Sept. 16, 1941. C. M. KENDRICK 2,255,782

FLUID PRESSURE MEANS AND SYSTEM

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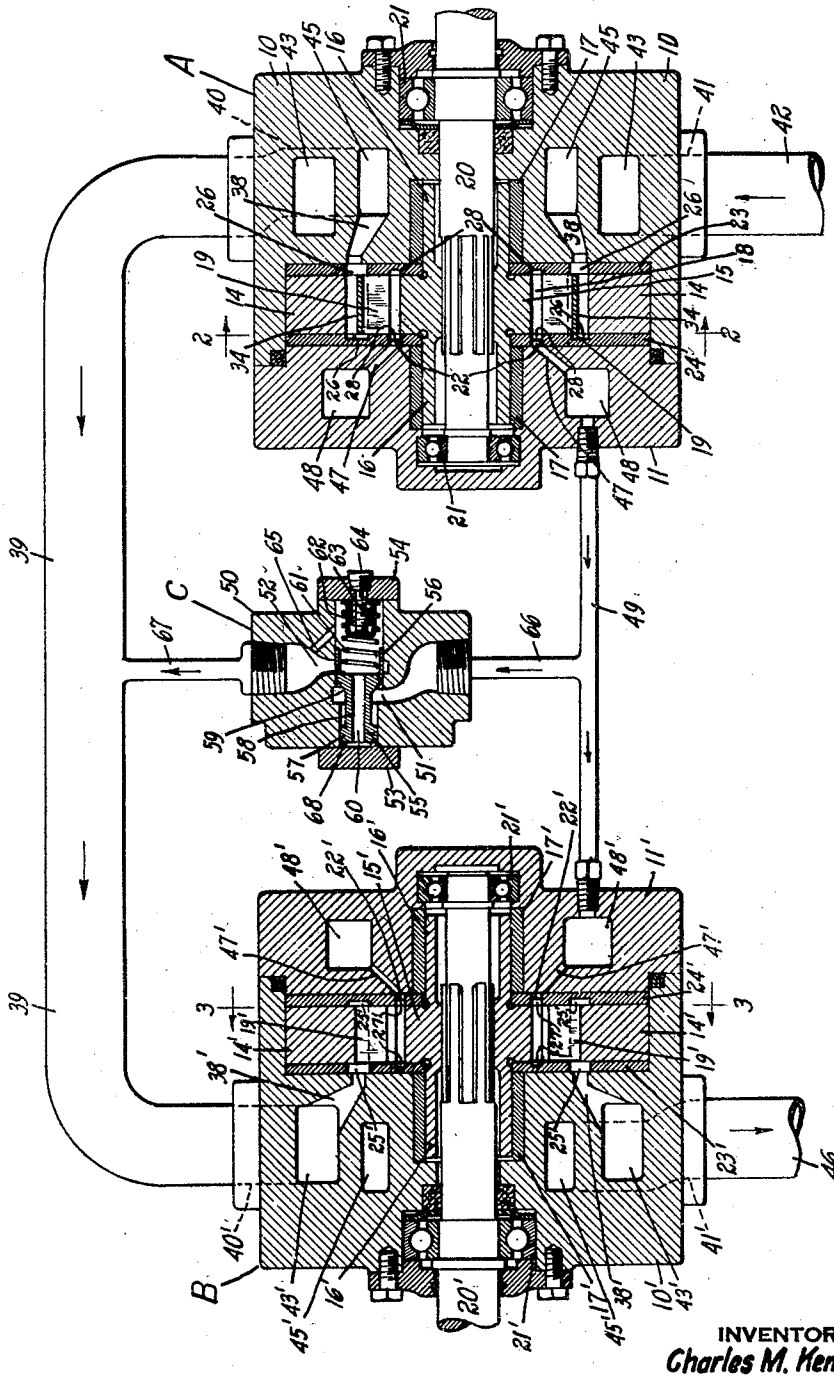


Fig. 1.

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Fig. 2.

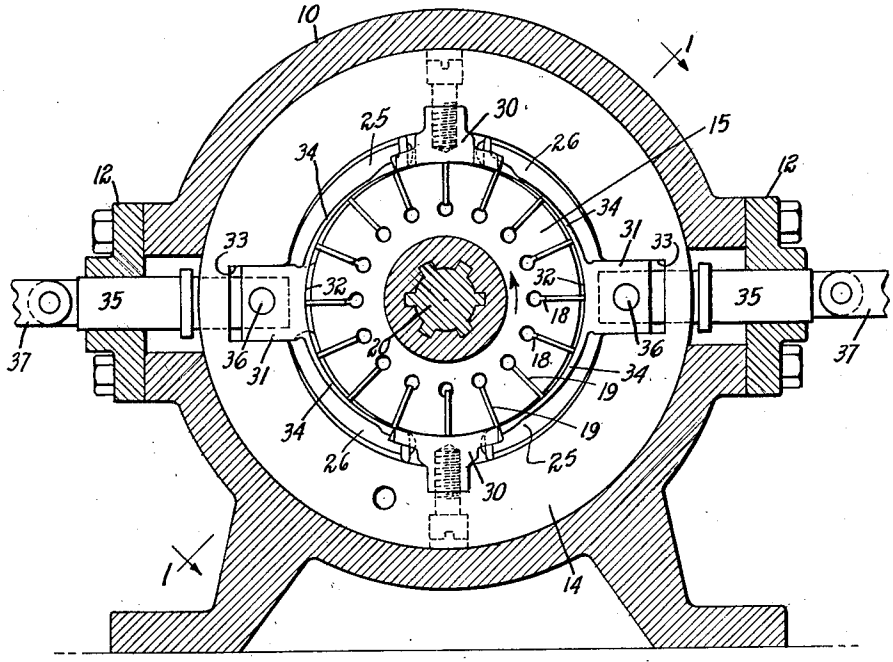
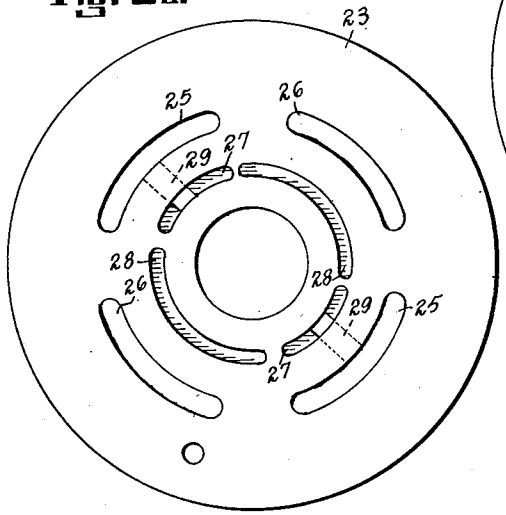


Fig. 2a.



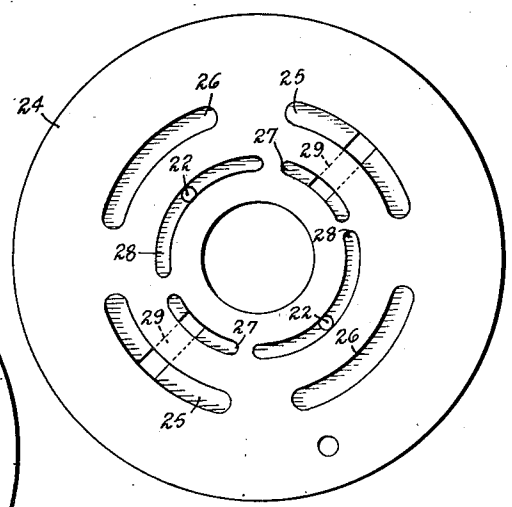


Fig. 2b.

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FLUID PRESSURE MEANS AND SYSTEM

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Fig. 3.

