June 17, 1941. H. A. CENTERVALL 2,245,570

FLUID PRESSURE DEVICE

Filed May 20, 1938 2 Sheets-Sheet 1

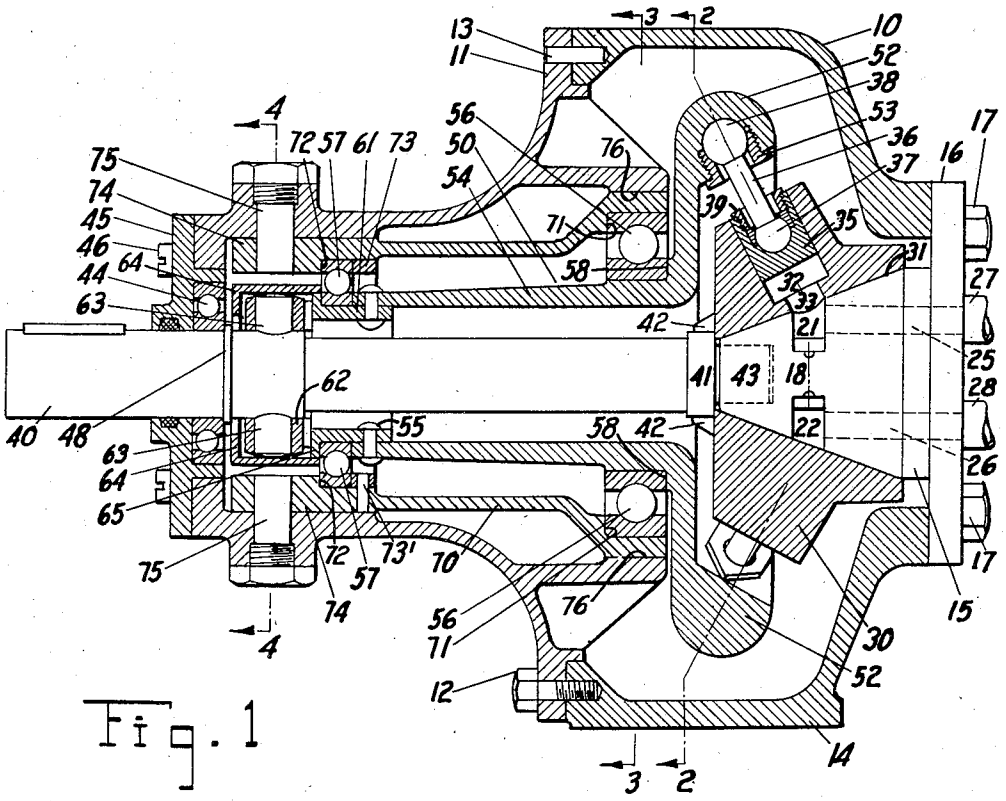


Fig. 1

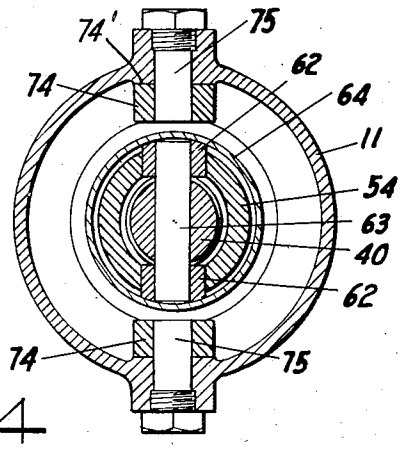


Fig. 4

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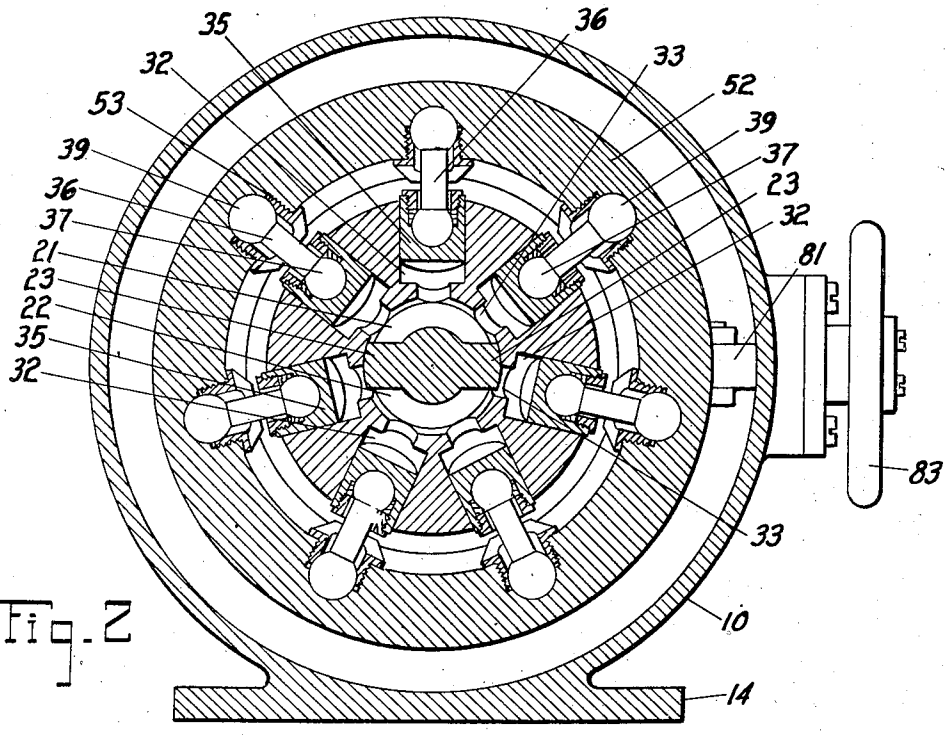


Fig. 2

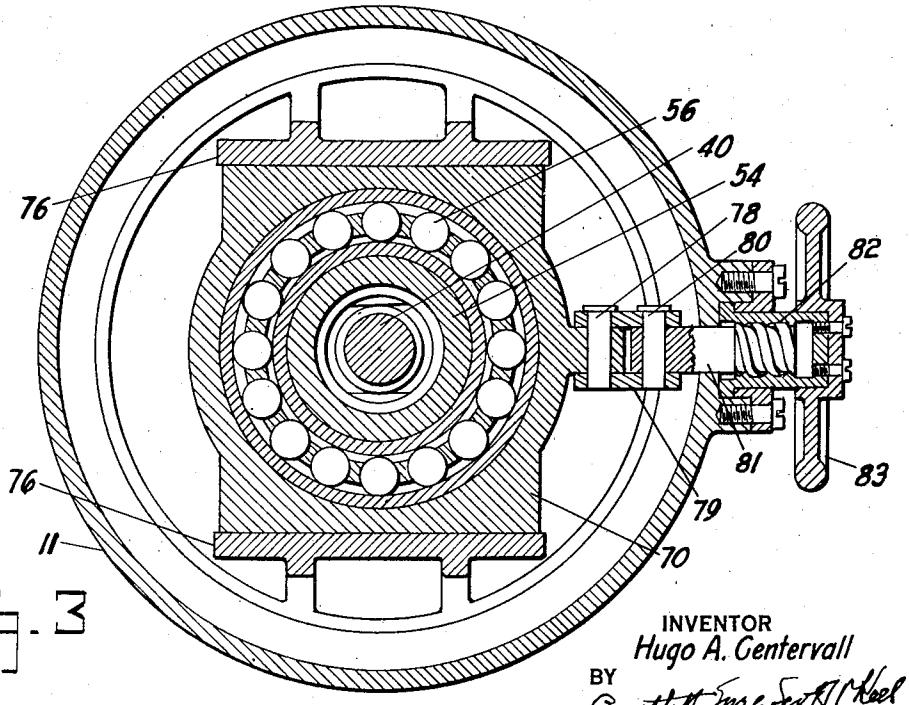


Fig. 3

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UNITED STATES PATENT OFFICE

2,245,570

FLUID PRESSURE DEVICE

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Application May 20, 1938, Serial No. 209,030

14 Claims. (Cl. 103—161)

This invention relates to pumps and fluid motors of the piston-and-cylinder type and in which there is relative rotation between the cylinder and valve elements, and particularly pumps and motors of the type wherein the cylinders are generally radially disposed with respect to the shaft or axis of rotation.

The truly radial cylinder pump or motor has, among others, the advantage that it may be practically designed and constructed for continuous operation under heavy loads but has the disadvantage that leakage between the rotatable cylinder body and the valve element will increase upon rise in pressure. One object of the invention is a novel and improved fluid pressure device of this general character embodying the advantages of the truly radial type and also the advantage that leakage between the valve and cylinder element is reduced to a minimum.

