

Feb. 16, 1954

W. H. DE LANCEY ET AL

2,669,189

ADJUSTABLE FLUID PUMP

Filed Sept. 5, 1947

3 Sheets-Sheet 1

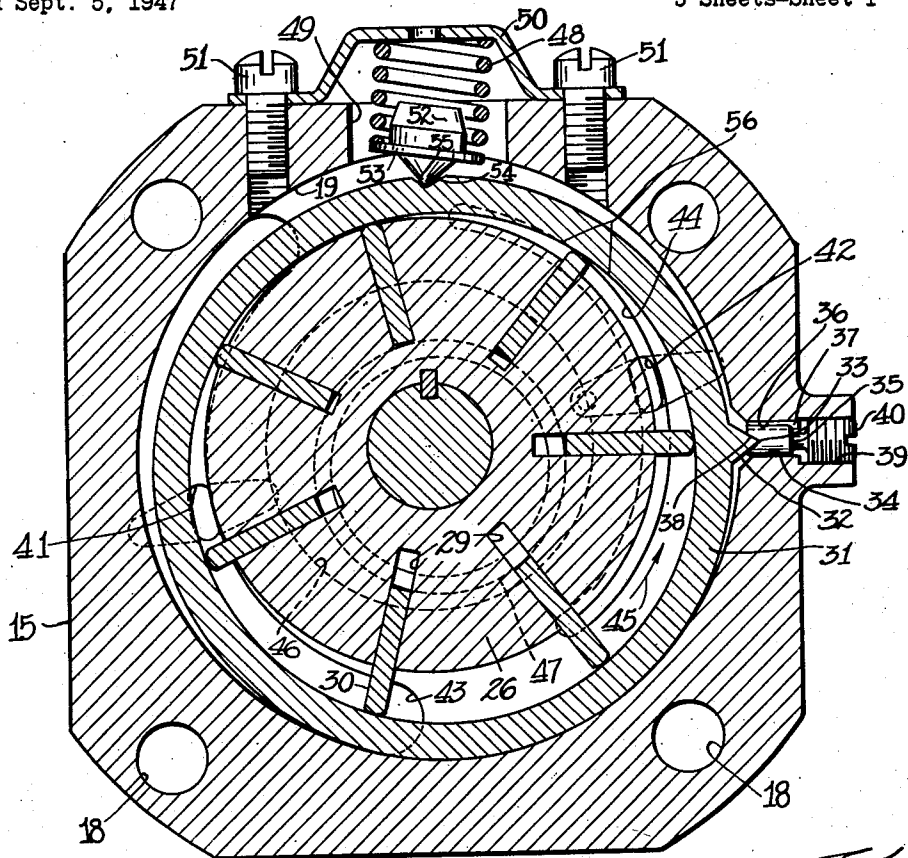


Fig. 1.

Fig. 3.

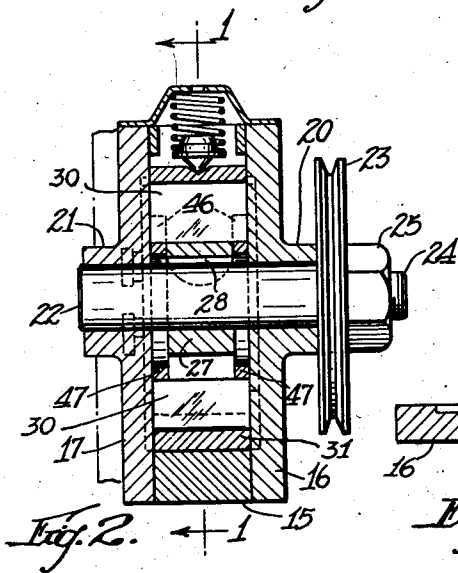


Fig. 2.

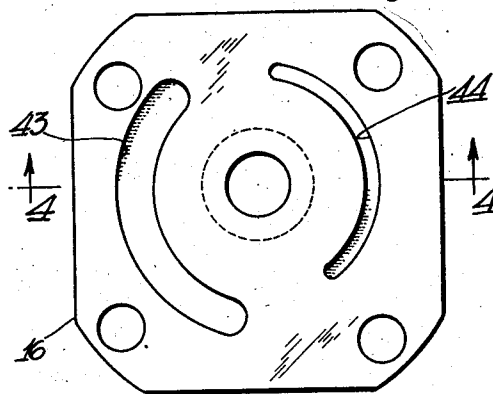


Fig. 4.

