May 11, 1954 H. GERKEN 2,678,003

BALL PISTON PUMP

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Fig. 1

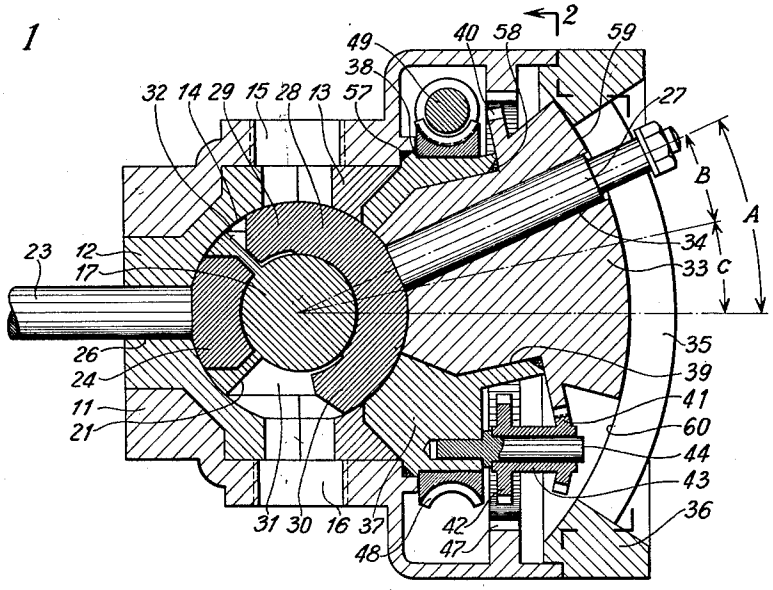
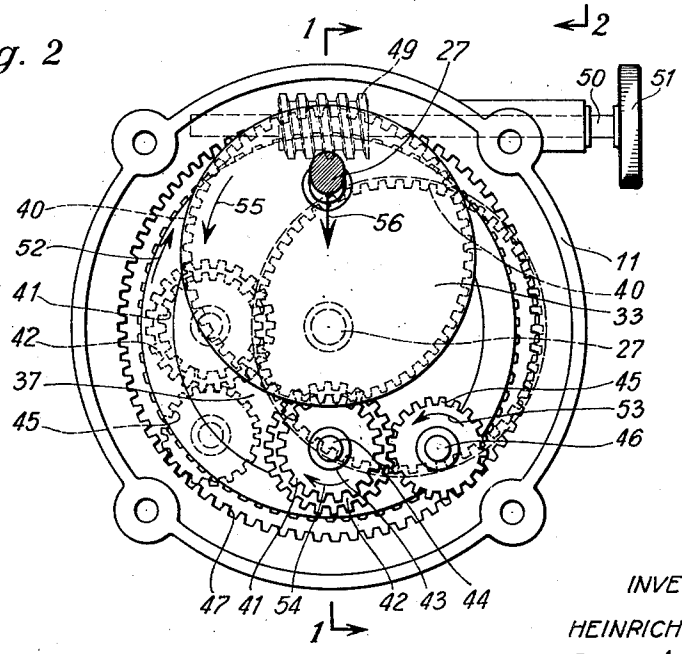


Fig. 2



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Fig. 3

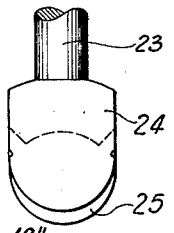


Fig. 4

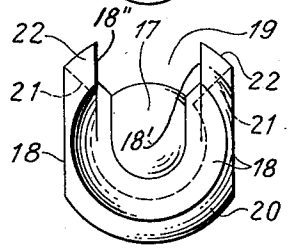


Fig. 5

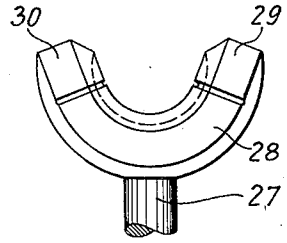
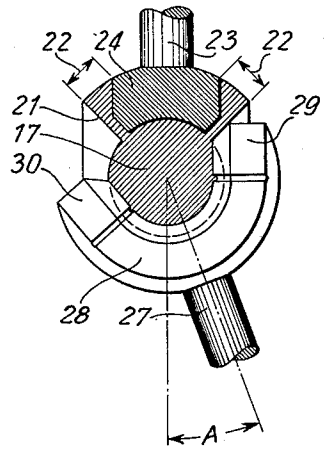