Another object is to provide a pump or fluid motor having novel and improved cylinder and valve elements which are simple to manufacture, are adjustable to take up any wear of their rubbing surfaces and which cooperate to more tightly seal the running joint between them responsive to increases in the operating pressure of the fluid.

A further object is to provide an improved crank or eccentric mechanism for reciprocating the pistons in the cylinders, this crank making it possible to employ several different types of operative connections between the pistons and said crank.

Other and more specific objects will appear from the following illustrative embodiments of the invention and the description thereof.

In the accompanying drawings:

Fig. 1 is a central longitudinal view, partly in section of a structure embodying the invention.

Figs. 2, 3 and 4 are views, partly in section, transverse the axis of rotation, taken along the lines 2—2, 3—3 and 4—4 respectively of Fig. 1 and looking in the direction of the arrows.

The pump or fluid motor selected for illustration is of the variable capacity type such as used in hydraulic transmissions for obtaining variable speed or torque but the structure may be used with like advantages in pumps or motors of fixed capacity. For purposes of description the structure will be considered as a pump in which a cylinder element rotates about a stationary valve element, though the structure is equally usable as a motor.

Referring now to the drawings, as shown in Fig. 1 the enclosing casing is preferably formed in two portions and comprises a rear member 10 to which the front member 11 is attached, as by cap screws 12, the two parts being positioned with respect to each other as by a dowel pin 13. The enclosing casing forms the support for the device and the member 10 is accordingly provided with a suitable base 14.

The rear casing member 10 is formed with a central aperture for receiving a stationary valve member 15 which is formed with a flange 16 by which it is supportingly attached to said rear casing member 10 as by cap screws 17. The structure includes a cylinder carrying body 30 rotatably mounted with respect to the valve member 15.

The valve member 15 is provided with a conical portion having a conical valve surface 18 symmetrically disposed about an axis, that is to say the valve surface 18 is the lateral surface of a truncated right circular cone. The valve's central portion forms the support and bearing surface for the rotatable cylinder carrying body 30 and the latter is accordingly provided with a central opening 31 adapted to serve as a valve chamber and formed with a conical surface corresponding to the conical valve surface 18 about which the body 30 is adapted to rotate and with which it forms a substantially fluid tight running joint or fit. The body 30 carries or is provided with a plurality of cylinders 32 (Figs. 1 and 2) symmetrically disposed in a generally conical arrangement, that is to say the center lines of the cylinders 32 are slanted or inclined from the radial position and in a direction generally opposite to the slant of the conical valve surface 18, as best shown in Fig. 1.

Each cylinder 32 is provided with a cylinder port 33 whose area is less than the area of its corresponding cylinder. The cylinder ports 33 are adapted to register, upon rotation of the cylinder body 30, with a pair of valve ports 21 and 22 respectively formed in the conical valve surface 18 and extending in a generally circumferential direction with respect thereto, the valve ports 21 and 22 being separated by a transverse land 23 as best shown in Fig. 2. Each cylinder 32 is also provided with a slidably fitted piston 35 which is adapted to be reciprocated, as the cylinder body 30 rotates, by any suitable crank or eccentric mechanism, a preferred embodiment of which is below described.

The valve ports 21 and 22 are appropriately connected as by longitudinal passages 25 and 26 respectively with suitable pipes 27 and 28 through which fluid is conveyed to and from the pump.

Upon rotation of the cylinder carrying body 30 and reciprocation of the pistons 35 by the crank mechanism, pressure fluid will be discharged into one or the other of the valve ports 21 or 22, the other of which will then be the suction or inlet valve port. For purposes of explanation it will be assumed that the valve port 21 is the discharge or high pressure port and that the valve port 22 is the suction or inlet port. All of the cylinders 32 whose cylinder ports 33 are at any instant in communication with the valve port 21 (see Fig. 2), will, of course, contain fluid under the same pressure as that in said valve port 21, that is, they will contain fluid under the same pressure as that which the pump is called upon to deliver.

