Jan. 8, 1929 1,697,952

L. O. FRENCH

FUEL INJECTION CONTROL MECHANISM

Filed Jan. 10, 1927

Fig. 1.

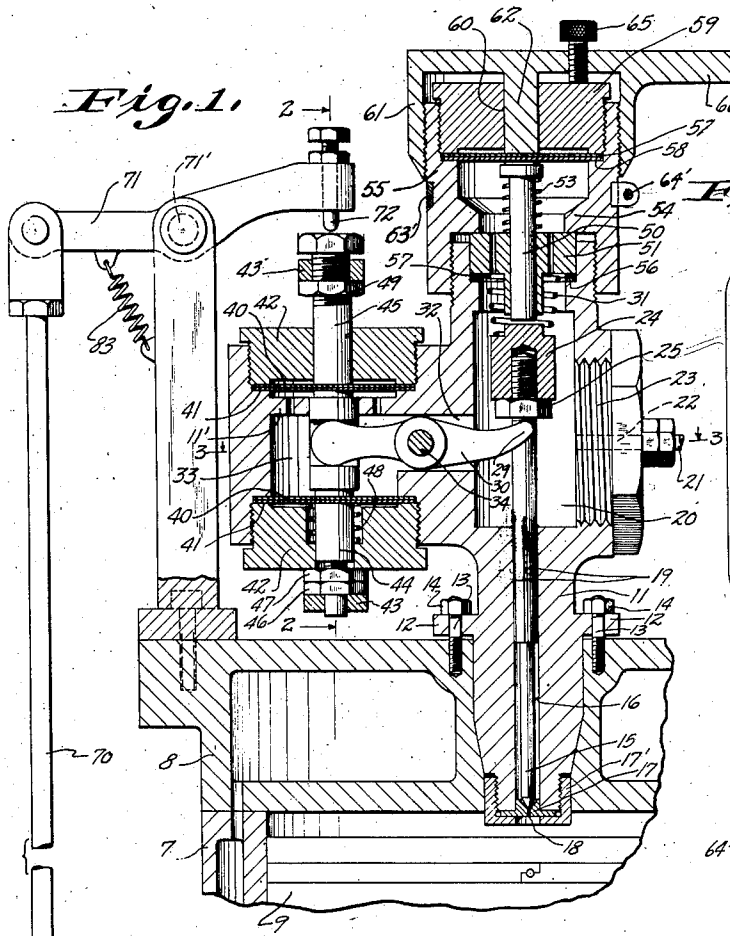


Fig. 2.

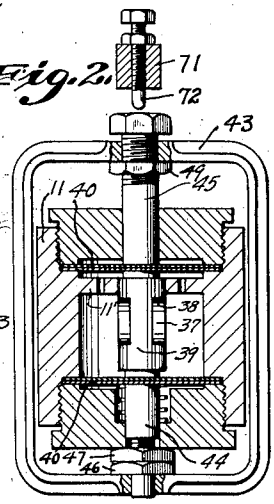


Fig. 4.

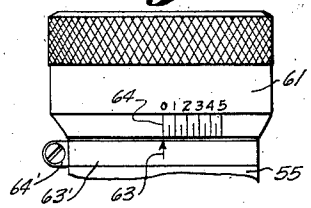


Fig. 6.

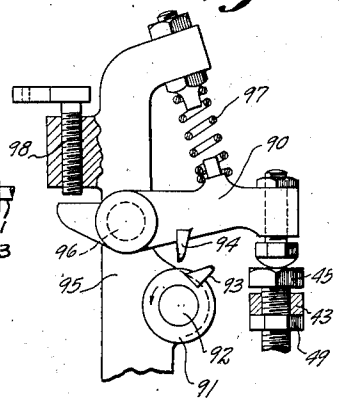


Fig. 3.

