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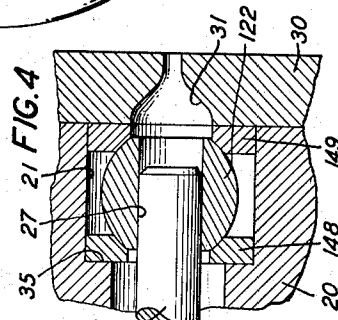
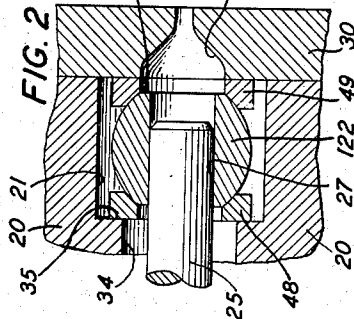
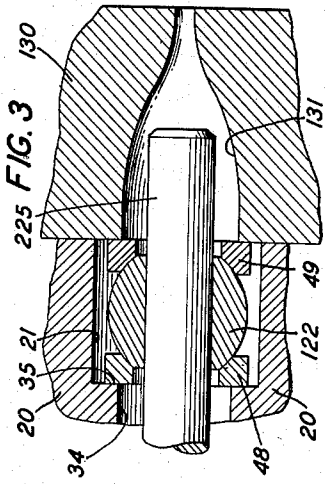
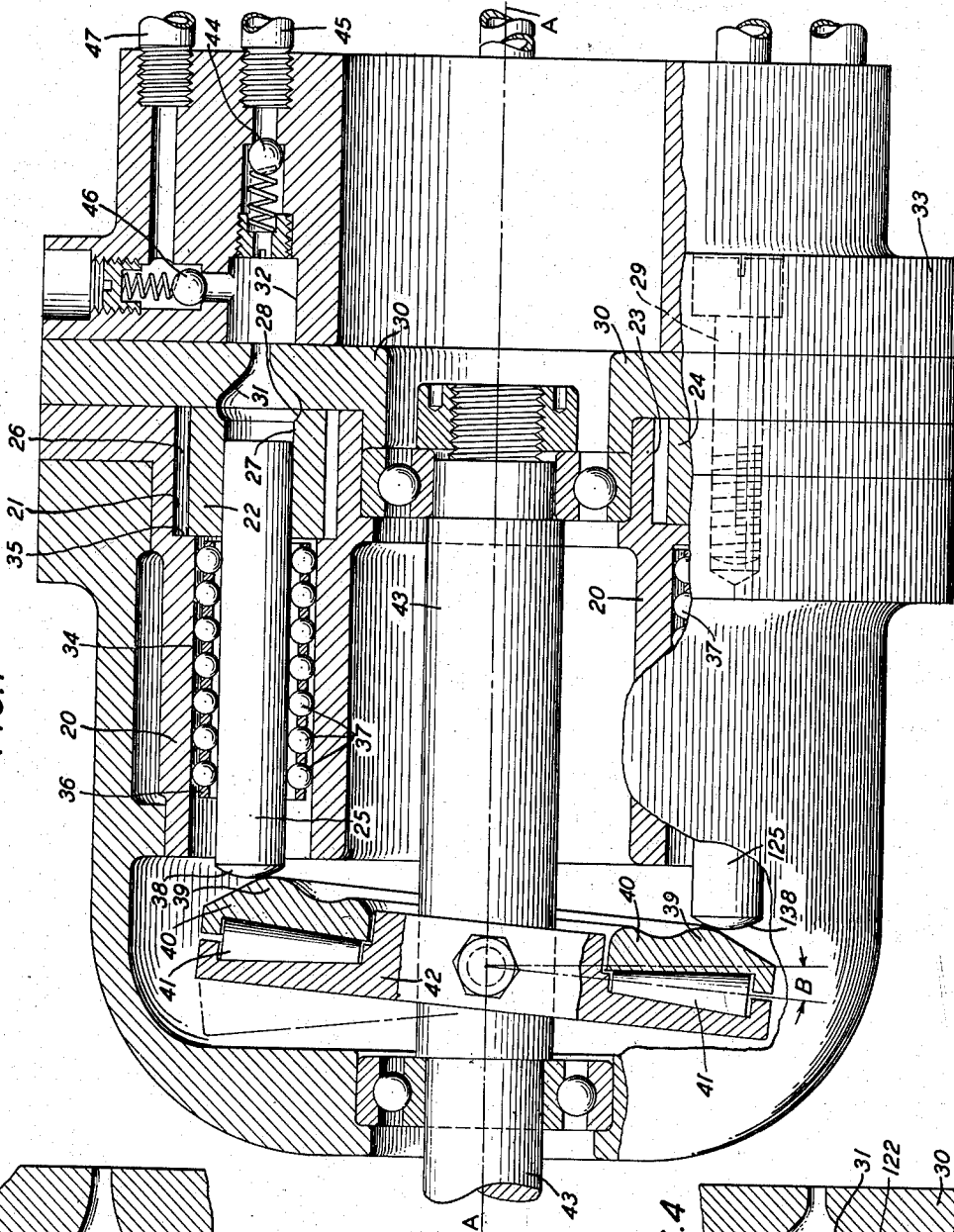
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RECIPROCABLE TELESCOPIC MEMBERS

