Nov. 12, 1957 H. L. NASH 2,812,719

ROTARY PUMP

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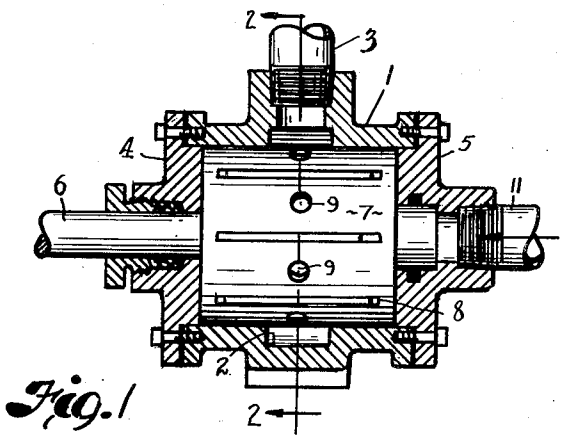


Fig. 1

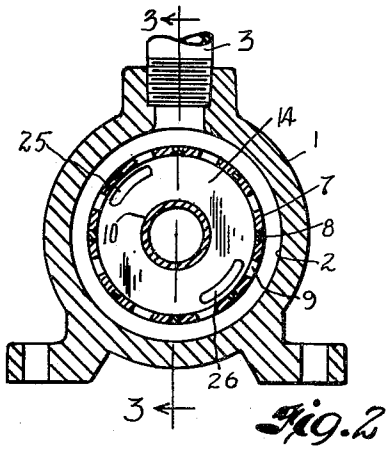


Fig. 2

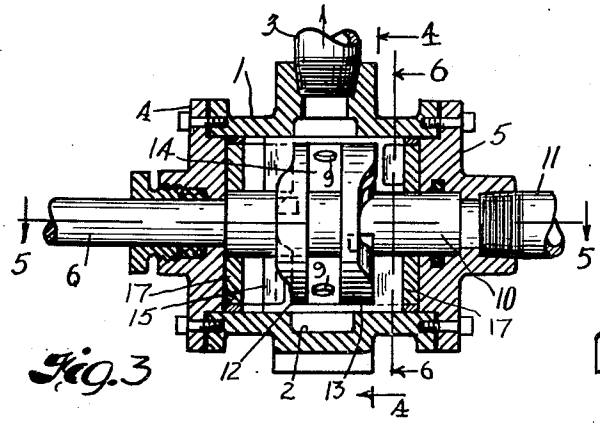


Fig. 3

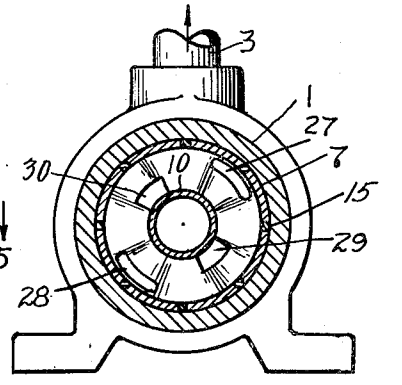


Fig. 4

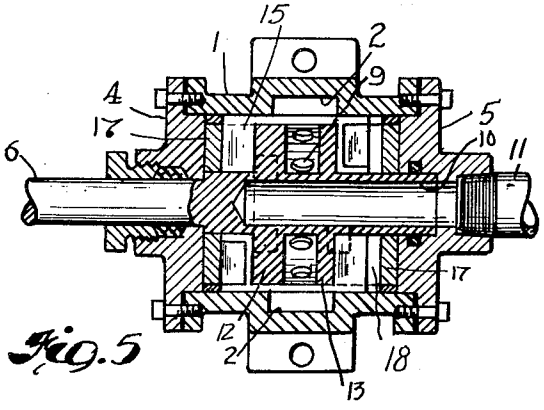


Fig. 5

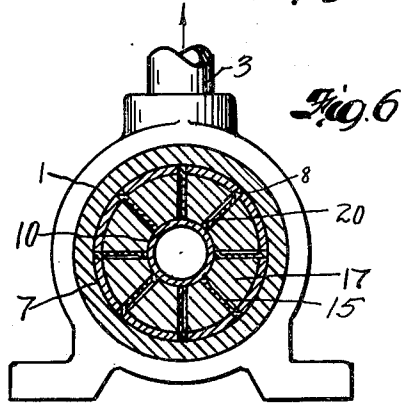


Fig. 6

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Nov. 12, 1957 H. L. NASH 2,812,719

