

Oct. 3, 1944.

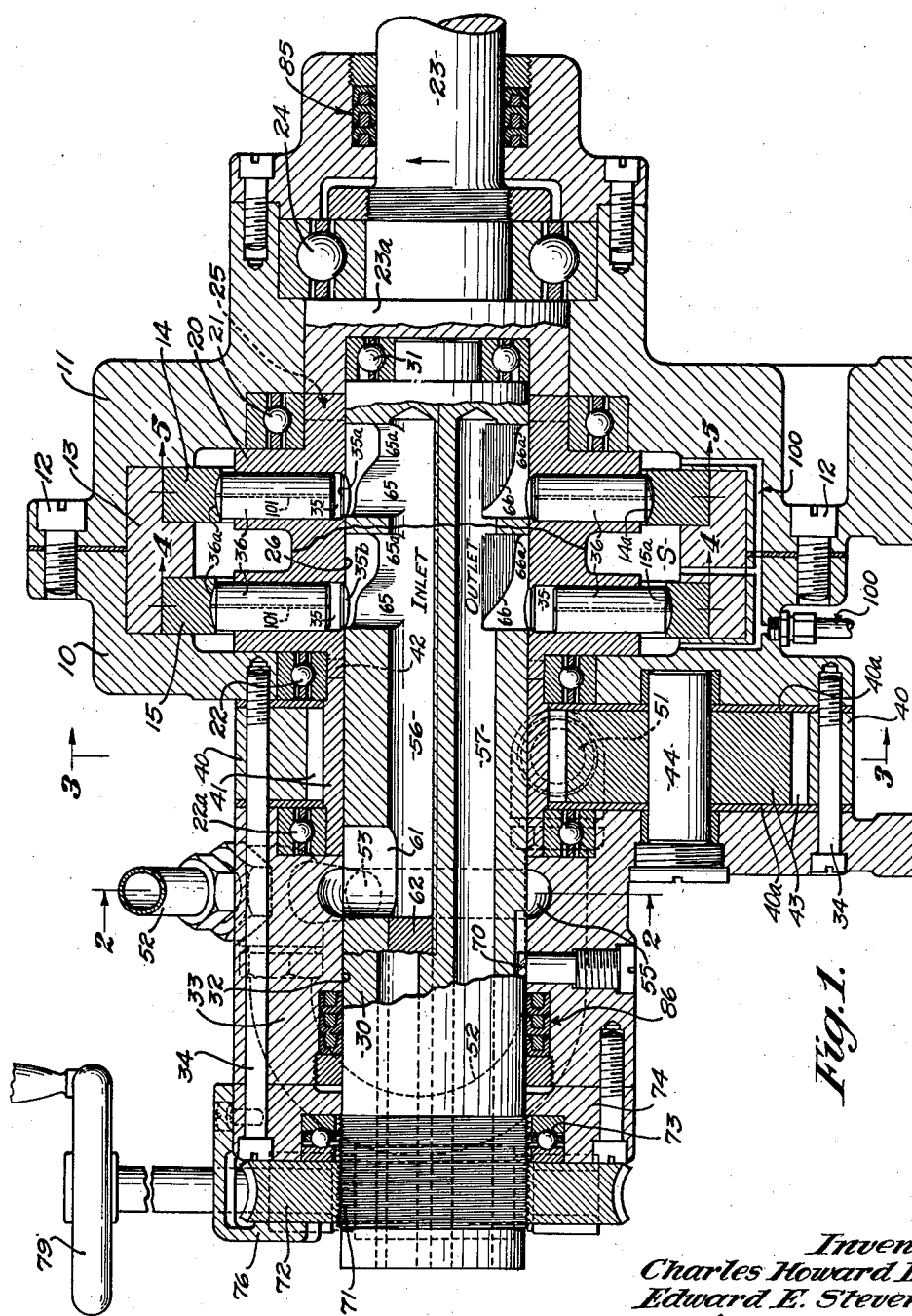
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2,359,513

