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INTERNAL COMBUSTION ENGINE

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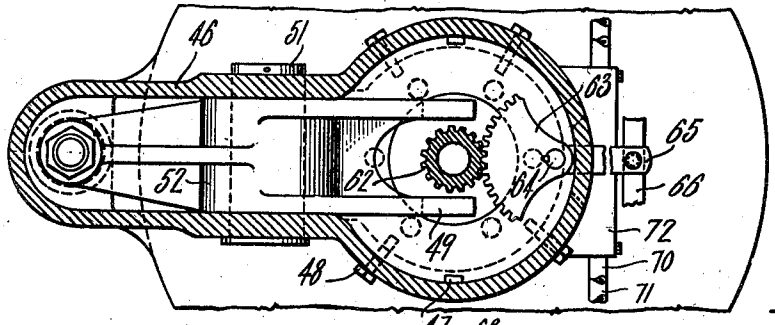


Fig. 2.

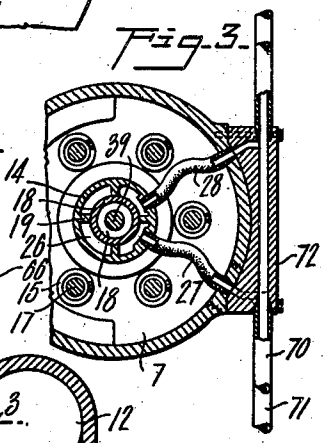


Fig. 3.

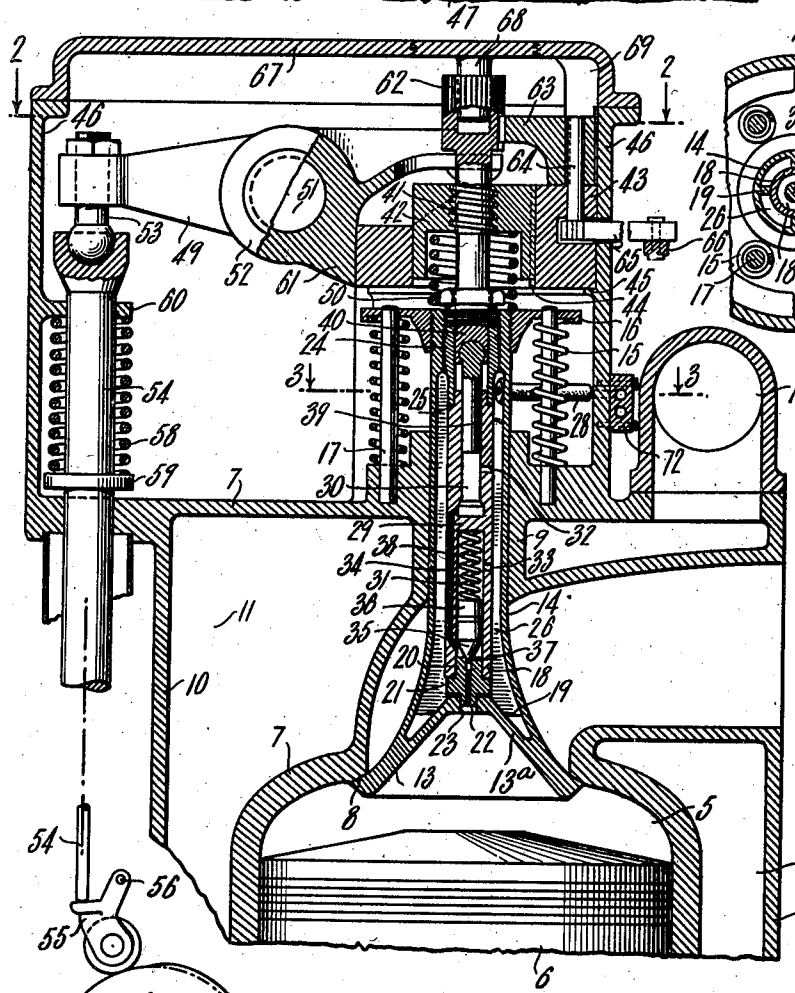


Fig. 1.

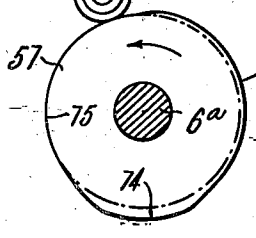


Fig. 4.

