March 25, 1947. W. S. FALLON 2,417,816

FLUID PUMP OR MOTOR

Filed Aug. 14, 1942 2 Sheets-Sheet 1

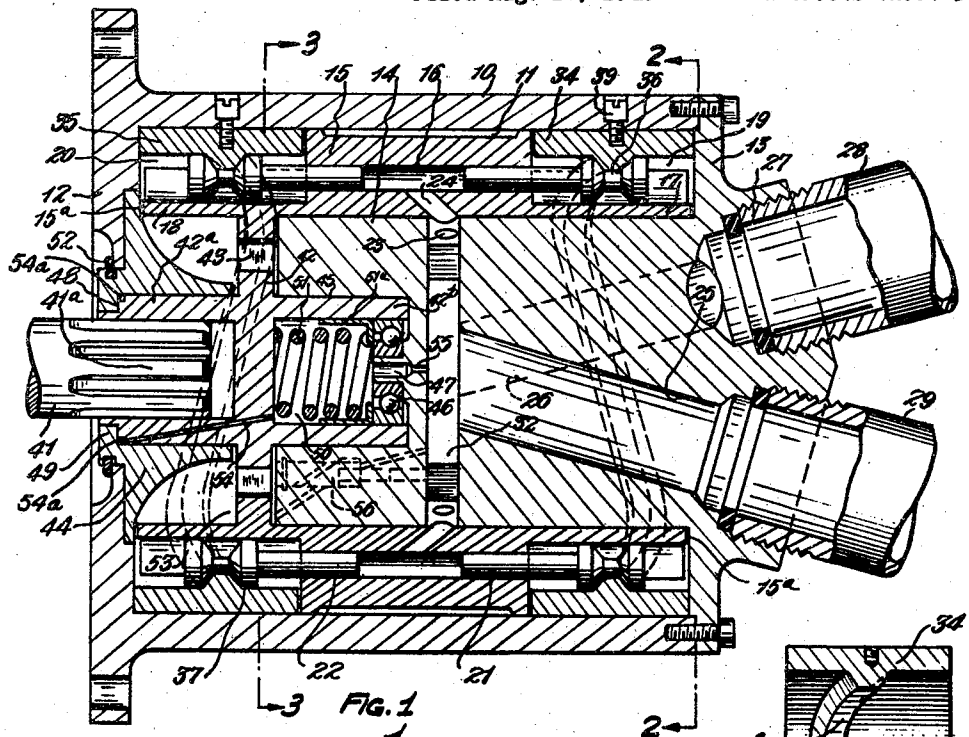

FIG. 1

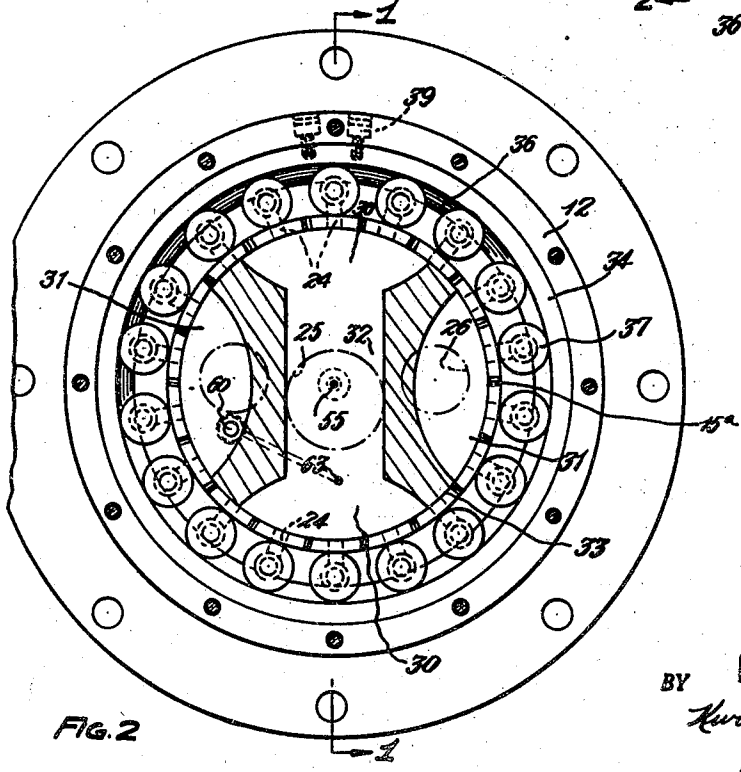

FIG. 2

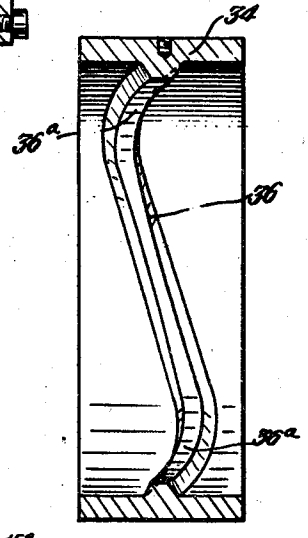

FIG. 8

INVENTOR.

