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P. C. TEMPLE  
HYDRAULIC MECHANISM

2,483,856

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2 Sheets-Sheet 1

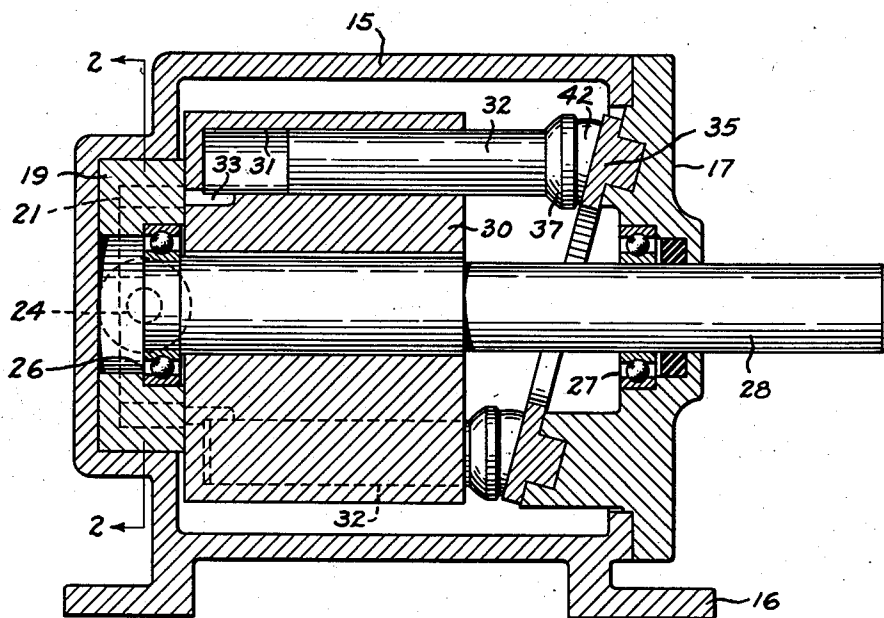


Fig. 1

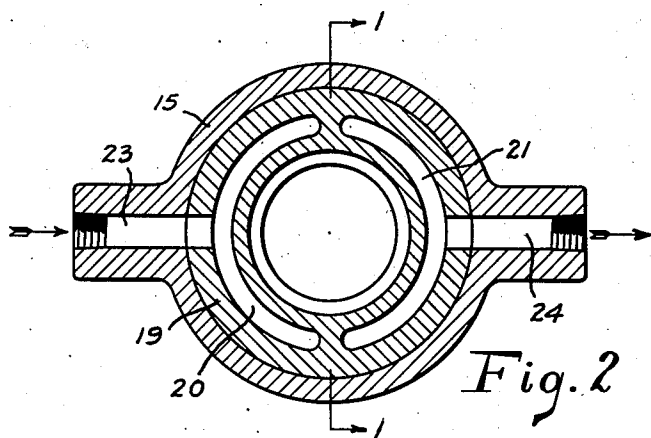


Fig. 2

Inventor  
PAUL C. TEMPLE

By *Albert G. Blodgett*  
Attorney

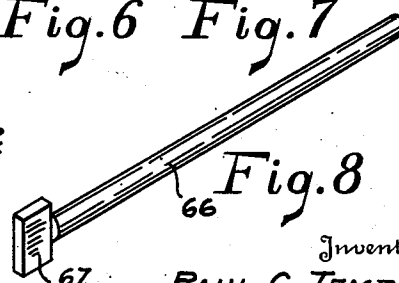
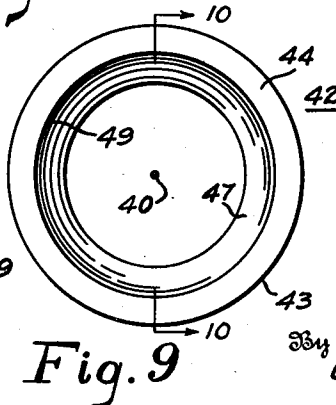
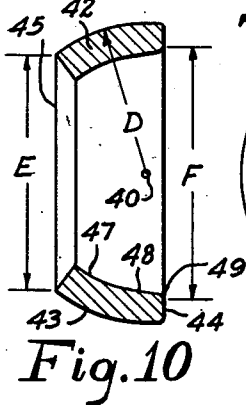
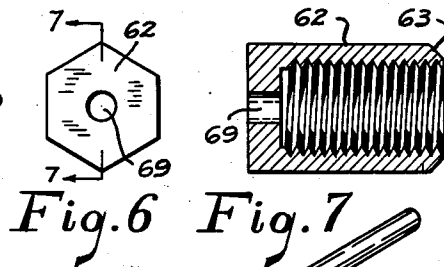
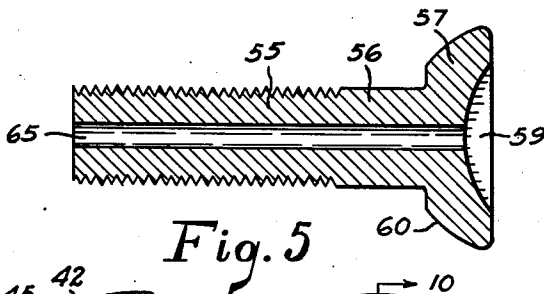
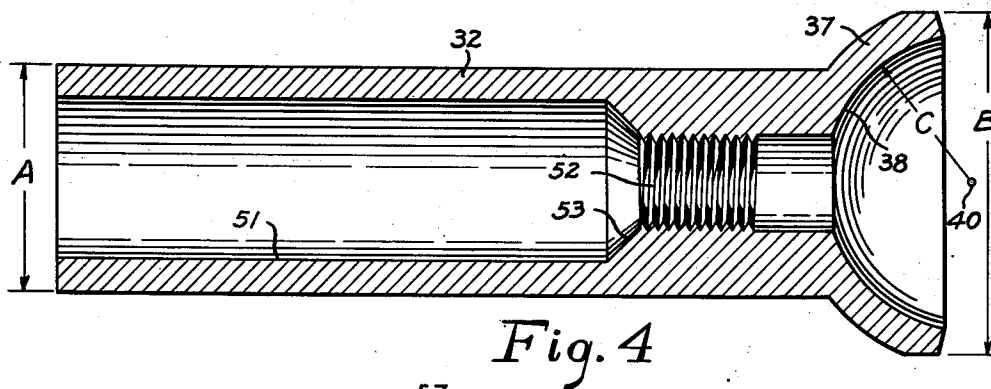
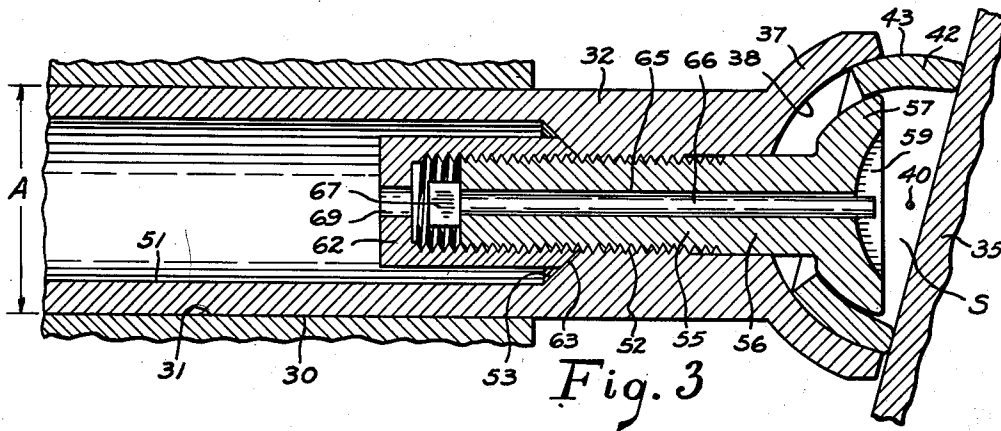
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Inventor  
PAUL C. TEMPLE

By Albert G. Blodgett  
Attorney

## UNITED STATES PATENT OFFICE

2,483,856

## HYDRAULIC MECHANISM

Paul C. Temple, Decatur, Ill., assignor to A. W. Cash Company, Decatur, Ill., a corporation of Delaware

Application March 8, 1945, Serial No. 581,678

12 Claims. (Cl. 103—162)

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This invention relates to hydraulic mechanisms such as pumps and motors, and more particularly to mechanisms of the type having reciprocable pistons carrying rocker shoes arranged to cooperate with suitable cam surfaces.

