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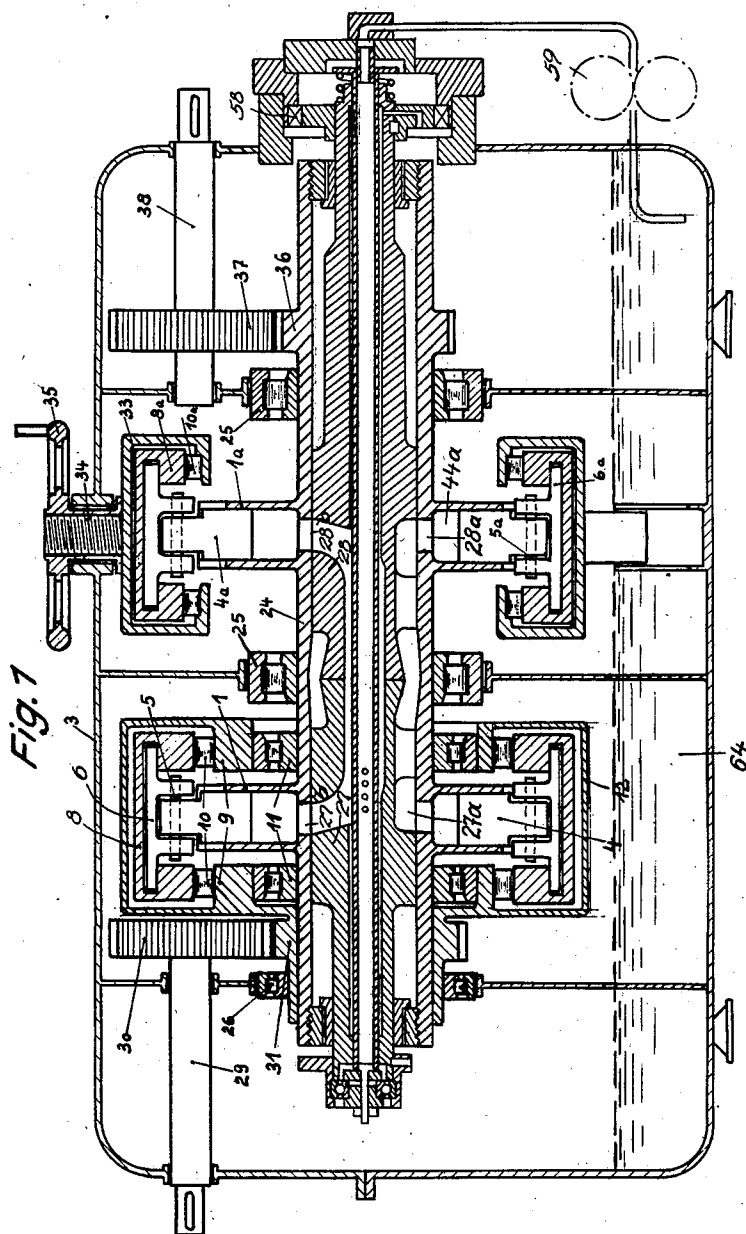
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2,220,636