BY WILMER S. FALLON

Kuris Hudson & Kent

ATTORNEYS

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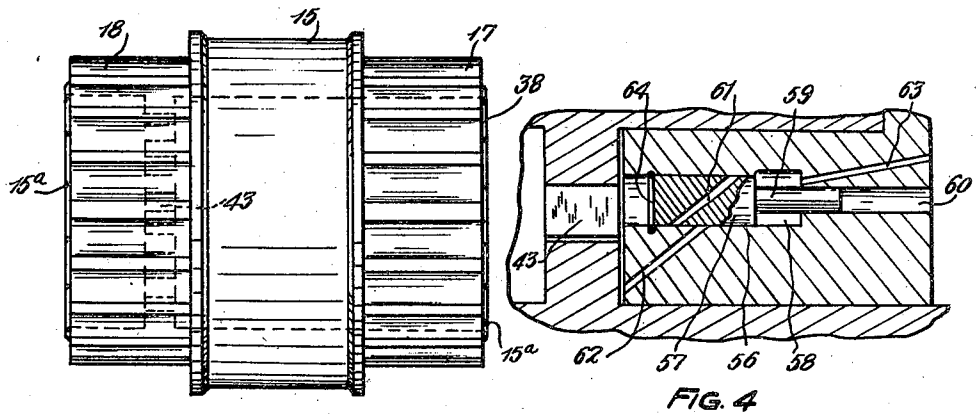

FIG. 4

FIG. 5

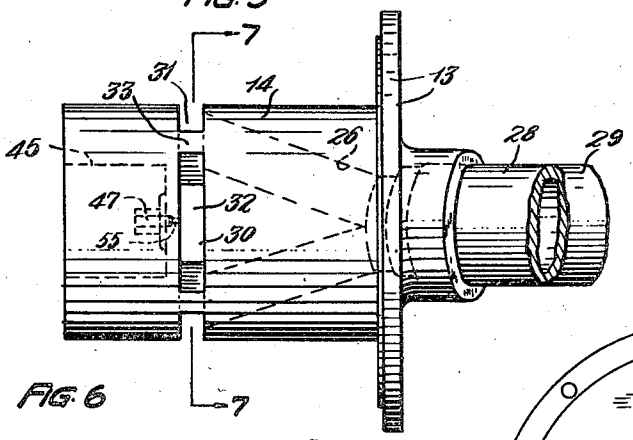

FIG. 6

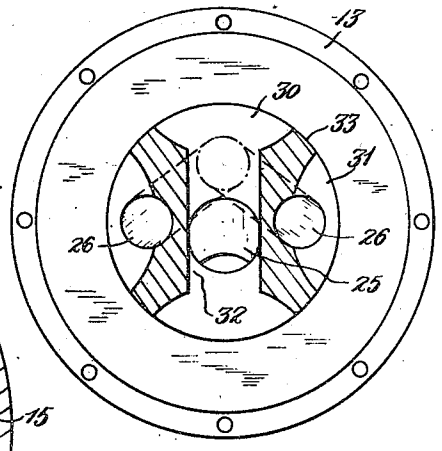

FIG. 7

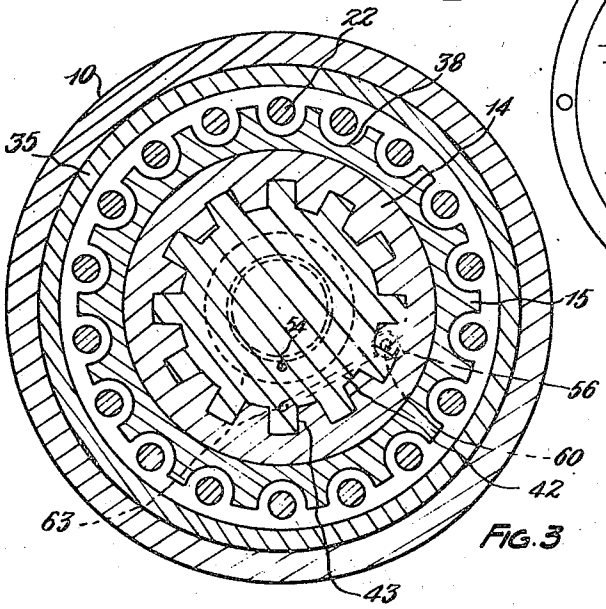

FIG. 3

INVENTOR.

