

June 8, 1954

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2,680,412

VARIABLE VOLUME VARIABLE PRESSURE PUMP

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3 Sheets-Sheet 1

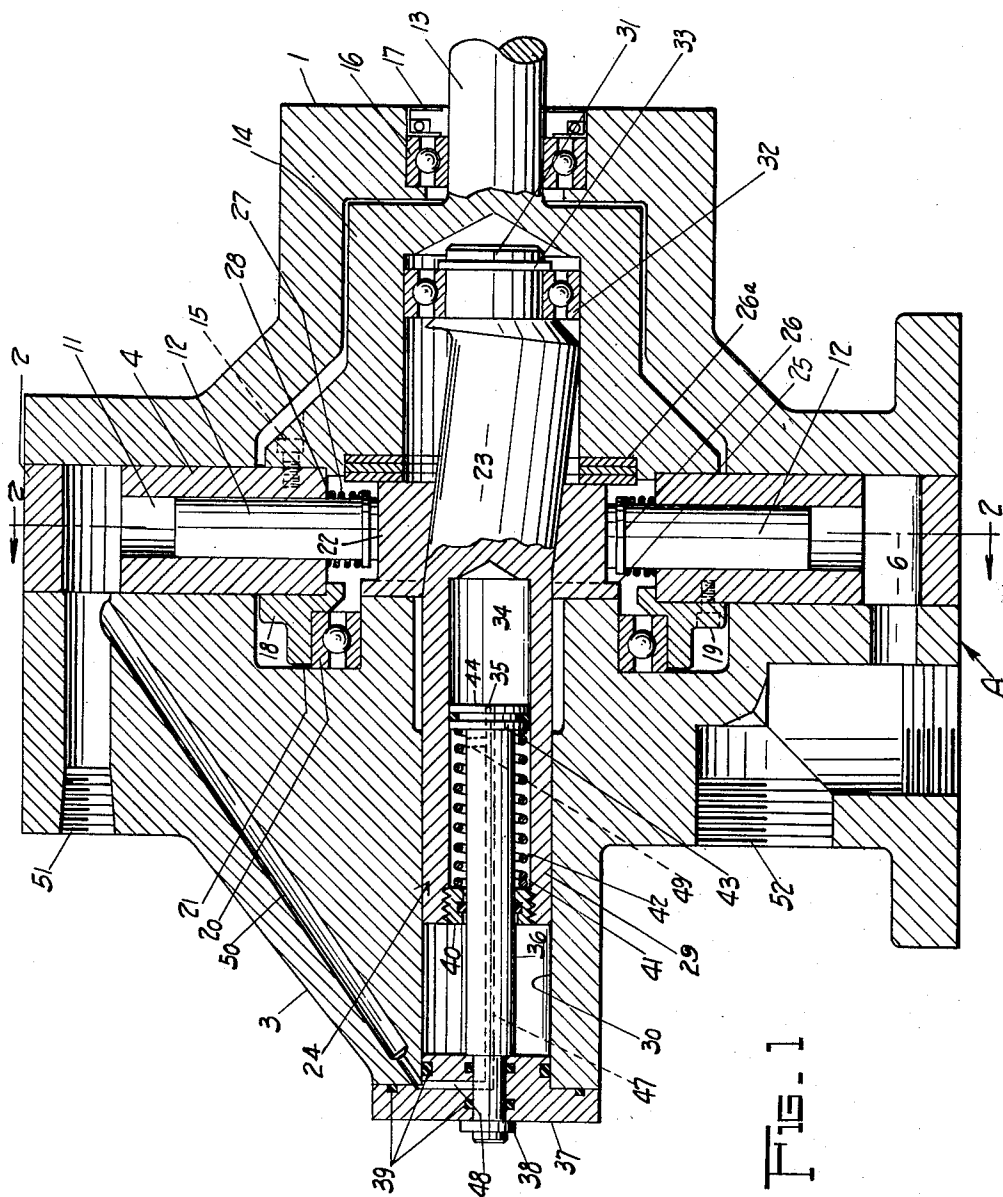


FIG. 1

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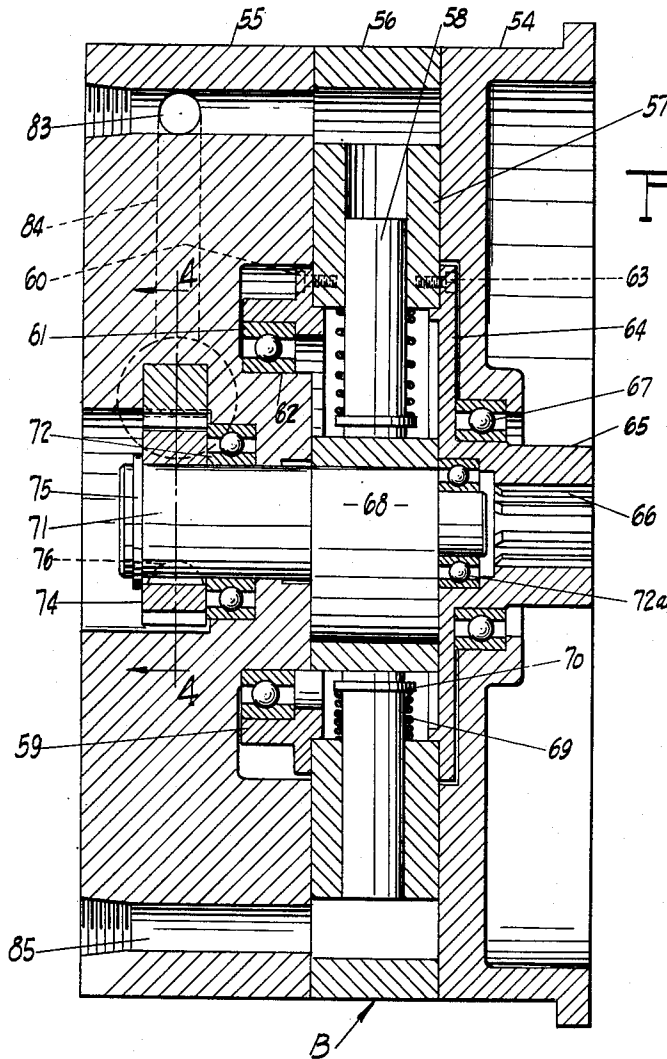


FIG. 3

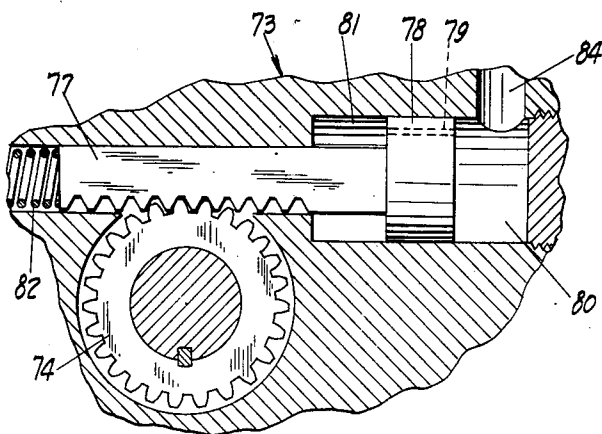


FIG. 4

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VARIABLE VOLUME VARIABLE PRESSURE
PUMP

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2 Claims. (Cl. 103—161)

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This invention relates to fluid pumping devices and more particularly to such devices adapted to pump hydraulic fluid under pressure for various applications. In particular this invention relates to pumps of the radial piston type and to the kind of pump within that class wherein the radial pistons are carried in a rotating member or rotor, the pump likewise including means to vary the stroke of the pistons automatically in response to various requirements of an hydraulic system wherein the pump is availed of for use.

Heretofore, hydraulic pumps have in many cases been provided with manual means to vary the stroke of pistons associated therewith, and in cases where automatic means have been availed of in other types of pumps using pistons, the means for varying the stroke have been very complicated so as to require undesirably difficult manufacture.

It is therefore a primary object of this invention to provide a pump of the radial piston type wherein constant horsepower requirements are present and yet the pump provides variable pressure and/or variable volume of fluid, in response to the demands of an hydraulic system.