ROTARY PUMP

Filed July 20, 1954 4 Sheets-Sheet 2

FIG. 8

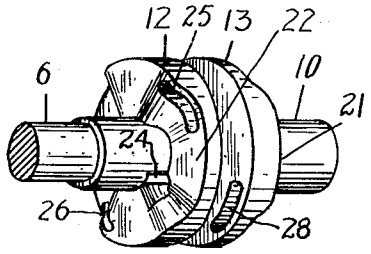


FIG. 9

Fig. 7

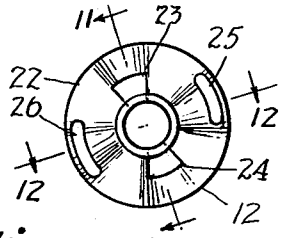


Fig. 8

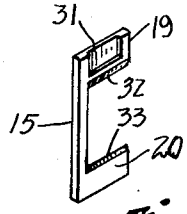


Fig. 10

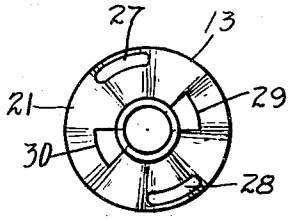


Fig. 9

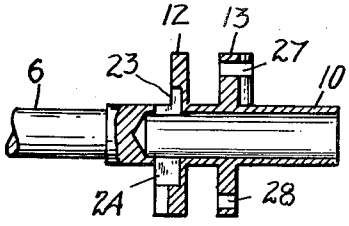


Fig. 11

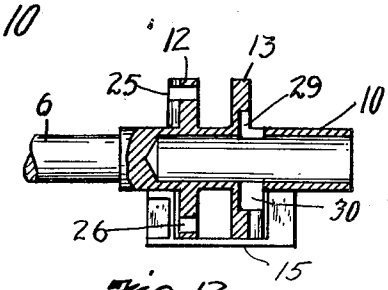


Fig. 12

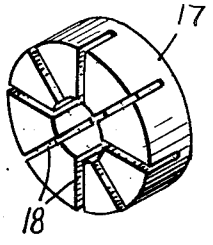


Fig. 13

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Nov. 12, 1957 H. L. NASH 2,812,719

