

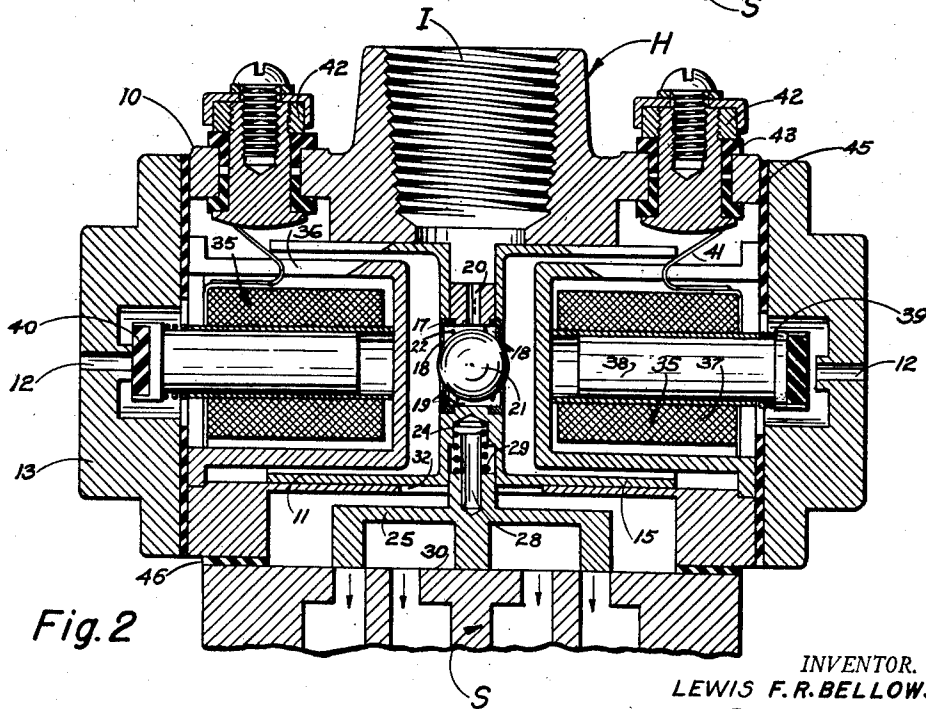
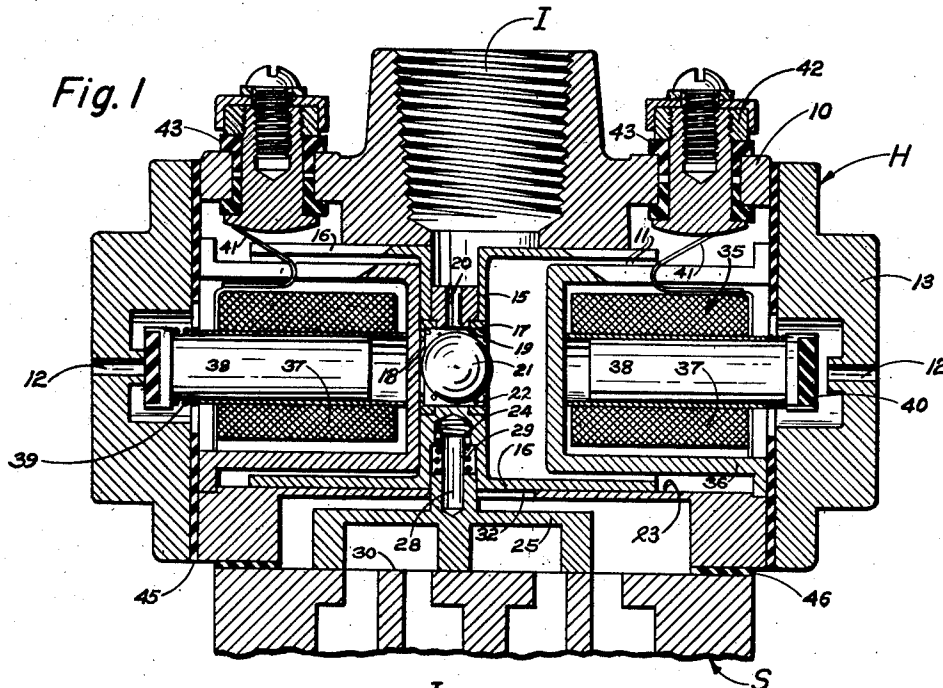
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L. F. R. BELLOWS
FLUID-POWERED ENGINE

