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INTERNAL COMBUSTION ENGINE

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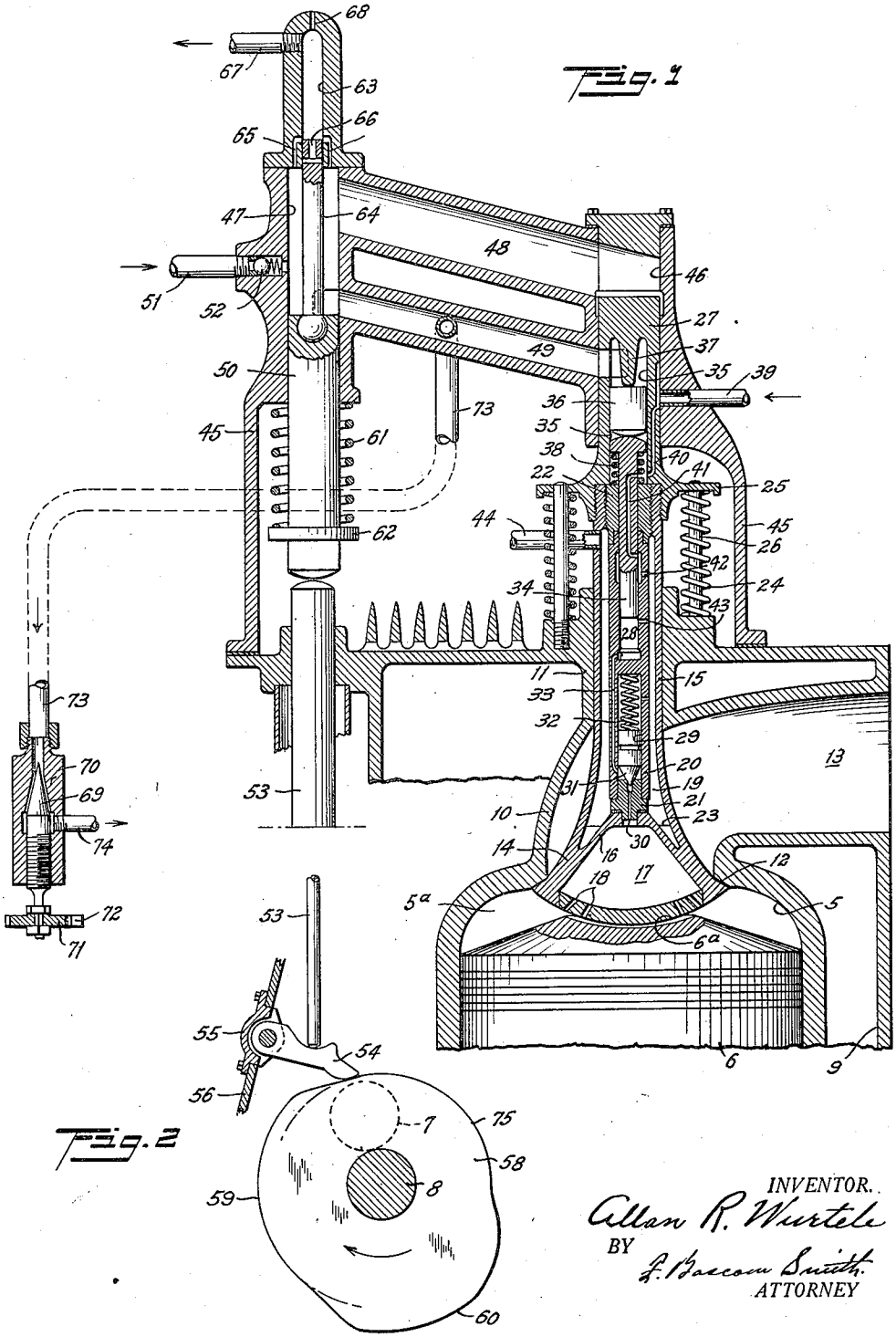


Fig. 1

Fig. 2

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INTERNAL COMBUSTION ENGINE

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18 Claims. (Cl. 123—32)

This invention relates to internal combustion engines, and more particularly to combined valve and fuel injection apparatus therefor.

One of the objects of the present invention is to provide novel valve and fuel pump actuating means for internal combustion engines.

Another object of the invention is to provide novel means for controlling the speed of solid fuel injection engines.

A further object is to provide novel apparatus whereby a valve and fuel pump may be actuated in proper sequence by a common means.

The above and further objects and novel features of this invention will more fully appear from the following detailed description 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 primarily had for this purpose to the appended claims.

