

[54] FUEL INJECTION CONTROL SYSTEM

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[52] U.S. Cl. 123/90.13, 91/402, 123/90.12, 123/90.15, 251/57

[51] Int. Cl. F01I 9/02, F15b 15/24, F16k 31/12

[58] Field of Search 123/90.12, 90.13, 90.15; 91/402; 251/57

[56] References Cited

UNITED STATES PATENTS

2,602,434	7/1952	Barnaby	123/90.12
3,003,471	10/1961	Bodem et al.	91/402 X
3,402,913	9/1968	Payne et al.	91/402 X

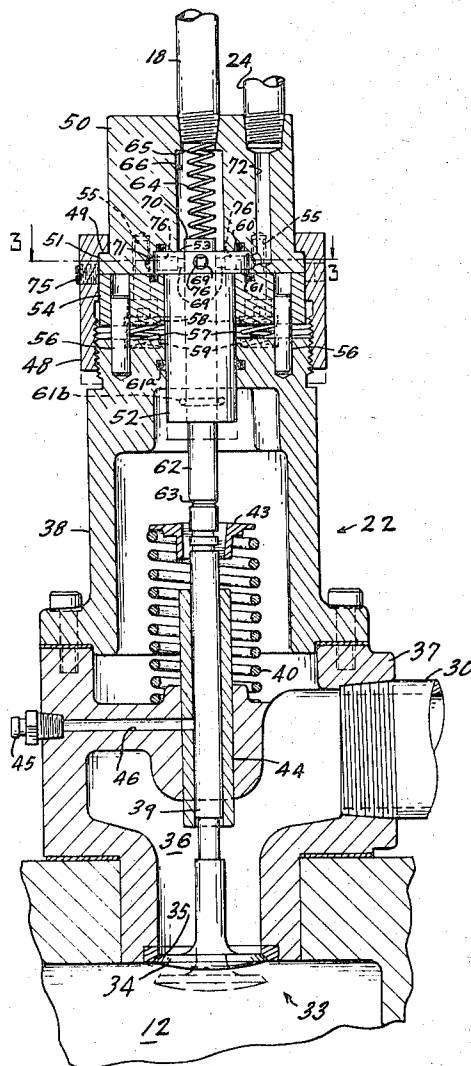
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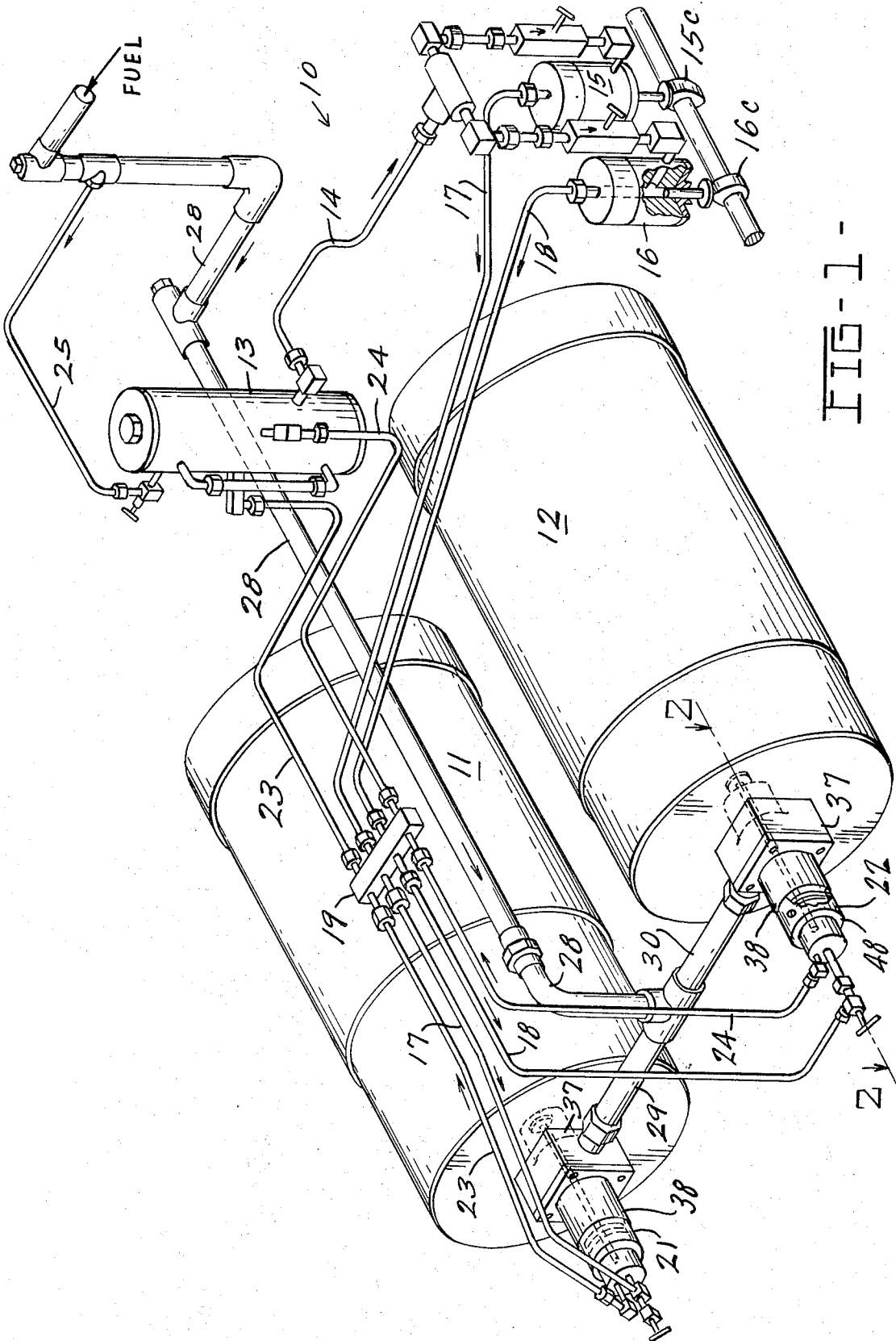
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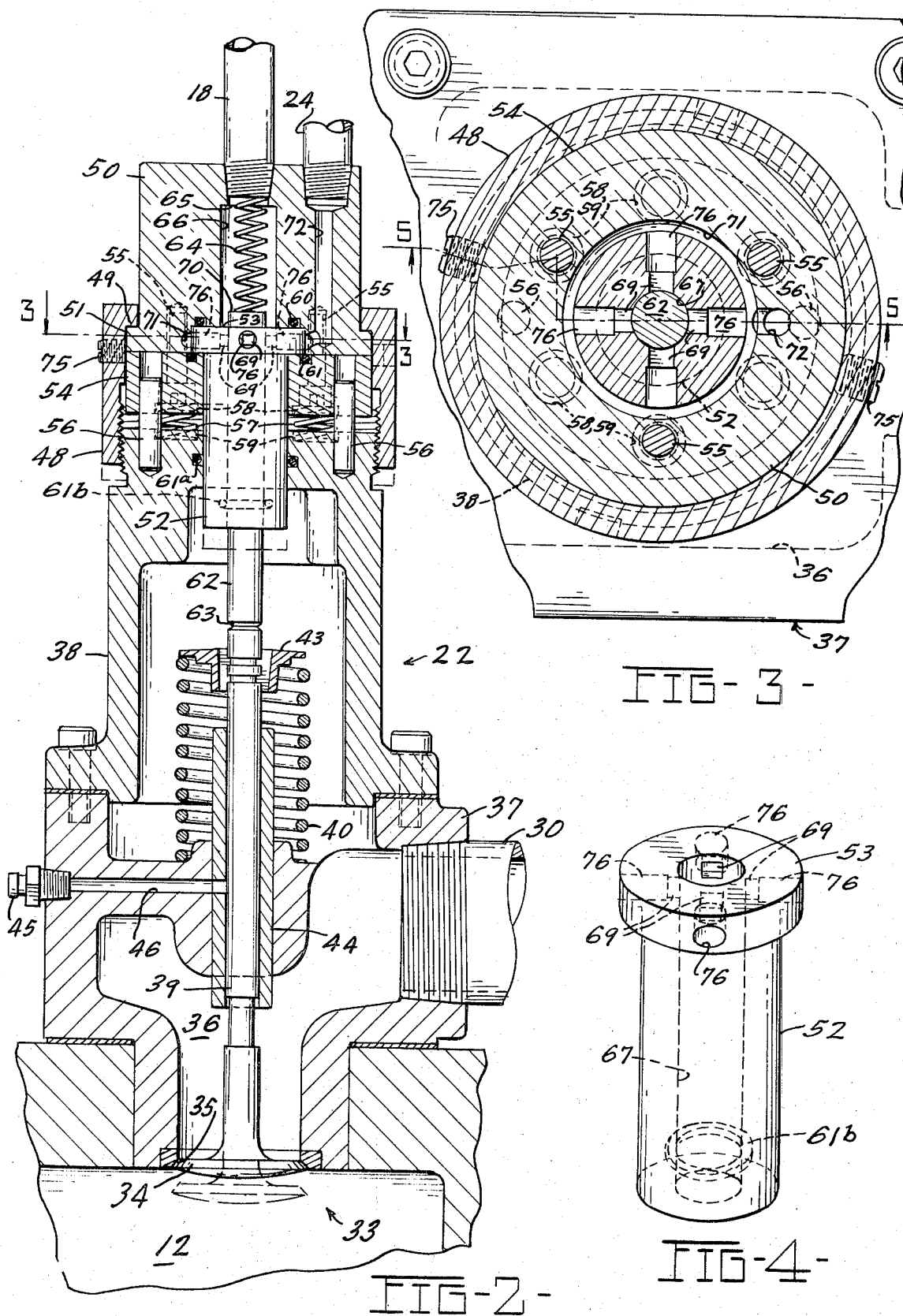
ABSTRACT