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INTERNAL COMBUSTION ENGINE

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20 Claims. (Cl. 123—32)

This invention relates to internal combustion engines of the Diesel type, and more particularly to combination valve and fuel injection apparatus therefor.

One of the objects of the present invention is to provide a novel combination of valve and fuel injection means for internal-combustion engines.

Another object of the invention is to provide novel pump means for supplying a solid fuel to the power cylinder of an internal-combustion engine, and novel means for actuating said pump means.

Still another object is to provide novel means for controlling the quantity of fuel supplied to the power cylinder of an internal-combustion engine during each power stroke of the piston therein.

A further object is to provide novel valve and fuel injection mechanism for an internal-combustion engine comprising only a small number of comparatively rugged parts which may be compactly arranged whereby the engine as a whole is greatly simplified, its reliability is increased and installation, operating and maintenance costs are minimized.

A still further object is to provide novel unitary actuating means for an internal-combustion engine valve and fuel injection mechanism, thereby reducing size and weight per horse-power output and minimizing the number of moving parts, thus cutting down friction losses and the probability of break-down.

The above and further objects and novel features of the invention will more fully appear from the following detailed description when taken in connection with the accompanying drawing. It is to be expressly understood, however, that the drawing is for the purpose of illustration only and is not designed as a definition of the limits of the invention, reference being had for this purpose to the appended claims.

In the drawing, wherein like reference characters refer to like parts throughout the several views;

Fig. 1 is a side elevation, partly in section and with parts broken away, illustrating a portion of an internal-combustion engine embodying one form of the present invention;

Fig. 2 is a top plan, partly in section and with parts broken away, taken on line 2—2 of Fig. 1;

Fig. 3 is a section taken on line 3—3 of Fig. 1 and having parts broken away;

Fig. 4 is a side elevation on a reduced scale illustrating one form of cam construction which may be employed in carrying out the invention.

One embodiment of the novel valve and fuel injection apparatus comprehended by the present invention is illustrated in the accompanying drawing, by way of example, in combination with one cylinder of a two-cycle, port-scavenging exhaust valve-in-head, Diesel type, internal-combustion engine. In the form shown, the latter comprises a power cylinder 5 and a piston 6 therein, said piston being connected in any suitable manner to the engine crank shaft 6a (Fig. 4). Preferably cylinder head 7 is cast integrally with the power cylinder and is provided with a centrally disposed exhaust port 8 and a valve stem guide 9. A jacket 10 encompasses and is cast integrally with both the cylinder and cylinder head, forming a chamber 11 through which a suitable cooling medium may be circulated, the latter being introduced into said chamber at the lower portion thereof through an inlet (not shown) and conducted away through an outlet pipe 12.

A novel valve is provided for controlling the flow of exhaust gases through port 8 and, as illustrated, it comprises an enlarged convex head portion 13 and a hollow stem 14 which extends outwardly through a guide 9. Valve 13, 14 is adapted to be normally held in closed position by suitable yielding means such as a plurality of springs 15 circumferentially disposed about the valve stem and interposed between cylinder head 7 and a flange or disc 16 threadedly mounted on the upper end of stem 14. Spindles 17, mounted on the cylinder head and slidably extending through openings in disc 16, may be provided for positioning springs 15.

In view of the intense heat to which the exhaust valve is subjected during operation of the engine and in view of the advantages obtained by injecting the fuel into the central portion of the combustion chamber, novel cooling means and fuel injection means are provided within valve 13, 14, whereby the life of the valve is increased, the operation and construction of the engine is greatly simplified, and efficiency enhanced. In the illustrated embodiment, such means are constituted by a cylindrical member 18 centrally disposed within valve stem 14, the same being positioned therein by means of a plurality of fins 19 (Fig. 3) cast integrally with the valve stem. A fuel injection nozzle 20 is pressed into the lower end of member 18 and is provided with an annular flange 21 adapted to seat against the inner face of valve head 13. An orifice 22 in said nozzle

communicates with power cylinder 5 through an opening 23 in valve head 13. Member 18 and nozzle 20 are adapted to be held against valve head 13 by a lock nut or sleeve 24 threaded into the upper end of valve stem 14, the lower end of said sleeve engaging a shoulder 25 adjacent the upper end of member 18.