In the drawing, wherein like reference characters refer to like parts,

Fig. 1 is a side elevation, partly in section and with parts broken away, illustrating one embodiment of the invention, and

Fig. 2 is a detail view, partly in section, showing one form of cam means which may be employed in carrying out the invention.

Only a single embodiment of this invention is shown, by way of example, in combination with one cylinder of a two-cycle, port scavenging, exhaust valve-in-head, solid fuel injection engine, the latter comprising a power cylinder 5, having a piston 6 adapted to reciprocate therein. Said piston is operatively connected as by means of a connecting rod (not shown) to crank pin 7 of crankshaft 8 (Fig. 2). A cooling water jacket 9 and a cylinder head 10 are preferably cast integrally with cylinder 5, said head being provided with a valve guide 11, an exhaust gas port surrounded by valve seat 12, and an exhaust gas passage 13.

A novel valve is provided for controlling the escape of exhaust gases from cylinder 5, said valve as shown comprising an enlarged head portion 14 and a hollow stem 15. An inwardly and upwardly extending flange 16 forms the upper wall of a precombustion chamber 17 in valve head 14, said chamber being in communication with cylinder 5 by means of orifices 18 in the lower face of the valve. Preferably the face of valve 14, 15 is arcuate and projects into a cup-shaped recess 6a in the crown of piston 6 when the latter is at the top of its stroke. The outer edges of piston 6 incline downwardly and outwardly, thus forming an annular combustion chamber 5a into which orifices 18 open. The outward rush of air when the valve head enters recess 6a tends to carry the burning fuel away from the piston crown, thereby preventing the burning of the latter.

The inner walls of an annular cooling chamber 19 in stem 15 are constituted by a cylindrical member 20 having an outside diameter somewhat less than the inside diameter of said stem. A flanged nozzle member 21 has a tight fit in the bore in the lower end of member 20 and seats against flange 16, said members being held in air-tight contact with flange 16 by a stub cylinder 22 threaded into the upper end of stem 15 and telescopically engaged with the upper end of member 20. A plurality of fins 23 within stem 15 and cast integrally therewith extend substantially the entire length of chamber 19 for the purpose of directing the flow of a suitable coolant through the valve. Additionally, said fins serve to reinforce flange 16 and to position member 20 centrally within the valve stem.

Valve 14, 15 is normally held against seat 12 by means of a plurality of springs 24 circumferentially arranged about stem 15 and interposed between cylinder head 10 and a flange 25 threaded onto the upper end of said stem. Guide pins 26, secured to cylinder head 10 and slidably extending through openings in flange 25, may be provided to prevent rotary movement of valve 14, 15 and to position springs 24. Cast integrally with flange 25 and projecting upwardly therefrom is a piston 27, the purpose of which will appear hereinafter.

Fuel pumping means are provided within valve 14, 15 for injecting fuel into precombustion chamber 17, or directly into cylinder 5, if it is desired to eliminate the precombustion chamber by removing the lower face of the valve. In the form shown, member 20 is bored at each end, thus forming a pair of opposed cylinders 28 and 29. Valve means are provided in cylinder 29 for controlling the passage of fuel through an orifice 30 in nozzle 21 into precombustion chamber 17. The valve means are constituted by a conical valve 31, the upper end of which serves as a piston in cylinder 29. Valve 31 is normally held against a seat formed on nozzle member 21 by means of a spring 32 interposed between the upper end of said valve and the inner end of cylinder 29. The space below the piston portion of valve 31 in said cylinder is in communication with the inner end of

cylinder 28 through a passage 33 in the walls of member 29.

The bore through stub cylinder 22 forms a continuation of cylinder 28 into which a plunger 34 extends. The upper end of said plunger is enlarged, the same having a loose fit in a cylinder 35 within piston 27. Preferably, the upper surface of plunger 34 is slightly rounded and is engaged by a similarly shaped piston member 36, thus permitting plunger 34 to properly aline itself at all times in cylinder 28. Fuel pump plunger 34, 36 is normally held against a stop 37 by means of a spring 38 interposed between the upper end of valve stem 15 and the enlarged portion of plunger 34. In the illustrated embodiment of the invention, fuel is supplied under a slight pressure to cylinders 28 and 29 through a conduit 39, passage 40 in piston member 27, cylinder 35 below the enlarged portion of plunger 34, passage 41 in said plunger, port 42 in member 20, chamber 19, and thence into cylinders 28 and 29 through port 43 and passage 33. A portion of the fuel circulates through chamber 19, thus cooling the valve, and returns to a sump through a connection 44.

