United States Patent

[11] 3,589,244

[72] Inventor **Francois C. Pruvot**
Billancourt, France

[21] Appl. No. **6,717**
[22] Filed **Jan. 29, 1970**
[45] Patented **June 29, 1971**

[73] Assignees **Regie Nationale Des Usines Renault**
Billancourt, France;
Automobiles Peugeot
Paris, France

[32] Priority **Jan. 29, 1969, Mar. 20, 1969**
[33] **France**
[31] **6,901,827 and 6,908,161**

[54] **BARREL-TYPE HYDRAULIC MOTORS AND PUMPS**
9 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **91/504,** 91/507
[51] **Int. Cl.** **F04b 1/02**
[50] **Field of Search** 91/504-507; 417/269

[56] **References Cited**

UNITED STATES PATENTS

2,649,741	8/1953	Henrichsen	91/507
3,136,264	6/1964	Wahlararu	91/507
3,277,835	10/1966	Wahlmark	91/507
3,373,696	3/1968	Geyel	91/499

Primary Examiner—William L. Freeh
Attorney—Stevens, Davis, Miller and Mosher

ABSTRACT: Hydraulic barrel-pump or motor of the variable cylinder capacity type wherein the output can be reversed by moving the cylinder barrel angularly about a pivot axis extending at right angles to the axis of rotation of said barrel, said barrel being formed with a slide-face, the bottom apertures of the cylinders opening into said slide-face, said slide-face being in rotary contact with the distributing slide-face of a distributor plate comprising a curved convex slide-face of a d consisting of a surface of revolution on its face opposite to said distributing slide-face, said distributor plate having formed therein a pair of fluid passages opening each into said distributing slide-face through a port having the shape of one portion of a circular annulus, and on the opposite side, through an orifice formed in said convex slide-face, said barrel revolving in a casing having formed therethrough a pair of inlet and outlet ports opening internally into a curved slide-face which is concave with respect to said pivot axis, said pump or motor being characterized in that an intermediate member formed with a pair of intermediate ducts extending therethrough is adapted to slide between said convex and concave slide-faces about said pivot pin, in such a manner that in all the relative positions of said plate, intermediate member and casing, the aforesaid pair of intermediate ducts connect said fluid passages to said inlet and outlet ports, respectively.

