Sept. 16, 1941. C. M. KENDRICK 2,255,786

REVERSIBLE VANE TYPE FLUID MOTOR

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Fig. 1.

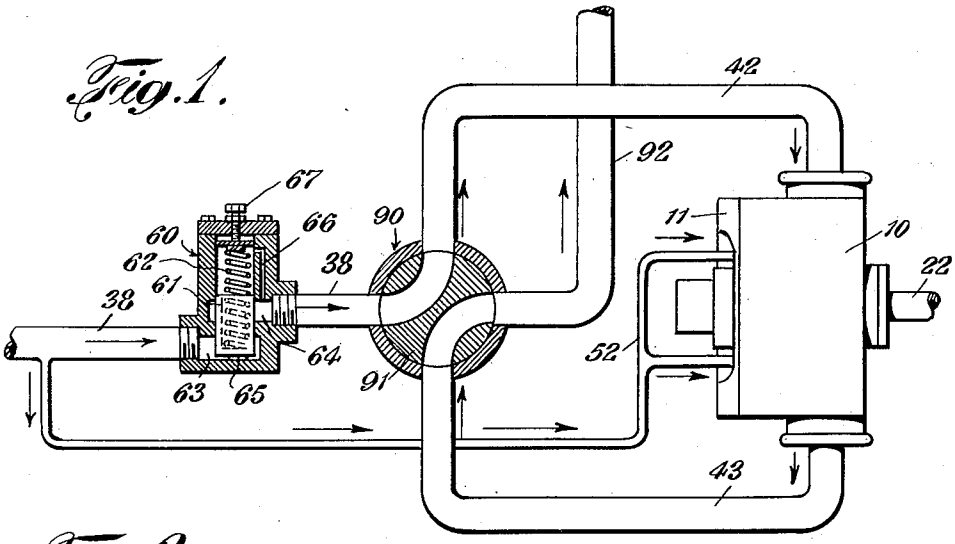


Fig. 3.

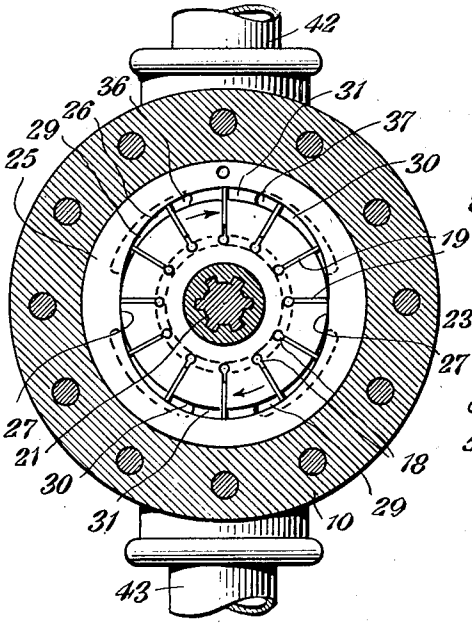
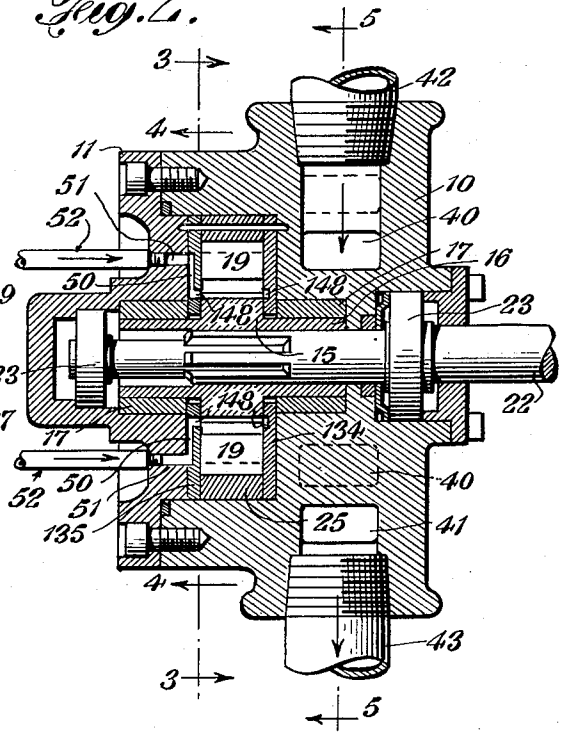


Fig. 2.



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Fig. 4.

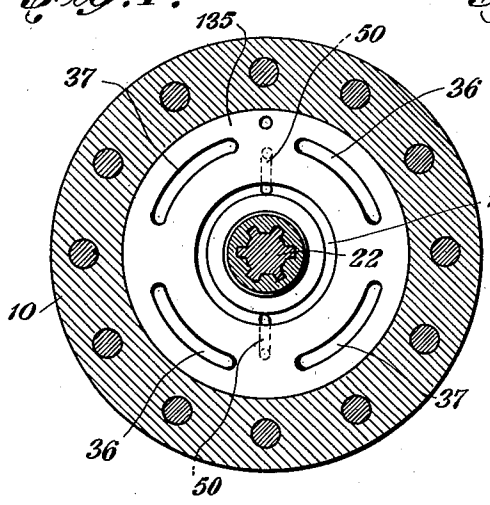


Fig. 5.

