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VARIABLE DISPLACEMENT FLUID APPARATUS

Filed Oct. 13, 1947

2 SHEETS—SHEET 1

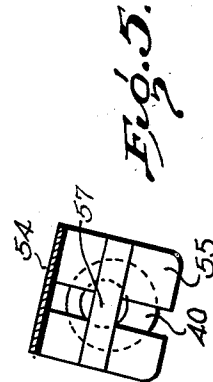
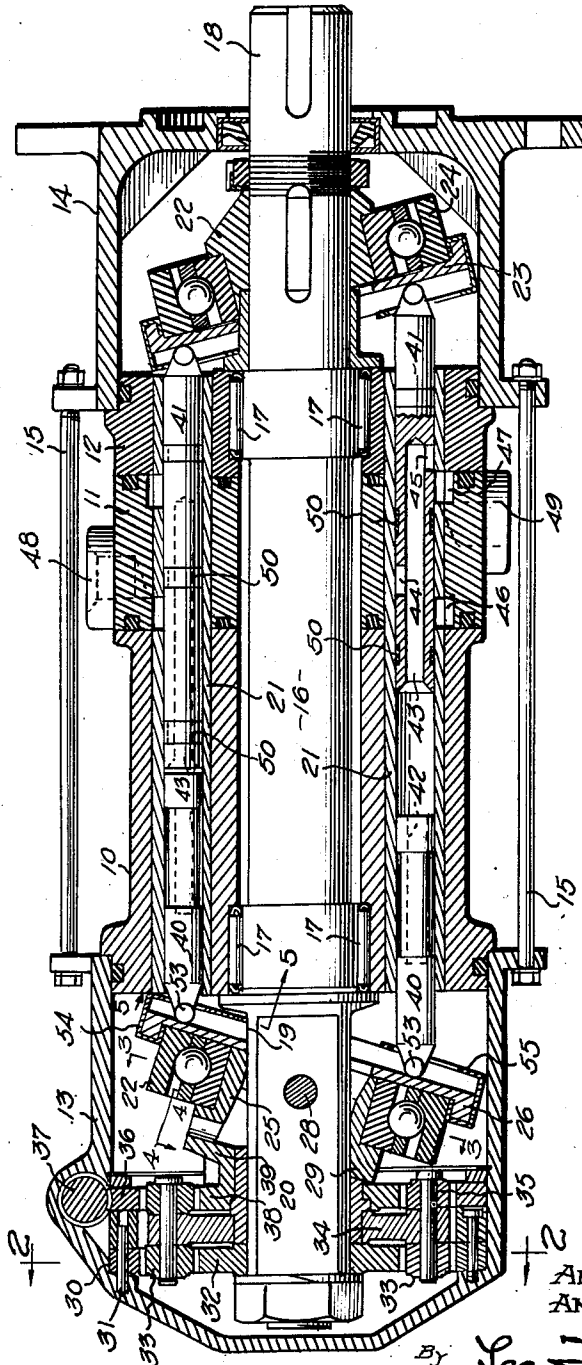
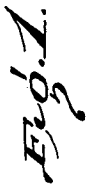


Fig. 5.