VARIABLE VOLUME PUMP

Filed Sept. 29, 1942

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

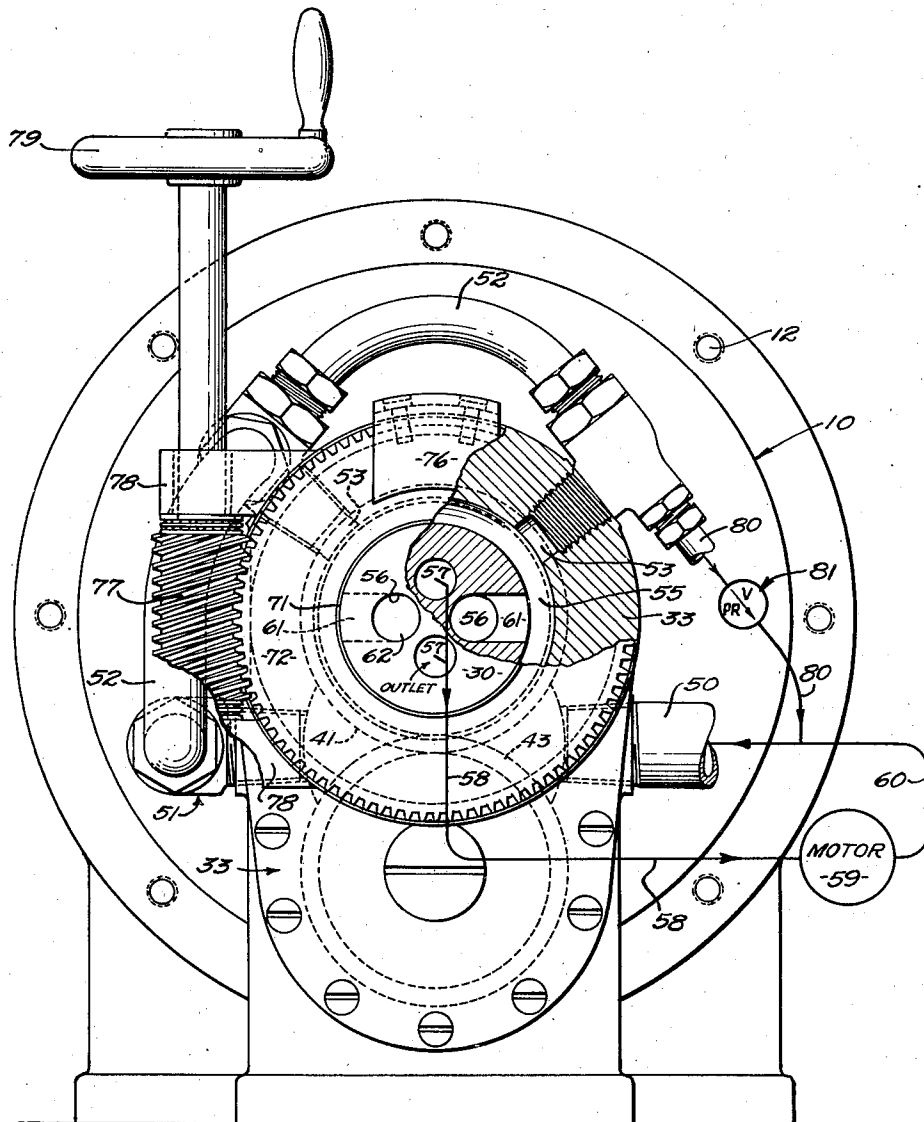


Fig. 2.

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4 Sheets-Sheet 3

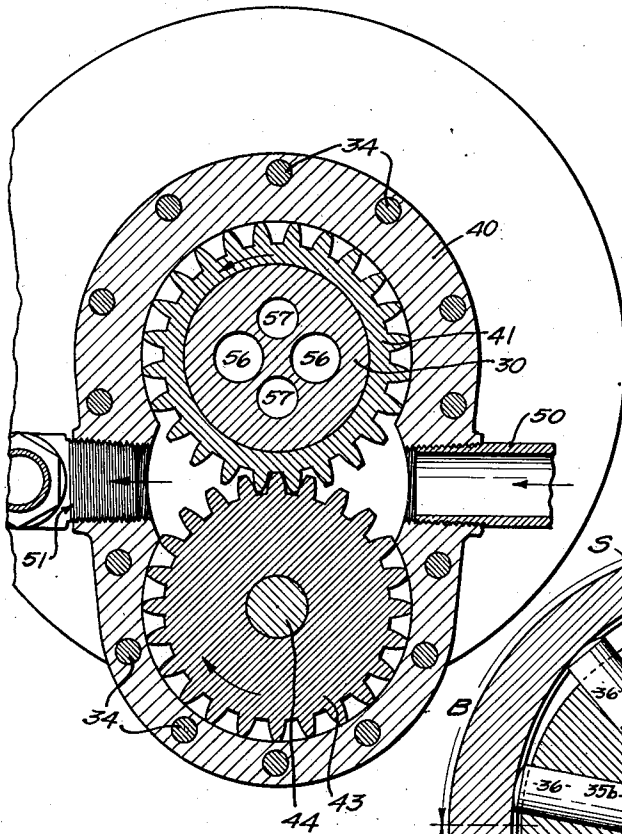


Fig. 3.

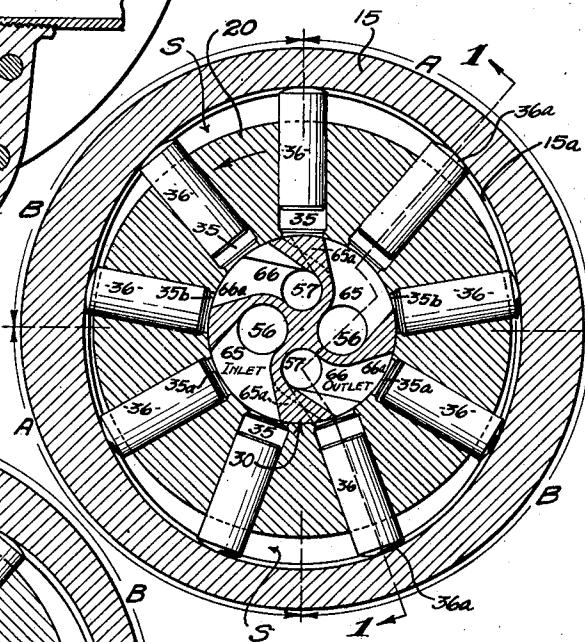


Fig. 4.