ROTARY PUMP

Filed July 20, 1954 4 Sheets-Sheet 3

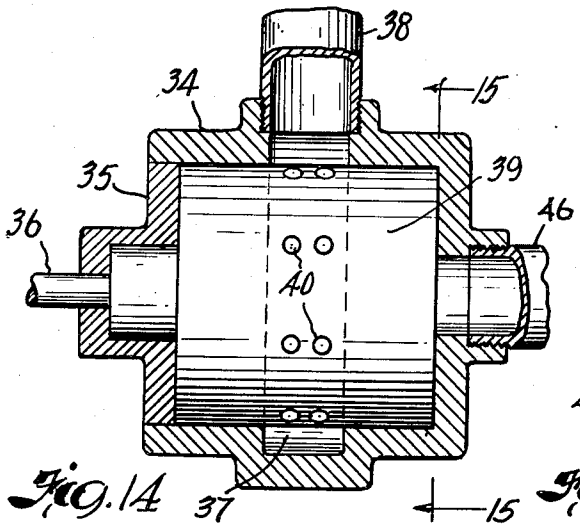


Fig. 14

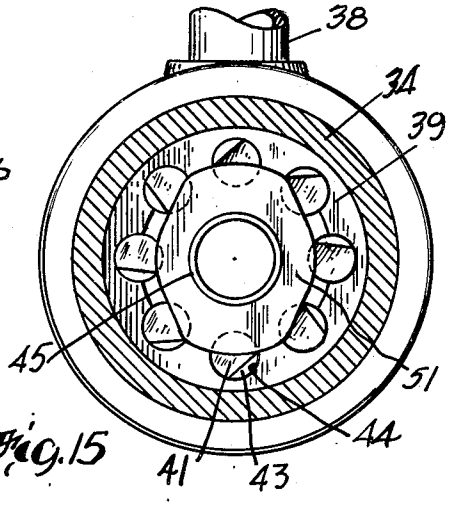


Fig. 15

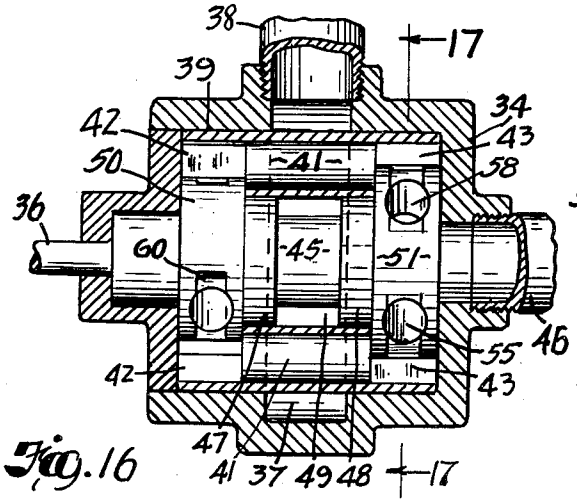


Fig. 16

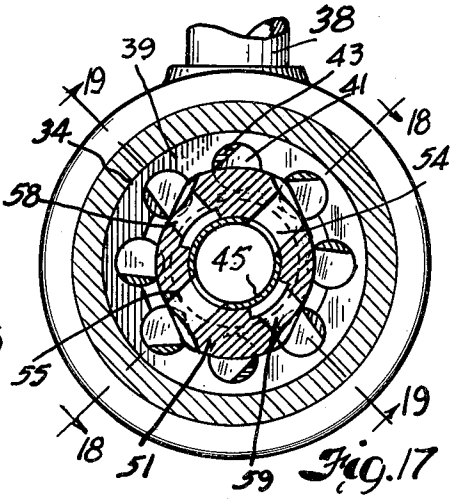


Fig. 17

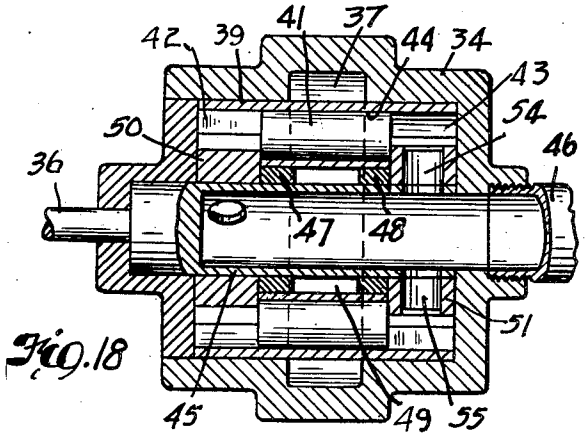


Fig. 18



Fig. 24

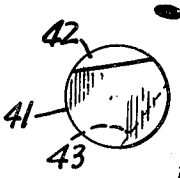


Fig. 25

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Nov. 12, 1957 H. L. NASH 2,812,719