BY WILMER S. FALLON

Kuris Hudson & Kent

ATTORNEYS

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FLUID PUMP OR MOTOR

Wilmer S. Fallon, Cleveland, Ohio

Application August 14, 1942, Serial No. 454,773

19 Claims. (Cl. 103—162)

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This invention relates to an improved construction for a hydraulic machine of the kind which is usable either as a pump or a motor. A general object of my invention is to provide an improved machine of this type which will operate efficiently, which is compact and which can be manufactured at reasonable cost. Another object is the provision of a hydraulic pump or motor in which the moving parts are hydraulically and mechanically balanced, thus substantially eliminating vibration from the device and reducing bearing loads and friction.

An other object is to provide a pump or motor in which the work done by each piston is substantially equally divided between the discharge and suction strokes of the piston. Another object is to provide a hydraulic pump or motor embodying a plurality of cylinders and pistons and in which the discharge is substantially without pulsation. Another object is to provide a driving connection for a hydraulic pump or motor arranged to compensate for misalignment or vibration in the connecting shaft without imposing substantial strains or vibrations on the pump.

A further object of my invention is to provide an improved machine of the kind mentioned in which novel sealing means is employed enabling the same to utilize or develop relatively high fluid pressures with minimum piston slip or fluid leakage.

Another object of my invention is to provide an improved machine of the kind referred to in which pressure-staged leakage chambers are employed to control fluid leakage from the cylinders.

A further object of my invention is to provide an improved construction for a fluid pump or motor in which the parts required are very few in number and can be readily assembled to produce a machine of this kind which is both dynamically and hydraulically balanced.

The invention may be further briefly summarized as consisting in certain novel combinations and arrangements of parts hereinafter described and particularly set out in the appended claims.

In the accompanying sheets of drawings,

Fig. 1 is a longitudinal sectional view taken through my improved hydraulic machine, as indicated by line 1—1 of Fig. 2;

Fig. 2 is a transverse sectional view of the machine taken on the irregular section line 2—2 of Fig. 1;

Fig. 3 is another transverse sectional view of the machine taken on line 3—3 of Fig. 1;

Fig. 4 is a partial sectional view on an enlarged scale showing a valve for controlling leakage fluid;

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Fig. 5 is an elevation of the rotor showing the same removed from the housing;

Fig. 6 is an elevation of the housing cover which contains the fluid inlet and outlet passages;

Fig. 7 is a transverse sectional view taken through the projection of the cover, as indicated by line 5—5 of Fig. 6; and

Fig. 8 is a detached view showing one of the cam rings in section.

More detailed reference will now be made to the drawings in which I have illustrated one embodiment of my improved hydraulic machine which is usable either as a pump or a fluid motor although from one standpoint it is particularly advantageous when used as a pump. It should be understood, however, that although the machine shown in the drawings is hereinafter described in considerable detail, the invention is not limited to this particular machine but can be embodied in various other similar apparatus.

My improved hydraulic machine as illustrated in this instance is intended for use as a pump and for convenience of description will hereinafter be referred to as a pump, although it could be used as a motor. As shown in the drawings my pump is provided with a housing 10 having a cylindrical recess or chamber 11 therein. The housing may have an integral wall or cover 12 formed on one end thereof, and at its opposite end may be closed by a removable cover 13 having a projection 14 which extends axially into the recess 11. A rotor 15 having an annular series of axially disposed cylinders 16 is journaled on the cover projection 14 for rotation in the housing 10. It will be noted that the areas on each end of the rotor are substantially equal so that fluid pressure within the housing will not result in any substantial axial thrust on the rotor; i. e., the rotor is hydraulically balanced in axial directions. In this instance the rotor is provided with eighteen such cylinders spaced twenty degrees apart, although any suitable number of cylinders can be used. The rotor 15 is constructed with reduced end portions 17 and 18 which cooperate with adjacent portions of the housing structure to define leakage spaces or chambers 19 and 20 within the housing, the purpose of which will be later described. Opposed pistons 21 and 22 are slidably operable in the cylinders 16, with the pistons 21 constituting one annular series and the pistons 22 constituting another annular series.

The rotor 15 is provided with an annular series

of circumferentially spaced ports 23 opening through the inner surface thereof. The ports 23 are connected with the respective cylinders 16 by passages 24 which communicate with the cylinders at a point in the inner portions of the cylinder walls substantially midway between the ends thereof. As shown in the drawings, the cover projection or journal 14 has a plurality of fluid passages therein for the admission and discharge of fluid. When my improved hydraulic machine is to be used as a pump, these passages comprise an inlet or suction passage 25 and a pair of exhaust or discharge passages 26. The discharge passages 26 may be arranged to straddle the inlet passage 25, as shown in Fig. 7, and may unite with each other at a point adjacent the cover opening 27 with which the diverging exhaust or discharge pipe 28 is connected. A similar pipe 29 may be connected with the diverging inlet passage 25.