Pressure fluid in the discharge or high pressure valve port, which is here assumed to be the valve port 21 as previously stated, acting upon the portion of the valve chamber 31 exposed thereto, will exert an axial force upon the cylinder body 30 tending to move it toward the left as viewed in Fig. 1. The amount of this axial force, for any given pressure of the fluid, will depend upon the vertical rise across the valve port (i. e. the difference in the radii at the points of the valve port's smallest and greatest diameter along the slant of its conical surface) and the circumferential length of said valve port.

This axial force tending to move the cylinder body 30 toward the left will be opposed, however, by the axial resultant of forces exerted upon the cylinder body 30 by the pressure fluid acting upon the constricted inner ends of all of the cylinders 32 which at any instant are in fluid communication with the high pressure valve port 21. The presence of the force producing this axial resultant is due to the inclination of the cylinders 32 and to the constriction of the cylinder ports 33 and the amount of this resultant, for any given pressure of the fluid, is dependent upon the degree of inclination of said cylinders, the extent of the constriction of the cylinder ports and the slant of the conical valve surface 18, and also upon the dimensions of the high pressure valve port 21.

The arrangement is accordingly made such that the axial resultant acting to move the cylinder body 30 toward the right, as viewed in Fig. 1, exceeds the opposing axial force tending to move said cylinder body 30 toward the left, so that pressure fluid in the high pressure valve port and in the cylinders 32 connected therewith has the effect of tending to move the cylinder body 30 toward the right and thus acts to more closely seal the running joint formed by the valve chamber 31 and the conical valve surface 18. The extent to which the axial resultant exceeds the opposing axial force acting toward the left may be varied through a relatively wide range by variation in the arrangement and relation of the several contributing parts, such as the angle of inclination of the cylinders, the amount of constriction of the cylinder ports, the slant of the conical valve surface, etc. The amount of this valve-sealing force, for any particular arrangement of the parts, is proportional to the amount of the pressure of the fluid. It therefore increases as the pressure of the operating fluid increases and provides maximum valve-sealing effect at the maximum operating pressure.

This arrangement by which the pressure fluid itself acts to more closely seal the running joint between the valve chamber 31 and the conical valve surface 18 in a pump or motor of the character herein set forth represents a substantial advance in these fluid pressure devices. As is well known, leakage of fluid through an opening of fixed size increases materially as the pressure rises, that is to say, the leakage therethrough is a function of the pressure. Maximum fluid pressures are, in practice, usually reached at the time the delivered volume of the pump (or the fluid volume active to operate a fluid motor) is relatively small so that the fluid which escapes through leakage constitutes a relatively large and important part of the volume being circulated. It will also be seen that, without this valve sealing feature, when a small fluid volume is being circulated and the operating pressure of the fluid is subject to wide and sudden variation, as is often the case, the amount of leakage fluid will vary considerably and will form a widely varying percentage of the total being circulated, so that uneven and irregular operation of the driven device will result. The valve-sealing action of the present invention functions to more tightly close the running joint between the valve chamber and valve surface, responsive to increase in pressure of the fluid, thus reducing leakage at high pressures and contributing toward steady and uniform operation of the driven member at low speeds. This is particularly important in pumps and fluid motors employed for exceedingly accurate control at low speeds, such for example as in certain types of ordnance applications.

The valve and cylinder body of the present invention have many other advantages. For example, the cylinder body may be moved toward the right, as viewed in Fig. 1, to compensate for wear of the valve chamber or valve surface and, due to the valve-sealing action, will tend to automatically assume the position in which clearance caused by any such wear is taken up. The valve and valve chamber arrangement also facilitate manufacture, as they may be lapped, one upon the other, the clearance between them during the lapping operation, brought about by the lapping compound, being automatically taken up after they are cleaned and assembled.

The cylinder body 30 is positioned on the valve's conical surface 18 by a flange or shoulder 41 near the inner end of the driving shaft 40, that is the flange 41 determines the limiting position toward the left (as viewed in Fig. 1) of the cylinder body 30, and the arrangement is made such that there is proper contact and relation between the valve chamber 31 and the valve surface 18 when the cylinder body 30 is in this position. The cylinder body 30 is adapted to be driven by the shaft 40 and a suitable operative connection is accordingly provided between them comprising, for example, jaws or teeth 42 on the flange 41 which may engage similar jaws (not shown) on the cylinder body 30.

