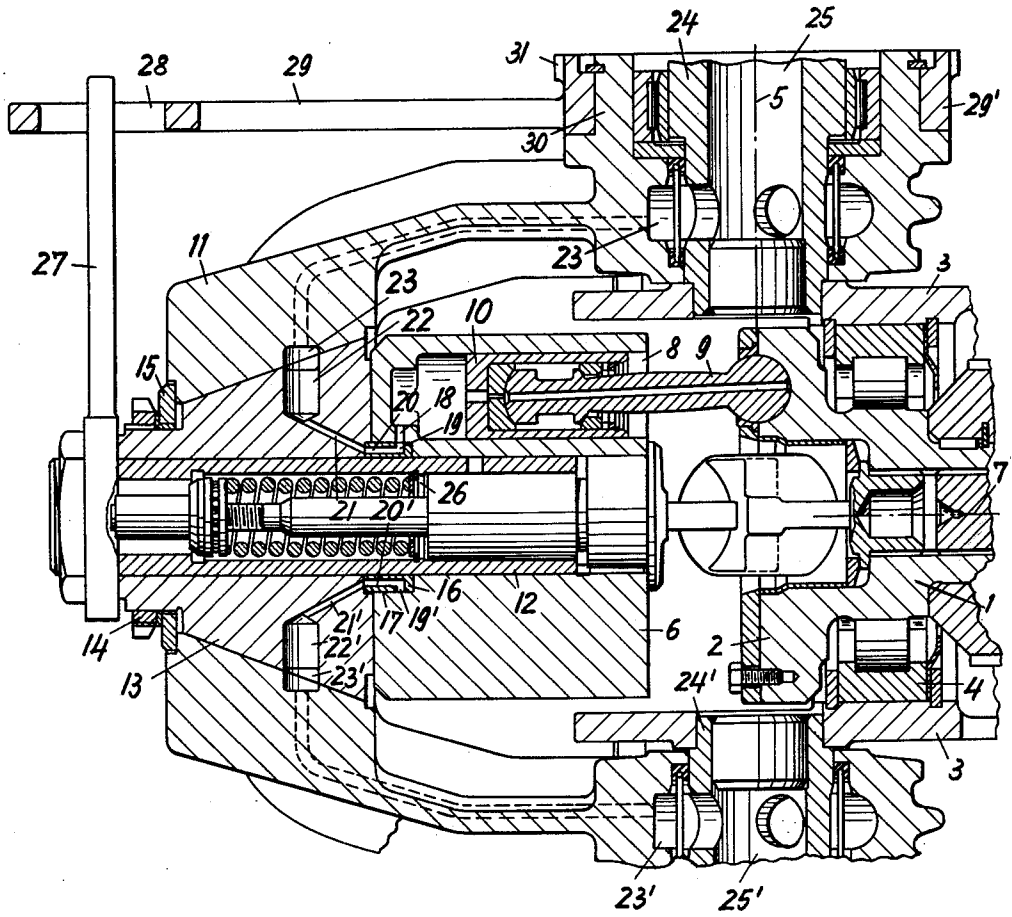
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HYDRAULIC AXIAL PISTON ENGINE

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Fig. 1



INVENTORS

REINHOLD G. KAMPS AND
WERNER J. BARTHOLOMÄUS

BY Dicke and Craig.