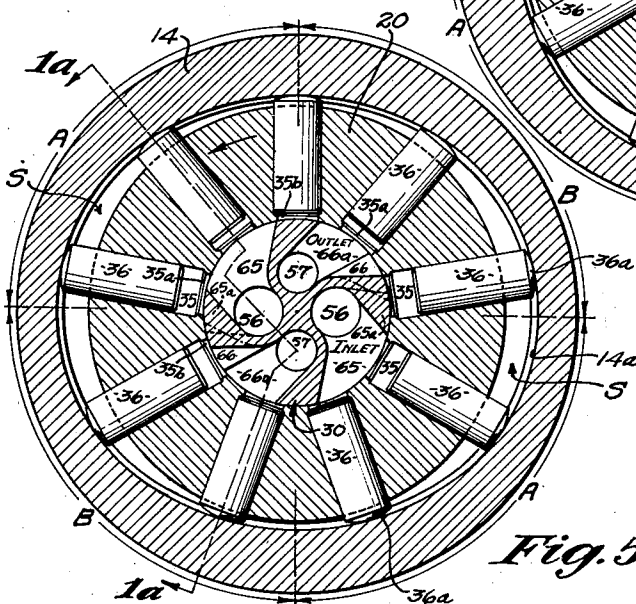


Fig. 5.

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VARIABLE VOLUME PUMP

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4 Sheets-Sheet 4

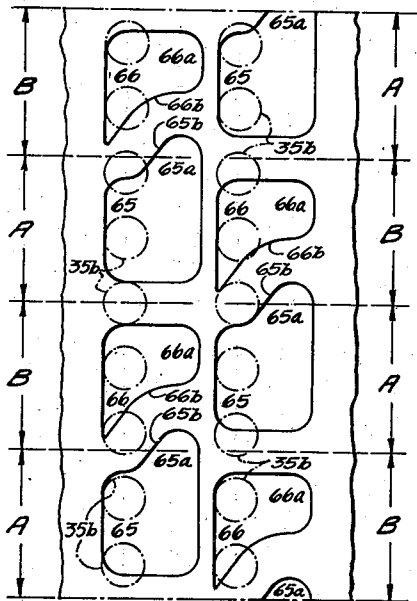


Fig. 6.

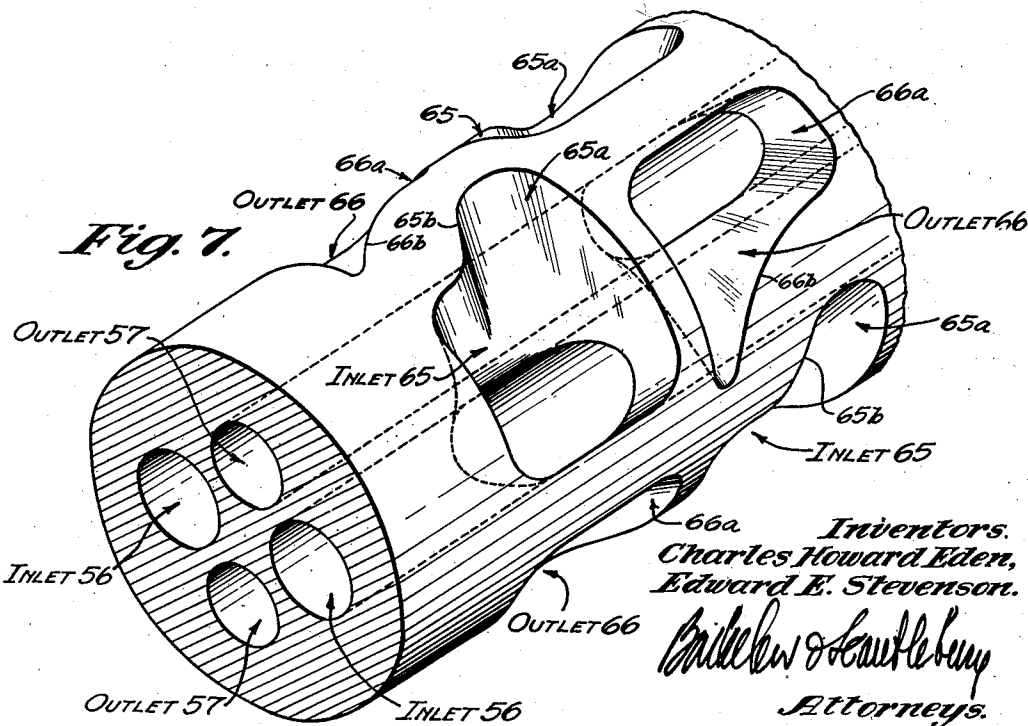


Fig. 7.

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UNITED STATES PATENT OFFICE

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VARIABLE VOLUME PUMP

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Application September 29, 1942, Serial No. 460,083

10 Claims. (Cl. 103—37)

This invention has reference generally to fluid pumps and motors, either for gases or liquids, and its general aim and accomplishment is the provision of a compact and efficient mechanism of the rotary type having various features of improvement and, further, capable of a variable capacity.

Although the invention is applicable generally and in any situation where such a pump or motor may be useful, it has been developed and designed particularly for use as a pump in a fluid pressure power transmission system such as is set out in our copending application, Ser. No. 334,558 filed May 11, 1940. It will therefore be described as a pump and with reference to such a closed circuit system as is set out in that application, but without limitation thereto. In such systems, and in many other situations, there is desired a compact, positively acting pump of the rotary type having little or inappreciable slippage, high efficiency and long life; and also one that may be adjusted to different capacities at high efficiency.