An annular cooling space or chamber 26 is thus formed within the valve stem through which a cooling medium may be circulated, such medium in the illustrated embodiment of the invention being constituted by the engine fuel which is conducted to and from said chamber by means of flexible conduits 27 and 28. Preferably, fins 19 extend for a major portion of the length of chamber 26 for the purpose of directing the flow of fluid therethrough in a manner to obtain maximum cooling effect. Fins 19, it will be noted, serve to give increased rigidity to the valve stem and to the upwardly and inwardly extending portion 13a of the valve face.

Novel fuel injecting means are provided for supplying measured quantities of fuel from chamber 26 to the engine power cylinder at pre-determined intervals depending upon the speed of the engine. For this purpose a partition 29 is provided intermediate the ends of cylinder member 18, thus forming an upper cylinder 30 and a lower cylinder 31 therein. Each of the latter cylinders is in communication with chamber 26 through radial openings 32 and 33, and the lower ends of said cylinders are in communication with each other through a passage 34 in the walls of cylinder member 18. Within lower cylinder 31 is a conical valve 35 carried by a piston 36 and adapted to engage a valve seat 37 formed on nozzle 20 to thereby cut off communication between the fuel supply and the power cylinder through orifice 22. Valve 35 is yieldingly maintained in closed position by suitable resilient means such as spring 38 interposed between valve piston 36 and partition 29. The fuel pumping means consists of a plunger 39 adapted to be reciprocated within cylinder 30 by means to be hereinafter described.

When the lower end of plunger 39 is above orifice 32, fuel from chamber 26 flows through the latter into pump cylinder 30. On the downward stroke of plunger 39 fuel is expelled through orifice 32 until the same is covered by the plunger, whereupon a fluid pressure is exerted by the fuel forced through passage 34 on the lower face of valve 35 sufficient to unseat the same against the pressure of spring 38, thereby permitting fuel to be pumped through nozzle orifice 22 into the power cylinder. Spring 38 is of sufficient strength to hold valve 35 on its seat until the desired injection pressure is built up in the fuel pump chamber by the downward movement of plunger 39 beyond port 32. Cylinder 30, passage 34 and the space below valve 35 in cylinder 31 constitute an expansible fuel metering chamber. The space above valve piston 36 is in communication with chamber 26 through radial port 33 and the fluid entering therethrough is effective to control the unseating movement of valve 35, thereby insuring the quick reseating of the same when a proper fuel charge has been pumped into the power cylinder. The quantity of fuel introduced into the power cylinder on each stroke of piston 6 is determined by the length of stroke of plunger 39 below port 32. It will be noted that the entire fuel injector assembly may be readily removed and disassembled without removing valve 13, 14 from the cylinder head.

Novel actuating means common to both valve 13, 14 and the fuel injection mechanism are provided for operating the same in proper sequence, thereby reducing the number of moving parts and adding to the extreme simplicity of the engine. Such means are so constructed that the transmission of vertical movement to the plunger 39, 40 and valve 13, 14 may be accomplished without subjecting the same to the undesirable side thrust such as is exerted on rocker arm actuated valves now in common use. In the illustrated embodiment, the fuel pump plunger is preferably formed in two parts, the lower portion 39 being secured as by means of a ball and socket joint to a vertically disposed shaft 40, the lower end of which has a sliding fit in a central bore of sleeve 24. Plunger 39 is thus free at all times to aline itself in pump cylinder 30. A groove may be provided in the side of shaft 40 for the purpose of venting air to the space in lock nut 24 below said shaft.

Threadedly mounted on shaft 40 as by means of acme threads 41 intermediate the ends of said shaft is a follower block 42, said threads constituting cam means for causing relative longitudinal movement between said shaft and block when the same are rotated relative to one another. Follower block 42 has a close fit and is adapted to reciprocate in a fixed guide block 43 but is held against rotary movement relative to said guide for a purpose to appear hereinafter by means of suitable splines 44. Guide block 43 is supported on an internal flange or shoulder 45 in a housing 46 which is preferably cast integrally with cylinder head 7 and is adapted to enclose the entire valve and valve actuating assembly. Said guide block is held against both angular and vertical movement in said housing by means of splines 47 and set screws 48. The upper surface of follower block 42 is adapted to be held in engagement with the inner bifurcated end of rocker arm 49 by means of a spring 50 interposed between said follower block and the upper end of valve stem 14, thus normally holding plunger 39 in raised position.

