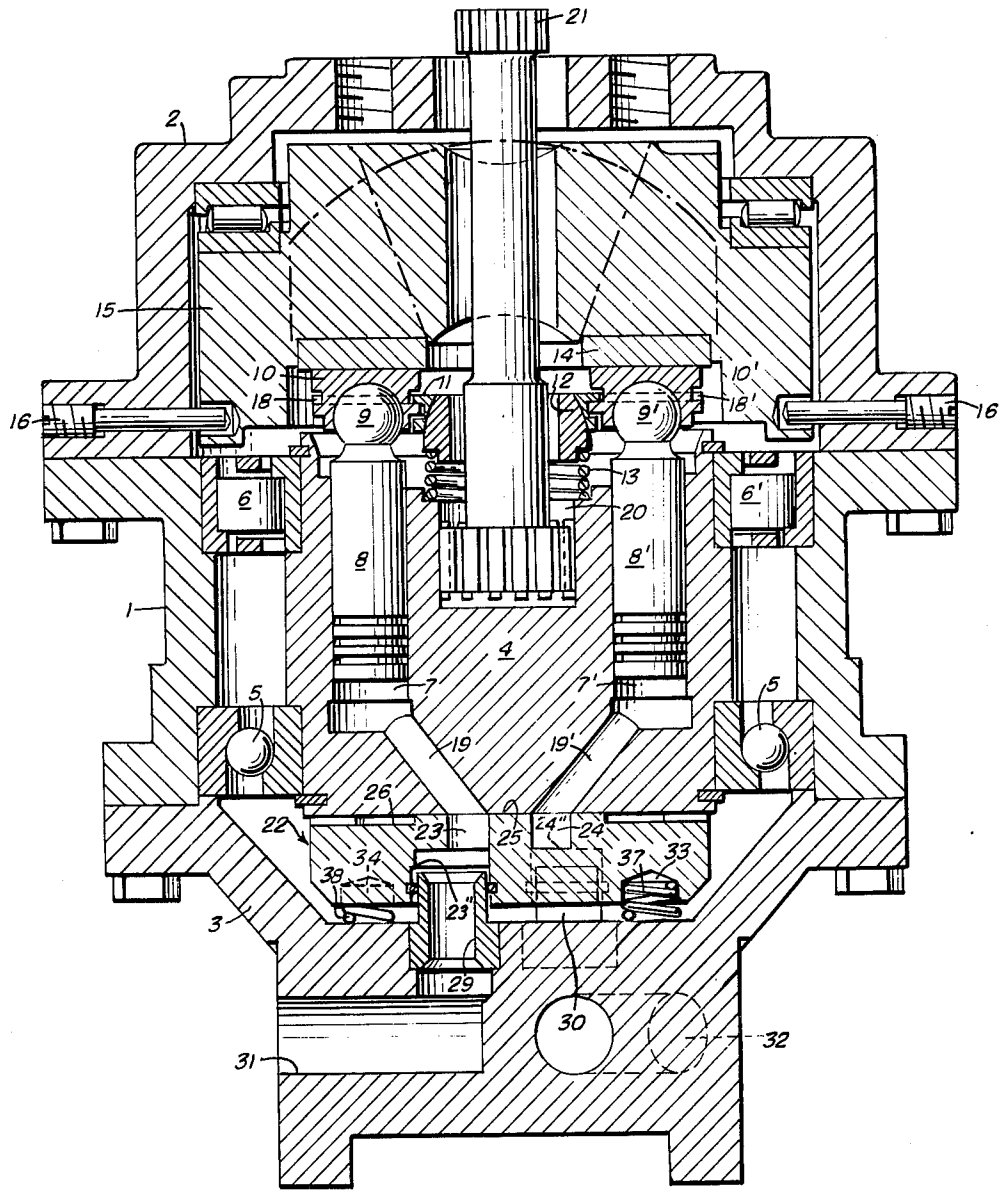
June 14, 1966 H. THOMA 3,255,673

AXIAL PISTON HYDRAULIC UNITS

Filed June 7, 1963 2 Sheets-Sheet 1

FIG. 1



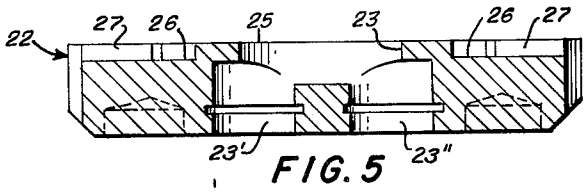


FIG. 5

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AXIAL PISTON HYDRAULIC UNITS

