Dec. 25, 1945. M. W. HUBER 2,391,575

REVERSIBLE ENGINE

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Fig. 1

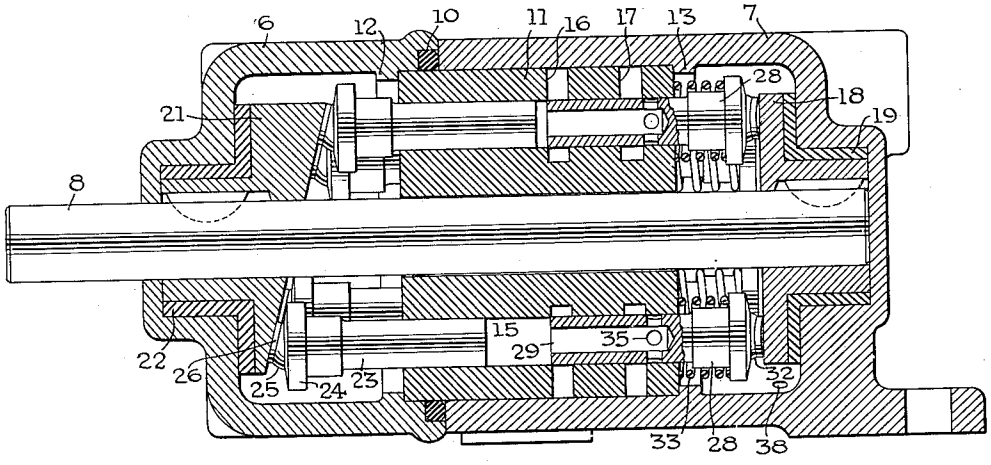


Fig. 2

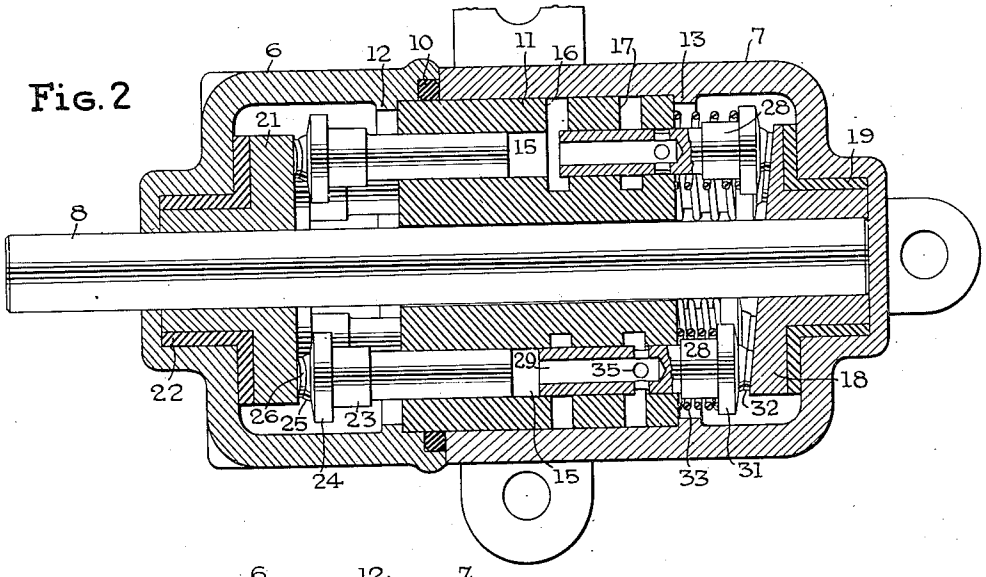
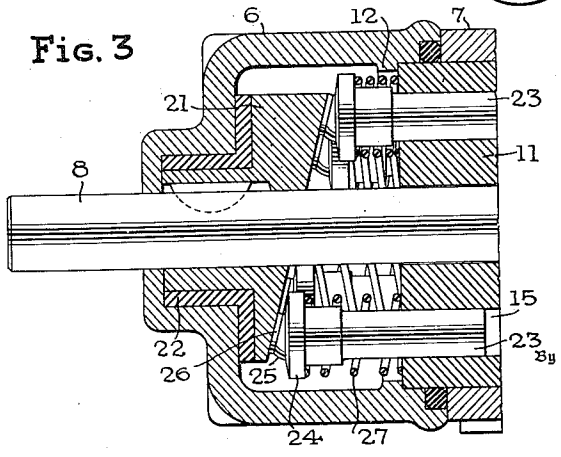