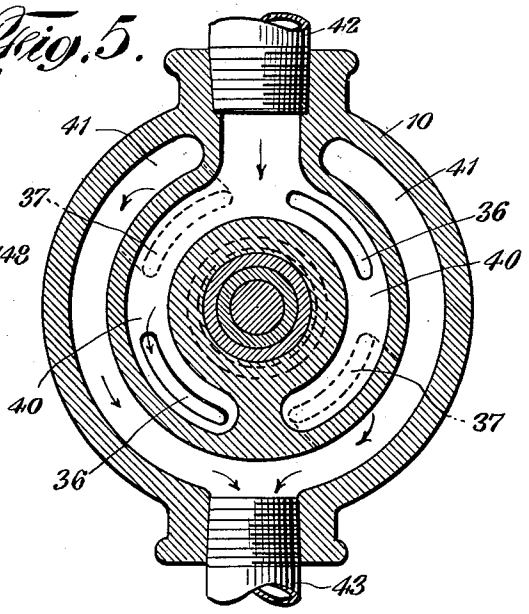
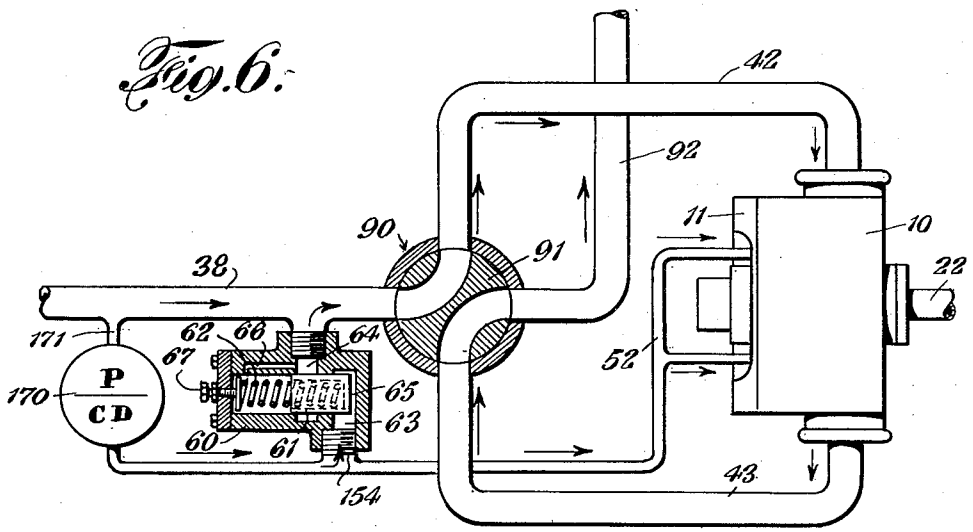


Fig. 6.



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UNITED STATES PATENT OFFICE

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REVERSIBLE VANE TYPE FLUID MOTOR

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Application September 14, 1940, Serial No. 356,734

13 Claims. (Cl. 121—87)

This invention relates to reversible rotary fluid motors and is concerned more particularly with motors of this sort in which the rotor is provided with a plurality of vanes arranged to move inwardly and outwardly thereof, for example, in a substantially radial direction, during the operation of the device. The present application is a continuation in part of a copending application filed March 28, 1938, Serial No. 198,449.

Fluid motors of this general class find their widest use at present as hydraulic devices, that is, devices for handling or whose motive fluid is a liquid, such, for example, as oil, and the motor of the present invention will be described in connection with such use. It will be understood, however, that the invention is applicable to motors operating with elastic fluids.

Vane type motors of this character are provided with a vane track which is adapted to contact the exposed ends of the vanes and to guide and control the inward and outward movement of the vanes. During operation of the device the vane track also cooperates with one or more of the vanes to radially separate the high pressure fluid area, on at least one of its circumferential ends, from the adjoining low pressure fluid area. The other end of the high pressure fluid area is also preferably defined by cooperation between another part of the vane track and one or more of the vanes, although this separation is sometimes effected by cooperation of a part of the vane track and some other member of the rotary assembly, such as the rotor. It is essential that this cooperating contact between the fluid separating vane or vanes and the vane track be maintained in order for the motor to function. It is also important and practically essential to maintain the exposed ends of the vanes continuously in contact with the vane track in order to obtain smooth, quiet and satisfactory operation of the device.

The principal object of this invention is to provide a reversible rotary vane type fluid motor capable of starting smoothly and operating satisfactorily at low rotative speeds as well as at higher speeds in either direction of rotation of its rotor.

Another object is to provide a reversible vane type fluid motor of this character that is simple in structure and inexpensive to manufacture.

A further and more specific object is to provide an improved rotary vane type fluid motor embodying simple and improved means for urging the vanes outward to maintain the necessary contact between the ends of said vanes and the vane track at all speeds of the rotary assembly and in both directions of rotation.

Other and more specific objects will appear from the description which follows.

The invention will be understood from a consideration of the accompanying drawings which illustrate, by way of example, embodiments of the invention in a fluid motor in which the vanes move outwardly and inwardly of the rotor in a substantially radial direction.

In the accompanying drawings:

Fig. 1 is a view, partly schematic, showing a side elevation of a fluid motor and its connections according to the present invention.