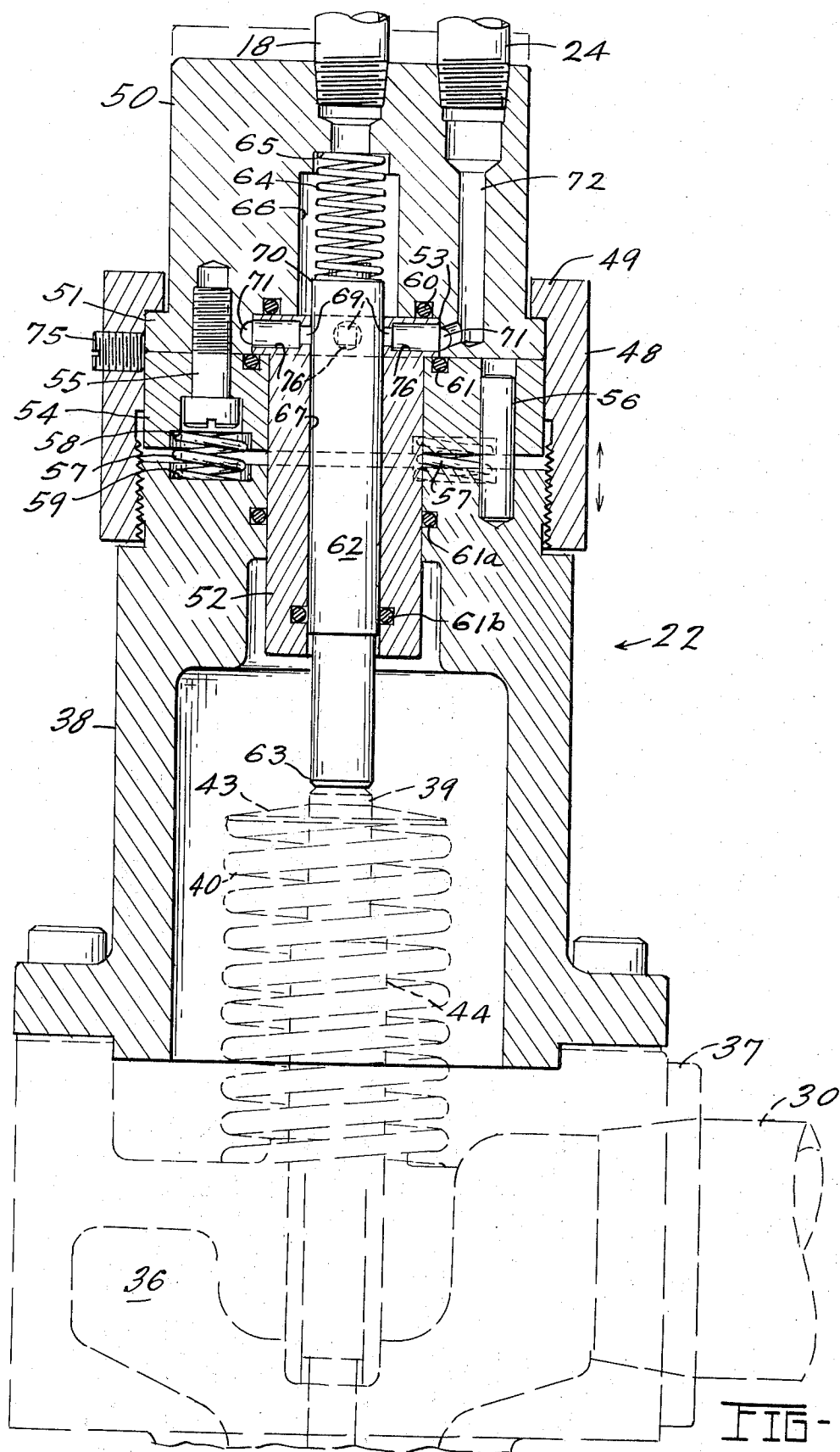
A hydraulic fuel injection control system for internal combustion gas engines which includes means at the valve end of the system for precisely adjusting the volume of the charge injected. In a two cylinder engine, the adjustment means is included on at least one injector valve in order to balance the size of the injected charges in the two cylinders. The adjustment means includes an external cylindrical adjustment sleeve threadably attached to the valve assembly adjacent the end of a valve plunger which operates the valve. About the plunger and connected to the adjustment sleeve is a slave cylinder through which the pressurized hydraulic fluid is received from a cam driven pump. The cylinder includes oil return spillports in communication with the valve plunger, the ports being axially movable with respect to the plunger by rotation of the collar upon screw threads. Axial movement of the ports effects an adjustment of the size of the charge by varying the point at which the plunger opens the spillports to relieve the hydraulic fluid pressure.