Many attempts have been made to balance the pistons hydraulically and to reduce friction and wear caused by rubbing between the shoes and cam surfaces. It is found however that with these prior mechanisms there is nevertheless a metal-to-metal contact between the shoes and the cam surfaces under operating conditions, as evidenced by the wear on these parts. This not only reduces the efficiency of the pump or motor, but it also necessitates frequent and expensive repairs.

It is accordingly one object of the invention to provide a pump or motor which will operate in a highly efficient manner throughout a long life of useful service without appreciable wear on any of the parts thereof.

It is a further object of the invention to provide a pump or motor of the type having reciprocable pistons carrying rocker shoes for sliding engagement with a cam surface, and to so construct the various parts as to substantially eliminate all friction and wear.

It is a further object of the invention to provide a pump or motor adapted for use with oil at high pressures, the mechanism having reciprocable pistons carrying rocker shoes, and the construction being such that the shoes will be supported for free movement on a film of oil at relatively low pressure.

It is a further object of the invention to provide a pump or motor adapted for use with oil at high pressures, and to arrange a simple and effective means for metering a small portion of the oil for the film lubrication of relatively moving parts of the mechanism.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

Referring to the drawings illustrating one embodiment of the invention, and in which like reference numerals indicate like parts,

Fig. 1 is a longitudinal section through a hydraulic mechanism, the section being taken on the line 1—1 of Fig. 2;

Fig. 2 is a section on the line 2—2 of Fig. 1;

Fig. 3 is an enlarged longitudinal section through one of the pistons and its associated parts;

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Fig. 4 is a longitudinal section through a piston removed from the assembly;

Fig. 5 is a longitudinal section through a retaining screw;

Fig. 6 is an end elevation of a lock-nut;

Fig. 7 is a section on the line 7—7 of Fig. 6;

Fig. 8 is a perspective view of an oil metering pin;

Fig. 9 is an end elevation of a rocker shoe; and

Fig. 10 is a section on the line 10—10 of Fig. 9.

The embodiment illustrated comprises a hollow casing 15 shaped generally as a horizontal cylinder with suitable supporting feet 16 therebeneath. A removable plate 17 is secured to the rear end of the casing, the terms "front" and "rear" being used in the specification and claims merely to describe the relative positions of the various parts. The front end of the casing is recessed to receive an annular block 19 which is suitably fixed in place and shaped to provide two opposed arcuate chambers 20 and 21 which are open at the rear face of the block. The casing 15 is provided with an inlet passage 23 leading to the chamber 20, and with an outlet passage 24 leading from the chamber 21. The block 19 and the end plate 17 support ball bearings 26 and 27 respectively, and in these bearings there is mounted a horizontal rotatable shaft 28 one end of which extends rearwardly through the plate 17. On the shaft 28 and within the casing 15 there is mounted a rotor 30 having a series of cylindrical bores 31 therein. The bores 31 are arranged in a circle about the shaft with their axes parallel therewith, and the bores are open at their rear ends, toward the end plate 17, to receive slidable pistons 32. At the front ends of the bores 31 suitable ports 33 are provided which open through the front face of the rotor, this face lying in close proximity to the rear face of the block 19. This construction is such that during the rotation of the rotor 30, each port 33 and its associated bore 31 will be connected alternately with the inlet chamber 20 and the outlet chamber 21. The annular block 19 and the adjacent front portion of the rotor 30 thus provide a valve means which serves to control the admission and discharge of fluid to and from the bores 31. On the inner or front side of the end plate 17 there is mounted an annular swash plate 35 which surrounds the shaft and provides a flat cam surface lying at an oblique angle to the axis of the shaft and facing forwardly toward the rotor.