2,641,229

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3 Sheets-Sheet, 1



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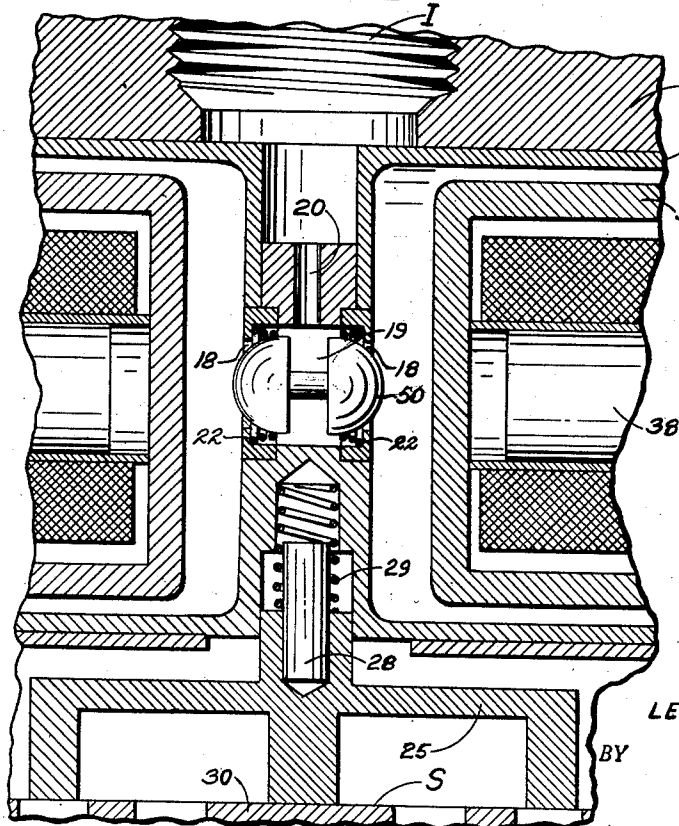
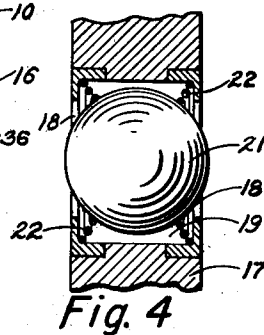
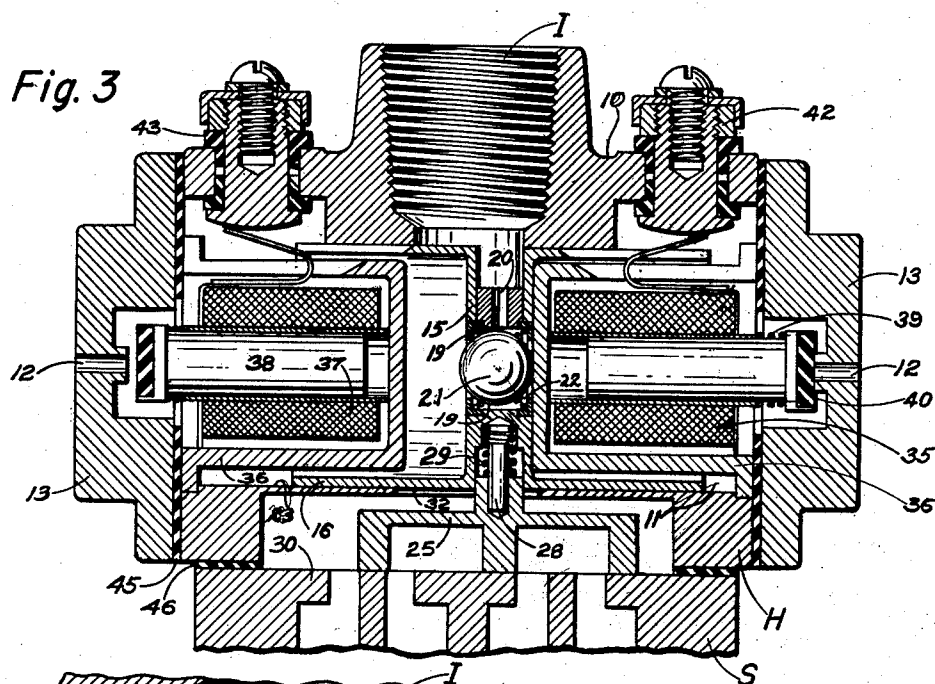
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FLUID-POWERED ENGINE