It will be seen that downward movement of follower block 42 by rocker arm 49 is first effective to actuate plunger 39, 40 and thereafter to open valve 13, 14 when the lower face of the follower block engages the upper end of valve stem 14. The side thrust exterted by rocker arm 49 on follower block 42 due to the pivotal mounting of the former is completely absorbed by fixed guide 43; hence only the vertical component of force is exerted on plunger 39, 40 and valve 13, 14.

Rocker arm 49 is pivotally mounted on a journal 51 supported at its ends in bearings in housing 46, said journal extending through a hub portion 52 intermediate the ends of the rocker arm. A pin 53 is adjustably secured adjacent the outer end of arm 49 and adapted to engage the upper end of a push rod 54, the lower end of which engages a cam follower 55 pivoted as at 56 on a frame member (not shown) of the engine. Member 55 is provided with a roller adapted to engage a rotatably mounted cam plate 57 which may, if desired, be drivably secured to, or cast integrally with, crank shaft 6a of the engine.

Rod 54 is yieldingly held in engagement with follower 55 and the latter in turn with the surface of cam plate 57 by means of a spring 58 interposed between a flange member 59 on rod 54 and a bracket 60 secured to housing 46. Counter-clockwise rotation of rocker arm 49 and hence the upward movement of follower block 42 may

be limited by means of a stop 61 on the rocker arm adapted to engage the adjacent surface of guide block 43. A portion of the guide block is cut away (Fig. 1) so as not to interfere with the movement of arm 49.

It will be noted that the actual stroke of plunger 39, 40 is constant, the length of the same, as will hereinafter appear, depending upon the cam surfaces of cam plate 57. Novel means are accordingly provided for controlling the "effective" stroke of said plunger, i. e. the length of its stroke in cylinder 30 below ports 32. Such means, in the form shown, consists of an enlarged portion 62 on the upper end of shaft 40, said enlarged portion being provided with longitudinally disposed gear teeth adapted to cooperate with a toothed sector 63. The latter is slidably supported on guide block 43 and is keyed to a vertical shaft 64 journaled in said block. The lower end of shaft 64 projects into a slot in the central portion of guide block 43 and is keyed to the inner end of an operating rod 65 which extends through a suitable opening in housing 46. Angular movement of operating rod 65 is thus adapted to transmit rotation through shaft 64, sector 63 and gear 62 to vertical shaft 40. Angular movement of the latter causes the same to move in a longitudinal direction relative to follower block 42 by reason of screw threads 41. Plunger 39, 40 is thus raised or lowered depending upon the direction of rotation of shaft 40, thereby changing the effective pumping stroke. The stroke of the fuel pump plungers in all of the cylinders of a multi-cylinder engine may be simultaneously adjusted by connecting the operating rods to a bar 66 extending longitudinally of the engine. The latter may be either manually controllable or connected to a suitable governing device. A cover 67 is provided for housing 46, the same having a guide 68 depending therefrom into a recess in the upper end of shaft 40. A lug 69 may also be cast with said cover for engaging the upper surface of sector 63.

Fuel may be conducted to and from a storage tank (not shown) through conduits 70 and 71 respectively which extend through block 72 secured to the outer surface of housing 46. The passages in block 72 are connected to chamber 26 in valve stem 14 by means of suitable flexible connections 27 and 28 (Fig. 3). Although only a supply connection is required, an outlet conduit, as shown, may also be used in order to get increased circulation and hence increased cooling of the valve.