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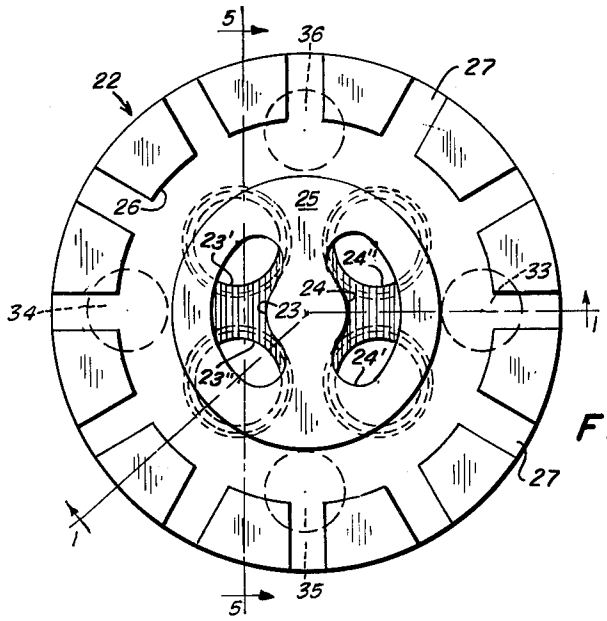

FIG. 2

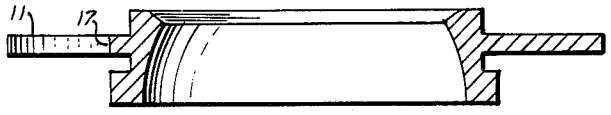

FIG. 3

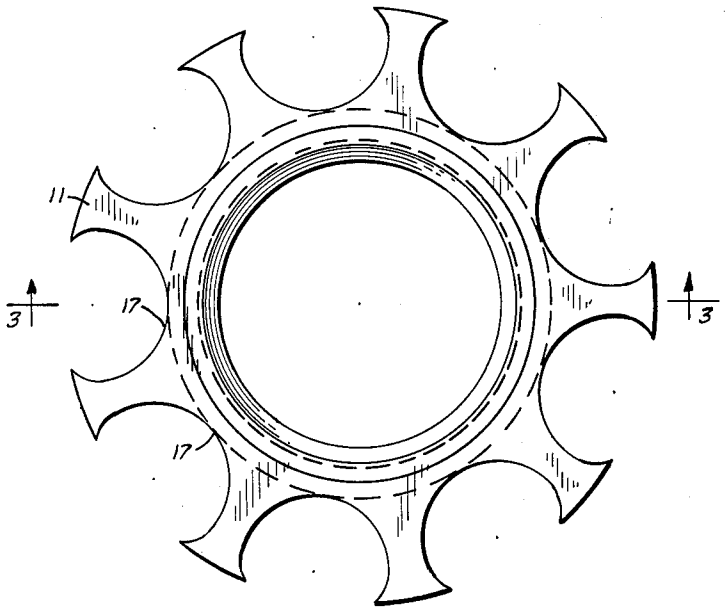

FIG. 4

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AXIAL PISTON HYDRAULIC UNITS

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Filed June 7, 1963, Ser. No. 286,317
Claims priority, application Switzerland, Oct. 9, 1962, 11,770
4 Claims. (Cl. 91—199)

The present invention relates broadly to the art of hydraulic units, more particularly to axial piston hydraulic units of the general type disclosed in German Patent No. 829,553.