Inventors:
Warren H. DeLancey
Harry L. Christobor Jr.
Bertram P. Ford
By Chester A. Williams
Attorney

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3 Sheets-Sheet 2

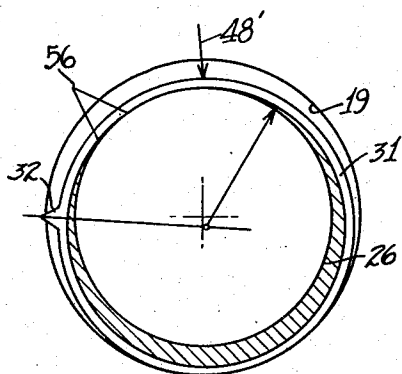


Fig. 5.

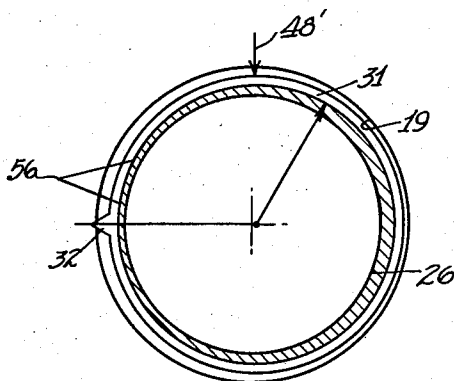


Fig. 6.

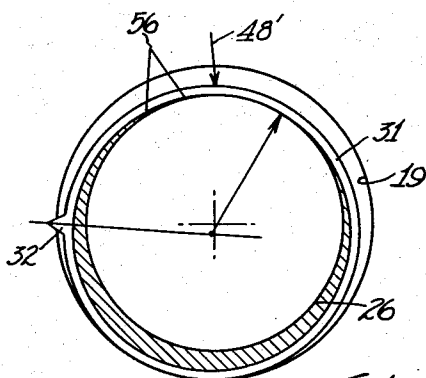


Fig. 7.

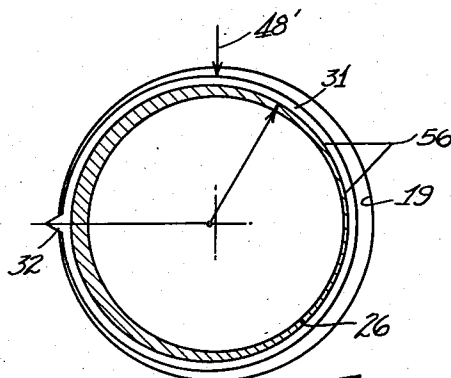


Fig. 8.

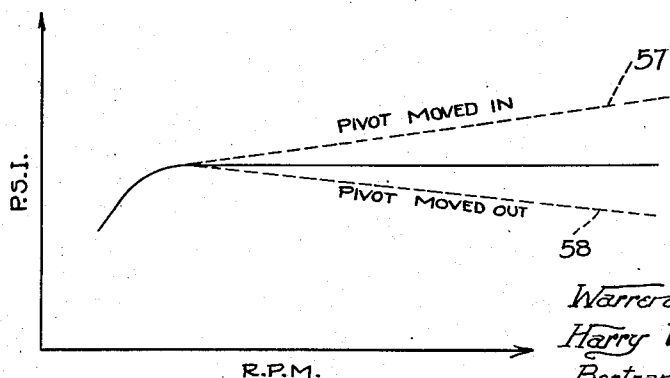


Fig. 9.

Inventors:

Warren H. DeLancey

Harry L. Christobor Jr.