Fig. 2 is an enlarged longitudinal sectional view, taken through the center line of the motor shown in Fig. 1.

Figs. 3 to 5 are sectional views transverse the axis of rotation of the rotary assembly, partly in section, drawn to the same scale as Fig. 2 and in which:

Fig. 3 is taken along the line 3—3 of Fig. 2 looking in the direction of the arrows, showing the rotor and its vanes and other parts of the fluid motor.

Fig. 4 is a view along the line 4—4 of Fig. 2, corresponding to Fig. 3 but looking in the opposite direction as indicated by the arrows and showing the rotor side of the cover end plate.

Fig. 5 is a view taken along the line 5—5 of Fig. 2, showing the fluid channels and their connections.

Fig. 6 is a view, partly schematic, corresponding generally to Fig. 1 but showing a modification.

Referring first to the embodiment illustrated in Figs. 1 to 5 the fluid circuit includes a fluid supply pipe 38 through which working pressure fluid for operation of the vane type fluid motor is supplied by any suitable source of pressure fluid, not shown. The fluid supply pipe 38 connects with the inlet port of a conventional reversing valve 90 having the exhaust port thereof connected with pipe 92 leading to the reservoir, not shown. The reversing valve 90 is also provided with two ports which are connected with fluid conduits 42 and 43 leading to the fluid channels 40 and 41 respectively of the vane type fluid motor, to be hereinafter more fully described. The arrangement is such that with the rotatable body 91 of the reversing valve 90 in the position shown in Fig. 1, the working pressure fluid from the supply pipe 38 will pass into the conduit 42 and fluid discharged by the vane type motor will pass out from said motor through the conduit 43 and into the exhaust pipe 92. Rotation of the rotatable

body 91 through 90° in a clockwise direction reverses these fluid connections and the flow of the fluid to and from the vane type motor, so that working pressure fluid then passes into the conduit 43 and fluid exhausted by the motor passes out through the conduit 42 and into the exhaust pipe 92.

As shown in Fig. 2 the motor includes a casing 10 and cover 11 which cooperate to form a cavity for the usual rotor 15 and associated parts. The rotor 15 is formed with a pair of hubs 16 by which it is rotatably supported in a pair of bushings 17 carried by the casing 10 and cover 11 respectively. The rotor also has a plurality of vanes 19 which are movable in a substantially radial direction inward and outward in the vane slots 18.

The motor shaft 22 is revolubly supported upon a pair of bearing members 23 carried by the casing 10 and cover 11 respectively and passes through the central bore of the rotor 15, with which it has a slidable splined connection as at 21 (Fig. 3). One end of the shaft 22, shown as broken off in Fig. 2, projects outward beyond the casing 10 for connection to the apparatus to be operated by the motor.

A vane track ring 25 (Figs. 2 and 3) surrounds the rotor and vane assembly and its inner circumferential surface 26 forms a track adapted to contact the outer ends of the vanes 19; for convenience this surface 26 will be termed the "vane track." The vane track 26 is of variable diameter but its curvature is preferably symmetrical on either side of a line passing through the center of the rotor 15.

The motor here illustrated is of the hydraulically balanced "double acting" type of hydraulic device in which each vane is reciprocated twice for each revolution of the rotor. As shown in Fig. 3 the space intermediate the periphery of the rotor 15 and the vane track 26 is accordingly divided into two fluid sections by means of two sealing chambers formed by cooperation of the rotor 15 and the ends of the vanes 19 with the vane track 26 at the region of the vane track's least diameter, which in this instance is adjacent the horizontal center line. The vane track 26 is preferably provided at each of these points of division or sealing chambers with an arc 27 (termed the sealing arc) substantially concentric with the rotor 15 and extending in a circumferential direction for a distance equal at least to the angular distance between a pair of adjacent vanes 19, in order that there shall be substantially no radial movement of the vanes 19 while passing thereacross.

Each fluid section includes a working space or chamber 31 (Fig. 3) flanked by a fluid area 29 and a fluid area 30, one of which will be the inlet area for that fluid section and the other of which will be the outlet area for that fluid section depending upon the direction of flow of the fluid in the conduits 42 and 43 and hence upon the direction of rotation of the rotor 15. Fluid is admitted to the spaces between the outer ends of the vanes as they move through whichever of the areas 29 or 30 is at the time the inlet area as the vanes approach the working space 31. Each working space is located at the region of the greatest diameter of the vane track 26 and extends circumferentially between the ends of the ports or slots 36 and 37, and preferably for an arcuate distance equal to or slightly greater than the distance between two adjacent vanes 19. Each fluid inlet area is thus at all times radially separated from the fluid outlet area of the same fluid section by at least one of the vanes 19 in cooperation with the vane track 26 and the difference in fluid pressures on the opposite side faces of such vanes causes the rotation of the rotor. Fluid is discharged into whichever of the areas is at the time the outlet area as the vanes recede from the working spaces 31. The surface of the vane track 26 within the working spaces 31 is preferably concentric with the rotor 15 and that intermediate the sealing arcs 27 and the working spaces is given any suitable curvature producing satisfactory rates of inward and outward movement of the vanes 19 as the rotor revolves.