How our present invention reaches the desired ends will be best understood from the following detailed description of the preferred and illustrative design shown in the accompanying drawings. In these drawings:

Fig. 1 is a central longitudinal section of an illustrative and typical pump structure embodying the invention, the sections through the two pump elements which are shown in Figs. 4 and 5 being taken respectively on the lines designated 1—1 and 1a—1a in those figures;

Fig. 2 is an end elevation, with parts in section on line 2—2 of Fig. 1, for illustrative purposes;

Fig. 3 is a cross section on line 3—3 of Fig. 1;

Fig. 4 is a cross section on line 4—4 of Fig. 1;

Fig. 5 is a cross section on line 5—5 of Fig. 1;

Fig. 6 is a developed diagrammatic view showing the shapes of the inlet and outlet ports;

Fig. 7 is a fragmentary perspective illustrating the formation of the ports which are shown diagrammatically in Fig. 6.

In the drawings a suitable main casing is illustrated as made up of parts 10 and 11 which are secured together, as by screws 12, and hold internally between them the ring 13 in which the two internally elliptic rings 14 and 15 are set. Two such elliptic rings, with their cooperating pump pistons, comprise a pump set which will give a substantially continuous and uniform delivery of fluid under pressure. The complete pump may comprise any suitable number of these sets; we here prefer to show a single set, sufficing to illustrate the invention.

A rotor 20 is concentrically mounted on bearings 21 and 22 within the casing, and is driven from a driving shaft 23 which projects into one

end of the casing and is mounted therein on bearing 24. The inner enlarged end 23a of shaft 23 has a clutch or other suitable driving engagement with rotor 20, as indicated at 25. Rotor 20 has an internal longitudinal bore 26 through which a relatively non-rotatable but adjustable distributor shaft 30 extends. This shaft contains inlet and outlet passages and ports and is adjustable lengthwise to change port registry with the cylinders in the rotor, all as will be described. The inner end of distributor shaft 30 is carried in a bearing 31 which is carried in the enlarged inner end of driving shaft 23, and the distributor shaft is also supported at or near its outer end by having suitable bearing support in the bore 32 of a cylindrical casing extension 33 which is secured to casing part 10 by suitable bolts or screws 34. The distributor shaft 30, and rotor 20, are thus independently journaled or carried in the casing of the pump, so that the contacting surfaces of the distributor shaft and of bore 26 of the rotor are not depended upon as journal bearings for either of those parts. Those surfaces are consequently relieved of any appreciable wear and may be originally made and then maintained in close enough fit to preclude liquid leakage.

Rotor 20 is provided with two axially spaced sets of radial cylinder bores 35, spaced and arranged as is best shown in Figs. 1, 4 and 5. Each cylinder carries a plunger or piston 36, preferably hardened and ground to a close fit in the cylinder and having a rounded hardened end 36a adapted to engage and follow the concave elliptic inner surface 14a or 15a of the two hardened elliptic rings 14 and 15. The major axes of the two elliptic surfaces 14a and 15a as here shown preferably lie at right angles to each other, as shown by Figs. 4 and 5. It will be well understood, without the necessity of further detailed description, how the two sets of pistons are reciprocated in their cylinders, when rotor 20 is revolved, by reason of their outer ends following the described elliptic surfaces. The relative arrangement of the two sets of pistons is such (see Figs. 4 and 5) that each piston of one set has a corresponding piston in the other set in an opposite phase of movement. With equally spaced pistons of equal number this condition is arranged if any one piston (e. g. the top piston in Fig. 4) is fully out when any piston of the other set (e. g. the top piston of Fig. 5) is fully in. By forming the inner surfaces of the rings so that the pistons will bear a little more heavily at one side of the ring race than at the other, the pistons will be slowly rotated about their own axis as they revolve, thus distributing the lubricant and also distributing wear.

A gear pump casing element 40 lies between the inner end of casing extension 33 and casing

part 10; this casing element 40 and associated wear plates 40a being held in place by the same screws or bolts 34 which hold casing extension 33 in place. Within the gear pump casing 40 one gear 41 surrounds the distributor shaft 30 and is carried in the casing in the bearing 22 which has been previously mentioned and also in a bearing 22a which is mounted in the casing extension 33. The gear element 41 is thus also journaled in the casing independently of distributor shaft 30, so that the interfitted surfaces of those two parts are substantially relieved of all wear. Gear element 41 is rotatively interconnected to rotor 20 by any suitable means, such as the clutch indicated at 42. The other gear element 43 of the gear pump is mounted within casing 40 on a stud shaft 44, as shown in Figs. 1 and 3. The inlet to the gear pump, which is also the initial inlet to the whole pump mechanism, is designated 50 in Figs. 1 and 3, being indicated in dotted lines in Fig. 1. The outlet from the gear pump is designated 51 in Figs. 2 and 3.

From the gear pump outlet 51 a pipe or tubing arrangement 52 leads to two ports 53 in casing extension 33, which communicate with an annular channel 55 in the inner bore of 33 surrounding distributor shaft 30. Distributor shaft 30 has in it a pair of diametrically opposed, longitudinal, inlet passages 56, and another pair of diametrically opposed, longitudinal, outlet passages 57. These passages are preferably arranged in the relative arrangement shown in Figs. 2, 4 and 5. As illustrated, all these passages are formed as bores extending from the outer (left hand) end of distributor shaft 30 to the vicinity of the inner (right hand) end of that shaft. The outlet passages 57 are open at the projecting outer end of the distributor shaft and may there connect with any suitable outlet piping or other distribution system as may be desired. In Fig. 2, the two outlet passages 57 are diametrically indicated as being connected by lines 58 with a fluid pressure motor 59, and the exhaust of the fluid pressure motor is indicated as connected by line 60 with the initial pump intake 50; forming a closed circuit system.