To provide for communication between the passages 25 and 26 and the cylinder ports 23, and to hydraulically balance the rotating rotor in radial directions, I construct the journal 14 with pairs of diametrically opposed circumferentially extending slot-like openings 30 and 31. The pair of diametrically opposed openings 30 are connected with each other and with the inlet passage 25 by a transverse slot or passage 32. The pair of diametrically opposed openings 31 are connected, respectively, with the discharge passages 26. The portions of the journal 14 lying between the adjacent openings 30 and 31 form arcuate lands 33 with which the rotor has running contact. During rotation of the rotor the openings 30 and 31 of the journal 14 and the intervening lands 33 are traversed by the cylinder ports 23 so that fluid can alternately pass into and out of the cylinders. While the cylinder ports are in communication with the openings 30, fluid is permitted to enter the corresponding cylinders, and as the ports of these cylinders arrive at the lands 33 in succession, such communication is cut off. As the cylinder ports travel beyond the lands 33, they are brought into communication with the openings 31, whereupon fluid from these cylinders is discharged through the passages 26. It will be noted that centrifugal force assists the flow of fluid into the cylinders from the inlet passage 32, thus eliminating the need for supercharging and also avoiding cavitation and vapor lock effects even though the pump is used under conditions of very low barometric pressure. Because of the equal and opposite arrangement of the intake ports and of the discharge ports, the hydraulic pressures on the rotor adjacent the intake ports are equal and opposite and the hydraulic pressures on the rotor adjacent the discharge ports are equal and opposite. The rotor therefore is in substantial hydraulic balance in radial directions, and thus the journal is not required to support the rotor against any substantial thrust due to hydraulic pressures.

Surrounding the reduced ends 17 and 18 of the rotor 15 I provide cam rings 34 and 35 which carry sinuous internal cams 36 having beveled sides and flat tops. The outer ends of the pistons 21 and 22 are provided with grooved heads or cam followers 37 which mesh with the cams 36 and have rolling contact therewith. The reduced ends of the rotor are provided with open guideways 38 which are aligned substantially with the respective cylinders 16 and in which the heads or cam followers of the pistons are reciprocably slidable and supported against the

inward thrust of the cams. The plunger portion of the pistons 21 and 22 is preferably of a smaller diameter than the head portion 37, as shown in the drawings, although the diameter of the plunger portion can be varied according to the displacement and pressure values desired to be obtained. The displacement and pressure can also be varied by changing the "throw" of the cams 36 upon which the stroke of the pistons is directly dependent. The cam rings 34 and 35 are mounted in the bore or recess of the housing 10 and are held against rotation by the screws 39. Each of the cams 36 is a "double-throw" cam, that is, will produce two inward or working strokes and two outward or suction strokes of each piston for each revolution of the rotor 15. The cams 36 have their neutral points 36a, that is, the points where the pistons change their direction of movement, positioned substantially, but preferably not exactly, opposite or in the same axial plane as the centers of the arcuate lands 33. There are four such neutral points in each double-throw cam.

I prefer to locate the screws 39 so as to position the cam rings 34 and 35 with the neutral points of one ring spaced ten degrees from the neutral points of the other ring, or in other words, with the neutral points 36a of the two rings offset five degrees in opposite directions from the centers of the arcuate lands 33. This has the effect of increasing the neutral areas of the cams so that there will be substantially no suction or displacement by the cylinders while the ports 23 are passing the lands 33, thereby eliminating wire drawing effects at the lands as well as objectionable shock. The ten degree offset between the neutral points of the two cams, which is one half of the angular spacing of the cylinders, causes the pistons 21 and 22 to reach their maximum stroke alternately, thereby increasing the number of pulsations to seventy-two for each revoultion of the rotor and at the same time reducing the amplitude of the pulsations by one half. It will therefore be seen that my pump is capable of delivering a stream of fluid at a relatively high pressure and which is a steady or substantially non-pulsating stream.

For connecting a power shaft, such as the shaft 41, with the rotor 15, I provide a coupling 42 having a spline connection 43 with the rotor. The coupling is constructed with oppositely extending sleeve portions 42a and 42b. The sleeve portion 42a is splined internally for connection with the splined end 41a of the stub shaft 41 and is journaled in a hub or axial projection 44 provided on the end wall or cover 12 of the housing. The normal clearance of the splined connection permits sufficient movement to protect the sealing means and pump mechanism from shocks, vibrations and slight misalignment of the driving unit, which might otherwise cause the seal to leak. The oppositely extending sleeve portion 42b is journaled in an opening 45 of the cover projection 14. The outer end of the sleeve portion 42a of the coupling is shouldered as indicated at 48 for close running engagement with an inwardly extending flange or projection 49 of the hub 44 so as to form a seal at this point. The recess of the sleeve portion 42b of the coupling provides a chamber 5 adapted to receive leakage fluid and to house a compression spring 51 which acts on the coupling to continuously press the shouldered portion 48 into sealing engagement with the flange 49. The inner end of the spring extends into a spring

seat or cup 51*a* which bears against the outer race of an anti-friction bearing 46. This anti-friction bearing may be mounted on a boss or spindle 47 of the journal 14.

