April 21, 1953 G. KUHN 2,635,586

PASSAGEWAY SYSTEM FOR FLUID OPERATED DEVICES

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Fig. 1.

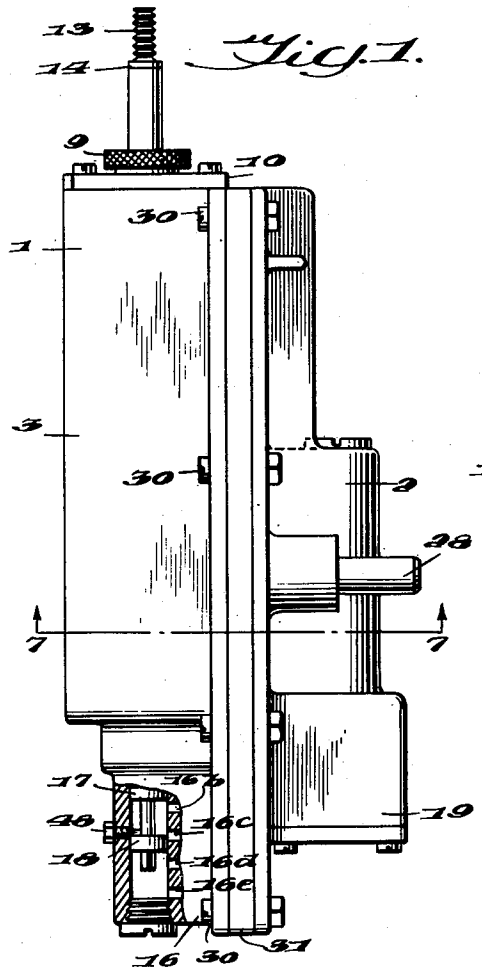


Fig. 3.

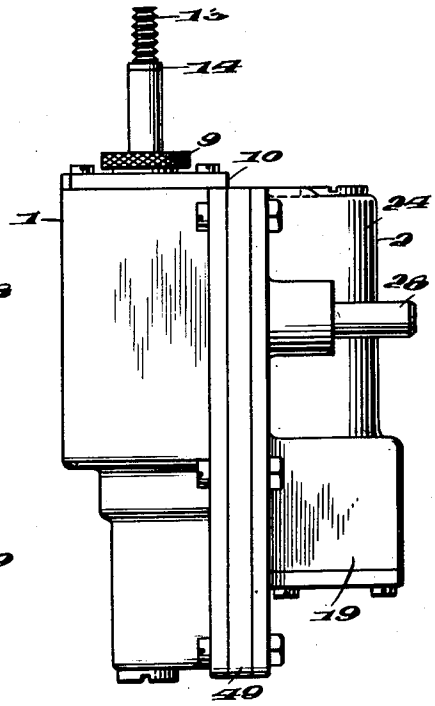
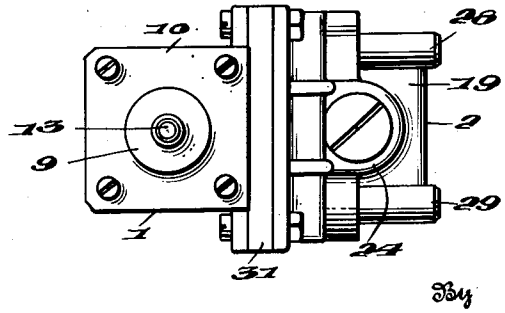


Fig. 2.



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PASSAGEWAY SYSTEM FOR FLUID OPERATED DEVICES

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Fig. 4.

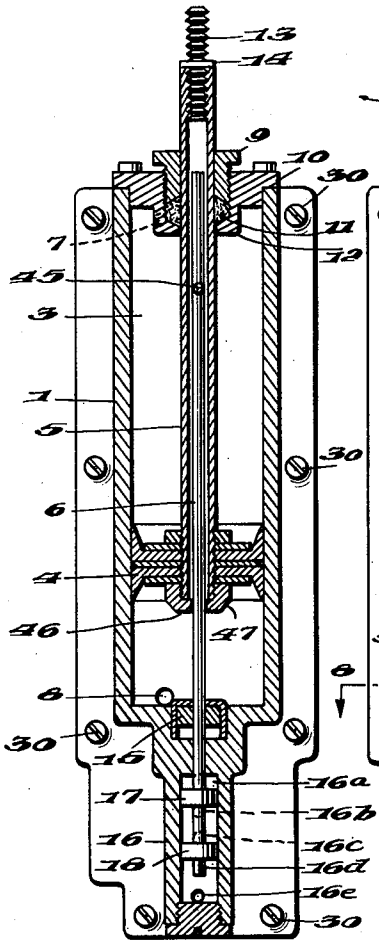


Fig. 5.

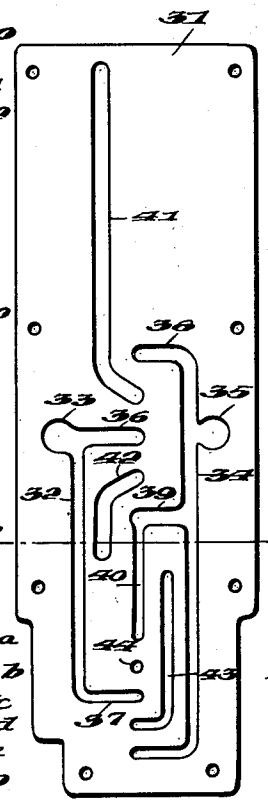


Fig. 6.