Fig. 6



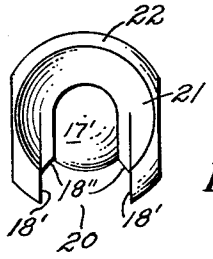


Fig. 4a

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Fig. 7

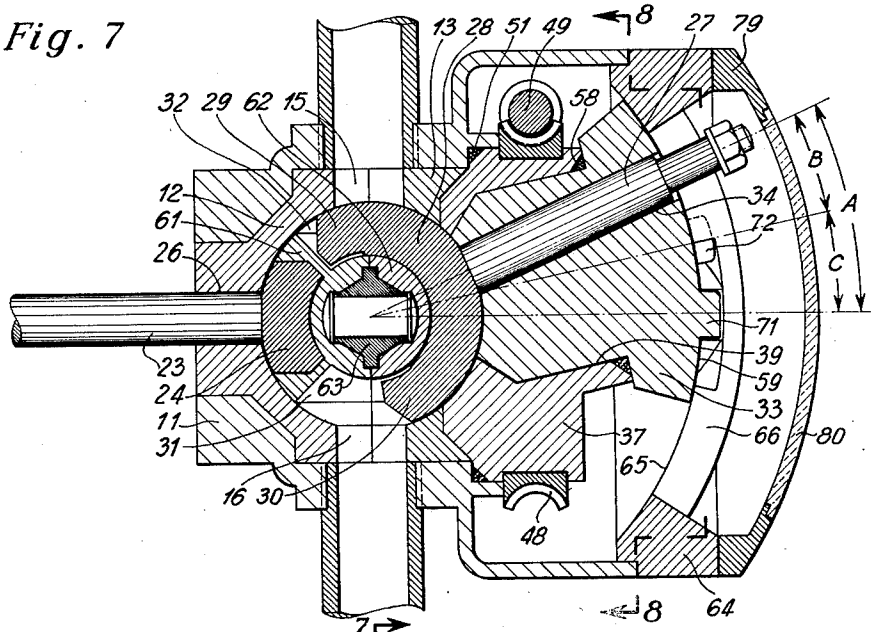
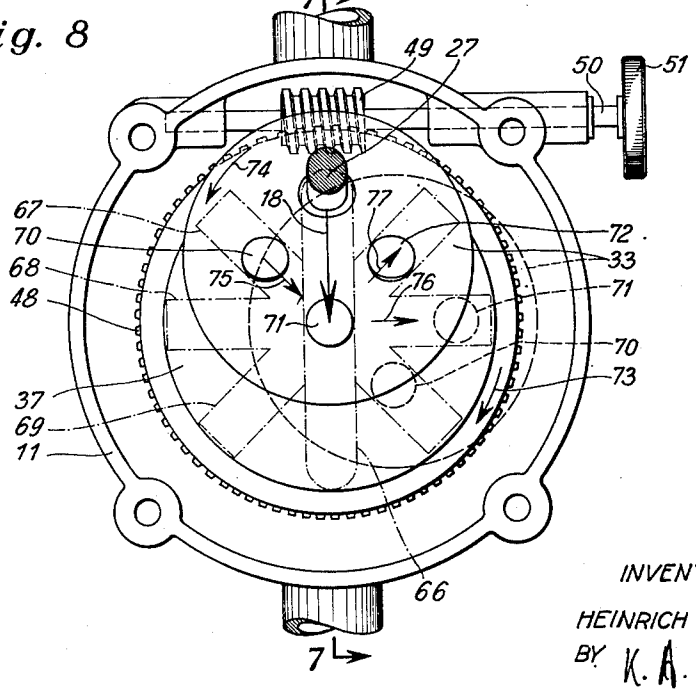