10 Claims, 5 Drawing Figures









FUEL INJECTION CONTROL SYSTEM

BACKGROUND OF THE INVENTION

The invention relates to hydraulically operated fuel injection systems, and more particularly to fuel metering control means for such systems in stationary gas engines used for gas transmission, power generation and analogous uses.

Hydraulic valve and pump operating mechanisms are well known. In general, a cam driven hydraulic pump applies a series of timed and metered charges of hydraulic fluid to a fuel valve in the engine cylinder, with the time and duration of the opening of the fuel valve solely dependent upon the hydraulic charges or signals derived from the pump. A spillport system wherein valve lift duration is controlled by the position of a hydraulic fluid spillport in the pump plunger cylinder or the valve plunger cylinder or both is disclosed in U.S. Pat. No. 2,602,434. In this system, there is a means for varying the duration and timing of the valve lift by rotational adjustment of the plungers at both pump and valve by a manual adjustment ring which turns the plungers to vary their inclined end face relative to a spillport.

In diesel fuel injection systems, particularly those employing a plunger pump which directly injects the fuel, means for axially varying the point at which fuel pressure in the pump is released to terminate an injection stroke are known. See U.S. Pat. Nos. 2,225,019, 2,813,523, and 3,673,996.

Prior art systems, however, have not provided a simplified, effective means for adjusting the volume of the fuel charge directly at the valve, where adjustment can be most responsive and accurate. The poppet valve adjustable hydraulic system disclosed in the above mentioned U.S. Pat. No. 2,602,434 involves the use of two adjustments, one at each end of the system. Particularly in multiple cylinder gas engines, there is need for a fuel control system having a simple, effective, easily operated charge size adjustment at the valve end of the cylinders in order to balance the charges in the two cylinders for balanced combustion. The prior art has not provided such a control system.

SUMMARY OF THE INVENTION

The present invention provides a fuel feed control system particularly useful in two cylinder fluid fuel engines such as natural gas but is also applicable to other forms of internal combustion engines. The hydraulically operated system employs a cam operated plunger pump which feeds fluid to a fluid chamber and a slave cylinder operating the plunger of a spring returnable valve. Pressurized fuel is admitted through a duct adjacent the valve head. Radially disposed spillports in the slave cylinder walls are provided to vent the system through an oil return line when the plunger end clears the ports. When the system is thus vented, the plunger and valve snap back to the closed position.

For adjustment of the volume of the fuel charge, apparatus is provided to facilitate axial adjustment of the position of the spillports, thereby varying the point at which the plunger end will clear the spillports to vent the hydraulic system. The apparatus comprises an adjustment sleeve threadably connected to the main valve housing along with a cap and barrel axially movable in response to rotation of the adjustment sleeve about the screw threads. The barrel defines the slave cylinder in-

cluding the spillports, so that when the adjustment sleeve is rotated, the point at which relief venting of the system occurs is altered, providing the required charge size adjustment.