The general construction as so far described is well known for use as a pump or motor, and it has also been proposed to mount rocker shoes on the

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rear ends of the pistons for sliding engagement with the swash plate. It is also known practice to employ a revoluble swash plate in conjunction with pistons which reciprocate in stationary bores, and the present invention may be applied to such construction, or in fact to any construction having a cam surface for sliding engagement with a rocker shoe on a reciprocable piston.

Referring now to Figs. 3 to 10 inclusive, it will be seen that the main body of each piston 32 is formed with a cylindrical outside surface having a diameter A such as to fit for close sliding engagement within the corresponding bore 31. On the rear end of the piston there is provided an integral enlarged portion or head 37 having an outside diameter B approximately fifty percent greater than the diameter A. This head 37 is formed with a rearwardly open socket 38 with a concave spherical surface having a radius C and a center 40. The radius C is approximately thirty percent greater than the radius A/2 of the piston. The center 40 is located on the axis of the piston and between the front surface of the swash plate 35 and the plane defined by the rear edge of the socket.

Within the socket 38 there is mounted a rocker shoe in the form of a ring 42 arranged for sliding engagement with the swash plate 35, although, as will be hereafter explained, no actual metal-to-metal contact will take place in normal operation. As shown in Figs. 9 and 10, this ring is provided with an outside convex spherical surface 43 having a radius D substantially equal to the radius C of the socket 38, the center of this surface being at 40. The rear edge of the ring is in the form of a plane annular surface 44. At the front of the ring the spherical surface 43 terminates at its intersection with a plane 45 in a circle having a diameter E which is substantially equal to the diameter A of the piston 32. The two planes 44 and 45 are parallel, and the center 40 lies between them but is considerably closer to the rear plane 44 than to the front plane 45. The inner surface of the ring is formed for the most part as a concave spherical surface 47 about the center 40 with a radius approximately equal to the radius A/2 of the piston, the rear portion of this surface 47 merging into a rearwardly and outwardly flaring surface 48 which is connected to the rear plane 44 by a slightly rounded corner surface 49. This corner surface 49 intersects the rear plane 44 on a circle having a diameter F slightly greater than the diameter A of the piston. If the diameter F exceeds the piston diameter A by approximately seven percent, the area of the swash plate which is exposed within the ring 42 will exceed the effective area of the piston 32 by approximately fifteen percent, since the area of a circle varies as the square of its diameter.

Means is preferably provided to retain the ring 42 in the socket 38 independently of the swash plate. For this purpose each piston 32 is provided with an elongated cylindrical chamber 51 which is open at its front end, the rear end of the chamber being connected to the socket 38 by a screw-threaded hole 52 smaller in diameter than the chamber. The rear portion of the chamber 51 is tapered abruptly inwardly to the hole 52, as indicated at 53. The hole 52 is arranged to receive the screw-threaded stem 55 of a screw 56 forming a retaining device, this screw having a head 57 on its rear end located within the ring and provided with a rearwardly-open slot 59 to receive a screw-driver or similar tool. The front

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outer surface 60 of the head 57 is spherical to conform substantially with the surface 47 of the ring 42. The front end of the stem 55 extends into the chamber 51 and receives a lock-nut 62 having its rear edge 63 beveled inwardly to correspond with the slope of the surface 53. At assembly the screw 56 will be adjusted to retain the ring 42 loosely in the socket 38, so that the ring may move freely in the socket as required to conform with the slope of the swash plate 35. The lock-nut 62 will be tightened firmly on the stem 55, and by reason of the engagement of the rear edge 63 of the nut with the tapered surface 53 the rear portion of the nut will be squeezed inwardly to afford a tight grip on the stem and prevent accidental loosening of the screw or nut.