A cycle of operation is as follows:

As power piston 6 nears the upper end of its stroke, compressing the air in the combustion chamber of the power cylinder 5, cam 73 on disc 57 engages cam follower 55, thereby rotating rocker arm 49 in a clockwise direction and moving follower block 42 and shaft 40 downwardly against the tension of spring 50. The combined effects of springs 15 plus the compression in cylinder 5 being considerably greater than that of spring 50, valve 13, 14 and hence fuel pump cylinder 30 remain stationary as plunger 39 moves downwardly. As heretofore pointed out, fuel is forced out through port 32 into chamber 26 until plunger 39 covers said port. Further downward movement of the plunger exerts a pressure through the fuel in pump cylinder 30, passage 34 and the space below valve 35 which is effective to raise said valve against the pressure of spring 38 and force fuel through nozzle orifice 22 into the power cylinder. As soon as plunger 39 has reached the lower end of its stroke, determined by the maximum height of cam surface 73, valve 35 is again seated by the pressure of spring 38. Preferably, the maximum stroke of plunger 39 as thus determined by the cam is equal to the distance between follower block 42 and the upper end of valve stem 14 when the same are in the positions illustrated in Fig. 1.

The fuel thus injected into the power cylinder is ignited by the heat of compression of the combustion supporting medium therein and the piston is driven downwardly by the expanding gases. During the downward stroke of the power piston, follower block 42 and plunger 39 are maintained, because of the dwell of cam 73, in the positions to which the same are moved by said cam. As piston 6 nears the lower end of its stroke, it uncovers inlet ports (not shown) circumferentially arranged in the walls of the cylinder, connecting said cylinder with a source of compressed air. Slightly before the piston uncovers the inlet ports, cam surface 74 engages cam follower 55, whereby exhaust valve 13, 14 is opened against the pressure of springs 15, the motion being transmitted from rocker arm 49 through follower block 42 to the upper end of the valve stem.

The exhaust valve remains open until just prior to the closure of the inlet ports on the up-stroke of the engine piston, the closure of said valve being timed by the termination of cam surface 74. It will be noted that the compressed air entering the inlet ports will thus thoroughly scavenge the power cylinder while the exhaust valve is open and supercharge the same for a short interval after said valve is closed.

As cam follower 55 leaves cam 74 permitting the exhaust valve to close, it engages the portion 75 of the cam disc, thereby also permitting follower block 42 and fuel pump plunger 39, 40 to return, under the influence of spring 50, to the positions shown in Fig. 1, whereupon fuel pump cylinder 30 is again filled with fuel oil for another cycle of operation.

If it is desired to reduce the speed of the engine, operating rod 65 is moved upwardly, as seen in Fig. 2, thereby rotating shaft 40 in a clockwise direction and causing the same to move upwardly relative to follower block 42 by virtue of threads 41. The effective pumping stroke of plunger 39 below port 32 will thus be lessened and the quantity of fuel pumped into the power cylinder will be decreased accordingly. The movement of operating rod 65 downwardly will be effective in like manner to increase the charge injected into the power cylinder and hence increase the speed of the engine. If it is desired to stop the engine, operating rod 65 is moved upwardly as far as it will go, thereby raising plunger 39 to such an extent that it will not cover ports 32 on its downward stroke. No pressure will then be built up in the metering chamber, and valve 35 will not open to permit the injection of fuel into the power cylinder.

There is thus provided novel valve and fuel injection apparatus for an internal-combustion engine together with novel means for actuating and controlling the same. The novel combination of elements thus comprehended by this invention greatly reduces the number of parts of the entire engine and renders the same compact and reliable. Unitary means are provided for operating the fuel injection mechanism and the only moving valves which are required in an en-

gine of the type illustrated, eliminating the additional rocker arms, push rods and cams heretofore employed. The necessity for a high pressure fuel pump remote from the power cylinders with the usual driving gear and attendant high pressure fuel lines, causing lag, inefficiency and unreliability, is obviated by the present invention. The parts are so constructed as to be readily assembled and disassembled by any ordinary mechanic and the compact arrangement renders it possible to fully enclose substantially all of the moving parts, if desired, without unduly increasing the bulk of the engine. All of these features result in a safe, efficient engine having considerably less weight per horse-power output than Diesel-type engines heretofore produced.