The present system further provides a finely adjustable system which is easily operated. The radially disposed spillports communicating with the plunger and slave cylinder are rectangular rather than circular in cross-section, so that the effective length of the plunger stroke change linearly with rotation of the adjustment sleeve, which would not be the case with circular spillports. This facilitates finer and easier adjustment of the system, particularly in the context of a two cylinder gas engine in which the charge of one cylinder must be balanced with the charge of the other for balanced load conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic perspective view of a fuel injection control system according to the present invention, shown in connection with a pair of combustion cylinders;

FIG. 2 is a cross-sectional view in elevation of a valve assembly including adjustment means according to the invention;

FIG. 3 is an enlarged sectional view taken along the line 3—3 of FIG. 2;

FIG. 4 is an enlarged perspective view of a slave cylinder barrel shown removed from the assembly of FIG. 2; and

FIG. 5 is an enlarged cross-sectional view of the valve assembly taken along the line 5—5 of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A fuel control system according to the invention is shown in FIG. 1 generally indicated by the reference number 10. The system 10 is operably connected to combustion cylinders 11 and 12, diagrammatically indicated as part of a two cylinder gas internal combustion engine. The hydraulic system 10 includes an oil reservoir tank 13 coupled by a hydraulic supply line 14 to the intakes of a pair of cam-operated plunger pumps 15 and 16. Cams 15c and 16c are driven by the engine of which the cylinders 11 and 12 are a part. Hydraulic supply lines 17 and 18 carry pressurized oil from the pumps 15 and 16 through a line support 19 to valve assemblies 21 and 22 connected into the heads of the combustion cylinders 11 and 12, respectively. Oil return lines 23 and 24 return the hydraulic fluid from the valve assemblies 21 and 22 through the line support 19 to the fluid tank 13. Also connected to the oil reservoir tank 13 is a valved pressure line 25 communicating, through a fuel supply line 28, with a pressurized source of gaseous fuel (not shown). Manifold fuel pressure is thus exerted on the surface of the hydraulic fluid in the tank 13 to maintain the fluid in the system 10 under pressure. The tank 13, pumps 15 and 16, valve assemblies 21 and 22, and the various fluid lines 17, 18, 23, and 24 make up a closed hydraulic system.

The fuel supply line 28 transmits fuel from the pressurized source to a pair of fuel conduits 29 and 30 which terminate in connection to the valve assemblies 21 and 22, respectively.

Referring now to FIGS. 2-5, the valve assembly 22 is shown in an enlarged cross-sectional view. A valve 33 including a valve head 34 and valve seat 35 is posi-

tioned in the combustion cylinder 12. Pressurized fuel is admitted to a chamber 36 adjacent the valve 33 through the fuel conduit 30 and will thus be admitted to the cylinder 12 under its own manifold pressure when the valve 33 is open, as it is shown in broken line position in FIG. 2. The valve assembly 22 includes a lower housing 37 connected to an upper housing 38 through which a valve stem 39 connected to the valve head 34 reciprocates. A compression spring 40 disposed between the lower housing 37 and a collar 43 on the valve stem 39 provides a biased closing force for the valve head 34. The valve stem 39 is slidable through a valve guide 44 which is rigidly mounted within the lower housing 37. A valve stem lubrication fitting 45 and line 46 are provided.

In this description and in the following claims; the expressions upward, downward, upper, lower, etc., characterize the valve assembly orientation as seen in FIGS. 2 and 5, with the understanding that the valve assembly can be installed in any orientation.

Threadably connected to the upper end of the upper housing 38 is an external adjustment sleeve 48. The sleeve 48 includes an upper collar 49 which retains a cap 50 by engaging a lower flange 51 thereon. The sleeve 48 rotates on its threads with respect to the cap 50 and the upper housing 38. A cylindrical barrel 52 having an upper flange 53 (shown in detail in FIG. 4) is mounted to the lower end of the cap 50 and retained there by means of a mounting sleeve 54 which is connected to the cap 50 preferably by means of bolts 55. This construction is best seen in FIG. 5. Guide pins 56 prevent the sleeve 54 from rotating with respect to the upper housing 38. To bias the sleeve 54, cap 50 and barrel 52 upward against the collar 49 of the external adjustment sleeve 48, compression springs 57 are mounted within recesses 58 and 59 in the sleeve 54 and the upper housing 38, respectively. O-rings 60 and 61 provide seals between the cap 50 and the barrel 52. Another O-ring 61a provides a seal between the lower end of the barrel 52 and the upper housing 38. A hydraulic elastomeric seal 61b is provided within the barrel 52 against the plunger 62.