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3 Sheets-Sheet, 2



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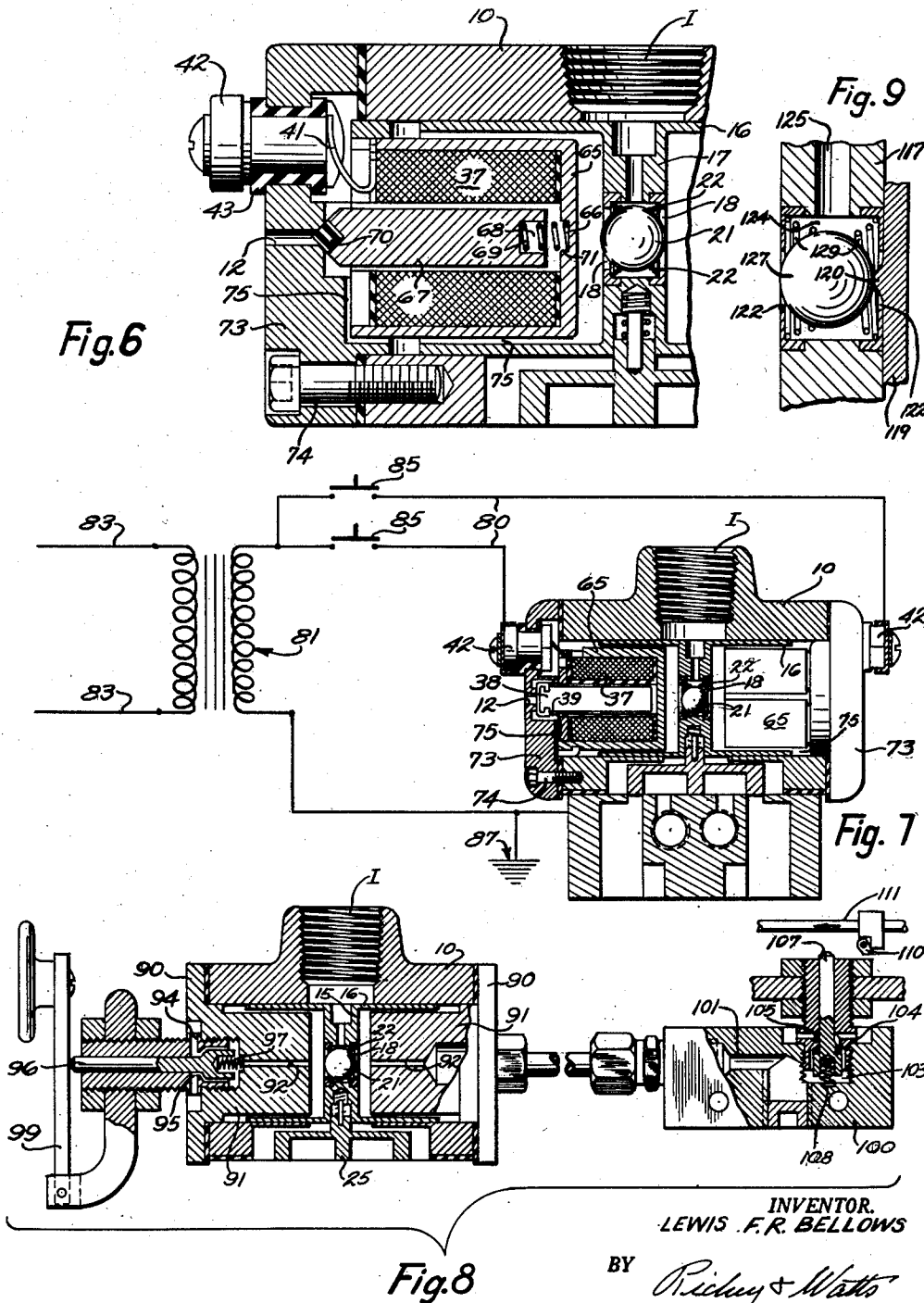
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FLUID-POWERED ENGINE

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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FLUID-POWERED ENGINE

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14 Claims. (Cl. 121-148)

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The present invention relates generally to the valve art and is more particularly concerned with a novel and useful, fast-acting, fluid-powered engine for operating fluid valves or other devices by means of a reciprocating floating piston acted on by pressure fluctuation controlled by hand, mechanical, or electrical means, or any suitable combination thereof.

Although such fluid-powered engines have long been known in the art, those conceived prior to the present invention have not been satisfactory for fast, continuous, shock-free action, especially when liquid may be introduced for lubricating purposes or may be formed inside the system of a gas-operated engine.