The inlet passages 56 are communicated with the annular recess passage 55 by ports 61, shown in Figs. 1 and 2, so located and of such length that the ports will remain in register with passage 55 throughout the longitudinal adjustment movement of distributor shaft 30. The inlet of fluid to inlet passages 56 being from the gear pump via passage 55 and ports 61; the outer ends of the bored passages 56 are stopped in any suitable manner, as by plugs such as shown at 62 in Fig. 1.

At the transverse plane of each of the piston and cylinder sets, distributor shaft 30 is provided with a set of two inlet ports 65 and two outlet ports 66, these inlet and outlet ports registering with the inner ends of the two sets of rotor cylinders 35. The inner open ends of the cylinders may thus be regarded as ports, registering with the shaft ports, and leading to the piston mechanism carried by the rotor. The inner ends of cylinders 35 are preferably reduced to form shoulders 35a, to prevent the pistons from moving inwardly so far as to enter the shaft ports 65, 66 or to ride on the distributor shaft. The reduced bores 35b thus become the actual cylinder ports which register with shaft ports 65, 66.

Inlet and outlet ports 65 and 66 communicate,

respectively, with the inlet and outlet passages 56 and 57 as is shown in Figs. 1, 4 and 5, and their outer ends are at the outer or peripheral surface of distributor shaft 30, where their outer ends may be registered by the cylinder ports 35b during their rotation. These ports 65 and 66 are, in one of their portions, of equal circumferential extent about the circumference of distributor shaft 30; but in other portions these ports are of unequal circumferential extent, as and for purposes which will be hereinafter described. Fig. 1 shows distributor shaft 30 in such a longitudinal position that the equal circumferential parts of the several ports are in register with rotor cylinders 35, and the sections of Figs. 4 and 5 show those parts of the ports which are of equal circumferential extent. The operation of the pump mechanism will first be explained as it is with the ports in the positions shown, and the optional method of operation which may be attained by shifting the distributor shaft longitudinally will then be explained.

Assuming the counter-clockwise direction of rotation indicated by the arrows in Figs. 4 and 5, the pistons 36 of the two piston sets will move outwardly during rotation through the quadrants indicated A and will be forced inwardly during rotation through the quadrants indicated B. In the aspects shown in Figs. 4 and 5, the inlet ports 65 are of such circumferential extent that the inner ends of cylinders 35 will register with them during the travel of pistons 36 throughout quadrants A. Thus, during the travels of the pistons and cylinders through quadrants A the pistons may move out and are moved out by the fluid pressure which is initially raised by the gear pump. The several cylinders of each set thus take in fluid during their travels throughout quadrants A.

During and throughout the piston travel through quadrant B they are moved inwardly by the elliptic track engaged by their outer ends; and outlet ports 66 are, in the aspect shown in Figs. 4 and 5, so sized and located that cylinders 35 register with those outlet ports throughout travel through quadrants B. The fluid which has been taken into the cylinders during travel through quadrants A is forced out under pressure during travel through quadrants B, through the outlet ports 66 and outlet passages 57 and thence to the high pressure side of whatever distributing lines are used (for instance through the lines 58 to the fluid pressure motor 59). If the pump mechanism is being used in a closed circuit system, such as here indicated, the exhaust from motor 59, or any other device which is energized by the pump pressure, flows through the return line 60 to the initial intake 50 of the gear pump. The gear pump is operated at the same speed as the piston pump elements, and it is designed to be of a capacity to supply the full capacity of the rotary piston elements at some suitable and relatively low pressure, say 20 or 25 lbs. per sq. in. The pressure raised by the gear pump is sufficient to insure that the piston cylinders each take a full charge of fluid during their intake strokes, and also sufficient, at least with the aid of centrifugal force, to move the pistons outwardly during their intake strokes.

Although the pumping capacity of the gear pump may be made, as nearly as may be, just equal to the capacity of the cylinder and piston elements, it is preferable to design the gear pump for a slight over-capacity in order to be

sure that the gear pump has the desired full capacity of the piston and cylinder elements. And that slight over-capacity, if present, may be taken care of by the by-pass arrangements which are hereinafter described. In the mode of operation which has so far been described, the pump will deliver at its maximum capacity per revolution.

Distributor shaft 30 is rotationally stationary but longitudinally movable, being splined in the casing extension 35 by the arrangement shown at 70. The outer end of shaft 30 is screw-threaded as shown at 71 and an internally threaded worm wheel 72 engages threads 71. Worm wheel 72 has end thrust in one direction against a bearing 73 which is set in a member 74 which forms the end portion of casing extension 33; and may have end thrust bearing in the opposite direction against a similar bearing, but is here shown as bearing simply against a bracket 76 attached to member 74. A worm 77 is mounted in bearings 78 carried by member 74, and a hand wheel 79 typifies any suitable means of rotating worm 77. By rotating the hand wheel distributor shaft 30 may be moved longitudinally. In Fig. 1 it is shown in its limiting right-hand position with relation to the other parts of the pump mechanism. It may be moved to the left through a distance about equal to the diameter of cylinders 35. When so moved toward the left the portions of the ports 65 and 66 which are directly shown in Figs. 4 and 5 are moved out of the plane of rotation of cylinders 35 and therefore out of registry with the cylinders, and the portions of the several ports which lie to the right in Fig. 1 are brought into registry with the cylinders 35.