It will be seen from the drawings and from the foregoing description that my improved hydraulic machine embodies a relatively small number of parts which are all designed so that they can be manufactured easily. The rotor with the pistons 21 and 22 therein, the cam rings 34 and 35, the coupling 42, and the hub 44 can all be assembled into or removed from the housing 10 through the open end thereof. When it is necessary to inspect or repair the working parts of the machine, it is only necessary to remove the cover 13 and the retaining screws 39, whereupon the rotor, cam rings, and coupling can be readily pushed or withdrawn from the bore of the housing. The hub 44 may, if desired, be connected with the end wall or cover 12 of the housing by means of the snap ring 52. The direction of rotation may be reversed by removing the cover screws and rotating the housing 10 90° in either direction, which interchanges the relative position of the intake and exhaust ports. This may be done without disconnecting or changing the diverging suction and discharge connections 28 and 29.

Another feature of my improved machine is the control of the "slip" or leakage of fluid between the cylinder walls and pistons and between the journal 14 and the inner surface of the rotor 15. Such slip or leakage is reduced to a minimum by maintaining a back pressure in the chambers 19 and 20 adjacent the outer ends of the cylinders. By maintaining such a back pressure in these chambers I find that the leakage of fluid out of the cylinders past the pistons and out of the discharge openings 31 along the surface of the journal 14 is opposed and greatly reduced. Also, as explained in greater detail below, the back pressure tends to equalize the work performed by the pistons and cam faces on the suction and discharge strokes.

The leakage chamber 19 is in communication with the leakage chamber 20 through the small clearance spaces existing between the inner ends of the cam rings and the rotor and between the rotor and the wall of the housing 10. The leakage chamber 20 is in communication with a leakage space or chamber 53, which is located inside the rotor and surrounds the hub 44, through circumferentially spaced grooves 15*a* in the adjacent end of the rotor 15. The chamber 53 is in restricted communication with the chamber 50 through a passage 54 of the coupling 42 and through the clearance space or tolerance existing between the sleeve portion 42*a* of the coupling and the bore of the hub 44. The passage 54 extends from the chamber 50 to an annular recess 54*a* adjacent the sealing shoulder 48, and thus eliminates any substantial fluid pressure on the thrust seal, although pressure is maintained within the housing. There is also restricted communication between the chambers 50 and 53 through the clearance space or tolerance between the portion 42*b* of the coupling and bore 45 of the projection 14. The chamber 50 is connected with the low pressure side of the machine, in this instance with the inlet passages 25 and 32, by means of a passage 55 extending through the spindle or boss 47.

The sealing effect thus obtained for the cylinders 16 can be further explained by the aid of a specific example. For a working pressure in the

cylinders 16 of approximately 1,500 pounds per square inch, the back pressure which should be maintained in the leakage chambers 19, 20 and 53 should be approximately one half of the working pressure, or about 750 pounds per square inch, although the back pressure to be maintained can be greater or less than this value. Since the chamber 50 is in communication with the low pressure side of the machine, the pressure in this chamber will be of substantially the same value as the pressure in the inlet passage 32, which may be zero pounds per square inch or some pressure not materially greater or less than this value. The desired pressure can be maintained in the leakage chambers 19, 20 and 53 by reason of the fact that only a relatively restricted communication is provided by the tolerances between the moving parts for the passage of the leakage fluid to the chamber 50 leading to the low pressure side of the machine. Because of this restricted communication, the pressures of the leakage fluid in the chamber 50 and in the chambers 19, 20 and 53 will have different values or stages, and hence the control of the slip or fluid leakage from the cylinders can, in a sense, be referred to as a "pressure-staged" or a "two-staged" control of the fluid leakage or slip.

With the machine operating as a pump, developing a working pressure of 1500 pounds per square inch in the cylinders 16, with an intake pressure at about atmospheric, and 750 pounds per square inch in the spaces 19 and 20, then on the working or discharge stroke of each piston the outward pressure on the piston within the cylinder is 1500 pounds per square inch. At the same time, the pressure of 750 pounds per square inch within the case exerts a pressure on the piston urging it inwardly. The areas acted on by the two pressures are equal so that the net force (disregarding friction) that must be exerted by the cam on the piston to produce the pressure of 1500 pounds per square inch, is only 750 pounds per square inch of piston area. On the suction stroke the outward pressure is atmospheric or less while the inward pressure remains at 750 pounds per square inch. Thus about the same amount of work must be done on the suction stroke as on the discharge stroke, but the maximum force exerted by the cam on the pistons is reduced to about half of what it would be if there were no back pressure. The maximum pressure between pistons and cams is substantially halved, and the work and wear between pistons and cams are distributed throughout the discharge and intake strokes. This greatly increases the life of the pump and makes possible the design of compact units with relatively small bearing surfaces. The same sort of action and the same advantages result when the machine is used as a motor.