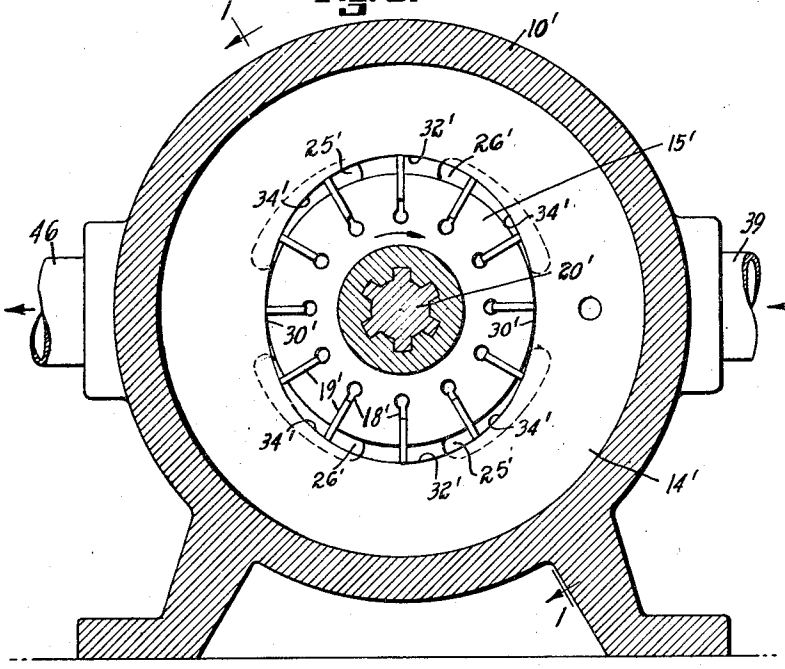


Fig. 3b.

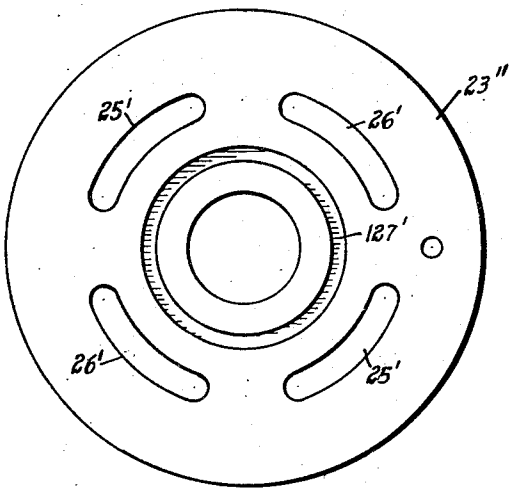
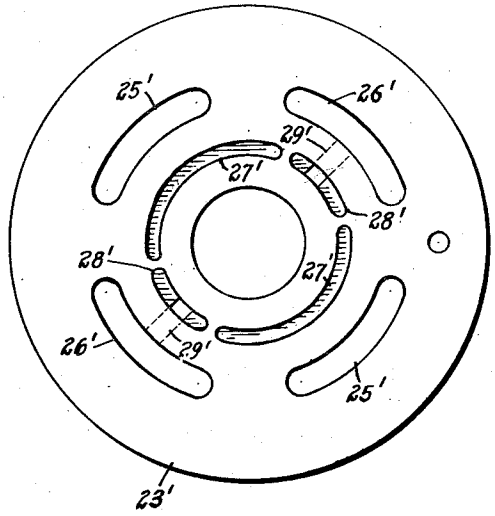


Fig. 3a.



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Fig. 4.

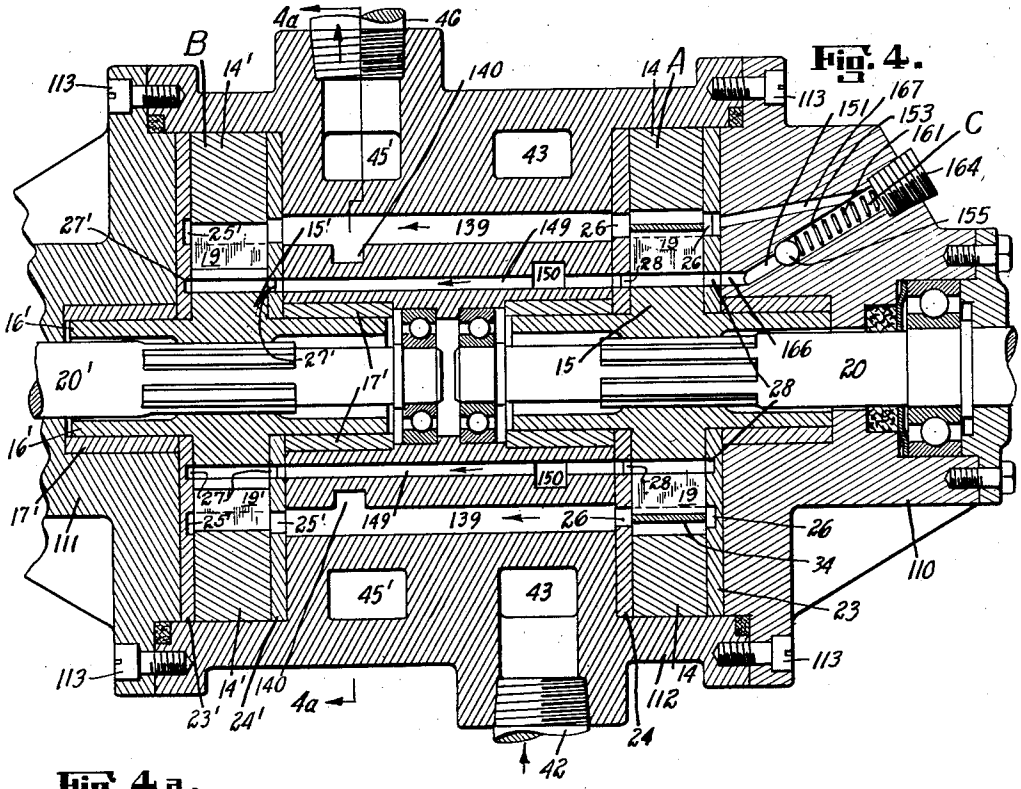
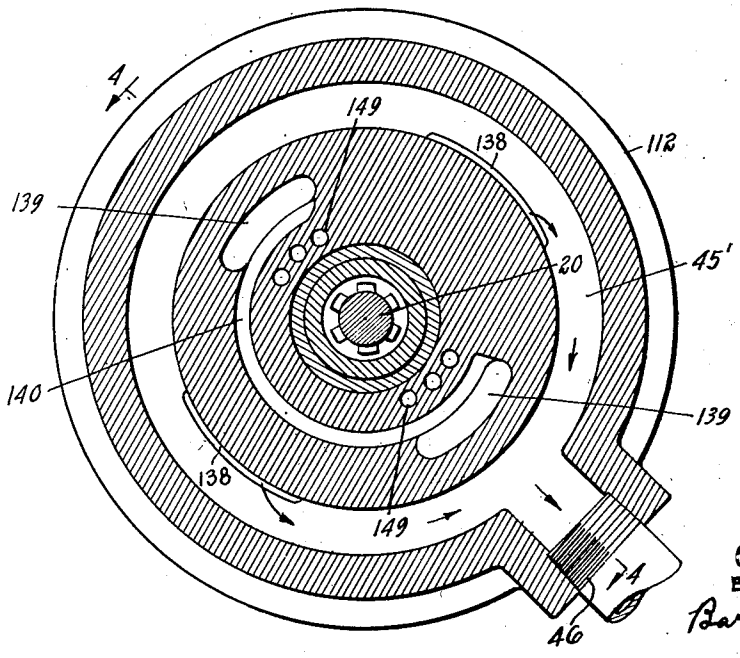


Fig. 4a.



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UNITED STATES PATENT OFFICE

2,255,782

FLUID PRESSURE MEANS AND SYSTEM

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Application May 5, 1939, Serial No. 271,874

16 Claims. (Cl. 60—53)

This invention relates to fluid pressure devices and systems which are adapted to transmit power by means of fluid under pressure.

The widest present use for devices and systems of this general class is as hydraulic devices and systems, that is to say, devices and systems for handling, or whose motive fluid is a liquid, such, for example, as oil. The present invention will accordingly be described in connection with such use, although it will be understood that the invention is also applicable to devices and systems operating with elastic fluids.

In fluid pressure devices and systems of the type under consideration it is frequently necessary or desirable to employ operating pressure fluids having different but related pressures. This is the case, for example, when the fluid system includes a fluid motor of the vane type in which the vanes move inward and outward of the rotor in a substantially radial direction. In vane motors of this character it is often necessary to force the vanes radially outward during certain portions of their rotary travel, particularly at starting and when the motor is operating at low rotative speeds, so that the outer ends of the vanes will be held firmly in contact with the surrounding vane track and thus provide a movable resistance to the pressure fluid admitted to the pressure areas at the outer ends of the vanes of the fluid motor, whereby rotary motion is imparted to the rotor and the driven shaft of the vane motor. A highly practical and satisfactory method for forcing the vanes of the motor radially outward against the vane track is by introducing or admitting, behind the inner ends of the vanes, pressure fluid having a pressure greater than but related to the pressure of the fluid admitted to the pressure areas at the outer ends of said vanes, as fully explained in my copending application filed March 28, 1938, Serial Number 198,449. Thus fluid under two different but related operating pressures is used; the fluid having the higher of these two pressures, which for convenience is termed the "differential high pressure fluid," is admitted to the radially inner ends of the vanes, while fluid under the lesser of these two pressures is admitted to the pressure areas at the outer ends of the vanes of the vane motor.