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FIG. 1



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RECIPROCABLE TELESCOPIC MEMBERS

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This invention relates to reciprocable telescopic members and more particularly to a cylinder and piston to be used in connection with liquids under high pressure.

There is a considerable class of hydraulic apparatus, both pumps and motors, in which an annular plurality of mutually parallel cylinders have their pistons elongated as integral piston rods which are abutted by a wobble plate secured to a rotating shaft coaxial with and central among the cylinders. If the pistons drive the wobble plate and thereby the shaft, the engine is a motor; contrariwise, it is a pump. Such hydraulic engines work, often, with high liquid pressures and with considerable stresses on the moving parts. In particular, the stress between the wobble plate and any one of the pistons has a fairly constant major component along the axis of the piston and cylinder which does the useful work of the engine. There is also, however, a minor component at right angles thereto which varies cyclically between zero and a maximum radially out from the main axis of the engine during each revolution of the shaft. This last component is negligible at low pressures, but becomes increasingly troublesome as higher pressures come into use, since it tends to cause the pistons to tilt in the cylinders, to cramp in them, and to score and ruin both cylinder and piston. There are other analogous structures where one of two telescopically interfitted parts reciprocates with respect to the other under more or less transverse stress tending to tilt one with respect to the other, where similar difficulties arise.

An object of the present invention is to provide a structural arrangement for mutually reciprocable telescopically interfitted parts, such as a cylinder and piston, to maintain strict coaxiality of the parts and ease of reciprocation under heavy stresses and particularly under transverse stress tending to bring one part out of coaxial alignment with the other.

With the above and other objects in view the invention may be embodied in a pair of relatively reciprocable and telescopically interfitted members, the inner member of which is of greater axial length than the outer, guiding means to support the portion of the inner member not contained within the outer member and to thereby support the inner member against major bodily displacement transverse to the axis thereof and against major angular displacement, and means to support the outer member positively against bodily displacement

along the axis thereof but with freedom to float rotatably and to float transversely to the axis thereof.

Other objects and features of the invention will appear from the following detailed description of one illustrative embodiment thereof taken in connection with the accompanying drawing in which the same reference numerals are applied to identical parts in the several figures and in which

Fig. 1 is a view in side elevation and partly in section of an apparatus constructed in accordance with the invention;

Fig. 2 is a partial similar view of a modified form;

Fig. 3 is a partial similar view of another modified form, and

Fig. 4 is a partial similar view of a third modified form.