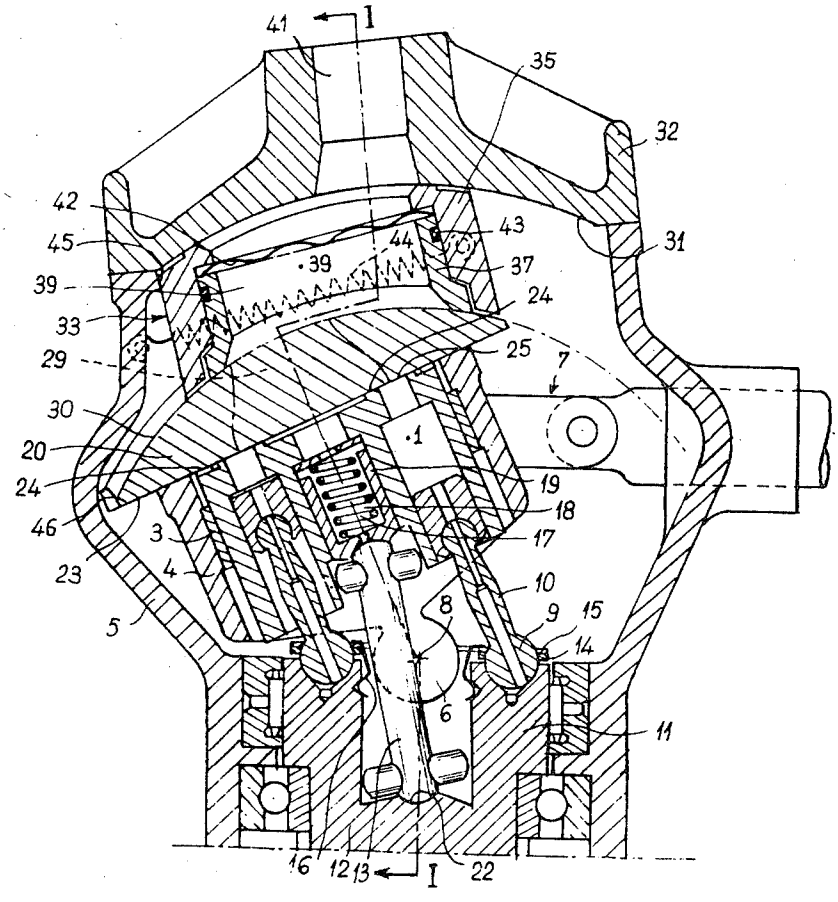


FIG. 1

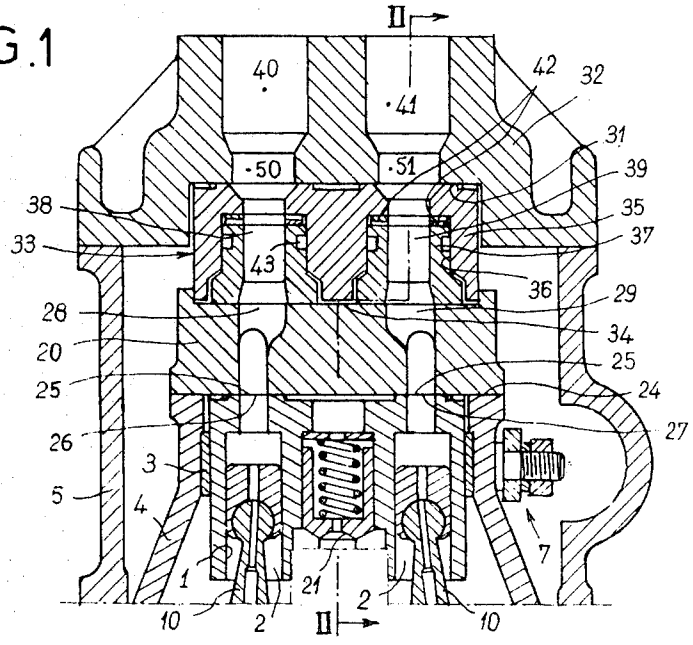

II
40
41
42
32
31
50
51
39
38
35
33
43
37
36
29
28
34
20
25
25
24
26
27
3
5
4
7
1
21
2
10
2
II
10

FIG. 2

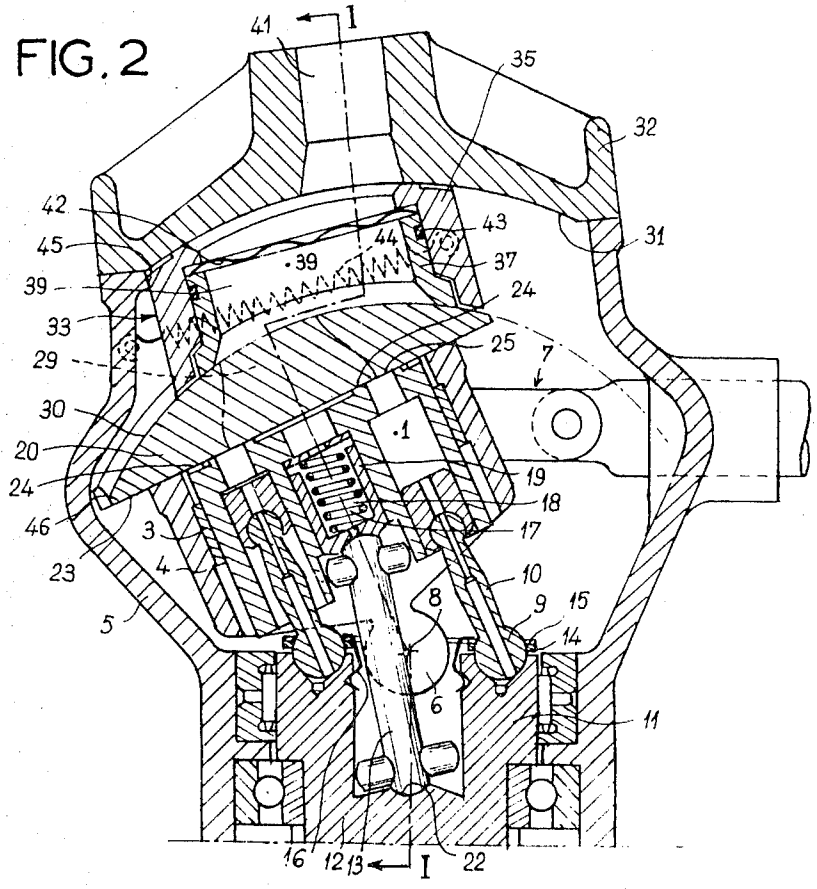

41
I
35
32
42
43
45
44
31
39
39
37
24
33
25
7
29
30
1
20
19
24
18
46
3
17
23
4
10
8
9
15
5
14
6
11
16
12
13
I
22

FIG. 3

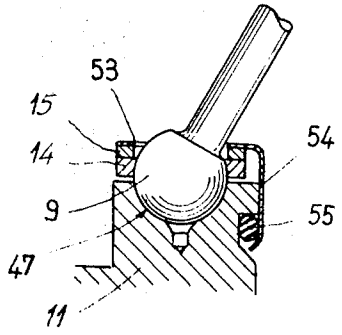


FIG. 5

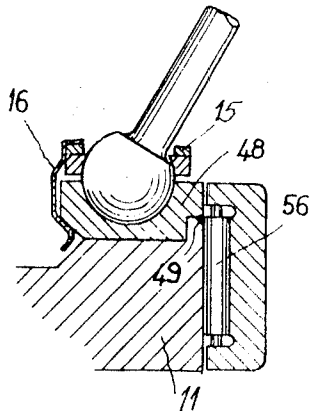


FIG. 6

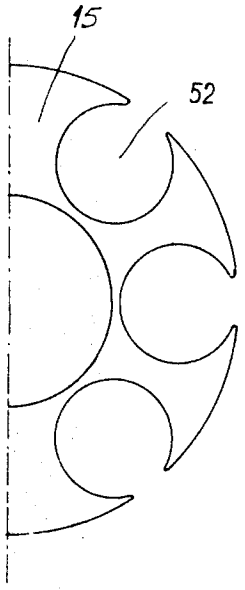
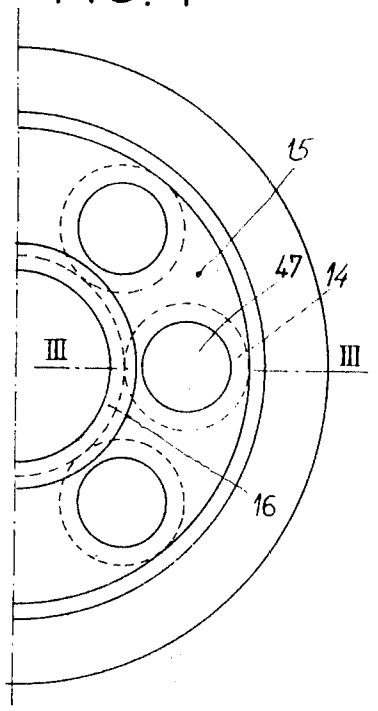


FIG. 4



BARREL-TYPE HYDRAULIC MOTORS AND PUMPS

The present invention relates in general to a variable-capacity, barrel-type hydraulic motors and pumps.

To simplify the disclosure, only pumps will be referred to in the following description, but it will be readily understood by those conversant with the art that the data concerning the pumps are applicable to, or can be extrapolated for, hydraulic motors in each case,

This invention relates more particularly to an improvement in or relating to hydraulic barrel pumps which permits modifying their cylinder capacity by modifying the angle between the barrel axis and the axis of the pump driving shaft, a zero angle corresponding to a zero cylinder capacity.