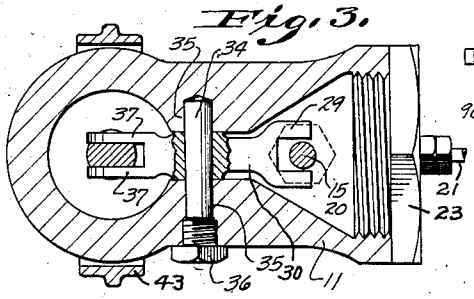
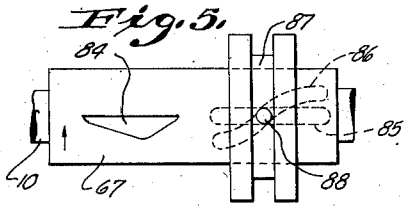
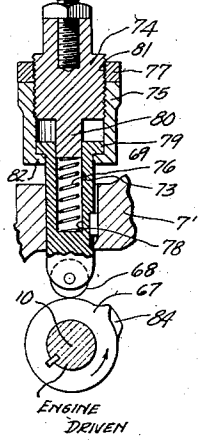


Fig. 5.





INVENTOR.

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UNITED STATES PATENT OFFICE.

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FUEL-INJECTION-CONTROL MECHANISM.

Application filed January 10, 1927. Serial No. 160,177.

The invention relates to internal combustion engines and more particularly to apparatus for controlling fuel fed to the cylinder of the engine.

The problem of mechanically controlling the injection of fuel into engines of small cubical displacement is a difficult one because of the minute quantities of fuel required per stroke. In mechanical systems it is difficult and in the smaller bore automotive engines impractical to meter the fuel by a mechanically-controlled-and-operated pump. A system wherein the fuel under pressure in a supply line is metered to the cylinder by a control valve offers one field of solution of this problem and one of the objects of this invention is to provide in such a system an improved metering valve which permits the accurate metering of the fuel in very small amounts.

A further object of the invention is to provide a fuel control valve wherein the amount of lift of the metering control valve is controlled by micrometrically adjustable stop mechanism obviating the use of a stuffing box.

A further object of the invention is to provide a fuel control valve wherein the use of a stuffing-box associated with the valve-lifting mechanism is obviated.

A further object of the invention is to provide a fuel injection system wherein the same charge amounts per cycle may be furnished through a wide range of engine speed and then reduced above a predetermined speed and shut off at the desired maximum speed.

The invention further consists in the several features hereinafter set forth and more particularly defined by claims at the conclusion hereof.

In the drawings Fig. 1 is a vertical sectional view of a fuel injector embodying the invention;

Fig. 2 is a detail sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a detail sectional view taken on the line 3—3 of Fig. 1;

Fig. 4 is a detail plan view of an actuating cam;

Fig. 5 is a vertical sectional view through part of the valve-operating mechanism.

Fig. 6 is a vertical view of an alternative form of rocker arm mechanism to replace that shown on the outside of the fuel chamber in Fig. 1.

In the drawings the numeral 7 designates the cylinder of an internal combustion engine of either the two or four cycle type, 8 the cylinder head secured thereto, 9 the piston working therein, and 10 a shaft, such as a cam shaft or other lay shaft, driven by the engine.

The fuel control valve, here shown as a fuel injector valve, embodies a casing 11 provided with lugs 12 through which studs 13 project and receive nuts 14 to clamp the injector to the head 8, the lower tapered end of said casing having a fluid-tight fit with said head.

A control valve 15 works in a bore 16 of the casing and seats against a member 17, clamped to the end of the casing by a flange nut 17′, provided with a discharge passage or spray orifice 18. The enlarged upper end of the valve stem is slidably mounted in the bore 16 and provided with grooves 19 to establish communication between a chamber 20 and the lower end of the bore 16. A fuel supply pipe 21 connects with a passage 22 in a detachable plug 23 and delivers fuel to the chamber 20.

The upper end of the stem of the valve 15 has threaded engagement with a cap-nut 24 adjustably secured thereto by a locknut 25, the nut 25 serving to lock the nut 24 in adjusted position, said nut 25 providing an annular shoulder with which the forked end 29 of a lever 30 is adapted to engage. The valve is normally held in its closed position by a spring 31 and when associated with a pressure fuel supply system by the pressure of the fuel.

The lever 30 works in the space provided by the chamber 20, a passage 32 and a chamber 33 and is pivotally mounted on a shaft 34 mounted in alined bores 35 in the casing, the open bore 35 being closed off by a screw-plug 36.