Bertram P. Ford

By Chester A. Williams

Attorney

Feb. 16, 1954

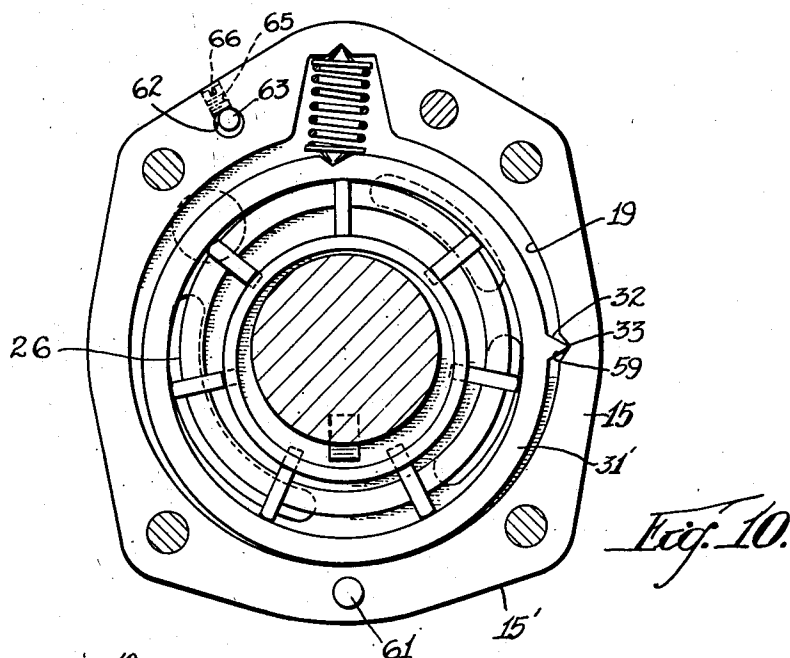
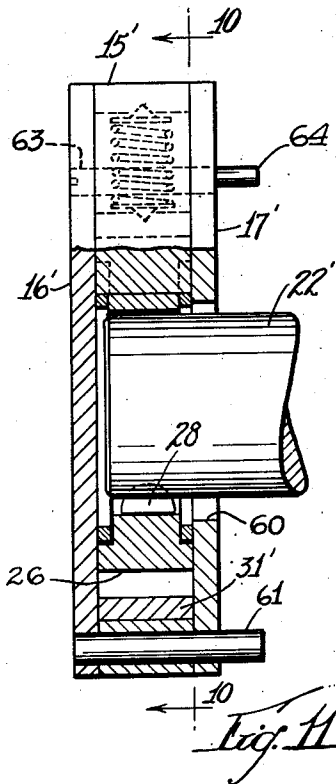
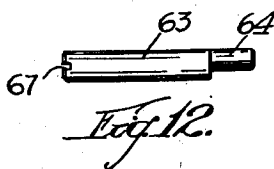
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3 Sheets-Sheet 3



Inventors:

Warren H. DeLancey

Harry L. Christensen Jr.

Bertram P. Ford

By *Chester A. Williams*

Attorney

UNITED STATES PATENT OFFICE

2,669,189

ADJUSTABLE FLUID PUMP

Warren H. De Lancey, Springfield, and Bertram P. Pond, Longmeadow, Mass., and Harry L. Chisholm, Jr., Buffalo, N. Y., assignors, by direct and mesne assignments, to Houdaille-Hershey Corporation, Detroit, Mich., a corporation of Michigan

Application September 5, 1947, Serial No. 772,292

6 Claims. (Cl. 103—120)

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This invention relates to a variable capacity fluid pump of the vane type, and more particularly to that type of variable capacity fluid pump in which the displacement automatically adjusts itself to compensate for variations in the driving speed or output requirements; the displacement being modulated from maximum to zero by comparatively slight increases of pressure after reaching a predetermined point. That is, the volume of the pump's output decreases as the delivery pressure increases, so that the pump is not required to operate against any appreciable back pressure in periods of zero output requirements.

The primary object of this invention is to provide a variable capacity pump of the above type with means whereby the pressure of the pump's fluid discharge may be made to either increase or decrease, within certain predetermined limits, in response to variations in the speed of the pump shaft. A more specific object of the present invention is to provide such a pump with manually adjustable means which, when operated, will cause the pressure of the pump's fluid discharge to either increase or decrease, depending upon the particular adjustments made, in response to an increase in the speed of the pump shaft.

With the above and other objects in view, as will hereinafter appear, the invention comprises the devices, combinations and arrangements of parts, hereinafter set forth and illustrated in the accompanying drawings of a preferred embodiment of the invention from which the several features of the invention and the advantages attained thereby will be readily understood by those skilled in the art. In the drawings:

Fig. 1 represents a vertical sectional view of a pump in which the present invention is incorporated, the section being taken transversely of the rotor shaft, substantially along the line 1—1 of Fig. 2.

Fig. 2 represents, on a smaller scale, a sectional view in a vertical plane substantially at right angles to the section of Fig. 1.

Fig. 3 represents a view of a detached inner face of one of the end plates of the present pump casing.

Fig. 4 represents a sectional view taken substantially along the line 4—4 of Fig. 3.

Figs. 5, 6, 7 and 8, each represents a diagrammatic view of the present pumping device for the purpose of illustrating the action of the pump as affected by certain adjustments.

Fig. 9 represents various performance curves which have been plotted in order to illustrate the

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action of the present pump after the same has been adjusted in various manners.