Fig. 3



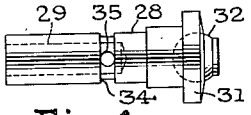


Fig. 4

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Fig. 5

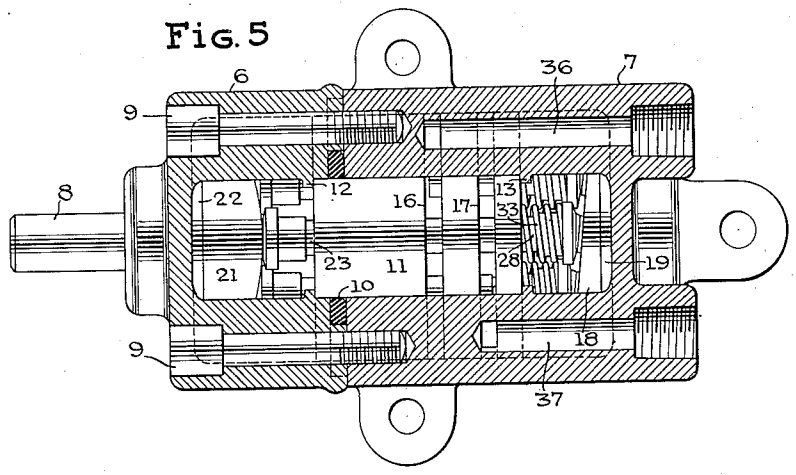


Fig. 6

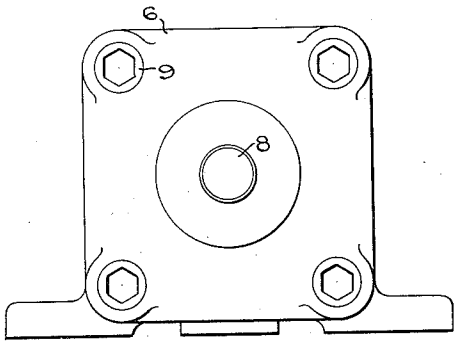
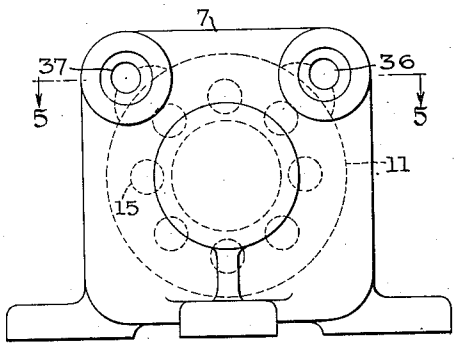


Fig. 7



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UNITED STATES PATENT OFFICE

2,391,575

REVERSIBLE ENGINE

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Application January 7, 1943, Serial No. 471,598

6 Claims. (Cl. 103—173)

This invention relates to engines of the expansible chamber type, the word "engine" being used in a generic sense to include motors and pumps.

The chief feature of novelty resides in the use of piston type admission and exhaust valves working in valve chambers which are extensions of the cylinders on which the main engine pistons work. Thus the fluid in any cylinder reacts in opposite directions on the piston and on the piston valve of that cylinder, and through the same upon the shaft of the engine. The instantaneous piston displacement in any cylinder is the algebraic sum of the instantaneous displacements of the piston and piston valve, but since the valve stroke is comparatively small this does not introduce any seriously disturbing effect.

The advantages of such arrangement are simplicity of construction, and the ease with which such leakage as occurs may be collected and discharged.

The device is intended primarily, but not exclusively, for use with liquids rather than elastic fluids. For simplicity, the mechanisms for translating reciprocating into rotary motion (and the converse) is illustrated as comprising swash plates, but equivalents can be substituted.

Reversal may readily be had by "port reversal" i. e. interchange of inlet and discharge ports.

In the accompanying drawings, the invention is illustrated in its essential aspects. Refinements such as antifriction bearings, special seals and the like, though often desirable, are omitted, as their adoption is a matter of design.

Fig. 1 is an axial section on a plane at a right angle to the mounting face.

Fig. 2 is an axial section on a plane parallel with the mounting face.

Fig. 3 is a fragmentary view, similar to a portion of Fig. 1, showing a modification.

Fig. 4 is an elevation of a piston valve.

Fig. 5 is a section on the line 5—5 of Fig. 7.

Fig. 6 is an elevation looking from the left end of the device.