In certain pump types the angle formed between the barrel axis and the pump shaft must be adapted to vary on either side of the zero cylinder capacity position to permit a reversal of the direction of the fluid flow output in the pipe lines connected to the pump. In fact, a pump of this character is frequently required for supplying power fluid to a hydraulic motor having two directions of rotation.

As a rule, this variation is obtained by pivotally mounting the pump body about an axis extending at right angles to the pump axis proper and lying in the plane of the circle containing the centers of the ball-shaped ends through which the piston rods are pivotally connected to the impeller plate. This arrangement causes the hydraulic fluid to compulsorily flow through inlet and outlet passages formed in the rotating support of the barrel, the fluid being sucked and delivered or forced through the fixed pivot shaft of this support provided to this end with shaft packings concentric to the barrel support bearings.

Barrel pumps are also known which comprise packings or seals permitting the flow of hydraulic fluid from one member to another member to which a rotary motion is imparted in relation to said one member. This fluid transfer can take place provided that the packing or seal has been properly calculated and manufactured, so as to reduce leakages and frictional contacts to a permissible or negligible value. Such packings or seals are currently used when the interface between these two members is plane or cylindrical.

In former French Pat. No. 1,411,439 and U.S. Pat. No. 3,107,632, packings of this type are illustrated in the case of a transfer of fluid through a barrel pump, from the distributor or swash plate to the end cover closing the pump body or casing.

While reducing the weight and overall dimensions of barrel pumps, this arrangement is also advantageous in that it permits balancing the efforts exerted on the barrel support by reducing the weight and inertia of this member while simplifying the pivot means associated therewith.

However, to maintain the balance between the efforts exerted on the pump barrel, the joint surface area should not exceed a certain value in order to avoid any undue increment in the hydraulic fluid pressure on the inner side of the joint surface against the member slidably engaging this joint. This limitation is attended by a small angular backlash or free motion of the barrel. Thus, known pumps permit an output variation down to zero value, but not a reversal in the pump output.

It is the object of the present invention to avoid the above-mentioned inconvenience without increasing the weight of the pump in comparison with the above-defined type. This invention is applicable more particularly to variable-capacity barrel pumps of the type wherein the output can be reversed by moving the barrel angularly about a pivot axis extending at right angles to the axis of rotation of said barrel formed with a slide-face in which the cylinder openings are formed. This slide-face is in rotary contact with the distributing face of a distributor plate comprising a curved convex slide-face consisting of a surface of revolution on its face opposite to the distributing face and having formed therein a pair of fluid passages opening each into said distributing face through a port having the shape of a portion of a circular annulus, and on the opposite side through an orifice formed in said convex slide-face. The barrel revolves in a casing having formed therethrough a pair of inlet and outlet ports opening internally into a curved slide-face which is concave with respect to the pivot axis. The pump according to this invention is characterized in that an intermediate member formed with a pair of intermediate ducts extending therethrough is adapted to slide between said convex and concave slide-faces, about said pivot axis, in such a manner that in all the relative positions of said plate, intermediate member and casing, the aforesaid pair of intermediate ducts connect respectively said fluid passages to the inlet and outlet ports, respectively.

In pumps thus designed the suction and delivery flows are no more directed through members revolving about the pivot axis of the barrel.

According to another particularly advantageous form of embodiment of this invention the cross-sectional surface areas of the orifices through which the intermediate ducts terminate at the convex slide-face of the distributing plate, and the cross-sectional areas of the orifices of said slide-face and also of the cylinder openings are so calculated that the hydraulic pressures exerted against said convex slide-face and the barrel face bounded by said circular annulus compensate substantially that pressure acting against the bottoms of the cylinders. so as to relieve at least partially the barrel support pivot shaft from the stress directed along the axis of rotation of said barrel.

This invention is also concerned with a device for retaining the ball-shaped heads of the piston rods of the hydraulic barrel-pumps and motors defined hereinabove, and also with a device for simultaneously securing and retaining a plurality of said ball-shaped heads in angularly spaced recesses formed in a supporting member requiring but a moderate machining precision.