ROTARY PUMP

Filed July 20, 1954 4 Sheets-Sheet 4

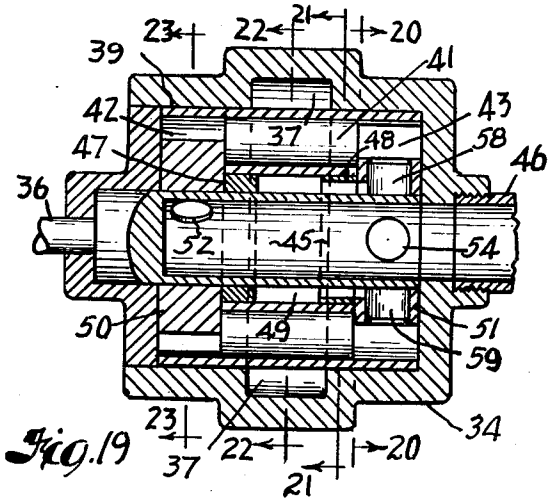


Fig. 19

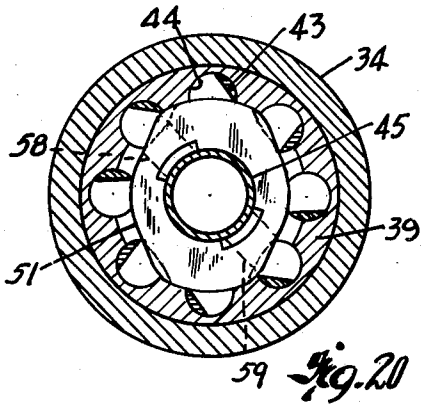


Fig. 20

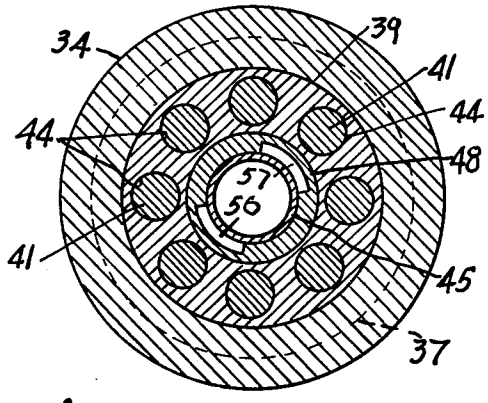


Fig. 21

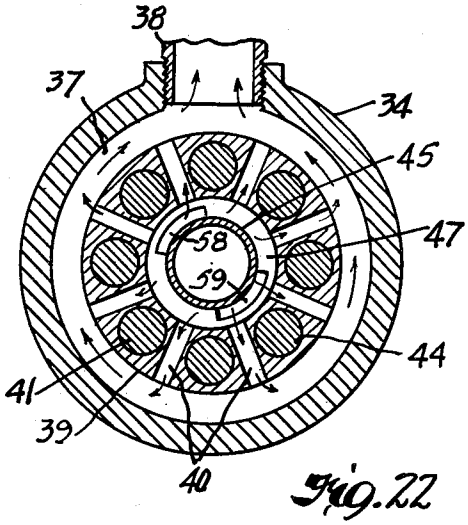


Fig. 22

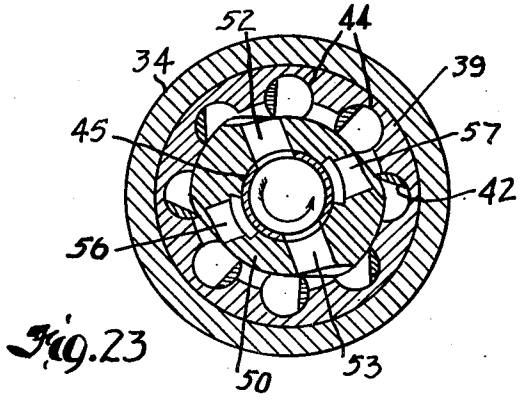


Fig. 23

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United States Patent Office 2,812,719 Patented Nov. 12, 1957

2,812,719

ROTARY PUMP

Humphrey L. Nash, Royalston, Mass., assignor of six-sevenths to Humphrey L. Nash, Jr., Dhahran, Saudi Arabia, and one-seventh to John Nash II, San Jose, Calif., as trustees

Application July 20, 1954, Serial No. 444,427

14 Claims. (Cl. 103—123)

This invention relates as indicated to a rotary pump, and more particularly to a pump in which the vanes, abutments, or valve members reciprocate or oscillate but do not travel with the rotor as is the case in a conventional rotary pump with guided vanes.

A great variety of rotary pumps has been designed in the past for various purposes, and large numbers are employed in air craft to deliver fuel to the engines and to operate the many hydraulically controlled devices. For such purposes, and especially for pumping fuel, there has been a steadily increasing demand for a pump which will not cavitate and thus produce a pulsating delivery, and which will be mechanically and hydraulically balanced as is a centrifugal pump but is positive in its displacement. The pump needs to be rather small and light in weight, yet of large capacity. It should not require too high a head to obviate the danger of vapor lock.

It is, accordingly, an object of my invention to provide a high speed rotary pump which will avoid cavitation and therefore will be non-pulsating in delivery.

It is a further object to provide such pump which will be of the continuous central flow type and will require only a low head for satisfactory operation.

Another object is to provide such pump utilizing relative rotation of the pumping zone boundaries with relatively little vane movement being involved, and without such vanes rotating with the rotor body.

Still another object is to provide a pump having positively acting vanes maintaining mechanical and hydraulic pressure balance and affording positive displacement.

Other objects of the invention will appear as the description proceeds.

To the accomplishment of the foregoing and related ends, said invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawing setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

In said annexed drawing:

Fig. 1 is a longitudinal section through a rotary pump embodying certain principles of my invention and showing the inner liner unsectioned;

Fig. 2 is a transverse section taken on the line 2—2 on Fig. 1;

Fig. 3 is a longitudinal section corresponding to Fig. 1 but showing the inner liner in section and thereby disclosing the rotor;

Fig. 4 is a transverse section taken on the line 4—4 on Fig. 3;

Fig. 5 is a longitudinal section taken on the line 5—5 on Fig. 3;

Fig. 6 is a transverse section taken on the line 6—6 on Fig. 3;

Fig. 7 is a perspective view of the rotor;

Fig. 8 is the left-hand end view of the rotor as seen in Fig. 7;

Fig. 9 is the right-hand view of such rotor as seen in Fig. 7;

Fig. 10 is a detail perspective view of one of the vanes adapted to be reciprocated by turning of such rotor;

Fig. 11 is a longitudinal section taken through the rotor on the line 11—11 on Fig. 8;

Fig. 12 is a longitudinal section through the rotor taken on the line 12—12 at right angles to Fig. 11;

Fig. 13 is a perspective view of one of the end guide members adapted to receive the vanes of Fig. 10;

Fig. 14 is a longitudinal section through another form of rotary pump embodying the basic principles of my invention;