The shaft 40, which is coaxial with the axis of rotation of the cylinder body 30, is revolubly supported on its reduced inner end 43 in an appropriate bore formed in the truncated end of the conical valve member. The shaft 40 is also supported by a bearing member 44 carried by the cover 45 which is attached to the casing member 11 as by cap screws 46. An end of the shaft 40 projects through a suitable opening in the cover 45 for connection with the initial source of power (not shown) and a shoulder 48 adjacent the bearing 44 locates the shaft 40 and prevents its undue displacement toward the left.

The preferred embodiment of crank or ec-

centric mechanism for reciprocating the pistons 35 includes a member broadly designated by the numeral 50, for convenience termed the "crank disk," which is best shown in Figs. 1 and 2. The crank disk 50 includes an enlarged disk-like portion formed with a rim or flange 52 with which the pistons 35 are operatively connected. Each piston is connected with the crank disk flange 52 by a short connecting rod 36, both ends of which are finished in ball terminals or spherical heads 37 and 38 respectively which are seated in suitable sockets in the piston 35 and the flange 52 respectively in which they are appropriately secured as by the threaded means 39 and 53. The crank disk 50 also includes a somewhat cylindrical or tubular portion 54 which surrounds the shaft 40, sufficient clearance being provided between the bore of said portion and said shaft 40 to permit shifting of the crank disk 50 as will be presently explained.

The crank disk 50 is preferably driven by the shaft 40 and is accordingly connected therewith by a universal joint of simple construction which is shown in Figs. 1 and 4. The universal joint includes a hollow sleeve 61, one end of which is received within the bore of the adjacent end of the crank disk's tubular portion 54, the two parts being rigidly connected as by rivets 55 so that together they form in effect a rugged unitary structure. The other end of the sleeve member 61 is formed with a pair of diametrically positioned slots (Fig. 4) to receive a pair of blocks 62 which are slidably fitted therein and are supported upon the ends of a rigid pin 63 driven through a hole in the shaft 40.

The arrangement is preferably made such that the center of the universal joint 60 is axially removed from the crank disc 52 a distance such that a line drawn from the center of said universal joint 60 to the point of piston rod connection 38 on said crank disk forms approximately a 90 degree angle with the center line of said cylinder in order that movement of the operative connection between the piston and the crank disk may be at a minimum. The blocks 62 are held in place upon the ends of the pin 63 by an annular housing 64 which is attached by suitable means, not shown, to the sleeve member. The housing 64 also assists in the lubrication of the joint by catching and holding the oil which is thrown off as the parts rotate and its end adjacent the cover 45 is provided with a flange or rim to prevent the escape of lubricant.

The crank disk 50 is rotatably supported by a relatively large bearing member 56 (Figs. 1 and 3) and a relatively small bearing member 57 (Fig. 1) which in turn are supported upon a surrounding, hollow, non-rotatable member 70, for convenience termed the "crank slide" although only one end thereof is slidable as will be presently explained. The bearing 56 is axially positioned by the shoulder 58 on the crank disk 50 and by the shoulder 71 on the enlarged end portion of the crank slide 70, which assists in preventing undue axial displacement of the crank disk 50 toward the left. The inner race of the bearing 57 is located by the end of the crank disk's tubular portion 54 and by a shoulder 65 formed on the sleeve member 61 and the outer race of said bearing 57 is located by a shoulder 72 on the crank slide 70 and by a retaining ring 73 held in place by any suitable means such as the pins 73'. By this construction the bearings 56 and 57 take the thrust and radial loads imposed upon the crank disk 50, transmitting them to the crank slide 70, and they also prevent undue axial displacement of the crank disk 50 in either direction.

The crank slide 70, which is of a generally annular or tubular cross section, is adapted to be shifted in order to vary and control the position of the crank disk 50 with respect to the cylinder body 30, by which the stroke of the pistons 35 is regulated. The end of the crank slide 70 adjacent the cover 45 is accordingly provided with a pair of axially extending arms 74 by which said crank slide 70 is pivotally supported upon a pair of trunnions 75 (Figs. 1 and 4). The trunnions 75 are in turn supported upon the casing member 11, being held in place by threaded engagement therewith, and are diametrically positioned with respect to the axis of the shaft 40 at a point along said axis in line with the center line of the universal joint. The enlarged end of the crank slide 70 adjacent the crank disk flange 52 is provided with a pair of parallel slides or faces which are supported upon a pair of transverse slideways formed in the casing member 11, as indicated at 76 in Figs. 1 and 3. Similar bearing slide surfaces 74' are provided between the arms 74 and the upper and lower inner surfaces at the end of casing part 11. By this arrangement the crank slide 70 may be shifted about the center formed by the trunnions 75, the slides moving in an arcuate path upon the slideways, and this movement of the crank slide 70 will, of course, produce similar movement of the crank disk 50.