In hitherto known devices for securing these ball-shaped heads of piston rods, use is made in general of an impeller plate formed with recesses or spherical seats machined in said plate or in inserts carried thereby. The chief drawback characterizing these known devices results from the complication of machining the plate and also from the difficulty of obtaining under mass-production conditions a low-tolerance stacking of the assembly comprising the spherical seats, the ball-shaped piston-rod end and the retaining member therefor.

Spherical seats are also known which are mounted in a recess formed in the plate and retained in position by crimping the seat to the plate, the ball-shaped ends of the piston-rods being also retained by crimping in said seats. The inconveniences observed with this device are due to the difficulty of assembling the parts, and also in properly crimping the seat on the ball-shaped heads, in disassembling the parts for repair purposes, not to mention the repairs themselves.

Devices for securing the ball-shaped heads of the piston-rods are also known wherein these heads are received in a part-spherical recess greater than a half-sphere. In this case, a cylindrical portion of the ball-shaped member which is coaxial with the rod permits the insertion of the ball-shaped head into the recess in a predetermined position and the rigid fastening of this ball-shaped head to its recess in another position.

It is known that it is difficult to obtain inner part-spherical recesses greater than a half-sphere. Consequently, this device which is not capable of retaining the ball-shaped head when the cylinder capacity of the pump is zero requires an additional retaining member to complement the spherical surface of the recess, this additional member being fitted on the rod provided with the ball-shaped head secured to the impeller plate.

It is therefore, inter alia, another object of this invention to avoid the above-mentioned inconveniences by providing a device for securing a piston-rod ball-shaped head in a part-spherical cavity of an impeller plate, which is characterized by the provision of a member having a part-spherical inner surface accommodating the ball-shaped head surface, and by the fact that said member, coacting in a known manner with said ball-shaped head, comprises an upper face connected to said

impeller plate, a lower face spaced from said plate and formed with a cavity corresponding in shape to the surface of said ball-shaped head and having a depth inferior or equal to the radius of said ball-shaped head.

The device thus provided facilitates the machining of the part-spherical recesses in said plate for their position in relation to the plate face is immaterial. However, the centers of the various recesses must lie substantially in a common plane. This requirement is easily met by resorting to a cold forging operation during which all the recesses are formed simultaneously.

Other features and advantages of this invention will appear as the following description proceeds with reference to the attached drawing illustrating diagrammatically by way of example a typical form of embodiment thereof. In the drawing: C,

FIG. 1 is a fragmentary axial sectional view of the pump, the section being taken along the line I–I of FIG. 2;

FIG. 2 is a section taken along the line II–II of FIG. 1;

FIG. 3 is a fragmentary section showing the pump shaft plate;

FIG. 4 is a fragmentary plan view from above of the plate;

FIG. 5 is a section showing a modified form of embodiment of the device, taken along the line V–V of FIG. 4, and

FIG. 6 is a plan view from above showing the element provided for retaining in position the member shaped to accommodate the ball-shaped head.

As illustrated in the drawing (FIGS. 1 and 2) the rotary cylindrical barrel 1 comprises a number of cylinders 2. This barrel 1 revolves in antifriction bearings 3 rigid with a support 4. This support 4 is mounted in the pump casing 5 by means of a pivot 6 comprising a pair of trunnions (not shown) rigid with said support and revolving in a pair of opposite recesses formed in the casing 5. It can pivot under the action of a control device 7 about a pivot axis 8 extending at right angles to the axis of rotation of the barrel and positioned in the plane containing the centers of the ball-shaped heads 9 of the rods of piston 10 mounted in the impeller plate 11 rigid in turn with the pump driving shaft 12. This shaft 12 drives the barrel 1 through the medium of a universal of Hooke's joint comprising a small rod 13 provided at its ends with driving studs adapted slidably to engage axial grooves formed in said barrel and said shaft, respectively

The ball-shaped heads 9 are connected to the impeller plate 11 through a device also forming an integral part of this invention and of which a few forms of embodiment are illustrated by way of example in FIGS. 3 to 6 inclusive.