It is a further object of this invention to provide a pump wherein means are provided for varying the volume and/or pressure in response to the requirements of the system.

It is a still further object of this invention to incorporate simple yet sensitive means for the above purposes which are automatic in operation in response to said requirements.

It is a further object of this invention to provide a novel arrangement of parts within the pump itself to effect the required responses.

A still further object is to provide a pump delivering high volume at low pressure, as required for fast traverse motion, a pump also making available low volume-high pressure delivery, required for holding power which many modern machines and machine tools must have available, at the same time eliminating necessity for using two or more pumps and a complex arrangement of relief, by-pass, and control valves availed of at the present time.

Other and further objects of this invention will be apparent upon a consideration of the description of the invention as disclosed in the drawings in which:

Figure 1 is a longitudinal sectional view of one form of the pump of this invention, disclosing the various parts thereof in the minimum-volume maximum-pressure relationship.

Figure 2 is a transverse sectional view taken about on the line 2—2 of Figure 1.

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Figure 3 is a longitudinal sectional view showing a somewhat different form of pump incorporating the principles of the invention therein.

Figure 4 is a fragmentary sectional view taken about on the line 4—4 of Figure 3 and illustrating certain of the operating parts of the modification of Figure 3.

Referring to Figure 1, it will be noted that the pump of my invention includes a drive-end housing generally denoted 1, of substantially circular exterior configuration, a rotor housing 2 adjacent thereto, and a control end housing 3 adjacent said rotor housing. These three housings are suitably fastened together in any preferred manner, not further illustrated since the same will be obvious to those skilled in the art and comprise the main pump housing generally designated A. A rotor member 4 of circular form being a section of a cylinder and to be more particularly described hereinafter, is supported interiorly of the pump between the drive end housing 1 and the control housing 3, within the rotor housing, and being of less diameter than the inner diameter thereof so as to be spaced slightly from the said rotor housing 2 (see Figure 2), an outlet chamber 5 and an inlet chamber 6 are formed, by the provision of lands or projections 7 and 8 formed integrally with the said rotor housing. The said lands or projections 7 and 8 are fitted with slide plates 9, adapted to engage the periphery of the rotor, the said slide plates being held in engagement with said periphery by means of the springs 10. The slide plates are of substantially rectangular form and extend throughout the width of the rotor housing and rotor so as to provide a minimum of clearance between the end faces thereof, and the housings 1 and 3.

The rotor 4 as shown in Figure 1, is adapted to rotate within the pump between the housings 1 and 3, being fitted thereto very closely, so as to provide a minimum amount of working clearance therebetween. The said rotor 4 includes a plurality of radially extending cylindrical chambers 11, the said cylindrical chambers carrying closely fitted pistons 12, for reciprocation therein, in a manner to be described.

The rotor 4 is supported for rotation interiorly of the pump, at one end, on the drive shaft 13, by means of a hollow extension 14, said latter member being hereinafter called a rotor drive member. The rotor drive member 14, is hollow interiorly and on its exterior is formed so as to provide clearance between the drive end housing 1, and the said drive member. The drive member 14 is suitably fastened to the rotor member 4, by means of the cap screws 15. The drive shaft 13

is rotatably supported in the housing 1, on a bearing 16, and a suitable seal 17 is provided adjacent the said bearing and in the end of the housing 1.

The rotor 4 is supported for rotation at the end opposite that just referred to, on a supporting member 18 fastened to the rotor 4, by means of cap screws 19 or in any other suitable manner as desired or required by the construction of the pump. The rotor supporting member 18 is in turn carried by a bearing 20, which bearing 20 is located in the annular opening 21, and pressed on a boss formed with the control end housing 3 as seen in Figure 1. A cam member 22 is supported on the shaft member or portion 23, of a cam operating unit generally designated 24, in a manner to be hereinafter described, interiorly of the rotor member or rotor 4. The cam member 22 is of circular configuration and is restrained from rotation relative the control end housing 3, as by the provision of key portions 25 formed integrally with said housing 3, as seen more clearly in Figure 2, extending vertically adjacent the center portion of said housing. A camming key way is provided in the cam member 22, adapted to receive therein the key portions 25 previously mentioned. It will therefore be noted that vertical movement of the cam 22, in a manner to be hereinafter set forth, is permitted, and that rotational movement of the said cam 22 is prevented. Suitable thrust plates 25a are provided to receive the thrust of cam member 22 against rotor drive member 14 (see Figure 1), when in accordance with conventional pump operation, a thrust relationship is present. The pistons 12 are maintained in constant contact with the periphery of the cam 22, at their inner ends by means of springs 27. Suitable snap rings 28 are seated in grooves formed adjacent the ends of the pistons 12, are provided, and the springs 27 surround the ends of the said pistons and are maintained thereon by the snap rings and contact with the inner periphery 28 of the rotor 4.