Fig. 10 represents a vertical sectional view of a modified form of the present invention, the section being taken transversely of the rotor shaft substantially along the line 10—10 of Fig. 11.

Fig. 11 represents a sectional view taken substantially at right angles to the section of Fig. 10.

Fig. 12 represents a side view of a cam pin which is incorporated in that pump disclosed in Figs. 10 and 11.

Fig. 13 represents a right-hand end view of the cam pin disclosed in Fig. 12.

Like reference characters refer to like parts in the different figures.

The present invention is incorporated in a pumping unit which comprises a casing member 15 of generally annular form and having a pair of end plates 16 and 17, secured on opposite sides to the casing member 15, as by suitable bolts that pass through registering holes 18, 18 provided respectively by all three of said casing parts. Thus, the plates 16 and 17 when so bolted to the casing member 15 provide enclosures for a substantially cylindrical space formed by a bore 19 of casing member 15, said space containing, as hereinafter described, the pump and automatic regulating instrumentalities of the present invention.

The plates 16 and 17 provide aligned substantially central hub portions 20 and 21, respectively, within which is suitably journaled a rotor shaft 22, said shaft being driven in any suitable manner, as by means of a drive belt, not shown, for a pulley 23, keyed or otherwise suitably secured to a threaded extension 24 of the shaft carrying a retaining nut 25 for said pulley. The shaft 22 passes through the cylindrical space of the pump housing and carries within said space a pump rotor 26, the latter having an inner hub portion 27 which surrounds said shaft, and is keyed thereto, as shown at 28. The pump rotor 26 is formed in the usual manner with a series of radial slots 29, 29 in each of which is disposed a radially slidable vane 30. The outer ends of said vanes are adapted to work against the interior periphery of a modulator ring 31 which surrounds the rotor 26 in the pump space provided by the cylindrical bore 19 of casing member 15, said member 31, as well as the several vanes 30, 30, extending across said space from side to side between opposite inner faces of the end plates 16 and 17.

The modulator ring 31 on its outer periphery is appreciably smaller in diameter than the bore

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19, and on its inner periphery is appreciably larger in diameter than the pump rotor 26; in consequence of this, there is ample opportunity in the pump space surrounding the rotor 26 for free movement of the member 31, into positions of varying eccentricity relative to the rotor 26, to vary the pumping action of the latter's slidable vanes 30, 30.

Referring particularly to Fig. 1, there is provided on the outer surface of the member 31, and preferably across its entire width, a rib 32 of substantially triangular cross section, and with side surfaces at an arcuate angle to each other so as to form at their intersection a virtual knife edge, as indicated at 33. For the reception of rib 32 the casing 15 is provided with a radially disposed bore 34 in which is slidably mounted a cylindrical pin 35. The bore 34 has formed longitudinally thereof a keyway 36 for the purpose of receiving a key 37 formed in the pin 35 so as to prevent the pin from rotating within the hole, but at the same time permitting the endwise movement of the pin within the bore. The left-hand end portion of the pin 35 is provided with a two-sided indentation or cleft 38, somewhat shallower than the rib 32 and with its intersecting sides at an appreciably larger angle to each other than the intersecting sides of said rib, thus to give ample clearance for free and frictionless rocking movement of the ring 31 on the axis afforded by the bottoming of the rib edge 33 in the angular indentation. Formed in the wall of the casing 15, and axially of the bore 34, is a threaded aperture 39 which is adapted to receive therein an adjusting screw 40, the function of which will be hereinafter set forth.

The modulator ring 31 presents a continuous unbroken interior cylindrical surface to the ends of the vanes 30, 30, there being no need to provide said ring with fluid openings to the spaces between the vanes since the egress of fluid to and its exit from said spaces, is obtained laterally by way of passages leading into the pump space through one or the other of the end plates 16 and 17. As herein shown, the end plate 17 provides a fluid intake passage whose angular and radial position is indicated by the broken lines at 41 in Fig. 1 and said plate 17 also provides a fluid delivery or discharge passage whose angular and radial position is indicated by the broken lines at 42 in Fig. 1. On both sides of the pumping space as extensions of these passages or ports 41 and 42 the opposite inner faces of the end plates 16 and 17 are preferably formed, as shown in Figs. 3 and 4 with elongated arcuate grooves 43 and 44, the former being in the fluid intake zone and the latter in the fluid delivery zone of the path of travel of the vanes 30, 30. The function of these grooves is principally to insure an unrestricted internal flow of the fluid as drawn into and expelled from the spaces between the vanes 30, 30 by the rotation of the rotor 26 within the ring 31 in the direction of arrow 45 on Fig. 1. The intake groove 43 is preferably made wide enough to overlap the ring 31 on both sides, thereby to give the entering fluid access to the space between said ring and the bore 19 and to reduce the fluid's tendency to foam by reason of undue restriction of its flow.

