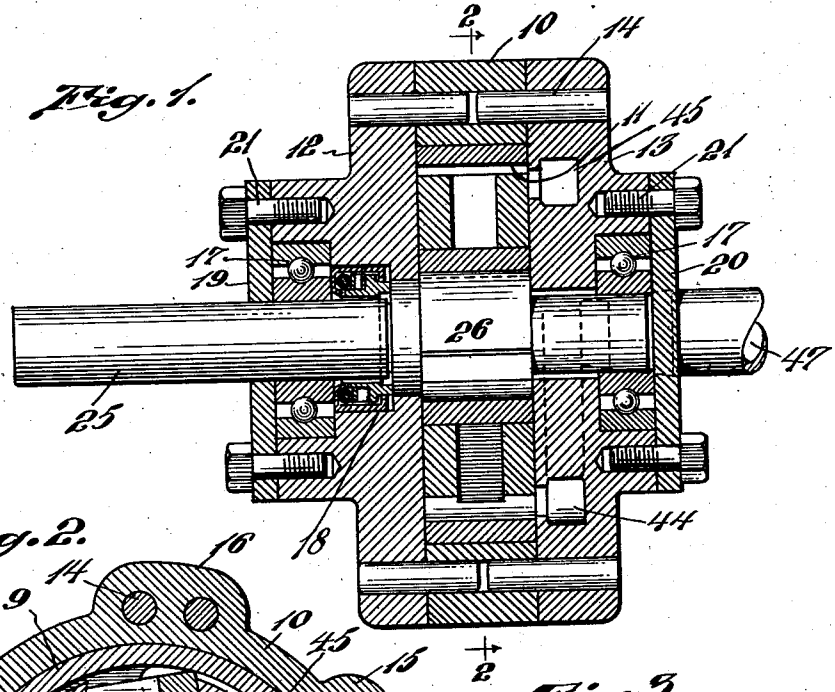


Fig. 2.

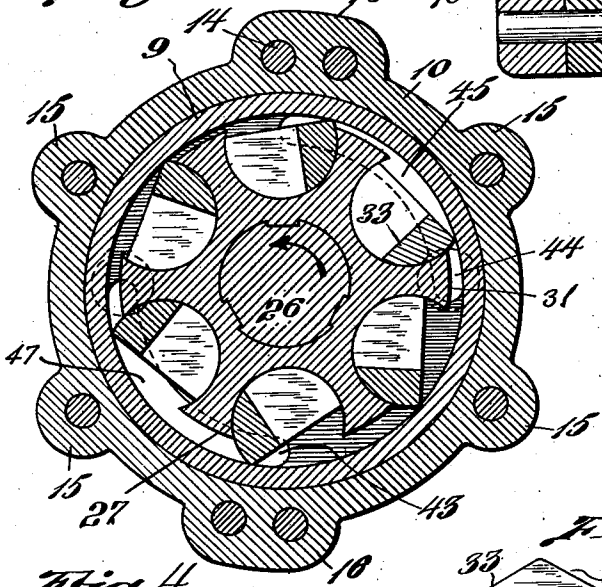


Fig. 3.

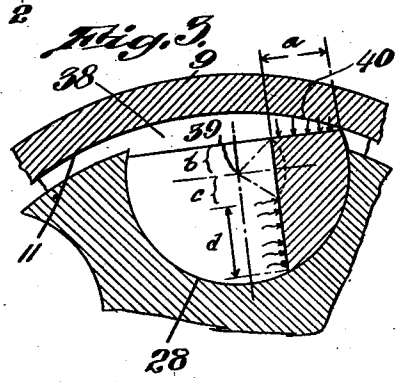


Fig. 4.

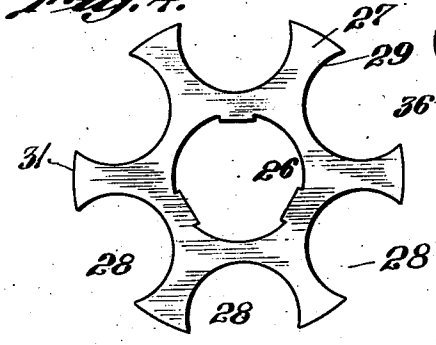
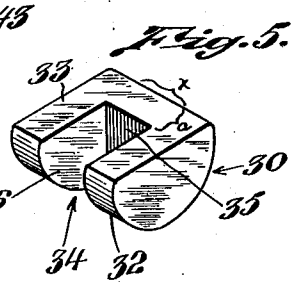


Fig. 5.