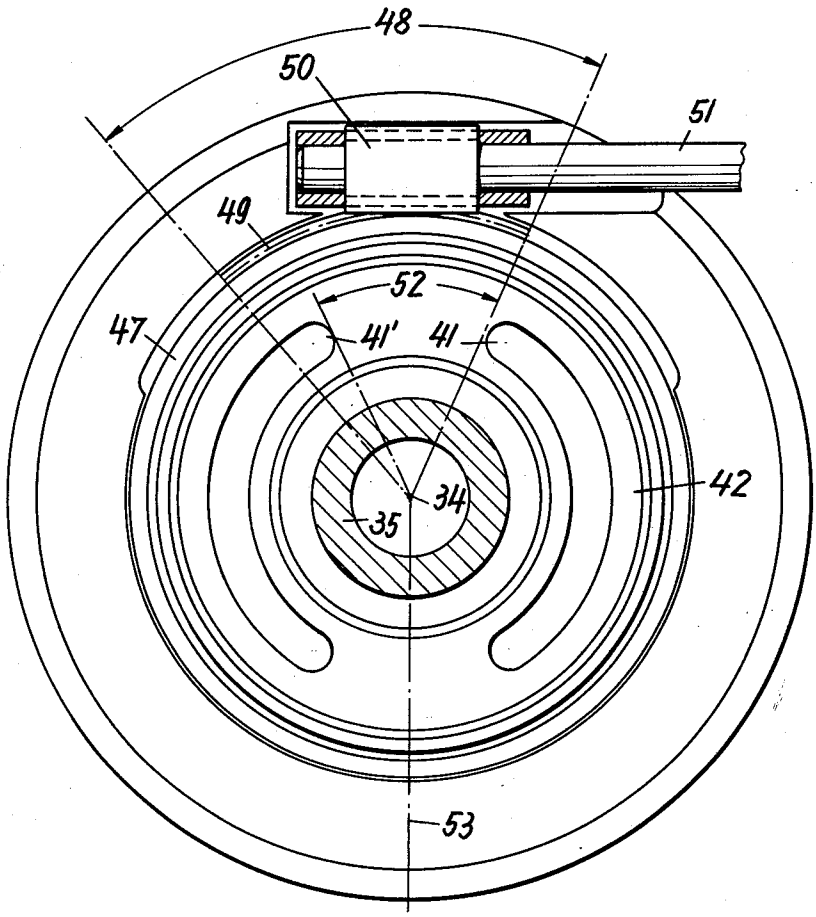
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Jan. 15, 1963 R. G. KAMPS ETAL 3,073,252

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Fig. 3



INVENTORS
REINHOLD G. KAMPS AND
WERNER J. BARTHOLOMÄUS

BY Dicke and Craig.

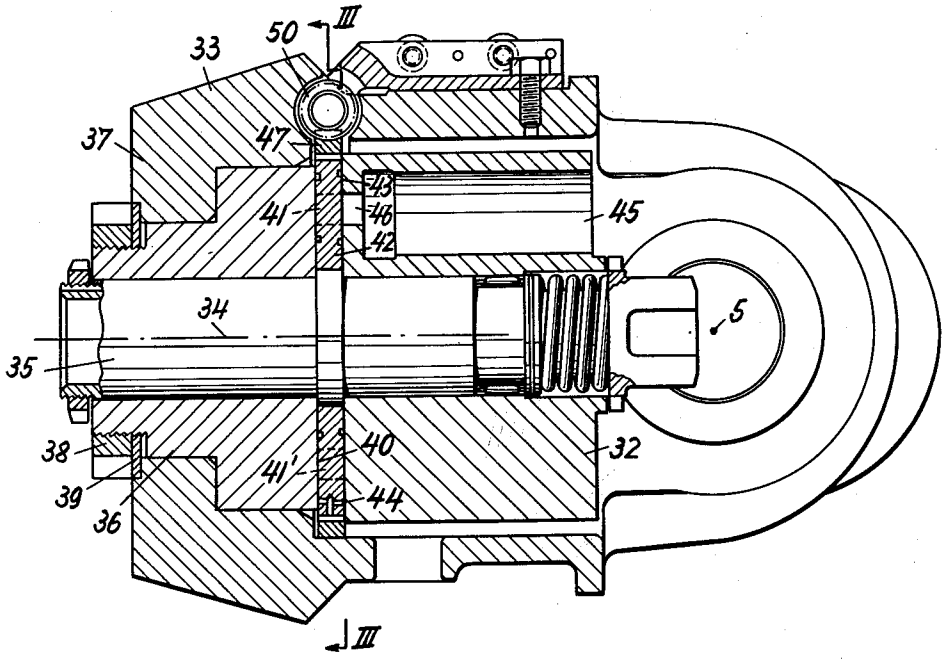
ATTORNEYS.

Jan. 15, 1963 R. G. KAMPS ETAL 3,073,252

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Fig. 2



INVENTORS
REINHOLD G. KAMPS AND
WERNER J. BARTHOLOMÄUS

BY Dicke and Craig.