As best shown in Fig. 2, the rotor's inner hub portion 27 is of less width, axially of the shaft 22, than the vanes 30, 30, this reduction of width resulting from the rotor's opposite faces being formed with circular recesses, as indicated by the broken lines of 46, 46 in Figs. 1 and 2. Since

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these recesses 46, 46 are intersected by the inner ends of the radial slots 29, 29, it follows that the end extremities of the inner edges of the several vanes 30, 30 are located in these face recesses 46, 46 of the rotor 26. Also located within such recesses 46 is a loose ring 47, encircling the shaft 22 and having an external diameter that gives it virtual peripheral contact with an end of the inner edge portion of each of the several vanes 30, 30 of the rotor. Each ring 47, 47, by its ability to move about freely in the associated recess 46, serves as a shiftable bracing for the vanes 30, 30, the said rings 47, 47 changing the positions in the respective recesses as the eccentricity between the rotor 26 and the surrounding ring 31 is increased or decreased, as the case may be, in the operation of the pump. Whatever the pumping position (eccentricity) may be, said rings 47, 47 maintain their peripheral contact with the inner edges of the vanes 30, 30 and thus insure the vanes' contact by their outer edges with the inner periphery of the modulating ring 31.

In Fig. 1 the modulator ring 31 is shown in its position of maximum eccentricity, relative to the rotor 26, its movement to this position (of maximum pumping action by the vanes 30, 30) being obtained by the thrust thereon of a suitable spring 48 arranged in an opening 49 in the wall of the casing 15. The backing for said spring is provided by a cap member 50 secured by screws 51, 51 to the casing member 15 and providing a fluid-tight cover for the opening 49. The pressure of the spring 48 against the ring 31 is preferably transmitted by pivot member 52 whose body portion snugly fits within the spring convolutions and provides a ring or flange 53 against which seats the end of the spring. The underside of the member 52 is formed with a substantially conical pivot point 54 and for the reception thereof the modulator ring 31, at the proper angular distance from its rib 32, is formed with a circular indentation 55 having sides that taper to a point, by a wider angle than the sides of the pointed pivot 54, to afford ample clearance for limited rocking movement between ring 31 and spring 23 in the ring's adjustment of itself, as hereinafter described, to positions of greater or lesser eccentricity relative to rotor 26, in response to changes in the pressure of the fluid on the delivery side of the pump. Should the ring 31, with the pump inactive or at rest, be in any way displaced, under pressure of the spring, from the position of Fig. 1 so as not to seat perfectly by its edge 33 in the angular indentation 38, it is evident that upon starting up of the rotor's rotation in the direction of the arrow 45, the ring 31 will be immediately and automatically moved to correct seating position, due to the pressure of the fluid against the interior surface of the ring in the zone of said seating, which causes the edge 33 to bottom in the indentation 38. If fluid in excess of output requirements is being delivered by the pump the resulting increase of fluid pressure in the wedge-shaped zone 56 between rotor 26 and modulator ring 31 becomes immediately effective against the ring's inner surface in said zone to move said ring, against the pressure of spring 48, toward a less eccentric position relative to rotor 26, which automatically reduces the pumping action of the vanes 30, 30 to a point in keeping with output requirements. Thus, under all conditions, the pump will normally automatically adjust itself to deliver fluid under pressure only in amounts required by the device or

devices which it supplies. In this connection it should be understood that when the modulator ring 31 shifts from its position of maximum eccentricity (as shown in Fig. 1) it will finally arrive at a position substantially concentric with the rotor 26, in which position the vanes 30, 30 will no longer function to pump fluid and thus the ring will remain in this concentric position until the fluid requirements are such that the pressure within the inner periphery of the ring will lessen thereby permitting the ring to again pivot about its fulcrum pin 35 to the end that it will shift toward its position of maximum eccentricity. Therefore, in the hereinabove described pumping device, in the event that the speed of the pump shaft increases, the pump's fluid output, and consequently the fluid pressure within the pump will also increase, with the result that the modulator ring 31 will shift from its position of maximum eccentricity to a position concentric with the pump shaft. As soon as this concentric position is reached, the pump's fluid output, and consequently its fluid pressure will drop, to the end that the fluid pressure will remain substantially constant at all shaft speeds. The fact that the modulator ring biasing spring 48 pivots as the ring 31 shifts also makes for a constant output pressure. In this connection, it is to be understood that as the modulator ring 31 shifts upwardly about its pivot pin 35 (see Fig. 1) the lower end portion of the spring 48 will shift to the right thereby reducing the effective lever distance from the spring to the fulcrum point, which action compensates for the fact that the effective thrust of the spring increases as it is progressively compressed.