INVENTOR
Robert Stevenson
BY Barlow & Barlow
ATTORNEYS

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Fig. 6.

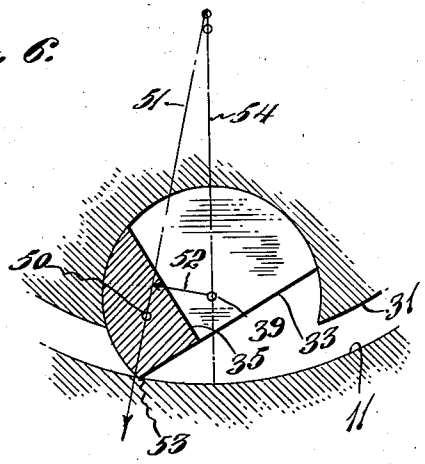


Fig. 7.

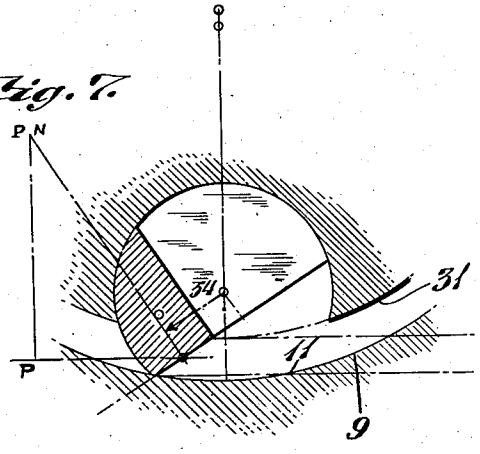


Fig. 8.

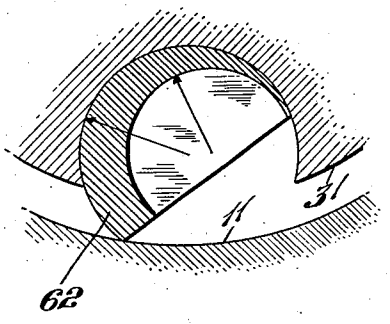
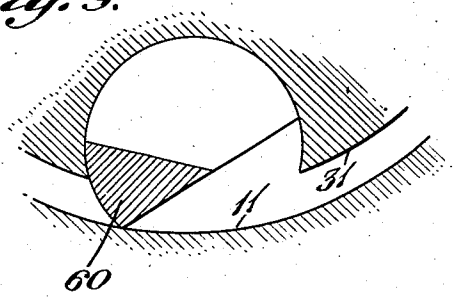


Fig. 9.



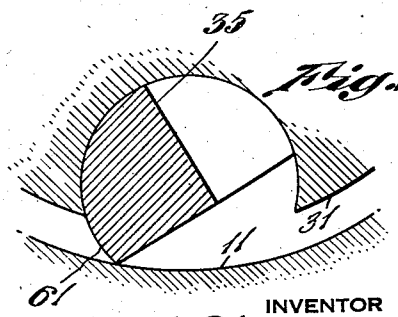


Fig. 10.

INVENTOR
Robert Stevenson
BY Barlow & Barlow
ATTORNEYS

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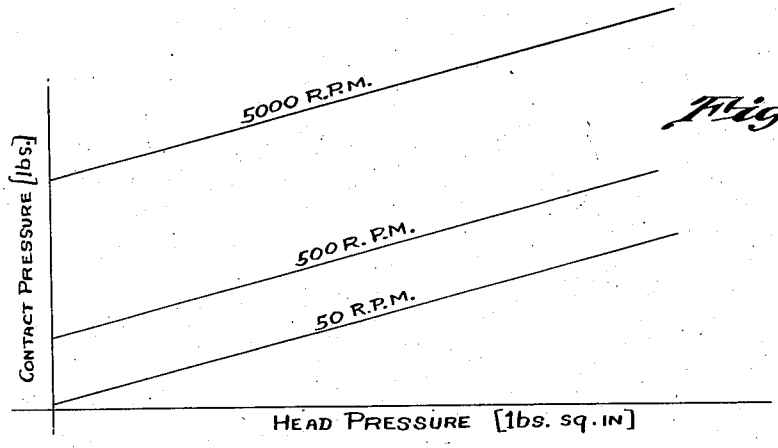


Fig. 11.