ATTORNEYS

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HYDRAULIC AXIAL PISTON ENGINE

Reinhold G. Kamps, Stuttgart-Bad Cannstatt, and Werner J. Bartholomäus, Wolfsburg, Germany, assignors to Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany

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The present invention relates to a hydraulic axial-piston engine of the type which comprises a main shaft provided with a driving flange, and a cylinder block adjacent to the driving flange and provided with cylinder bores which are coaxial with the main shaft when the cylinder block is in its central position, and each of which contains a piston which is pivotally connected to the driving flange by means of a connecting rod. The cylinder block of such engine is rotatable about its longitudinal axis and mounted within a housing which contains a control mechanism for connecting the cylinder chambers to different points where the fluid pressure produced by the machine may be utilized. The housing, in turn, is mounted on another stationary housing so as to be pivotable about a transverse axis which extends within a plane passing through the pivotal axes of the connecting rods within the driving flange, and it is provided with two outer connections for conducting the operating fluid to its point of use.

Axial piston engines of the aforementioned type have the disadvantage, especially if the cylinder housing is pivoted or the rotation of the cylinder block is reversed, of having fluid pressure peaks occur at the area of control during operation of the engine; i.e., at the zone or area of location of the elements for controlling passage of hydraulic fluid to or from the cylinder chambers. The term "pressure peaks" designates short-timed pressure increases beyond the normal operating pressure and they occur by reason of changes in the operational conditions of the engine caused for example by angularly displacing the cylinder block of the engine relative to its driving member and by movement of the pistons while the piston ports are out of communication with the control apertures therefore. Therefore, depending upon the amount of pressure or excess pressure at this zone of location of the control elements, it is desirable that these elements be shifted in phase for the purpose of adapting or matching the final pressure produced in the individual cylinders to the pressure prevailing in the main pressure line. If the control elements of the housing are constructed unsymmetrically relative to the central longitudinal plane of the housing, which is perpendicularly disposed relative to the pivotal axis of the housing to obtain a certain phase displacement for the above purpose, the mentioned disadvantage i.e., the occurrence of pressure peaks, would not be eliminated but is only delayed if the cylinder housing is pivoted about its axis or the rotation of the cylinder block is reversed. Although a limited compensation for such pressure peaks has been obtained prior to this invention by the so-called canting of the pivoted housing, such procedure will only be possible to a very limited extent, and it will also result in a change in the output characteristic of the machine.

It is an object of the present invention to overcome the above-mentioned disadvantages by mounting at least the control portion of the housing which is located adjacent to the cylinder block and contains the mentioned control elements so as to be able to turn within a certain angular degree relative to the other parts of the housing and about the longitudinal axis thereof without affecting the conduits leading from the control elements to the outer points of connection.

The change in rotative position of the control portion just referred to brought about by such turning is effective to alter the relative positions of the control elements carried thereby with the result of compensating for the pressure peaks referred to above by varying the registry of the apertures in such control elements with the apertures in the cylinder block communicating with the respective cylinders. One important feature of the present invention is the valve member, which is formed in one modification as a sleeve having radial channels that extend outward to connect with the individual cylinder bores in the cylinder block.

It is another feature of the invention that such control sleeve is mounted on the conventional shaft which supports the cylinder block and extends through the housing in an axial direction thereof, and that the partial rotation of the control sleeve relative to the housing may be produced by a corresponding rotation of the mentioned shaft.

In another embodiment of the invention the valve member consists of a separate plate member formed with inlet and outlet apertures therein and located between end surfaces of the cylinder block and the cylinder block housing. These two control apertures and the connecting channels in the cylinder block leading to the individual cylinder bores and terminating in the corresponding end surface of the cylinder block are concentrically disposed to the rotary axis of the cylinder block and cooperate with each other in the axial direction. The mentioned control member preferably forms a circular disk with arcuate control apertures therein, and may be rotatably adjusted by additional means within a certain angle of movement about the longitudinal axis of the housing, and thus also relative to the housing, as well as to the connecting channels of the cylinder bores, in the cylinder block, without thereby affecting the continuity of the other channel connections leading to the points on the outside of the housing at which the pressure produced by the pistons is drawn off to some other point if use.