The cam 22 may preferably be formed in two parts as seen in Figure 2, and includes a shaft opening therein, the axis of said shaft opening lying at an angle to the normal axis of said cam, bolts being provided to maintain the two parts together. The cam operating unit 24, previously referred to, includes a hollow shaft 29, the shaft portion 23 being connected thereto, preferably integrally. The axis of the shaft portion or member 23, lies at an angle to the axis of the shaft 29 and is adapted to be received in the shaft opening in the cam 22 previously described. The control end housing 3 is provided with a cylindrical opening 30, in which the shaft 29 is adapted to reciprocate, this reciprocation in turn imparting movement to the cam member 22 in a vertical direction, by reason of the angular relationship of the axis of the shaft portion 23 with the axis of the shaft 29.

Shaft portion 23 of the unit 24 is provided at one end with a round bearing portion 31 adapted to receive thereon a bearing 32, the said bearing being held in place on the portion 31 by means of a snap ring 33. The bearing 32 is mounted so as to fit closely in the hollow rotor drive member 14, but at the same time is permitted to reciprocate therein in a manner to be hereinafter set forth. It will be clear that during this reciprocation, the drive member 14 may be rotated with respect to the shaft portion 23 but will not impart any rotative motion to the said shaft portion 23.

The hollow shaft 29 of the operating unit 24 includes a chamber 34 adapted to receive therein a piston member 35. The piston member 35 is connected to a shaft 36, the said shaft 36 in turn being secured to an end cap 37 on the housing 3, by means of a snap ring 38 adjacent the end of said shaft 36. The end cap 37 is sealingly engaged with the control end housing 3 in any suitable manner, the seals 39 being provided therefor. A suitable threaded cap member 40 is fitted into the end of hollow shaft 29 of the unit 24 so as to provide a chamber 41 surrounding the shaft 36. Interiorly of the said shaft 29, a suitable compression spring 42 surrounds the shaft 36, and is confined between cap 40 and a surface 43 of the piston member 35 previously referred to. It will be noted that the areas of the face 43, and an opposite face 44, of the piston member 35, are unequal by reason of the connection of the shaft 36 with the face 43 of the piston member, as shown in Figure 1. A passage 47 extends axially through the shaft 36, one end of the passage 47 opening into the chamber 34 previously referred to, the other end of said passage being in alignment with a radial passage 48 formed in the end cap 37. A port 49 is provided, whereby the passage 47 communicates with the chamber 41. The radial passage 48 in the end cap 37 previously mentioned, is aligned so as to communicate with an angularly extending passage 50 formed in the control end housing 3, the said passage 50 in turn communicating with a discharge outlet or port 51, the said port 51 opening into the outlet chamber 5 previously referred to. An inlet port 52 is provided, the same being shown in Figure 1 as having alternative directions of opening whereby to communicate with the inlet chamber 6 previously mentioned.

As shown in the drawing Figures 1 and 2, the pump and its related parts are in the position of minimum stroke-maximum pressure operation, since the cam 22 is in axial alignment with the center of the rotor 4, the pistons occupying what is known as a zero stroke position. It will be noted that movement of the cam operating unit 24 to the left will cause the cam 22 to move downwardly from its position shown in Figure 1 whereby the cam will no longer be in the zero stroke position but will have been moved downwardly by reason of the offset shaft portion 23 of the said unit 24 having been moved to the left, imparting movement to the cam as above described.