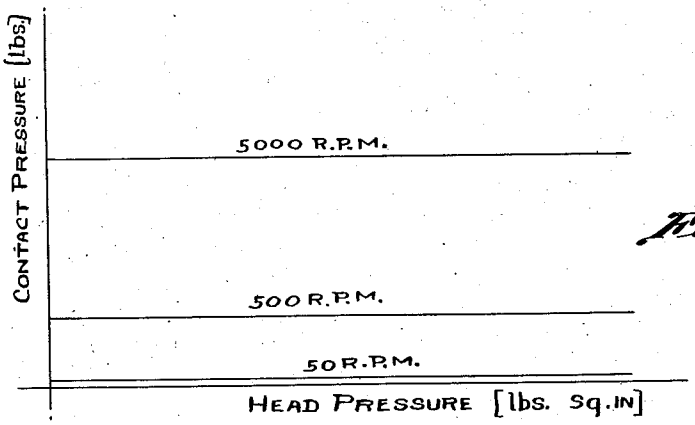


Fig. 12.

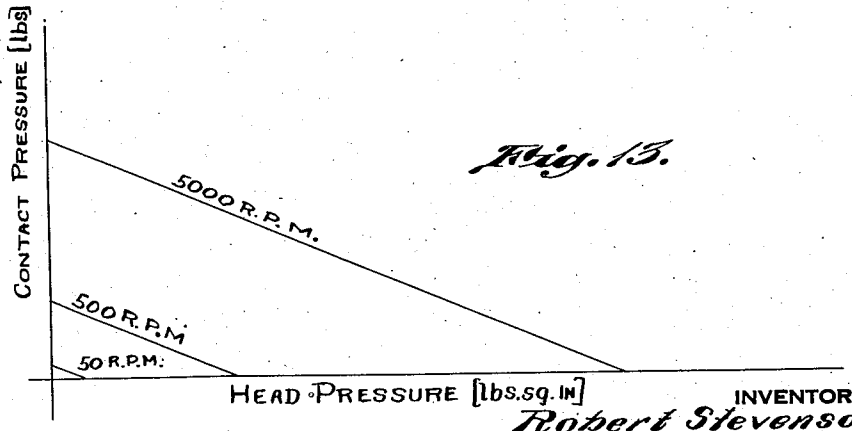


Fig. 13.

INVENTOR
Robert Stevenson
BY Barlow & Barlow
ATTORNEYS

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UNITED STATES PATENT OFFICE

2,367,068

ROTARY PUMP

Robert Stevenson, Providence, R. I., assignor to Stevenson Engineering Corporation, a corporation of Rhode Island

Application July 4, 1942, Serial No. 449,740

4 Claims. (Cl. 103—140)

This invention relates to a rotary pump of the type in which the rotor is rotatably mounted relative to a cylindrical casing and there are vane members in the rotor which are moved into and out of the rotor for engagement with the casing during the rotation of the rotor in the casing.

In the use of rotary pumps of this character some difficulty has been encountered in controlling the vane members because of the pressure which has been developed in the pump. If springs or other mechanical action is depended upon for operating the members, faults are liable to occur.

One of the objects of this invention is to provide a vane in the rotor which will be controlled entirely by the forces developed in the pump during operation and thus an elimination of the use of springs, gears or other mechanically-acting parts.

Another object of this invention is to provide a construction whereby the shaping of the vane to provide surface areas may be so arranged that the forces tending to move the vanes may be selected to obtain the desired function.

Another object of the invention is to provide an arrangement whereby the amount of pressure that may be developed will be limited only by the strength of materials used.

Another object of the invention is to provide a pump which at a certain predetermined revolutions per minute will maintain a constant head or pressure on the discharge side of the pump by reason of the vanes of the rotor automatically opening to such extent as is necessary to allow slip of some of the fluid being pumped past the vanes.

Another object of the invention is to provide a pump in which no relief valve or bypass is needed by reason of the action of the rotor vanes serving to accomplish the function that the relief valve or bypass ordinarily accomplishes.

With these and other objects in view, the invention consists of certain novel features of construction, as will be more fully described and particularly pointed out in the appended claims.

In the accompanying drawings:

Fig. 1 is a central sectional view through the pump.

Fig. 2 is a sectional view taken at substantially right angles to Fig. 1 and on line 2—2 of Fig. 1.

Fig. 3 is a fragmental sectional view on an enlarged scale, showing one of the vane members, a part of the rotor, and a part of the casing.

Fig. 4 is an end view of the rotor alone.

Fig. 5 is a perspective view of the vane member alone.

Figs. 6 and 7 are fragmental sectional views with diagrammatic illustration of certain forces which act on the vane.