The opposite end of the lever 30 is forked and the rounded bifurcation 37 thereof pivots on ledges formed by notches 38 in a rod 39, one end of which is guided in an apertured partition 11′ formed integral with or secured to the casing 11. Each end of the rod 39 abuts against the central portion of a flexible metal

diaphragm 40, formed of one or more laminations, which is clamped at its outer portion against an annular shoulder 41 by a nut 42 in threaded engagement with the casing and having a centrally disposed bore.

The diaphragms 40 are clamped to the rod 39, so as to produce movement thereof when they are flexed, by means of an exteriorly disposed yoke 43 and rods 44 and 45 associated therewith and alined with said rod. The rod 44 engages the central portion of the lower diaphragm at its inner end and has a nut 46 mounted on the reduced threaded end thereof forming an adjustable abutment secured by a locknut 47 which may engage the nut 42 to form a stop, said nuts being adjustable to limit the clearance position of the free end of the lever 30. The lower central portion of the yoke 43 is apertured to receive the end of the rod 44 and abuts against the nut 46. The rod 45 is in the form of a bolt engaging the central portion of the upper diaphragm at its inner end and having threaded engagement at the upper portion of its shank with a threaded opening in the upper central portion of the yoke so that the bolt forms the movable jaw of a clamp and screwing this bolt inwardly serves to clamp the parts together and when so clamped the yoke is secured in this position by a locknut 49. While the natural resiliency of the diaphragms tends to hold the parts and the lever 30 in a central position, a spring 48 interposed between the lower diaphragm and a shoulder in the lower nut 42 insures the return movement of these parts to a clearance position of the lever 30, which position is limited by the adjustment of the nuts 46 and 47.

With this construction a downward pressure exerted upon the upper end of the yoke, as by the engagement of a tappet lever therewith, causes the yoke, together with the rods 39, 44 and 45 and the central portions of the diaphragms, to move downwardly thereby depressing the end 37 of the lever 30 and raising its other end 29 so that it engages the lower face of the nut 25 and lifts the valve off its seat to allow fuel to pass into the engine cylinder. This construction obviates the use of a stuffing-box and produces a balanced arrangement since the pressure exerted on one diaphragm is balanced by that exerted on the other and in order to keep the areas of the diaphragms small and prevent fatigue thereof the arm of the lever connected with the valve is made longer than that connected with the rod 39 so that a small movement of the diaphragm produces a greater movement of the opposite end of the lever. This has the further advantage of insuring sufficient clearance between the lever and the nut 25 so that if the valve or its seat wears it will not be necessary to readjust this clearance for long periods of time and the spring 31 may be relatively light. The clearance between the lever and the nut 25 may be adjusted by adjusting the lever from outside of the casing, as previously described, or the nuts 24 and 25 may be adjusted while the valve is in assembled position upon the removal of the plug 23. On larger engines if larger lifts are necessary the diaphragms 40 may, of course, be made larger.

Where the valve 15 is used to meter the fuel supplied to the engine, I prefer to provide means independent of the valve actuator for varying or adjusting the lift of the valve and for this purpose I have shown a stop rod 50 slidably mounted and guided in a block 51 and having its upper end held firmly against a diaphragm 52 by a spring 53 interposed between said end and the block 51. The block 51 is clamped to the casing 11 by the inwardly-extending flange 54 of a tubular casing member 55 having threaded engagement with the casing and forcing the block against the shoulder 56 in the casing or against a plurality of annular shims 57 resting thereon which provide a means for initially determining the position of the lower end of the stop-rod when the diaphragm 52 is in a normal position and for subsequent adjustment in case the nut 24 is shifted from its initial position. The block being tightly clamped between the shoulder 56 and the shoulder formed by the lower face of the flange 54 forms a fluid-tight connection therewith. The valve-closing spring 31 engages the block 51 at one end and the nut 24 at its other end. The outer portion of the diaphragm 52 is clamped against an annular shoulder 58 by a nut 59 in threaded engagement with the member 55 and having a central bore 60. The outer upper end portion of the member 55 is threaded to adjustably receive a cap-nut member 61 which has a pin 62 projecting therefrom and extending through the bore 60 into engagement with the diaphragm so that as the nut 61 is screwed down the pin 62 depresses the central portion of the diaphragm and hence moves the rod 50 downwardly. The casing 55, or a part thereof, is preferably provided with an index line 63 and the nut with index lines 64 graduated to read in thousandths or subdivisions thereof so that when the rod 50 is moved down until it engages the nut 24 on the upper end of the valve in a closed position, the nut 61 may be turned back a trifle, determined by the scale, to give the desired clearance between the rod 50 and the valve to determine the lift of the valve. The index line 63 may be on a split collar 63′ mounted in a recess in and rotatable relative to the casing and settable to a zero position when the valve is closed and clamped in this position by a screw 64′. The nut may be rotated by hand and locked in adjusted position by a screw 65 or an arm 66 on the member 61 may be suitably connected for remote control opera-