These two different but related pressures have heretofore been provided by two methods disclosed in the above mentioned application. According to one method, the whole supply of fluid going to the vane motor is passed through a "differential pressure" or resistance valve which maintains the pressure of the fluid in its inlet port at a value exceeding by a substantially constant amount or differential the pressure of the fluid in its outlet port. This method has been found to work very satisfactorily but it involves a power loss incident to the pressure drop across the "differential pressure" valve and this loss applies to the greater portion of the total fluid supply (i. e., the entire portion of the fluid that passes to the pressure areas at the outer ends of the vanes) as only a relatively small part of the total is supplied to the inner ends of the vanes at the "differential high pressure" value existing in the valve's inlet port.

According to the second of these two methods, a separate, auxiliary pump is employed to boost the pressure of the fluid supplied to the inner ends of the vanes to a value exceeding by a substantially constant amount the pressure of the fluid that passes to the outer ends of the vanes. This method is more efficient, as a general rule, than that of passing the entire fluid volume through a "differential pressure" valve but it requires a separate booster pump and, when this pump is operated at a constant speed, as is usually the case, it also has the handicap of providing a substantially constant supply of "differential high pressure fluid" irrespective of the speed at which the vane motor is being operated and irrespective of the volume of fluid required for the inner ends of the motor's vanes.

An object of the present invention is to provide a fluid pressure device and system of the character above indicated in which one rotary piston element pump, for example a vane type pump, delivers fluid at two different pressures, one of said pressures being related to but greater than the other.

Another object is to provide a fluid pressure device and system of this character in which the volume of fluid delivered at each of these two pressures may be conformably and simultaneously varied from minimum to maximum.

A further and more specific object is to provide a fluid system of this character that includes a vane type pump and a vane type fluid motor and in which the vane type pump supplies fluid at one pressure for admission to the pressure areas of the vane motor to act upon the exposed outer ends of the vanes and also supplies fluid at a higher but related pressure to be admitted to the inner ends of the vanes to force them radially outward.

A further object is a novel power transmission unit characterized by its efficiency in operation,

its compactness, and the economy of manufacture.

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

The invention will be understood from consideration of the accompanying drawings which illustrate, by way of example, embodiments of the present invention.

In the drawings:

Fig. 1 is a view, partly diagrammatic and partly in section, including a longitudinal sectional view of a rotary piston element pump unit taken along the line 1—1 of Fig. 2 and also including a corresponding longitudinal sectional view of a rotary piston element motor unit taken along the line 1—1 of Fig. 3;

Fig. 2 is a view of the pump unit, in vertical transverse section, taken along the line 2—2 of Fig. 1;

Fig. 2*a* is a view of one of the end plate elements of the pump unit showing the face thereof adjacent the rotor;

Fig. 2*b* is a view of the other of the end plate elements of the pump unit, showing the face thereof adjacent the rotor;

Fig. 3 is a view of the motor unit, in vertical transverse section, taken along the line 3—3 of Fig. 1;

Fig. 3*a* is a view of one of the end plate elements of the motor unit showing the face thereof adjacent the rotor;

Fig. 3*b* shows a modification of the end plate element of the motor unit;

Fig. 4 is a longitudinal sectional view along the line 4—4 of Fig. 4*a* and illustrates a modification; and

Fig. 4*a* is a transverse sectional view along the line 4*a*—4*a* of Fig. 4.

Figs. 1, 2, 2*a*, 2*b*, 3 and 3*a* are also shown in co-pending application filed February 12, 1941, Serial Number 378,524, in which certain parts of the subject-matter thereof are claimed.

Referring now to these drawings, as shown in Fig. 1, I have illustrated the present invention as embodied in a fluid system including a rotary piston element pump, here shown as a vane type pump A, and a rotary element fluid motor, here shown as a vane type fluid motor B. The pump A and the motor B may both be of fixed "stroke" or capacity per revolution or both of them may be of variable stroke, or one may be of variable stroke and the other of fixed stroke. In the present embodiment I have shown the pump A as of variable stroke and the motor B as of fixed stroke, as will be hereinafter more fully explained.

In the particular embodiment of pump structure shown the pump casing is in two axially separable parts 10 and 11 (Fig. 1) which are suitably fastened together as by cap screws, not shown, and which cooperate to form a cavity for the rotor 15 and associated parts. The rotor 15 is rotatably supported by its hubs 16 which extend into bushings 17 carried by the casing parts 10 and 11 respectively and said rotor also has a slidable splined connection with the driving shaft 20 (Figs. 1 and 2) which passes through the bore of said rotor and is revolubly supported by a pair of bearings 21. A pair of mating end plates 23 and 24 are disposed on opposite sides of the rotor and between the spacer ring 14 and the casing parts, the arrangement being such that the rotor turns freely while its sides and the sides of the vanes 19 form substantially fluid-tight running fits with the adjacent faces of said end plates. The end plates 23 and 24 are provided with holes at their centers through which pass the rotor hubs 16, and are also provided with ports and fluid passages to be later described.

As best shown in Fig. 2 the pump A is a rotary piston multi-section or part pump consisting of two pumping sections or halves which are separated from each other by fixed abutments 30 and which discharge into a common discharge channel 45, to be presently described. The rotor 15 is provided with a multiplicity of vane slots 18 in each of which is a vane 19 adapted to move radially inward and outward therein as the rotor revolves. The radially outward ends of the vane 19 follow a trackway that controls their inward and outward movement and which comprises the two fixed abutments 30, two movable abutments 31 and connecting flexible track elements 34. The movable abutments are slidably supported in slideways 33 formed in the spacer ring 14 on the interior of the casing and are adapted to be radially adjusted with respect to the circumferential rotor surface. The work of pumping by the exposed outer ends of the vane 19 is done as the vanes move across an arc 32 on each movable abutment, termed the "working" or "pumping" arc, the fluid being received at one end of this arc and discharged at the other. Regulation of the "stroke" or volumetric capacity per revolution of the pump is effected by moving or radially adjusting the movable abutments 31 to vary the distance separating the pumping arcs 32 from the circumferential rotor surface; the flexible track elements 34 have extensible connections with the fixed abutments 30 thereby permitting adjustment of the movable abutments 31 without change of position of said fixed abutments 30.

The movable abutments 31 are adapted to be moved by means of a pair of adjusting rods 35 which are attached thereto as by the pivot pins 36. The adjusting rods extend through suitable holes in the spacer ring 14 and in the side covers 12 which close the horizontal adjusting rod bores formed in the casing part 10. Movement or adjustment of the adjusting rods 35 and movable abutments 31 may be effected by any suitable means, not shown, which may be conveniently connected with the links 37 on the outer ends of the adjusting rods. It will be understood that the volume of fluid pumped by the outer ends of the vanes of each pumping section is dependent upon the distance between the circumferential surface of the rotor 15 and the pumping arc 32 of the corresponding movable abutment 31 so that the output of each half of the pumping section may be infinitely varied at will. It will also be understood that the total volume of fluid pumped by the outer ends of the vanes comprises the combined volumes pumped thereby as the vanes pass across the pumping arcs of the two pumping sections. The particular structure of the rotor 15, vanes 19, fixed abutments 30, movable abutments 31, interconnecting track elements 34, etc., form no part of the present application but a part of my co-pending application, Serial No. 366,931 filed Nov. 23, 1940, which is in part a continuation of application, Serial No. 247,586, filed Dec. 24, 1938.

As already stated, fluid is admitted to the pumping chambers or pumping arcs at the sides of the vanes as they approach each pumping arc and fluid is discharged from the pumping chamber in like manner as the vanes recede therefrom.

In the embodiment of Figs. 1 and 2, all admission and discharge to and from the outer ends of the vanes 19 is accomplished through ports in the end plate 23, these ports comprising a pair of diametrically opposite arcuate inlet ports 25 and a similar pair of outlet ports 26 as shown in Fig. 2a. The outlet ports 26 of the end plate 23 are also shown in the sectional view of Fig. 1. The end plate 24 (Fig. 2b) is likewise provided with similar ports 25 and 26 (here shown in Figs. 1 and 2b as recessed and not extending through the end plate 24) which serve principally as "balance ports" to contain fluid under the same pressure as that in the corresponding ports in the end plate 23 in order to substantially balance the hydraulic forces acting on the sides or axial ends of the vanes to prevent binding thereof.