Fig. 1 discloses a wobble plate driven pump, particularly adapted to pump small volumes of liquid from heavy pressure against still heavier pressure, and comprising a cylinder block 20 in which are four cylinder housing chambers parallel to each other and spaced equally both from and about a main machine axis A—A. One of these cylinder housing chambers 21 is shown in full section in the upper part of Fig. 1 and contains a pump cylinder proper 22. Another cylinder housing chamber is indicated at 23 diametrically opposite the chamber 21 with respect to the axis A—A and containing a cylinder 24. The other two of the four cylinder chambers and their contained cylinders and associated elements are not shown: One, lying in front of the axis A—A has been cut away by the section, and the other is hidden at the rear. Since the system comprising any one of the four cylinders and its related elements is identically similar to any other and the invention pertains to the cylinder and piston structure, it will suffice for present purposes to consider the cylinder 22, its piston 25 and elements related thereto. The housing chamber 21 is a cylindrical recess in the plane right face of the cylinder block 20. The cylinder proper 22 is externally a cylinder of somewhat smaller diameter and of the same length as the chamber 21, so that there is an annular space 26 between the wall of the housing chamber 21 and the outer wall of the cylinder 22. The cylinder has a cylindrical bore 27 running through it, coaxial with the chamber 21 and axially parallel to the axis A—A. At its right end the bore 27 is conically widened or countersunk at 28.

A common cylinder head 30 is secured on the right end face of the block 20 by an annular plurality of screws 29 and clamps the cylinder 22 against the rear or left wall of the recess or chamber 21. In the head 30 is a reversely arcuately curved, funnel-shaped chamber or passage 31 whose large end matches and registers with the flared countersink 28 of the cylinder bore 27, and whose small end communicates with a pressure chamber 32 in a cap 33 secured on the head 30 by the screws 29.

The piston 25 in the bore 27 may be considered for present purposes as a rigid, solid cylindrical rod whose outer diameter so matches the diameter of the bore 27 as to form a freely slidable and yet liquid tight fit therewith. The right or front end of the piston is plane and square across with the outer edge broken enough to avoid too great sharpness and danger therefrom to the liquid film between the piston and cylinder. The piston is so dimensioned that, when it is in the position of its farthest excursion into the cylinder, as illustrated in the upper part of Fig. 1, the length of the rearward or left portion of the piston still outside of the chamber is up to preferably several times the length within the cylinder, say about six times as shown. This long rear portion of the piston 25 is housed within a considerably larger bore 34, coaxial with and in effect a counterboard extension of the chamber 21, but of less diameter than this to provide a stop shoulder 35 against which the cylinder 22 is clamped by the cylinder head 30.

In the annular space between the wall of the bore 34 and the piston 25 is an annularly cylindrical ball cage 36 containing a plurality of bearing balls 37 on which the outer or rear part of the piston is supported and guided in the bore 34 as the piston head reciprocates in the bore 27. The rear or left end of the piston is formed as a spherically curved rocker surface 38 to make contact with and rock on the toroidally curved rocker surface 39 on a wobble drive ring 40 which is also the front race for a ring of bearing cones 41 whose rear race is on the periphery of a wobble plate 42 secured on a shaft 43 journaled to have the axis A—A as its axis. The wobble plate 42 is a disc rigidly secured on the shaft 43 so that the disc is out of perpendicularity to the shaft by the angle B.

The shaft 43 may be driven in rotation by any suitable motive means not shown. The shaft then rotates the wobble plate or disc 42, which is so called because it appears to wobble or reciprocate angularly to and fro as it rotates on the axis A—A which is not perpendicular to the plane of the axes of the cones 41. The drive ring 40 does not rotate about the axis A—A, but is forced to rock to and fro by the "wobble" component of the motion of the plate 42. At each revolution of the plate 42, in wobbling from the position indicated by dot-and-dash lines in Fig. 1 to the position shown in full lines, the ring 40 drives the piston 25 rightwardly to the position shown, putting pressure on liquid filling the chambers 31 and 32. The check valve 44 prevents escape of liquid via the intake pipe 45; but the exhaust check valve 46 opens to permit liquid to escape via the exhaust pipe 47. On the return stroke, as soon as pressure on the piston begins to be relieved by the wobble plate backing away, liquid under pressure from the intake opens the valve 44, forces the piston back and refills the chambers 31 and 32.