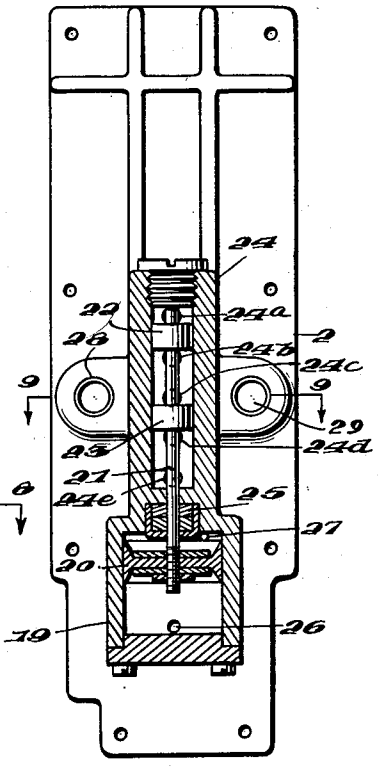


Fig. 7.

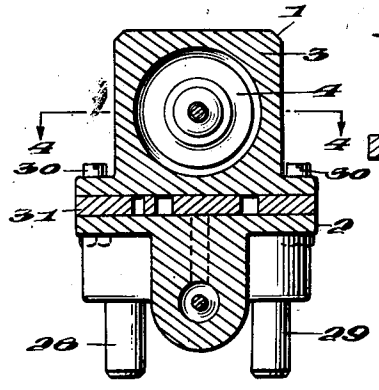


Fig. 8.

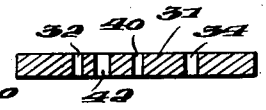
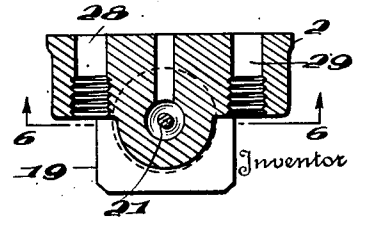


Fig. 9.



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PASSAGEWAY SYSTEM FOR FLUID OPERATED DEVICES

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Fig. 10.

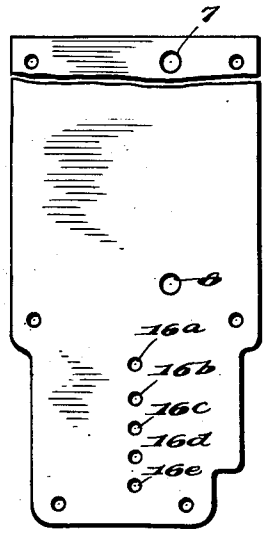


Fig. 11.

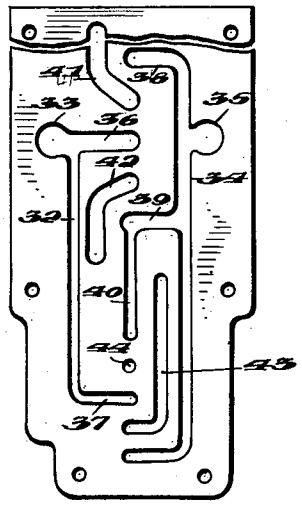


Fig. 12.

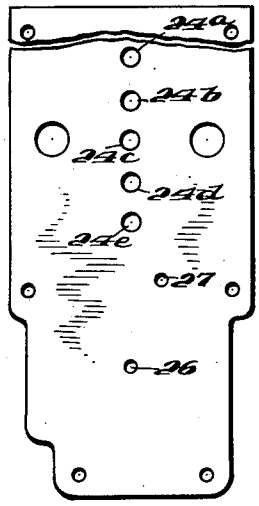


Fig. 17.

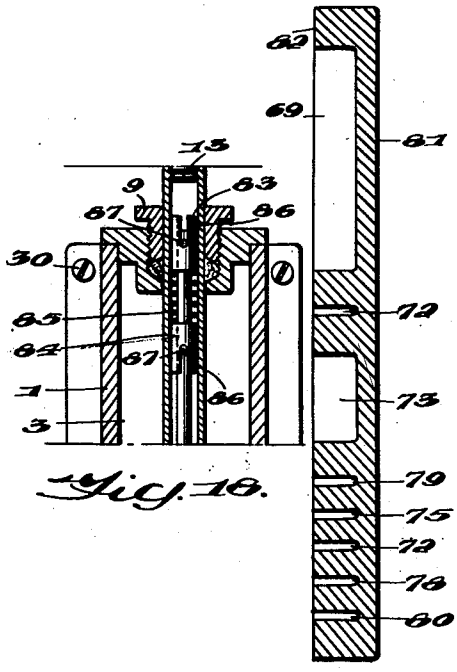
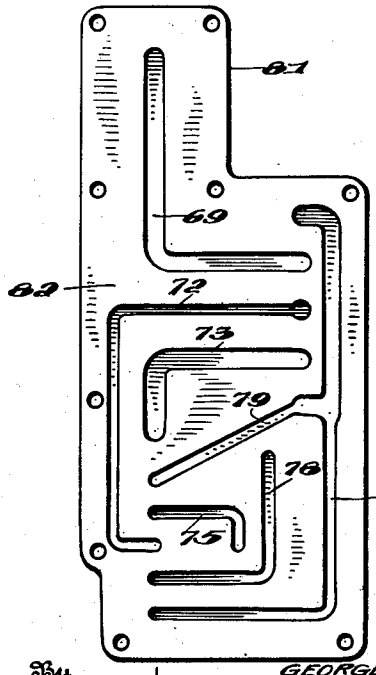


Fig. 16.