The action of the cams against the pistons has a tendency to urge the cam followers 37 of the pistons away from the cams radially inwardly against the supporting guide ways 38. Inasmuch as the discharge and suction areas of the cams are equal and opposite and as the amount of work done on the suction stroke is about equal to the amount of work done on the discharge stroke, these mechanical forces against the rotor are substantially balanced out. Furthermore, the centrifugal force imparted to the pistons during their rotation urges the pistons against the cams and counteracts the radially inward pressure of the pistons against the bores and guide ways 38.

Centrifugal force acts advantageously in another manner when my machine is operated as

a pump, for centrifugal force assists the flow of fluid from the intake or suction passages through the passages 24 into the cylinders; i. e., centrifugal force acting on the fluid as it flows to the cylinders tends to increase the pressure in the cylinders as compared to the intake pressure. As the passages 24 open into the inner periphery of each cylinder there are no pockets in which vapor can be trapped. Hence the pump may be operated without danger of cavitation or vapor lock and will operate efficiently with low pressures on the intake side.

In maintaining the back pressure of the leakage fluid, I may find it desirable to employ a valve for controlling the passage of fluid from the interior of the rotor into the inlet passage 32 on the low pressure side of the machine. In Figs. 1 and 4 I show a piston valve 56 being used for this purpose. The valve 56 is located in the inner end of the journal 14 and comprises a head or plunger portion 57 which is slidable in a passage or chamber 58 and a stem portion 59 which is slidable in a passage or chamber 60. The outer end of the chamber 58 receives leakage fluid from the chamber 53 so that the pressure of such fluid will act directly against the outer face or end of the plunger portion 57. The passage or chamber 60 communicates with one of the openings 31 of the high pressure side of the machine so that the pressure of the fluid in the discharge passage will act directly against the end or face of the stem portion 59. The face of the plunger portion 57 is preferably larger than the face of the stem portion 59, as shown in Fig. 4, and the ratio of the areas of these faces may be approximately two-to-one.

When the pressure of the leakage fluid increases in relation to the pressure of the fluid in the discharge passage of the pump, the valve 56 will be shifted toward the right, and when the pressure of the leakage fluid drops with respect to the pressure in the discharge passage, the valve will be shifted toward the left to its normal position in which it is shown in Fig. 4. The plunger portion 57 of the valve is provided with a passage 61 which is adapted to register with a passage 62 whenever the valve is shifted toward the right by a relative increase in the pressure of the leakage fluid. Whenever the passage 61 of the valve is in communication or register with the passage 62, it also communicates with the chamber 58 and with a passage 63 leading into the inlet passage 32. When the valve 56 has been shifted toward the right as the result of an increase in the pressure of the leakage fluid, the passage 61 connects the passages 62 and 63 so that leakage fluid can then pass directly through the valve and into the suction or low pressure side of the machine without being required to traverse the remaining restricted passage or tolerance space between the sleeve portion 42a and the hub 44, which it would otherwise have to do in order to reach the chamber 50 and the passage 55. The valve 56 is thus responsive to a pressure differential between the leakage fluid and the fluid in the discharge or high pressure side of the machine and will serve to maintain the leakage fluid at a more nearly constant pressure value. The valve 56 may be held against withdrawal from the valve chamber 58 by means of a snap ring 64.

When my improved machine is operated as a pump, it will be found that a very high pressure can be built up and maintained and that a substantially smooth and even flow of fluid can be delivered because pulsations have been substantially eliminated. It will also be seen that centrifugal force acts on the incoming fluid and causes the same to flow more readily into the cylinders and that the back pressure maintained in the leakage fluid serves to control and reduce the leakage of fluid from the cylinders past the pistons and between the surfaces of the rotor and journal. The cams with which the pistons cooperate are so formed or generated that they cause the pistons to operate with simple harmonic motion, which is a factor also contributing to the ability of my machine to operate smoothly at high speed.

While I have illustrated and described my improved hydraulic pump or motor in considerable detail, it will be understood, of course, that I do not wish to be limited to the particular details and arrangements herein disclosed, but regard my invention as including all changes and variations coming within the scope of the appended claims.

Having thus described my invention, I claim:

1. A fluid pump or motor comprising a housing having high pressure and low pressure fluid passages, a rotor operable in said housing and having cylinders therein adapted to be connected in succession with said high and low pressure passages, pistons operable in said cylinders, leakage chambers at the outer ends of said cylinders, a passage connecting said leakage chambers with said low pressure passage, and a piston valve controlling said passage, said valve having one end exposed to pressure from the leakage chambers and another end of relatively reduced area exposed to the pressure of said high pressure passage.