The apparatus is particularly adapted for use with a liquid lubricant, preferably oil, and the construction is such as to "float" the rocker shoes 42 on films of oil and prevent metallic contact of these shoes with the swash plate 35 or the sockets 38. For this purpose a restricted longitudinally extending passage is provided through each of the screws 56. Since it is very difficult as a practical matter to drill long holes of small diameter in metal parts, a hole or passage 65 of appreciable diameter is drilled axially through each screw, and within this hole there is placed a pin 66 with a slightly smaller diameter, to restrict the passage. A flattened head 67 is formed on the front end of the pin, and the nut 62 overlies this head to retain the pin in its proper position. This nut is provided with a hole 69 through which oil from the chamber 51 may flow rearwardly and enter the passage 65. The diameter of the pin 66 in relation to the diameter of the hole 65 will determine the effective cross-sectional area of the passage.

It will now be apparent that the apparatus may be used either as a pump or as a motor. During the rotation of the rotor 30, the ports 33 will communicate with the inlet chamber 20 while the corresponding pistons 32 are moving rearwardly, and with the outlet chamber 21 while the corresponding pistons are moving forwardly. If oil is supplied to the inlet 23 at high pressure and exhausted from the outlet 24 at a lower pressure, the apparatus will function as a motor, and the shaft 28 may be connected to another machine to drive the same. On the other hand, if oil is supplied to the inlet 23 at low pressure and the shaft 28 is rotated by a suitable source of power, the apparatus will serve as a pump, and oil may be discharged from the outlet 24 at a higher pressure. In this respect the operation is similar to that of many prior pumps and motors.

Referring to Fig. 3, it will be seen that the piston head 37, the ring 42, and the swash plate 35 serve to enclose a space S into which oil from the cylinder bore 31 may flow through the restricted passage 65. The oil pressure throughout the space S will be substantially uniform, despite the presence of the screw head 57, since the latter is so loosely adjusted that oil may flow freely around the same and through the ring 42. In other words, the effect of the oil pressure on the socket 38 and on the ring 42 is the same as though the screw head 57 did not exist. The portion of the surface of the swash plate 35 which is surrounded by the annular surface 44 of the ring 42 is fully exposed to contact with the fluid within the ring. The oil pressure in the space S will create a force tending to move the ring 42 and piston 32 away from the swash plate 35, the amount of this force being equal to the oil pressure per unit area

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times the area of a circle having a diameter  $F$ . The component of this force in a direction along the axis of the piston will be the force multiplied by the sine of the angle between the swash plate 35 and the piston axis. For a balanced condition of the piston, this axial component will equal the force exerted on the piston by the pressure of the oil in the cylinder bore 31. We may designate this pressure by the symbol  $P$ , and the pressure in the space  $S$  by the symbol  $p$ . If now we assume that the angle between the swash plate 35 and the piston axis is 75 degrees, and that the area of the circle with diameter  $F$  exceeds the effective area of the piston with its diameter  $A$  by 15 percent, balanced conditions would be represented by the following equation:

$$P = 1.15 p \sin 75 \text{ degrees}$$

whence  $p = .9P$ .

Consequently, if  $P$  is 1000 lbs. per square inch,  $p$  will be approximately 900 lbs. per square inch, and we will have a pressure differential of 100 lbs. per square inch forcing a tiny stream of oil through the restricted passage 65 into the space  $S$ . If no oil could escape from this space, the pressure therein would increase slightly and lift the ring 42 slightly away from the swash plate, thus allowing oil to escape between these parts and lowering the pressure. Actually the piston will be hydraulically balanced with the ring 42 remaining at a very slight distance from the swash plate and a thin film of oil flowing continuously from the space  $S$  across the surface 44 of the ring. There will also be a thin film of oil escaping continuously between the outer surface 43 of the ring 42 and the socket 38 under the influence of the 900 lbs. pressure within the space  $S$ . However, the pressure on this film will be comparatively low, since the diameter  $F$  is only slightly greater than the diameter  $E$  and the ring is held in its socket with only a light hydraulic pressure sufficient to prevent excessive oil flow. The size of the pin 66 in relation to the diameter of the passage 65 is such that the flow of oil along the passage under the 100 lbs. pressure differential will be a very small fraction of the oil which enters and leaves the bore 31 through its port 33. Such oil as does escape past the rings 42 will be collected in the casing 15 and returned in known manner to a suitable reservoir.