Each outlet port 26 of the end plate 23 registers with a similar port formed in the side walls of the casing member 10 which is connected by a slanted passage 38 with the outlet conduit 45 as shown in Fig. 1. The outlet conduit 45 is suitably connected, as indicated by the dotted lines at 46 in Fig. 1, with a passage 39 leading to the vane motor B. The inlet ports 25 of the end plate 23 are similarly connected with the inlet conduit 43 or they may be connected therewith in any other suitable manner, and the conduit 43 is connected with the fluid supply pipe 42, as indicated by the dotted lines at 41 in Fig. 1, which may be connected with a suitable reservoir, not shown.

When the rotor 15 revolves in a counter-clockwise direction as viewed in Fig. 2 fluid enters through the inlet ports 25 of the end plate 23 and passes between the outer ends of those vanes 19 that are in the inlet area of each of the two pumping sections of the pump. Pumping is accomplished by the rotary motion of the outer ends of the vanes 19 as they sweep across the pumping arcs 32, said vanes 19 thus forcing fluid into the outlet area of each of the two pumping sections from which it passes out through the outlet ports 26 of the end plate 23 and into the discharge channel 45. As already stated, the size of the pumping chambers and the volume of fluid delivered by the pump are determined by the distance of the pumping arcs 32 from the rotor 15; as this distance may be varied in infinitely small increments from minimum to maximum, the size of the pumping chambers, and hence the volume of fluid pumped by the outer ends of the vanes, may likewise be varied from minimum to maximum.

The structure of the motor B (Fig. 1) is identical with that as already described in connection with the pump A except in certain parts to be presently explained. For convenience in distinguishing between pump and motor parts in the explanation which follows, the parts of the motor which are identical with those of the pump have been designated by the same reference numeral by adding "prime" ('), as for example the rotor of the pump A is designated by the reference numeral 15 and the rotor of the motor B by the reference numeral 15', etc.

The motor B as here illustrated is also a rotary piston multi-section or part device as best shown in Fig. 3, but as already stated is of fixed stroke or capacity per revolution. It is accordingly provided with a non-adjustable vane track comprising a vane track ring 14' having an interior vane-contacting track or surface. The vane track surface may be given any suitable contour but is preferably provided with concentric arcs 30' at its regions of least diameter and concentric working arcs or chambers 32' at its regions of greatest diameter, the arcs 30' and 32' being joined by intermediate connecting portions 34' of any suitable curvature producing satisfactory rates of inward and outward movement of the vanes 19' as the rotor 15' revolves.

Pressure fluid is admitted to the exposed outer ends of the vanes 19' as they approach the working arcs 32' and acts against the exposed outer ends of said vanes as they move across said working arcs, thus imparting rotary motion to the rotor 15' and the driven shaft 20'. Fluid is discharged from the outer ends of the vanes 19' as they recede from the working arcs 32'. All admission and exhaust to and from the outer ends of the vanes 19' is accomplished through inlet and outlet ports in the end plate 23' identical in arrangement with the already described ports of the pump's end plate 23 as will be evident from Fig. 3a, but it will be noted that the ports 25' of the motor B are the high pressure ports and that the discharge ports 26' are its low pressure ports whereas the reverse relative pressure condition exists in the inlet ports 25 and outlet ports 26 of the pump A.

The inlet ports 25' in the end plate 23' of the motor B are connected with the motor's inlet channel 43' by means of registering ports in the side walls of the casing member 10' and slanted passages 38', as plainly shown in Fig. 1 wherein a sectional view through the ports 25' is illustrated. The inlet channel 43' of the motor B is connected with the passage 39 leading from the pump A as indicated by the dotted lines 46' of Fig. 1. The discharge ports 26' of the end plate 23' are connected in a similar manner, not shown, with the discharge channel 45' which in turn is connected with the return passage 46, as indicated by the dotted lines at 41', which leads to the reservoir, not shown. In this connection it may be pointed out that the fluid passages between the outlet channels of the motor B and the corresponding ports 26' in the end plate 23' are identical with the corresponding outlet passages of the pump A; the sectional view of the motor B is taken through its inlet areas whereas the sectional view of the pump A is taken through its outlet area so that the exact arrangement of all ports and passages may be readily understood therefrom, although it will be understood that these exact arrangements are not necessary and may be varied if desired. The end plate 24' is also provided with recessed inlet ports 25' and outlet ports 26', similar to the ports in the pump end plate 24; these ports in the end plate 24' serve principally as "balance ports," as all fluid is admitted to and exhausted from the outer ends of the vanes 19' through the ports of the end plate 23', as already stated. The particular structure of the vane track ring 14', rotor 15' and plates 23' and 24', etc., forms no part of the present application but a part of application Serial Number 198,449, filed March 28, 1938, and it will be understood that any other suitable structure may be employed.

With the parts of the motor B in the position illustrated in Fig. 3 and with the pump A in operation and adjusted so that fluid is being pumped by the outer ends of its vanes 19, pressure fluid from the pump A will enter the inlet ports 25' of the motor B and rotate the rotor 15' and driven shaft 20' in a clockwise direction as viewed in Fig. 3. The speed of rotation of the rotor 15' of the motor B is determined by the volume of fluid ad-

mitted to the outer ends of its vanes 19' which in turn is determined by the volume of fluid delivered thereto by the pump A; the speed of rotation of the rotor 15' of the motor B may thus be infinitely varied from minimum to maximum by corresponding variation in the output of the pump A. In order for operation to take place however, it is necessary that the vanes 19' be firmly in contact with the vane track surface at the working arcs 32' and that there be similar contact between the ends of the vanes 19' and the vane track at the arcs 30' to thereby separate the two fluid sections of the motor B. This contact between the vanes 19' and the vane track is accomplished by introducing behind the radially inner ends of said vanes 19' fluid having a pressure greater than but correlated with the pressure of the fluid admitted to the inlet ports 25'. The means by which this higher pressure fluid (for convenience hereafter termed "differential high pressure fluid") is produced and its pressure regulated and by which it is supplied to the inner ends of the vanes 19' of the motor B are important features of the present invention and will now be described.

Referring now to Fig. 2*a*, the pump end plates 23 and 24 are each formed with two pairs of arcuate recesses or grooves 27 and 28 in the faces thereof adjacent the rotor 15. These recesses 27 and 28 are positioned to register successively with the inner ends of the vane slots 18 as the rotor 15 revolves and they act as ports or passages for fluid to and from said vane slots 18 and hence are termed "vane slot ports."

The vane slot ports 27 are connected with the inlet ports 25 by radial passages or grooves 29 on the outer faces of the end plates 23 and 24 and the length of said vane slot ports 27 is such that the inner ends of each vane slot 18 connects therewith during the time that the outer end of its corresponding vane 19 is moving across the flexible interconnecting track element 34 that lies in each of the inlet areas of the pump A; the inner end of each vane slot 18 is thus connected with the fluid inlet supply during the time that its corresponding vane 19 is moving through the inlet areas of the pump A and is approaching the pumping arcs 32. The inner end of each vane slot 18 is thus filled with fluid as its corresponding vane 19 moves radially outward under the action of centrifugal force while said vane 19 is passing from each fixed abutment 30 toward the contiguous pumping arc 32.

Fluid entering the inner ends of the vane slots 18 through the vane slot ports 27 as explained above is discharged into the vane slot ports 28 as the outer end of each vane 19 moves inward during the time it is passing from the pumping arc 32 of each pumping section through the corresponding outlet area of the pump and on to the contiguous fixed abutment 30. This will be understood by referring to Fig. 2 in which it will be observed that the vanes 19 occupy the extreme radially outward position when their outer ends are in contact with the pumping arcs 32; it will also be observed that said vanes 19 are moved progressively inward as said vanes traverse the interconnecting track element 34 intermediate said pumping arc 32 and the contiguous fixed abutment 30; and it will further be observed that the vanes 19 occupy the extreme radially inward position when their outer ends are in contact with the fixed abutments 30. It will thus be seen that each vane 19 functions as a piston reciprocating in its vane slot 18, the inner end of which serves as a cylinder therefor, and it will also be seen that each vane 19 is reciprocated twice for each revolution of the rotor 15. It will further be seen that admission of fluid to the inner ends of the vane slots 18 takes place simultaneously with admission of fluid to the outer end of the corresponding vanes 19 and that fluid is likewise discharged from both the inner and outer ends of the vanes as said vanes recede from the pumping arcs 32 and approach the fixed abutments 30. The vane slot ports 28 are preferably made of such length that they also connect with the inner ends of those vane slots 18 whose vanes 19 are in contact with the pumping arcs 32 and the fixed abutments 30 so that fluid pressure is applied to the inner ends of such vanes to assist in holding their outer ends firmly in contact with the vane track surfaces as said vanes move across the fixed and movable abutments.