As hereinabove noted, it is a primary object of the present invention to provide a variable capacity pump of the above described type with means whereby the pressure of the pump's fluid discharge may be made to either increase or decrease, within certain predetermined limits, in response to variations in the speed of the pump shaft. In order to accomplish this objective, the present invention contemplates the provision of the hereinabove noted fulcrum pin 35. Referring particularly to Fig. 1, it is to be understood that the fulcrum pin 35 may slide radially of the shaft rotor 26 and lengthwise within the bore 34. It is to be understood that as the adjusting screw 40 is advanced into or retracted from the threaded casing aperture 39, it will be effective to shift the modulator ring 31 back and forth relative to the rotor 26 thereby altering the eccentricity of the ring with respect to the rotor. As hereinabove noted, the above described pumping unit has its fulcrum pin 35 so adjusted that the modulator ring 31 may be shifted, under the influence of fluid pressure to a position substantially concentric with the rotor 26. However, in the event that the fulcrum pin 35 is shifted radially of the pump shaft from that position disclosed in Fig. 1 entirely different pumping characteristics will obtain for the primary reason that when the ring is so shifted it can no longer be located in a position concentric with the pump shaft. For example, with the fulcrum pin shifted inwardly toward the shaft 22, the ring 31, after moving away from its position of maximum eccentricity in response to an increase in shaft speed, will merely be relocated in a position of slightly less eccentricity relative to the shaft. It therefore follows that, as the shaft speed continues to increase, the fluid pressure will be in-

creased in spite of the fact that the ring is no longer in its position of maximum eccentricity.

Shifting the fulcrum pin outwardly away from the shaft 22 tends to reverse the pumping action of the unit. In other words, if the fulcrum pin is shifted far enough in an outwardly direction the functions of the inlet and discharge ports will be completely reversed. As this reversal effect is heightened as the ring pivots about its fulcrum point away from its initial position; it follows that as the shaft speed increases, the pump will be less efficient and thus the fluid pressure will decrease.

It is to be also understood that by shifting the modulator ring fulcrum point radially of the shaft, a secondary result is effected. For example, when the fulcrum point is moved inwardly toward the pump shaft 22, it will be found that the zone of applied thrust outwardly against the inner wall of ring 31 will shift in a direction away from the ring-biasing spring 48 and toward the ring fulcrum pin 35, as the ring is shifted away from its position of maximum eccentricity. Referring particularly to Fig. 5, there is diagrammatically shown a vertical section through the present pumping unit and illustrating the pump with its modulator ring 31 in its position of maximum eccentricity and with the fulcrum pin 35 shifted inwardly from that position which is disclosed in Fig. 1. Fig. 6 is an illustration similar to Fig. 5 only disclosing the pump with its modulator ring 31 in its position of minimum eccentricity. By comparing Fig. 5 and Fig. 6 it is to be understood that as the ring 31 moves from its maximum to its minimum position of eccentricity relative to the shaft 22, the zone of applied fluid thrust will shift in a counter-clockwise direction. Thus, when this zone of thrust so shifts, the pump will be required to produce a greater thrust against the ring in order to continue to move the ring toward its position of minimum eccentricity. This is for the reason that the effective lever distance from the spring 48 (represented in Figs. 5 to 8 inclusive by arrow 48') to the fulcrum point is not reduced, during the ring's movement, in the same proportion as is the effective lever distance from the zone of applied fluid thrust to the fulcrum point. Thus, as the shaft speed increases, the fluid pressure will also increase.