A coil compression spring 17 axially disposed in a cavity 18 formed in a fixed sleeve 19 of antifriction material causes the barrel 1 to bear (also by virtue of the inner pressures) against the distributor or swash plate 20 rigid with said support 4. This sleeve 19 is retained in position by the small rod 13 constituting the barrel driving member. This small rod 13 comprises a pair of part-spherical end surfaces engaging the one a cavity 21 formed in sleeve 19 and the other another cavity 22 formed in said driving shaft 12.

The distributing slide-face 22 of swash plate 29 engages the companion slide-face 24 of barrel 1 into which open axial openings 25 formed in the bottom of cylinders 2. The distributing slide-face 23 has formed therein delivery and suction ports 26 and 27, respectively, having the shape of elements of a circular annulus and communicating each with two passages 28 and 29, respectively, which open into the other slide-face of said plate which constitutes a convex cylindrical surface 30.

The convex slide-face 30 is parallel to a cylindrical concave slide-face 31 formed on the inner side of the cover plate 32 of the pump casing; according to this invention, it is separated from this last-named concave slide-face by a cylindrical intermediate member 33 in rotary sliding contact therewith. The axis of the convex and concave slide-faces as well as of the intermediate member 33 merges into the pivot axis 8. Under these conditions, the intermediate member 33 can pivot about this last-mentioned axis 8.

The slide-face 34 of intermediate member 33 is in sliding contact with the convex slide-face 30 of distributor or swash plate 20 and the total surface area of this slide-face corresponds substantially to the surface area of the slide-face of member 33 which engages the concave slide-face 31 of the pump cover plate 32.

The intermediate member 33 comprises three essential component elements, including a main block 35 formed with a pair of parallel elongated recesses 36 each slidably engaged by a tubular member 37 of elongated cross-sectional configuration. Apertures formed in the face of the main block 35 which engages the concave slide-face 31 constitute the extensions of the passages formed in said tubular member 37 and provide therewith intermediate duct means 38 and 39, permitting the communication between the passages 28 and 29 on the one hand, and inlet and outlet ducts 40 and 41 formed in said cover 32 on the other hand. Springs 42 mounted in prestressed condition between shoulders formed in the bottom of recesses 36 and the inner ends of tubular members 37 urge these members and the main block 35 away from each other. Thus, the block 35 and the tubular members 37 are constantly kept in fluidtight engagement the former with the concave slide-face 31 of cover 32 and the latter with the convex slide-face 30 of distributing or swash plate 20.

Seals 43 prestressed in grooves formed in the outer periphery of tubular members 37 prevent any fluid leakage between the walls of these members 37 and the walls of recesses 36.

It will be noted that the intermediate duct means 38 and 39 still connect the passages 28 and 29 to the inlet and outlet ducts 40 and 41, respectively, irrespective of the relative positions of the distributing or swash plate 20, intermediate member 33 and pump over 31.

Besides, at least one traction spring 44 connects the casing 5 to said intermediate member 33 and urges same towards a first stop 45 provided in said casing 5 and a second stop 46 provided on one of the ends of the convex slide-face 30 of distributing plate 20. To permit the relative movement of member 33 with respect to plate 20, other means may be used, such as a gear or linkage system, adapted to cause the movement of member 33 in proportion to the angle of pivotal movement of the barrel support 4.

The connection according to this invention between the ball-shaped heads 19 of rods 10 and the plate 11 is illustrated in FIGS. 3 to 6.

As clearly apparent from FIG. 3 the impeller plate 11 is formed with part-spherical cavities 47 receiving the spherical heads 9. These cavities 47 may be obtained by machining or cold-forging. However, as illustrated in FIG. 5, they can also be machined in a separate member or insert 48 secured to the pump shaft plate 11 by a weld spot 49 or any suitable assembling means.

Each ball-shaped head 9 coacts with a retaining plate 14 formed with a part-spherical inner face and consisting if desired of sintered material. These plates 14 shaped to accommodate the ball-shaped heads are somewhat spaced from the plate surface as clearly shown in FIGS. 3 and 5.