The volume of fluid pumped by the inner ends of the vanes 19, per revolution of the rotor 15, for any particular rotor and vane assembly is dependent upon and varies conformably with the stroke of the vanes which, as already explained, is determined by the distance between the pumping arcs 32 and the circumferential rotor surface and may be infinitely varied at will. The volume of fluid pumped by the inner ends of the vanes may thus be infinitely varied from minimum to maximum and variation in the volume pumped by the inner ends of the vanes is effected simultaneously and conformably with variation in the fluid volume pumped by the outer ends of said vanes as they move across the pumping arcs.

Fluid pumped by the inner ends of the vanes 19 of the pump A is utilized to provide the differential high pressure fluid to force the vanes 19' of the motor B radially outward against the vane track. The vane slot ports 28 of the pump A are accordingly connected in any suitable manner with the vane slot ports 27' of the motor's end plate 24'. In the present instance the fluid passages providing this interconnection include a hole 22 in each of the vane slot ports 28 in the pump's end plate 24 and said hole 22 registers with a passage 47 leading to a channel 48 formed in the pump casing member 11. The channel 48 is connected as by a pipe 49 with a corresponding channel 48' in the motor casing member 11' and said channel 48' is connected through a passage 47' by a hole 22' with each vane slot port 27' in the motor's end plate 24'.

At this point it should be noted that the end plates 23' and 24' of the motor B are provided with vane slot ports 27' and 28' corresponding generally to the already described vane slot ports of the pump's end plates. The vane slot ports of the motor's end plates 23' and 24' differ from those of the pump's end plates however in that the vane slot ports 27 (which in this instance are its high pressure vane slot ports) are not only co-extensive with the inlet ports 25' but are preferably of such length that each vane slot 18' connects therewith during the time that the vane 19' therein is traversing the arc 30' and the working arc 32' of each fluid section as well as while traversing the intermediate portion 34' of the track that lies in the inlet area of each fluid section of the motor B, as plainly shown in Fig. 3. Fluid entering the inner ends of the vane slots 18' of the rotor 15' is discharged into the vane slot ports 28' which are connected with the outlet ports 26' of the end plates 23' and 24' by radial passages 29' on the outer faces thereof.

In order to assure that the vanes 19' of the motor B are forced radially outward against

the vane track it is necessary that the volume of fluid pumped by the inner ends of the vanes 19 of the pump A be equal to or greater than the actual fluid volume required to produce such radially outward movement of the vanes 19' of the motor B. That is to say, the volume of fluid pumped per revolution of the rotor 15 of the pump A by the inner ends of its vanes 19, at any stroke or capacity of the pump A, must have a relation to the corresponding volume of fluid pumped by the outer ends of said vanes 19 that is equal to or greater than the relation of the fluid volume required for the inner ends of the motor's vanes 19' per revolution of its rotor 15' with respect to the fluid volume that must be admitted to the outer ends of the motor's vanes 19' in order to produce one revolution of the rotor 15'. This relation will vary with particular embodiments and is due in part, for instance, to the porting provided for the inner end of the vane slots 18' of the motor B, as will be more fully explained presently in connection with the modified end plate 23'' shown in Fig. 3b.

With the arrangement illustrated in Figs. 1, 2, 2a, 2b, 3 and 3a, the flow of fluid with respect to the inner ends of the vanes of the pump and motor is as follows: Upon rotation of the pump rotor 15 in a counter-clockwise direction, fluid will flow from the supply pipe 42 into the inlet conduit 43, and to the inlet ports 25 of the pump's end plate 23, and will fill the spaces between the outer ends of the vanes 19 as they pass through the pump's inlet areas. Fluid also passes from the ports 25 of both end plates 23 and 24, through the radial passages 29 on the outer faces of said end plates, to the vane slot ports 27 of both end plates and into the inner ends of the vane slots 18. As the vanes 19 are moved inwardly while passing across the interconnecting track elements 34 in the outlet areas of the pump, fluid is pumped by the inner ends of said vanes 19 into the vane slot ports 28 of the end plate 24, through the holes or ports 22 in said end plate 24, into the passages 47, the channel 48, the pipe 49 and into the channel 48' of the motor B; thence through the passages 47', holes or ports 22' of the end plate 24' vane slot ports 27' of the end plate 24' and thence below the inner ends of the vanes 19' to force them outwardly and into contact with the vane track as the rotor 15' of the motor B turns in a clockwise direction. After passing the working arcs 32', the vanes 19' are forced inwardly as they pass across the cam surface of the vane track's intermediate connecting portions 34' that are positioned in the motor's outlet areas and fluid is discharged by the inner ends of the vanes 19' this fluid passing out through the vane slot ports 28' of both of the end plates 23' and 24', through the radial passages 29' on the outer faces of said end plates and into the outlet ports 26' of both of the end p'ates 23' and 24'; fluid passing out through the ports 26' of the end plate 24' passes across the rotor through the spaces between the outer ends of the vanes 19', into the ports 26' of the end plate 23', thence, together with the fluid discharged by the outer ends of the vanes and the fluid that is discharged by the inner ends of the vanes 19' through the ports 26' of the end plate 24', into the discharge channel 45' and finally into the return passage or pipe 46.

Theoretically it is merely necessary that the inner ends of the pump's vanes 19 supply precisely the volume of fluid required by the inner ends of the motor's vanes 19' but in commercial practice this is difficult if not impossible of attainment because of variation in leakage, fits of the parts, etc., which will occur as between individual pumps and motors even though made to the same dimensions and close tolerances. In practice therefore it is necessary that the inner ends of the pump's vanes supply fluid in excess of the volume actually required by the inner ends of the motor's vanes 19'. This may be accomplished in numerous ways, such, for example, as by making the vanes 19 of the pump A thicker than the vanes 19' of the motor B so that the inner end of each pump vane has an area greater than that of each motor vane 19'. In the present embodiment however this is accomplished by the simple method of providing the pump's rotor 15 with a greater number of vanes than are provided in the motor's rotor 15'; this is clearly shown in Figs. 2 and 3 in which it will be observed that the pump's rotor 15 is provided with sixteen vanes whereas the motor's rotor 15' is provided with twelve vanes.

It is also necessary to provide a path of escape for the excess fluid pumped by the inner ends of the pump's vanes 19 and not required by the inner ends of the motor's vanes 19'. Moreover, it is necessary that the pressure of the fluid admitted to the inner ends of the vanes 19', to force them radially outward against the vane track, be greater than but correlated with the pressure of the fluid admitted to the ports 25'. The means by which both these requirements are met will now be described.

Referring to Fig. 1, the passage 49 is connected with a passage 66 leading to the fluid inlet port of a "differential relief" or "pressure reducing" valve C. The outlet port of the valve C is connected to a passage 67 leading to the passage 39. The function of the valve C is to regulate the flow of fluid (i. e., the excess fluid not required by the motor's vanes 19') from the passage 49 to the passage 39 in such manner that the pressure of the fluid in the passage 49 exceeds by a substantially constant, predetermined amount the pressure of the fluid in the passage 39 in order to provide "differential high pressure" relation to the fluid supplied to the inner ends of the motor's vanes 15' with respect to the pressure of the fluid supplied to the outer ends thereof. The valve C may accordingly assume any suitable form of "differential pressure," resistance, "relief" or "pressure reducing" valve capable of accomplishing this function. The particular structure of the valve C illustrated in Fig. 1 has been found to function reliably and satisfactorily in practice and will now be described.

The valve C includes a housing 50 provided with a valve bore in which a valve piston 55 is slidably fitted. The valve piston 55 is formed with two heads of unequal diameter, the diameter of the head 56 exceeding the diameter of the head 57, and the valve bore is similarly formed with two unequal diameters in order to provide sliding fits with said heads. The heads 56 and 57 are separated by a "neck" or reduced portion 58 having a tapered end 59 adjacent the head 56, and the neck 58 and its tapered end 59 are of such length that one or the other of them is in communication with the valve's inlet port

51 in all positions of adjustment of the valve piston 55.

The valve piston 55 is urged toward its fully closed position, in which it is shown in Fig. 1, by a spring 61, one end of which is received within a recess in the adjacent end of the valve piston 55 and the other end of which bears against a somewhat "hat-shaped" abutment piece 62. The abutment piece 62 also bears against a screw 63 carried by the cover 54 and said screw 63 provides means by which the compression of the spring 61 may be adjusted; in the present instance the screw 63 is of the headless type and a pipe plug 64 closes the outer end of the enlarged opening provided for use in adjusting said screw's position.