Engines of this type depend for their operation on reducing the imposed fluid pressure alternatively on opposite ends of a movable piston, and re-equalizing these pressures between piston movements. Rebalancing of the imposed pressure requires channels either through or around the piston, which are of small total area in relation to the vents required to unbalance the travel piston. Obviously, the presence in this system of liquids of high viscosity compared to the operating fluid, which is normally a gas, delays the rebalancing of fluid pressure in the system and precludes rapid action of the piston. Furthermore, the expansion chamber behind the piston is necessarily of relatively large volume in order that the desired piston motion will be obtained under the expansive force of the operating fluid, and consequently a relatively long period is required for evacuation of the said fluid when piston movement is to be reversed.

The present invention assures rapid operation in these engines, regardless of the presence of high viscosity liquids in the passageways or vents. Also, according to this invention, shocks due to stopping rapidly moving pistons can be virtually eliminated and faster piston action can, at the same time, be obtained through the automatic equalization of the operating fluid pressures in these engines during the last 5% of the piston's travel in either direction.

Those skilled in the art will gain a better understanding of the present invention upon referring to the drawings accompanying and forming part of this specification, in which:

Fig. 1 is a fragmentary, cross-sectional view of a solenoid-controlled engine embodying this invention;

Fig. 2 is a view similar to Fig. 1 with the parts disposed in an intermediate position to indicate the operation of the mechanism;

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Fig. 3 is a view similar to Figs. 1 and 2 showing the parts of a similar engine in an extreme position opposite to that of Fig. 1;

Fig. 4 is an enlarged, sectional view of a head of the piston of Fig. 3, equipped with a spring-mounted ball check valve member;

Fig. 5 is a fragmentary, cross-sectional view of a solenoid-controlled engine embodying still another form of the present invention, the parts thereof being disposed in neutral or intermediate position;

Fig. 6 is a fragmentary, cross-sectional view of another solenoid-controlled engine embodying this invention;

Fig. 7 is a partially diagrammatic view of an electrical system including a solenoid engine generally resembling that of Fig. 6, said engine being shown in partial section;

Fig. 8 is a partial sectional view of another engine of this invention generally resembling the engine of Fig. 6 and equipped with manual and remote mechanical means for operating said engine; and,

Fig. 9 is an enlarged, sectional view of a head of a piston generally resembling that of Fig. 4, but having a relatively smaller ball check valve member.

The same parts in these several views bear the same reference characters.

Generally speaking, an engine of this invention comprises a housing having an inlet opening in a side wall and exhaust vents in opposing end walls, means for controlling the flow of gas in the housing through said exhaust vents, and a piston in the housing for reciprocating movement between the said opposed ends in response to fluid pressures obtaining in the two portions of the housing separated by the piston head, said piston having a head and skirts projecting in opposite directions from the head and a passage open to said inlet opening and having outlet openings communicating with the exhaust vents. Further, this engine has valve means for controlling flow of fluid into these portions from the housing inlet opening and through the piston head, this valve means being movable with and relative to the head and disposed within said passage for closing said outlet openings. In the usual form this piston will be secured to a sliding valve mechanism which will move with the piston and with respect to the housing and the member defining the valve openings.

In addition, in general, the valve means referred to above comprises a body which is movable with and relative to the head of the piston

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and is disposed within said head to seat sealingly against valve seats on either side of the head around the outlet ports. This body, in accordance with the preferred embodiment of this invention, is resiliently supported so that normally it will stand in such a position that both ports are open; and at the same time, it should be of such size that it may be acted upon by means external to the piston to unseat it from either valve seat. Alternatively, the said body may be so dimensioned or shaped that it will not project through the outlet ports, in which case the external means for unseating should be designed to extend into the piston head to effect the opening of one or the other outlet port (Fig. 9). Further, this body will function together as a double-acting, check-valve mechanism, seating at one time against one of the seats and at another time against the other seat to effect reciprocating motion of the piston, as will be described below in detail.

More specifically and with reference to Figs. 1, 2 and 3, the present engines each comprise a housing H having an inlet opening I in the mid-section of its side wall 10 and a cylindrical space 11 communicating with the atmosphere outside the housing through axially aligned vents 12 in opposing end walls 13 of the housing. Reciprocating piston 15 moves in the cylinder along the common axis of vents 12 under the influence of differential fluid pressures acting on the piston and regulated in a manner hereinafter to be described. This piston comprises a pair of hollow, cylindrical guides 16 projecting oppositely from a head 17 having two outlet ports 18 communicating with vents 12 and a valve chamber 19 in the head. An inlet passage 20 is provided in head 15 to connect chamber 19 and inlet I. A valve member comprising a ball 21 is disposed in chamber 19 wherein it may move to a limited extent under the influence of fluid pressure in the cylinder and under pressure directly applied by contact with stationary elements to be described, to open or close port 18. Ball 21 is spring-mounted, as is clearly shown in Fig. 4, opposed, balanced, tapered, coil springs 22 being provided to assure that both ports 18 will be open and that the ball will occupy a static position in repose. In this instance the ball is of such diameter in relation to chamber 19 and ports 18 that it will project through either port in closing it, but when engaged by external unseating means the ball will not be displaced to such an extent that the opposite port will be sealed in the absence of a fluid pressure differential across the head. The outer cylindrical surfaces of guides 16 bear against cylindrical surfaces 23 defined within housing H, the portion of the outside area of the guides thus engaged being more than half the total of said area, whereby the load is at all times distributed well throughout the piston and housing, assuring longer life and better performance over protracted periods and furthermore assuring proper alignment of the piston in the housing. These engaging elements are premachined for close fits to prevent leakage therebetween during operation.