HYDRAULIC TRANSMISSION GEAR

Filed June 11, 1938

4 Sheets-Sheet 1



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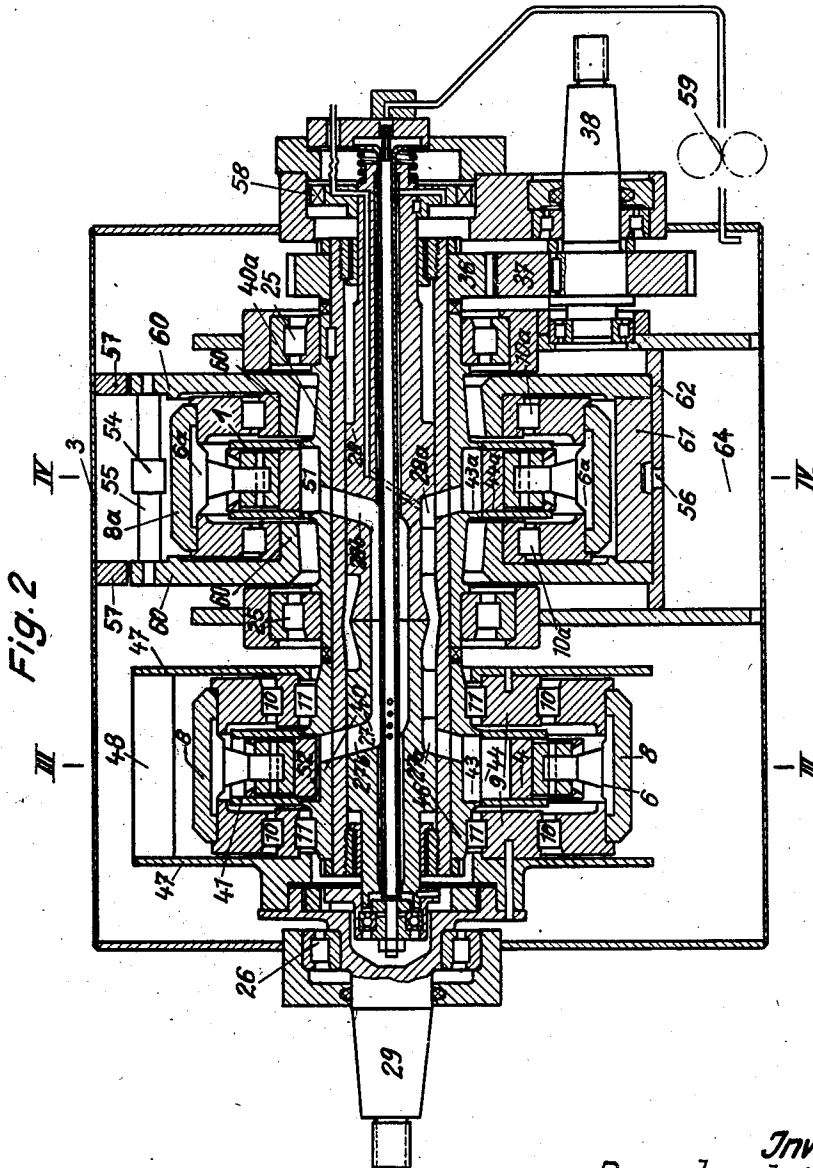
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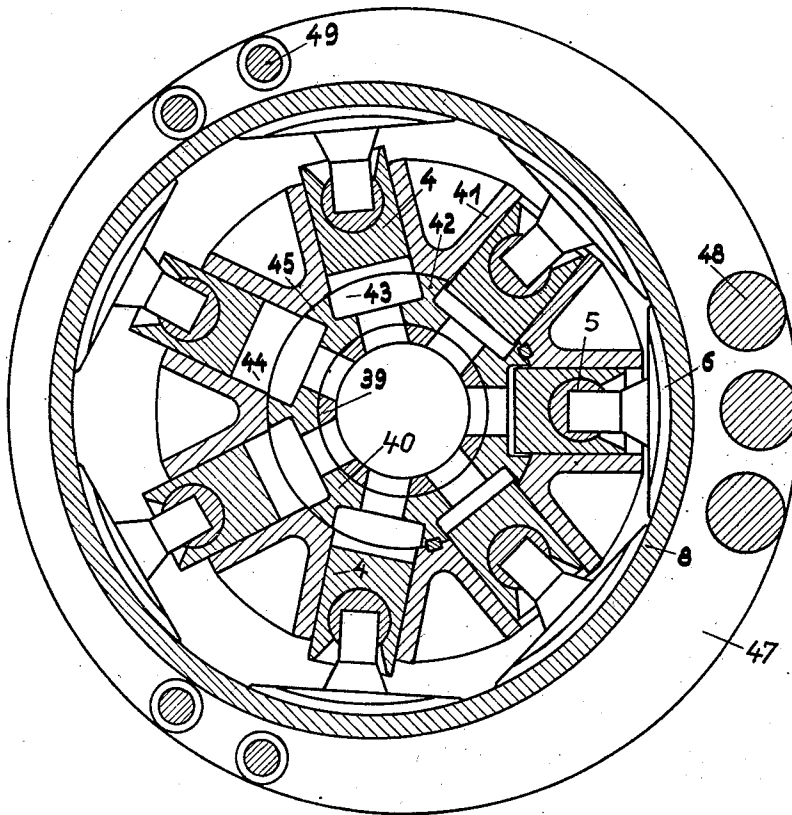
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Fig. 3