The sides or axial ends of the working spaces, the fluid areas 29 and the fluid areas 30 are defined by a pair of mating disc-shaped members 134 and 135 (Fig. 2), for convenience termed "end plates," which are provided with holes at their centers through which pass the hubs 16 of the rotor 15. The outer surfaces of the end plates 134 and 135 fit snugly against the adjacent wall surfaces of the casing 10 and cover 11 respectively and form substantially fluidtight fits with the several ports and passages to be presently described. The inner or opposing faces of the end plates 134 and 135 form fluidtight fits with the sides of the vane track ring 25 by which they are axially positioned with respect to the rotor 15 in such manner that the rotor is permitted to turn freely while its sides and the sides of the vanes 19 form substantially fluidtight running fits with the adjacent faces of the end plates 134 and 135. The end plate 134 will hereinafter be termed the "casing end plate" and similarly the end plate 135 will be termed the "cover end plate."

Each of the end plates 134 and 135 is formed with two pairs of arcuate slots 36 and 37 respectively as shown in Figs. 3 to 5. Either pair of these ports may be the inlet ports and the other pair will then be the outlet ports depending upon the direction of flow of fluid in the circuit; that is to say, the pair of ports 36 will be the inlet ports and the pair of ports 37 will be the outlet ports when the conduit 42 is connected with the supply pipe 38 and working pressure fluid flows therethrough to the motor whereas the pair of ports 37 will be the inlet ports and the pair of ports 36 will be the outlet ports when the rotatable body 91 of the reversing valve 90 is rotated to connect the conduit 43 with the supply pipe 38. The flow of fluid to and from the outer ends of the vanes 19 takes place only through the ports 36 and 37 of the casing end plate 134. The ports 36 and 37 of the cover end plate 135 function principally as "balance ports" to contain fluid under the same pressure as that in the corresponding ports of the casing end plate 134 in order to produce hydraulic balance of the rotating parts as already stated.

The portion of the fluid circuit for conveying fluid to and from the outer ends of the vanes 19 also includes a pair of channels 40 and 41 respectively (Figs. 2 and 5) which are formed in the casing 10 and which are approriately connected with the fluid conduits 42 and 43 respectively. The fluid channel 41 is also appropriately connected with the ports or slots 37 in the casing end plate 134 as indicated by the dotted lines of Fig. 5 and the fluid conduit 40 is similarly connected with the ports or slots 36 in said casing

end plate 134. With the arrangement hereinbefore described, operating pressure fluid admitted to the conduit 42 will pass into the ports 36 of the casing end plate 134 and the fluid areas 29 connected with said ports 36 which will then be the inlet areas as above explained. Operating pressure fluid acting on the adjacent faces of the vanes 17 that are then in contact with the portion of the vane track within the working spaces 31 will cause rotation of the rotor 15 and shaft 22 in a clockwise direction as viewed in Fig. 3. The fluid areas 30 connected with the ports 37 of the casing end plate 134 will then be the outlet or discharge areas and the fluid discharged by the outer ends of the vanes will pass out through the ports 37 of said end plate 134, into the channel 41 and out through the conduit 43. Similarly operating pressure fluid admitted to the conduit 43 will pass to the ports 37 of the casing cheek plate 134 causing rotation of the rotor 15 and shaft 22 in a counter clockwise direction as viewed in Fig. 3, and fluid exhausted by the outer ends of the vanes 19 will pass out through the ports 36 of the casing end plate 134 into the channel 40 and finally out through the conduit 42.

With the parts in the position shown in Fig. 3, working or operating pressure fluid entering the fluid areas 29 will act against the adjacent faces of the vanes 19 which at the instant are in contact with the arcs 31 of the vane track 26 and the force thus exerted will produce clockwise rotation of the rotary assembly and the driven shaft 22 as viewed in Fig. 3. In order for this operation to take place, however, it is necessary that the vanes 19 which separate the areas 29 from the fluid areas 30 at the arcs 31 be firmly in contact with the vane track and that there be similar contact between the ends of the vanes 19 and the vane track at the sealing arcs 27. It is also important and practically essential for quiet operation that contact between the vanes 19 and the vane track be maintained throughout the movement of the vanes 19 through the fluid inlet areas, as sudden and abrupt outward movement of the vanes would otherwise result and would produce noise, wear and unsatisfactory operation. This contact of the vanes 19 at the arcs 27 and 31 and the track-following action of the vanes 19 as they pass through the fluid inlet areas will not dependably result however unless the vanes 19 are acted upon by an adequate radially-outward force.

In the motor herein shown this force is produced and brought to bear on the inner ends of the vanes by improved means for continuously supplying to the inner ends of all the vanes fluid having a controlled pressure higher than that of the fluid in the inlet areas. The means employed for this purpose will now be described.