Fig. 8



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Fig. 9

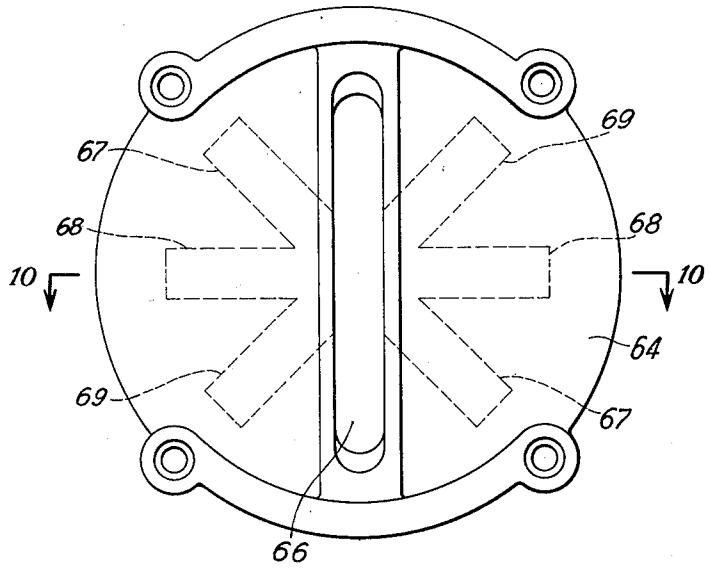
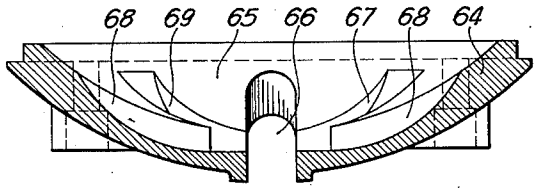


Fig. 10



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UNITED STATES PATENT OFFICE

2,678,003

BALL PISTON PUMP

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Application June 20, 1951, Serial No. 232,644

Claims priority, application Germany July 14, 1950

8 Claims. (Cl. 103—3)

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This invention relates to ball piston pumps and compressors operating on the universal joint principle and comprising a spherical rotor, a drive shaft having a slide and a stub shaft having a slide, the slides individually slidably engaging grooves in said rotor, and means for adjusting the discharge of the pump or compressor by shifting said stub shaft in a plane including the axis of said stub shaft and the axis of said drive shaft and thereby varying the angle between said stub shaft and said drive shaft, all as more fully described hereinafter and as claimed.

The discharge of rotary ball piston pumps and compressors operating on the universal joint principle may be varied and adjusted by changing the position of the stub shaft relative to the drive shaft, as is well known. In previous attempts to provide such adjustability of the stub shaft and overcome the sealing difficulties involved therein, the bearing for the stub shaft was placed in a member that could be rotated from the outside of the pump casing for purposes of discharge adjustment. On such rotation of the bearing member, the stub shaft was rotated around the axis of the drive shaft, i. e. out of a plane passing through the drive shaft and the position of the stub shaft prior to the adjustment. Such rotation changed the pump chambers without changing the angle between stub shaft and drive shaft. In all adjustment positions except the one resulting in maximum pump discharge, each chamber would first suck fluid from the inlet and then again return at least part of this sucked-out fluid to the inlet. Such arrangements are not efficient and do not permit fine adjustments to be made.

The objects of this invention are to provide efficient and accurate means for adjusting the discharge of rotary universal joint principle pumps; to provide such means permitting fine and stepless adjustment; to provide an arrangement in which the sealing problem is effectively solved; and to provide visual means for observing the adjustment position.

According to this invention, the foregoing objects are achieved by providing an arrangement that permits varying and adjusting the angle between the stub shaft and the drive shaft in a given plane. It might appear as if that could simply be accomplished by adjustably positioning the stub shaft bearing in a slot provided in the pump casing. Such simple solution, however, is not practical because, aside from the sealing difficulties involved, in order to provide adequate range of adjustment, the slot would have to be so

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long that it would interconnect the inlet and outlet chambers which, of course, would make the pump inoperative.