Under the heavy pressure engendered by the

forward stroke of the piston in the chamber 31, there may be some minute elastic yielding of the various members and parts. Hence the countersunk or chamfered surface 28 is formed on the cylinder 22. The back pressure on this surface forces the cylinder 22 back against its seat 35, so that there will be no leakage past the cylinder seat 35 and into the bore 34.

The piston 25 is fitted to the cylinder 22 with sufficient nicety so that no packing or piston rings or the like are needed. The thin film of liquid between is sufficient to seal this sliding joint even at very high pressures. With such nicety of fitting, the original attainment and subsequent maintenance of strict coaxiality of the piston 25 and the cylinder bore 27 is difficult, especially considering that the principal length of the piston is supported and guided during operation by the bearing balls 37 running in the bore 34. In the construction just described, however, the cylinder 22 floats in the chamber 21, being slidable therein on the seat 35 in any transverse direction, and thus can follow any small lateral displacement of the axis of the piston to remain strictly coaxial therewith, where otherwise the piston would tend to tilt and jam in the cylinder. Thus one factor tending to make trouble in such structures generally, is obviated.

There remains a more serious difficulty. In operation, the contact point of the toroidal wobble ring drive surface 39 with the spherical drive surface 38 of the piston shifts cyclically to and fro, from a position on the axis of the piston at midstroke to an extreme position toward the axis A—A as shown in Fig. 1 at both the top and bottom of the ring where the surfaces 39 are in contact with the drive surfaces 38 and 38 of the pistons 25 and 125, at either end of a stroke. When this contact point is in the axis of the piston at midstroke, all the force of the drive ring against the piston acts in the axial direction; but, as the contact point moves away from the piston axis inwardly with respect to the axis A—A of the ring, there is an increasing component of force delivered by the ring to the piston transverse to the axis of the latter. Where relatively low liquid pressures are in question, this transverse force component may be negligibly immaterial; but when high pressures come into play, it may become seriously troublesome. Acting transversely to the direction of motion of the piston and to the latter's supports, this force component tends to tilt the piston cyclically out of its proper alignment, and tends to cramp the piston in the cylinder, break the liquid seal and lubrication film between these, and mechanically damage both.

Hence, besides making the cylinder 22 float in the chamber 21 transversely to its axis, it may well be preferable to render the cylinder tiltable also with respect to the line of normal motion of the piston. In Fig. 2, the outer surface of the cylinder 122 is made spherical and this sphere is supported in two correspondingly shaped bearing rings 48 and 49. The ring 48 has a flat rear face to bear against the stop shoulder 35; and the ring 49 has a flat forward face to bear against the cylinder head 30. The assembly consisting of the cylinder 122 and the rings 48 and 49 then floats in the chamber 21 axially thereto, as a whole, as the cylinder 22 does in Fig. 1. In addition, the spherical block 122 will float rotatably in its bearings 48 and 49 and will thus follow any slight tilt of the piston 25 not prevented by the bearing balls 37. The inner diameter of the ring 49 is made somewhat larger than the bore 27 of the cylinder

122 and the forward end of the cylinder is cut transversely flat across as at 128. Liquid pressure on this face 128 then seals the sphere 122 into its seat in the ring 48 and also seals this ring against its seat 35. Since the cylinder 122, in this construction, is free to follow both transaxial bodily displacements and tilts of the piston, all of the difficulties described are obviated.

There still remains the possibility that the lever arm of the piston 25 in the cylinder 122 to rotate this in the bearing rings may be too short. Hence, as in Fig. 3, the piston 225 may be made to extend through the cylinder 122 and have its outer end in the chamber 131 at all times. The cylinder 122 then becomes in effect a bearing and the piston 225 a plunger acting in the chamber 131.

The structure of Fig. 1 is applicable where only possible transaxial bodily displacements of the piston are to be rendered harmless. Where both such displacements and angular displacements are in question, the structures of Figs. 2 or 3 may be employed.