As shown in Figs. 3 to 5, the end plates 134 and 135 are each formed with an annular vane slot port 148 which continuously connects with the inner ends of all the vane slots 18. In order that these vane slot ports 148 may receive a supply of fluid, the vane slot port 148 in the cover end plate 135 is connected with the branched ends of a pipe 52 as shown in Figs. 1 and 2. The fluid connections between the vane slot port 148 and the cover end plate 135 and the branched ends of the pipe 52 include a hole drilled through the cover end plate 135 (Figs. 2 and 4) which connects said vane slot port 148 with a groove 50 recessed in the outer face of the cover end plate 135, that is, the face adjacent the wall surface of the cover 11. Each groove 50 registers with an axial passage 51 extending through the cover 11 to which its end of the branch pipe 52 is suitably connected as shown in Fig. 2. The vane slot port 148 in the casing end plate 134 is not directly connected with the fluid supply, but receives its supply of fluid through the inner ends of the vane slots 18 and thus acts in part as a "balance port" to balance the hydraulic force acting on the sides or axial ends of the vanes 19 and the rotor 15.

The present invention also includes improved means whereby the pressure of the fluid supplied to the vane slot ports 148 is at all times correlated with and exceeds by a substantially constant amount the pressure of the fluid actually existing in whichever of the fluid areas are at the time the inlet areas. This difference in pressure is maintained irrespective of the amount of pressure in the fluid inlet areas or frequency of change thereof, and the means by which this is accomplished will now be described.

Referring to Fig. 1, the inlet pipe 38 is provided with a valve 60 which includes a valve body 61 slidably mounted in the valve bore therein and which is urged inward toward its fully closed position by a spring 62. The inner end of the valve body 61 is adapted to be acted upon at all times by the pressure of the fluid in the valve's fluid receiving port 63 and is accordingly provided with a small stop 65 to prevent its inner end surface from contacting the closed end of the valve bore when said valve body 61 is in its fully closed position as shown in Fig. 1. The outer end of the valve body 61, which has the same area as the inner end thereof, is similarly adapted to be acted upon by fluid having the same pressure as that in the valve's fluid discharging port 64 and the outer end of the valve bore is accordingly connected with said discharging port 64 as by a passage 66 which enters the valve bore at a point which will not be covered when the valve body 61 is in its fully open position.

When operating pressure fluid is admitted to the inlet pipe 38 it passes first to the valve's receiving port 63 where it acts upon the inner end of the valve body 61 and raises said valve body 61 against the spring 62. This movement of the valve body 61 opens the valve 60 and permits pressure fluid to pass into the valve's discharging port 64 whence it immediately passes into the outer end of the valve bore and acts upon the outer end of the valve body 61. Two oppositely acting forces are thus brought to bear upon the valve body 61, the force tending to move it outward comprising the action of the pressure fluid against its inner end and the opposing force tending to move the valve body 61 inward comprising the force exerted by the pressure fluid acting upon its outer end in combination with the force exerted by the spring 62. The valve body 61 is accordingly moved until the opposing forces balance, in which position it provides an orifice through the bore of the valve 60 of the proper size to create the necessary difference of pressures of the fluid in the receiving port 63 and discharging port 64 respectively, due to the resistance of flow through said orifice, as determined by the spring 62.

As the areas of the inner and outer ends of the valve body 61 are equal, this balancing of forces acting on the valve body 61 is determined entirely by relative pressures existing in the receiving port 63 and discharging port 64 respectively and is independent of absolute pressures; that is to say, substantially the same difference

exists in these pressures regardless of the actual amount of pressure in either of said ports. This difference is therefore maintained substantially constant throughout the entire range of operating pressures. The valve body 61 will also move immediately to compensate for any change in operating conditions, such as variation in the amount of fluid passing into the inlet pipe 38, change in viscosity of the operating fluid, etc.

The pressure of the fluid in the valve's discharging port 64 is substantially the same as the pressure in whichever of the areas 29 or 30 are at the time the inlet areas of the motor and is determined by the motor's load. The valve 60 therefore operates to maintain the fluid in its receiving port 63 at a pressure higher by a substantially constant amount than the pressure of the fluid in whichever areas of the motor are its inlet areas. This difference in pressures is maintained under all operating conditions. The higher pressure in the valve's receiving port 63, and consequently in its connected portion of the pipe 38, is accordingly termed the "differential high pressure."

The pipe 52 is connected with the fluid inlet pipe 38 at a point where it will always receive the differential high pressure fluid. As shown in Fig. 1, this connection is made with the fluid inlet pipe 38 at a point in advance of the valve 60, i. e. with the portion of the fluid inlet pipe 38 which leads to the valve's receiving port 63. The pipe 52 and hence also the vane slot ports 148 thus always receive a supply of the differential high pressure fluid, the pressure differential of which is made sufficient to force outward and to maintain proper contact between the ends of the vanes 19 and the vane track 26. The inner ends of all the vanes 19 are thus continuously supplied with fluid having sufficient pressure to keep them in proper operating position regardless of the direction in which the motor is being operated, and the pressure of this fluid is always definitely related by a relatively constant difference to the pressure of the working pressure fluid acting on the outer ends of the vanes 19. The amount of this pressure differential is determined by the spring 62 and may be varied by adjustment of the screw 67 (Fig. 1). In practice it has been found that a pressure differential of from about 10 lbs. to 75 lbs. per sq. in. is usually sufficient and the amount, which never need be very great, may be varied as conditions require but is preferably kept at the minimum.