Another preferred feature of the invention consists in making the control member, which may be turned about the longitudinal axis of the housing, of two parts, which preferably consist of a control disk which exerts a sealing action in an axial direction and contains one of the control elements, and a control sleeve which exerts a sealing action in a radial direction and contains the other control element. Both the control disk and the control sleeve control the channels leading to the individual cylinder bores in the cylinder block and are rotatable independently of each other, for example, on the one hand, from the outside of the housing by means of a gear sector secured to the outside of the control member and, on the other hand, by the shaft which extends through the housing in the longitudinal axial direction thereof. Such turning is preferably produced automatically, for example, in accordance with the hydraulic pressure prevailing at the respective control element.

Further objects, features, and advantages of the present invention will appear from the following detailed description thereof, as well as from the accompanying drawings, in which—

FIG. 1 shows a longitudinal section through an axial piston engine according to the invention;

FIG. 2 shows a longitudinal section through the housing and cylinder block of an axial piston engine according to a modification of the invention, and taken in a direction transverse to the pivotal axis of the housing; while

FIG. 3 shows a cross section taken along line III—III of the housing according to FIG. 2.

Referring to the drawings, the axial piston engine as shown in FIG. 1 consists of a main shaft 1 which serves

either as a driving or driven shaft and terminates at one end in a driving flange 2, and is rotatably mounted by means of a roller bearing 4 in a stationary housing 3 at a point immediately adjacent to driving flange 2. The latter is connected with a cylinder block 6 which is adapted to pivot about a transverse axis 5. The longitudinal axis of cylinder block 6 when in its central position as shown in FIG. 1 extends coaxially with axis 7 of main shaft 1. At the side facing driving flange 2, cylinder block 6 is provided with a plurality of cylinder bores 8 which are concentrical with the longitudinal axis thereof and each of which guides a piston 10, the rod 9 of which is pivotally mounted on driving flange 2. The transverse axis 5 about which cylinder block 6 may pivot is disposed within a plane which passes through the pivoting centers of connecting rods 9 within driving flange 2.

Cylinder block 6 is surrounded by a further housing 11 which is mounted on the stationary housing 3, preferably at both sides of the main shaft, so as to be pivotable about transverse axis 5.

A hollow shaft 12 which also serves as a support of cylinder block 6 is mounted in housing 11 in such a manner that, when housing 11 is not pivoted, the longitudinal axis of cylinder block 6 will extend coaxially to axis 7 of main shaft 1. That part of housing 11 which supports shaft 12 forms a conical member 13 which is made independently of the other part of the housing. It is inserted into the housing from the inside thereof and secured thereto at the end projecting from housing 11 by means of a washer 15 and a nut 14. Coaxially with the housing 11, conical member 13 has a central bore in which shaft 12 is rotatably guided but prevented from shifting in the axial direction. At the end surface of cylinder block 6 which faces toward conical member 13, shaft 12 further carries an outer control sleeve 16 which is rigidly secured to the shaft and precisely finished and fitted so that during the operation of the machine it will form a tight seal relative to the rotating cylindrical wall 17 of an annular recess in cylinder block 6.

The inner end or bottom of each individual cylinder bore 8 has a channel 18 extending radially inwardly which during the operation of the machine is cooperating with two arcuate grooves 19, 19' in the outer periphery of control sleeve 16 which, in turn, connect with channels 20, 21, 22, 23 and 20', 21', 22', 23', respectively, which terminate on each side of housing 11 in a hollow shaft 24 and 24', respectively, which are rotatably mounted in the stationary housing 3 about the pivotal axis 5 and serve as journals around which housing 11 is capable of pivoting. Bores 25 and 25' in shafts 24 and 24', respectively, may lead outwardly to a suitable point of connection not illustrated in the drawing where the pressure produced by pistons 10 may be utilized. When control sleeve 16 is in its central position, the two grooves 19 and 19' each of which forms a segment of a circle with a common center, will be symmetrical relative to the central longitudinal plane of housing 11 which extends perpendicularly to the pivotal axis 5 of the housing. Channels 20 and 20' in control sleeve 16 and/or that portion of channels 21 and 21' which communicates with channels 20 and 20', respectively, should likewise form arcuate slots so as to maintain a connection between the respective channels when control sleeve 16 is being rotated.