Fig. 7 is an elevation at the right end of the device. In this view the outlines of the cylinder block and cylinder bores are indicated in dotted lines.

The housing of the engine is in two parts 6 and 7, which mate in a plane, to which the axis of the shaft 8 is normal. The two portions form a housing which is externally of approximately square cross section, but which has an internal cylindrical bore. This conformation permits the connecting screws 9 to be housed in the four corners. It also affords space for the inlet and the discharge passages. A conventional circular sealing gasket 10 is used. This merely prevents leakage of liquid which is not under pressure.

A cylinder block 11, having an axial central opening slightly larger than shaft 8, makes a precise slip fit in the cylindrical bore of part 7 of the housing and is confined between the annular flanges 12 and 13 formed in respective portions of the housing. The cylinder block 11 has a number of cylinder bores 15, all at least approximately parallel with the axis of shaft 8, and arranged in circular series around the shaft. Their angular spacing around the shaft is preferably uniform, as shown, and true parallelism, as shown, is preferred.

The cylinder block is encircled by spaced circumferential port forming grooves 16 and 17 which intersect all the bores 15 and preferably extend inward beyond the same, as shown. Either may serve as the inlet port and the other as the discharge port, and this is true whether the device be used as a motor or as a pump. Interchange of inlet and discharge is related to the direction of rotation of shaft in either case, as will be explained.

Splined to the inner (right hand) end of shaft 8 is a swash plate 18 which turns in a combined thrust and radial bearing 19. Its obliquity is relatively small (say 5°) since it serves to actuate the valve pistons through a small reciprocatory range. Keyed to shaft 8 immediately within portion 6 is the swash plate 21 which turns in a combined thrust and radial bearing 22. It has a relatively larger obliquity, say 25°, for it coacts with the main pistons which should have a substantial range of reciprocating motion. For a motor, the obliquity may be somewhat larger than for a pump, and the angle shown is a reasonable compromise value.

The high point of swash plate 18 is displaced 90° (relatively to the axis of shaft 8) from the high point of swash plate 21 to give the proper phase relation between the reciprocation of the valves and main pistons.

The main pistons actuated by swash plate 21 are single acting plungers 23 each having a head 24 with a universally tiltable thrust surface, here shown as a confined ball 25 with flat boss 26. Return springs 27 (see Fig. 3) are needed if the device is used as a pump. They can be used but are unnecessary if the device is used as a motor. Hence they are omitted from Figs. 1 and 2 which illustrate the motor embodiment.

The valves, actuated by swash plate 18, are

plungers 28 with counterbores 29 leading from their inner ends. They have heads 31 with ball thrust elements 32 and return springs 33.

Each plunger 28 has an encircling groove 34 which communicates by drilled ports 35 with its counterbore 29. The valve proper is that portion of the plunger between the inner end of the plunger and the groove 34. At mid stroke of the valve this laps the two port grooves 16 and 17.

When liquids are to be handled either in a pump or motor, a positive lap is not desirable. The condition sought is zero lap, with any error on the side of negative lap or clearance. Substantial clearance is obviously to be avoided because both ports would be open simultaneously, allowing slip. With elastic fluids, a slight positive lap is often desirable.

The shaft 8 may drive or be driven through any suitable connections. Formed in the corners of housing portion 7 are a passage 36 which communicates with port grooves 16 and a passage 37 which communicates with port groove 17.

Either passage 36 or 37 may be the supply connection and the other the discharge connection. If the engine be used as a motor, interchange of the ports 36 and 37 as between supply and exhaust will cause reversal of direction of rotation of shaft 8 (commonly called port reversal, in the engine art). The engine will operate as a pump if the shaft 8 be driven in either direction, but the direction of flow depends on the direction of drive.

The port 38 typifies a relief passage to carry leakage from the cam spaces within the housing and thus prevent development of fluid pressure within such spaces. The port may lead to any drain. If the engine operates as a pump, connection could be to the suction line, and if as a motor, then to the exhaust line. Obviously, if a port reversing valve is used, account must be taken of the changing characteristics of the ports between the reversing valve and the engine. Various expedients will suggest themselves.

In its broadest aspects, the invention contemplates the use of a piston and a piston valve to define an intervening working space in a cylinder, regardless of the relative positions of cylinder and shaft and regardless of the form of mechanical connections between the shaft and piston and between the shaft and valve. The valve connections may differ in type from the other.