For purposes of its movement and adjustment, the crank slide 70 is connected as by a pin 78 (Fig. 3) with one end of a pair of short parallel links 79 whose other end is connected by the pin 80 with a laterally movable member 81, for convenience termed the "adjusting rod." Movement of the adjusting rod 81 may be effected by any suitable means and as here illustrated this is accomplished by threaded engagement of said adjusting rod 81 with a sleeve 82 held against axial movement and adapted to be rotated by a hand wheel 83.

When the shaft 40 is rotated, for example in a counter-clockwise direction as viewed in Figs. 2 and 3, it will drive the cylinder body 30 and, through the universal joint, will also drive the crank disc 50. The position of the crank disk flange 52 with respect to the cylinder body 30 determines the length of the stroke of the pistons 35 and the direction of flow of the fluid.

There will be no reciprocation of the pistons 35 when the crank disk 50 is co-axial with the shaft 40 and with the axis of rotation of the cylinder body 30, in which position the parts are shown in Figs. 1, 2 and 3, as the points of connection of the connecting rods 36 on the flange 52 are concentric with the axis of rotation of the cylinder body. The pump is then in its zero stroke or neutral position at which no fluid will be delivered.

Displacement of the adjusting rod 81 toward the right, as viewed in Fig. 3, will swing the crank slide 70 about the trunnions 75, producing a corresponding movement of the crank disk 50 which is carried thereby. The crank disk flange 52 will thus be swung in a slightly arcuate path transversely of the axis of rotation of the cylinder body 30 so that the centers of rotation of the two members will be eccentric with respect to each other, causing the pistons 35 to reciprocate. With the parts rotating in a counter-

clockwise direction as viewed in Figs. 2 and 3 the pistons **35** will move inward during the portion of their rotary travel above the horizontal centerline, so that the valve port **21** will be the discharge or high pressure port, and will move outward during the portion of their rotary travel above the horizontal center line, so that the valve port **22** will be the suction or inlet port. The amount of reciprocation of the pistons **35**, that is the length of their stroke, is determined by the amount of eccentricity of the center of rotation of the crank disk flange **52** with respect to the axis of rotation of the cylinder body **30**, which in turn is determined by the extent of the shifting or swinging of the crank slide **70** and crank disk **50**. The amount of this eccentricity, and hence the stroke of the pistons **35** and the delivery of the pump, may be infinitely varied from zero to maximum by means of the hand wheel **82**.

Movement of the crank disk **50** through its neutral position and toward the left thereof, as viewed in Figs. 2 and 3, will obviously reverse the pistons' reciprocation and hence the direction of flow of the fluid, so that the valve port **21** will become the suction or inlet port and the valve port **22** will become the discharge or high pressure port.

Where a fixed stroke of the pistons is desired, as is often the case when the device is used as a fluid motor, the crank slide **70** may be carried upon suitable stationary supports which may be substituted for the slides and for the trunnions **75**, or the crank slide **70** may be eliminated and suitable stationary supports provided in the casing member **11** for the bearings **56** and **57**.

The crank mechanism of the present invention is particularly suited for use with the conically arranged cylinders of the cylinder body **30** and these members cooperate to provide a pump or fluid motor having many advantages in addition to those already mentioned. Both of these members, for example, are positively driven by the driving shaft in timed relation to each other so that there is no drag upon either of them or upon the pistons in the cylinders. There is very little variation in the angular velocity of the crank disk flange **52** because only a small amount of angular displacement of the crank disk **50** is necessary to produce a piston stroke of practical and satisfactory length, and in fact the variation in angular velocity is so small that it may be neglected for all practical purposes. Only one relatively large bearing is required and both of the other bearings used in the pump are small and inexpensive, thus reducing cost. The generally tubular and flanged construction of the parts gives rigidity without excessive weight and contributes to make the pump or motor rugged and suited for heavy work.