Both ends of the valve piston 55 are adapted to be acted upon by fluid having the same pressure as that in the valve's outlet port 52. The outlet port 52 is accordingly connected with the passage 65 which connects with the end of the valve bore containing the spring 61 at a point which will not be covered by the head 56 when the valve piston 55 is in its maximum open position. A hole or passage 60 extends axially through the valve piston 55 so that both ends of the valve bore will contain fluid under the same pressure as that in the valve's outlet port 52.

With this arrangement it will be seen that the valve piston 55 is urged toward its fully open position (or toward the right as viewed in Fig. 1) by a fluid-exerted force determined by the pressure of the fluid in the inlet port 51 and equal in amount to the force produced by the action of this pressure fluid upon a surface area equal to the difference in the areas of the two heads 56 and 57. Similarly the valve piston 55 is urged toward its fully closed position (or toward the left as viewed in Fig. 1) by fluid-exerted force determined by the pressure of the fluid in the inlet port 52 and equal in amount to the action of this pressure fluid upon an area equal to the difference in areas of the heads 56 and 57, and this fluid-exerted force is supplemented by the force of the spring 61 acting in the same direction.

The valve piston 55 is accordingly moved by one or the other of these opposing forces whenever they are unbalanced and will be so moved until these opposing forces are made equal to each other by change in the relative pressures in the inlet port 51 and outlet port 52 produced by movement of the valve piston 55. In this manner the valve piston 55 moves to regulate the flow of fluid from the passage 49 to the passage 39 to provide pressure in the passage 49 that exceeds the pressure in the passage 39 by an amount determined by the force exerted by the spring 61. This relative difference in pressures is maintained irrespective of absolute pressures; that is to say, irrespective of the actual amounts of the pressures existing in the inlet port 51 and outlet port 52 respectively and, within the limits of the "rate" of the spring 61, is likewise maintained substantially constant irrespective of the volume of fluid passing through the valve C. The valve piston 55 is immediately moved to its fully closed position, as shown in Fig. 1, by the spring 61 whenever the difference in pressures is less than the amount determined by said spring and in the fully closed position the head 57 completely closes the outlet port 52 thus cutting off all fluid communication between the valve's inlet port 51 and outlet port 52.

The cover 53 is provided with a narrow flange 68 which projects into the valve bore and acts as a stop for the valve piston 55 so that substantially all of the adjacent end of the valve piston is continuously exposed to pressure fluid even when the valve is in its closed position.

The valve C thus functions to regulate the flow of excess fluid pumped by the inner ends of the pump's vanes 19 so that differential high pressure relationship is at all times maintained between the pressure of the fluid supplied to the inner and outer ends of the motor vanes 19'; that is to say, the pressure of the fluid supplied to the inner ends of the vanes 19' at all times exceeds by a substantially constant, predetermined amount the pressure of the fluid supplied to the outer ends thereof. The amount of this pressure difference may be adjusted as required by means of the screw 61 and is preferably kept at the lowest value producing satisfactory operation of the vanes 19' of the motor B. In practice it has been found that pressure differential of from ten to thirty-five or forty pounds per sq. in. is usually sufficient although differential pressures up to and including seventy-five pounds per sq. in. have been successfully employed in systems of this general character.

The present invention has numerous advantages. For example, the vane type pump supplies fluid at two different pressures, thus making it unnecessary to pass the entire output of the pump through a pressure reducing or differential pressure valve, thus increasing the efficiency of the transmission. Moreover, when a variable capacity vane pump is employed, as in the present instance, the volume of fluid delivered at each of the two relative pressures is varied in corresponding or substantially proportional amounts so that any change in one will produce a corresponding change in the other, thereby assuring an ample supply of fluid at each of these two different pressures and at the same time avoiding any material excess in the volume needed at any time. In this connection it should be noted that the volume of fluid required by the inner ends of the motor vanes 19' will always bear a proportional relationship to the volume of fluid required by the outer ends of said vanes 19', and these two volumes will change proportionately with change in rotative speed of the rotor 15'. For example, to use purely arbitrary figures in which leakage is neglected, let us assume that a fluid volume of 10 gals. per min. admitted to the outer ends of the vanes 19' causes the rotor 15' to revolve at 600 R. P. M. and that a fluid volume of 1 gal. per min. is then required by the inner ends of the vanes 19'; a fluid volume of 20 gals. per min. would have to be admitted to the outer ends of the motor vanes 19' to cause the rotor 15' to revolve at 1200 R. P. M. and a fluid volume of 2 gals. per min. would then be required by the inner ends of said vanes 19' at this speed. It will thus be seen that variation in the volume of fluid pumped by the outer ends of the pump vanes 19, in order to alter the speed of motor B, will simultaneously vary the fluid volume supplied to the inner ends of the motor vanes 19' in accordance with the requirements thereof at the changed speed of the motor.

The small differences in the pressures of the fluid pumped by the inner and the outer ends of the pump vanes 19, according to the present embodiment, does not adversely affect the operation of the pump A and is so small that it does

not cause undue deflection or increase in wear of the flexible interconnecting track elements 34.

As already stated, the volume of fluid that must be supplied to the inner ends of the motor's vane slots 18', in order to produce satisfactory contact between the vanes 19' and the vane track, will depend in part upon the arrangement of the vane slot ports of the motor's end plates 23' and 24' which may be varied in several ways. For example, both end plates 23' and 24' may be provided with a single, annular vane slot port 127' as illustrated in the modified end plate 23'' of Fig. 3b, in which such a single vane slot port 127' is substituted for the two pairs of vane slot ports 27' and 28' of the embodiment of Fig. 3a previously described; the radial passages 29' of Fig. 3a are omitted in the modified end plate 23'' and there is no fluid connection between the inner ends of the vanes 19' and the outlet ports 26' when such modified end plates are employed. The vane slot port 127' is connected with the supply of differential high pressure fluid pumped by the inner ends of the pump vanes 18, this connection being made as through the holes 22'. With this modified arrangement differential high pressure fluid is continuously supplied to the inner ends of all the vane slots 18' and it is only necessary to supply differential high pressure fluid to the inner ends of the vanes 19' in volume sufficient to make up for leakage in this portion of the fluid circuit, and this is a considerably smaller fluid volume than is required with the separate inlet and outlet vane slot ports 27' and 28' respectively, as in Fig. 3a. With this arrangement the vanes 19' are acted upon by the differential high pressure fluid while the outer ends thereof are passing through the low pressure or outlet areas of the motor B so that wear and friction on the corresponding portions of the vane track are somewhat greater than with the arrangement of the end plates of Fig. 3a. The construction of Fig. 3b also has the advantage, however, of somewhat greater simplicity of manufacture.

Another conspicuous advantage of the present invention is that it makes it possible to provide an extremely compact vane type transmission which is smaller and lighter than can be obtained with systems and constructions heretofore employed. This will be understood from consideration of the modification shown in Figs. 4 and 4a.

The transmission illustrated in Figs. 4 and 4a includes a pump A and a motor B, the internal parts of which (such as rotors, vanes, shafts, vane tracks, etc.) are identical with those of the embodiment of Figs. 1, 2, 2a, 3 and 3a. The pump end plates of this embodiment differ from those of Fig. 1, however, in that the ports 25 and 26 extend through the pump end plate 24 and are recessed in the end plate 23; this also applies to the motor end plates 23' and 24' although it will also be understood that modified end plates of the type illustrated in Fig. 3b may be employed in the motor B if preferred. In this instance, however, the pump A and motor B are housed in casing members comprising three axially separable parts 110, 111 and 112, respectively. The parts 110 and 111 are attached, as by cap screws 113, to the part 112 and said part 112 may be said to be a casing member common to both pump and motor; this facilitates assembly and permits separate axial adjustment of the parts of the pump and motor units. Fluid is supplied from a reservoir, not shown, through the supply pipe or passage 42 which is connected with the inlet channel 43, as clearly shown in Fig. 4, from which the fluid passes to the pump's inlet ports 25 and vane slot ports 27 of its end plate 24 through passages not illustrated in Fig. 4 but which may be identical with the arrangement described in connection with the embodiment of Fig. 1.

Fluid discharged by the outer ends of the pump vanes 19 passes through the discharge ports 26 in the pump end plate 24 and into passages 138 extending axially through the casing member 112 and connecting with the inlet ports 25' in the end plate 24' of the motor B. In the present instance a separate passage 138, having the same general cross-section as that of the ports 26 and 25', is provided for each of the pump's outlet or discharge ports 26, as clearly shown in Fig. 4a, and these two passages 138 are connected by a passage 140 in order to equalize the fluid pressure existing in them. With this arrangement fluid discharged by the outer ends of the pump vanes 19' passes through the straightest and shortest possible path of travel to the outer ends of the motor vanes 19', thus reducing power losses.