Fig. 15 is a transverse section taken on the line 15—15 on Fig. 14;

Fig. 16 is a longitudinal section corresponding to Fig. 14 but showing the inner liner also sectioned to disclose the rotor and associated parts;

Fig. 17 is a transverse section taken on the line 17—17 on Fig. 16;

Fig. 18 is a longitudinal section taken on the line 18—18 on Fig. 17 through one set of ports;

Fig. 19 is a longitudinal section taken on the line 19—19 on Fig. 17;

Fig. 20 is a transverse section taken on the line 20—20 on Fig. 19;

Fig. 21 is a transverse section taken on the line 21—21 on Fig. 19;

Fig. 22 is a transverse section through the outlet port taken on the line 22—22 on Fig. 19;

Fig. 23 is a transverse section taken on the line 23—23 on Fig. 19;

Fig. 24 is a perspective view of a double vane or abutment member utilized in the Fig. 14 to Fig. 23 embodiment; and

Fig. 25 is an end view of such vane member indicating the relative orientation or inclination of the respective vane end portions.

Referring now more particularly to Figs. 1–13 inclusive, the embodiment of my invention there illustrated comprises an outer cylindrical housing 1 having an inner peripheral groove 2 therein communicating with outlet 3. End plates 4 and 5 are secured to the respective ends of such cylinder by means of screws and are provided with axial openings journalling a rotor adapted to be driven through drive shaft 6. Tightly fitted within cylindrical housing 1 is an inner sleeve 7 having eight equally spaced longitudinally extending slots 8 therein with apertures 9 centrally located intermediate such slots to place the interior of sleeve 7 in communication with annular groove 2 leading to outlet 3.

The rotor comprises an axial tubular hub portion 10 journalled in end plate 5 and communicating with pump inlet 11. Integral therewith are two circular cam members 12 and 13 fitting within sleeve 7 and having flat faces spaced apart to define a central cavity 14 (Fig. 3) in communication through openings 9 with annular groove 2 and outlet port 3. The axially outer end faces of cams 12 and 13 are formed with cam surfaces adapted to engage and reciprocate double vanes 15 fitting in slots 8 in sleeve 7 and lying in planes radially of the rotor. End blocks 16 and 17 non-rotatably fixed in sleeve 7 are formed with radial slots such as 18 (see Fig. 13) of a depth to receive the abutments proper 19 and 20 of the respective vanes 15. Rotation of the rotor consequently serves to reciprocate such vane abutments axially in and out of slots 18 through engagement of such abutments with the cam faces of cam members 12 and 13.

Such cam faces may be generated by a line (a radius

of definite length) revolving around the axis of rotation of the rotor and perpendicular thereto. Such radius is caused to revolve for 45° in a primary position, then a further 45° while also moving parallel to the axis of rotation to a secondary position, then 45° in such secondary position and then 45° while moving back to its primary position, this being again repeated until a revolution is complete. As best shown in Figs. 3, 7, 8 and 9, the rotor cam members 12 and 13 are identical in their cam faces except that they are indexed to bring a high such as 21 opposite a low such as 22. Consequently, the vanes 15 will always be reciprocated positively, the vane abutment engaging a high such as 21 being entirely withdrawn within a slot 18 with the other vane abutment engaging a low such as 22 being substantially entirely withdrawn from its slot 18 and in effective pumping position.

Each rotor cam member is provided with four ports, two diametrically opposite inlet ports such as 23 and 24 leading from the interior of tubular rotor hub 10 to the axially outer cam faces where the latter are in process of dropping to the low areas 22 and two diametrically opposite ports 25 and 26 piercing the cam members to place central cavity 14 in communication with the axially outer sides of the cam members where the low regions 22 change to the high regions 21. The inlet ports 23, 24 of cam member 12 are accordingly opposite the outlet ports 27 and 28 of cam member 13 (Fig. 11) and the outlet ports 25 and 26 through cam member 12 are opposite the inlet ports 29 and 30 of cam member 13. The ports 23—24, 25—26, 27—28, and 29—30 are, as shown in Figs. 4 and 7 to 9, circuferentially coextensive with the respective cam surfaces.

The faces of the vane abutments may be relieved to avoid pressure thereon as at 31 (opposite faces of the respective abutments 19 and 20 being thus relieved) and the inner edges of such abutments 32 and 33 must be beveled to afford line contact with the cam faces of the cam members 12 and 13.

In this form of pump, the pumping zones can be any number desired. Of course, all other factors being equal, the capacity of the pump will depend upon the number of pumping zones. The cam surfaces should be carefully machined to provide a close sliding fit with the vanes, and the transition of the cam surfaces from the highs to the lows should be smoothly contoured.