Another feature of the arrangement shown in Fig. 1 is that it assures proper contact between the ends of the vanes 19 and the vane track 26 before any pressure fluid is admitted to the fluid inlet areas where it can act upon the exposed ends of said vanes. This is due to the fact that the valve body 61 completely cuts off communication between the portions of the pipe 38 which are connected with the receiving port 63 and discharging port 64 whenever the difference in pressures is less than the amount determined by the spring 62, as would be true when the motor is not in operation. Thus no fluid can pass through the valve 60 until the pressure in its receiving port 63 (and hence in the vane slot ports 148) rises sufficiently to lift the valve body 61 against the spring 62; that is to say, until the differential high pressure has been established. The vanes 19 will therefore be forced into their proper operating positions a slight time before the operating pressure fluid strikes their outer ends. This is important at starting and assures that the motor will begin to operate promptly, smoothly and quietly.

It will be seen from the foregoing that operating pressure fluid entering the pipe 38 will, if the motor is idle, first act to move the vanes 19 outward to their operating positions and that immediately thereafter operating pressure fluid will act against the exposed ends of the vanes 19 at the arcs 31, as already explained, to produce rotation of the rotor 15 and driven shaft 22. It will also be seen that the differential high pressure acts to maintain proper operating position of the vanes 19 as long as any fluid passes through the valve 60, that is to say, whenever the motor is in operation. The direction of rotation of the rotor 15 and shaft 22 are determined by the position of the rotatable body 91 of the reversing valve 90. With the rotatable body 91 in the position shown in Fig. 1, working pressure fluid from the pipe 38 will pass into the conduit 42 and as already explained will pass to the ports 36 and fluid areas 29 to cause clockwise rotation of said rotor and shaft. The rotation of the rotatable body 91 through 90° in a clockwise direction will connect the fluid supply pipe 38 with the conduit 43 so that working pressure fluid will pass through the ports 37 and fluid areas 30 and will cause rotation of the rotor 15 and shaft 22 in a counter-clockwise direction as viewed in Fig. 3. Differential high pressure fluid is continuously supplied to the inner ends of all the vanes (i. e. in both directions of rotation of the rotor 15 and also during the entire time that reversal of its direction of rotation is being effected) so that the motor will start smoothly and operate satisfactorily in either direction of rotation. The operation of the motor and speed of rotation of the rotor 15 and shaft 22 are regulated and controlled by the amount of working pressure fluid admitted to the supply pipe 38, which may be controlled by any suitable means, not shown.

This arrangement has many advantages. For example, the structure is extremely simple and inexpensive. A rotary vane type fluid motor constructed according to the present invention will start smoothly and promptly in either direction of rotation and will also operate smoothly and satisfactorily at all speeds from very low speeds up to speeds that are relatively high in both directions of rotation. Such a motor has distinctive properties of acceleration and deceleration because its rotating masses are small and the working parts are substantially balanced with respect to hydraulic forces imposed thereon. For this reason the motor may be reversed very rapidly and in practice such reversal under inertia load has been effected at rates up to and including approximately 60 reversals per minute with the rotor attaining an approximate speed of 1100 R. P. M.

The arrangement shown in Fig. 6 differs from that of Fig. 1 only in the means by which the differential high pressure fluid is obtained. The branched pipe 52 is in this instance connected with the discharge port of a small auxiliary pump 170 which may be driven by any suitable means, not shown, and which is made such that it at all times supplies a quantity of fluid in excess of the amount required by the vane slot ports 148. The pipe 52 is also connected by a pipe 154 with the fluid receiving port of the valve 60 whose fluid discharging port is connected by a pipe 155 with the fluid supply pipe 38. The excess fluid not needed by the vane slot ports

148 exhausts through the valve 60 into the pipe 38 and the valve 60 acts to maintain a differential in the pressures of the fluid in the pipes 38 and 152 respectively in a manner similar to that already explained. The pressure of the fluid in the pipe 52 and hence in the vane slot ports connected therewith is thus definitely related to the pressure of the fluid in the pipe 38 which is substantially the same as the pressure in whichever of the areas are at the time the fluid inlet areas, and the differential in pressures is continuously maintained.

The inlet port of the pump 170 is preferably connected as by a pipe 171 with the fluid inlet pipe 38, so that its supply of fluid has the same pressure as that of the fluid in said pipe 38. This has the advantage of reducing the work of the pump 170, as it is then necessary for said pump 170 to increase the pressure of the fluid only by the amount of the pressure differential, which is a relatively small amount. This makes it possible to use a less expensive pump than would otherwise be required for this purpose. The arrangement of Fig. 6 also has the advantage of reducing the volume of fluid raised to the differential high pressure level to only a little more than must be supplied to the vane slot ports in order to obtain proper vane action.

The embodiment of Fig. 6 operates as a reversible vane type fluid motor in the same manner as already explained in connection with the embodiment illustrated in Figs. 1 to 5 and provides equally satisfactory operation in both directions of rotation.

It will be understood that the several embodiments of my invention have been described for the purpose of illustrating the operation and construction of the apparatus of my present invention and that changes may be made without departing from the spirit of the invention.