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PASSAGEWAY SYSTEM FOR FLUID OPERATED DEVICES

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Fig. 14.

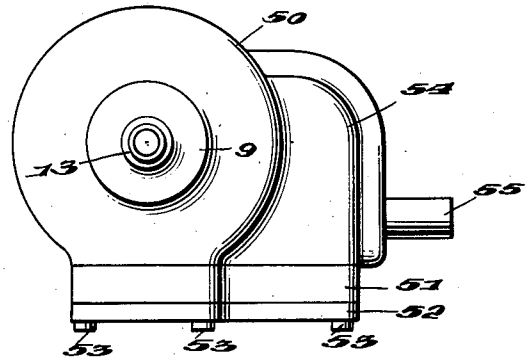
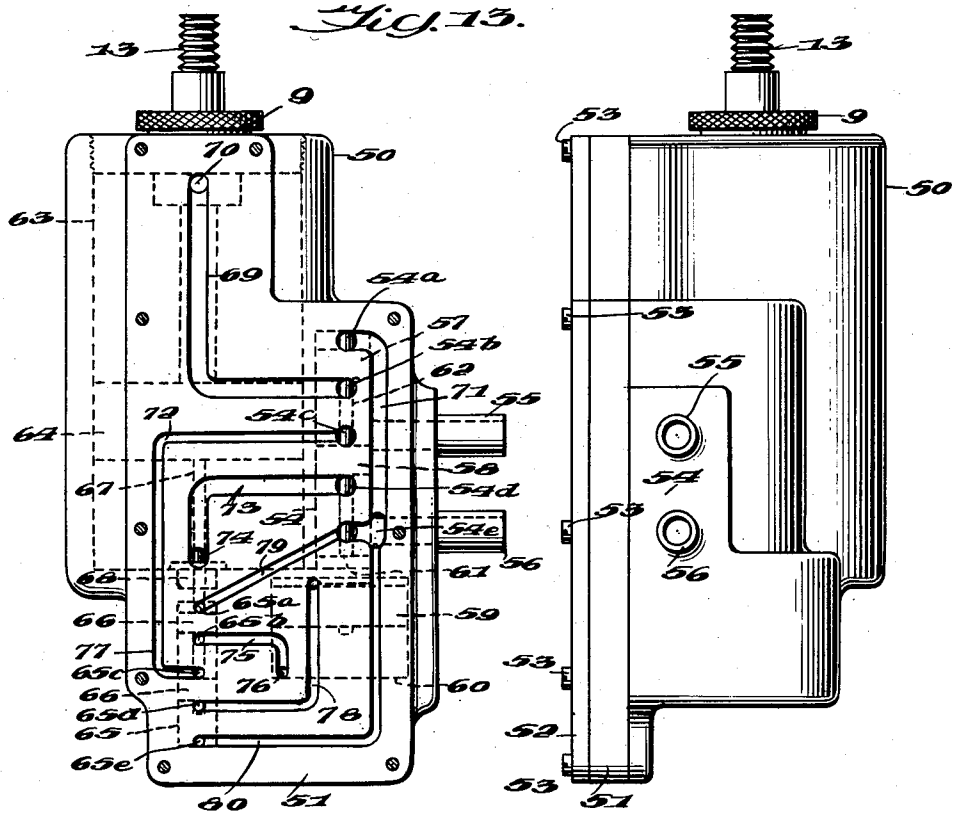


Fig. 15.

Fig. 13.



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Patented Apr. 21, 1953 2,635,586

UNITED STATES PATENT OFFICE

2,635,586

PASSAGEWAY SYSTEM FOR FLUID OPERATED DEVICES

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Application November 17, 1948, Serial No. 60,590

14 Claims. (Cl. 121—157)

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The invention relates to fluid operated devices and more particularly to devices of this character for producing relatively slow reciprocatory motion.

Formerly, the production of fluid operated devices has not been commercially feasible since it has been necessary to form a number of fluid conducting passageways in the housing or housings of the device, the passageways communicating with fluid receiving chambers formed therein. As the housings are uniformly made of cast metal, the formation of the desired passageways in the castings is, of course, difficult and expensive. By the present invention, however, the formation of the passageways in the housings is entirely eliminated and in their stead a plate-like member is employed having slots forming fluid conducting passageways which when two housings are used is firmly clamped between relatively smooth faces thereof, or when a single housing is employed is rigidly secured to a relatively smooth outer face thereof so that the slots function as intended. The slots in the plate-like member communicate with ports or apertures which extend from the relatively smooth face of the housing to the chambers thereof into which fluid is successively admitted and exhausted. The ports are preferably drilled in the housing or are formed in any other desired manner and, as they communicate with the slots in the plate-like member, the slots form fluid conducting passageways through which fluid flows from one selected port to another.