As plunger 34 is moved downwardly in cylinder 28 relative to valve 14, 15 by means to be hereinafter described, a fluid pressure is established in cylinder 28, passage 33, and cylinder 29 below the piston portion of valve 31 after said plunger covers port 43. The pressure thus set up is effective to lift valve 31 against the pressure of spring 32 and permit fuel to be injected into precombustion chamber 17 through nozzle orifice 30. The quantity of each charge of fuel thus pumped into said chamber is determined by the length of the stroke of plunger 34.

Novel means are provided for actuating plunger 34 and valve 14, 15 whereby mechanical wear necessitating frequent adjustment and overhaul, as well as mechanical noises incident to present-day constructions, are eliminated. The provision of a single actuating means for both the fuel pump and engine valve effects a large saving in the number of necessary parts, thus simplifying contruction, minimizing the possibility of failure, and decreasing the initial and operating costs of the engine. As shown, the novel actuating means are constituted by a housing member 45 secured by any suitable means to cylinder head 10 and provided with a pair of cylinders 46 and 47, in the former of which valve piston 27 is adapted to operate. Cylinder 47 is in communication with cylinder 46 through a passage 48 and with cylinder 35 in piston 27 through a passage 49 and a port in the side of said piston at a point above piston member 36.

Cylinder 47 and a piston 50 operable therein constitute a fluid pressure pump for exerting a pressure on pistons 36 and 27 to operate fuel pump plunger 34 and valve 14, 15 respectively. Preferably the actuating fluid is taken from the engine lubricating oil system, said fluid being supplied to cylinder 47 through a conduit 51 having a one-way valve 52 therein.

Reciprocation of pump piston 50 is accomplished through a push rod 53, said piston and push rod having curved engaging surfaces to permit self-alignment in the guides provided therefor. The lower end of push rod 53 rests upon a cam follower 54 which is pivotally secured at one end to a bracket 55 which is in turn secured to an engine frame member 56. The other end of said follower engages a cam surface preferably formed on a cheek 58 of the engine crankshaft 8. Two cam surfaces 59 and 60 are provided on cheek 58, the former of which, as will be hereafter pointed out, controls the actuation of the fuel pump plunger, and the latter controls the operation of the engine exhaust valve. Follower 54 is held in engagement with disc 58 by a spring 61 interposed between housing 45 and a flange 62 adjacent the lower end of piston 50.

A cylinder 63, having a bore somewhat smaller than cylinder 47, is secured to the top of housing 45 in alignment with said latter named cylinder. A plunger 64, pivotally secured to piston 50, projects into cylinder 63, the upper end thereof being just below the opening of passages 65 into said cylinder, which passages connect cylinders 47 and 63, when plunger 64 is in its lowered position. A T-shaped passage 66 is provided in the upper end of plunger 64, the horizontal portion thereof being adapted to register with passages 65 at the desired point in the stroke of said plunger to relieve the pressure in cylinder 47 for a purpose to appear hereafter. Cylinder 63 is connected to a sump (not shown) by means of a conduit 67, and with atmosphere through a small air leak passage 68. Passages 48 and 49 preferably slope upwardly toward opening 68 to facilitate the escape of air bubbles in the hydraulic actuating system through passages 65 and 68.

As pointed out above, the length of stroke of plunger 34 below port 43 determines the size of fuel charge injected into the engine cylinder. Novel means are provided for controlling the stroke of said plunger without varying the stroke of piston 50. The novel control means provided may be located in any convenient place, mechanical connections being rendered unnecessary. As shown, such means are constituted by a needle valve 69 threadedly mounted in a valve housing 70, there being one such control valve for each cylinder of the engine. Suitable means, such as a pinion 71 and a cooperating rack 72, may be provided for adjusting said valve which controls the passage of fluid from a conduit 73, connecting housing 70 and passage 49 to the sump through a conduit 74. The greater the leakage through valve 69, 70, the shorter will be the stroke of plunger 34, 36. The areas of pistons 36 and 50 are so proportioned in relation to the height of cam 59 as to permit the injection of a proper maximum charge of fuel when valve 69 is in closed position.

In operation, crankshaft 8, as viewed in Fig. 2, rotates in a clockwise direction, and when follower 54 engages the base circle 75 of disc 58, piston 6 is moving upwardly, compressing air in cylinder 5, and the valve and fuel pump parts are in the position shown in the drawing. When follower 54 engages cam 59, differential piston 50, 64 is moved upwardly against the pressure of spring 61. The initial movement of plunger 64 closes passages 65, and upon further movement, piston 50 establishes a pressure in passages 48 and 49, which pressure is effective to move plunger 36, 34 downwardly, closing port 43 and setting up a pressure in pump cylinder 28. This latter pressure is transmitted through passage 33 to the lower face of valve 31, lifting the same against the pressure of spring 32, whereupon a charge of fuel is injected into precombustion chamber 17 through nozzle orifice 30. Valve 14, 15 is held stationary at this time because of the tendency of the fluid pressure in the hydraulic fluid chamber 48, 49 to take the course of least resistance, the pressure of springs 38 and 32 be-

ing considerably less than the combined pressure of springs 24 and the gaseous pressure acting against the face of valve 14, 15 in cylinder 5.