The outer end of hollow shaft 12, which contains additional elements on its inside 26 for maintaining cylinder 6 in a close sealing engagement with conical member 13, carries a lever 27, the free outer end of which is guided within a longitudinal slot 28 in another lever 29. Lever 29, in turn, terminates in an annular flange 29' which is mounted on a flange 30 on housing 11 which supports the hollow stationary shaft 24, so as to permit lever 29 to turn or pivot to a certain angular extent about the axis 5. For this purpose, flange 29' has on its outside spur gear teeth 31 by means of which lever 29 may be pivoted by any suitable means so as to adjust the operation of control sleeve 16, for example, in accordance with the pressure of the fluid within the machine.

If, for example, the main shaft 1 is used as a drive shaft and rotated by a power plant, not shown, such as, for example, an internal combustion engine, and if the two outlets which connect with bores 25 and 25' are connected to an oil circulating system in which another axial piston engine is provided, which will then act as an oil or hydraulic motor, the entire arrangement will then form a hydrostatic transmission. The oil contained in such circulatory system will be circulated by the pistons 10 of the axial piston engine as illustrated and at the same time drive the oil motor when housing 11 is pivoted about axis 5 toward one or the other side from the central position as shown in which it is coaxial with main shaft 1. The direction of circulation of the oil depends in such case upon the direction of rotation of main shaft 1 and the direction in which housing 11 is pivoted. Therefore, in order to reverse the direction of circulation without also reversing the direction of rotation of main shaft 1, it is necessary to reverse the direction in which housing 11 is pivoted. Such adjustment of the pivoting direction also reverses the direction of rotation of the main shaft of the oil motor which then acts as a driven shaft. The phase displacement of the controlling axial piston engine which is produced according to the invention by turning the control sleeve 16 by means of the control lever 29 may then be utilized for controlling the operation of the control members, i.e. the arcuate grooves 19 and 19', relative to the connecting channels 18 in the rotating cylinder block 6.

In the axial piston engine according to the modification of the invention as shown in FIGS. 2 and 3, the pistons and driving elements are omitted since they are of the same type as shown in FIG. 1 and described above. However, various other elements shown in FIGS. 2 and 3 differ from those in FIG. 1, as, for example, the cylinder block 32, as shown in FIG. 2, the housing 33 which surrounds cylinder block 32 and is adapted to pivot about the transverse axis 5, and the shaft 35 which supports cylinder block 32 and is mounted on housing 33 in a direction of the longitudinal axis 34 thereof. Similar to the first embodiment as shown in FIG. 1, shaft 35 is not secured directly to housing 33 but by means of an insert 36, the front end of which forms a sealing surface and the other end of which projects beyond the end wall 37 of housing 33 to be secured to the latter by means of a washer 39 and a nut 38. However, the required control members are not disposed directly on the end surface 40 which faces toward cylinder block 32, as this was done in similar machines prior to this invention, but the control member as such is formed by an element separate from insert 36, that is, by a circular control disk 42 which is provided with arcuate apertures 41 and 41'. This control disk 42 is mounted on shaft 35 so as to be rotatable thereon to a certain angular extent and also forms a sealing member so as to seal the end surface 40 of insert 36 in an axial direction relative to end surface 43 of cylinder block 32. Annular grooves 44 are provided on both sides of disk 42 to conduct oil under pressure to the respective gliding surfaces for adequately lubricating the same.

The symmetrical arcuate apertures 41 and 41' in control disk 42 which are of similar shape as grooves 19 and 19' in FIG. 1 are each operatively associated with channels 46 which extend concentrically with the rotary axis 34 of cylinder block 32 and connect the respective cylinder bores 45 with control disk 42. Control apertures 41 and 41' are each connected in a manner similar as shown in FIG. 1 by means of suitable channels with a respective connecting point on the outside of the housing. These connecting points are disposed similarly as in FIG. 1 in the direction of the transverse axis 5 and on each side of housing 33.

Control disk 42 is rigidly secured within a ring 47 of substantially the same width which, as shown particularly in FIG. 3, carries on its outer periphery a row of radial gear teeth 49 which extend along the sector of an arc 48 and engage with a pinion 50, the shaft 51 of which may be rotated as desired. The angle of gear sector 48 is slightly larger than the angle 52 of the sector which is formed between the longitudinal axis 34 of housing 33 and the opposite ends of the two control apertures 41 and 41' which are disposed symmetrically to the longitudinal plane 53 (i.e. the plane of the drawing of FIG. 2) which extends transversally to the pivoting axis 5.