It is to be understood that the foregoing is merely an exemplifying disclosure of several embodiments and that changes may be made without departing from the spirit of the invention. For example, while in the particular embodiment shown the center line of cylinder **32** in Fig. 1 is inclined to the left (looking at Fig. 1), to form an angle substantially less than 90° (approximately 60°) to the left thereof with the axis of the rotating cylinder body and also an angle slightly less than 90° to the left thereof with the axial-center line plane intersection with the surface **18**, it is understood that these inclinations and relative inclinations may be varied within limits, although the arrangement shown is that preferred when the crank arm and piston rod mechanisms herein shown are used. The slant of the cylinders may be varied over a wide range, any particular slant being dependent upon other factors such as the slant of the valve surface **18**, the type of crank and piston rod mechanism employed, etc., but the preferred arrangement of slant of the cylinders is from approximately 5° to 40° from the radial position.

I claim:

1. In a fluid pressure device of the character set forth, the combination of a rotatable member provided with cylinders inclined from a truly radial position and at an angle not greater than 40°, each cylinder being provided at one end with a port of smaller area than the main chamber of the cylinder, a stationary member having a valve surface inclined in a direction generally opposite to the slant of said cylinders and having channels which are adapted to register with said cylinder ports, pistons movable in said cylinders and means for reciprocating said pistons, the axis of each cylinder being slanted at an angle of more than 90° to the inclined valve surface and in a direction toward the decreasing diameter thereof.

2. In a fluid pressure device of the character set forth, the combination of a central valve member having a conic valve surface, a cylinder body rotatable about the axis of said conic valve surface and provided with cylinders inclined in a direction generally opposite to the slant of said conic valve surface, said cylinders being constricted adjacent said valve surface, the axis of each cylinder forming an acute angle with the generatrix of said conic valve surface in the direction toward the vertex thereof, pistons in said cylinders and means for reciprocating said pistons, the arrangement being such that the cylinders approach more nearly a radial than an axial position.

3. In a fluid pressure device of the character set forth, the combination of a central valve member having a truncated right circular conic valve surface, fluid admission and exhaust ports in said valve member extending in a circumferential direction with respect to said conic valve surface, a cylinder body rotatable about the axis of said conic valve surface and having a central opening of substantially the same configuration as said conic valve surface, said central opening forming a valve chamber, cylinders in said cylinder body connected with said central valve chamber opening by restricted cylinder ports adapted to register successively with said admission and exhaust ports of said valve member as said cylinder body rotates, said cylinders being disposed in a generally truncated conical arrangement slanting in a direction generally opposite to the slant of said conic valve surface but approaching more nearly a radial than an axial position, pistons in said cylinders, and means for reciprocating said pistons, the axis of each cylinder forming an acute angle with the generatrix of said conic valve surface in the direction toward the vertex thereof.

4. In a fluid pressure device of the character set forth, the combination of a central valve member having a conic valve surface, a cylinder-carrying member having a valve chamber surrounding said valve surface, one of said members being rotatable with respect to the other about the axis of said conic valve surface, said cylinder-carrying member being provided with cylinders slanting in a direction generally opposite to the slant of said conic valve surface but approaching

more nearly a radial than an axial position, said cylinders being constricted adjacent said valve surface, pistons in said cylinders, and means for reciprocating said pistons, the axis of each cylinder being slanted more than 90° to the slant of the conic valve surface of said central valve member and toward the apex of said conic valve surface thereof.

5. In a fluid pressure device of the character set forth, a rotatable cylinder body, cylinders in said body, pistons in said cylinders, a revoluble shaft, and means for reciprocating said pistons comprising a ring angularly displaceable with respect to the axis of rotation of said cylinder body in an arcuate path transverse said axis, means for rotatably supporting said ring, a slidable support for said last named means, said slidable support being movable about a pivot adjacent one end thereof and supported by a slideway extending through the arcuate path of movement of said slidable support about said pivot, and operative connections between said ring and said pistons.

6. In a fluid pressure device of the character set forth, a rotatable cylinder body, cylinders in said body, pistons in said cylinders, a revoluble shaft, and means for reciprocating said pistons comprising a member supported upon a bearing element and rotatable about a center eccentric to the axis of rotation of said cylinder body, operative connections between said pistons and said rotatable member, the eccentric center of said rotatable member being disposed in an arc having its center aligned with the axis of rotation of said cylinder body at a point axially spaced from said piston connections and from said bearing element, said arc extending transverse the axis of rotation of said cylinder body.