The configurations and relative extents of the port extensions 65a and 66a, and their effect upon the functioning of the pump, may best be understood from consideration of Figs. 6 and 7. Fig. 6 is a diagrammatic development of the series of ports and Fig. 7 is a fragmentary prospective illustrative of the port formation. In Fig. 6 the relative direction of rotation (of the rotor and cylinders with reference to the ports), is indicated by the arrow, and the successive quadrants of normal intake and out-put are indicated by the letters A and B. The portions of the ports which have been previously described and which in Fig. 1 lie on the section lines 4—4 and 5—5 are those portions of the several ports which lie toward the left in Fig. 6 and are designated by the numerals 65 and 66. Each inlet port 65 has an extension 65a toward the right (in a direction axial of distributor shaft 30) and this inlet port extension is also extended in the direction of rotation by an amount, in this particular instance, equal to something less than half the effective registering length of port 65. Thus, the port extension 65a reaches over into the immediately succeeding outlet quadrant B far enough that when a cylinder in its rotation has passed completely out of register with port extension 65a, that cylinder and its piston is, in this particular instance, nearly halfway through the succeeding outlet quadrant and the piston is accordingly in about the middle of its fluid expulsion or compression stroke. Thus, in the operation of the pump when port extension 65a is in register with the cylinders, each cylinder takes in its full charge of fluid during the intake quadrant A and then during a portion of the succeeding expulsion quadrant B it expels a proportionate part of the fluid which has been

previously taken in. This expelled portion is compressed back into the inlet passages communicating with the inlet port, and is taken care of by the by-pass arrangement to be described.

Each outlet port 66 has corresponding extensions 66a toward the right of lesser circumferential extent than the main port 66. In this particular instance the circumferential extent of a port extension 66a is such that each cylinder is in registry with the port extension during the latter part of each outlet quadrant B. Consequently, in this mode of operation of the pump, each piston expels only about one-half its full capacity into the outlet passages of the pump; and the resultant over-all pumping capacity of the pump as a whole is thus reduced to about one-half its full capacity per revolution. The shapes and spacings of the adjacent edges 65b and 66b of the inlet and outlet ports are such that the cylinder ports do not register with both 65 and 66 at the same time, and such that any pump capacity intermediate full and half may be had by moving the distributor shaft appropriately.

The gear pump, which is rotating at even speed with the rotor and piston assembly, pumps a fixed volume of fluid to the piston intake ports per revolution. To take care of the fractional volume which is pumped back into the intake ports by the pistons in the last described mode of operation, and also to take care of any slight excess volume of the pump in the first described mode of operation, a suitable by-pass system may be employed. For instance a by-pass with a loaded valve may be installed, leading from any suitable point in the passages between the gear pump and the rotor cylinders, to the initial intake to the gear pump. As an instance, Fig. 2 shows diagrammatically a by-pass line 80 leading from the piping 52 to the line 60 that leads to the gear pump inlet 50. This by-pass line 80 is indicated as including a loaded valve 81, and that valve will be loaded to hold only the initial and relative low pressure which is raised by the gear pump. This pressure need be only a small fraction of the final pressure raised by the piston units; consequently the loss of efficiency is not large when the pump is operating at less than full capacity.

Although the described structure is such, and the relatively rotating parts are so journaled, that a very close fit may be made and maintained between the distributor shaft and the other parts to reduce or preclude leakage, suitable packing glands are provided at 85 on driving shaft 23 and at 86 on the left hand or outer end of the distributor shaft to preclude leakage of any fluid from the whole pump mechanism. The packing gland at 85 makes the right-hand end of the pump fluid-tight. The packing gland at 86 makes the left-hand end of the pump fluid-tight and, in particular, prevents any leakage toward the left along shaft 30 from the annular passage 55. Leakage toward the right from annular passage 55 is precluded by the close fit that is maintained between shaft 30 and gear element 41. And any leakage that may occur along or around the shaft within the limited space between gear element 41 and packing gland 86 is of no consequence as that leakage only has egress through the ports 61 which lead into the inlet passages 56.

With the whole pump mechanism thus packed to prevent over-all leakage, the space S between rotor 20 and outer casing 10—11 may have a

pressure built up in it somewhat higher than the pressure at which cylinders 35 take fluid on their intake strokes from the high pressure side of the gear pump. During continuous operation some leakage may take place past the pistons during their compression strokes; and a pressure somewhere between the intake and discharge pressures would thus build up in space S, to oppose outward movement of the pistons.

In fact, we prefer to provide small longitudinal passages 101 (Fig. 1) through the pistons to insure a slow passage of fluid, usually oil, to the outer piston ends and to rings 14 and 15, to insure lubrication. At the operating speeds and pressures for which the mechanism is designed and intended, centrifugal force alone, or that force plus the intake pressure, may force the pistons out, even though all leakage pressure is held at packings 65 and 66. If, however, in any case the operating speeds and pressures are too low to move the pistons out positively, leakage from space S may be allowed, either by not using one or both packings 65 and 66, or by connecting space S either with the intake or discharge of the gear pump. For instance a small pressure venting passage may be provided at 100 (Fig. 1) to vent space S either to atmospheric pressure or to the intake pressure of the gear pump. For instance, the whole pump mechanism may commonly be set in an oil reservoir from which the gear pump intakes and into which the exhaust from motor 59 discharges; and vent 100 may simply discharge into that reservoir. In such an arrangement the intake pressures on the pistons 36 will always positively force them out no matter how small centrifugal force may be.