In the lower central portion of the piston, as viewed in these drawings, a recess 24 is provided to receive in secure engagement a sliding element 25 of a slide valve assembly S to be operated by the device of this invention. The engaging boss of sliding member 25 carries a dowel 28 and a compression spring 29 which bears against the inner end wall of said recess and

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thereby maintains member 25 in good sealing contact at all times with opposing portions 30. A slot 32 is provided in the lower side of housing H to receive dowel 28, etc., so that the piston and slide member may move reciprocally in engagement with each other and relative to the housing.

Solenoid units 35 are disposed within the housing H and are enclosed therein in cylindrical casings 36 secured in position relative to the housing and provided with openings in their side walls through which fluid may flow in its travel from closure openings 18 to exhaust vents 12. These solenoids are suitably of conventional form comprising coils 37 and cores 38 movable axially within the coils under magnetic force applied when the coils are energized and under force of springs 39 when the coils are deenergized. These cores are provided at their outer ends with rubber sealing discs 40 for engagement with opposing surface portions of the housing walls to seal vents 12 when the solenoid circuits are open and the cores are extended to the maximum under the action of springs 39. Connection of the solenoid coils in each case with a source of electric power (not shown) outside the housing is effected by means of a wire clip 41 connected to the coil and to a cylindrical plug 42 of the usual adjustable type extending through an opening provided in side wall 10 for the purpose and is insulated from housing H by means of gaskets 43 of suitable electrical insulating material. Conventional timing means and relays, neither of which is illustrated, may be provided in the solenoid control circuits, as those skilled in the art will understand, for automatic high speed operation of said solenoids in timed relation to piston 15.

The assembly and disassembly of the engine of Fig. 1 is relatively simple and easily carried out, as will be appreciated when it is considered that the end walls of the housing H are separate elements removably, but fluid-tightly secured to the central body portion of the housing, suitably by means of screws (not shown) and suitable gaskets 45. Furthermore, slide valve assembly S or equivalent is likewise secured to the central portion of the housing, suitable gaskets 46 being used. Thus, disconnection and removal of these two parts from the housing enables free access to the entire interior of the housing and to the piston and its valve member simply by withdrawing the solenoids and their casings from the housing, dropping the slide 25 and lifting out the piston.

In the operation of this engine, air or other suitable fluid, preferably a gas, is introduced into housing H through inlet I and flows into the spaces on opposite sides of piston head 17 through passage 20, chamber 19 and ports 18. With the piston in its extreme left position, as indicated in Fig. 1, and with head 17 bearing against left coil casing 36, ball 21 is engaged with the said casing and is disposed so that both right and left ports 18 are open. Both right and left vents 12 are closed and the air pressure on both sides of the piston head therefore, is balanced and the piston is in static position. Right coil 35 is then energized, resulting in the opening of right vent 12 to the atmosphere, as illustrated in Fig. 1. The ball is forced, under the resulting air pressure differential across the piston head, into sealing engagement against the right side of the said head, closing right port 18. The flow of live air through inlet I passage 20 and into the left

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chamber through left port 18 continues, causing the piston to travel to the right with the ball remaining seated as indicated in Fig. 2. When the travel of the piston to the right is nearly completed, the ball engages right coil casing 36 and is unseated. Piston travel is completed when the piston head engages casing 36, as illustrated in Fig. 3, and the ball at this stage is so positioned as described above that both right and left ports 18 stand open. Right coil 35 thereupon may then be deenergized, resulting in the closing of right vent 12 and balancing of air across the piston head through chamber 19 and ports 18. Thus the piston again is in a neutral condition and motion of the piston is not again begun until the left coil 37 is energized resulting in the opening of left port 12 and unbalancing of the air pressure across the piston head and consequently seating of the ball to the left. The piston, consequently, may be reciprocated intermittently between the two extreme positions indicated in Figs. 1 and 3 and may be operated in this way continuously depending upon the type of control and operation desired.