A description of the operation of the pump shown in Figures 1 and 2 will further clarify the construction thereof and its suitability for incorporation in hydraulic systems which require the same.

Initially, a rotating prime mover such as an electric motor or the like, is suitably fastened to the drive shaft 13 to impart rotative movement thereto, and thereby the rotor drive member 14 and the rotor 4, together with the pistons 12 carried thereby. Initially, it should be explained that this description of operation will be based on the assumption that the rotor is moving in a clockwise direction as indicated by the arrow in Figure 2. Since the pump in the condition of operation shown in Figure 2, would be operating at maximum pressure (in pounds per square inch), the fluid pressure in the outlet chamber 5 would be the same maximum pressure as in the chambers at the ends of the pistons 12. This pressure is in turn communicated to passages 50, 48, 47 and 49, to the chambers 41 and 34.

Since the area of the face 44 of the piston 35 is greater than the area of the face 43 of said piston the total force on the face 44 will be greater than the total force on the face 43. This differential of forces will cause the shaft 29 to move to the right until the spring 42 has been compressed sufficiently so that the force exerted thereby equals the differential of forces on the faces 43 and 44, since the spring is of the usual construction, the actual force exerted by the spring is equal to the force exerted by the spring totally deflected, multiplied by the ratio of actual deflection, divided by the total deflection.

As was previously noted, the pump pressure, (in the drawing of Figure 1) has caused the cam operating unit 24 to move to the right so that the spring force equals the differential of forces on the faces 43 and 44. In this position the cam 22 has moved so that the outer periphery thereof is centered axially of the rotor 4, and therefore no reciprocation of the pistons 12 will take place. This is known as the maximum pressure-minimum volume position of the pump, at which position no fluid is transmitted but the pressure is maintained. If the pressure demands of the system, to which the pump is connected begins to fall, the pressure in the chamber 34 will also drop. The total forces acting on the faces 43 and 44 will correspondingly drop, the difference of the forces on said faces, thereby being smaller. The spring 42 will therefore expand until the spring force is equal to the smaller differential of forces. It will be obvious that the operating unit 24 will thereupon move to the left, thereby changing the position of the cam 22, and thus the stroke of the pistons 12 is increased. The volume of fluid pumped by the pistons is therefore increased. The angle of the shaft portion 23 of the operating unit 24, is so proportioned that the stroke of the pistons, as imparted thereto by the cam 22, will vary directly inversely to the pressure. The function of pressure times flow volume remains constant, and since horsepower is a function of pressure times flow volume, the horsepower requirements of the pump will remain constant.

If the pressure demands of the system fall to zero pounds per square inch, there will be no differential of forces on the faces 43 and 44 of the piston 35. This will permit the spring 42 to expand to its maximum length and thereby move the operating unit 24 to the left, in which position the right hand end of the chamber 34 will be substantially adjacent the face 44 of the piston 35. It is obvious that in this position the operating unit 24 will have been moved to its extreme left position and thereby the cam 22 will be at the bottom position of its movement. The periphery of the cam 22 will of course therefore, be in eccentric relation with respect to the rotor 4. Since rotor 4 is revolving, the pistons will reciprocate in the cylindrical chambers 11 provided therefor, thus imparting a pumping motion to the said pistons. In order to further explain the cycle of action of this pump, a particular chamber will be designated at the end of one of the pistons 12, namely, chamber 53 (Figure 2). As the piston associated with the chamber 53, begins to move outwardly with respect to the center of the rotor, during rotation of the latter, such motion will expel any fluid in the said chamber into the outlet chamber 5 previously mentioned and thus into the port 51 and passages 50, 48, 47 and 49 connected therewith, whereby the forces will be imparted to the respective faces of the

piston 35 as has been previously set forth. When the piston 12, associated with the chamber 53, has reached the extreme outward position of movement in contact with the cam 22, by reason of the eccentricity of the latter, substantially all of the fluid in the said chamber 53 will have been expelled therefrom into the outlet chamber 51. At this point the piston above just referred to, will be passing the projection or land 8. As it passes land 8, the inward stroke of the piston will commence and will continue, to thereby create a vacuum within the chamber 53 into which fluid will rush until the end of the stroke of the piston 12, the same being then at the low point of the cam 22. At this point the chamber 53 will be passing the land or projection 7, and thereafter will commence its outward stroke to continue the cycle before noted. It will be clear that the fluid will enter the inlet port 52 under the vacuum created by the inward movement of the piston 12 previously described.