Each vane slot port 28 of the pump end plate 24 is connected in a generally similar manner with the corresponding vane slot port 27' of the motor end plate 24' that is axially in line therewith, this connection being made through passages 149 which likewise extend axially through the casing member 112 as shown in Fig. 4. In the present embodiment a plurality of passages 149 are employed to connect each vane slot port 28 with the corresponding vane slot port 27' of the motor B in order to provide ample area for free fluid flow without increasing the dimensions of the casing ports, and all of said passages 149 are connected by a suitable passage 150 (Fig. 4) to equalize the pressure of the fluid therein.

Fluid discharged by the motor vanes 19' passes out through the discharge ports 26' of the motor end plate 24' and through appropriate passages 138 (Fig. 4a) into the discharge channel 45' (Figs. 4 and 4a) which in turn is connected with the return passage 46 leading to the reservoir, not shown.

As in the embodiment previously described, pressure of the fluid discharged by the inner ends of the pump vanes 19 is maintained at a pressure exceeding by a substantially constant amount the pressure of the fluid discharged by the outer ends of said vanes 19 and this correlation of pressures is accomplished by a valve mechanism C. In Fig. 4 the valve mechanism C is illustrated as a simple relief valve of the ball and spring type, although it will be understood that a valve of the type shown in Fig. 1, or any other suitable type, may be employed. As illustrated in Fig. 4, all passages leading to, from and forming part of the valve C are formed in the casing member 110, thus adding to the simplicity and compactness of the transmission. In this instance one of the vane slot ports 28 of the pump end plate 23 is provided with a suitable opening which connects with a passage 166 leading to the valve's inlet port or passage 151 which is adapted to be closed by a ball 155 freely movable in an enlarged bore or passage 153. The contiguous surface of the ball 155 is thus exposed to fluid under the same pressure as that in the vane slot ports 28 of the pump end plates and the force thus exerted urges the ball 155 away from its fully closed position in which it is shown

in Fig. 4. The bore or passage 153 also contains a spring 161 which urges the ball 155 toward its fully closed position and the force exerted by said spring 161 is supplemented by the force exerted upon said ball 155, in the same direction, by fluid under the same pressure as that in the discharge ports 26 of the pump end plates, one of which is connected with the bore or passage 153 as by a passage 167.

With this arrangement the ball 155 moves to regulate the flow of excess fluid pumped by the inner ends of the pump vanes 19 so that the pressure of the fluid in the pump's vane slot ports 28 is kept at a value that exceeds the pressure of the fluid in the pump's discharge ports 26 by a substantially constant amount determined by the spring 161. This regulation is effected, of course, by varying and controlling the flow and resistance to flow of fluid from the vane slot port 28 to the discharge port 26, and in this manner acts to provide the desired differential in pressures between the pressures of the fluid admitted to the inner and outer ends of the motor vanes 19'. It will frequently be the case that a valve of the ball and spring construction illustrated in Fig. 4 will not maintain the differential in pressures within the same close limits that can be obtained with other valve structures, such as that illustrated in Fig. 1 for example, but results obtainable with the construction of the valve of Fig. 4 will prove satisfactory in many instances and the simplicity, compactness and low cost of its structure recommend its use where practical. In the construction illustrated in Fig. 4 a pipe plug 164 serves the double purpose of closing the bore or passage 153 and of acting as an abutment piece for the outer end of the spring 161.

The operation of the embodiment illustrated in Figs. 4 and 4*a* is substantially the same as that already described in connection with the embodiment of Fig. 1 and will be understood from the foregoing.

While I prefer to employ pumps and motors of the "double" or "double-acting" type, each of which includes two fluid sections, it will be understood that the invention is not limited to such use and that, for example, multi-section pumps and fluid motors of other types may be employed as well as pumps and fluid motors of the "single" or "single-acting" type which include only a single fluid section. It will also be understood that the embodiments of the invention described herein are merely for the purpose of illustrating the invention and that changes (some of which have been indicated herein) may be made without departing from the spirit of the invention, the scope of which is defined in the appended claims.

I claim:

1. Fluid pressure means comprising a rotary vane type pump and a rotary vane type fluid motor, said pump and said motor each having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof as the corresponding rotor revolves, said pump and said motor also each having a vane track which the vanes follow as the rotor rotates, means for causing the outer ends of said pump vanes to pump one fluid volume to the outer ends of said motor vanes and means for causing the inner ends of said pump vanes to pump to the inner ends of said motor vanes another fluid volume at a pressure higher than the pressure of the fluid volume pumped to the outer ends of said motor vanes to thereby urge said motor vanes into contact with said motor vane track.

2. Fluid pressure means comprising a rotary vane type pump and a rotary vane type fluid motor, said pump and said motor each having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof as the corresponding rotor revolves, said pump and said motor also each having a vane track which the vanes follow as the rotor rotates, means for causing the outer ends of said pump vanes to pump one fluid volume to the outer ends of said motor vanes, means for causing the inner ends of said pump vanes to pump another fluid volume to the inner ends of said motor vanes to thereby urge said motor vanes into contact with said motor vane track and means for maintaining the fluid pumped by the inner ends of said pump vanes at a pressure higher than but dependent upon the pressure of the fluid pumped by the outer ends thereof.

3. Fluid pressure means comprising a rotary vane type pump and a rotary vane type fluid motor, said pump and said motor each having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof, said pump and said motor also each having a vane track for imparting to the vanes their inward movement, means for causing the outer ends of said pump vanes to pump one fluid volume to the outer ends of said motor vanes, means for causing the inner ends of said pump vanes to supply to their inner ends of said motor vanes fluid in excess of the volume required to urge said motor vanes into contact with the vane track, and means for combining this excess with the fluid volume pumped by the outer ends of said pump vanes.

4. Fluid pressure means comprising a rotary vane type pump and a rotary vane type fluid motor, said pump and said motor each having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof, said pump and said motor also each having a vane track for imparting to the vanes their inward movement, means for causing the outer ends of said pump vanes to pump one fluid volume to the outer ends of said motor vanes, means for causing the inner ends of said pump vanes to supply to the inner ends of said motor vanes fluid in excess of the volume required to urge said motor vanes into contact with the vane track, and means for combining this excess with the fluid volume pumped by the outer ends of said pump vanes, said last named means comprising valve mechanism active to regulate the flow of said excess fluid to maintain the fluid pumped by the inner ends of said vanes at a pressure exceeding by a substantially constant amount the pressure of the fluid pumped by the outer ends of said pump vanes.

5. In a fluid pressure means of the character indicated, the combination of a rotary vane pump, a rotary vane fluid motor operated by said pump, means establishing direct communication between the inner ends of the vanes of the pump and the inner ends of the vanes of the motor to thereby urge said motor vanes into their operating positions independent of the action of centrifugal force, means for causing the inner ends of said pump vanes to deliver fluid in excess of the volume required to urge said motor vanes into said operating positions, means for maintaining the fluid pumped by the inner ends of said pump vanes at a pressure sufficient to move said motor vanes into operating position and means for sup-

plying to the outer ends of said motor vanes fluid pumped by the outer ends of said pump vanes.

6. Fluid pressure means including a variable delivery rotary vane type pump and a rotary vane type fluid motor, said pump and said motor each having a rotor provided with vane slots and vanes movable radially inward and outward therein as said rotor revolves, pump inlet ports and passages for admitting a supply of fluid to the inner and to the outer ends of said pump vanes, pump outlet ports for the discharge of fluid from the outer ends of said pump vanes, separate pump outlet ports for the discharge of fluid from the inner ends of said pump vanes, motor inlet ports for admission of pressure fluid to the outer ends of said motor vanes, separate motor inlet ports for admitting pressure fluid to the iner ends of said motor vanes, a first fluid connection between said first named pump outlet ports and said first named motor inlet ports, a second and separate fluid connection between said second named pump outlet ports and said second named motor inlet ports, a third fluid connection between said first and second fluid connections, said third fluid connection including a resistance valve, motor outlet ports for the inner and the outer ends of said motor vanes, means for causing the inner ends of said pump vanes to discharge into said second fluid connection fluid in excess of the volume required to urge said motor vanes into their operating positions independent of the action of centrifugal force, and means for simultaneously and comformably varying the fluid volumes discharged by the inner and the outer ends of said pump vanes.