The invention, therefore, specifically relates to certain improvements in hydraulic units of a type which can also be termed swash plate motor or pump units. Such units include axially disposed pistons which have a spherical head to engage a complementary shaped socket on a slipper that bears against a non-rotatable inclined plate generally referred to in the art as a swash plate. The lateral forces produced by the piston against the inclined plate are transmitted by the pistons back to the cylinder block where they are absorbed by appropriate bearings. The fluid flow to and from the axially disposed cylinders is by way of a non-rotating control, or timing plate, formed with segmentally shaped inlet or delivery openings or ports. In the known devices the segmentally shaped inlet or delivery ports are in alignment with the piston accommodating bores or cylinders.

It is therefore one object of the present invention to provide an improved structural relationship of such axial piston hydraulic units in which the ports through which fluid flows to and from the cylinders are offset inwardly from the circle of rotation of the piston accommodating cylinders so as to substantially reduce leakage and other losses.

It is another object of the invention to provide an improved axial piston hydraulic motor unit in which the non-rotating timing or distribution plate is mounted in the casing in such a manner as to permit slight adjusting movements, the mounting or suspension of the plate being such as to provide a force against the plate to overcome the pressure reaction between the timing plate and the cylinder block, due to the imbalance of the pressures on the timing plate from the delivery ports. This mounting also produces a certain excess of pressure that holds the timing plate in intimate contact with the cylinder block. This excess pressure acts on the timing plate axially to avoid tilting moments between the timing plate and the adjacent face of the cylinder block, as the pressure against the timing plate from the said ports is located very close to the axis.

Other and further objects and advantages of the present invention will be apparent from the following specification taken with the accompanying drawings, in which:

FIGURE 1 is a section taken on line 1—1 of FIGURE 2,

FIGURE 2 is a plan view of the non-rotating control or timing plate,

FIGURE 3 is a section taken on line 3—3 of FIGURE 4 of element 17 which retains the piston heads in a common plane.

FIGURE 4 is a plan view of the device of FIGURE 3, and

FIGURE 5 is a cross-sectional view on an enlarged scale illustrating the timing plate.

In the drawings, FIGURE 1, the unit includes a generally cylindrical casing 1 and end closures 2 and 3. A cylindrical block 4 is rotatably mounted in casing 1 on bearings 5 and 6. Bearings 5 and 6 are of a type to positively restrain the cylinder block against axial movement. A plurality (from 5 to 8 bores, for instance) of bores 7, 7', etc. are arranged about the axis of the cylinder block 4 parallel to the axis of the block. The open ends of each of the bores are toward the closure 2. A piston 8 or 8' (one for each bore 7, 7' etc.) is positioned in each bore and is provided with a generally spherical head 9 or 9' etc. to provide for universal movement of a slipper 10 or 10' mounted on the spherical head. Slippers 10, 10' are pressed axially outwardly by a retaining plate 11. Retaining plate 11, in turn, is pressed outwardly by a spring 13 pressing inwardly on cylinder block 4 and outwardly on a member 12 having a spherical surface that coacts with a spherical surface on retaining plate 11, so that retaining plate 11 can assume any desired angle with respect to the axis of the cylinder block 4. Slippers 10, 10' are pressed outwardly against a swash plate 14 that is carried by a yoke 15 rockable about an axis 16—16 so that the inclination of swash plate 14 can be varied to lengthen or shorten the stroke of the pistons.

Retaining plate 11, as seen in FIGS. 3 and 4, is provided with a plurality of notches 17 each to embrace one slipper 10, 10' etc., each slipper 10, 10' being provided with a groove 18 to receive retaining plate 11. It is seen, therefore, that retaining plate 11 is adapted to bear on slippers 10, 10' in either direction, and the hook shape of the recesses 17 tends to prevent radial outward movement of the slippers, and therefore the ends of the pistons are retained in axial alignment with the bores. Also, the lower side of the groove in the slipper may press outwardly or upwardly on the retaining plate.