The engine of Fig. 5 differs from that of Fig. 3 only in the form of valve member for controlling piston ports 18. Instead of the ball of the former, a dumb-bell plug 50 is provided. The enlarged, rounded end portions of this plug are of such size as to be capable of closing the ports and projecting therethrough for engagement with opposing ends of casing 36.

Furthermore, the plug can move lengthwise in chamber 19 and in repose will allow air flow through both ports 18, a pair of opposed balanced coil springs 22 bearing on the ends of plug 50 assuring this condition. The operation of this device, therefore, is essentially the same as that of the device of Fig. 3 inasmuch as the two closure openings may, under certain circumstances, be open at the same time, as indicated in Fig. 5 or one or the other may be closed and the plug moved from one position to another to accomplish this effect rapidly and under relatively small air pressure differentials. Furthermore, the outlet ports will both stand open when plug 50 is displaced to a maximum degree by engagement with either coil casing 36, provided there is no substantial air pressure differential across the piston head.

The engine of Fig. 6 differs from that of Fig. 3 in several important respects, but the two are of the same general design and operation and embody the same basic invention. The ball valve member 21 is disposed in chamber 19 of piston head 17 where it is centered in repose between balanced coil springs 22 so that the ports 18 will not be sealed untimely by the ball under external forces such as gravity. As a difference, solenoid casings 65 of this valve are unslotted but have axial recesses 66 facing vents 12 and solenoid cores 67 are axially recessed at 68 to receive and retain compression springs 69. The noses of cores 67 carry rubber pads 70 of square cross-section to seal and project into the vents when the coil is deenergized and compression springs 69 exert their effect without interference by magnetic forces in coils 37. Plugs 42 are disposed in end walls 73 of the valve housing and are electrically insulated therefrom by gaskets 43 and electrically connected to coils 37 by clips 41.

Bolts 74 are provided to secure end walls 73 to the main body of the valve housing as indicated in Fig. 6.

The flow of air between ports 18 and vents

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12 in this Fig. 6 engine differs from that of the foregoing devices in that it flows around the end of casings 65, passageways 75 being provided between portions of said casings and end walls 73.

The engine of Fig. 7 generally resembles that of Fig. 1, but is provided with an end wall 73 as shown in Fig. 6. Thus electrical connections to solenoid coils 37 are made through the ends of the engine housing and solenoid casings 65 are unslotted, and a space is provided between a portion of each of these casings and main body H of the housing and end walls 73 to define a passageway 75 for air flow between ports 18 and vents 12. As before, ball 21 is spring-mounted on opposed, balanced, coil springs 22 and piston 16 is operated by means of air delivered through inlet I of body H, solenoid cores 38 regulating air flow through vents 12, as described above. Terminals 42 are connected to a source of electric current (not shown) by means of lines 80 and transformer 81, line voltage being delivered through wires 83 to the transformer. A pair of switches 85, which may be the conventional limit-, micro-, or foot-types, or may be relays, are provided in lines 80 to govern the flow of current to the solenoids; and the circuit is grounded as indicated at 87.

The engine of Fig. 8 likewise bears a general resemblance to that of Fig. 1, but is not provided with solenoid means and is not electrically-controlled in its operation. This engine comprises the usual body portion 10 with its air-inlet I and piston 15 with its spring-mounted ball 21 to regulate the flow of air through the piston head and through ports 18, as described in detail above. Further, piston 15 carries a sliding element 25 of a slide valve assembly. End walls 90 of the engine close the opposite ends of body H and have cylindrical axial projecting portions 91 telescopically disposed within guides 16. Axial apertures 92 are provided in portions 91 and at their outer ends these apertures are enlarged and provided with screw threads for the receipt of valve members 94 which are screwed thereinto and define vents 95. Flow of air through the engine thus is generally the same as described in the discussion of Fig. 1 device to the point where where air emerges through ports 18, whereupon it flows through apertures 92 and out of the engine through vents 95.

To regulate the flow of air through the engine and through these vents manual means, such as indicated at the left side of Fig. 8, may be provided. This means includes a valve stem or plunger 96 disposed within the enlarged portion of aperture 92 on the left side of the engine for sealing engagement with member 94. A compression spring 97 bears against the plunger and against the opposing part of member 91 and resiliently urges this sealing engagement of these parts. A hand lever 99 is disposed adjacent to the engine for engagement with the outer end of stem 96, whereby motion of the lever toward the engine will result in compression of spring 97 and opening of vent 95 to the ends and objects described above.