I claim:

1. In a reversible rotary vane type fluid motor having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof, a casing therefor including a vane track for guiding the vanes in their in and out movement, a chamber adjacent the rotor having on the circumferential sides thereof two fluid areas either of which may be the inlet area and the other of which will then be the outlet area, said chamber functioning as a working chamber for whichever of said areas is at the time the inlet area and extending in a circumferential direction a distance substantially equal to the distance between the outer ends of a pair of adjacent vanes when in contact with the portion of the vane track in said chamber, means for connecting either of said areas with working pressure fluid to thereby make it the inlet area and means for uninterruptedly supplying to the inner ends of the vanes through at least a portion of their rotary travel fluid under pressure higher than the greatest pressure then existing in either of said areas, irrespective of which area is at the time the inlet area and during the period of reversal of the direction of rotation of the rotor.

2. In a reversible rotary vane type fluid motor having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof in a substantially radial direction, a casing therefor including a track for guiding the vanes in their in and out movement and provided with two diametrically opposed working chambers, each working chamber having on opposite circumferential sides thereof two fluid areas either of which may be the inlet area and the other of which will then be the outlet area, said chambers and areas being positioned adjacent the rotor whereby the radially outer ends of said vanes are subjected to the respective pressures of the fluid therein as they pass therethrough, means for connecting either of the two fluid areas adjacent one of said working chambers and the diametrically opposed fluid area adjacent the other of said working chambers with working pressure fluid to thereby make them the inlet areas and means for continuously supplying to the inner ends of the vanes, throughout at least the portion of their rotary movement in which the outer ends are passing intermediate the areas which at the time are the outlet areas, fluid having a pressure greater than but related to the pressure of said working pressure fluid, irrespective of which of said areas are the inlet areas and during the period in which the working pressure fluid is being disconnected from one pair of diametrically opposed areas and connected with the other.

3. In a reversible rotary vane type fluid motor having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof, a casing therefor including a vane track for guiding the vanes in their in and out movement, two fluid areas either of which may be the inlet area and the other of which will then be the outlet area, means for connecting at will either of said areas with working pressure fluid to thereby make it the inlet area, a port connected with the inner ends of said vanes during at least a portion of their rotary movement, and means for maintaining in said port a fluid pressure correlated with the pressure of the working pressure fluid and sufficient in amount to produce on the inner end of each vane in communication with said port an outward force exceeding the opposing inward force simultaneously exerted on said vane by action of pressure fluid on the outer end thereof, whereby said vane is kept in contact with said track throughout the time that its inner end is connected with said port irrespective of which of said areas is connected with the working pressure fluid.

4. In a reversible rotary vane type fluid motor having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof, a casing therefor including a vane track for guiding the vanes in their in and out movement, a working chamber adjacent the rotor having on opposite circumferential sides thereof two fluid areas either of which may be the inlet area and the other of which will then be the outlet area, means for connecting either of said areas with working pressure fluid to make it the inlet area and means continuously supplying to the inner ends of all of said vanes fluid under pressure greater than but related to the pressure of said working pressure fluid irrespective of changes in pressure in said working pressure fluid and irrespective of which of said areas is at the time the inlet area and during the period in which the working pressure fluid is being disconnected from one of said areas and connected with the other.

5. In a reversible rotary vane type fluid motor having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof, a cas-

ing therefor including a vane track for guiding vanes in their in and out movement and provided adjacent the rotor with a working chamber having on opposite circumferential sides thereof two fluid areas either of which may be the inlet area and the other of which will then be the outlet area, a supply line for the working pressure fluid, a reversing valve having its inlet port connected with said supply line, separate fluid connections from said reversing valve to each of said areas, a differential pressure valve positioned in said supply line at a point in advance of said reversing valve, said differential pressure valve being arranged to cut off communication between said supply line and said reversing valve when the motor is not operating and to establish such communication only after a predetermined difference in pressures exists on the inlet and outlet sides of said differential pressure valve, a supply port adapted to continuously connect with the inner ends of all of said vanes, and a fluid connection leading to said supply port from a point in said supply line in advance of said differential pressure valve.

6. In a reversible rotary vane type fluid motor having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof, a casing therefor including a vane track for guiding the vanes in their in and out movement and provided adjacent the rotor with a working chamber having on opposite circumferential sides thereof two fluid areas either of which may be the inlet area and the other of which will then be the outlet area, a supply port adapted to continuously connect with the inner ends of all of said vanes, a pump having a discharge conduit and adapted to deliver into said discharge conduit a volume of fluid in excess of the volume required by the inner ends of said vanes, a fluid connection between said discharge conduit and said supply port, a second fluid connection between said discharge conduit and the supply of working pressure fluid and valve means in said last named fluid connection active to regulate the flow therethrough of excess fluid delivered by said pump to maintain the fluid in said discharge conduit under pressure related to and greater than the pressure of said working pressure fluid.

7. In a reversible rotary vane type fluid motor having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof, a casing therefor including a vane track for guiding the vanes in their in and out movement and provided adjacent the rotor with a working chamber having on opposite circumferential sides thereof two fluid areas either of which may be the inlet area and the other of which will then be the outlet area, a supply line for said working pressure fluid, a booster pump having its inlet port connected with and receiving its supply of fluid from said supply line, said booster pump also having a discharge conduit and delivering into said discharge conduit fluid in excess of the volume required by the inner ends of said vanes, a vane slot port adapted to continuously connect with the inner ends of all of said vanes, a fluid connection between said discharge conduit and said vane slot port, a second fluid connection between said discharge conduit and said supply line, and valve means in said last named fluid connection active to regulate the flow therethrough of the excess fluid delivered by said booster pump to maintain the fluid in said discharge conduit under pressure related to and greater than the pressure of said working pressure fluid.