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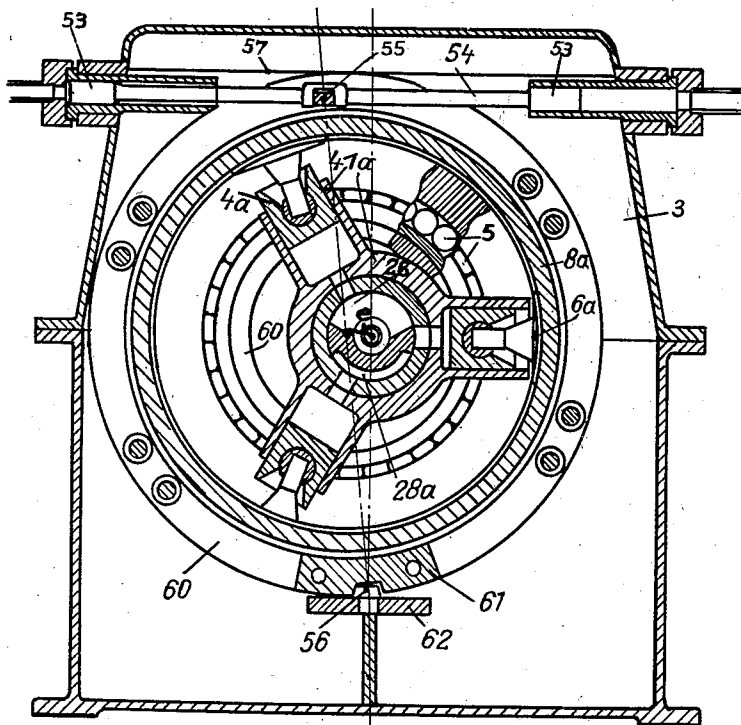
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4 Sheets-Sheet 4

Fig. 4



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UNITED STATES PATENT OFFICE

2,220,636

HYDRAULIC TRANSMISSION GEAR

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Kiel-Pries, Germany, a corporation of Germany

Application June 11, 1938, Serial No. 213,286
In Germany June 16, 1937

12 Claims. (Cl. 60—53)

This invention relates to a hydraulic gear in which the power is transmitted partly by hydraulic and partly by purely mechanical means. Two cylinder assemblies are provided in which the cylinders are arranged in star formation. These cylinder assemblies are fixedly interconnected by a central tube and are mounted so as to revolve about the tube as a whole in a housing. The cylinder bores are open to the periphery of the cylinder assemblies, the pistons working in the cylinders closing the cylinders to the exterior. The pistons are connected with members which surround the cylinder assemblies and which impart to the pistons the reciprocating movement in the revolving assemblies. This stroke movement of the pistons is produced by eccentrics arranged on both sides of a cylinder assembly. These eccentrics are rotatably mounted on the central tube which forms the pivotal axis of the combined cylinder assemblies, and are mechanically interconnected in such a manner that they rotate at exactly the same speed. On these two eccentrics there is rotatably mounted a ring and with this ring are connected sliding or rolling members which co-operate with the pistons to thrust them to and fro in the cylinders. The eccentricity of the aforesaid eccentrics is constant, so that the stroke of the pistons associated therewith is fixed.

A change in the piston stroke is provided for only in the case of the pistons of the second cylinder assembly. These pistons are also moved to and fro by sliding or rolling members which are connected with a freely revolving ring. This ring, however, is not mounted on eccentrics, but on a support device which does not rotate during operation. This support device is so arranged that its position in relation to the gear axis can be changed. It may be disposed concentrically in the gear or may also assume any eccentric position therein within two limiting positions. The alteration in position of the support member is effected by the control device of the gear. Now, in order that a minimum amount of force may be required to effect this adjustment, the support member is so designed that, when adjusted, it can roll on a base provided therefor. This base member at the same time absorbs the piston forces which act on the supporting member so that during operation the supporting member is invariably pressed firmly on to the base member.