2. A machine of the character described comprising a housing having a recess therein, a cover on the housing having a projection extending axially into said recess, said projection having high and low pressure fluid passages therein, a rotor mounted on said projection and having a series of axially extending cylinders and fluid passages for connecting said cylinders with said high and low pressure passages during rotation of the rotor, opposed pistons operable in said cylinders, said rotor having reduced end portions, and cam rings mounted in the housing and surrounding said reduced ends of the rotor, said rings having sinuous internal cams thereon and said pistons having followers cooperating with said cams.

3. A machine of the character described comprising a housing having a recess therein, a cover on the housing having a projection extending axially into said recess, said projection having high and low pressure fluid passages therein, a rotor mounted on said projection and having a series of axially extending cylinders and fluid passages for connecting said cylinders with said high and low pressure passages during rotation of the rotor, opposed pistons operable in said cylinders, said rotor having reduced end portions provided with open guideways axially aligned with the respective cylinders, cam rings mounted in the housing and surrounding said reduced portions of the rotor, and sinuous internal cams on said rings, said pistons having cam followers cooperating with said cams and slidable in said guideways.

4. A machine of the character described comprising a housing having a recess therein, a cover on the housing having a projection extending

axially into said recess, said projection having high and low pressure fluid passages therein, a rotor mounted on said projection and having a series of axially extending cylinders and fluid passages for connecting said cylinders with said high and low pressure passages during rotation of the rotor, opposed pistons operable in said cylinders, said rotor having reduced ends cooperating with adjacent portions of the housing to define leakage chambers, cam rings surrounding said reduced ends of the rotor, and sinuous internal cams on said rings and cooperating with said pistons, one of said leakage chambers being in communication with the other leakage chamber and said other leakage chamber having restricted communication with said low pressure passage.

5. In a pump of the character described, a housing having an axial journal therein, a rotor mounted on said journal and having an annular series of axially disposed cylinders, said journal having fluid inlet and discharge passages and arcuate lands therebetween and said rotor having ports cooperating with said passages and lands for controlling the flow of fluid into and out of the cylinders during rotation of the rotor, sets of opposed pistons operable in said cylinders, and sinuous annular cams engaged by the respective sets of pistons for causing reciprocation of said pistons, said cams having their neutral points offset angularly and in opposite directions from the midpoints of said lands.

6. In a pump of the character described, a housing having a substantially cylindrical wall and also having a journal provided with inlet and discharge passages and intervening lands, a cylinder- and piston-carrying rotor on said journal and its cylinders having ports cooperating with said passages and lands, and an internal sinuous cam on the inner surface of said cylindrical wall adapted to cause reciprocation of the pistons of said rotor, said pistons each comprising a plunger portion slidable in the cylinders and an annularly grooved head portion engaging said cam and adapted to be pressed thereagainst by centrifugal force.

7. In a pump of the character described, a housing having a substantially cylindrical wall and also having a journal provided with inlet and discharge passages and intervening lands, a cylinder- and piston-carrying rotor on said journal and its cylinders having ports cooperating with said passages and lands, and an internal sinuous cam in the inner surface of said cylindrical wall and having beveled sides and a flat top and adapted to cause reciprocation of the pistons of said rotor, said pistons each comprising a plunger portion slidable in the cylinders and a head portion adapted to be pressed against said cam by centrifugal force and having a beveled annular groove in which said cam engages.

8. In a pump of the character described, a housing having a projection extending axially thereinto from one end thereof and terminating in spaced relation to the other end of the housing, a cylinder- and piston-carrying rotor journaled on said projection for rotation in said housing, said rotor having internal teeth thereon, and a coupling rotatably supported by said projection and said other end of the housing and having external teeth in mesh with the internal teeth of said rotor.

9. A machine of the character described comprising a housing having a recess therein, a member supported by the housing and projecting axially into said recess, a rotor within the housing and surrounding projecting member and journalled for rotation with respect thereto, said rotor having a series of axially disposed cylinders therein and ports communicating with the respective cylinders, and a pair of opposed pistons operable in each cylinder, said projection having inlet and discharge passages therein with which said cylinders are connected in succession by said ports.

10. A machine of the character described comprising a housing having a recess therein, a member supported by the housing and projecting axially into said recess, a rotor within the housing and surrounding said projecting member and journalled for rotation with respect thereto, said rotor having a series of axially disposed cylinders therein and ports communicating with the respective cylinders, a piston operable in each cylinder, said projection having inlet and discharge passages therein with which said cylinders are connected in succession by said ports, and rigid means associated with the housing for positively reciprocating said pistons in both intake and discharge directions during rotation of said rotor.

11. A machine according to claim 10 wherein cam means are provided for positively imparting a plurality of intake and discharge strokes to each piston during each revolution of said rotor, and wherein said projection is provided with a corresponding number of equally spaced intake and exhaust passages.