The principal object of the invention is to concentrate the complete system of interconnecting fluid passages in a single flat layer located between the housing portions of the device and away from all the working parts and operating chambers.

When the housing portions are sand-cast and machined, the most practical method is to incorporate this layer in a separately fabricated flat plate adapted to be clamped between flat faces of the housing portions, these faces serving as the top and bottom closures for the slot-like passages in the plate.

When the housing portions are die-cast or plastic-molded, it may be more expedient to make the passage layer integral with the face of one of the housing portions, the latter portion then serving as the top closure for the passages.

In either case, when the two housing portions are taken apart, the complete system of passageways becomes open and exposed, the coacting surface of the two portions of the device being substantially flat to provide a fluid-tight relationship therebetween.

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The primary feature of the invention consists in providing means which is engageable with a face of a fluid operated device and is provided with slots forming passageways for conducting fluid from one fluid receiving chamber of the device to another.

Another feature of the invention consists in providing a plate-like member which may be clamped between two housings of a fluid operated device for conducting fluid to and from fluid receiving chambers in the housings.

A further and more specific feature of the invention consists in providing a plate-like member with elongated slots forming passageways to conduct fluid from one fluid receiving chamber of a fluid operated device to another fluid receiving chamber thereof.

A still further feature of the invention is to provide a construction wherein the passage system is independent from the mechanical system so that either can be replaced without affecting the other.

In the drawings,

Figure 1 is a side elevational view of a fluid operated device having two opposed housings.

Figure 2 is an end view of the device illustrated in Figure 1.

Figure 3 is a slightly modified form of the device in which the housing for the power operated piston is reduced in length.

Figure 4 is a sectional view taken through the housing containing the power piston, the view being taken approximately on the line corresponding to line 4—4 of Figure 7.

Figure 5 is an elevational view of the plate-like member of Figure 1 which is clamped between the two housings of the device and is formed with a plurality of slots forming fluid conducting passageways.

Figure 6 is a sectional view of the other housing of the device illustrated in Figure 1, the section being taken approximately on a line corresponding to line 6—6 of Figure 9.

Figure 7 is a cross sectional view of the device taken approximately on the line 7—7 of Figure 1.

Figure 8 is a cross sectional view of the plate-like member taken on the line 8—8 of Figure 5.

Figure 9 is a cross sectional view of the housing illustrated in Figure 6 taken on the line 9—9 of Figure 6.

Figure 10 is an elevational view of the inside face of the housing shown in Figure 4, the view being foreshortened for purposes of clarity.

Figure 11 is a foreshortened view of the plate-like member illustrated in Figure 5.

Figure 12 is a foreshortened view of the inner face of the housing illustrated in Figure 6.

Figure 13 is a front view of a modified form of the invention with the cover which is usually employed removed.

Figure 14 is an end view of the device shown in Figure 13 including the cover not shown in Figure 13.

Figure 15 is a side view of the device shown in Figure 13 with the cover applied.

Figure 16 is an inside view of a cover plate which may be employed in connection with the form of the invention illustrated in Figure 13 in place of the plate-like member and the cover.

Figure 17 is a sectional view taken on line 17—17 of Figure 16.

Figure 18 is a detail modified view of the construction at the upper end of the rod which is movable by the power piston.

Referring more particularly to the drawings illustrating the embodiment of the invention shown in Figures 1 to 12, inclusive, the fluid operated device there shown is formed of two complementary housings 1 and 2 respectively, each of which may advantageously be formed with two fluid receiving chambers. Housing 1 has a principal chamber 3 in which a power piston 4 is adapted to reciprocate, the piston being rigidly connected to a sleeve 5 which encircles a rod or stem 6. Movement of the piston 4 in a downward direction, as viewed in Figure 4, is caused by the admission of fluid under pressure into chamber 3 through a port 7 in housing 1, the fluid on the opposite side of the piston being exhausted from the opposite end of the housing through a port 8. The relative position of the parts shown in Figure 4 correspond to that occupied by them when the piston is moving downwardly. It will, of course, be appreciated that, when the piston is to be moved upwardly, as viewed in Figure 4, fluid under pressure is admitted into chamber 3 through port 8 and the fluid on the opposite side of the piston is exhausted from the chamber through port 7.

One end of sleeve 5 is movable through a suitable gland nut 9 which is threaded into the removable end 10 of the main chamber 3. Suitable packing 11 surrounds the sleeve 5, it being pressed to the required amount between the bottom of the packing gland and the upper face of a recess formed in the downwardly extending boss 12 of the removable end 10. A stud or plug 13 is preferably screw threaded in the outwardly projecting end of the sleeve and it is maintained in proper position by a jam nut or the like 14 which is adapted to abut the outer end of the sleeve. A portion of the threaded stud preferably projects beyond the end of the sleeve 5 so that it may be conveniently attached to mechanism which is to be operated by the reciprocating movement imparted to the piston.

At the other end of the housing the rod 6 projects through a suitable packing member 15 into a relatively smaller coaxially arranged chamber 16 and it is there provided with piston valves 17 and 18 constituting pilot valve means, the packing 15 normally holding the rod in its proper position. As the piston 4 moves downwardly moving the sleeve 5 with it, the inner end of the screw threaded stud is engageable with the upper end of the rod 6, the engagement between the stud and the rod occurring just before the piston reaches the end of its stroke. The rod is, therefore, moved downwardly causing piston valves 17 and 18 to couple selected ports in

chamber 16, the ports which terminate in the relatively smooth inside face of housing 1 being respectively designated 16*a*, 16*b*, 16*c*, 16*d* and 16*e*. By means to be hereinafter explained, fluid under pressure is then admitted to port 8 while fluid on the opposite side of the piston is exhausted through port 7 and the piston is thereby caused to move upwardly or in the opposite direction.

The other housing 2 is preferably formed with a chamber 19 for a piston 20. Rigid with the piston and movable therewith is a rod 21 carrying a pair of piston valves 22 and 23 respectively, which are movable within a chamber 24 for coupling desired ports so as to control movement of the power piston 4, the ports in chamber 24 being respectively designated 24*a*, 24*b*, 24*c*, 24*d* and 24*e* (Figure 6). In extending from chamber 19 to chamber 24 in which the valves 22 and 23 are disposed, the rod 21 passes through a suitable packing member 25. This mechanism which controls the direction of movement of power piston 4 is shown in Figure 6 in the position it occupies when the power piston 4 is moving downwardly. The piston 20 of the control valve unit is, like the power piston, actuated by fluid pressure, fluid under pressure being admitted into chamber 19 to move the piston upwardly through a port 26 while a port 27 is provided in the upper part of chamber 26 through which fluid may be exhausted during upward movement of piston 20.

Housing 2 is also formed with suitable portions whereby the fluid may be introduced into the device and through which the fluid may be exhausted therefrom, the inlet port for the fluid pressure being designated 28 and the exhaust port being designated by the numeral 29. These ports may be advantageously formed as bosses or nipples so that each may be easily connected with a hose or the like (not shown), the inlet and exhaust ports preferably being of such construction that they may be readily connected to a suitable source of supply, such as the water supply system of a house.

As indicated, the housings are formed with relatively smooth inside faces in which the ports heretofore described respectively terminate so that a plate-like member 31 having correspondingly smooth faces may be clamped between them by any suitable means, such as screws 30. This plate-like member is formed with a plurality of slots of varying shapes which respectively overlie and communicate with the ports to form passageways through which fluid is conducted from one fluid receiving chamber to another. The many ports heretofore mentioned may be conveniently drilled or otherwise formed in the housings so that they lead directly to the respective chambers with which they communicate.

The plate-like member 31 has a slot 32 provided with a cylindrically shaped offset portion 33 which when the device is assembled, as shown in Figure 1, communicates with inlet port 28. A slot 34 is formed in the plate-like member having a similarly shaped portion 35 which is adapted to communicate with the exhaust port 29. Both of slots 32 and 34 are irregular in shape and have portions which communicate with the desired ports in the housings. Thus slot 32 has a leg 36 which at its inner end communicates with port 24*c* of housing 2 and at its lower end it has a leg 37 which communicates with port 16*c* of housing 1. Similarly the slot having the exhaust port 35 is provided at its upper end with a leg 38 which communicates with port 24*a* in housing 2. In-

termediate its ends slot 34 is formed with an angular slot 39, the outer end of which communicates with port 24e of housing 2, while the other leg 40 of slot 39 communicates with port 16a of the housing 1.

In addition to the slots 32 and 34, the plate-like member 31 is formed with additional slots which communicate with other ports in the two housings. Thus there is slot 41 which at one end communicates with port 7 at one end of chamber 3 of housing 1 and at its other end communicates with port 24b of housing 2. Another slot formed in the plate-like member which affords a passage for fluid from a port in one housing to a port in another housing is slot 42. This slot, like slot 41, bends intermediate its ends, one end thereof having communication with port 8 of housing 1 and the other end having communication with port 24d of housing 2. An angular slot 43 is also provided which communicates at one end with port 27 in the upper portion of chamber 19 and at its other end with port 16d of housing 1.

In addition, the plate is apertured, as indicated at 44, so as to communicate with port 26 in the lower end of chamber 19 and with port 16b in housing 1. Thus the slots in the plate-like member afford passageways interconnecting respective ports of the two housings through which fluid may flow, the direction of flow of the fluid being controlled by the respective positions of piston valves 17, 18, 22 and 23.

Assuming that the power piston 4 is moving downwardly, it will be perceived that the piston valves 17 and 18 are in their uppermost positions, piston valve 17 being disposed between ports 16a and 16b and piston valve 18 being disposed between ports 16c and 16d. With the pistons in these positions, port 16c is in open communication with leg 37 of slot 32 and as the fluid presses equally against both pistons 17 and 18 in opposite directions, their positions are not affected. Furthermore, as port 16b is in open communication with port 16c, the fluid under pressure passes through aperture 44 through port 26 into chamber 19 so that piston 20 is maintained in the position shown in Figure 6. Just before the power piston 4 reaches the limit of its movement, the stud or plug 13 engages the upper end of the rod 6 thereby moving it downwardly and causing piston valves 17 and 18 to move in a corresponding direction.

When the valves 17 and 18 are moved downwardly, ports 16a and 16b are coupled and ports 16c and 16d are coupled. Thus fluid under pressure enters port 16c from leg 37 of slot 32 and then flows out of the space between the piston valves to port 16d, the fluid then being conducted through passageway 43 to port 27 in the upper part of chamber 19. Moreover, port 26 in the lower end of chamber 19 is in communication with port 16b through port 44. Thus as port 16b and port 16a are coupled, fluid below the piston 20 is exhausted from chamber 19 through port 44 into port 16b and thence through port 16a which communicates with slot 40 leading to the exhaust 35, as the piston 20 moves downwardly therein under the pressure of fluid which is admitted through port 27. Piston 20 is, therefore, moved downwardly causing piston valves 22 and 23 to move correspondingly and couple ports 24a and 24b and ports 24c and 24d. As port 24a communicates with leg 38 leading to the exhaust 35, a small portion of the fluid used to cause the power piston to move downwardly is exhausted through port 7 from where it flows into slot 41, the lower end of slot or passageway 41 being in communication with port 24b. Movement of the power piston upwardly is accomplished almost simultaneously with the shifting of the piston valves as fluid under the desired pressure promptly flows through port 8 which communicates with the lower end of slot 42, the upper end of which communicates with port 24d. Fluid under pressure, therefore, flows from slotted leg 36 into port 24c and thence into port 24d through slot 42 into port 8.

Thus the shifting of the rod 6 at the end of the stroke of the power piston causes the piston valves 22 and 23 to shift into a position enabling fluid to be exhausted from one end of the main chamber 3 and to be supplied to the other end thereof.

To reverse the movement of the power piston as it approaches the end of rod 6, a pin or the like 45 which projects on opposite sides of the rod is engaged by the inturned portion 46 of a nut 47 secured to the lower end of sleeve 5. When the pin is so engaged, the piston valves 17 and 18 move into the positions shown in Figure 4 and the piston valves 22 and 23 as well as piston 20 are caused to move into the positions shown in Figure 6.

As the fluid operated device is capable of being disposed in any position while being operated, suitable means such as a screw 48 may be conveniently employed for preventing unintentional movement of the rod 6. The screw is threaded into the main housing 1 where its inner end extends into the small chamber 16 and bears with suitable pressure upon the portion of the rod 6 between the piston valves 17 and 18, the end of the screw being advantageously provided with a fiber or plastic tip so as not to mar the rod. Figures 1 and 4 show the pilot valve means 17 and 18 in the same position, in which, as may be seen in Figure 1, piston valve 17 abuts against the screw 48, while piston valve 18 is adapted to abut against the opposite side of the screw when the rod is moved by action of the sleeve 5 to which the power piston is connected.

All features of construction of the fluid operated device heretofore described are exactly the same in the shorter fluid device illustrated in Figure 3, the sole difference between the two forms of the invention is that the power piston in the fluid operated device shown in Figure 1 has a longer stroke than the power piston of the device illustrated in Figure 3. A plate-like member 49 is clamped between the two housings in the same manner as plate 31 is clamped between housings 1 and 2, the only difference in the plate-like members of the two devices being that slot 41 in the plate-like member is shortened so that its upper end communicates with the upper end of the shorter main chamber of housing 1 shown in Figure 3.

In the modified form of the invention shown in Figures 13, 14 and 15, the power piston and control valves are disposed side by side in a single housing which is formed with a relatively smooth outer face. Overlying the outer face of this single housing 50 is a plate-like member 51 having slots somewhat similar to those formed in plate-like member 31 which act in the same manner and for the same purposes as those slots. A cover 52 overlies the outer face of the plate-like member 51 and is secured to the housing by suitable screws or the like 53 so that the slots are made fluid-tight.

In this embodiment of the invention, the fluid flows into a control chamber 54 through a boss

or nipple 55 and fluid flows out from the chamber through a similar outlet boss or nipple 56. This chamber 54 otherwise corresponds in all respects to chamber 24 of the form of the invention illustrated in Figures 1 to 12, inclusive. A pair of spaced piston valves 57 and 58 identical with piston valves 22 and 23 are movably mounted in chamber 54 and they are operated by a piston 59 which is movable within a chamber 60 in the same manner as piston 20. Intermediate the chambers 54 and 60 is a small chamber 61 for receiving suitable packing (not shown) through which extends a rod 62 connecting the piston in chamber 60 to the piston valves in chamber 54.

The remainder of housing 50 contains a relatively large chamber 63 for a power piston 64, a smaller chamber 65 in which spaced piston valves 66 are movable by a rod 67 which is actuated in the same manner as rod 6 in the form of the invention illustrated in Figures 1 to 12. Like that rod, rod 67 extends through suitable packing contained in a chamber 68.

Like either of the housings 1 or 2, the outer face of housing 50 is formed with a plurality of ports and the plate-like member 51 is formed with slots providing passageways through which fluid is conducted from one port to another. Thus slot 69 in the plate-like member 51 communicates with a port 70 at the upper end of chamber 53 and also with port 54*b* in chamber 54. Another port 54*a* however, which communicates with a slot 71, is adapted to conduct the fluid to the port 54*e* leading to the exhaust or outlet 56. Immediately below port 54*b* is port 54*c* which communicates with the inlet 55. Leading from this port is an angularly shaped passageway 72 whose lower end communicates with a port 65*c* in chamber 65. The plate-like member is also formed with a slot 73 which has communication at one end with port 54*d* and at the other end with port 74 in the lower end of the power piston chamber 63. When the piston valves in chamber 54 occupy the same positions with respect to the ports as do piston valves 22 and 23 shown in Figure 6, the power piston 63 is being moved downwardly, the fluid on the under side of the piston exhausting through port 74 into passageway 73 and then through port 54*d* to the outlet 56. At the same time the piston valves in chamber 65 are in the same position as shown in Figure 4 and ports 65*b* and 65*c* are, therefore, coupled so that fluid entering ports 65*c* flows through the space between the valves 66 emerging at port 65*b*. When port 65*b* is coupled with port 65*c*, the fluid passes through port 65*b* into passageway 75 discharging through port 76 in the lower portion of chamber 60. Thus during downward movement of the power piston, the piston in chamber 60 is maintained in an elevated position corresponding to that shown in Figure 6, holding the piston valves which are movably mounted in chamber 54 in proper position.

Just before the power piston finishes its stroke, the valves in chamber 54 are moved downwardly in precisely the same manner as described in connection with Figure 6. In this new position, ports 65*c* and 65*d* are coupled so that the fluid flowing through passage 77 into port 65*c* flows into port 65*d* and by means of slot 78 conducts the fluid to the upper end of chamber 60. The piston in this chamber is, therefore, caused to move downwardly and thus shift the positions of the piston valves in chamber 54. It is to be noted that, when the valves in chamber 65 have been moved downwardly in the same manner as described in connection with Figure 4, communication is then established between ports 65*a* and 65*b*.

When the valves in chamber 54 have been moved downwardly by piston 59, ports 54*c* and 54*d* are coupled and ports 54*a* and 54*b* are likewise coupled. Port 54*c* is then placed in communication with the source of fluid pressure and the fluid flows through port 54*d*, passageway 73 and discharges through port 74 into the lower end of the power piston chamber 63. As the piston starts to move upwardly, the fluid above it is exhausted through port 70 into passage 69, then through port 54*b* to port 54*a* and to the outlet 56. As in the principal form of the invention, ports 65*a* and 65*d* at opposite ends of chamber 65 communicate with passages 79 and 80, respectively, which lead to port 54*e* and thence to the outlet 56.

It will be appreciated that the plate-like member 51 which is operatively interposed between the power piston and control valves serves the same purpose as plate-like member 31 in the form of the invention first described and that the slots may be easily formed in either member by stamping or the like. In both members the slots form a system of enclosed fluid conducting passageways by virtue of the closure members lying on opposite sides of the system of fluid conducting ports.

In Figures 16 and 17, a form of construction is illustrated in which the cover 52 and the plate-like member 51 are formed integrally to provide a cover 81. The inner face 82 is formed with a plurality of grooves of the same shape and configuration as the slots formed in plate-like member 51; and the inner face is adapted to be secured to the same face of the housing 50 as the plate-like member 51. As the grooves in the inner face of the cover 81 function in the same manner and for the same purposes as the slots in the plate-like member 51, they are identified by the same reference numerals as the slots.

Figure 18 shows a modified construction of the upper or outer end of rod 6 for absorbing abrupt shocks which may be transmitted to it. On the outer end of rod 6 are two slidable sleeves 83 and 84, respectively, which are normally maintained in spaced relation by spring 85. Each sleeve is slotted, as indicated at 86, to receive a pin or the like 87 which need not project beyond the periphery of the sleeve. The pin in slot 86 of sleeve 83 limits the upward movement thereof, while the pin in the slot in sleeve 84 holds the sleeve in its desired elevated position.

With this construction, it will be seen that, when the stud 13 moves toward the end of the rod, it first engages the upper end of the sleeve 83 rather than the upper end of the rod. It thereby compresses the spring 85 and causes the rod to move in the direction in which the piston has been moving. Moreover, when the piston moves in the opposite direction, the inturned portion 46 of nut 47 engages the lower sleeve 84 to shift rod 6 correspondingly in the opposite direction. When the packing 15 is new and consequently offers substantial resistance to movement of the rod, spring 85 will be substantially compressed before movement of the rod is obtained. The sleeves, however, are arranged so that they will be engaged by the piston before it has completed its full stroke. The piston valves, therefore, will promptly shift when the sleeves are engaged and cause the power piston to quick-

ly change its direction of movement without pause at the end of each stroke.

In the specification and claims hereof the term "fluid" is used in the broad sense to denote any flowing substance, such as water, oil, gas, steam, air and the like. Moreover, the expression "fluid operated device" means any mechanism containing moving parts which affect or are affected by the flow of fluid through the device, such as motors, pumps, compressors, control devices, etc.

The applicant prefers to use "flat" plates and housing faces simply because they are the easiest and cheapest to produce and not because they are essential to the invention. What is essential is that the contacting faces match. Thus matching grooves and ridges or male and female interlocks may be added to the contacting surfaces for easier positioning or for better sealing against leakage, or even a slight curvature may be imparted to the matching faces without departing from the spirit of the invention or in any way modifying its intended function.

What I claim is:

1. In a fluid operated device, a housing having a plurality of fluid receiving chambers, fluid actuated mechanism movable within said chambers, said housing having a face provided with ports communicating with said chambers, and means overlapping said face and rigid with respect thereto having a plurality of elongated passageways respectively communicating with said ports for conducting fluid from one chamber to another.

2. In a fluid operated device, a housing containing a plurality of fluid receiving chambers, fluid actuated mechanism movable within said chambers, said housing having a face provided with a plurality of openings respectively communicating with the chambers thereof, a plate-like member overlapping said face and rigid with respect to said face, said plate-like member having elongated slots providing passageways communicating with said openings for conducting fluid from one opening to another, and means secured to the outer face of said member to render said passageways fluid tight.

3. In a fluid operated device, a housing having a plurality of fluid receiving chambers, fluid actuated mechanism movable within said chambers, said housing having a face provided with ports communicating with said chambers, means rigid with and overlapping said face having a plurality of passageways for conducting fluid from one port to another, and a cover overlappingly secured to the outer face of said means to render said passageway fluid tight.

4. In a fluid operated device, a housing containing a plurality of fluid receiving chambers, fluid actuated mechanism within said chambers, said housing having a relatively smooth surface provided with a plurality of ports respectively communicating with said chambers, and a relatively smooth plate overlapping said surface rigid with respect to said housing having slots providing passageways communicating with said ports for conducting fluid from one chamber to another.

5. In a fluid operated device, a pair of housings each having a substantially flat, solid wall portion and fluid receiving chambers, fluid actuated mechanism movable within said chambers, a plurality of bores in said flat walls perpendicularly thereof, said housings having a face communicating with the chambers thereof, and a substantially flat layer clamped between said housings having a plurality of slot-like passageways communicating with said chambers.

6. In a fluid operated device, a pair of housings respectively having fluid receiving chambers and a substantially flat solid wall portion, fluid actuated mechanism movable within said chambers, each of said housings having a plurality of bores communicating with the chambers thereof, and a relatively substantially flat layer clamped between said housings having a plurality of slot-like passageways communicating with said ports.

7. In a fluid operated device, a pair of housings respectively having fluid receiving chambers, fluid actuated mechanism movable within said chambers, each of said housings having a substantially flat surface formed with a plurality of ports communicating with the chambers thereof, and a substantially flat plate clamped between said surfaces of the housings, said plate having a plurality of slot-like passageways respectively communicating with said ports.

8. In a fluid operated device, two complementary housings respectively containing a plurality of fluid receiving chambers, said housings having adjacent substantially flat surfaces formed with a series of openings communicating with the chambers thereof, and a substantially flat plate provided with a series of slot-like passageways clamped between said surfaces and having communication with said openings.

9. A fluid operated device having a pair of housings, power piston means in one of said housings, valve means in the other housing for successively controlling the flow of fluid to opposite sides of the power piston, said housings being respectively formed with chambers within which said means are movable, each of said housings being provided with a substantially flat surface having a plurality of ports respectively communicating with the chambers thereof, and a substantially flat plate clamped between said surfaces of the housings having slot-like passageways interconnecting selected ports.

10. A fluid operated device having a pair of housings, each of said housings having fluid receiving chambers and a substantially flat face, a power piston and pilot valve means movably mounted in the chambers of one of said housings, bores through said flat faces leading to said chambers, control valve means movably mounted in the chamber of the other of said housings, said control valve means being actuated by fluid upon movement of said pilot valve means to successively admit fluid to opposite sides of the power piston, each of said housings having a face formed with a series of openings respectively communicating with the chambers thereof, and a substantially flat plate clamped between the face of said housings, said plate being formed with slot-like passageways communicating with selected bores in the respective faces of said housings.

11. A fluid operated device having power piston means, control valve means for selectively controlling the flow of fluid to opposite sides of the power piston means, and a plate-like member interposed between said power piston means and said control valve means, said plate-like member having a plurality of elongated slots operatively interconnecting said power piston means and said control valve means.

12. A fluid operated device having a power piston, pilot valve means operated by said power piston, control valve means actuated upon movement of said pilot valve means, and substantially

flat plate-like means operatively interposed between said control valve means and said pilot valve means, said plate-like means having slots forming passageways for conducting fluid from one valve means to the other and from said control valve and to said power piston.

13. A substantially flat plate adapted to be operatively interposed between adjacent parts of a fluid displacement device provided with a plurality of ports, said plate having a system of slot-like passageways through which fluid is adapted to pass from one of said parts to the other.

14. In a fluid operated device, two housing portions, each having a substantially flat, solid wall portion, a plurality of operating chambers within one of said housing portions, a plurality of bores in the solid wall perpendicularly thereto of the last mentioned housing communicating with said chambers, and a substantially flat layer interposed between said housings, said layer containing a system of slot-like passageways interconnecting said bores, said housing portions and said layer being clamped together in fluid-tight relationship.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
129,726	Glasson et al.	July 23, 1872
469,173	Pattin et al.	Feb. 16, 1892
827,428	Davis	July 31, 1906
2,029,240	Kuhn	Jan. 28, 1936
2,129,765	Hodsdon	Sept. 13, 1938
2,183,538	Butler	Dec. 19, 1939
2,345,837	Smith	Apr. 4, 1944