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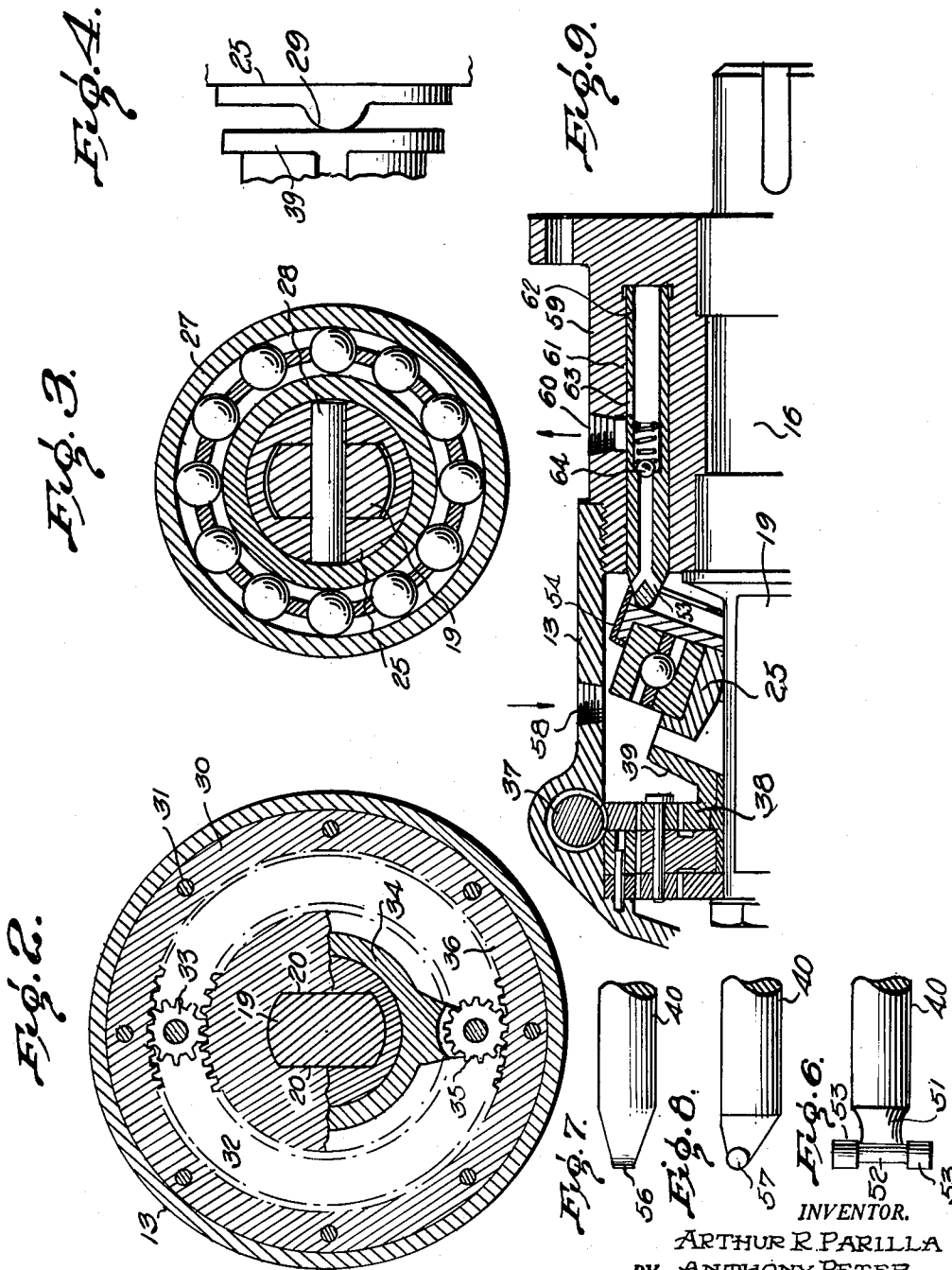
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2 SHEETS—SHEET 2



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See *Fig. 1* Townsend

UNITED STATES PATENT OFFICE

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VARIABLE DISPLACEMENT FLUID APPARATUS

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6 Claims. (Cl. 103—38)

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Our invention relates to fluid apparatus adapted to serve as a pump or motor, and this application is a continuation in part of our copending application Serial No. 545,346 filed July 17, 1944, now Patent No. 2,428,809.

An object of this invention is to provide control means operative to vary the fluid displacement of the apparatus and thus to regulate the volume of fluid passed therethrough.

Another object is to provide in a fluid apparatus having pistons reciprocable and rotatable by end contact with wobble plates or the like, means coupling the wobble plates and pistons in a manner to insure positive reciprocal movement of the pistons at all times during the actuation of the wobble plates and without impedance to rotary movement of the pistons.

Other objects include those comprised in our prior copending application above identified as well as those apparent to persons skilled in the art.

In the drawings:

Figure 1 is substantially a vertical longitudinal section through the apparatus;

Figure 2 is a section taken on the line 2—2 of Figure 1;

Figure 3 is a section taken on the line 3—3 of Figure 1;

Figure 4 is a section taken on the line 4—4 of Figure 1;

Figure 5 is a section taken on the line 5—5 of Figure 1;

Figure 6 is a fragmentary elevation of the outer end portion of a piston forming an element of the assembly;

Figure 7 is an elevation similar to Figure 6 but illustrating an alternative embodiment of piston end structure;

Figure 8 is a fragmentary elevation similar to Figure 7 but illustrating a further alternative embodiment of piston end structure;

Figure 9 is a longitudinal vertical section of an alternative structural embodiment of the apparatus.

In the embodiment of the apparatus shown in Figure 1 the structure comprises an axially bored, cylindrical, sectional housing including a combined main body and end section 10, an intermediate manifold section 11, and an end section 12 held in assembled relation by end cap housings 13 and 14 secured by tie bolts 15. A shaft 16 extends axially through the sections and is journaled on roller bearings 17 in the end sections 10 and 12. The shaft 16 extends at one end entirely through the cap housing 14 to

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provide an external end 18 arranged for operative connection with power take-off or input means, not shown. At its other end the shaft is provided with a tongue 19 having two parallel plane side faces 20 chordal to the perimeter of the shaft. The tongue is preferably an integral part of the shaft and extends fully into but not through the end cap 13.