When the fulcrum pin 35 is shifted outwardly from the shaft a reverse condition will obtain. Thus, as the ring moves away from its initial position, the zone of applied fluid thrust will shift away from the fulcrum point and toward the spring. Therefore, the pump will be required to produce less thrust against the ring in order to continue to move the ring away from its initial position. Therefore, as the pump speed increases, the pump's fluid pressure will tend to decrease. Figs. 7 and 8 each illustrates, in diagrammatic form, the present pump unit with its fulcrum pin 35 shifted outwardly from that position which is disclosed in Fig. 1. Also Fig. 7 illustrates the pump with its modulator ring 31 in its position of maximum eccentricity, while Fig. 8 illustrates the pump with its modulator ring in its position of minimum eccentricity. By comparing Figs. 7 and 8 it is to be understood that as the modulator ring shifts from its position of maximum to its position of minimum eccentricity relative to the rotor, the zone of applied fluid thrust will shift in a clockwise direction as hereinabove described.

By providing the present type of fluid pump

with an adjustable modulator ring fulcrum pin, it is to be understood that this construction will permit the pump unit to be built to relatively loose tolerances as far as the pivot or fulcrum location is concerned and by a simple adjustment during testing the fulcrum pin may be positioned in that location which will produce the desired pump characteristics.

Referring particularly to Fig. 9, there is illustrated several performance curves which illustrate the fact that as the fulcrum pin is shifted inwardly relative to the rotor shaft, the fluid pressure will tend to increase as the rotor shaft speed correspondingly increases. Curve 57 illustrates this condition. The curve 58 illustrates the reverse condition which obtains whenever the fulcrum pin is moved outwardly from the rotor shaft and thus causes the pump's fluid pressure to decrease as its shaft speed increases.

Figs. 10 to 13, inclusive, illustrate a modified form of the hereinabove described invention. Figs. 10 and 11 illustrate a van type pumping unit which is broadly similar to that disclosed in the preceding figures. However, the modified pumping unit is provided with no adjustable fulcrum pin and in lieu thereof this device has provided on the inner surface of its bore 19 a two-sided indentation 59, somewhat shallower than the modulator ring rib 32 and with its intersecting sides at an appreciably larger angle to each other than the intersecting sides of the rib thus to give ample clearance for free and frictionless rocking movements of the ring 31 on the axis afforded by the bottoming of the rib edge 33 in the angular indentation 59.

Referring particularly to Fig. 11 it is to be understood that the modified form of pump device is adapted to have its end plate 17' disposed in a flush relation with a machine surface of a driving unit, not herein disclosed. This particular driving unit has extending therefrom a rotary shaft 22' the free end portion of which extends into the pumping unit in a manner substantially the same as that disclosed in Fig. 2, with the exception that the shaft 22' does not extend clear through the pumping unit but is covered over by an end plate 16'. However, the shaft 22' is keyed to a rotor 26 and functions in the same fashion as the shaft 22 which is disclosed in the Figs. 1 and 2. However, it is to be particularly noted that the end plate 17' of the modified form of the device is provided with a shaft-receiving aperture 60 the diameter of which is slightly larger than the diameter of the pump shaft 22'. The present pump casing is adapted to be rotatably mounted upon a pivot pin 61 which, in turn, is secured within the machined surface of the driving unit to which the pump is adapted to be secured. Also, the present pumping unit is provided with an aperture 62 in which is rotatably mounted a cam pin 63. Referring particularly to Fig. 12, it is to be understood that the cam pin 63 is substantially cylindrical in shape and has formed at one end portion thereof a cylindrical cam element 64. Also, the casing 15' of the present pumping unit has a threaded aperture 65 formed therein for the purpose of receiving a set screw 66 which functions to lock the cam pin 63 in any desired position within the casing 15'. The cam portion 64 of the pin 63 is adapted to be received within an aperture provided within the machined surface of the driving unit and thus, if the pin 63 is thereafter rotated, it is to be understood that the entire pump casing 15' will be turned about the pivot 61.

A screw driver slot 67 is provided in one end of the pin 63 to facilitate the adjustment of the pin 63.

From the above it will be readily appreciated that as the pin 63 is so adjusted, the casing 15' will be turned about the pivot 61 to the end that the modulator ring 31' will be shifted eccentrically of the rotor 22'. By properly adjusting the pin 63 the modulator ring 31' will be made to approximate those adjustments which are performed in the first form of the present invention by means of the fulcrum pin 35.