As already mentioned, both cylinder assemblies which act as pump and motor are fixedly connected together. The central pipe, which establishes this connection, at the same time forms

an outer sleeve for the two rotary valves of the pump and motor. These valves are arranged one behind the other in the axial direction inside this sleeve and bear against each other with their annular surfaces so as to make a tight joint but are adapted to be rotated in relation to each other. Under the liquid pressures, these valves can adjust themselves axially in their sleeve, as they are so connected with the eccentrics which drive them, as to allow for lateral movement in relation thereto. This connection, however, is such that the valves, in the direction of rotation, must invariably maintain their determined angular position in relation to the eccentrics with which they are associated. These valves form rotating chambers closed by the inner wall of the central sleeve namely a pressure chamber and a suction chamber, which by their rotation control the ducts for the supply and discharge of the liquid to and from the working cylinders. In principle, the pressure chamber is so arranged that it is disposed on the periphery of the valve, whereas the suction chamber is located in the interior of the valve. By means of this arrangement, the working liquid presses the valves axially against those surfaces with which the valves make a fluid-tight joint, so that even at maximum working pressures leaks do not occur between the valves or between the valves and the sleeve. The form of construction and arrangement of the valves referred to above has already been described in my prior Patents Nos. 2,141,166 and 2,141,168, issued December 27, 1938.

The gear according to the present application operates, in principle, in the same manner as that described in the above-mentioned patents. Among the advantages of the present construction as compared with the apparatus of the said patents is that the entire length of the gear is available to accommodate the valve. As valves of this type need be of only small diameter, it is also possible to arrange the bearings for the eccentric of the piston mechanism around the valve sleeve without requiring a bearing of an unduly large diameter which would be impractical for high-speed operation. On the contrary, by using bearings of high load carrying capacity and a self-sealing valve, the length of the bearing causes the surface pressures therein to be very small, also high hydraulic pressures can be used, in consequence whereof the output which can be transmitted is increased.

Either the input to the gear may be applied to the aforesaid rotatable eccentrics, while the out-

put can be taken from the rotatable cylinder assemblies or vice versa.

When the input power is applied to the eccentrics starting from zero which can be effected only with throttling, the liquid pressures remain at the same value over the entire range of control with constant output. When the input power is applied to the cylinder assemblies, however, it is possible to start from zero without throttling, but the liquid pressures are varied.

Typical embodiments of the invention are shown diagrammatically in the accompanying drawings in which—

Fig. 1 shows a longitudinal section through the gear;

Fig. 2 shows a longitudinal section through another form of construction of the gear;

Fig. 3 is a cross-section taken on line III—III of Fig. 2 (on a somewhat larger scale);

Fig. 4 is a cross-section taken on line IV—IV of Fig. 2 showing the adjusting device.

In the form of construction shown in Fig. 1 the drive is effected, for example, by the shaft 29 by way of the toothed wheels 30 and 31 to the eccentrics 9. These latter are interconnected mechanically by a stirrup 12, so that both eccentrics 9, which are rotatably mounted on the member 24 must always rotate together. A ring 8 is rotatably mounted on the two eccentrics. The centre point of this ring will, therefore, on rotation of the eccentrics 9, be moved over a circular path, although the ring itself need not rotate. The ring is carried with frictional contact only between it and the bearing 10 and slippers 6. The slippers, which are constrained to contact invariably with an inner face of the ring, impart a reciprocating movement to the pistons 4, with which they are connected by crosshead bolts 5. The valve 27 is connected with the wheel 31 so that it is caused to rotate with the eccentrics 9. The arrangement of the valve 27 is such that the port 27b is always in position to permit an outwardly moving piston to suck oil into its cylinder, while the port 27a of the valve 27 is always in position to permit oil to be forced out by an inwardly moving piston. The port 27a therefore forms the pressure chamber. The cylinder assembly 1 is fixedly connected with the cylinder assembly 1a by means of the tube 24, and the two cylinder assemblies together with the tube are rotatably mounted in the casing 3 by means of the bearings 25, 26. With this arrangement the driving moment of the two eccentrics 9 are transmitted as torque to the rotor 1, 1a, 24, 36. From the pressure chamber 27a, 28a, the oil passes into the cylinder 44a, the pistons of which move outwardly when the rotor rotates. The speed of the rotor 1, 1a, 24, 36 is so adjusted that the amount of oil delivered can be taken up by the motor cylinders 44a. The cylinders, in which the pistons are just moving inwards, invariably lie over the port 28b, of the valve 28, so that the oil flows back to the container 64, from whence it is again sucked by the pump 59. Now, just as a torque is exerted on the first cylinder assembly 1, namely by transverse forces of the piston, so in the case of the second cylinder assembly 1a a further torque is transmitted to the second cylinder assembly by the transverse piston forces. This effect is dependent upon the eccentric disposition of the support member 33. In the example of construction shown in Fig. 1, the eccentric position of the support member 33 is adjustable by means of the hand wheel 35 and the spindle 34. A freely rotatable ring 8a which transmits the

piston movement is constrained to participate in the adjusting movement, since it is connected with the member 33 by means of the roller bearing 10a. The output, which corresponds to the two torques transmitted to the rotor 1, 1a, 24, 36 during its rotation, is transmitted to the driving shaft 38 by means of the toothed wheels 36, 37.