If angular displacements only are at stake, the structure of Fig. 4 may be sufficient. This is identical with the arrangement shown in Fig. 2 in every way except that the bearing rings 148 and 149 fit snugly into the chamber 21 and so the cylinder 122 supported in these rings cannot float transversely.

It will be noted that in all four figures any large displacement of the piston, either bodily or angular, is positively prevented by the long bearing provided by the bearing balls 37, while any minor displacement of either kind which cannot be positively suppressed by the ball bearing is rendered harmless by the mounting of the cylinder to be bodily transversely floating or to be rotatably floating or to be both.

What is claimed is:

1. A pair of relatively reciprocable and telescopically interfitting members, the inner member of which is of greater axial length than the outer, guiding means to support the portion of the inner member not contained within the outer member and to thereby support the inner member against major bodily displacement transverse to the axis thereof and against major angular displacement, and means to support the outer member positively against bodily displacement along the axis thereof but with freedom to float transversely to the axis.

2. A pair of relatively reciprocable and telescopically interfitting members, the inner member of which is of greater axial length than the outer, guiding means to support the portion of the inner member not contained within the outer member and to thereby support the inner member against major bodily displacement transverse to the axis thereof and against major angular displacement, and means to support the outer member positively against bodily displacement along the axis thereof but with freedom to float rotatably and to float transversely to the axis thereof.

3. A cylinder, a piston reciprocable in the cylinder and having a piston rod rigid therewith, guide means for the piston rod to support the same against major bodily displacement transverse to the axis thereof and against major angular displacement, and means to support the cylinder positively against bodily displacement along the axis thereof but with freedom to float transversely to the axis.

4. A cylinder, a piston reciprocable in the cylinder and having a piston rod rigid therewith, guide means for the piston rod to support the same against major bodily displacement transverse to the axis thereof and against major angular displacement, and means to support the cylinder positively against bodily displacement along the axis thereof but with freedom to float rotatably and to float transversely to the axis thereof.

5. A block having a cylinder receiving recess therein and a bore communicating with the floor of the recess and coaxial with the recess, a cylinder in the recess and resting against the floor thereof and of less external diameter than the internal diameter of the recess, means to press the cylinder against the floor of the recess to support the cylinder against bodily displacement along the axis thereof but with freedom in the recess to float transversely to the axis, a piston reciprocable in the cylinder, a piston rod rigid on the piston and extending into the bore, and bearing means in the bore between the wall thereof and the piston rod to support the same against major bodily displacement transverse to the axis thereof and against major angular displacement.

6. A block having a cylinder receiving recess therein and a bore communicating with the floor of the recess and coaxial with the recess, a cylinder in the recess and having a piston receiving bore therethrough and having its outer surface spherically curved, a supporting ring interposed between the floor of the recess and one end of the cylinder and having one face shaped to fit the floor of the recess and the opposite face shaped to fit the spherical outer surface of the cylinder, means to press the cylinder against the ring to support the cylinder against bodily displacement but with freedom to float rotatably on the ring, a piston reciprocable in the bore of the cylinder, a piston rod rigid on the piston and extending into the bore in the block, and bearing means in the bore between the wall thereof and the piston rod to support the same against major bodily displacement transverse to the axis thereof and against major angular displacement.

7. A block having a cylinder receiving recess therein and a bore communicating with the floor of the recess and coaxial with the recess, a cylinder in the recess and of less diameter than the recess and having a piston receiving bore therethrough and having its outer surface spherically curved, a supporting ring of less diameter than the recess interposed between the floor of the recess and one end of the cylinder and having one face shaped to fit the floor of the recess and the opposite face shaped to fit the spherical outer surface of the cylinder, means to press the cylinder against the ring to support the cylinder against bodily displacement but with freedom to float rotatably on the ring and to float transversely to the axis of the recess, a piston reciprocable in the bore of the cylinder, a piston rod rigid on the piston and extending into the bore in the block, and bearing means in the bore between the wall thereof and the piston rod to support the same against major bodily displacement transverse to the axis thereof and against major angular displacement.

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