The main feature of this invention is a novel bearing arrangement for the stub shaft employing two rotatable members, one being rotatable in a bearing in the pump casing co-axial with the drive shaft and being provided with an eccentric bore, and the other rotatable member being rotatable in said bore and having therein an eccentric bearing for the stub shaft. The axes of both rotatable members and of the stub shaft bearing pass through the center of the spherical rotor. Means are provided on the outside of the pump casing for rotating, directly or through a suitable transmission, the rotatable member that is rotatable in the bearing provided in the pump casing, in order to adjust the angle between stub shaft and drive shaft by shifting the stub shaft in the plane passing through both shafts. To this end, the turning motions of the two rotatable members are interlocked by the use of spur or worm gearing, guides or linkages. This arrangement makes it a simple matter to seal off the joints at the rotatable members. The face of the second rotatable member can be made spherical-convex to engage a spherical-concave surface of the cover screwed to the pump casing; this provides in every adjustment position of the stub shaft uniform specific pressure on the contact surfaces between the stub shaft bearing parts, the rotary members and the casing. The slot in the casing cover in which the stub shaft is guided can be covered by a window permitting convenient inspection of the stub shaft position, i. e. of the discharge adjustment.

The abovementioned objects as well as other objects of my invention will appear more clearly from the following description and from the appended drawings in which like numerals are used to designate like parts throughout the several views, and in which:

Fig. 1 is a view, partly in section along line 1—1 of Fig. 2, of a ball piston pump according to my invention;

Fig. 2 is a view, partly in section along line 2—2 of Fig. 1, with the cover 36 removed;

Fig. 3 is a fragmentary view of the drive shaft member of the pump shown in Figs. 1 and 2;

Fig. 4 is a view of the spherical rotor of the pump shown in Figs. 1 and 2;

Fig. 4a is a side view of the member shown in Fig. 4 taken at a right angle to said figure;

Fig. 5 is a fragmentary view of the stub shaft member of the pump shown in Figs. 1 and 2;

Fig. 6 is an assembly, partly in cross-section, of the parts shown in Figs. 3, 4 and 5;

Fig. 7 is a view of a modified pump, partly in section along line 7—7 of Fig. 8;

Fig. 8 is a view, partly in section along line 8—8 of Fig. 7, with both covers removed;

Fig. 9 is a view of the cover 64 of the pump shown in Figs. 7 and 8; and

Fig. 10 is a view in section along line 10—10 of Fig. 9.

Referring now to Figs. 1 to 6, the pump according to my invention has a casing 11 with liners 12 and 13 forming a spherical chamber or cavity 14 with which inlet and outlet passages 15 and 16 communicate and in which a spherical rotor 17 is disposed.

As shown in Fig. 4, the rotor 17 has four flat faces 18 located 90 degrees apart from each other (only three being visible in Fig. 4), and two grooves 19 and 20 disposed at right angles to each other, each extending through an arc greater than 180 degrees and being faced at each end, as indicated at 21. This leaves narrow land areas 22 between the middle portion of groove 19 and the ends of groove 20 (and vice versa) preventing short-circuiting of the fluid being pumped between the inlet and outlet passages 15 and 16.

The rotor may be described in other words as being formed by a sphere whose diameter is that of the land areas 22 and into which a groove 19 extending 270° around the center of the sphere and a groove 20 are machined, the latter extending also 270° around the center of the sphere and being at a right angle to the groove 19. The bottoms of the grooves form surface portions of a smaller sphere 17' which is concentric within the larger sphere. The middle portions of the grooves taking up about one third of the aforementioned 270° have parallel side wall portions 19', the parallel side wall portions of groove 19 being in planes at a right angle to the parallel side wall portions of groove 20. The parallel side wall portions are connected with the bottoms of the grooves by inclined surfaces 18'' forming an angle of 90° whose point coincides with the center of the spheres. The side walls 21 of the ends of the grooves are a continuation of the inclined surfaces 18'' of the middle portion of the grooves and are parts of surfaces of right angled cones whose apex coincides with the center of the spheres.

The drive shaft member, shown in Fig. 3, consists of a drive shaft 23 with a flat side 24 connected thereto and adapted to fit into groove 19. The slide 24 comprises two horns 25, only one of which is visible in Fig. 3. The drive shaft 23 is rotatable in a bearing 26 formed in the pump casing 11 and more specifically in the liner 12 (see Fig. 1). A stub shaft member, shown in Fig. 5, consists of a stub shaft 27 with a flat slide 28 connected thereto and adapted to fit into groove 20. The slide 28 comprises two horns 29 and 30. The stub shaft 27 is mounted in a bearing (to be described later) in such manner that it is inclined at an angle A to the axis of drive shaft 23. The extension of grooves 19 and 20 through arcs greater than 180 degrees provides relatively large guide and sealing surfaces for the slides 24 and 28.