Figs. 8, 9 and 10 are fragmental sectional views of modified forms of vane members.

Figs. 11, 12 and 13 are graphs showing different relationships which may be had.

In proceeding with this invention I provide a casing and a rotary member within the casing with a series of vanes in the rotor which will move relative to the rotor and will force fluid from the intake port to the outlet port of the casing. There are several forces which I deal with in connection with the design of the vanes of the rotor. One of these forces that must be taken into consideration in the particular construction of the vanes which I provide, is the centrifugal force which is exerted on the vane by the rotation of the rotor in the casing. Thus the center of gravity of my vane member with reference to the point or center about which it may turn or rotate is one force with which I deal. Another force with which I deal is that of the resistance of the fluid being pumped to movement by the vane which might be called the inertia of the fluid being pumped and this force will exert a certain moment upon the vane tending to rotate it in a direction opposite to that direction resulting from the action of the centrifugal force. The area with which I calculate the center of effort of this force will be important upon the action of the vane. This force will also vary with the weight of the fluid being pumped. Another force with which I deal is that of the pressure developed in the casing during the series action of the vanes and is that pressure in that compartment of the casing to which the vane is exposed or subjected to the pressure of this fluid, and the particular shape of the vane which may cause an exposure of areas in one position or another position and the amount of these areas will affect the action of the vane.

From the forces at work in the operation of my pump as above indicated, it will be readily apparent that the first of these forces may be somewhat varied by the particular shape and location of the center of gravity or mass of the vane of the rotor, but that even after this is determined the speed of rotation of the rotor will provide a variable factor upon this force. The second force will vary according to the speed of rotation, the area of vane exposed, the space through which the fluid is moved and the weight of the fluid being pumped.

The third force may be very closely controlled

by the particular design or shaping of the vane and will not appreciably be a function of the revolutions per minute or speed of rotation of the rotor. Thus with the above guide in mind I may design a vane which at a certain number of revolutions per minute will pump a fluid of a known specific gravity or weight up to a certain head or pressure and at this point the vane will open and will cease to pump or build up pressure any further, the control of the vane being wholly by these pressures which are developed within the pump itself.

With reference to the drawings, the casing consists of a body part 10 of generally ring shape having a lining 9 with a cylindrical inner surface 11 while there are end sections 12 and 13 abutting the opposite ends of this body member 10 and held snugly thereagainst by suitable means such as screw bolts. Dowels 14 extend through bosses 15 and 16 to align the parts of the casing. The end sections 12 and 13 are provided with ball bearings 17, and section 12 is provided with a construction 18 similar to that shown in my copending application, Serial No. 388,015. These bearings are held in position by the cover members 19 and 20 secured by bolts 21 to the respective end sections 12 and 13. The bearings 17 and 17 are in an axial alignment with each other in each of the end sections 12 and 13 for the reception of a shaft designated generally 25 in these bearings. The bearings are mounted eccentrically with reference to the cylindrical surface 11 so that a positive movement of the vanes of the pump may be had.

The shaft 25 is enlarged as at 26, and has secured thereto a rotor member 27 so that this rotor member will be rotated by driving of the shaft. The rotor 27 is cylindrical in shape and is provided with a plurality of arcuate recesses 28 in its cylindrical surfaces, the surfaces each providing a good bearing support 29 for a vane member designated generally 30 and shown in perspective in Fig. 5 for freely rockably mounting the same in the recess 28. As shown in Fig. 2 the cylindrical outer surface 31 of the rotor will come closest to the inner cylindrical surface 11 of the casing lining 9 at the upper portion of Fig. 2, where the spacing of the rotor and the casing will be rather close, while at the lower portion of Fig. 2 the spacing of the surface of the rotor and the inner surface of the casing lining will be at the maximum distance.

The vane member 30 has a cylindrical surface 32 which is mutilated by being cut parallel to the axis of the cylinder at a point to one side of its center to present a side 33 in substantially a single plane. The member is slotted as at 34 at right angles to its axis presenting a surface 35 at right angles to this surface 33 at the end of the slot, while the side walls 36 of the slot are at right angles to the surfaces 33 and 35. This slotting or shaping of this vane member may be somewhat varied, so long as the shaping is such as to accomplish the relationships substantially as follows.