In an axial piston engine as shown in FIGS. 2 and 3, the control disk 42 may also be designed so as to be turned by the inner shaft 35 rather than from the outside. In such event, the outer gear teeth 49 on control disk 42, as well as the outer pinion 50 may be omitted, and control disk 42 will be secured to shaft 35 which may then be rotatably mounted similar as shown in FIG. 1. Control disk 42 may then also be of a smaller outer diameter than the adjacent end surface of insert 36.

Although the invention has been illustrated and described with reference to the preferred embodiments thereof, it is to be understood that it is in no way limited to such embodiments or the details thereof, but is capable of numerous modifications within the scope of the appended claims. Thus, for example, the control function may be further improved if the control member which may be turned about the longitudinal axis of the housing will be made of two parts, which consist, for example, of a control disk which exerts a sealing action in the axial direction and contains one control element, and a control sleeve which exerts a sealing action in the radial direction and contains the other control element, both of which then control the channels leading to the individual cylinder bores in the cylinder block and may be turned independently of each other, for example, on the one hand, from the outside of the housing, by means of a gear sector which is connected to the control member, and, on the other hand, by means of the shaft which extends through the housing in the direction of the longitudinal axis thereof. The control member may, however, also consist of two superimposed control disks of substantially the same shape and provided with similar control apertures, which may be turned independently of each other. Such a two-part control member will not only permit any desired variation of the phase displacement but also of the control characteristics as such, for example, by varying the size of the angle within which the pressure fluid may be discharged from the individual cylinders. Thus, for example, it would be possible to regulate the rotary adjustment of one control member, which controls the high-pressure side of the machine, in accordance with the pressure of the fluid in the machine at the high-pressure side, as well as the rotary adjustment of the other control member, which controls the low-pressure side of the machine, in accordance with the pressure of the fluid in the machine at the low pressure side thereof.

Having thus fully disclosed our invention, what we claim as new is:

1. A hydraulic axial piston unit utilizing in its operation a hydraulic fluid comprising a main shaft having a driving flange thereon, a pivotal cylinder block adjacent to said driving flange and having a plurality of cylinder bores therein disposed concentrically to the axis of said

main shaft when said cylinder block is in its neutral position, a piston slidably mounted in each of said cylinder bores and pivotally connected to said driving flange, said cylinder block having a plurality of channels therein leading from the inside of said cylinder bores to an outer surface of said cylinder block, a housing surrounding said shaft and said cylinder block, means for mounting said cylinder block on said housing so as to be rotatable about its longitudinal axis relative to said housing, means for mounting said housing on a stationary part of said unit so as to be pivotable about a transverse axis extending within the plane passing through the pivotal center of said pistons on said driving flange, said housing having two connecting channels on the outside thereof for respectively receiving and discharging fluid to the working chambers of said pistons, a plurality of conduits within said housing connected to said connecting channels, means for avoiding undesirable pressure peaks in the working chambers of said piston unit consequent upon the movement of said housing about said transverse axis comprising pressure-responsive control means in said housing for selectively controlling the connection of said first-mentioned channels to said connecting channels to thereby effect a phase displacement thereof, said control means comprising, at least one member having control apertures therein adapted to communicate with said first-mentioned channels and being in close sliding engagement with said cylinder block, and means for turning said member within a certain angular distance about the longitudinal axis of said housing and relative to said housing and said cylinder block without thereby affecting the continuity of said control apertures to said conduits, said turning means comprising a shaft within said cylinder block and extending in the axial direction thereof, said control member comprising a sleeve having said control apertures therein, said sleeve being non-rotatably secured to said shaft and disposed substantially within said cylinder block, said turning means further including means for turning said shaft and thus said control sleeve with said apertures within said angular distance, each of said channels in said cylinder block extending from one of said cylinder bores radially inward to said control sleeve so as to communicate with the control apertures therein.

2. A hydraulic axial piston unit as defined in claim 1, wherein said means for turning said shaft includes means secured to said shaft and disposed exteriorly of said housing.

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