The cycle of action of a piston as just described, will of course be followed by each one of the pistons therein. During the last described condition of operation of the pump, wherein the cam 22 had moved to its lowermost position, thereby imparting the maximum stroke to the piston, the pump will be delivering the maximum volume of fluid at the minimum pressure of fluid.

In view of the above description, it will be apparent that any combination of pressure and volume may be automatically selected depending upon the demands of the system in which the pump of my invention is incorporated. It might also be noted that in accordance with best construction principles in the art in which this invention is found, the relative clearances between the respective parts will be held to a minimum so as to reduce to a minimum the leakage problems which are sometimes encountered.

It should also be noted that the pump above described may be rotated in a counterclockwise direction, the inlet and outlet ports 51 and 52 thereby being reversed, so that the pump will thus be a constant volume pump.

The modification of the pump of my invention, disclosed in Figures 3 and 4, includes similar parts therein and is adapted to operate in a similar manner to the pump of Figures 1 and 2. In this modification however, the cam adjusting means or cam operating unit, is the primary constructional difference.

As shown in Figure 3, the pump comprises a drive end housing 54 and a control end housing 55 adapted to support therebetween a rotor housing 56, the latter being of substantially the same configuration as that shown in Figure 2, including the lands or projections 7 and 8 of said figure, and the slide plates 9 backed by the springs 10. The housing members above referred to are suitably fastened together in any desirable manner comprising a main housing B and enclose the rotor 57 therein, the latter being substantially the same type of rotor as in the previously described form of my invention. The pistons 58, supported in radial cylindrical chambers of the rotor 57, are adapted to reciprocate therein for the purposes of pumping fluid. The rotor is supported for rotation in the pump by a rotor supporting member 59. The member 59, bearing 61 and annular opening 62 are substantially identical to the corresponding parts disclosed in Figure 1. At the opposite side of the rotor and engaged therewith for support thereby, by means of cap screws 63 or the like, is a rotor drive member 64.

The said member 64 is a plate-like member and is formed integrally with the drive shaft 65 of the pump. The said drive shaft 65 includes therein, a blind female drive section 66 and is rotatably supported in the drive housing 54 upon a bearing 67. A suitable seal may be incorporated adjacent the bearing 67 to prevent the escape of the hydraulic fluid in the pump in accordance with known practice in this art.

The pistons 53 are adapted to coact with a cam or eccentric 68, the said cam being located generally substantially centrally of the rotor 57, by means of suitable springs 69 surrounding the inner ends of the said piston members 53, abutting at their outward extremities the inner surface of the rotor 57 and at their inner extremities, seated upon snap rings 70 fitted in grooves in the inner end of the piston whereby the tension of the said springs will maintain the pistons in constant engagement with the cam or eccentric 68.

The said cam or eccentric 68 is provided with a shaft 71 preferably formed integrally therewith, the shaft 71 in turn supporting the eccentric, said shaft being fitted in a bearing 72. The bearing 72 is seated in a suitable opening provided in the control end housing 55 as seen in Figure 3. A suitable seal may be provided adjacent the bearing 72 to prevent the escape of fluid in accordance with known practice. On the opposite end of shaft 71, adjacent cam or eccentric 68, a bearing 72a is fitted into a suitable opening in the drive shaft 65. Adjacent the bearing 72 just mentioned, the cam operating unit generally designated 73 (see Figure 4) is shown as including a spur gear 74 maintained in engagement with the end of the shaft 71 by means of a snap ring 75 or in any other suitable manner, and held against rotation relative said cam 71 by means of a key 76, said key being seated in a key way of the shaft 71 and a corresponding key way in the spur gear 74.