When follower 54 reaches the top of cam 59, passages 65 and 66 will come into register, thereby releasing the pressure in passages 48 and 49 through conduit 67, thus allowing the return of plunger 34 by spring 33, and the reseating of valve 31 by spring 32. The upper end of piston 50 will at this time assume a position just below the upper edge of passage 49, as indicated by the dotted line. As piston 6 nears the top of its stroke, the fuel charge in precombustion chamber 17 is ignited by the heat of compression of the combustion supporting medium therein and in cylinder 5. The burning fuel expands through orifices 18 into cylinder 5 where it is completely burned driving cylinder 6 downwardly.

When piston 6 nears the bottom of its stroke, uncovering air inlet ports (not shown) in the walls of cylinder 5, such construction being well-known in the art, follower 54 engages cam 60 to further lift piston 50, closing passage 49 and moving port 66 out of register with passages 65. A fluid pressure is thereupon established in passage 49, which pressure acts on piston 27 and is effective to open exhaust valve 14, 15. The latter remains open during the engagement of follower 54 with the dwell of cam 60, and cylinder 5 is scavenged by the injection of air under pressure through the inlet ports referred to above. Valve 14, 15 is closed by springs 24 as follower 54 rides down off of cam 60, the closing action of the same being cushioned by the fluid pressure in hydraulic fluid chamber 47, 48. Said valve is preferably permitted to close just prior to the closure of the inlet ports by piston 6 on the upstroke of the latter, thus allowing cylinder 5 to be supercharged. Follower 54 engages surface 75 of cheek 58 during the major portion of the compression stroke of piston 6, and another cycle is initiated when said follower again engages cam 59.

As pointed out above, the speed of the engine is controlled by varying the stroke of fuel pump plunger 34, and hence the size of fuel charges injected into the engine cylinders. The stroke of said plunger is varied by controlling the leakage from the hydraulic fluid chamber through valve 69 during the first portion of the movement of piston 50, thus varying the available fluid in said chamber for displacing piston member 36. The fluid which escapes from the hydraulic fluid chamber during each cycle of operation is replaced through make-up conduit 51 and valve 52 when the parts are in the position shown.

There is thus provided novel valve and fuel pump actuating apparatus for internal combustion engines which eliminates the usual mechanical wear and noises and results in a decrease in the number of necessary parts for successful and efficient operation, at the same time reducing the initial cost and upkeep expenses. An engine valve and fuel pump may, in accordance with the present invention, be operated by a common means which assures smooth yet positive action. A novel cam-crankshaft is provided for actuating the hydraulic pumping means of the present invention wherein cam surfaces are formed on the crankshaft cheeks and so positioned as to counter-balance the crankpins. Additionally, novel means are provided in combination with the hydraulic actuating means for controlling the stroke of the fuel pump plunger for the purpose of varying the engine speed, whereby the control mechanism may be placed at a distance from the engine with no necessity for mechanical connections while at the same time increasing the fineness of control. The number of parts, and particularly the number of moving parts, is greatly reduced, as is the bulk and weight of the engine per unit of power output.

Although only one embodiment of the invention is illustrated and described, it is to be expressly understood that the same is not limited thereto, but that various mechanical changes as well as changes in the design and arrangement of parts illustrated may be made without departing from the spirit of the invention. For example, valve 14, 15 may, if desired, be actuated by mechanical means, as will now be apparent to those skilled in the art. Reference will be had primarily to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. The combination in an internal combustion engine of a power cylinder having a port, valve means for said port, pump means in said valve means, and common fluid pressure means for actuating said pump and valve means.

2. The combination in an internal combustion engine of a power cylinder having a port, valve means for said port, pump means including a plunger in said valve means, common fluid pressure means for actuating said pump and valve means, and control means for varying the stroke of said plunger, said control means including valve means communicating with the fluid chamber of said fluid pressure means.

3. The combination in an internal combustion engine having a power cylinder of pump means for injecting fuel into said cylinder, hydraulic means including a fluid chamber for actuating said pump means, and control means for said pump means including adjustable valve means connected to said fluid chamber.