tion either manually or under the action of the engine's governor, if such is provided.

With this construction it will be noted that as the yoke is depressed the valve 15 is only permitted to lift the amount determined by the position of the stop 50 whose adjustment permits very accurate control of the valve and may be made while the engine is running.

As a means for acuating the valve I have shown in Figs. 1 and 5 an actuator in the form of a cam 67 mounted on a shaft 10 driven by the engine. The connections between said cam and the valve include a roller 68 on a tappet 69 operatively connected by a rod 70 with a lever 71 pivoted at 71' and carrying an adjustable screw tappet member 72 engageable with the head of the bolt 45. The tappet 69 is formed by the parts 73, 74, 75, a spring 76 and nut 77. The part 73, suitably guided in a part of the engine crank case, has a central bore 78 and a flange 79 and carries the roller 68 at its lower end. The part 74 is secured at one end to rod 70 and has a plunger portion 80 working in the bore 78 and a threaded portion 81. The part 75 is in the form of a sleeve-nut adjustably engaging the portion 81, to which it is locked by the nut 77, and has an inwardly-extending flange 82 engageable with the flange 79. The spring 76 is mounted in the bore 78 and acts to move the parts 73 and 74 to an outer position and forms a yielding drive connection therebetween which permits the parts of the tappet to be moved as a unit by the cam 67 until the valve 15 has been lifted and stopped and thereafter compresses so that the part 73 moves while the part 74 and the linkage connected therewith remains stationary during the remainder of the lift of the cam 67. The weight of the tappet and its associated parts may maintain the roller 68 against the cam or a spring may also be used as, for example, the tension spring 83.

With this yielding drive construction the lift of the cam first takes up the clearance between the screw 72 and the head of the rod 45, then moves the yoke downwardly and lifts the valve 15 the amount permitted by the stop 50 and during the remainder of its lift the drive connection yields. This permits the cam to have a lift which will not cause the valve to be lifted because of expansion of the linkage with increase in the temperature and because of small inaccuracies in the cam surface and which at the same time permits the valve to be lifted through the range of lift within the extent of adjustment of the stop 50. However, for small bore engines this lift is preferably made a small amount in order to furnish the engine with the very small amounts of fuel required and particularly on starting when the duration of lift is relatively longer with the cam 67 rotating slowly. The amount of fuel metered to the engine depends upon the amount and duration of the lift of the valve. The duration of lift is determined by the profile of the cam 67 whose lift portion 84 is preferably tapered, as shown in Fig. 5, so that the duration of lift becomes a function of the speed of the engine which, depending upon the taper, may increase or decrease the amount of fuel supplied to the engine at different speeds by a longitudinal adjustment of the cam 67 on the shaft 10. The timing may be automatically effected by having the tapered side of the portion 84 the advancing side but it is preferred to have the timing adjustment independent of cam profile and this may be effected by an angular advance of the cam or its shaft in any of the well known ways. As shown, the shaft 10 has a longitudinally disposed slot 85 therein, the cam has oppositely disposed slots 86 therein of varying angularity and a collar 87 is mounted on the cam and carries a pin 88 passing through the slots 85 and 86, with the result that when the collar is moved by a forked arm (not shown) operatively connected with the annular groove 87 in said collar, said collar advances the pin 88 lengthwise along the shaft 10 and by reason of the slots 86 this motion is translated into an angular and longitudinal movement of the cam. By a proper shaping of the slots 86 the cam is advanced or retarded to best suit the power characteristics of the engine and its shape may be obtained by trial runs at different speeds and different timings.