As the rotor rotates in the direction of the arrow shown in Fig. 2 on the center shaft 26, centrifugal force will be developed in each of the vanes and if this is to one side of the center 39 of the vane (see Fig. 3) there will be a tendency to turn the vane about the axis 39 which is the center of the socket or recess 28. In Fig. 6 I have illustrated a section through the center of the vane and it will be readily apparent that the center of gravity of the vane must be determined in order that calculations of the centrifugal force may be had. Inasmuch as the portion of this vane on either side of the slot is symmetrical with reference to a line through the center of the arc of the vane it will be quite readily apparent that by reason of the solid portion of the vane between these two side portions, or the part of the vane at the end of the slot will cause the center of gravity to be on that side of the axial line through the center. This will be located in the trailing side of the center of rotation of the vane with respect to the direction of rotation of the rotor. By usual and known mathematics in engineering practice the center of gravity may be determined, and I have illustrated in Fig. 6 at 50 such location, and I have drawn a line 51 from the center of the axis of rotation of the shaft 26 through this center of gravity, and have also drawn a line 52 representing the perpendicular distance from a radial line 51 to the center 39 of the vane. Therefore it will be apparent that there is a force acting along the line 51 with a moment proportional to the distance of the line 52 tending to rotate the vane to cause its edge 53 to contact the inner cylindrical surface 11 of the casing. This represents a centrifugal force and will vary with the speed of rotation of the rotor and with the position of the vane in its recess. It is a force tending to force contact of the edge 53 with the casing at all times. If the surface 35 is moved closer to the radial line 54 through the center in Fig. 6 there will be an increase in the mass and also the center of gravity will move closer toward the center line and the radius 52 will be decreased; the increase of the mass about counteracts the shortening of the radius 52, but for any given configuration or shaping of the blade calculation should be made that a determination of the exact effect may be had.

The inertia pressure will be that which the fluid exerts in opposition to the movement of the rotor and may be illustrated by Fig. 7. The surface of the vanes subjected to this pressure will be that which extends for the entire width of the rotor and that portion of the vane which extends into the space between the periphery 31 of the rotor and the inner surface 11 of the liner 9. This surface is a rectangle and the center of this rectangle will be that at which the force will be figured. The area and the weight of the fluid calculated at this point about the distance that this point is from the center 39 as shown at 54 will give the moment tending to move the blade away from having its edge in contact with the cylindrical surface 11 toward which the centrifugal force forces it. This pressure will vary with the weight of the fluid being pumped, the revolutions per minute and the distance of the periphery 31 from the surface 11 which varies because of the eccentricity of the rotor mounting.

A third force dealt with is that caused by the pressure of the fluid itself to which the vane is subjected. Referring particularly to Fig. 3, the area 38 between the rotor and its casing will contain fluid at some pressure namely the head of the pumped fluid. The fluid will engage the surface 33 and also the surface 35 and the pressure of the fluid will press upon each portion of the surface in an amount equal to the pressure of the fluid in this area. The pressure along some of these surfaces will tend to rotate the vane 30 about its center 39 (see Fig. 3) in one direction, while the pressure on other surfaces will tend to rotate this vane member about the center 39 in the op-

posite direction. For illustrative purposes I have broken up these surfaces into different sections in Figs. 3 and 5 so that the action of the fluid pressure may be more clearly appreciated. With reference to Fig. 5 the section of the surface 33 between the parallel lines designated "x" distance apart, and between the parallel lines bounded by the surface 35 and the edge of the vane, and denoted "a" distance in a section which will be effective as represented by the arrows 40 (Fig. 3) tending to force the vane member away from the surface 11. In this relationship the pressures on the surfaces 33 of the two portions of the vane on either side of the slot will be substantially in balance as the areas are symmetrical and are on either side of the center of the vane. Therefore, the area represented by the surface 33 at the end of the slot and represented by the dimensions "x" and "a" (Fig. 5) will be that which will be taken into account. The surface 35 may be broken up into sections, designated as shown in Fig. 3 as "b," "c," and "d." Area "b" of surface 35 extending from the top edge 33 downwardly to the line extending perpendicular from the center of rotation of the vane to surface 35 would be effective also to move the member 30 in the same direction as the area heretofore mentioned, or would supplement the force tending to move the vane 30 away from the surface 11. Area "c" which is the same in dimension as the area "b" being on the opposite side of the center 39 would tend to force the vane 30 toward the surface 11 while the area "d" which is the remaining area of the surface 35 would also tend to force the vane 30 toward the surface 11. Thus we have areas "a" plus "b" tending to force the vane in one direction while the areas "c" plus "d" are tending to force the vane in the opposite direction. The areas "b" and "c" being equal provide a balanced area and the area "d" being slightly larger than the area "a" would provide a greater unbalanced area than the extent of the remaining flat surface in the slotted area and thus a differential of pressure tending to force the vane 30 against the surface 11 and thus hold them in engagement. It will of course be apparent that if I move the line or surface 35 nearer or on the other side of the center of rotation 39 there will be a change in the relative areas "a," and "b," "c" and "d" and a different differential of these pressures will result.