As in our said prior application, the housing assembly is provided with a circumferential series of equidistantly spaced bores arranged radially of the shaft receiving bore with their axes parallel thereto. Each bore mounts a cylinder liner 21 open from end to end and comprising a single unit coextensive in length with the length of the assembled housing sections 10, 11 and 12.

Within the confines of the cap 14 the shaft 16 has keyed or otherwise suitably mounted thereon a fixed angle wobble plate 22 having an inclined rotary bearing plate 23 carried by the outer race 24 of a ball bearing assembly forming a part of the wobble plate structure. At the other end of the apparatus within the cap 13 the shaft tongue 19 has pivotally mounted thereon a variable angle wobble plate 25 similar to the wobble plate 22 in that it carries a rotary bearing plate 26 on the outer race 27 of its ball bearing assembly. With reference to Figure 3, it will be seen that the wobble plate 25 pivots on a pin 28 disposed transversely through the shaft tongue 19 with its axis perpendicular to the axis of the shaft. On its outer face the plate is formed with a pair of rounded ribs or projecting elements 29 arranged in diametrically opposed relation in a plane disposed at right angles to the axis of the pivot pin 28.

Control means for varying the angle of inclination of the wobble plate 25 to regulate the output or input of the apparatus is disposed in the cap housing 13. In the present embodiment of our invention the means comprises a double planetary gear train. The outer set has an outer ring gear 30 fixed on the cap 13 by appropriate securing means 31. The sun gear 32 is fixed to the shaft tongue 19 for rotation with the shaft 16 and drives at its R. P. M. the planet gears 33. Those gears 33 are journaled on a spider 34 that is freely rotatable on the shaft tongue and which carries the planet gears 35 of the inner set. The ring gear 36 of the inner set is normally locked by meshed engagement with a worm gear on an actuator crank 37 which extends externally of the housing for manual or other operation. The planet gears 35 drive

the sun gear 38 which is mounted for rotary shifting movement with respect to the shaft tongue 19 in a direction dependent upon actuation of the worm crank 37. The second sun gear 38 is provided on its inner face with an annular cam 39 having an inclined bearing surface continuously in contact with the rounded ribs 29 of the variable wobble plate. By this arrangement, relative rotary shifting of the cam 39 varies the angle of inclination of the wobble plate and thus alters the stroke of pistons reciprocable in the cylinders 21.

Each cylinder liner 21 receives a pair of pistons 40 and 41 operatively engaged at their outer ends by the wobble plates in a manner to effect simultaneous reciprocation and rotation of the pistons. The pistons 40 at the variable wobble plate end of the apparatus are relatively shorter in length than the pistons 41 and are counter-bored from their inner ends for substantially half their length to provide chambers 42. The pistons 41 are counterbored from their inner ends for the major portion of their length to provide chambers 43 and each is formed with a pair of wall ports 44 and 45 spaced apart circumferentially one hundred and eighty degrees and spaced apart axially a distance appropriate for registry with ports in the liners 21 that are in communication with a pair of annular manifold passageways 46 and 47 in the manifold section 11. These passageways in turn communicate with the respective conduit ports 48 and 49 through which fluid is admitted to or passed from the apparatus. Preferably, the pistons 41 are provided with rings 50.

As shown in Figure 6, the outer end of each piston is formed with a reduced neck 51 terminating in a T-head 52 having enlarged cylindrical ends 53. The length of the head is somewhat greater than the diameter of the piston, and the cylindrical surfaces of the portions 53 are in line bearing contact against the bearing plate 23 or 26 of the adjacent wobble plate. By reason of this contact, which is continuous, the inclination of the wobble plate operates as the wobble plate is rotated to reciprocate the pistons and at the same time to rotate them for valving the fluid ports. In order to insure positive outward movement of the pistons under all conditions of their expansion stroke operation we provide on the wobble plate adjacent each piston a spring clip 54 suitably affixed rigidly to the wobble plate or its bearing plate. The spring clip is bifurcated to provide arms 55 which are engaged behind the cylindrical portions 53 of the T-head on the end of the adjacent piston. These arms 55 function to impart a positive outward pull to the pistons on their expansion strokes and, as they straddle the pistons, they present no interference to rotation of the pistons.

An alternative embodiment of piston end is shown in Figure 7 in which the outer end of the piston 40 is tapered in frusto-conical form and terminates in a plane contact face 56 having a diameter smaller than the diameter of the piston. The small bearing surface 56 is fully adequate when in contact with the bearing plate of the wobble plate to insure the necessary rotation and reciprocation of the piston. Figure 8 illustrates a further alternative embodiment of piston end in which the piston 40 is provided with a cross head 57 similar to the cross head 52 shown in Figure 6. In the embodiment of Figure 8 the axis of the cross head 57 is at right angles to the axis of the piston and is eccentric with respect to the

axis of the piston. This construction provides for a highly efficient line contact of the piston and with the adjacent wobble plate.