Mounted for slidable reciprocation within the barrel 52 is a valve plunger 62, the lower end 63 of which abuts the upper end of the valve stem 39. A compression spring 64 extending between the top end of the plunger 62 and a seat 65 in the cap 50 maintains the plunger 62 and valve stem 39 in abutting relationship.

The compression spring 64 resides in enclosed fluid chamber 66 in communication with the oil supply line 18 from the pump 16. The plunger 62 acts as a piston within a slave cylinder 67 defined by the barrel 52 just below the chamber 66, so that as the hydraulic pump 16 forces oil through the line 18 into the chamber 66, the plunger 62, valve stem 39, and valve head 34 are moved downward against the compression spring 40 to open the valve 33. Thus the time for initial opening of the valve 33 is set by the pump 16 which is in turn controlled by its cam 16c.

To define the duration of the valve opening, a plurality of spillport vents 69 are provided in the upper flange 53 of the barrel 52. When a shoulder 70 of the valve plunger 62 reaches the spillports 69, the pressurized fluid in the chamber 66 is immediately spilled or vented through the spillports 69 and their connected annular passageway 71 to an oil return passageway 72 and thence into the oil return line 24. The annular passage-

way 71 is formed in the cap 50 and is disposed for communication with all the spillports 69 and the fluid return passageway 72, as best seen in FIGS. 3 and 5. When the spillports 69 are open to relieve the pressure in the cylinder 66, hydraulic fluid is returned to the fluid tank 13 and the compression spring 40 immediately returns the plunger 62, valve stem 39, and valve head 34 to the closed position.

As discussed above, the adjustment sleeve 48 is threadably connected to the upper housing 38. Rotation of the sleeve 48 thus moves the sleeve 48 axially with respect to the plunger 62 which is moved axially only by oil pressure as described. Axial movement of the sleeve 48 also moves the axial position of the cap 50, barrel 52, and mounting sleeve 54. With downward movement of the adjustment sleeve 48, the collar 49 assures corresponding downward movement of the cap 50, barrel 52, and mounting sleeve 54. With upward movement of the sleeve 48, the compression springs 57 assure that the cap 50 again follows the collar 49 and correspondingly moves upward. This axial movement of the cap 50 and barrel 52 with respect to the plunger 62 varies the relative axial position of the relief spillports 69 to vary the point at which the plunger shoulder 70 will clear the relief spillports 69 to vent the system. Thus the duration of valve opening and consequently the size of the fuel charge injected through the valve 33 into the cylinder 12 can be controlled by rotation of the screw threaded adjustment sleeve 48. Rotation of the sleeve 48 to move it and the spillports 69 in a downward direction will lengthen the stroke of the valve plunger 62 to increase the volume of the fuel charge. FIG. 5 shows the sleeve 48 and spillports 69 in nearly lowermost, maximum stroke position, while FIG. 3 indicates a higher, shorter stroke position.

A set screw 75 is provided in the adjustment sleeve 48 for locking it against rotation when the charge size has been satisfactorily adjusted.

FIG. 3 indicates the relative positions of the cap 50, bolts 55, guide pins 56, annular fluid passageway 71, spillports 69, slave cylinder 67, and valve plunger 62. Spillport passageways 76 link the annular fluid passageway 71 with the spillports 69.

Referring now to FIG. 4, the spillport 69 shape is square or rectangular rather than circular. This external or radially outer end can be circular but the inner face next to the plunger is preferably square or rectangular. This rectangular configuration facilitates easier and more accurate adjustment of the valve plunger stroke by providing a substantially linear variation of relief port area exposure to the hydraulic fluid. Thus a given increment of rotation of the sleeve 48 will have a corresponding given axial movement of the spillports 69, with a corresponding given change in the fuel charge size, over the entire range of adjustment. This means that the external sleeve can be calibrated in a linear manner and also facilitates the matching of adjustments from cylinder to cylinder.