In operation, as the rotor turns, fluid is drawn in through inlet port 11 to the interior of rotor hub 10 from which it flows radially outwardly through the ports 23, 24, 29, 30 to the respective pumping chambers containing the vane abutments 19 and 20.

Assuming that the rotor is in a position with the edges 32 and 33 of vanes or abutments in engagement with the cam faces along radial lines corresponding to the ends of the inlet and outlet ports and of the inclined or sloped portions of the cam faces (or, in other words, along radial lines corresponding to the ends of the high and low dwell portions of such cam faces), it is evident that, upon rotation of the rotor, each intake cavity defined by three successive vanes progressively increases in size or volumetric capacity while in communication with the entire extent of the associated intake port of the rotor and thus cavitation is eliminated.

Similarly, each rotor discharge port is always in full, unrestricted communication with the associated discharge cavity defined by three successive vanes. In this way, the pump operates without pulsation and is mechanically and hydraulically balanced.

In contradistinction, a conventional rotary pump with guided vanes carried by the rotor and engaged with the cam surface of a ported housing draws fluid through an intake port which is progressively cut off by a vane whereby the intake cavity is not completely filled with fluid and discharges fluid through a discharge port which initially has highly restricted communication with the discharge cavity as a vane passes the edge of the discharge port. Such throttling of the intake and discharge of fluid results in cavitation and in pulsating delivery of fluid by such conventional pump.

Referring now more especially to the Figs. 14–25 embodiment of the invention, the pump there illustrated comprises a cylindrical housing 34 generally similar to housing 1 and having a removable end plate 35 through which rotor drive shaft 36 passes. An inner peripheral groove 37 in housing 34 corresponds generally to groove 2 and communicates with the radial outlet 38. An inner cylindrical sleeve or liner 39 is fitted non-rotatably within housing 34 and is provided with eight sets of radially disposed passages 40 extending from the inner periphery of liner 39 and communicating with peripheral groove or channel 37.

Each end of liner 39 is recessed to receive rotor cams as described more in detail below. Eight cylindrical vane members 41 having pumping abutments 42 and 43 at their respective ends are pivotally mounted in eight cylindrical openings 44 extending parallel to the axis of sleeve 39 intermediate the sets of passages 40. The central body portions of the vanes 41 are fitted within the thicker central portion of liner 39 with the abutment or valve portions 42 and 43 projecting into the enlarged axial recesses in the respective ends of the liner. As best shown in Fig. 25, the abutments 42 and 43 lie at angles to one another as further explained below.

The rotor comprises an axial tubular portion 45 in communication with axial inlet port 46 and in driven connection at its other end with drive shaft 36. Two annular shoulders 47 and 48 fixed to tubular portion 45 for rotation therewith fit snugly within the inner periphery of liner 39 for rotation relative thereto and define a central annular chamber 49 therebetween in communication through passages 40 with peripheral groove 37 and outlet 38.

Also mounted on the tubular rotor portion 45 for rotation therewith are two cam members 50 and 51 of general oval contour, one such cam being indexed relative to the other. The outer peripheries of such cams engage the flat faces of abutments 42 and 43 of the respective vane ends positively to oscillate the same as the rotor turns. Diametrically opposite inlet passages 52 and 53 extend radially through cam 50 immediately following the diametrically opposite highs or lobe portions of the cam, communicating with the interior of the tubular rotor portion 45, and diametrically opposite inlet passages 54 and 55 similarly extend through cam 51.

Outlet passages 56 and 57 immediately preceding the highs or lobes of cam 50 extend radially inwardly from the outer periphery of such cam and then parallel to the axis of the rotor through annular shoulder 47 to central cavity 49. Similarly, outlet passages 58 and 59 extend radially inwardly from the outer periphery of cam 51 immediately preceding the highs or lobes of such cam, and then parallel to the rotor through annular shoulder 48 to central cavity 49.

The operation of the pump may now be clearly understood. Fluid enters main axial inlet 46, passing into the interior of tubular rotor hub 45 and thence radially outwardly through passages 52, 53, 54, and 55 to the pumping chambers immediately behind the highs of lobes of the respective rotor cam members 50 and 51. As best shown in Fig. 23, the fluid thus delivered is trapped between adjacent abutments of vanes 41 and then expelled through exhaust ports 56, 57, 58, and 59 into central annular chamber 49 from which it flows outwardly through passages 40 to outer annular channel 37 and thence to main outlet port 35. The outer ends of the ports in cams 50 and 51 lie in valleys or recesses such as 60 (Fig. 16) so that fluid may be delivered to and expelled from the pump chambers smoothly and continuously, such valleys extending to the beginning and end

of each arcuate contour of the cam lobes conforming to the inner arcuate borders of the recesses formed in the respective ends of liner 39 and defining such pumping chambers.