In the embodiment of the invention illustrated in Figure 9 the apparatus utilizes only one wobble plate which is variable for adjustment as in the form shown in Figure 1. The embodiment shown in Figure 9 has substantially the same arrangement of shaft 16 with its reduced tongue 19 mounting the variable wobble plate 25. The inclination of the wobble plate is adjusted by the same planetary gear mechanism and the elements are designated by the same reference characters as those employed in Figure 1. In this embodiment the end cap housing 13 is provided with a fluid port 58 through which fluid is admitted to or passed from the apparatus. The cap is fixed to a body casing 59 which is provided with a fluid port 60 in communication with a cylinder 61 provided in the casing. A piston 62 slidably and rotatably mounted in the cylinder end at its other end is provided with the same connection of cross head 53 and spring clip 54 illustrated in the embodiment of Figure 1. The piston 62 is formed with an axial passage 63 which opens at the outer end of the piston into the chamber formed within the cap 13. In the inner end of the passage 63 a check valve 64 is suitably mounted at the inner end of the counterbore 65 of the piston. The counterbore opens at the inner end of the piston to the interior of the cylinder. As in the preceding embodiment, the piston 62 is provided with a port for registry with the port 60 as the piston is reciprocated and rotated within the cylinder. In the operation of this alternative embodiment of the apparatus, the fluid is passed through the body of the piston past the check valve which opens on the expansion stroke of the piston and closes on the compression stroke.

In operation, variation of the angle of inclination of the variable wobble plate alters the stroke of the pistons 40 and thus varies the displacement. As the angle of inclination approaches a right angle with respect to the axis of the shaft 16 the piston stroke becomes shorter. When the wobble plate is disposed at a right angle to the shaft axis the set of pistons 40 is at zero stroke and the displacement is at one-half its maximum value, as the stroke of the opposed set of pistons is fixed. If the adjusting movement of the variable wobble plate is continued until its angle of inclination parallels that of the fixed wobble plate all pistons will be moving unidirectionally and the net displacement will be zero. If the inclination of the variable wobble plate is continued beyond the angle of zero displacement it will reverse the flow of fluid through the apparatus.

Port valving is accomplished by rotation of the constant stroke pistons and no ports are required in the variable stroke pistons except in the alternative embodiment shown in Figure 9. The pistons 40 may be solid if desired.

We claim:

1. Fluid apparatus comprising a cylinder having an inlet port and an outlet port, a piston rotatable and reciprocable therein to control at least one of said ports, a rotatable element inclined with respect to the cylinder axis and directly abutting an end of the piston for rotating and reciprocating the piston as said element is rotated, cam means slidably engaging and normally rotating with said inclined element, and mechanism for shifting said cam means relative to said inclined element during rotation of the

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two whereby to vary the angle of inclination of said element and alter the stroke of the piston.

2. Fluid apparatus comprising cylinders having inlet and outlet ports, a pair of opposed pistons rotatable and reciprocable in each cylinder, one set of pistons controlling the ports by rotation, an inclined element rotatable at a fixed angle of inclination relative to the port controlling pistons, means provided for said port controlling pistons bearing against said inclined element for imparting rotation to the pistons as the element is rotated, an inclined element rotatable relative to the other set of pistons and in engagement therewith, said last named element being variable as to inclination, and control means engaged with said last named element to vary the angle of inclination thereof.

3. Fluid apparatus comprising a cylinder having a port in its wall, a piston rotatable and reciprocable in the cylinder and controlling the port by rotation, the piston having a fluid passage opening through its outer end, means for admitting fluid through said passage, a check valve in the passage, an inclined element engaging the outer end of the piston and rotatable to impart rotation and reciprocation to the piston, and means for changing the angle of inclination of said element to vary the stroke of the piston.

4. Fluid apparatus comprising a cylinder, a piston rotatable and reciprocable therein, a shaft rotatable relative to the cylinder, a wobble plate on the shaft and rotatable therewith to actuate said piston, said wobble plate being pivotally mounted on the shaft on an axis at right angles to the shaft axis, control mechanism engaging the wobble plate and shiftable on the shaft for rocking the plate on its pivot to vary its incli-

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nation relative to the shaft axis, and planetary gear means on the shaft for actuating the control mechanism.

5. The structure of claim 4, and said planetary gear means including a self-locking actuator worm in mesh with a ring gear of the planetary gear.

6. Fluid apparatus comprising a cylinder having a port in its wall, a piston rotatable and reciprocable in the cylinder and controlling the port by rotation, the piston having a fluid passage opening through its outer end, means for admitting fluid through said passage, a check valve in the passage, and an inclined element engaging the outer end of the piston and rotatable to impart rotation and reciprocation to the piston.

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