In the assembled pump there are formed four similar chambers between the faces 21 of the grooves 19 and 20 on the one hand, and the ends of horns 25, 29 and 30 on the other hand. During operation, the drive shaft 23 is rotated by any suitable power means (not shown). The slide 24, connected with shaft 23, causes the rotor 17 to rotate. The rotor 17 in turn, through slide 28, imparts rotation to stub shaft 27. Due to the angular disposition of stub shaft 27 relative to drive shaft 23, however, an oscillating motion is imparted to the rotor 17 during its rotation, causing the aforementioned chambers to open and close during each revolution of the drive shaft 23. In Fig. 1, one such chamber is shown at 31 in the open condition, and another at 32 in the closed condition. Consequently, as the drive shaft 23 and with it rotor 17 revolves, said four chambers open and close to produce a pumping action, opening on suction and closing on discharge to give four discharges per revolution.

It is apparent that the discharge of the pump can be regulated by varying the angle A between the drive shaft 23 and the stub shaft 27. The means for providing adjustability of the stub shaft form the main feature of this invention.

As shown in Figs. 1 and 2, a rotatable bearing member 33 has eccentrically formed therein a bearing 34 for the stub shaft 27, the latter extending into and being guided by a slot 35 in a cover 36 attached to casing 11. Another rotatable member 37 is rotatable in a bearing 38 formed in casing 11 co-axially with the drive shaft bearing 26. The rotatable member 37 has eccentrically formed therein a bore 39 in which the member 33 is rotatable. The previously mentioned angle A between the drive shaft 23 and the stub shaft 27 consists of the sum of angle B between the stub shaft bearing 34 and the axis of rotatable member 33 plus angle C between the axis of bore 39 and the axis of bearing 38, said angles B and C being preferably equal. The axes of bore 39 (and rotatable member 33) and of bearing 34 (and stub shaft 27) both pass through the center of the spherical rotor 17, as clearly shown in Fig. 1.

The rotatable member 33 carries a gear 40 meshing with a bevel gear 41 which, together with a spur gear 42, is mounted on a sleeve 43 rotatable on a shaft 44 on rotatable member 37. Another spur gear 45, rotatable on a shaft 46 on rotatable member 37, meshes with the spur gear 42 and with an internal gear 47 fixed to casing 11. The rotatable member 37 has attached thereto a worm gear 48 meshing with a worm 49 on shaft 50 extending to the outside of casing 11 and provided with a knob 51.

By manually turning knob 51, the rotatable member 37 may thus be rotated in a clockwise direction as indicated by arrow 52 in Fig. 2. This causes spur gear 45, rolling on internal gear 47, to turn in a counterclockwise direction as indicated by arrow 53. Spur gear 42, meshing with spur gear 45, consequently rotates clockwise, as shown by arrow 54, and bevel gear 41 rotates with it, causing the gear 40 and, with it, the member 33 to rotate counterclockwise, as indicated by arrow 55, while, at the same time, the axis of bore 39 in which member 33 turns, rotates clockwise, being located in member 37. Due to these interlocked movements, the stub shaft 27, guided in slot 35, moves in the plane 1—1 (that is in the plane of Fig. 1) as indicated by arrow 56, until eventually the positions shown in broken lines in Fig. 2 are reached, wherein the drive shaft 23 and the stub shaft 27 are co-axial and the angle A is zero. With this adjustment, the previously described oscillating motion of the rotor 17 ceases, the chambers 31 and 32 become

equal in size, and the discharge of the pump is zero. Further turning of the knob 51 in the same direction brings the stub shaft 27 below the axis of the drive shaft 23 and causes the pump to discharge again, but now in a reverse direction so that what formerly was the inlet is now the outlet, and vice versa.