To the other ends of the bores 7, 7' etc. are provided with ports 19, 19' that extend inwardly toward the axis of the cylinder block so that the mouths of the ports opposite closure 3 are clustered within a small circle near the axis of rotation. The lower end of the cylinder block is otherwise solid.

The upper end of the cylinder block 4 is provided with a splined bore 20 to receive the driving shaft 21 by which the cylinder block may be rotated. Bore 20 extends only partly into, not through, cylinder block 4.

Timing plate 22, seen in FIGS. 1 and 2, has two arcuate or kidney-shaped ports, one for suction 23, one for exhaust 24. These ports are located to come into registry with the ports 19, 19' which lie very near to the axis of rotation. The surface of the timing plate 22 is provided with a plane surface 25 at the center of a radius so that it extends radially beyond ports 23 and 24. A circular groove 26 bounds area 25, and radial grooves 27 extend radially from groove 26 outwardly to provide a plurality of lands 28. The surfaces 25 and 28 bear against the rotary cylinder block 4. The lower closure 3 is provided with two bushings 29 and with two bushings 30 extending upwardly into timing plate 22. Bushings 29 and 30 are provided with appropriate packings to seal the bushings to the timing plate 22. As seen in FIGURES 2 and 5, bores 23', 23'' are provided to accommodate bushings 29 and bores 24', 24'' accommodate bushings 30.

In the lower face of timing plate 22 are bores 33, 34, 35 and 36, in which springs 37, 38, 39 and 40 are placed. Bushings 29, 29' and 30, 30' connect to inlet and outlet passages 23 and 24 of the timing plate to inlet 31 and outlet 32, respectively. While two bushings may be used, one at each port 23 and 24, it will be noted that, preferably as suggested by FIG. 2, four bushings are used, that is, two bushings 29 for port 23 and two bushings 30 for port 24.

With respect to the provision of the groove in the slippers 10, 10' etc., assuming the device to be in use as a pump, it will be noticed that power is required to pull piston 8 out of cylinder 7 in order to draw liquid in through port 19. Spring 13 presses retaining plate 11 upwardly. If springs 13 is not strong enough, slipper 10

will prevent retaining plate **11** from moving upwardly. If spring **13** is made strong, there is a strong tendency for the spherical surface of **12** to develop too much friction against the spherical surface of the retaining plate **11**, especially as the arcuate surfaces extend for only a short arc and are generally parallel to the direction of bias by spring **13** so the spherical surfaces are rather wedge-like.

It will be noted that if the retaining plate **11** is not parallel to swash plate **14** the slippers **10** will not be against swash plate **14** at the fully extended condition of the pistons **30**. There will be a portion of each revolution where each slipper **10** on its piston is supported above the retaining plate **11** since there will be no upward force against slipper **10** in the axial direction.

It has been found that, at high speeds especially, the pistons of such a pump are not pulled out to their full stroke possibilities and, as they are turned with respect to the swash plate **14**, the slipper **10** will again contact swash plate **14** with a hammer-like blow that has a strong component normal to the piston and is detrimental to the machine. There is, of course, also a hammer-like axial thrust by the swash plate against the slipper **10** that will develop undesired pressure variations in the pressure liquid.

In the present device, it is seen that the groove in slipper **10** prevents axial movement of retaining plate **11** with respect to the piston-slipper assembly so that the slippers **10**, **10'**, etc., are all held to rotate in the plane of retaining plate **11** at all times, whether or not plate **11** is parallel to swash plate **14**. It will further be seen that, in the part of the revolution where the port **19** opens as it passes into position over pressure port **24**, there will be an upward thrust of fluid pressure which, without the groove **18**, will press the piston outwardly so that the slipper and piston would extend above the plate **11**. In this device the plate **11**, by pressure of the lower or upwardly facing surfaces of grooves **18**, **18'** is biased upwardly in the direction of the bias of spring **13**.

The somewhat hook-shaped portions of retaining plate **11** surrounding slippers **10** will be found to contact the slippers **10** in a manner to restrain slippers **10** against outward movement. The greatest outward vector of force occurs in the quadrant of rotation between the fully extended position of the pistons and the half stroke position on the pressure side of the device. The vector is inward for part of the revolution and is of little effect because the piston is then well supported.