If the gear pump is omitted from the mechanism and the piston pump elements used alone, the initial intake pressure to the pistons may be maintained high enough, either in a closed or open system, to insure full outward movement of the pistons and the taking of full charges.

Although the whole mechanism has been described as functioning to compress a fluid, acting as a pump, the same mechanism may be used as a motor simply by inverting its operation. If pressure fluid be applied at the high pressure side of the mechanism (at what has been described as the high pressure outlet) and a lower pressure be maintained at the low pressure side (that has been described as the initial inlet of the pump) the course of fluid through the mechanism will be reversed and the mechanism will act as a motor to deliver power at shaft 23. In such use the gear pump unit may if desired be dispensed with, as it also may in some circumstances when using the mechanism as a pump. But if, as a motor, the gear unit is retained, a two-stage mechanism results, just as there are two stages in the described pump.

Further the mechanism is applicable, either as pump or motor, to gas fluid as well as liquid. The illustrated form has been particularly designed for use with liquid, but the mechanism is inherently capable of operation with gaseous fluids as well.

In some of the broader aspects of our invention the elliptic ring and radial plunger combination, although preferred, is merely illustrative of various and well known forms of rotary pump or motor mechanisms that may be used. In other aspects however, a unit having alternating intake and expulsion strokes forms a characteristic part of the invention; and the described mechanism is preferred.

We claim:

1. A fluid pressure mechanism which includes a rotor having an axial bore, a port at the bore surface, and mechanism which takes and expels fluid through said port during revolution of the port through successive angles of rotation, and which includes a relatively non-rotating axial distributor shaft with an inlet and an outlet port at the shaft periphery adapted to be registered successively by the rotor port, characterized further in that: the distributor shaft is longitudinally movable, the several distributor ports have two parts which lie respectively in two longitudinally spaced planes normal of the shaft axis, the parts of the ports which lie in one said plane being substantially equal in circumferential extent and the parts of the ports which lie in the other plane being one relatively longer and one relatively shorter in circumferential extent.

2. A fluid pressure mechanism which includes a rotor having an axial bore, a port at the bore surface, and mechanism which takes and expels fluid through said port during revolution of the port through successive angles of rotation, and which includes a relatively non-rotating axial distributor shaft with an inlet and an outlet port at the shaft periphery adapted to be registered successively by the rotor port, characterized further in that: the distributor shaft is longitudinally movable, the inlet and the outlet ports have two parts which lie respectively in two longitudinally spaced planes normal of the shaft axis, the port parts which lie in one said plane are substantially equal in circumferential extent, and of the port parts which lie in the other plane that of the inlet port is relatively longer and that of the outlet port is relatively shorter.

3. In a fluid pressure mechanism having a casing, a rotor with fluid pressure piston mechanism and having an internal non-rotative longitudinally movable distributor shaft with inlet and outlet passages and ports communicating with the rotor mechanism; the combination of a rotary gear pump of two gear elements one of which is journaled in the casing concentrically about the distributor shaft in a position longitudinally spaced from the rotor, rotary coupling means between said gear element and the rotor independent of the distributor shaft, and a conduit connecting the outlet of the gear pump and the inlet passage of the distributor shaft, the distributor shaft being longitudinally movable through both the rotor and said concentrically journaled gear.

4. In a fluid pressure mechanism, a casing, a central longitudinal distributor shaft non-rotatively mounted in the casing for longitudinal movement therein, a rotor journaled in the casing concentrically about the distributor shaft, piston mechanism associated with the rotor, the distributor shaft having longitudinal inlet and outlet passages and transverse ports communicating with the rotor, a gear pump of two gear elements mounted in the casing, journals supporting one of the gear elements in the casing concentrically about the distributor shaft and in a position longitudinally spaced from the rotor, means rotatively coupling the rotor and said gear element independently of the distributor shaft, and a conduit connecting the outlet of the gear pump with the inlet passage of the distributor shaft, the distributor shaft being longitudi-

nally movable through both the rotor and said concentrically journaled gear.

5. In fluid pressure mechanism, a casing, a central longitudinal distributor shaft mounted in the casing to be non-rotative but longitudinally movable, a centrally bored rotor journaled in the casing concentrically about the distributor shaft to rotate thereabout in a fixed radial plane, said rotor having ports at its central bore surface which bore surface fits the central distributor shaft closely, the distributor shaft having longitudinal inlet and outlet passages and having inlet and outlet ports at its periphery adapted to be registered by the rotor ports, each of the shaft ports having two parts of different circumferential extent adapted selectively to be moved into registry with the rotor ports by longitudinal movement of the distributor shaft, and means for moving the distributor shaft longitudinally.