It will now be apparent that the rocker rings 42 will "float" on films of oil, without any metal-to-metal contact with the swash plate 35 or the socket 38. Because the diameter  $E$  of the opening at the front of the ring is substantially equal to the diameter  $A$  of the piston, and since the diameter  $F$  of the opening at the rear of the ring is only slightly larger, the forward thrust on the piston will be brought about principally by the pressure of the oil itself in the space  $S$ , acting on the exposed surface of the socket 38 and of the screw 56. The force holding the ring in its socket will be only a slight force, and as a result the ring will rock with entire freedom to accommodate itself to the angularity of the swash-plate. Consequently, in contrast to prior mechanisms, there will be no tendency for the annular surface 44 of the ring to bear unevenly against the oil film which separates it from the swash plate and thereby break through this film at a localized area into metallic contact with the swash plate. Prolonged tests with this construction, operating under very high oil pressures, have shown that not the slightest wear or metallic friction is encountered.

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Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A hydraulic mechanism comprising a member having a bore therein, valve means controlling the admission and discharge of fluid to and from the bore, a piston slidable in the bore and provided with a socket in its outer end, an annular rocker shoe mounted in the socket, cam means providing a surface for sliding engagement with the shoe, the member and the cam means being relatively revoluble, a retaining device for the shoe having a stem mounted in the piston and a head on the stem located within the shoe, the said device having a passage extending longitudinally therethrough to conduct fluid from the bore to the interior of the shoe, and a pin mounted in the passage to restrict the same.

2. A hydraulic mechanism comprising a member having a bore therein, valve means controlling the admission and discharge of fluid to and from the bore, a piston slidable in the bore and provided with a socket in its outer end, an annular rocker shoe mounted in the socket, cam means providing a surface for sliding engagement with the shoe, the member and the cam means being relatively revoluble, the piston having a screw-threaded hole extending longitudinally therethrough, a retaining device for the shoe having a screw-threaded stem located in the hole and a head on the stem located within the shoe, and a lock nut on the inner end of the stem.

3. A hydraulic mechanism comprising a member having a bore therein, valve means controlling the admission and discharge of fluid to and from the bore, a piston slidable in the bore and provided with a socket in its outer end, an annular rocker shoe mounted in the socket, cam means providing a surface for sliding engagement with the shoe, the member and the cam means being relatively revoluble, the piston having a chamber in its inner end and a screw-threaded hole connecting the chamber with the socket, the surface of the chamber adjacent the hole tapering inwardly to the hole, a retaining device for the shoe having a screw-threaded stem located in the hole and a head on the stem located within the shoe, and a lock nut mounted on the inner end of the stem and engaging the said tapering surface.

4. A hydraulic mechanism comprising a member having a bore therein, valve means controlling the admission and discharge of fluid to and from the bore, a piston slidable in the bore and provided with a socket in its outer end, an annular rocker shoe mounted in the socket, cam means providing a surface for sliding engagement with the shoe, the member and the cam means being relatively revoluble, the piston having a screw-threaded hole extending longitudinally therethrough, a retaining device for the shoe having a screw-threaded stem located in the hole and a head on the stem located within the shoe, the said device having a passage extending longitudinally therethrough to conduct fluid from the bore to the interior of the shoe, a pin mounted in the passage to restrict the same, the pin having a head on its inner end, and a lock nut mounted on the inner end of the stem and overlying the head on the pin to retain the pin in its proper position.

5. A hydraulic mechanism comprising a member having a bore therein, valve means controlling the admission and discharge of fluid to and from the bore, a piston slidable in the bore and

provided with a socket in its outer end with a concave spherical surface, a rocker ring mounted in the socket and having a convex spherical surface for engagement therewith, the outer edge of the ring providing an annular surface with an inside diameter somewhat greater than the piston diameter, cam means providing a surface for sliding engagement with the said annular surface of the ring, the member and the cam means being relatively revoluble, the said convex spherical surface of the ring terminating at the inner edge of the ring in a circle having a diameter only slightly less than the inside diameter of the said annular surface, and means providing a restricted passage to conduct fluid from the bore to the interior of the ring, the portion of the surface of the cam means which is surrounded by the said annular surface being fully exposed to contact with the fluid within the ring.