Means for remotely and mechanically operating this Fig. 8 engine is indicated on the right side of this drawing and comprises a valve body 100 having an inlet port passageway 101 communicating with right vent 95 of the engine through a conduit 102. This body 100 further is provided with an outlet port passage 103 which is threaded and into which is screwed a valve sealing member 104, defining an outlet port 105.

Valve stem 107, quite like stem 96, is provided to close and seal port 105 by firm engagement with body 104 and a compression spring 108 is provided within passage 103 to resiliently urge this engagement, after the manner described above in reference to the spring 97.

The valve stem is carried in suitable supporting structure through which it extends for engagement with a cam 110 carried on a reciprocating element 111. Cam 110 is mounted in such a way that on passing the stem 107 in travel to the left, i. e. toward the engine, the stem will be driven into body 110, opening port 105. On the other hand, when cam 110 is moved in the opposite direction it does not depress the stem, but is turned on a pivot by the stem and port 105 remains sealed under the action of spring 108.

Referring to Fig. 9, a piston head 117, quite like head 17, described above, is illustrated in engagement on its left side with a coil casing 119 having an axially disposed lug 120 projecting through left outlet port 122 of the head. As in said head 17, a chamber 124 is provided in head 117 and a passageway 125 connects this chamber with a source of air under pressure, as for instance, inlet I of an engine housing. Right and left ports 122 are sealed by means of a ball 127 disposed in chamber 124, this ball differing, however, from ball 21 in that it is so dimensioned with respect to the said ports 122 that it cannot project to any appreciable extent there-through for engagement with a coil casing such as casing 36 of the Fig. 1 device. However, ball 127 is similar in other respects to ball 21, being, for example, displaceable to a maximum extent due to the action of lug 120, so that in the position illustrated in Fig. 9 the ball seals neither of the outlet ports and the piston is in a neutral position with air pressure balanced across the head. Also, as before, a pair of opposed balanced springs 129 are provided in chamber 124 to bear against opposite sides of the ball and resiliently oppose movement of the ball toward either of the outlet ports. These springs, like those described in detail above, should not function under any ordinary operating circumstances to stop the flow of air through either of the outlet ports in the head. Closure of the outlet ports in this manner independently of the ball, i. e. when the ball is not positioned to sealingly close one or the other of the ports, may result in the piston being moved at times when such movement is not desired.

Having thus described the present invention so that those skilled in the art may be able to understand and practice the same, I state that what I desire to secure by Letters Patent is defined in what is claimed.

I claim:

1. An engine comprising a housing having an inlet opening and exhaust vents, means for opening and closing said vents, a piston in said housing having a head and skirts projecting in opposite directions from the head, said piston having a passage open to said inlet opening and having outlet openings from the passage communicating with said vents, and means movable with and relative to the head and disposed within said passage and supported by the piston for closing one of said outlet openings under predetermined fluid pressure circumstances and closing the other said opening under other fluid pressure circumstances.

2. An engine comprising a housing having an inlet opening and exhaust vents, means for open-

ing and closing said vents, a piston in said housing having a head and skirts projecting in opposite directions from the head, said piston having a passage open to said inlet opening and having outlet openings from the passage communicating with said vents, means movable with and relative to the head and disposed within said passage for closing one of said outlet openings under predetermined fluid pressure circumstances and closing the other said opening under other fluid pressure circumstances, and resilient means in said head and movable therewith and engaging the closure means for resiliently opposing movement of said closure means to close either of said outlet openings.

3. An engine comprising a housing having an inlet opening and exhaust vents, means for opening and closing said vents, a piston in said housing having a head and skirts projecting in opposite directions from the head, said piston having a passage open to said inlet opening and having outlet openings from the passage communicating with said vents, means including a ball movable with and relative to the head and disposed within said passage for closing one of said outlet openings under predetermined fluid pressure circumstances and closing the other said opening under other fluid pressure circumstances, and means including a pair of opposed balanced springs in the head and engaging the ball to resiliently oppose movement of the ball to close either of said outlet openings.

4. An engine comprising a housing having an inlet opening and exhaust vents, means for opening and closing said vents, a piston in said housing having a head and skirts projecting in opposite directions from the head, said piston having a passage open to said inlet opening and having outlet openings from the passage communicating with said vents, and means movable with and relative to the head and disposed within said passage for closing said outlet openings, said means being responsive to fluid pressure differentials across the head to close the outlet openings on the low pressure side of the piston and to occupy a neutral position with the said outlet openings communicating with each other when there is no substantial pressure differential across said head.