12. A machine of the character described comprising a housing having a recess therein, a rotor journalled for rotation within the housing, said rotor carrying cooperative elements to provide a pumping action, said housing providing a plurality of evenly spaced circumferentially opening intake passages and a plurality of evenly spaced circumferentially opening discharge passages disposed between said intake passages, and ports in said rotor leading to said cooperative elements and arranged successively to connect said elements to said intake and discharge passages, whereby the hydraulic pressures acting on said rotor are substantially balanced in radial directions.

13. A pump comprising a rotor having a plurality of axially extending cylinders, a piston in each of said cylinders, rigid mechanical means for positively reciprocating said pistons in both intake and discharge directions during rotation of said rotor, a member extending axially within said rotor and upon which said rotor is journalled, said member having inlet and discharge openings therein, said rotor having a series of ports extending outwardly from juxtaposition with said inlet and discharge openings to openings in the inner portions of the walls of said cylinders, the cylinders being connected in succession with said inlet and discharge passages by said ports during rotation of said rotor, the arrangement being such that the action of centrifugal force assists the flow of fluid through said ports into the cylinders from said member.

14. A machine of the character described comprising a housing, a cylinder within the housing, a piston operable within the cylinder, a leakage chamber within the housing adjacent the cylinder, means for maintaining a pressure in said leakage chamber equal to substantially one-half the discharge pressure of the pump, one end of said piston being exposed to pressure in said leakage chamber, whereby the pressure in said

leakage chamber opposes the pressure in said cylinder.

15. A machine of the character described comprising a housing having fluid inlet and discharge passages therein, a rotor operable in the housing and having cylinders adapted to be connected with said inlet and discharge passageways during rotation of the rotor, two opposed pistons operable in each said cylinder, leakage chambers within said housing into which the outer ends of said pistons extend, means for maintaining a substantial fluid pressure in said leakage chambers, the pressure in said leakage chambers acting on the outer ends of said pistons, whereby the pressure in the leakage chamber acts on the pistons in opposition to the pressure within the cylinders.

16. A machine of the character described comprising a housing having a cylindrical recess therein, a cover on the housing having a projection extending axially into said recess, an annular body rotatable in said housing and journalled on said projection, said body having a series of axially disposed cylinders therein and ports communicating with the respective cylinders at an intermediate point thereof, and a pair of opposed axial pistons operable in each cylinder, said projection having inlet and discharge passages therein with which said cylinders are connected in succession by said ports.

17. A machine of the character described comprising a housing having a cylindrical recess therein, a projection connected with said housing and extending axially into said recess, an annular body rotatable in said housing and journalled on said projection, said body having a series of cylinders therein and also having ports in its inner periphery communicating with the respective cylinders, and a pair of opposed axial pistons operable in each of said cylinders, said projection having fluid inlet and discharge passages therein and also having ports and intervening lands on the periphery thereof arranged to traverse the cylinder ports for connecting the cylinders in succession with said inlet and discharge passages, the ports of said projection comprising a pair of substantially diametrically opposed inlet ports and a pair of substantially diametrically opposed outlet ports located substantially midway between the inlet ports.

18. A machine of the character described comprising a housing having fluid inlet and discharge passages therein, one of said passages carrying fluid at a relatively high pressure and the other at a relatively low pressure, a rotor operable in the housing and having cylinders adapted to be connected with said inlet and discharge passages during rotation of the rotor, pistons operable in said cylinders, leakage chambers adjacent said cylinders, and means connecting said chambers with the said passage which carries the relatively low pressure including a pressure actuated valve adapted to maintain the pressure in said leakage chambers substantially above the pressure in said low pressure passage.

19. In an apparatus of the type described, a housing, fluid pump or motor elements therein, a rotatable shaft operatively connected to said elements and extending through one end of the housing, and fluid connections for said elements disposed at the other end of the housing, said fluid connections comprising inlet and outlet passageways formed within said housing and extending to the exterior of said housing in acute angle diverging relation to each other and to the axis of the housing.

WILMER S. FALLON.

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1,211,879	Robertson	Jan. 9, 1917
1,938,735	Andrews	Dec. 12, 1933
1,430,602	Sykora	Oct. 3, 1922
1,229,009	Allison	June 5, 1917
2,204,374	Metzgar	June 11, 1940
2,143,637	Vollman	Jan. 10, 1939
648,352	Blanton	Apr. 24, 1900
785,071	Pugh	Mar. 14, 1905
1,136,363	Pepper	Apr. 20, 1915
1,180,190	Robertson	Apr. 18, 1916
1,697,854	Coursen	Jan. 8, 1929
1,785,355	Lawser	Dec. 16, 1930
1,842,569	Richer	Jan. 26, 1932
2,129,828	Dunn	Sept. 13, 1938
2,157,692	Doe et al.	May 9, 1939
2,283,348	Adams et al.	May 19, 1942