As shown in Figure 4, the spur gear 74 of the cam operating unit 73 is engaged with a rack member or piston rod 77, the said member 77 being preferably rectangular shaped in cross section and having teeth formed thereon, the said piston rod 77 being connected to piston 78. The piston 78 is provided with suitable passages 79 made by drilling or the like. The passages 79 in the pistons 78, are adapted to connect chambers 80 and 81 at opposite sides thereof formed in the chamber in which the piston reciprocates. At the end opposite the piston, the rod 77 is adapted to engage a spring 82, the said spring in turn being seated upon a suitable portion of the housing provided therefore. The chamber 80 is connected to an outlet port 83, by means of a passage 84 formed in the housing 55. The last named outlet passage and connecting passage, correspond to the passages 51 and 50 of the pump shown in Figure 1. A suitable inlet passage or port 85 is provided, which corresponds to the inlet port 52 of the previously disclosed form of my pump.

It will be clear from the foregoing that movement of the piston member 78, in response to an increase of outlet pressure will impart a rotative motion to the spur gear 74, whereby the shaft 71 connected to the cam 68, will likewise be rotated, to thereby impart rotation to the cam 68 as mentioned and thus increase or decrease the stroke of the pistons 53 previously referred to. This operation of course will correspond to the movement of the cam 22 of Figure 1, to increase or de-

crease the stroke of the pistons in response to pressure changes in the hydraulic system to which the pump of this disclosure is connected.

In the position of the parts of the modification disclosed in Figures 3 and 4, the cam eccentric 68 is shown in a maximum volume-minimum pressure position as contrasted with the position of the cam 22 of Figures 1 and 2. As the pressure in the system increases, the eccentric or cam 68 will turn toward the minimum-volume maximum pressure position whereby the eccentric or cam 68 will be in a position wherein its periphery will approach a concentric relationship with the rotor 57 and cause the pistons 53 to move toward their zero stroke position. At the zero stroke position, no fluid will be delivered and thus the pressure in the system will be maintained. In view of the foregoing, it will be clear that the last described form of my pump invention, discloses a device which operates in substantially the same manner as the unit of Figures 1 and 2, the difference residing in the form of cam and the mechanism of the cam operating unit. Each pump is constructed so as to provide means responsive to pump outlet pressure for controlling or varying the stroke of the pistons therein.

It is of course contemplated that changes in proportion and size of the parts in their various forms, may be made in accordance with the requirements of the system, or systems with which the pump of my invention is used.

Having thus described my invention, and disclosed the same in the drawings, what I claim as new is set forth in the following claims:

1. In a pump of the class described, in combination, a housing, fluid inlet and outlet chambers in said housing, a rotor in said housing, cylinders and pistons in said rotor, the pistons being radially operable therein, means for rotating said rotor whereby fluid under pressure is delivered to said outlet chamber, a cam axially disposed with relation to said rotor for moving said pistons and varying the stroke thereof, a cam operating unit engaging said cam, and means for translating pressure developed in said outlet chamber into movement of a part of the cam operating unit to vary the stroke of said pistons, said unit including a shaft member shiftable axially of the rotor, the cam being supported on said shaft member, a pressure chamber formed in said shaft, a fixed piston having opposite faces of different areas confined in said pressure chamber, and conduit means to transfer fluid under pressure from the outlet chamber to the opposite faces in the pressure chamber, whereby the pressure differential effects movement of the shaft as specified.

2. In a pump of the class described, in combination, a housing, fluid inlet and outlet chambers in said housing, a rotor in said housing, cylinders and pistons in said rotor, the pistons being radially operable therein, means for rotating said rotor whereby fluid under pressure is delivered to said outlet chamber, a cam axially disposed with relation to said rotor for moving said pistons and varying the stroke thereof, a cam operating unit engaging said cam, and means for translating pressure developed in said outlet chamber into movement of a part of the cam operating unit to vary the stroke of said pistons, said unit including a shaft member shiftable with respect to the rotor, the cam being operable by said shaft, a piston having opposite faces of different areas being engaged with said shaft, a pressure chamber being provided for said pis-

ton, and conduit means being provided to transfer fluid under pressure from the outlet chamber to the pressure chamber for application to said opposite faces, whereby the pressure differential effects movement of the cam to vary the stroke as specified.

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