7. Fluid pressure means including a rotary vane type pump and rotary vane type fluid motor, said pump and said motor each having a rotor provided with vane slots and vanes movable radially inward and outward therein as the rotor thereof revolves, pump inlet ports and passages for admitting a supply of fluid to the inner and to the outer ends of said pump vanes, pump outlet ports for the discharge of fluid from the outer ends of said pump vanes, separate pump outlet ports for the discharge of fluid from the inner ends of said pump vanes, motor inlet ports for admitting pressure fluid to the outer ends of said motor vanes, separate motor inlet ports for admitting pressure fluid to the inner ends of said motor vanes, a first fluid connection between said first named pump outlet ports and said first named motor inlet ports, a second and separate fluid connection between said second named pump outlet ports and said second named motor inlet ports, means for maintaining a substantially constant differential pressure in said second fluid connection above the pressure in said first fluid connection irrespective of the pressure in said first fluid connection, and motor outlet ports for fluid discharged by said motor vanes.

8. Fluid pressure means including a rotary vane type pump and rotary vane type fluid motor, said pump and said motor each having a rotor provided with vane slots and vanes movable radially inward and outward therein as the rotor thereof revolves, pump inlet ports and passages for admitting a supply of fluid to the inner and to the outer ends of said pump vanes, pump outlet ports for discharge of fluid from the outer ends of said pump vanes, separate pump outlet ports for discharge of fluid from the inner ends of said pump vanes, means for simultaneously varying the fluid volumes discharged respectively into said first and said second named pump outlet ports, motor inlet ports for admitting pressure fluid to the outer ends of said motor vanes, separate motor inlet ports for admitting pressure fluid to the inner ends of said motor vanes, a first fluid connection between said first named pump outlet ports and said first named motor inlet ports, a second fluid connection between said second named pump outlet ports and said second named motor inlet ports, means for correlating the pressures in said first and second fluid connections to maintain in said second fluid connection a pressure greater than but related to the pressure in said first fluid connection, and motor outlet ports for fluid discharged by said motor vanes.

9. Fluid pressure means including a rotary vane type pump and a rotary vane type fluid motor, said pump and said motor each having a rotor provided with vane slots and vanes movable radially inward and outward therein as the rotor thereof revolves, pump inlet ports and passages for admitting a supply of fluid to the inner and to the outer ends of said pump vanes, pump outlet ports for the discharge of fluid from the outer ends of said pump vanes, separate pump outlet ports for the discharge of fluid from the inner ends of said pump vanes, motor inlet ports for admission of pressure fluid to the outer ends of said motor vanes, separate motor inlet ports for continuously admitting pressure fluid to the inner ends of all of said motor vanes, a first fluid connection between said first named pump outlet ports and said first named motor inlet ports, a second and separate fluid connection between said second named pump outlet ports and said second named motor inlet ports, a third fluid connection between said first and said second fluid connections, said third fluid connection including a resistance valve active to maintain in said second fluid connection a pressure greater than the pressure in said first fluid connection, and motor outlet ports for fluid discharged by the outer ends of said motor vanes.

10. Fluid pressure means including a rotary vane type pump and a rotary vane type fluid motor, said pump and said motor each having a rotor provided with vane slots and vanes movable radially inward and outward therein as said rotors revolve, an enclosing casing for said pump and motor including a member common to both pump and motor, pump inlet ports and passages for admitting a supply of fluid to the inner ends and to the outer ends of said pump vanes, pump outlet ports for the discharge of fluid from the outer ends of said pump vanes, separate pump outlet ports for the discharge of fluid from the inner ends of said pump vanes, motor inlet ports for the admission of pressure fluid to the outer ends of said motor vanes, separate motor inlet ports for admitting pressure fluid to the inner ends of said motor vanes, a first fluid connection formed in said common casing member and connecting the outlet ports for the outer ends of said pump vanes with the inlet ports for the outer ends of said motor vanes, a second and separate fluid connection formed in said common casing member and connecting the outlet ports for the inner ends of said pump vanes with the inlet ports for the inner ends of said motor vanes, a third fluid connection between said outlet ports for the outer and for the inner ends of said pump vanes, means for maintaining in said second fluid connection a pressure greater than the pressure in said first fluid connection, and motor outlet

ports for the discharge of fluid by said motor vanes.

11. In a fluid pressure means of the character indicated, the combination of a rotary vane pump, a rotary vane fluid motor operated by said pump, means for admitting a fluid supply to the inner and outer ends of said pump vanes, means for supplying to the outer ends of said motor vanes fluid pumped by the outer ends of said pump vanes, outlet means for the outer ends of said motor vanes, means establishing direct communication between the inner ends of the vanes of the pump and the inner ends of the vanes of the motor to thereby urge said motor vanes into their operating positions independent of the action of centrifugal force, and means for causing the inner ends of said pump vanes to deliver fluid in excess of the volume required to urge said motor vanes into said operating positions, said last named means comprising pump vanes the combined areas of all the inner ends of which exceed the combined areas of the inner ends of all the motor vanes.

12. Fluid pressure means comprising a pair of separate rotary piston elements, fluid inlet means for the inner and outer ends of the pistons of one of said elements, fluid outlet means for the outer ends of the pistons of the other of said elements, separate passages establishing communication between the outer and inner ends of the pistons of the elements, and means for maintaining the fluid in the passage between the inner ends of the pistons of the elements at a pressure greater than but related to the pressure of the fluid in the passage between the outer ends of said pistons.

13. In a fluid pressure means, the combination of a multi-pressure pump supplying two separate fluid volumes of different but related pressures, a rotary vane fluid motor operated by said pump, means for supplying one of said volumes to the outer ends of the vanes of the motor and means for supplying the other of said volumes to the inner ends of the vanes of the motor and for maintaining the pressure thereof at an amount sufficient to move said motor vanes into operating positions.

14. In a fluid pressure means, the combination of a vane type fluid motor having a plurality of vanes, a multi-pressure pump supplying two separate fluid volumes, one a relatively large volume of one pressure and another a relatively small volume of higher pressure, means for admitting to one end of the vanes said smaller volume of fluid at said higher pressure, and means for simultaneously admitting to the other ends of said vanes said larger volume of fluid at said lower pressure to thereby impart rotary motion to the motor, means for correlating the pressures of said high and low pressure volumes to maintain therebetween a pressure difference sufficient to move said motor vanes into their operating positions, and outlet means for the ends of said motor vanes receiving said larger volume of fluid at said lower pressure.

15. Fluid pressure means comprising a multi-section rotary vane type pump and a multi-section rotary vane type fluid motor operated by said pump, each section of said pump and said motor comprising an inlet area, a working chamber and an outlet area, said pump and said motor each having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof in a substantially radial direction, said pump and said motor also each having a vane track for imparting to the vanes their inward movement and for guiding said vanes in their outward movement, means for causing the outer ends of said pump vanes to pump one fluid volume as they pass from the inlet area to the outlet area of each section of said pump, means for causing the inner ends of said pump vanes to pump another fluid volume as the outer ends of said pump vanes pass through the outlet area of each section of said pump, means for admitting the fluid pumped by the inner ends of said pump vanes to the inner ends of said motor vanes as the outer ends of said motor vanes pass through the inlet area of each section of said motor to thereby urge said motor vanes into contact with the vane track of said motor, means for admitting the fluid pumped by the outer ends of said pump vanes to the outer ends of said motor vanes as said motor vanes pass through the inlet area and working chamber of each section of said motor to thereby impart rotary motion to the rotor of said motor, means for substantially equalizing the pressure of the fluid volumes pumped by the inner ends of said pump vanes in all of the sections of said pump, means for substantially equalizing the pressure of the fluid volumes pumped by the outer ends of said pump vanes in all of said sections of said pump, and means for maintaining the substantially equalized pressure of the fluid pumped by the inner ends of said pump vanes at a pressure greater than the substantially equalized pressure of the fluid pumped by the outer ends of said pump vanes.

16. Fluid pressure means comprising a rotary vane type variable capacity pump and a rotary vane type fluid motor, said pump and said motor each having a rotor provided with a plurality of vanes movable inwardly and outwardly thereof as the corresponding rotor revolves, said pump and said motor also each having a vane track which the vanes follow as the rotor revolves, means for causing the outer ends of said pump vanes to pump one fluid volume to the outer ends of said motor vanes, means for causing the inner ends of said pump vanes to pump to the inner ends of the motor vanes another fluid volume at a pressure sufficient to move said motor vanes into contact with said motor vane track and means for simultaneously varying the fluid volumes pumped by the inner and outer ends respectively of said pump vanes.

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