6. In fluid pressure mechanism, a casing, a central longitudinal distributor shaft mounted in the casing to be non-rotative but longitudinally movable, a centrally bored rotor journaled in the casing concentrically about the distributor shaft to rotate thereabout in a fixed radial plane, said rotor having ports at its central bore surface which bore surface fits the central distributor shaft closely, the distributor shaft having longitudinal inlet and outlet passages and having inlet and outlet ports at its periphery adapted to be registered by the rotor ports, each of the shaft ports having two parts of different circumferential extent adapted selectively to be moved into registry with the rotor ports by longitudinal movement of the distributor shaft, means for moving the distributor shaft longitudinally, a gear pump of two gear elements mounted in the casing, one of said gear elements having an axial bore fitting the distributor shaft closely but movably, journals for said gear element in the casing concentric with the shaft, a coupling between that gear element and the rotor, and a conduit connecting the outlet of the gear pump with the inlet passage of the distributor shaft.

7. In fluid pressure mechanism, a casing, a central longitudinal distributor shaft mounted in the casing to be non-rotative but longitudinally movable, a rotor having a central bore closely but movably fitting the distributor shaft, the rotor being journaled in the casing concentrically about the distributor shaft and constrained to rotate in a fixed plane, the rotor having radial cylinders in a common radial plane with their inner ends open at the rotor bore, radially reciprocating pistons associated with the rotor and the casing so as to move radially inwardly and outwardly during successive angles of rotation, the distributor shaft having longitudinal inlet and outlet passages reaching to the vicinity of the plane of the rotor and having inlet and outlet ports at its periphery, each of the shaft ports having two parts of different circumferential extent adapted selectively to be moved into the plane of rotation of the rotor cylinders by longitudinal movement of the shaft, and means for moving the distributor shaft longitudinally.

8. In fluid pressure mechanism, a casing, a central longitudinal distributor shaft mounted in the casing to be non-rotative but longitudinally movable, a rotor having a central bore closely but movably fitting the distributor shaft, the rotor being journaled in the casing concentrically about the distributor shaft and constrained to rotate in a fixed plane, the rotor having radial cylinders in a common radial plane with their

inner ends open at the rotor bore, radially reciprocating pistons associated with the rotor and the casing so as to move radially inwardly and outwardly during successive angles of rotation, the distributor shaft having longitudinal inlet and outlet passages reaching to the vicinity of the plane of the rotor and having inlet and outlet ports at its periphery, each of the shaft ports having two parts of different circumferential extent adapted selectively to be moved into the plane of rotation of the rotor cylinders by longitudinal movement of the shaft, means for moving the distributor shaft longitudinally, a gear pump of two gear elements mounted in the casing, one of said gear elements having an axial bore fitting the distributor shaft closely but movably, journals for said gear element in the casing concentric with the shaft, a coupling between that gear element and the rotor, and a conduit connecting the outlet of the gear pump with the inlet passage of the distributor shaft.

9. In fluid pressure mechanism, a casing, a central longitudinal distributor shaft mounted in the casing to be non-rotative but longitudinally movable, a rotor having a central bore closely but movably fitting the distributor shaft, the rotor being journaled in the casing concentrically about the distributor shaft and constrained to rotate in a fixed plane, the rotor having radial cylinders in a common radial plane with their inner ends open at the rotor bore, radially reciprocating pistons associated with the rotor and the casing so as to move radially inwardly and outwardly during successive angles of rotation, the distributor shaft having longitudinal inlet and outlet passages reaching to the vicinity of the plane of the rotor and having inlet and outlet ports at its periphery, each of the shaft ports having two parts of different circumferential extent adapted selectively to be moved into the plane of rotation of the rotor cylinders by longitudinal movement of the shaft, the distributor shaft having one end within the casing in the vicinity of the rotor and its opposite end projecting from one end of the casing, a power shaft entering the casing at the first mentioned end of the distributor shaft and rotatively directly coupled with the rotor, a packing gland in the casing surrounding the power shaft, a packing gland in the casing surrounding the distributor shaft near its projecting end, and means applied to the projecting end of the distributor shaft for moving it longitudinally.

10. In fluid pressure mechanism, a casing, a central longitudinal distributor shaft mounted in the casing to be non-rotative but longitudinally movable, a rotor having a central bore closely but movably fitting the distributor shaft, the rotor being journaled in the casing concentrically about the distributor shaft and constrained to rotate in a fixed plane, the rotor having radial cylinders in a common radial plane with their inner ends open at the rotor bore, radially reciprocating pistons associated with the rotor and the casing so as to move radially inwardly and outwardly during successive angles of rotation, the distributor shaft having longitudinal inlet and outlet passages reaching to the vicinity of the plane of the rotor and having inlet and outlet ports at its periphery, each of the shaft ports having two parts of different circumferential extent adapted selectively to be moved into the plane of rotation of the rotor cylinders by longitudinal movement of the shaft, the distributor shaft having one end within the casing

in the vicinity of the rotor and its opposite end projecting from one end of the casing, a power shaft entering the casing at the first mentioned end of the distributor shaft and rotatively directly coupled with the rotor, a packing gland in the casing surrounding the distributor shaft near its projecting end, means applied to the projecting end of the distributor shaft for moving it longitudinally, a gear pump of two gear elements mounted in the casing, one of said gear elements having an axial bore fitting the distributor shaft closely but movably, journals mounting said gear element in the casing concentric with the distributor shaft and longitudinally adjacent the side

of the rotor that lies toward the projecting end of the distributor shaft, a direct coupling between that gear element and the rotor, a lateral port in the distributor shaft extending from its longitudinal inlet passage to its periphery at a point between said gear element and the end of the casing from which the distributor shaft projects, an annular passage in the casing registered by said last mentioned port, and a conduit connecting the outlet of the gear pump with the annular passage.

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