It should be emphasized that the shifting of the stub shaft, i. e. the change in the angle A, takes place in the plane of Fig. 1. It is apparent that attainment of tight seals between casing 11 and rotary member 37 on the one hand, and between rotary members 37 and 33 on the other hand, presents no problem, especially if packing rings 57 and 58 are provided, as shown in Fig. 1. The face 59 of the rotary member 33 is convex-spherical and engages a concave-spherical surface 60 on the inside of cover 36, so that a tight joint between these parts is likewise provided. Since the adjustment of stub shaft 27 is attained by rotation of circular surfaces, the specific pressure on all bearing surfaces of the parts of the adjustment mechanism is equal in all angular positions of the stub shaft 27.

In Figs. 7 to 10 are shown modifications of the pump and of the mechanism for adjusting the stub shaft. In this arrangement, the spherical rotor consists of two hollow halves 61 and 62 jointed together by a central member 63 which is connected to both halves 61 and 62 by suitable screw means (not shown). The pump casing 11 with liners 12 and 13, drive shaft 23 with slide 24, stub shaft 27 with slide 28, rotatable members 37 and 33 including stub shaft bearing 34 are like those of Figs. 1 to 6, as are the means for rotating the member 37, comprising worm gear 48, worm 49, shaft 50, and knob 51.

However, the mechanism for interlocking the rotary motions of rotary members 33 and 37 to provide shifting of the stub shaft 27 in a given plane is different from the gearing arrangement shown in Figs. 1 and 2, although the same result is attained. In this modification, the casing 11 has attached thereto by screws (not shown) a cover 64 with a concave-spherical surface 65 concentric with rotor 61, 62 and engaging the convex-spherical surface 59 on rotatable member 33. In the cover 64 is provided a slot 66 (similar to slot 35 of Fig. 1) through which the stub shaft 27 passes. The cover 64 has, furthermore, three diametrically extending grooves 67, 68 and 69 which are disposed at angles of 45 degrees to each other and to slot 66, as clearly shown in Figs. 9 and 10.

The rotatable member 33 is provided on surface 59 with three guide pins 70, 71 and 72 which may be formed integrally on member 33, as shown, or which may be separate rods press-fitted or screwed into suitable holes in member 33. The guide pins 70, 71 and 72 are arranged to slide back and forth in grooves 67, 68 and 69, respectively. For a clearer understanding, the slot 66 and the grooves 67, 68 and 69 have been indicated in Fig. 8 by dash-dotted lines.

With the stub shaft 27 at its maximum elevation in which its axis includes the angle A with the axis of bearings 26 and 38 the rotary member 33, stub shaft 27 and guide pins 70, 71 and 72 occupy the positions shown by solid lines in Fig. 8. On rotating the rotary member 37 in a clockwise direction, as indicated by arrow 73, by turning the knob 51 or by other suitable means, the rotary member 33, resting in the eccentric bore 39 of member 37, is forced to rotate counter-clockwise, as indicated by arrow 74. During such rotation of member 37 through 90 degrees, the guide pin 70 moves through groove 67 in the direction of arrow 75 to the dotted position; the guide pin 71 moves through groove 68 in the direction of arrow 76 to the dotted position; the guide pin 72 moves through groove 69, at first in the direction of arrow 77, then stops, and returns to the position shown in solid lines; the stub shaft 27 moves through slot 66 in the direction of arrow 78 to the position formerly occupied by guide pin 71; and the rotatable member 33, in addition to its counter-clockwise rotation, shifts to the position indicated by dotted lines. In this new position, the angle A becomes zero, i. e. the axes of drive shaft 23 and stub shaft 27 coincide. When that occurs, the discharge of the pump becomes zero, as has been fully explained in connection with Figs. 1 to 6.