4. The combination in an internal combustion engine of a power cylinder having a port, a valve for said port, a fuel pump having a plunger in said valve, common means including a single cam surface for successively actuating said valve and pump, and means for varying the stroke of said plunger for controlling the speed of the engine.

5. In an internal combustion engine, a power cylinder having a port, a valve for said port, means within said valve for injecting fuel into said cylinder comprising means forming a fuel chamber and a plunger in said chamber, valve means controlling communication between said chamber and said cylinder adapted to be unseated by fluid pressure in said chamber, and common hydraulic means for actuating said plunger and valve.

6. In an internal combustion engine, a power cylinder having a port, a valve for said port, means within said valve for injecting fuel into said cylinder comprising means forming a fuel chamber and a plunger in said chamber, valve means controlling communication between said chamber and said cylinder adapted to be unseated by fluid pressure in said chamber, common hydraulic means for actuating said plunger and valve, and means associated with said hydraulic means for varying the stroke of 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 within said valve including a pump cylinder having communication with said power cylinder and a plunger recipro-

cable in said pump cylinder, valve means controlling communication between said cylinders adapted to be unseated by movement toward said plunger by fluid pressure established by relative movement of said pump cylinder and plunger, and hydraulic means for imparting relative movement to said pump cylinder and plunger.

8. In an internal combustion engine, a power cylinder having a port, a valve for said port, fuel pumping means within said valve and movable therewith including a pump cylinder having communication with said power cylinder and 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, hydraulic means for imparting relative movement to said pump cylinder and plunger, and means associated with said hydraulic means for varying the relative movement of said pump cylinder and plunger to control the size of fuel charge injected into the power cylinder.

9. In an internal combustion engine, a power cylinder having a port, a valve for said port, means for pumping measured quantities of fuel into said cylinder, and hydraulic means for actuating said valve and pump means including a cylinder and a piston operable therein, and cam means for actuating said piston, the first portion of the stroke of said piston being effective to actuate said pump means and continued movement thereof being effective to actuate said valve.

10. In an internal combustion engine, the combination of pump means, a valve, hydraulic means for successively actuating said pump means and valve, said last named means including a cylinder having a fluid therein and a piston operable in said cylinder, means for actuating said piston, and means for relieving the pressure in said cylinder after actuation of said pump means.

11. In an internal combustion engine, the combination of pump means, a valve, hydraulic means for successively actuating said pump means and valve, said last named means including a cylinder having a fluid therein and a piston operable in said cylinder, means for actuating said piston, and valve means associated with said hydraulic means for varying the extent of actuation of said pump means.

12. In apparatus of the class described, a valve, a fuel pump, and means including a single hydraulic pump for successively actuating said valve and fuel pump in timed relation.

13. In an engine, a valve, a fuel pump having a plunger movable independently of the valve, and a single cam-operated pump for successively actuating the valve and plunger by fluid pressure in timed relation.

14. The combination in an internal combustion engine of a power cylinder having a port, a valve for said port having a hollow stem, the upper portion of said stem constituting a piston, pump means in said hollow stem including a plunger adapted to reciprocate independently of said valve, yielding means normally holding said plunger in raised position, means limiting the movement of said plunger by said yielding means, fluid pressure means for moving said plunger in the other direction, and means for actuating said valve.

15. The combination in an internal combustion engine of a power cylinder having a port, a valve for said port having a hollow stem, means for supplying fuel to said stem, a plunger in said stem for pumping fuel into said power cylinder, a piston member in said stem having engagement with the upper end of said plunger, resilient means holding said plunger in engagement with said member, means for applying a fluid pressure to said member to move said plunger independently of said valve, and means for actuating the latter.

16. In an internal combustion engine having a power cylinder with a port and a valve for said port, the combination therewith of a fuel pump having a plunger in said valve, common means including a single fluid pressure pump for successively actuating said valve and plunger, and means for varying the stroke of said plunger for controlling the speed of the engine.

17. In apparatus of the class described, a power cylinder having a port, a valve for said port, fuel pumping means having a plunger for injecting fuel into said cylinder, hydraulic means including a cylinder having fluid therein and a piston operable in said last named cylinder for hydraulically actuating said plunger during the first portion of the stroke of said piston in one direction and for hydraulically actuating said valve during the second portion of the movement of said piston in the same direction, and means associated with said hydraulic means for varying the stroke of said plunger.

18. In apparatus of the class described, a power cylinder having a port, a valve for said port, fuel pumping means having a plunger for injecting fuel into said cylinder, hydraulic means including a fluid chamber and a movable member operable in said chamber for hydraulically actuating said plunger during a portion of a movement of said member in one direction and for hydraulically actuating said valve during another portion of the movement of said member in the same direction.

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