Although only a single embodiment of the invention has been illustrated and described, it is to be expressly understood that the same is not limited thereto but that various changes may be made without departing from the spirit of the invention. For example, the novel combination of elements shown is not limited to use on two-cycle engines, but may be used in combination with those operating on a four-cycle principle. Also the cavity formed in the valve head illustrated may be converted into a pre-combustion chamber of a suitable size by positioning an apertured plate across the bell end of the valve, if desired. Various other changes may also be made in the design and arrangement of parts illustrated as will now be apparent to those skilled in the art. Reference will be primarily had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. In an internal-combustion engine provided with a power cylinder having a port, a valve for said port having an enlarged head portion and a hollow stem, and means for actuating said valve for opening and closing said port, the combination therewith of means within said valve for injecting fuel into said power cylinder comprising means forming a fuel chamber, a plunger adapted to exert pressure on the fuel in said chamber, means for actuating said plunger when the valve is closed, valve means in said chamber controlling communication between the latter and said power cylinder and adapted to be unseated by the fluid pressure in said chamber, and yielding means resisting the unseating movement of said valve means.

2. In an internal-combustion engine provided with a power cylinder having a port therein and a valve for said port having an enlarged head portion and a hollow stem, the combination therewith of fuel pumping means within said valve including a pump cylinder having communication with said power cylinder, a plunger reciprocable in said pump cylinder, valve means controlling communication between said cylinders adapted to be unseated by fluid pressure established by relative movement of said pump cylinder and plunger, and means exterior of said power cylinder for imparting movement to said plunger when the valve for the power cylinder is in closed position.

3. In an internal-combustion engine provided with a power cylinder having a port and a valve for said port having an enlarged head portion and a hollow stem, the combination therewith of means within said valve for injecting fuel into said power cylinder including means forming a fuel chamber, a plunger reciprocable in said chamber, and valve means controlling communication between said chamber and said power cylinder adapted to be unseated by fluid pressure in said chamber, and means for varying the effective delivery stroke of said plunger including a longitudinally movable member, cam means on said plunger adapted to cooperate with said member, and means for relatively rotating said plunger and member whereupon said cam means becomes effective to impart relative longitudinal movement thereto.

4. In an internal-combustion engine provided with a power cylinder constituting a fuel combustion space and having a port and a valve for said port, the combination with said valve of means for injecting measured quantities of fuel into said cylinder comprising means forming an expansible chamber in said valve, means for supplying fuel to said chamber through a port in the walls thereof, a plunger reciprocable in said chamber and adapted to open and close said port, valve means controlling communication between said chamber and cylinder adapted to be unseated by fluid pressure after said plunger closes said port, and means for controlling the extent of the stroke of said plunger after closure of said port including cam means on said plunger adapted to impart longitudinal movement thereto when the same is rotated, and means for rotating said plunger.

5. In an internal-combustion engine provided with a power cylinder having a port, a valve for said port, and a source of fuel supply, the combination with said valve of means for injecting fuel from said source into said cylinder including means forming a metering chamber for said fuel in said valve, valve means controlling communication between said chamber and cylinder, a plunger operable in said chamber for varying the volume thereof, said plunger being adapted to open and close communication between said source and said chamber and exert fluid pressure on said valve means for unseating the same when communication with said source is closed, and means for controlling the stroke of said plunger after the closure of communication with said source including a longitudinally movable member, means for holding said member against rotation, cam means on said plunger adapted to cooperate with said member, and means for rotating said plunger to render the cam means operable to impart longitudinal movement to said plunger.

6. In an internal-combustion engine provided with a power cylinder having a port and a valve for said port having an enlarged head portion and a hollow stem, the combination therewith of a member disposed within said valve to form an annular cooling space therein, an expansible chamber in said member, means for introducing a fuel into said chamber, a plunger operable for varying the volume of said chamber, valve means for controlling communication between said chamber and cylinder adapted to be unseated by fluid pressure in said chamber, and means exterior of said valve for actuating said plunger.

7. In an internal-combustion engine provided with a power cylinder having a port and a valve for said port, the combination with said valve of fuel pumping means therein including a fuel chamber having communication with the power cylinder and a plunger in said chamber, and common means exterior of said cylinder for successively actuating said plunger and valve.

8. In an internal-combustion engine provided with a power cylinder having a port, a valve for

said port and yielding means normally seating said valve, the combination with said valve of fuel pumping means therein including a fuel chamber, a valve controlling communication between said chamber and said cylinder adapted to be unseated by fluid pressure in said chamber, and a plunger operable in said chamber, and common means exterior of said cylinder for successively actuating said plunger and first-named valve.