7. In a fluid pressure device of the character set forth, a rotatable cylinder body having cylinders disposed in a generally conical arrangement with respect to the axis of rotation thereof, pistons in said cylinders and means for reciprocating said pistons comprising a ring supported upon a bearing element and having operative connections with said pistons, said ring forming the base of a substantially conic structure shiftable in an arc transverse of the axis of rotation of said cylinder body about a pivot adjacent the conic apex thereof and axially removed from all planes traversed by said bearing element and said piston connections.

8. In a fluid pressure device of the character set forth, a rotatable cylinder body having cylinders inclined with respect to the axis of rotation thereof, pistons in said cylinders, a revoluble shaft, and means for reciprocating said pistons comprising a crank element having a universal connection with said shaft, said crank element being angularly displaceable with respect to said shaft and said cylinder body in a path transverse the axis of rotation of said cylinder body, adjustable means for supporting said crank element comprising a slidably supported member movable about a pivot radially spaced from said universal joint and radially in line therewith, means for adjusting said crank supporting means, and operative connections between said pistons and said crank element.

9. In a fluid pressure device of the character set forth, a rotatable cylinder body, cylinders in said body, pistons in said cylinders, a revoluble shaft, and means for reciprocating said pistons comprising a crank member having a universal connection with said shaft, said crank member including a ring rotatable about a center eccentric to the axis of rotation of said cylinder body and said ring also having operative connections with said pistons, said ring being slidably supported for movement in an arc transverse the axis of rotation of said cylinder body and defined by a radius extending from said eccentric center to the center of said universal joint.

10. In a fluid pressure device of the character set forth, a rotatable member provided with cylinders slanting lengthwise with respect to the axis of rotation thereof, each cylinder being provided at one end with a port of smaller area than the main chamber of said cylinder, a stationary member having a conic valve surface slanting in a direction generally opposite to the slant of said cylinders and having channels adapted to register with said cylinder ports, pistons movable in said cylinders and means for reciprocating said pistons comprising a slidably supported rotatable ring angularly displaced with respect to the axis of rotation of said cylinder body in an arcuate path transverse said axis, and operative connections between said pistons and said ring.

11. In a fluid pressure device of the character set forth, the combination of a central conical valve member having ports on the surface thereof, with a cylinder assembly unit including an outer valve member having a bearing surface corresponding to the bearing surface of said central valve member, said outer valve member having passages leading from the cylinders with constricted ports leading to the ports of said central valve member, said cylinders being inclined to the axis of rotation of the cylinder unit but approaching more nearly a radial than an axial position, pistons in said cylinders and means for reciprocating said pistons, the axis of each cylinder forming an acute angle with the generatrix of said conic valve surface in the direction toward the vertex thereof.

12. In a fluid pressure device of the character set forth, the combination of a central tapered valve member, with a cylinder assembly unit rotatable about said central valve member with the cylinders inclined to the axis of the central valve member in the direction of the taper thereof, pistons in said cylinders and means for reciprocating said pistons, the axis of each cylinder being slanted at an angle of more than 90° to the tapered valve member.

13. In a fluid pressure device of the character set forth, a central conical valve member, a cylinder assembly unit rotatable about said central valve member with cylinders therein disposed at an angle to the axis of the central valve member and including an outer valve member of conical shape cooperating with said central valve member, pistons in said cylinders, a crank member having operative connections with said pistons and journalled eccentrically to the axis of the valve member, and a shaft coupled to said eccentrically mounted crank and cylinder assembly unit, said crank member including a crank-supporting member pivoted at one end thereof and slidably mounted at its other end, a bearing element carried by said crank-supporting member adjacent its slidably mounted end, and a rotatable crank element supported by said bearing and universally connected with said shaft at a point axially in line with the pivoted end of said crank-supporting member.

14. In a fluid pressure device of the character set forth, a shaft, a cylinder assembly unit journalled for rotation about the axis of said shaft

and coupled to said shaft for rotation therewith, the cylinders of said unit being inclined to the axis of rotation, a crank arm having a universal driving connection with said shaft at a point removed from said cylinder assembly unit and in the direction of the inclination of the cylinders, said crank arm being journaled in a member having a pivot axially in line with said universal connection and a slidably supported surface positioned at a point intermediate the cylinder assembly unit and the universal joint for rotation about an axis inclined to the axis of rotation of the cylinder assembly unit and operating connections between said crank arm and said cylinders.

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