The above described preferred embodiment provides a fuel injection control system easily and readily adjustable from the valve end of the system. This adjustability directly at the valve, along with the specifically described arrangement and cooperation of the various components, facilitates the attainment of a high degree of accuracy in the adjustment of the duration of the intake valve stroke, which is particularly advantageous in balancing combustion in the cylinders of a multiple cyl-

inder internal combustion engine. For example, accurate balancing of the loads carried by a two cycle engine can be easily accomplished by monitoring the exhaust temperatures from each. If the temperatures are not in substantial balance, a simple adjustment to either cylinder can be made using the valve adjustment described to restore load balance.

Various other embodiments and alterations to the preferred embodiment will be apparent to those skilled in the art and may be made without departing from the spirit and scope of the following claims.

I claim:

1. A hydraulic fuel valve control system including a driven hydraulic pump connected in a closed hydraulic circuit to a hydraulically operable valve assembly extending into a combustion chamber to intermittently admit a fuel to the combustion chamber, said valve assembly including a housing with a valve disposed therein in communication with a source of fuel and said combustion chamber, means for biasing said valve in closed position, an axially movable plunger positioned to open said valve when moved downwardly, said plunger disposed within a sleeve which includes spillport relief vents, hydraulic fluid supply and return lines connecting said pump with a fluid chamber above said plunger and with said relief vents, respectively, an axially translatable cap extending above and secured to said sleeve for axial movement therewith, and an external adjustment sleeve peripherally engaging said cap and threadably connected to said housing, whereby, when said plunger is moved downwardly by hydraulic pressure from said pump, said valve will open and remain open until said spillports are uncovered by said plunger to release pressure thereupon, and whereby incremental rotation of said adjustment sleeve will adjust the axial position of said sleeve and its spillports to vary the duration of said valve is held open by said plunger.

2. The apparatus of claim 1 wherein said cap includes a lower flange and said adjustment sleeve includes an upper hold-down collar engaging said lower flange, with at least one compression spring operably connected to said housing and to said cap biasing said cap from said housing.

3. In an internal combustion engine, a fuel injection control system comprising a source of hydraulic fluid including a plunger pump actuated by a cam operably connected to such engine and effective to supply fluid pressure pulses in timed relation to engine speed;

a valve assembly operably connected to said plunger pump by a fluid supply and a fluid return line, said valve assembly extending into a combustion cylinder of the engine, said valve assembly comprising a housing having a chamber in communication with a source of fuel, a valve in said chamber extending into the cylinder, an axially extending reciprocable valve plunger within said housing extending upward out of said housing and positioned to axially reciprocate with said valve, means for biasing said valve and valve plunger upward toward a closed position, a barrel circumjacent a portion of said plunger defining a cylinder about said plunger, said barrel including a relief vent in communication with said plunger and said cylinder, means for establishing fluid communication between said fluid supply line and said plunger and cylinder, means for returning hydraulic fluid from said relief vent to said fluid return line, and relief vent adjustment

means comprising a slidable connection between barrel and the upper end of said housing, an adjustment sleeve threadably connected to the upper end of said housing and axially movable toward or away from said housing in response to rotation about said housing and means for operably connecting said barrel to said sleeve for axial movement therewith.

4. The apparatus of claim 3 wherein said barrel connecting means comprises a cap connected to said barrel, said cap having an outwardly extending lower circular flange, said adjustment sleeve having an inwardly extending collar engaging said flange from above, a compression spring mounted between said housing and said cap biasing said housing and said cap apart, and means for preventing rotation of said cap with respect to said housing.

5. A valve assembly, comprising:

a housing including a valve seat and a fuel chamber for connection to a fuel source;

a valve head adjacent said valve seat adapted to reciprocate between open and closed positions, said valve head being connected to a valve stem extending upward in said housing;

a compression spring connected to said valve stem biasing said valve stem and valve head toward an upward, closed position;

a valve plunger abutting said valve stem and extending further axially upward;

a cylinder circumjacent the upper end of said valve plunger including a plurality of relief spillports, said cylinder being axially translatable with respect to said housing, said valve plunger being axially reciprocal within said cylinder;

means for connecting a source of pressurized hydraulic fluid in communication with the upper end of said valve plunger;

means for connecting said relief spillports to a fluid return line; and

an adjustment sleeve threadably connected to the upper end of said housing and axially movable toward or away from said housing in response to rotation about said housing, and means for operably connecting said cylinder to said sleeve for axial movement therewith,

whereby, the axial position of said relief spillports may be externally adjusted by rotation of said adjustment sleeve.