5. An engine comprising a housing having an inlet opening and exhaust vents, means for opening and closing said vents, a piston in said housing having a head and skirts projecting in opposite directions from the head, said piston having a passage open to said inlet opening and having outlet openings from the passage communicating with said vents, and means including a ball movable with and relative to the head and disposed within said passage for closing said outlet openings, said means being responsive to fluid pressure differentials across the head to close the outlet opening on the low pressure side of the piston and to occupy a neutral position with the said outlet openings communicating with each other when there is no substantial pressure differential across the head to close the outlet opening on the low pressure side of the piston and to occupy a neutral position with the said outlet openings communicating with each other when there is no substantial pressure differential across said head.

6. An electrically-controlled, air-powered engine comprising a housing having an inlet opening and exhaust vents, electrical means for opening and closing said vents in timed relation, a

reciprocating piston in said housing, said piston having a head and hollow cylindrical guides extending from the head and having remote open ends and inlet openings at adjacent ends, and a valve member in said head having an inlet opening and a valve chamber communicating with said guide inlet openings, and a ball movable with and relative to the head and disposed in the valve chamber for closing said guide inlet openings.

7. A solenoid-controlled engine comprising a housing having an inlet opening and exhaust vents, solenoid units controlling said vents, a piston in said housing having a head and skirts projecting in opposite directions from the head, said piston having a passage open to said inlet opening and having outlet openings from the passage communicating with said vents, and means movable with and relative to the piston and disposed in said passage for closing said outlet openings.

8. A solenoid-controlled engine comprising a housing having an inlet opening and exhaust vents, solenoid units therein controlling said vents, casings for said units, a piston having a head between said casings and skirts telescoping the latter, said piston having a passage open to said inlet opening and having outlet openings from the passage to the spaces between said piston and said casings, and means movable with and relative to the piston and disposed in said passage for closing said outlet openings.

9. A solenoid-controlled engine comprising a housing having an inlet opening and exhaust vents, solenoid units therein controlling said vents, casings for said units, a piston having a head between said casings and skirts telescoping the latter, said piston having a passage open to said inlet opening and having substantially circular outlet openings from the passage to the spaces between said piston and said casings, and a ball carried by said piston in said passage and having a diameter greater than the diameter of said outlet openings, said ball being movable relative to said piston to project through and close either of said outlet openings and contact either of said casings.

10. A solenoid-controlled engine comprising a housing having an inlet opening and exhaust vents, solenoid units therein controlling said vents, casings for said units, a piston having a head between said casings and skirts telescoping the latter, said piston having a passage open to said inlet opening and having substantially circular outlet openings from the passage to the spaces between said piston and said casings, and an elongated plug movable with said piston and disposed in said passage and having enlarged rounded end portions larger than said outlet openings, said plug being movable relative to said piston to project through and close either of said outlet openings and contact either of said casings.

11. An engine comprising a housing having an inlet opening and exhaust vents, manual means for opening and closing said vents, said means comprising spring-mounted plungers movable to

close said vents and operating levers associated with said plungers, a piston in said housing having a head and skirts projecting in opposite directions from the head, said piston having a passage open to said inlet opening and having outlet openings from the passage communicating with said vents, and means movable with and relative to the head and disposed within said passage for closing said outlet openings.

12. An engine comprising a housing having an inlet opening and exhaust vents, mechanical means for automatically opening and closing said vents, said means comprising valve bodies having inlet ports and outlet ports communicating with said exhaust vents, spring-mounted plungers movable to close said outlet ports, and cam means to engage said plungers and move them relative to said bodies, a piston in said housing having a head and skirts projecting in opposite directions from the head, said piston having a passage open to said inlet opening and having outlet openings from the passage communicating with said vents, and means movable with and relative to the head and disposed within said passage for closing said outlet openings.

13. An engine comprising a housing having an inlet opening and exhaust vents, manual means for opening and closing said vents, a piston in said housing having a head and skirts projecting in opposite directions from the head, said piston having a passage open to said inlet opening and having outlet openings from the passage communicating with said vents, enlarged opposed abutment members in said piston and secured to the housing and telescoped in said skirts, and means including a spring-mounted ball movable with and relative to the head and disposed within said passage for engaging said abutment members and closing said outlet openings.

14. An engine comprising a housing having an inlet opening and exhaust vents, mechanical means for automatically opening and closing said vents, a piston in said housing having a head and skirts projecting in opposite directions from the head, said piston having a passage open to said inlet opening and having outlet openings from the passage communicating with said vents, enlarged opposed cylindrical abutment members in said piston having axial apertures communicating with said passage and vents and being supported by and secured to the housing and telescopically related to said skirts, and means movable with and relative to the head and disposed within said passage for closing said outlet openings.

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