6. A hydraulic mechanism comprising a member having a bore therein, valve means controlling the admission and discharge of fluid to and from the bore, a piston slidable in the bore, the piston having an enlarged head on its outer end provided with an outwardly open socket therein with a concave spherical surface having a radius appreciably greater than that of the piston, a rocker ring mounted in the socket and having a convex spherical surface with a radius substantially equal to that of the socket, the said surface of the ring terminating at the inner edge of the ring in a circle having a diameter substantially equal to the piston diameter, the outer edge of the ring providing an annular surface with an inside diameter somewhat greater than the piston diameter, cam means providing a surface for sliding engagement with the said annular surface of the ring, the member and the cam means being relatively revoluble, and means providing a restricted passage to conduct fluid from the bore to the interior of the ring, the portion of the surface of the cam means which is surrounded by the said annular surface being fully exposed to contact with the fluid within the ring.

7. A hydraulic mechanism comprising a member having a bore therein, valve means controlling the admission and discharge of fluid to and from the bore, a piston slidable in the bore, the piston having an enlarged head on its outer end provided with an outwardly open socket therein with a concave spherical surface having a radius considerably greater than that of the piston, the center of the spherical surface being located on the axis of the piston and outwardly beyond the outer edge of the socket, cam means providing a surface facing the socket and located outwardly beyond the said center, the member and the cam means being relatively revoluble, a rocker ring mounted in the socket and having a convex spherical surface with a radius substantially equal to that of the socket, the said surface of the ring terminating at the inner edge of the ring in a circle having a diameter substantially equal to the piston diameter, the outer edge of the ring providing an annular surface for sliding engagement with the said surface of the cam means, the inside diameter of the said annular surface being somewhat greater than the piston diameter, and means providing a restricted passage to conduct fluid from the bore to the interior of the ring, the portion of the surface of the cam means which is surrounded by the said annular surface being fully exposed to contact with the fluid within the ring.

8. A hydraulic mechanism comprising a mem-

ber having a bore therein, valve means controlling the admission and discharge of fluid to and from the bore, a piston slidable in the bore, the piston having an enlarged head on its outer end provided with an outwardly open socket therein with a concave spherical surface having a radius appreciably greater than that of the piston, a rocker ring mounted in the socket and having a convex spherical surface with a radius substantially equal to that of the socket, the outer edge of the ring providing an annular surface with an inside diameter greater than the piston diameter, the said convex surface of the ring terminating at the inner edge of the ring in a circle having a diameter only slightly less than the inside diameter of the said annular surface, cam means providing a surface for sliding engagement with the said annular surface of the ring, the member and the cam means being relatively revoluble, and means providing a restricted passage to conduct fluid from the bore to the interior of the ring, the portion of the surface of the cam means which is surrounded by the said annular surface being fully exposed to contact with the fluid within the ring.

9. A hydraulic mechanism comprising a member having a series of cylindrical bores therein which are arranged in a circle about an axis and parallel therewith, valve means controlling the admission and discharge of fluid to and from the bores, the bores being open at their rear ends, pistons slidable in the bores and extending outwardly from the rear ends thereof, the rear end of each piston having an enlarged head thereon, a swash plate located adjacent to the piston heads and lying at an oblique angle to the axis, the member and the swash plate being relatively rotatable about the axis, each piston head having a rearwardly open socket therein with a concave spherical surface having a radius considerably greater than that of the piston, the center of the spherical surface being located on the axis of the piston and between the rear edge of the socket and the front surface of the swash plate, a rocker ring mounted in each socket and having an outer convex spherical surface with a radius substantially equal to that of the socket, the outer surface of the ring terminating at the front in a circle having a diameter substantially equal to the piston diameter, the ring having a plane annular rear surface for sliding engagement with the swash plate and the inside diameter of the said annular rear surface being slightly greater than the piston diameter, and means providing a restricted passage to conduct fluid from each bore to the interior of the corresponding ring, the portions of the surface of the swash plate which are surrounded by the annular rear surfaces of the rings being fully exposed to contact with the fluid within the rings.