9. In an internal-combustion engine provided with a power cylinder having a port and a valve for said port, the combination with said valve of fuel pumping means therein including a fuel chamber having communication with the power cylinder, and a plunger operable in said chamber, said valve having a cooling space surrounding said pumping means and being in communication with said chamber, and common means for actuating said plunger to pump fuel into said cylinder and subsequently to actuate said valve.

10. In an internal-combustion engine provided with a power cylinder having a port and a valve for said port having a cooling space therein, the combination with said valve of fuel pumping means therein including a fuel chamber having communication with the power cylinder and a plunger in said chamber, common means for successively actuating said plunger and valve, and means for varying the effective pumping stroke of said plunger.

11. In an internal-combustion engine provided with a power cylinder having a port and a hollow valve for said port, the combination with said valve of a member disposed in said valve to form an annular cooling space therein, flow directing means in said space, and pump means in said member for injecting fuel into said cylinder.

12. In an internal-combustion engine provided with a power cylinder having a port and a hollow valve for said port, the combination with said valve of a member disposed in said valve to form an annular cooling space therein, pump means in said member for injecting fuel into said cylinder, and common means for successively actuating said pump means and said valve.

13. In an internal-combustion engine provided with a power cylinder having a port and a hollow valve for said port, the combination with said valve of a member disposed in said valve to form an annular cooling space therein, pump means including a plunger in said member for injecting fuel into said cylinder, common means for successively actuating said pump means and said valve, and means for positioning said plunger to vary the effective pumping stroke of the same.

14. In combination, a hollow valve, a seat for said valve, yielding means for normally holding said valve on said seat, pump means in said valve, and common means for successively actuating said pump means and said valve.

15. In an internal-combustion engine provided with a power cylinder having a port and a valve for said port having a cooling space therein, the combination with said valve of pump means within the valve including a cylinder having communication with a source of fuel through a port in the walls thereof, a plunger operable in said pump cylinder and adapted to control communication through said last-named port, means exterior of said valve for imparting a constant stroke to said plunger, and means for varying the movement of said plunger relative to said last-named port.

16. In an internal-combustion engine provided with a power cylinder having a port and a valve for said port, the combination with said valve of pump means within the valve including a fuel chamber and a plunger operable in said chamber, means for actuating said plunger to pump fuel from said chamber into said cylinder, and means for moving said plunger longitudinally, independently of said actuating means, for varying the effective pumping stroke of the same.

17. In an internal-combustion engine provided with a power cylinder having a port in the head thereof, a crank shaft, a piston in said cylinder adapted to be operatively connected to said crank shaft, and a valve for said port having an enlarged head portion and a hollow stem, the combination with said valve of fuel pumping means therein, and common means for actuating said pump means and said valve including a pivoted rocker arm, cam means on said crank shaft, and means interposed between said cam means and said rocker arm.

18. In apparatus of the class described, a valve having an enlarged head portion and an elongated hollow stem, said valve head having an opening therein, a member within said valve stem having a passage therethrough in communication with said opening and having an outer diameter substantially less than the inner diameter of said stem, the lower end of said member being adapted to engage a seat around said opening, a sleeve threaded into the upper end of said stem and adapted to engage said member to hold the latter in engagement with said seat, and a plunger reciprocable in said member.

19. In an internal-combustion engine provided with a power cylinder having a port and a valve for said port, the combination with said valve of fuel pumping means including a plunger within said valve, a fixed guide exterior of said valve, a member slidable in said guide and adapted to engage said plunger and valve, and means for reciprocating said member including a pivoted rocker arm to successively actuate said valve and plunger, whereby only a vertical force is exerted upon said valve and plunger.

20. In apparatus of the class described, a cylinder, a plunger adapted to be reciprocated therein, said cylinder having a fluid inlet port adapted to be opened and closed by said plunger, a second cylinder, a nozzle in the end of said second cylinder, a valve in said second cylinder adapted to control an orifice in said nozzle, a conduit connecting the lower end of said first cylinder to said second cylinder at a point below the body portion of said valve, and yielding means for normally holding said valve in closed position, whereby movement of said plunger after closure of said port will exert a fluid pressure on said valve to cause the same to open against said yielding means.

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