However, the scheme offers peculiar advantages where a circular series of parallel cylinders encircles the drive shaft. A swash plate is convenient for each drive, because it gives harmonic motion (or a close approximation thereof). However, a swash plate is merely a special type of cam and other cams can be used, as well as other drives familiar in the pump art for use with this typical cylinder and shaft arrangement.

I claim:

1. In an expansible chamber engine, the combination of a rotary shaft; any number of expansible chamber units, each comprising an open ended cylinder having supply and exhaust ports, a main piston closing one end of the cylinder, and a distributing valve of the piston type closing the other end of the cylinder, whereby an intervening working space is formed, the piston valve serving to connect said supply and exhaust ports alternately with the working space; and mechanical connections between the shaft and main pistons and between the shaft and piston valves so arranged that as the shaft rotates the main pistons reciprocate and the piston valves reciprocate with a shorter stroke than, and each valve reciprocates substantially 90° out of phase with, the corresponding main piston.

2. In an expansible chamber engine, the combination of a rotary shaft; any number of expansible chamber units, each comprising an open ended cylinder having supply and exhaust ports, the axis of the cylinder being substantially parallel with the axis of said shaft, a main piston closing one end of the cylinder, and a distributing valve of the piston type closing the other end of the cylinder, whereby an intervening working space is formed, the piston valve serving to connect said supply and exhaust ports alternately with the working space; and mechanical connections between the shaft and main pistons and between the shaft and piston valves, said connections comprising cams on the shaft respectively related with followers on the pistons and on the piston valves, and so formed that as the shaft rotates the main pistons reciprocate and the piston valves reciprocate with a shorter stroke than, and each valve reciprocates substantially 90° out of phase with, the corresponding main piston.

3. In an expansible chamber engine, the combination of a rotary shaft; any number of expansible chamber units, each comprising an open ended cylinder having supply and exhaust ports, the axis of the cylinder being substantially parallel with the axis of said shaft, a main piston closing one end of the cylinder, and a distributing valve of the piston type closing the other end of the cylinder, whereby an intervening working space is formed, the piston valve serving to connect said supply and exhaust ports alternately with the working space; a swash plate fixed on the shaft and arranged to coact with the main pistons; and a second swash plate of less obliquity than the first fixed on the shaft with its high point displaced with reference to the shaft axis 90° from the first swash plate, and arranged to coact with the piston valves.

4. In an expansible chamber engine, the combination of a rotary shaft; any number of expansible chamber units, each comprising an open ended cylinder having supply and exhaust ports, the axis of the cylinder being substantially parallel with the axis of said shaft, a main piston closing one end of the cylinder, and a distributing valve of the piston type closing the other end of the cylinder, whereby an intervening working space is formed, the piston valve serving to connect said supply and exhaust ports alternately with the working space; mechanical connections between the shaft and main pistons so arranged that as the shaft rotates the pistons reciprocate; and a cam on the shaft arranged to reciprocate the piston valves with an amplitude sufficient to perform the distributing function, the piston valves and the ports which they control being so arranged that said amplitude is decidedly less than the amplitude of reciprocation of the related pistons.

5. In an engine of the type in which a series of parallel cylinders encircle a shaft with which they are substantially parallel, the combination of a housing divided transversely into two portions and having combined radial and thrust bearings alined with each other and in opposite ends of the housing; cams, one sustained by and rotatable in each of said bearings; a shaft mounted to turn with both said cams and withdrawable from at least one thereof; a cylinder block posi-

tioned between the portions of the housing interposed between the cams, and having a bore to receive the shaft, a surrounding circular series of cylinder bores extending from end to end of the block, and two encircling port grooves which intersect the cylinder bores; a series of pistons, one piston working in one end of each of said bores and coacting with one of said cams; a series of piston type distributing valves, one valve working in the other end of each of said bores and coacting with said port grooves, and with the other of said cams; and means associated with said housing for establishing independent fluid flow connections with the port grooves in the cylinder block.

6. The combination of a cylinder block having a cylinder bore extending from end to end thereof and a pair of spaced ports communicating with said bore; a piston reciprocable in one end of said bore; a piston type valve reciprocable in the other end of said bore whereby an intervening working space is defined between the piston and piston valve, said piston valve being counterbored from its inner end and having an encircling groove in communication with said counterbore, the portion of the valve between its inner end and said groove serving to control the ports in the cylinder block; a rotatable shaft; and connections between the shaft and the piston and between the shaft and distributing valve serving to constrain them to reciprocation in a definite phase relation, the amplitude of reciprocation of the distributing valve being small as compared to the amplitude of reciprocation of the piston.

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