The timing or control plate **22** must form a practical seal against the end of the cylinder block **4**. There is a plane of contact **25** between the timing plate and the cylinder block, and it is at once clear to the skilled mechanic that there will be sufficient fluid under pressure from the pressure port squeezed outwardly between the timing plate and the cylinder block to lubricate the plane of contact. Fluid also tends to be withdrawn from between the cylinder block and the timing plate at the suction port. In the present structure, the face-to-face contact between the cylinder block and timing plate that can be subject to pressure from the ports is limited to a small disc at the center of the timing plate. This small area is bounded by annular groove **26**. Radial grooves **27** are provided leaving lands **28** to form bearing surfaces to press against the end of the cylinder block. Since the area including the ports is small and located so close to the center of rotation, it cannot develop a significant tendency to cock the timing plate **22** with respect to the cylinder block **4**, and the pressures that need to be exerted by springs **37**, **38**, **39**, **40** are therefore reduced. The land areas **28** give a broad bearing base counteracting any tendency toward cocking that may occur. The real reason for the springs **37**, **38**, **39** and **40** is not to provide sealing pressure between the cylinder and timing plate but primarily to retain the plate against the cylinder when the pump is not in operation.

During the time that a piston as it descends to force liquid out of the ports **19**, **19'** via port **24** served by bushings **30**, the only downward pressure on timing plate **22** is against the web between the two bushings **30**, seen in FIGURE 2, and there is an upward pressure against the shoulders of timing plate **22** overhanging the bushings which will be greater than the downward pressure since the area of the shoulders is greater than the area of the web between the bushings. By making the bushings larger and closer together, this effect may be augmented. There will, of course, be direct pressure on the timing plate **22** from each cylinder at each end of the pressure stroke during the time ports **19**, **19'** partly overlap port **24**. Similarly, there is a negative pressure between each cylinder and the timing plate at port **23**, so that at each end of port **23** there is a negative pressure tending to balance the positive pressure at the ends of port **24**.

It is clear, then, that by the structure of the present device the pressure area, sealing against the cylinder block, has been reduced; the tendency of the timing plate to cock with respect to the cylinder has been reduced; the bearing area between the timing plate and cylinder block has been improved as to location and extent; the operation of the device has been made more reliable by eliminating sources of excessive wear; the efficiency of the device has been improved by structure causing the pistons to follow the swash plate more accurately; and the breakdown of the device due to pistons being subjected to excessive side thrust is eliminated.

What is claimed is:

1. In an axial piston hydraulic unit of the type including a casing, a rotatable cylinder block within the casing, said casing having a plurality of piston accommodating bores extending parallel to the axes of rotation of said cylinder block, a piston reciprocably disposed in each of said bores, each having a piston and extending outwardly from said cylinder block, swash plate means mounted in said casing positioned to operate said pistons upon relative rotation of said cylinder block and casing, said swash plate means being provided with an aperture including the extension of the axis of rotation of said cylinder block, a rotatable shaft drivingly secured to said cylinder block adjacent said swash plate extending outwardly of said casing through said aperture in said swash plate, means operatively secured to each piston end to maintain said piston ends in a common plane, said cylinder block having an end face remote from said swash plate constituting a distribution end, ports leading inwardly toward the axis of rotation of said cylinder block from each of said piston accommodating bores to said distribution end so that said ports at said distribution end are clustered closely about the axis of rotation of said cylinder block, a timing plate having a first face in face-to-face contact with said distribution end of said cylinder block and a second face parallel to said first face, the improvement comprising said timing plate having two kidney-shaped openings in said first face opening toward said cylinder block opposite said ports in said distribution end of said cylinder block, four bores extending into said timing plate from said second face, said four bores being clustered closely adjacent the extension of the axis of rotation of said cylinder block, said four bores forming a pair of inlet bores and a pair of outlet bores, each pair of said bores joining one of said two kidney-shaped openings to form inlet and outlet passages through said timing plate, spring means to hold said timing plate against said cylinder block and shoulder means presented toward said four bores whereby pressures at said four bores will press said timing plate toward said cylinder block, said first face of said timing plate being provided with an annular groove outwardly of said kidney-shaped openings and having spaced radial grooves extending outwardly from said annular groove to the edge of said first face.