If rotation of rotatable member 37 is continued beyond 90 degrees, the stub shaft 27 moves downward in slot 66 below the central position and the pump begins to discharge again at a gradually increasing rate, but in a reverse direction, as previously explained. During this continued rotation of member 37, the guide pin 70 moves in groove 67 at first further in the direction of arrow 75, then reverses its motion and returns towards the dotted position; the guide pin 71 moves in groove 68 in a direction opposite to that indicated by arrow 76 towards the solid line position; and the guide pin 72 moves in groove 69 in a direction opposite to that indicated by arrow 77 through and beyond the center. If the rotation of member 37 is continued through another 90 degrees, the angle between the axis of stub shaft 27 and the axis of bearings 26 and 38 reaches its maximum value A. Thus, with this modification, as with the embodiment shown in Figs. 1 to 6, the stub shaft 27 may be steplessly adjusted from maximum angularity on one side through zero to maximum angularity on the other side, whereby the pump discharge is varied from maximum rate of flow in one direction through zero to maximum rate of flow in the opposite direction.

In the arrangement of Figs. 7 to 10, additional cover means 79 are provided to cover up the end of stub shaft 27 projecting through slot 66, the cover means 79 being fitted with a window 80 co-extensive with slot 66 to permit observation of the position of stub shaft 27 in slot 66, indicative of the pump discharge adjustment.

A particular advantage of the stub shaft adjustment according to my invention is that it permits a fine, stepless adjustment such as has been unattainable hitherto. When pumping highly viscous or more or less congealing liquids, my adjustment makes it possible to vary the discharge and with it the power requirement of the pump to match the capacity of the drive motor and so avoid overloading the motor. The usefulness of my novel adjustment is, of course, not confined to the exact type of universal joint principle pump shown, but extends to other types such as those employing pin joints between shafts and rotor in place of the cooperating slides and grooves herein disclosed.

While I have shown and described what I consider the preferred embodiments, I realize that modifications other than those disclosed herein may be made without departing from the spirit of my invention, and reference is, therefore, made

to the following claims for a definition of the scope of my invention.

What I claim is:

1. A ball piston pump comprising a casing having a spherical chamber therein and an inlet and an outlet for said chamber, a solid spherical rotor slidably concentrically fitted in said chamber and having two longitudinal grooves in its surface, said grooves being disposed at a right angle to each other, two flat substantially semi-circular slides slidably fitted in said grooves, each slide having a spherical outer surface portion slidably concentrically fitting in said chamber, a drive shaft connected with one of said slides, a stub shaft connected with the other of said slides, and means movably connected with said casing for shifting said stub shaft with the slide to which it is connected in a plane containing the axis of said stub shaft and the axis of said drive shaft and thereby varying the angle between said stub shaft and said drive shaft.

2. A pump as defined in claim 1, each of said grooves extending through an arc greater than 180 degrees and having end faces substantially conforming with the end faces of said slides.

3. A pump as defined in claim 1 comprising two co-axial bearings disposed in said casing on opposite sides of said rotor, said drive shaft passing through one of said bearings, a rotatable member independent of said drive shaft and extending through the other of said bearings, a bore in said rotatable member having an axis passing through the center of said spherical rotor and inclined to the axis of said bearings, bearing means rotatably fitted in said bore and comprising a bearing for said stub shaft, said bearing having an axis passing through the center of said spherical rotor and inclined to the axis of said bore, and means supported in and extending to the outside of said casing for rotating said rotatable member.

4. A pump as defined in claim 3, said last named means comprising a worm gear attached to said rotatable member, a worm meshing with said worm gear, a shaft for said worm supported in and extending to the outside of said casing, and means connected with said last named shaft for rotating said last mentioned shaft.

5. In a pump as defined in claim 3, a cover for said casing, a slot in said cover, said stub shaft extending through and being guided in said slot, a concave-spherical inside surface on said cover, and a convex-spherical outside surface on said bearing means slidably engaging said concave-spherical surface on said cover.

6. In a pump as defined in claim 3, an internal gear fixed in said casing, a pair of intermeshing spur gears rotatably mounted on said rotatable member, one of said spur gears meshing with said internal gear, and means cooperating with the other of said spur gears to rotate said bearing means.

7. In a pump as defined in claim 3, a cover for said casing, a slot in said cover, said stub shaft passing through and being guided by said slot, three grooves extending diagonally across said cover and being disposed at angles of 45 degrees to each other and to said slot, and three guide pins on said bearing means, each of said guide pins being arranged to slide back and forth in one of said grooves on rotation of said rotatable member.

8. In a pump as defined in claim 7, cover means mounted over said cover, and a window in said cover means co-extensive with said slot.

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