In order to learn the true behavior that may be expected of the vanes I must add those forces tending to rotate the vane in a counter-clockwise direction as seen in Fig. 3 and subtract from this the forces tending to rotate the vane in a clockwise direction as shown in Fig. 3. A resultant force for the contact pressure at the point 53 between the vane and the inner surface of the casing may thus be determined at known weights of fluids pumped and at a certain number of revolutions per minute of the rotor.

It will be readily apparent that with these variables I may so design the vane and select the speed that at a certain speed of the rotor I will obtain a certain head or pressure developed in the pumped fluid and a certain contact pressure between the vane and casing. A graph illustrating the head pressure plotted against the contact pressure shows in Fig. 11 a selection of values where the contact pressure increases as the head pressure increases. In Fig. 12 the selection of values such that the contact pressure remains constant even though the head pressure increases, while in Fig. 13 I show a selection of values whereby the contact pressure will become nil at a certain head pressure and thereafter any increase in head pressure will cause the vanes to separate from the surface 11 sufficiently to bypass all excess fluid.

This contact pressure does increase as the rotor is speeded up, due to the increase in centrifugal force in the construction which I have illustrated in Fig. 5. If a high speed pump is found necessaary a different design in the vane may be had to move the center of gravity nearer to the center line and thus diminish this contact pressure if less wear or friction is desirable.

It will also be readily apparent that the characteristics of this pump may be readily changed by merely removing vanes of one design such as shown in Fig. 5 and dropping in their place vanes of a different design. Thus by merely having such parts as the vanes interchangeable the characteristics of the pump may be changed radically and I may utilize a pump for widely varying work by merely changing the vanes thereof.

In Fig. 9 I have shown a design of vane 60 in which the center of gravity is moved further from the center of rotation and the weight of the vane decreased. In Fig. 10 the opposite is true, as here the center of gravity of the vane 61 is moved closer to the center of rotation and the weight of the vane increased; also in both of these designs the pressure of the fluid in the pocket will act upon the vane similarly to the action heretofore explained but different values will be obtained.

In Fig. 8 I have shown a somewhat different design with the weight of the vane 62 at one side (the trailing side) of the center of rotation with respect to the motor and the inner surface on the arc of a circle.

It will of course be plain that as the rotor turns in the direction shown by the arrow in Fig. 2 on the center shaft 26 liquid will be picked up through the inlet 43 fed through conduit 47 and then by rotation of the vane member as the eccentricity occurs the fluid will be forced out through the discharge opening 44 as the vane member is squeezed toward a position to reduce the volume as at 45 or the volume of the area 38 as heretofore described.

I claim:

1. In a rotary pump, a casing having a cylindrical compartment therein, a cylindrical rotor eccentrically mounted with reference to the central axis of said compartment and provided with a plurality of recesses in its peripheral cylindrical surface each recess having an arcuate surface of cylindrical generation, a vane member in each recess having a cylindrical arc providing a bearing surface engaging the surface of said recess and slidable therealong and also a flat surface parallel to a plane in which the vane axis lies, each member rockable into engagement with the inner cylindrical surface of the casing, and each member being moved by reason of the rotation of the rotor and by reason of the relatively eccentric mounting of the rotor and the casing, each member being slotted between its ends from one edge of said flat surface toward the opposite edge thereof to present a surface at an angle to said flat surface whereby said flat surface and said slot formed surface are pressed upon by the fluid in the compartment contacting the member, the shaping of said slot being such as to so relate the flat surface and slot formed surface that the desired differential of fluid pressures exerted on said

last named surfaces may exist to urge the member in the direction desired.

2. The rotary pump as set forth in claim 1 wherein the slot is so shaped and sized as to extend inwardly from one edge to a point beyond the axial center of the vane.

3. The rotary pump as set forth in claim 1 wherein the slot is so shaped and sized as to present a surface extending at right angles to the said flat surface.

4. The rotary pump as set forth in claim 1 wherein the slot is so shaped and sized as to present a surface extending at right angles to the said flat surface and of an extent greater in an unbalanced area than the extent of the remaining flat surface in the slotted area.

ROBERT STEVENSON.