As a cam lobe engages and positively rocks a vane abutment, this will, of course, cause the abutment at the other end of the same vane to be rocked to contact the low (or following side) of a cam lobe of the other cam profile. As the rotor continues to turn, a following lobe of such latter cam will now engage and positively oscillate the opposed vane abutment and thereby rock the abutment at the other end of the vane to conform to the following contour of such lobe of the first cam. In other words, the respective cams alternately assume the burden of positively oscillating any individual vane.

The Figs. 14–23 embodiment of the invention has some practical advantages over the Figs. 1–13 embodiment in that the former is rather easier to machine to the tolerances desired. Its cam profiles are developed by a line moving parallel to the axis of rotation and the highs, lows, and transition zones may each be any equal division of 360°. As seen above, the vanes oscillate about axes parallel to the axis of rotation and their abutments or tips are held in contact with complementary zones of the rotor cams.

Referring again to the pump structures illustrated in Figs. 1–13 and Figs. 14–25, a notable feature thereof which has been described hereinbefore, but which is deemed worthy of further emphasis, is the constant pulsationless displacement of these pumps during each increment of rotation of the rotors therein. Thus, fluid under pressure will be delivered by these pumps without pulsation as long as the rotors therein are rotated at constant angular velocity or constant R. P. M.

In the pump illustrated in Figs. 1–12, the pulsationless displacement is achieved by (1) making the alternate dwell portions 21 and 22 of the cam surfaces and the alternate inclined dwell joining or vane actuating portions of equal circumferential extent, (2) providing fluid intake and discharge passages 23—24 and 27—28 of the same circumferential extent as the inclined portions of the cam surfaces, and (3) spacing the cam-contacting vanes or abutments 19—20 circumferentially apart a distance equal to the circumferential extents of such dwell and inclined portions of the cam surfaces. In this way, as the rotor is rotated in the pump housing 1, the displacement of the cavities defined between the rotor, the housing 1, and the vanes 19 and 20 will be constant during each increment of rotation of the rotor.

In other words, as the rotor rotates, fluid will be displaced at constant rate from the cavities defined between the first and third ones of three successive vanes 19 and 20, said first and third vanes being held against movement by the dwell portions 21 and 22 of the cam surfaces, and only the second or middle vanes being actuated by the inclined portions but at that time the rotor intake and discharge passages 23—24 and 27—28 communicate with the entire cavities between said first and third vanes.

Similarly, in the pump illustrated in Figs. 14–25, the cylindrical dwell portions of the cam members 50 and 51 are of the same circumferential extent as the alternate, relatively inclined portions therebetween and successive vanes or abutments 41 are similarly spaced apart from each other the same amount as the circumferential extent of the dwell and inclined portions aforesaid; and, furthermore, the fluid intake and discharge passages 54—54 and 58—59 in the rotor are coextensive circumferentially with said inclined or vane actuating portions of the cam members 50 and 51. Thus, the volume of each pumping or displacement cavity changes at a constant rate per increment of rotation of the rotor whereby the pump delivery will be pulsationless, if the angular velocity of the rotor is constant.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims, or the equivalent of such, be employed.

I therefore particularly point out and distinctly claim as my invention:

1. A rotary pump comprising a hollow housing, a rotor journalled therein and defining a chamber therewith, a series of circumferentially spaced apart vanes movably guided in said housing and with respect to which said rotor rotates in contact, said vanes subdividing such chamber into at least two cavities, said rotor being formed with a continuous vane contacting cam surface which includes alternate dwell and inclined portions of substantially equal angular extent and effective during rotation of said rotor to immovably maintain the vanes successively contacted thereby in two different positions and to permit movement of said vanes progressively from one such dwell position to the other and then vice versa, the rotor contacting portions of successive vanes being spaced apart approximately the same angle as the angular extent of each of said dwell and inclined portions, said rotor being formed with fluid intake and discharge passages in the respective inclined portions and co-extensive therewith, such passages communicating with the respective cavities and spanning the space between successive vanes.

2. The rotary pump of claim 1 wherein said vanes extend generally radially of such chamber and are axially movable therein, such cam surface being formed on an end of said rotor for contacting the corresponding end of said vanes.

3. The rotary pump of claim 1 wherein said rotor is formed with a duplicate cam surface, a duplicate series of vanes are actuated by such duplicate cam surface and wherein said series of vanes and said duplicate series of vanes are interconnected together for positive movement responsive to rotation of said rotor.