We claim:

1. In a variable delivery fluid pump having, an outer housing providing fluid intake and delivery connections, a rotor having radially slidable vanes and rotatable in said housing, a pivotal mounting means carried within said housing, a modulator ring rockably mounted at its periphery within said housing and upon said pivotal mounting means so as to surround said rotor and to cooperate by its inner surface with said vanes to produce the pumping action, and spring means urging said ring about said pivotal mounting means to eccentric position relative to said rotor for maximum pumping action by said vanes, said spring means having a turning moment on said ring which is opposed by a turning moment produced by the pumping pressure acting on an inner surface area of said ring between said pivotal mounting means and said spring means, in a direction to move said ring toward concentric or non-pumping position; the improvement which consists in that the rotor modulator ring not only is rockable but also is adjustably shiftable generally radially of the rotor on a line between the axis of the rotor and said pivotal mounting means and in the provision of means for adjusting said pivotal mounting means and thereby said modulator back and forth generally radially of said rotor so as to shift the center of said modulator ring back and forth across the center of said rotor when said ring is in its position of minimum eccentricity relative to said rotor for increasing or decreasing the fluid pressure of the pump for any given rotor speed, said adjustable means comprising a member operatively movably mounted relative to, and extending through, said housing so as to be actuable during the operation of said pump unit.

2. In a variable delivery fluid pump, an outer housing providing fluid intake and delivery connections, a rotor having radially slidable vanes and rotatable in said housing, a pivotal mounting means carried by and within said housing, a modulator ring disposed within said housing and being pivotally mounted at its periphery upon said pivotal mounting means so as to surround said rotor and present an unbroken interior surface to said vanes for the pumping action thereby, said housing surrounding said modulator ring in spaced relation to enable pivotal movement of the modulator ring back and forth relative to the rotor and transversely to the direction of pivotal movement, means carried by said housing comprising a member movable relative to the housing and operatively connected to said pivotal mounting means for adjusting said pivotal mounting means, and consequently said modulator ring, back and forth radially of said rotor, and spring means carried by said housing at a point substantially ninety degrees from said pivotal mounting means about said rotor for urging said modulator ring about said pivotal mounting

means to eccentric position relative to said rotor for maximum pumping by said vanes, said spring means having a turning moment on said modulator ring which is opposed by the turning moment produced by pumping pressure acting on an inner surface area of said modulator ring between said pivotal mounting means and said spring means in a direction to move said modulator ring toward concentric or non-pumping position the back and forth movement of said modulator ring being within an effective range affording substantial increase of pressure at one extreme and substantial decrease in pressure at the other extreme with identical rotor speed.

3. In combination in a variable delivery fluid pump, an outer housing providing fluid intake and delivery passages, a rotor in said housing, a modulator ring in said housing surrounding said rotor and presenting an unbroken circular interior surface spaced from the rotor, means on the rotor cooperating with said surface for effecting a pumping action in the rotation of the rotor, a biasing spring normally operating on said modulator ring to move it to maximum eccentricity relation to the rotor, and pivot means on which the modulator is rockable into and out of said eccentric position relative to the rotor, said pivot means including a fulcrum, and means for adjusting said fulcrum into selective positions relative to said rotor on a line transverse to the rotor axis and including a device operable from outside said housing for varying the effective lever distance from said spring to the fulcrum point of the modulator at said pivot means throughout a substantial range at one extreme of which pump pressure is increased and at the other extreme of which pump pressure is decreased at any given speed of the rotor.

4. In combination in a variable delivery fluid pump, an outer housing providing fluid intake and delivery passages, a rotor in said housing and rotatable about a fixed axis, a modulator ring in said housing surrounding said rotor and pre-

senting an unbroken circular interior surface spaced from the rotor, means on the rotor cooperating with said surface for effecting a pumping action during rotation of the rotor, a biasing spring normally operating on said modulator ring to move it along a first path crosswise of said rotor axis to a maximum eccentricity relation to the rotor, pivot means on which the modulator ring is rockable into and out of said eccentric position relative to the rotor, said pivot means including a fulcrum and means for adjusting said fulcrum and said modulator ring into selective adjusted position relative to said rotor along a second path crosswise of the rotor axis and also crosswise of said first path, said means for adjusting said fulcrum comprising an element movable relative to said housing and having a portion operable from outside said housing, whereby the fluid pressure at the pump delivery passage may be varied at any given speed of the rotor.

5. The combination as defined in claim 4 wherein the pivot means for the modulator ring is fixed relative to the housing and the housing is movably mounted relative to said fixed rotor axis for movement relative thereto by said adjusting means.

6. The combination as defined in claim 3 wherein said pivot means is fixed relative to said housing and said housing is movably mounted relative to said rotor for adjustment relative thereto by said adjustment means.

WARREN H. DE LANCEY.
BERTRAM P. POND.
HARRY L. CHISHOLM, JR.

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