The retaining plates 14 are mounted on the ball-shaped heads 9 (FIGS. 4 and 6) by means of a punched washer 15 formed with a number of circular notches 52 disposed at spaced intervals along the outer-periphery of said washer 15. This punched washer 15 engages the retaining plate 14 according to the arrangement illustrated in FIG. 3 by crimping another washer 53 formed with a cylindrical skirt 54 engaging the plate 11 through the interposition of a resilient element 55.

In the modified form of embodiment of FIG. 5 the washer 15 is held against the plates by a resilient ring 16 urging the washer 15 against the surface of the pump shaft plate. This washer 15 may be flexible enough to accommodate the differences in height between the plates 14 when these are mounted on the ball-shaped heads 9 fitted in the corresponding recesses of plate 11.

Similarly, the resilient ring **16** may either bear against different points of the periphery of washer **15** in order to accommodate a possible variation in height or retaining plates **14** without increasing the play, or load only the three highest retaining plates **14**. The rotary impeller plate **11** is mounted in the pump or motor body through the antifriction bearings **56**.

Finally the pump according to this invention comprises the conventional accessories of barrel pumps, such as the lubrication ducts extending for example through the pistons, the ball-shaped connecting heads and their rods **10**, these rods **10** and the ball-shaped heads **9**, or additionally the cavity **18** and the cavity **21** of one of the spherical heads of driving rod **13**.

The principle of operation of barrel pumps is well known to technicians and therefore the description of the pump components disposed between the driving shaft **12** and the convex slide-face **30** of distributor plate **29** is not deemed necessary.

It is obvious on the one hand that the pump output is subordinate to the inclination of barrel **1**, supports **4** and distributor or swash plate **20** on either side of the zero-cylinder capacity position which is the position wherein the axis of rotation of the barrel is coincident with the axis of the driving shaft, and on the other hand that the fact of passing through this position of zero cylinder capacity implies the reversal of the direction of flow through the ports **40** and **41** of pump cover **32**.

In the case of the position illustrated in FIG. **2** the intermediate member **33** urged by spring **44** engages the stop **45** of casing **5** and as the barrel **1** has its maximum inclination the pump operates with its maximum output. The fluid sucked into the pump cylinders **2** and forced by the pistons flows into the two passages of the distributor plate and the pair of intermediate ducts **38** and **39** respectively of intermediate member **33**, so as to be sucked from or forced into the inlet and outlet ducts **40** and **41** of cover **32**.

As the barrel **1** pivots, the output decreases and eventually becomes zero when the axis of rotation of the barrel is coincident with the axis of the impeller plate **11**. If the barrel support **4** is pivoted beyond this position about the axis **8** by means of the control device **7**, the stop **46** of distributor plate **20** carries along the intermediate member **33** until the barrel support **4** reaches its limit position on the right-hand side of FIG. **2**.

The advantage resulting from the interposition of an intermediate member **33** according to this invention is obvious. If this member were not used, i.e. if the convex slide-face **30** of distributor or swash plate **20** were in direct sliding contact with a corresponding concave slide-face formed in the pump casing, the force exerted by the pressure on the convex slide-face **30** would be applied to a circular arc corresponding to the angular displacement of the barrel support **4** plus the circular arc corresponding to the length of openings **28** and **29**. Now this force would be far in excess of the tractive effort exerted on the pivot means **6** of support **4** and caused by the counterpressure exerted against the bottom of cylinders effecting their delivery function or phase. In the case of the device according to this invention, the pressure exerted against the convex slide-face **30** applies only to a circular arc bounded by the transverse walls of the intermediate member **33** following the distributor or swash plate **20** along substantially one-half of its angular excursion. The effort reduction thus obtained permits reducing considerably, or even cancelling, the difference between said tractive effort and said pressure, so as to balance the efforts exerted on the barrel.

Finally, the orifices **28** and **29** of distributing plate **20** and the orifices **50** and **51** of cover **32** may advantageously have a configuration elongated in the direction of their movement, so that the surface area of these orifices are constantly inscribed within the limit of the surface area of the openings of the intermediate ducts **38** and **39** of intermediate member **33**. Thus a greater angular excursion of the assembly comprising the barrel, the barrel support and the distributor plate may be obtained without modifying the surface area inscribed in the openings of the intermediate ducts **38** and **39**.