4. The rotary pump of claim 1 wherein said rotor is provided with another cam surface engaged with said series of vanes, said cam surfaces being effective to positively move said vanes during rotation of said rotor.

5. The rotary pump of claim 1 wherein said vanes have rotor cam surface contacting edges which are moved generally radially during rotation of said rotor.

6. The rotary pump of claim 1 wherein said vanes are mounted in said housing for oscillation about an axis parallel to the axis of rotation of said rotor and have rotor cam surface contacting edges which are moved generally radially responsive to rotation of said rotor.

7. The rotary pump of claim 6 wherein said rotor has a duplicate cam surface, wherein said vanes have duplicate edges contacting such duplicate cam surface, such edges and duplicate edges of said vanes being effective to cause a positive oscillation thereof responsive to rotation of said rotor.

8. A rotary pump comprising a hollow housing; a rotor journalled therein; a series of substantially uniformly circumferentially spaced apart vanes movably mounted in said housing and having rotor contacting edges; said housing, rotor, and vanes defining therebetween a plurality of cavities which respectively increase and decrease in volumetric size responsive to movement of said vanes; means for positively moving said vanes including a cam surface on said rotor which, responsive to rotation of said rotor, progressively moves the second one of three successive vanes while the first and third ones are held against movement and thus varies the volumetric size of the cavity defined between said housing, said rotor, and said first and third vanes; said rotor being formed with fluid intake and discharge passages communicating with the respective cavities and spanning the space between said first and second vanes.

9. A rotary pump comprising a hollow housing; a rotor journalled therein; a series of substantially uniformly circumferentially spaced apart vanes movably mounted in

said housing and having rotor contacting edges; said housing, rotor, and vanes defining therebetween a plurality of cavities which respectively increase and decrease in volumetric size responsive to movement of said vanes; said rotor being formed with a vane contacting cam surface which, responsive to rotation of said rotor, progressively moves the second one of three successive vanes while the first and third ones are held against movement and thus varies the volumetric size of the cavity defined between said housing, said rotor, and said first and third vanes; said rotor being formed with fluid intake and discharge passages communicating with the respective cavities and spanning the space between said first and second vanes.

10. In a rotary pump, the combination of a hollow housing, a rotor journalled therein and defining a chamber therewith, a series of at least four equi-angularly spaced apart rotor contacting vanes movably mounted in said housing and subdividing such chamber into at least two cavities, said vanes having rotor contacting edges which are adapted to be moved responsive to rotation of said rotation of said rotor, said rotor having a cam surface which engages said vanes and which, during rotation of said rotor, is effective to maintain the first and third of three successive vanes in a position of rest and to move the second one of said three successive vanes, said rotor being formed with fluid intake and discharge passages in communication with the respective cavities and spanning the space between said first and second vanes.

11. The rotary pump of claim 10 wherein said rotor is formed with a duplicate vane contacting cam surface and wherein said vanes straddle such cam surfaces and are positively reciprocated axially thereby.

12. The rotary pump of claim 10 wherein said rotor is formed with a duplicate vane contacting cam surface, wherein such cam surfaces are formed on the periphery of said rotor and are circumferentially offset with respect to each other, and wherein said vanes are oscillatorily mounted in said housing and have generally radially movable and circumferentially offset rotor contacting edges respectively contacting such duplicate cam surfaces.

13. In a rotary pump, the combination of a hollow housing, a rotor journalled therein and defining a chamber therewith, a series of at least four equi-angularly

spaced apart rotor contacting vanes movably mounted in said housing and sub-dividing such chamber into at least two cavities, said vanes having rotor contacting edges which engage said rotor in line contact and which are adapted to be moved responsive to rotation of said rotor, said rotor having a cam surface which is engaged by said vanes and which is effective to so move the middle one of three successive vanes while the first and third are held in a rest position, said rotor being formed with fluid intake and discharge passages which are coextensive with the spaces between successive vanes and in register with the portions of the cam surfaces effective to move such rotor contacting edges of said vanes.

14. A rotary pump comprising a hollow housing, a rotor journalled therein and defining a chamber therewith, a series of at least four equi-angularly spaced apart rotor contacting vanes movably mounted in said housing and sub-dividing such chamber into at least two cavities which respectively continuously increase and decrease in size during rotation of said rotor, said rotor being formed with a cam surface which includes vane actuating portions and dwell portions of angular extent equal to the angular spacing of successive vanes for actuating alternate ones of said vanes in opposite directions and for maintaining the vanes adjacent the actuated vanes in a rest, cavity-closing position, said rotor being formed with fluid intake and discharge passages in constant communication with the respective cavities and angularly co-extensive with such vane actuating portions of said cam surface.

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