2. In an axial piston hydraulic unit of the type including a casing, a rotatable cylinder block within the casing, said casing having a plurality of piston accommodating bores extending parallel to the axes of rotation of said cylinder block, a piston reciprocably disposed in each of

said bores, each having a piston end extending outwardly from said cylinder block, swash plate means mounted in said casing positioned to operate said pistons upon relatively rotation of said cylinder block and casing, said swash plate means being provided with an aperture including the extension of the axis of rotation of said cylinder block, a rotatable shaft drivingly secured to said cylinder block adjacent said swash plate extending outwardly of said casing through said aperture in said swash plate, means operatively secured to each piston end to maintain said piston ends in a common plane, said cylinder block having an end face remote from said swash plate constituting a distribution end, ports leading inwardly toward the axis of rotation of said cylinder block from each of said piston accommodating bores to said distribution end so that said ports at said distribution end are clustered closely about the axis of rotation of said cylinder block, a timing plate having a first face in face-to-face contact with said distribution end of said cylinder block and a second face parallel to said first face, the improvement comprising said timing control plate having two kidney-shaped openings in said first face opening toward said cylinder block opposite said ports in said distribution end of said cylinder block and being provided with an annular groove outwardly of said kidney-shaped openings and having spaced radial grooves extending outwardly from said annular groove to the edge of said first face, four bores extending into said timing plate from said second face, said four bores being clustered closely adjacent the extension of the axis of rotation of said cylinder block, said four bores forming a pair of inlet bores and a pair of outlet bores, each pair of said bores joining one of said two kidney-shaped openings to form inlet and outlet passages through said timing plate, and means to bias said timing plate toward said distribution end of said cylinder block.

3. In an axial piston hydraulic unit of the type including a casing, a rotatable cylinder block within the casing, said casing having a plurality of piston accommodating bores extending parallel to the axes of rotation of said cylinder block, a piston reciprocably disposed in each of said bores, each having a piston end extending outwardly from said cylinder block, swash plate means mounted in said casing positioned to operate said pistons upon relative rotation of said cylinder block and casing, said swash plate means being provided with an aperture including the extension of the axis of rotation of said cylinder block, a rotatable shaft drivingly secured to said cylinder block adjacent said swash plate extending outwardly of said casing through said aperture in said swash plate, said cylinder block having an end face remote from said swash plate constituting a distribution end, ports leading inwardly toward the axis of rotation of said cylinder block from each of said piston accommodating bores to said distribution end so that said ports at said distribution end are clustered closely about the axis of rotation of said cylinder block, a timing plate having a first face in face-to face contact with said distribution end of said cylinder block and a second face parallel to said first face, said timing plate having two kidney-shaped openings in said first face opening toward said cylinder block opposite said ports in said distribution end of said cylinder block, four bores extending into said timing plate from said second face, said four bores being clustered closely adjacent the extension of the axis of rotation of said cylinder block, said four bores forming a pair of inlet bores and a pair of outlet bores, each pair of said bores joining one of said two kidney-shaped openings to form inlet and outlet passages through said timing plate, means to bias said timing plate toward said distribution end of said cylinder block, the improvement comprising each said piston being provided with a spherical portion adjacent said swash plate and a slipper element mounted for universal movement on each said spherical portion, said slipper elements being each adapted to bear against said swash plate, each of said slipper elements being provided with a circumferential groove, and a planar retaining plate having a plurality of notches in its periphery, each notch being adapted to embrace the grooved portion of one slipper element to bear against one or other wall of said groove whereby all said slipper elements are positively held in a common plane.

4. The device of claim 3, in which said notches are provided with hook-like edges adjacent the periphery of said retaining plate.

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