10. A hydraulic mechanism comprising a member having a series of cylindrical bores therein which are arranged in a circle about an axis and parallel therewith, valve means controlling the admission and discharge of fluid to and from the bores, the bores being open at their rear ends, pistons slidable in the bores and extending outwardly from the rear ends thereof, the rear end of each piston having an enlarged head thereon, a swash plate located adjacent to the piston heads and lying at an oblique angle to the axis, the member and the swash plate being relatively rotatable about the axis, each piston head having a rearwardly open socket therein with a concave spherical surface having a radius consider-

ably greater than that of the piston, the center of the spherical surface being located on the axis of the piston and between the rear edge of the socket and the front surface of the swash plate, a rocker ring mounted in each socket and having an outer convex spherical surface with a radius substantially equal to that of the socket, the outer surface of the ring terminating at the front in a circle having a diameter substantially equal to the piston diameter, the ring having a plane annular rear surface for sliding engagement with the swash plate and the inside diameter of the said annular rear surface being slightly greater than the piston diameter, and a retaining device for the ring including a longitudinally extending stem mounted in the piston and a head on the rear end of the stem located within the ring, the retaining device having a restricted longitudinal passage therethrough to conduct fluid from the corresponding bore to the interior of the ring, the portions of the surface of the swash plate which are surrounded by the annular rear surfaces of the rings being fully exposed to contact with the fluid within the rings.

11. A hydraulic mechanism comprising a rotor mounted for rotation about an axis and having a series of cylindrical bores therein which are arranged in a circle about the axis and extend parallel therewith, valve means controlling the admission and discharge of fluid to and from the bores, the bores being open at their rear ends, pistons slidable in the bores and extending outwardly from the rear ends thereof, the rear end of each piston having an enlarged head thereon providing a rearwardly open socket with a concave spherical surface having a radius considerably greater than that of the piston, a swash plate located adjacent to the piston heads and lying at an oblique angle to the axis of the rotor, a rocker ring mounted in each socket and having an outer convex spherical surface with a radius substantially equal to that of the socket, the ring having a plane annular rear surface for sliding engagement with the swash plate and the inside diameter of the said annular rear surface being greater than the piston diameter, the outer surface of the ring terminating at the front in a circle having a diameter only slightly less than the inside diameter of the said annular surface, and means providing a restricted passage to conduct fluid from each bore to the interior of the corresponding ring, the portions of the surface of the swash plate which are surrounded by the annular rear surfaces of the rings being fully exposed to contact with the fluid within the rings.

12. A hydraulic mechanism comprising a rotor mounted for rotation about an axis and having

a series of cylindrical bores therein which are arranged in a circle about the axis and extend parallel therewith, valve means controlling the admission and discharge of fluid to and from the bores, the bores being open at their rear ends, pistons slidable in the bores and extending outwardly from the rear ends thereof, the rear end of each piston having an enlarged head thereon, a swash plate located adjacent to the piston heads and lying at an oblique angle to the axis of the rotor, each piston head having a rearwardly open socket therein with a concave spherical surface having a radius considerably greater than that of the piston, the center of the spherical surface being located on the axis of the piston and between the rear edge of the socket and the front surface of the swash plate, a rocker ring mounted in each socket and having an outer convex spherical surface with a radius substantially equal to that of the socket, the outer surface of the ring terminating at the front in a circle having a diameter substantially equal to the piston diameter, the ring having a plane annular rear surface for sliding engagement with the swash plate and the inside diameter of the said annular rear surface being slightly greater than the piston diameter, and a retaining device for the ring including a longitudinally extending stem mounted in the piston and a head on the rear end of the stem located within the ring, the retaining device having a restricted longitudinal passage therethrough to conduct fluid from the corresponding bore to the interior of the ring, the portions of the surface of the swash plate which are surrounded by the annular rear surfaces of the rings being fully exposed to contact with the fluid within the rings.

PAUL C. TEMPLE.

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