8. In a reversible rotary vane type fluid motor having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof, a casing therefor including a vane track for guiding the vanes in their in and out movement, two fluid areas either of which may be the inlet area and the other of which will then be the outlet area, separate unrestricted fluid supply connections leading to said areas, a reversing valve for supplying fluid pressure to either of said connections at will, said motor casing having a port for supplying fluid pressure to the inner ends of said vanes during at least a part of their rotary movement and means for maintaining in said port fluid pressure greater than the pressure in the inlet area irrespective of which of said fluid areas is the inlet area.

9. The combination of a reversible rotary vane type fluid pressure device having a rotor including a plurality of vanes movable inwardly and outwardly thereof, a casing therefor including a track for guiding the vanes in their in and out movement and provided with a working chamber having interchangeable high and low pressure areas on opposite circumferential sides thereof adjacent the rotor, the outer ends of said vanes being subject to the respective pressures in said chamber and said areas while passing therethrough, a source of pressure fluid continuously connected with the inner ends of said vanes during at least a portion of each rotation of the rotor and means for maintaining the pressure of the fluid connected to the inner ends of said vanes at a pressure greater than but correlated to the greatest pressure existing at the time in either of said areas, irrespective of which of said areas is the high pressure area and during the interval of interchange of high pressure from one area to another.

10. The combination of a reversible rotary vane type fluid motor having a rotor including a plurality of vanes movable inwardly and outwardly thereof, a casing therefor including a track for guiding the vanes in their in and out movement and provided with a working chamber having interchangeable high and low pressure areas on opposite circumferential sides thereof adjacent the rotor, the outer ends of said vanes being subject to the respective pressures in said chamber and said areas while passing therethrough, a pressure fluid line, fluid flow control means connected with said line and with the exhaust and having two connections with said motor one with each of said areas, said fluid flow control means having an element movable to connect said line with either of said areas or with the exhaust, a source of pressure fluid continuously connected with the inner ends of said vanes during at least a portion of each rotation of the rotor and means for maintaining the pressure of said fluid connected to the inner ends of said vanes at a pressure greater than but correlated to the greatest pressure existing in either of said areas, irrespective of whether said supply line is connected with one of said areas or with the exhaust.

11. In a reversible vane type rotary fluid motor, a rotor having a plurality of vanes movable inwardly and outwardly thereof, a vane track for guiding said vanes in their in and out movement, interchangeable inlet and outlet ports for the outer ends of said vanes, an inlet port for the inner ends of said vanes, a reversing valve

having unimpeded fluid connections with the inlet and outlet ports for the outer ends of said vanes, a supply pipe leading to said reversing valve, a supply pipe leading to the inlet port for the inner ends of said vanes and means for maintaining a differential pressure relationship between the fluids in said supply pipes.

12. The combination of a reversible rotary vane type fluid pressure device having a rotor including a plurality of vanes movable inwardly and outwardly thereof, a casing therefor including a track for guiding the vanes in their in and out movement and provided with a working chamber having interchangeable high and low pressure areas on opposite circumferential sides thereof adjacent the rotor, the outer ends of said vanes being subject to the respective pressures in said chamber and said areas while passing therethrough, a port arranged to connect with the inner ends of said vanes during at least a portion of each rotation of the rotor, a pump having a discharge conduit connected with said port and means for maintaining the pressure of the fluid supplied by said pump to said port at a pressure correlated with the pressure of the fluid in whichever of the areas is the high pressure area and sufficient in amount to produce on the inner ends of the vanes a radially-outward force exceeding the greatest radially-inward force simultaneously exerted on said vanes by action of pressure fluid on the outer ends thereof, irrespective of which of said areas is at the time the high pressure area and during the interval of interchange of high pressure from one area to another.

13. In a reversible rotary vane type fluid motor having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof in a substantially radial direction in slots formed therein, a casing therefor including a track for guiding the vanes in their in and out movement, two fluid areas either of which may be the inlet area and the other of which will then be the outlet area, means for connecting at will either of said areas with working pressure fluid to make it the inlet area, a pair of substantially co-extensive mating ports disposed on axially opposite sides of the rotor and arranged to connect with the inner ends of the vanes during at least a portion of their rotary movement, said ports being positioned axially opposite one another whereby the force exerted in an axial direction on said rotor and vanes by pressure fluid in one of said ports is opposed and substantially balanced by the force exerted on said rotor and vanes by pressure fluid in the other of said ports, and means for maintaining in said ports fluid pressure correlated with the pressure of the working pressure fluid and sufficient in amount to produce on the inner end of each vane in communication therewith an outward force exceeding the opposing inward force simultaneously exerted on said vane by action of pressure fluid on the outer end thereof, whereby said vane is kept in contact with said track throughout the time that its inner end is connected with said ports irrespective of which of said areas is connected with the working pressure fluid, said last named means comprising a supply of said fluid of correlated pressure and means directly connecting said supply with only one of said ports, with the other port of said mating pair connected with said supply solely through said first named port and the inner ends of said slots.

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