The described conditions prevail up to the point where the adjustable support member 33 assumes a position of zero eccentricity, that is, a concentric position. However, when it is shifted beyond such position the associated pistons have an inwardly directed movement when their cylinder chambers are in communication with the pressure chamber. Consequently these pistons will then force oil under pressure through the chambers 28a, 27a to the part of the gear which previously operated as a pump and which now operates as motor. This results in a further increase in the revolutions of the rotor, which is now rotated more rapidly by the oil under pressure than the drive eccentric. In such event therefore the pump and motor exchange functions.

In Fig. 2 the oil is forced from the cylinders 44, 43 to the chambers 27a, 28a and thence to cylinder 43a. After this cylinder is filled it again empties having rotated to the position of the cylinder 51, into the chamber 28b, 27b, whence the oil is sucked back to cylinder 52. With this arrangement the eccentrics can be driven direct, i. e., without intermediate transmission members, while as the other side of the gear must be free to permit the introduction of fresh oil, discharge of pressure oil (for the purpose of control or the automatic control, etc.), the intermediate gearing 36, 37, 38 or the like is necessary.

In Figs. 2 and 3, the tubular connecting member 24 of Fig. 1 is in the form of a supporting tube 39, on which the motor and pump are mounted. This tube also serves as a guide sleeve for the valve 27, 28. In this case the cylinder assemblies consist of two parts, hub parts 40, 40a fixedly mounted on the tube 39, and cylinder parts 41, 41a. From Figs. 2 and 3 it can also be seen that these hub parts are thickened at their middle portions. The thickened parts of the hubs contain, respectively, short radial bores 43, 43a which have a somewhat greater diameter than the cylinders 44, 44a in the cylinder parts 41, 41a, so that the pistons 4, 4a, when in their extreme inward position protrude into these bores 43, 43a without touching the walls thereof. From Fig. 3 it can be seen that by thickening the middle portion of a hub part the closing walls 45 which close one cylinder from another are of relatively great width. The hub part 40, which the eccentric rings encircle, is preferably made of hardened steel so that it at the same time serves as roller tracks for the inner bearings 11 for the eccentrics. By this type of construction a smaller diameter is obtained. Furthermore, the cylinder bores can be bored or honed accurately to size. The cylinders can be brought very near to the centre without danger of leakage from one to the other. In this form of construction the bearings 11 for the eccentrics bear against tubular lateral prolongations 46 of the hub part 40. In this arrangement two cams 9 are connected by two disc-shaped members 47 which are fastened firmly together by means of bolts 48, 49. According to Fig. 3 the arrangement of bolts 48 is also used to balance the unbalanced rotating mass comprising the eccentrics 9, the bearings 10, 11, ring 8, slippers 6 and pistons 4.

Figs. 2 and 4 show a device for adjusting the

piston stroke. As shown, a supporting member 60, 61 on which the ring 8a is mounted and which is pressed constantly against the surface 62 by the piston pressures, can roll on this surface, whereby its eccentricity is altered. According to Fig. 4 the rolling effect is produced by oil under pressure which acts on one of the pistons 53. The piston force is transmitted by the mechanism 54 to the cross member 55 and thus produces the rolling movement of the member 60, 61. In order that the adjustment may be accurately effected, the surface 62 is provided with a tooth 56 which prevents the rolling member from sliding.

Furthermore, there are provided on the casing cover ribs 57 which prevent the rolling member 60, 61 from being lifted from its proper position when the power transmitted by the gear fluctuates. It is evident that with this arrangement the degree of eccentricity can be varied on both sides of a zero point, but in other respects there can be no change in the direction of eccentricity in relation to the housing. Now, as the valve 28 must always assume the same relative position whatever the eccentricity, the valve needs to be fixed only in relation to the housing. This is effected by means of the claw coupling 58 which otherwise allows the valve full freedom of movement.