6. A valve assembly, comprising:

a housing including a valve seat and a fuel chamber for connection to a fuel source;

a valve head adjacent said valve seat adapted to reciprocate between open and closed positions, said valve head being connected to a valve stem extending axially upward in said housing;

a compression spring connected to said valve stem biasing said valve stem and valve head toward an upward, closed position;

a valve plunger abutting said valve stem and extending further axially upward;

a cylinder circumjacent the upper end of said valve plunger including a plurality of relief spillports, said cylinder being axially movable with respect to said housing and defining a length of axial travel from a lower maximum valve stroke position to an upper minimum valve stroke position, said valve

plunger being axially reciprocable within said cylinder;

means for connecting a source of pressurized hydraulic fluid in communication with the upper end of said valve plunger;

means for connecting said relief spillports to a fluid return line; and

means for externally adjusting the position of said cylinder and spillports within said length of axial travel.

7. A valve assembly according to claim 6 wherein said relief spillports are rectangular.

8. In an internal combustion engine, a fuel injection control system comprising a source of hydraulic fluid including a plunger pump actuated by a cam operably connected to such engine and effective to supply fluid pressure pulses in timed relation to engine speed;

a valve assembly operably connected to said plunger pump by a fluid supply and a fluid return line, said valve assembly extending into a combustion cylinder of the engine, said valve assembly comprising a housing having a chamber in communication with a source of fuel, a valve in said chamber extending into the cylinder, an axially extending reciprocable valve plunger within said housing extending upward out of said housing and positioned to axially reciprocate with said valve, means for biasing said valve and valve plunger upward toward a closed position, a barrel circumjacent a portion of said plunger defining a cylinder about said plunger, said barrel including a relief vent in communication with said plunger and said cylinder, said barrel and relief vent being axially movable with respect to said housing and defining a length of axial travel from the lower maximum valve stroke position to an upper minimum valve stroke position, means for establishing fluid communication between said fluid supply line and said plunger and cylinder, means for returning hydraulic fluid from said relief vent to said fluid return line, and external means for adjusting the axial position of said barrel and relief vent, whereby the stroke of said plunger is externally adjustable.

9. A hydraulic fuel valve control system including a driven hydraulic pump connected in a closed hydraulic circuit to a hydraulically operable valve assembly extending into a combustion chamber to intermittently admit a fuel to the combustion chamber, said valve as-

sembly including a housing with a valve disposed therein in communication with a source of fuel and said combustion chamber, means for biasing said valve in closed position, an axially movable plunger positioned to open said valve when moved downwardly, said plunger disposed within a sleeve which includes axially aligned rectangular spillport relief vents, hydraulic fluid supply and return lines connecting said pump with a fluid chamber above said plunger and with said relief vents, respectively, and means for axially adjusting the position of said sleeve and its spillports with respect to said housing whereby, when said plunger is moved downwardly by hydraulic pressure from said pump, said valve will open and remain open until said spillports are uncovered by said plunger to release pressure thereupon, and whereby adjustment of the axial position of said spillports will vary the duration that said valve is held open by said plunger.

10. A hydraulic fuel valve control system for multiple cylinder internal combustion engines comprising, at least one driven hydraulic pump operably connected to a hydraulic supply line to provide an intermittent series of pressure pulses in timed relation to engine speed, a hydraulically operated valve assembly associated with each of said cylinders with each of said valves connected to a hydraulic supply line such that such pressure pulses are applied thereto with desired timing to open said valve; each of said valves comprising a valve head and seat interconnected between a source of fuel and the combustion chamber of that cylinder, means for biasing said valve head in closed position, a valve plunger extending axially upwardly away from said valve and having its upper end terminating in a hydraulic pressure chamber connected to said supply line, a sleeve including spillports disposed circumjacent said plunger with said spillports positioned adjacent said pressure chamber whereby movement of said upper end of said plunger below said spillports is effective to vent said chamber, said sleeve being axially movable with respect to said valve plunger and defining a length of axial travel from a lower maximum valve stroke position to an upper minimum valve stroke position, and external means for varying the axial position of said sleeve within said length of axial travel whereby the duration and stroke of the valve opening and the volume of fuel in each cylinder can be adjusted externally of the respective valve assembly.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,872,844

Dated March 25, 1975

Inventor(s) Alfred C. Gates

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the claims:

Column 6, line 2, this line should read:

--said barrel and the upper end of said housing, an--

Signed and sealed this 20th day of May 1975.

(SEAL)

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks