Oct. 8, 1963 H. THOMA 3,106,138

PISTON TYPE HYDROSTATIC POWER UNITS

Filed June 27, 1960 2 Sheets-Sheet 1

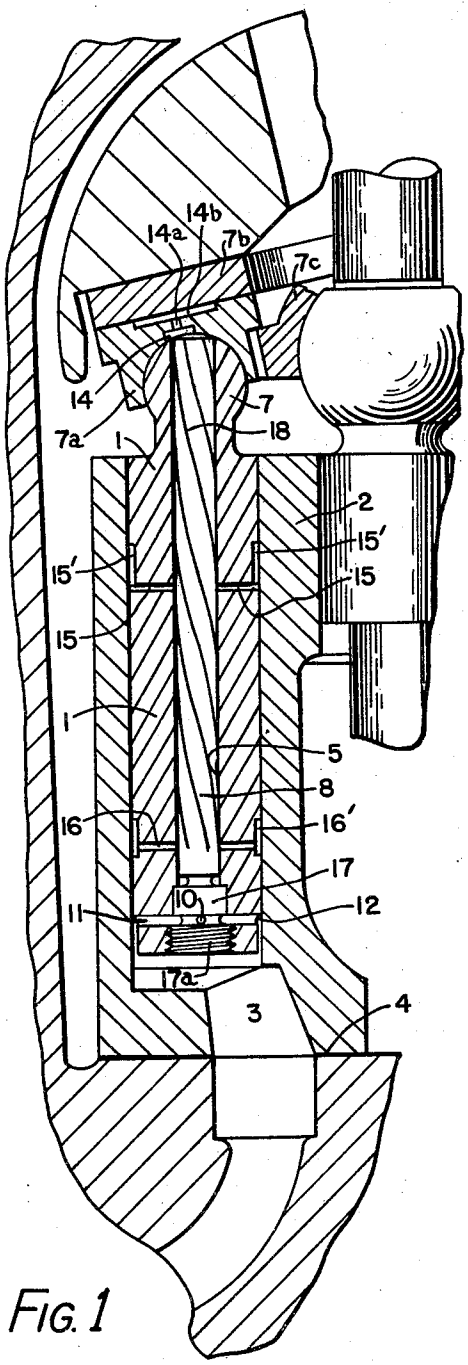


FIG. 1

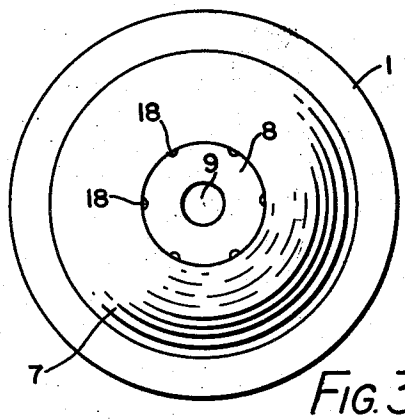
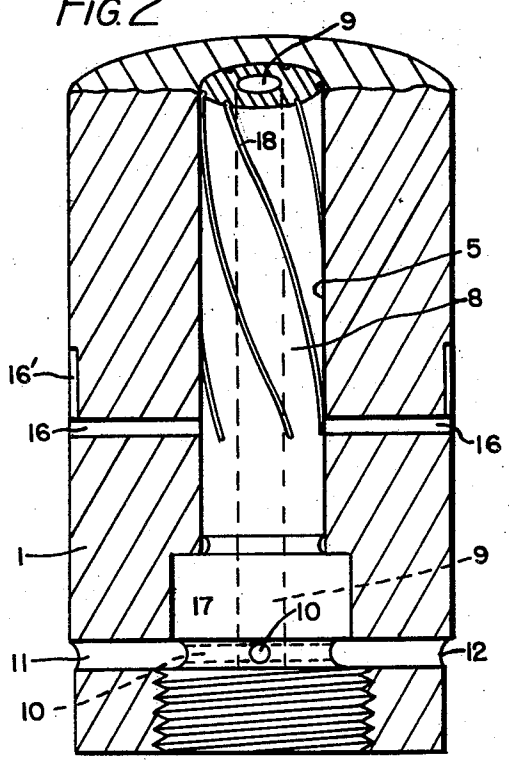


FIG. 3

FIG. 2



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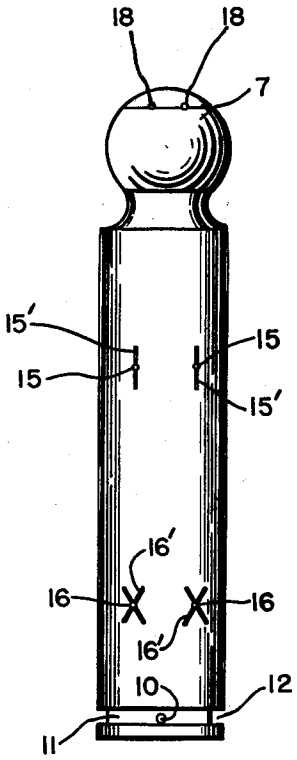


FIG. 4

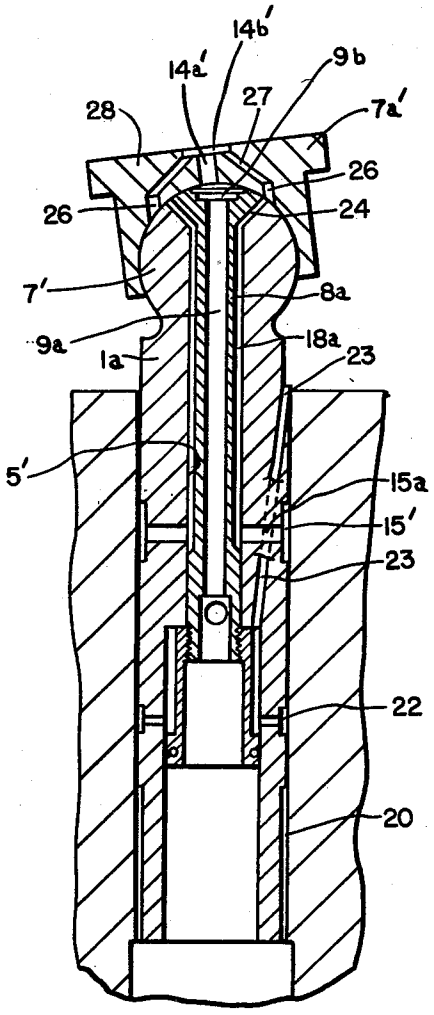


FIG. 5

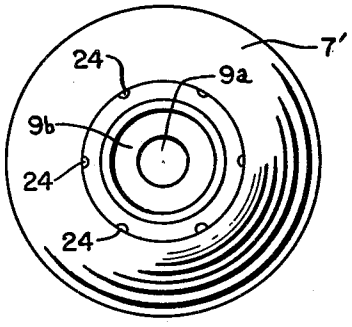


FIG. 6

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PISTON TYPE HYDROSTATIC POWER UNITS

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This invention relates to piston type hydrostatic power units particularly such units in which pistons operate or are operated by a rockable shoe arranged between the outer ends of the pistons and an abutment such as a swash-plate, such as is shown, for example, in U.S. Patents 1,710,567, 1,945,391 and 2,093,477 or a ring as in U.S. Patent 1,954,853.

Hydrostatic axial piston units are known, in which the outer ends of pistons, operating in cylinder bores in a cylinder block in exactly or substantially parallel relationship to the axis of the cylinder block, carry a joint ball which has a rockable shoe which bears against a swash-plate which is usually fixed but which sometimes co-rotates at the average circumferential speed of the individual pistons and shoes. Hydrostatic radial piston units are also known in which the outer ends of pistons operating radially in cylinder bores in a rotor are each provided with a rockable shoe which bears against a driving ring which is fixed or co-rotates at the average circumferential speed of the individual pistons.

In such constructions, whether of the axial or radial type, a considerable lateral pressure is produced between the piston and the cylinder walls, especially near the outer ends of the cylinder bores, and this causes difficulty, especially at high speeds. According to the invention, this lateral pressure which, in known constructions, is to be interpreted as a mechanical load similar to that occurring in the case of a crosshead, together with its wear and heating phenomena is to be obviated according to the present invention by supporting this lateral pressure by means of controlled pressure oil areas.

It is, therefore, an object of the present invention to provide conduit means for supplying oil under pressure between the pistons and cylinder walls in those areas where lateral pressure between them is developed during operation.

Another object is to provide valve means in said conduit means so arranged as to supply oil under pressure only to those areas which at the time are under lateral pressure.

Another object is to provide valve means in said conduit means actuated as an incident to the rocking of the piston shoe relative to the piston in such a manner as to supply oil under pressure only to those areas which at the time are under lateral pressure.

Another object is to provide such conduit means adapted to supply oil under pressure to the space between one side of the piston and the cylinder wall near the outer end of the cylinder and at the opposite side of the piston near the inner end of the piston.

Another object is to so construct the pistons and the piston shoes as to admit no oil to said conduit means when the shoe is co-axial with the piston and to supply oil under pressure to one or more conduits terminating at the shoe to one side of the axis while not supplying oil to the other conduits terminating at the other side of the piston axis.

Further objects and advantages of this invention will be apparent from consideration of the specification as illustrated by the accompanying drawings of possible embodiments of the invention, in which drawings:

FIG. 1 is a partial cross-sectional view of a piston type hydrostatic power unit illustrating one form of embodiment;

FIG. 2 is a partial enlarged cross-sectional view of the lower end of the piston of FIG. 1, the axial tube 8 being, however, shown in elevation;

FIG. 3 is a top view of the piston of FIG. 1;

FIG. 4 is an elevational view of the piston of FIG. 1;

FIG. 5 is an axial cross sectional view of a piston and piston shoe, illustrating a modified form of construction; and

FIG. 6 is a top view of the piston of FIG. 5, shown on an enlarged scale.

Referring to said drawings, 1 indicates one of the pistons of an axial piston hydrostatic power unit which may be used either as a pump or hydraulic motor. Said piston is reciprocable in cylinder bores in a cylinder block 2. Each cylinder is provided with a cylinder port 3 cooperating with the usual kidney shaped valve ports in the valve plate 4, connected respectively to the intake and delivery conduits.

The outer end of the piston is formed with the sperical ball 7 which is located in a spherical socket in the piston shoe 7*a* which is slidable on the abutment ring or swash-plate 7*b*. The shoe 7*a* may be held against the ring 7*b* by the usual spider 7*c*.

Piston 1 is formed with an axial bore 5 within which is tightly pressed the conduit rod 8. As shown, the latter is formed with a plurality of helical grooves 18 (6 being shown), the outer end of which grooves terminate in the surface of the ball 7. 15 indicates transverse ducts in the piston (6 being used in the form shown). The outer ends of these bores 15 may communicate with oil distribution grooves 15' (FIGS. 1 and 4). It will be noted that the pitch of the helical grooves 18 is so chosen that a half turn around the rod 8 is made from the upper end of the rod to the several ducts 15. The lower end of rod 8 is preferably enlarged as at 17 and is preferably also formed with an enlarged threaded head 17*a* engaged with threads in the piston. When the rod 8 is screwed in place an oil type connection is formed between the enlargement 17 and the piston, preferably with the aid of a gasket. 9 indicates a central bore in the rod 8 which bore terminates in line with transverse ducts 10 in rod 8. 11 indicates transverse ducts in the piston which open into circumferential groove 12 which communicates with the space between the piston and the cylinder wall a short distance from the inner end of the piston. If desired, the end of the piston may be made slightly smaller in diameter to permit oil at sufficient pressure to enter the ducts 11. The space between the piston and cylinder wall is so small that only filtered oil can enter ducts 11. The oil flows through ducts 11 and 10 into bore 9 and into the pocket 14 in the shoe 7*a*. From said pocket, the oil may pass through duct 14*a* into a pocket 14*b* in the face of the shoe to lubricate and hydraulically balance the shoe 7*a* on the swash-plate ring 7*b*. When the shoe 7*a* is coaxial with piston 1, as when the swash-plate 7*b* is perpendicular to the pistons, no oil can enter ducts 18. However, when the shoe is tilted as shown in FIG. 1, pressure oil in the pocket 14 enters that helical groove 18 which starts the farthest to the left in FIG. 1, passes down said groove half way around the rod 8 and enters the duct 15 on the opposite side of the piston, through which duct it flows into the space between the piston and the cylinder wall. If the tilt of shoe 7*a* is sufficient or the diameter of pocket 14 is made sufficiently large, oil may also enter one or two adjacent grooves 18 and pass therethrough to the adjacent ducts 15 (not shown). It will therefore be seen that oil under pressure is led from the cylinder space below the piston through the ducts 11 and 10, bore 9, pocket 14 and one or more grooves 18 to one or more ducts 15 and distributed on that side of the piston where the lateral pressure occurs.

The helical grooves 18 are preferably made very fine

so as to provide a throttling effect. This aids in the automatic pressure balancing so as to provide only enough oil pressure between the piston and the cylinder walls to separate them slightly, whereby excess oil leakage is avoided.

Transverse contact pressure also occurs at the inner end of the piston on the side opposite to the point where the pressure is exerted at the outer end of the cylinder bore. While this pressure is less, it may be counterbalanced by continuing the helical grooves **18** (as shown) to a point in line with the six transverse ducts **16**. As shown, the helical grooves make a half turn in the distance between the ducts **15** and the ducts **16** so that any groove **18** which supplies oil to the duct **15** on one side of the piston will also supply oil to the duct **16** on the other side of the piston. This is easily accomplished by making the distance from the upper end of rod **8** to the ducts **15** the same as the distance from the ducts **15** to the ducts **16**. If this is not convenient a variable pitch helical groove may, of course, be employed. The oil may be spread to any extent desired by providing oil distribution grooves **16'** (FIGS. 1 and 4). Furthermore, helical grooves may be formed on the inner surface of the bore **5** similar to grooves in a rifle barrel, in which event the exterior of the rod **8** may be smooth.

Another form of construction is illustrated in FIG. 5 in which the piston **1***a* is formed with a central bore **5'** within which is pressed the central conduit rod **8***a*, formed with external grooves **18***a* which terminate at their inner ends in ducts **15***a* which may be formed with oil distribution grooves **15'**. The upper end of the rod **8***a* is formed with a conical head having grooves **24** herein which constitute a continuation of grooves **18***a*. If preferred, **24** may be drilled holes in the piston ball **7'**. In this form, controlled pressure oil areas at the inner end of the piston are not provided. Throttling grooves **20** are shown formed in the piston surface to permit pressure oil from the cylinder to balance the transverse pressures at the inner end of the piston. The piston is shown provided with an annular groove **22** communicating through bore **23** with the exterior. Pressure oil may pass through the central bore **9***a* in the rod **8***a* to an oil pocket **9***b* at its upper end and thence through duct **14***a'* to a pocket **14***b'* in the face of the shoe **7***a'*. The shoe is shown formed with an annular groove **26** connected by one or more ducts **27** to the pocket **14***b'*, which as stated is supplied with high pressure oil through bore **9***a*. The radius of the groove **26** is such with respect to the grooves or bores **24** that when the shoe **7***a'* is perpendicular to the piston no communication occurs between **26** and **24**. If, however, the shoe is inclined leftward, as shown in FIG. 5, pressure oil may flow from annular groove **26** through duct **24**, groove **18***a* and duct **15***a* to the oil distribution groove **15'** at the right side of the piston. In this way, an oil pressure area is formed at the proper side of the piston to relieve the transverse pressure developed there. This form of construction has the advantage over that shown in FIGS. 1, 2, 3 and 4 in that it is somewhat simpler because it is not necessary to form helical grooves and straight fluting may be used. It will also be noted that instead of providing the co-axial conduits as grooves on conduit rod **8***a* (or within the bore **5'**) the rod **8***a* may be dispensed with and the conduits **18***a* may be formed as holes drilled in through the ball **7'**.

If it is also desired to provide balancing oil pressure areas at the bottom end of the piston, this can be accomplished by continuing the fluting in a helical form for 180 degrees to the lower end of the correspondingly lengthened rod **8***a* where ducts such as ducts **16** of FIGS. 1 and 2 would be provided.

The invention may be applied equivalently to axial piston pumps and motors having inclined cylinder axes, which constitute as it were a transition to the radial piston pump or motor construction, and also to radial piston pumps or motors having a shoe adjustable at an angle or similar

structural elements at their outer piston end. Whether the shoe has plane, cylindrical or spherical surfaces externally is obviously irrelevant to the invention. In the case of a pure radial piston transmission, the spherical member illustrated at the outer piston end in the accompanying drawings may be replaced by a cylindrical element which is connected to a corresponding shoe, or else these pistons may be provided with an external cylindrically drilled bushing which is connected to a cylindrical member which is in turn disposed on the shoe. In that case, the valving of the pressure oil sections would be effected in the piston itself or else in an assoicated crosshead instead of the spherically movable surfaces in the corresponding cylindrical slide surfaces. The valving would then proceed in a single plane, so that it would be sufficient to have two alternately pressurized relieving surfaces on the piston with their pressure oil supply for the latter, or the corresponding arrangement on a crosshead.

It is also possible to provide a crosshead in known manner on the outer piston end in the case of the axial piston transmission as well, in order to use its slide surfaces or the relieving thereof for the arrangement according to the invention. In these and in other cases it is also possible to replace the ball head of the pistons shown in FIGURES 1, 3, 5 and 6 by a ball cup which surrounds a ball element which in turn is connected to a slide shoe. In this case too the described expedients of slidable valving apertures in the corresponding cooperating slide surfaces obviously permit the automatic control in accordance with the invention of the pressure oil areas on the piston or crosshead, only insignificant structural modifications being required in comparison with the exemplified embodiments illustrated in the drawings.

The invention is not intended to be limited to the several illustrative forms shown and described which are to be understood as illustrative only and not as limiting, as various changes in construction and arrangement may be made, including combining features of the said forms, all coming within the scope of the claims which follow.

I claim:

1. A hydrostatic power unit of the type having a piston reciprocating in a cylinder and a force transmitting member hinged to said piston in such a way as to permit relative movement between said piston and said force transmitting member, conduit means extending from the end of the piston adjacent said force transmitting member and communicating with the exterior of the piston, means to supply oil under pressure to said force transmitting member and valving means controlled by relative movement between said piston and said force transmitting member for controlling the flow of pressure oil into said conduit means, the conduit means comprising an axial bore in the piston and a rod pressed into said bore in the piston together with conduit grooves formed at the junction of the rod and bore.

2. A hydrostatic power unit of the type having a piston reciprocating in a cylinder and a force transmitting member hinged to said piston in such a way as to permit relative movement between said piston and said force transmitting member, conduit means extending from the end of the piston adjacent said force transmitting member and communicating with the exterior of the piston, means to supply oil under pressure to said force transmitting member and valving means controlled by relative movement between said piston and said force transmitting member for controlling the flow of pressure oil into said conduit means, the conduit means comprising an axial bore in the piston and a rod pressed into said bore in the piston, said rod being formed with conduit grooves on its outer surface.

3. A hydrostatic power unit of the type having a piston reciprocating in a cylinder and a force transmitting member hinged to said piston in such a way as to permit rela-

tive movement between said piston and said force transmitting member, conduit means extending from the end of the piston adjacent said force transmitting member and communicating with the exterior of the piston, means to supply oil under pressure to said force transmitting member and valving means controlled by relative movement between said piston and said force transmitting member for controlling the flow of pressure oil into said conduit means, the conduit means comprising an axial bore in the piston and a rod pressed into said bore in the piston, said rod being formed with helical conduit grooves on its outer surface.

4. A hydrostatic power unit of the type having a piston reciprocating in a cylinder and a shoe hinged to said piston in such a way as to permit relative rocking movement between said piston and said shoe, a plurality of generally radial ducts in said piston near the central portion of the piston and extending to the exterior thereof, the same plurality of generally radial ducts in said piston located near the inner end of said piston and extending to the exterior thereof, the same plurality of conduits extending from the end of the piston adjacent to said shoe and each communicating with one of said first mentioned ducts, and then extending to and communicating with that one of said second mentioned generally radial ducts which is on the opposite side of the piston from the said first mentioned duct, means to supply oil under pressure to said shoe and valving means controlled by relative rocking movement between said piston and said shoe for controlling the flow of pressure oil into said conduits.

5. The combination according to claim 4 in which that part of the conduits extending from the first ducts to the second ducts constitute part of a helix.

6. The combination according to claim 4 in which the conduits are formed as a helix making a half turn from the shoe to the first ducts and a second half turn from the first ducts to the second ducts.

7. The combination according to claim 4 in which the conduits are formed as a helix making a half turn from the shoe to the first ducts and a second half turn from the first ducts to the second ducts, and in which the distance from the shoe to the first ducts is the same as from the first ducts to the second ducts.

8. A hydrostatic power unit of the type having a piston reciprocating in a cylinder and a shoe spherically hinged to said piston in such a way as to permit relative movement between said piston and said shoe, a plurality of conduits extending from the end of the piston adjacent to said shoe and opening at points equally spaced from the axis of the piston and each communicating with the exterior of the piston, a circular pocket formed in the spherical surface of the shoe which contacts with the spherical part of the piston, which pocket is of a different radius than the radius of the locations of the openings of the conduits in the spherical piston surface but connecting with at least one of said conduits when the shoe is tilted relative to the piston, and means to supply oil under pressure to said pocket, whereby the supply of oil to said conduits is controlled by relative movement between said piston and said shoe, the radius of the pocket being smaller than the radius of the locations of the openings of the conduits in the spherical piston surface and the conduits being so formed that each conduit opens at the exterior of the piston at a point on the opposite side of the piston axis from the point at which it starts in the spherical piston surface.

9. A hydrostatic power unit of the type having a piston reciprocating in a cylinder and a shoe spherically hinged to said piston in such a way as to permit relative movement between said piston and said shoe, a plurality of conduits extending from the end of the piston adjacent to said shoe and opening at points equally spaced from the axis of the piston and each communicating with the exterior of the piston, a circular annular groove formed in the spherical surface of the shoe which contacts with the spherical part of the piston, the inner radius of the circular annular groove being greater than the radius of the locations of the openings of the conduits in the spherical piston ball surface but connecting with at least one of said conduit openings when the shoe is tilted relative to the piston, and means to supply oil under pressure to said annular groove, whereby the supply of oil to said conduits is controlled by relative movement between said piston and said shoe, the conduits being so formed that each conduit opens at the exterior of the piston at a point on the same side of the piston ball axis as that from which it starts in the spherical piston surface.

10. A hydrostatic power unit of the type having a piston reciprocating in a cylinder and a force transmitting member hinged to said piston in such a way as to permit relative movement between said piston and said force transmitting member, conduit means extending from the end of the piston adjacent said force transmitting member and communicating with the exterior of the piston, an oil passage extending from the inner end of said piston to the outer end thereof adjacent to said force transmitting member and serving to supply oil under pressure to said force transmitting member and valving means controlled by relative movement between said piston and said force transmitting member for controlling the flow of pressure oil into said conduit means, the said oil passage extending from the inner end of the piston to the outer end thereof comprising at least one generally radial duct near the inner end of the piston connected to the space between the cylinder wall and the piston and serving to conduct oil from said space to an axial passage in the piston which extends to the outer end thereof.

11. A hydrostatic power unit of the type having a piston reciprocable in a cylinder and formed with a ball at its outer end and a shoe having a spherical socket embracing said ball, so that said shoe is hinged to said piston to permit universal relative rocking movement between said piston and said shoe, a plurality of conduits extending from the ball end of the piston from points equally spaced from the axis of the piston and communicating with the exterior of the piston, an oil passage extending from the inner end of said piston to the outer end thereof and serving to supply oil under pressure to a circular pocket formed in the spherical socket in said shoe, said pocket being so formed, located and dimensioned as to form a connection to at least one of said conduits when said shoe is tilted, whereby the oil supply to said conduits is controlled by tilting movement between said ball ended piston and said spherical socket in said shoe.

12. A hydrostatic power unit of the type having a piston reciprocable in a cylinder and formed with a ball at its outer end and a shoe having a spherical socket embracing said ball, so that said shoe is hinged to said piston to permit universal relative rocking movement between said piston and said shoe, a plurality of conduits extending from the ball end of the piston from points equally spaced from the axis of the piston and communicating with the exterior of the piston, an oil passage extending from the inner end of said piston to the outer end thereof and serving to supply oil under pressure to a circular pocket formed in the spherical socket in said shoe, said pocket being so formed, located and dimensioned as to form a connection to at least one of said conduits when said shoe is tilted, whereby the oil supply to said conduits is controlled by tilting movement between said ball ended piston and said spherical socket in said shoe, the pocket in the spherical socket in said shoe comprising a circular groove whose inner radius is larger than the radius of the locations of the openings of the conduits in the ball, and the conduits being so formed that each conduit opens at the exterior of the piston at a point on the same side of the

piston axis as that from which it starts in the spherical piston ball surface.

13. A hydrostatic power unit of the type having a piston reciprocable in a cylinder and formed with a ball at its outer end and a shoe having a spherical socket embracing said ball, so that said shoe is hinged to said piston to permit universal relative rocking movement between said piston and said shoe, a plurality of conduits extending from the ball end of the piston from points equally spaced from the axis of the piston and communicating with the exterior of the piston, an oil passage extending from the inner end of said piston to the outer end thereof and serving to supply oil under pressure to a circular pocket formed in the spherical socket in said shoe, said pocket being so formed, located and dimensioned as to form a connection to at least one of said conduits when said shoe is tilted, whereby the oil supply to said conduits is controlled by tilting movement between said ball ended piston and said spherical socket in said shoe, the radius of the pocket being smaller than the radius of the locations of the openings of the conduits in the spherical piston ball surface and the conduits being so formed that each conduit opens at the exterior of the piston at a point on the opposite side of the piston axis from the point at which it starts in the spherical piston ball surface.

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