Of course, various modifications and variations may be brought to the specific form of embodiment of the present invention which is shown and described herein, without departing from the scope of the invention as set forth in the appended claims.

What I claim is:

1. Hydraulic barrel-pump or motor of the variable cylinder capacity type comprising a barrel formed with a slide-face and cylinders therein opening into said slide-face, a distributor plate having a distributing slide-face in rotary contact with said barrel slide-face and a curve convex slide-face formed by a surface of revolution on the face opposite to said distributing slide-face, a pair of fluid passages formed in said distributor plate each opening into said distributing slide-face through a port having the shape of one portion of a circular annulus and opening into the curved convex slide-face through an orifice formed therein, a casing having said barrel mounted therein for movement about a pivot axis extending at right angles to the axis of rotation of said barrel, a pair of inlet and outlet ports in said casing opening internally into a curved slide-face which is concave with respect to said pivot axis, and an intermediate member having a pair of intermediate ducts extending therethrough and adapted to slide between said convex and concave slide-faces about said pivot axis in such a manner that in all the relative positions of said plate, intermediate member and casing, the aforesaid pair of intermediate ducts connect said fluid passages to said inlet and outlet ports, respectively whereby the output can be reversed by moving the cylinder barrel angularly about said pivot axis.

2. Hydraulic barrel-pump or motor according to claim **1**, wherein the cross-sectional passage areas of said intermediate ducts leading into said convex slide-face of said distributor plate, the passages of said distributor plate and said barrel cylinders are so calculated that fluid pressures exerted against said convex slide-face and barrel face bounded by said circular annulus substantially balance the pressure acting against the bottom of said cylinders and at least partially relieve the pivot of said barrel from the load directed along the axis of rotation of said barrel.

3. Hydraulic barrel-pump or motor according to claim **1**, wherein said intermediate member comprises a main block in which a pair of elongated parallel recesses are formed, a tubular member of elongated cross-sectional configuration received in fluidtight sliding engagement in each of said recesses, intermediate ducts consisting of openings formed in the bottom of said recesses and of the inner passages of said tubular members, spring means mounted in prestressed condition between shoulders formed in the bottom of said recesses and the inner ends of said tubular members constantly urging said tubular members and said block away from each other.

4. Hydraulic barrel-pump or motor according to claim **3**, further comprising a first limit stop provided in said casing, spring means urging said intermediate member against said stop, another limit stop disposed on said distributor plate on the same side as said first stop so that said distributor plate can carry along said intermediate member from substantially the middle of the stroke of said distributor plate about said pivot axis.

5. Hydraulic barrel-pump or motor according to claim **1**, wherein said convex and concave slide-faces are cylindrical.

6. Hydraulic barrel-pump or motor according to claim **1**, further comprising pistons slidably mounted in the barrel cylinders, an impeller plate, rods each having one ball-shaped end engaged in corresponding cavities in said impeller plate and the other end connected to a respective piston, retaining means holding said one end in said cavity and comprising a small plate having a part-spherical inner surface corresponding in shape to the surface of said ball-shaped end and of a depth not greater than the radius of said ball-shaped end, and an upper face connected to said impeller plate through a member adapted to be secured to said plate with a lower face out of contact with said plate.

7. Hydraulic barrel-pump or motor according to claim 6, wherein a plurality of said ball-shaped ends are simultaneously fastened to said impeller plate by said plate consisting of a punched washer formed with a plurality of angularly spaced peripheral notches.

8. Hydraulic barrel-pump or motor according to claim 7, wherein said punched washer is engaged on the retaining members by another washer formed with a skirt adapted to engage said supporting plate after interposition of a resilient element therebetween.

9. Hydraulic barrel-pump or motor according to claim 7 further comprising an insert secured to said impeller plate and having the recesses for receiving said ball-shaped rod heads are machined therein, the upper face of said retaining member being held against said plate by means of a resilient ring attached both to said punched washer and to said plate insert.