I claim:

1. An infinitely variable hydraulic transmission system comprising a pair of rotatably mounted shafts from one to the other of which power is to be transmitted, two sets of radially arranged cylinders rotating as a unit with one of said shafts, two eccentrics of fixed stroke rotating with the other shaft and arranged on opposite sides of one of said cylinder sets, pistons operating in the cylinders of the last mentioned set and engaging said eccentrics, a non-rotary variable stroke eccentric, pistons operating in the cylinders of the other set and engaging the non-rotary eccentric, and valve means controlling the flow of hydraulic medium through said cylinders.

2. A variable hydraulic transmission system as claimed in claim 1, in which the two eccentrics of fixed stroke are connected by members which also serve as balance weights to balance the eccentric mass constituted by piston driving members.

3. A variable hydraulic transmission system as claimed in claim 1, wherein each cylinder set comprises two parts, namely a part including the radially arranged cylinders and a hub part which is provided with laterally extending projections which serve as bearings for the eccentrics.

4. A variable hydraulic transmission system as claimed in claim 1, wherein each cylinder set comprises two parts, namely a part including the radially arranged cylinders and a hub part which is provided with laterally extending projections which serve as bearings for the eccentrics, the middle portion of the hub part between the projections being of substantially greater diameter than the projections and provided with radial bores forming continuations of the cylinders and having a greater diameter than the cylinder bores at the part including the cylinders.

5. A variable hydraulic transmission system as claimed in claim 1, wherein the two cylinder sets are axially spaced and inter-connected by the central sleeve which is journaled in bearings in the casing and constitutes a guide sleeve for the valves.

6. A variable hydraulic transmission system as claimed in claim 1, wherein the non-rotary eccentric for the adjustment of the piston stroke is arranged to roll upon a flat surface, and is settable to any desired eccentric position in relation to the axis of the system.

7. A variable hydraulic transmission system as claimed in claim 1, wherein the non-rotary eccentric for the adjustment of the piston stroke, is arranged to roll upon a flat surface and is settable to any desired eccentric position in relation to the axis of the system, and the flat surface and also the periphery of the said eccentric are provided with interengaging members.

8. A variable hydraulic transmission system as claimed in claim 1, wherein the non-rotary eccentric for the adjustment of the piston stroke is arranged to roll upon a flat surface, and is settable to any desired eccentric position in relation to the axis of the system, and the flat surface and also the periphery of the said eccentric are provided with interengaging members consisting of a coniform tooth and a corresponding recess.

9. A variable hydraulic transmission system as claimed in claim 1, wherein the non-rotary eccentric for the adjustment of the piston stroke is arranged to roll upon a flat surface and is settable to any desired eccentric position in relation to the axis of the system by a control device arranged to exert a force on the said eccentric at a point on its periphery opposite the interengaging members provided on the flat surface and the eccentric.

10. A variable hydraulic transmission system as claimed in claim 1, wherein the valves are arranged inside the sleeve and are associated with their appropriate eccentrics bearing against each other with annular surfaces held in a tight joint by means of the pressure of the fluid medium.

11. A variable hydraulic transmission system as claimed in claim 1, wherein the valves are arranged inside the sleeve and rotated by the rotary eccentrics have ports receiving medium under pressure from said cylinders, said valves having axial movement within the central sleeve and said ports being so located therein that the medium under pressure in the ports holds the valves against sealing surfaces.

12. A variable hydraulic system comprising a casing, an input shaft and an output shaft, two assemblies of cylinders arranged within said casing in star formation, pistons arranged within the cylinders and adapted to displace a fluid medium, eccentrics positively connected to said input shaft and engaging the pistons of the cylinders of one assembly forming the pump of the system, a non-rotary annular eccentric support engaging the pistons of the cylinders of the other assembly forming the motor of the system, a control device for altering the eccentricity of the annular support with respect to the position of the other assembly, a rigid connection between both cylinder assemblies, said connection being coupled with the output shaft, a central sleeve extending over the whole length of the system and forming the pivotal axis of the combined cylinder assemblies and of the first mentioned eccentrics, and two valves arranged one behind the other in the axial direction inside said sleeve, one valve serving each cylinder assembly, and controlling the ducts for the supply and discharge of the fluid medium to and from the working cylinders.

BERNHARD BISCHOF.