Under some conditions of service it is desirable to furnish constant quantity fuel charges through a wide range of engine speed. While a tapered cam can be used for constant quantity regulation for a small range of speed, the extent of movement of such a cam for a wide range is too great to be satisfactorily handled by an engine governor. To meet these conditions I have shown in Fig. 6 a hammer member or tappet 90 associated with a cam 91 mounted on an overhead cam shaft 92 driven by the engine. This cam has a projection 93 with an abrupt descent engageable with a toothed projection 94 on the member 90 pivoted to a support 95 at 96 so that when the lever or hammer 90 is raised by the interaction of the projections 93 and 94 energy is stored up in a spring 97 interposed between said lever and support 95 and when these projections pass each other this energy is expended and causes the member 90 to deliver a blow upon the head of the bolt 45 of sufficient strength to move the parts associated therewith, as previously described, to lift the valve 15 to the extent determined by the stop. Since the lever 90 delivers a free blow the duration of the opening movement of the valve 15 is independent of the engine speed so that the same amount of fuel will be furnished the

engine through a wide range of engine speeds. This construction also provides a yieldable lost motion connection between the actuating cam and the valve 15. To prevent the engine exceeding a maximum speed after the engine has passed through the predetermined range of speed mentioned above, the cap member may be turned under the action of the governor to decrease the lift of the valve, or the amplitude of movement of the lever 90 may be decreased by an adjustable screw stop 98 mounted in the support 95 and turnable under the action of the governor to a position to engage and limit the free movement of the lever 90, and in either case the decrease of lift of the valve cuts down the fuel supply and finally, when maximum speed has been reached, the valve is not lifted so that the fuel supply is cut off.

I have shown the control valve 15 as the control valve of the fuel injector and this is the preferred construction, but it may be used as a metering control valve in the fuel discharge line to control the action of a spray valve opened automatically by the pressure of the fuel. Where the valve is used as a metering valve the fuel, introduced in the supply line 21 by any suitable pumping mechanism, may be maintained therein at constant pressure by a suitable pressure valve or accumulator in said line, or it may be built up to the desired pressure by suitable pumping mechanism during the time of the available injection period. The valve, however, is not to be limited to a metering control valve unless specified, and I further desire it to be understood that this invention is not to be limited to any particular form or arrangment of parts except in so far as such limitations are included in the claims or necessitated by the prior art.

What I claim as my invention is:

1. In a fuel injection system, the combination with a fuel metering control valve, of operating means for said valve including a spring hammer operating in cyclic synchronism with the engine to impart substantially equal valve-opening impulses of substantially equal duration independent of the engine speed to cause said valve to supply the engine with substantially constant quantity fuel charges through a wide range of speed, and means, independent of said operating means, to positively limit the lift of said valve.

2. In a fuel injection system, the combination with a fuel metering control valve, of operating means for said valve including a spring-hammer to impart substantially equal valve-opening impulses of substantially equal duration independent of the engine speed to cause said valve to supply the engine with substantially constant quantity of fuel charges through a predetermined speed range, and means operating above said speed range to reduce the lift of said valve and stop the operation thereof at a predetermined maximum speed.

3. In a fuel control valve, the combination with a casing having a chamber and an outlet passage, of a valve mounted therein and controlling the passage of fuel through said outlet, a pair of oppositely disposed, flexible, metal diaphragms closing off a part of said chamber, means connecting said diaphragms interiorly and exteriorly whereby both diaphragms are flexed on the application of pressure applied thereto outside of said casing, and means operatively connecting the interior connection between said diaphragms to said valve to open the same when the diaphragms are flexed.

4. In a fuel control valve, the combination with a casing having a chamber and an outlet passage, of a valve mounted therein and controlling the passage of fuel through said outlet, a pair of oppositely disposed, flexible, metal diaphragms closing off a part of said chamber, means connecting the central portions of the diaphragms to move together including a member in said chamber clamped to and disposed between the diaphragms, and a lever pivotally connected to said member and operatively connected to said valve for opening the same when pressure is applied to said diaphragms exteriorly of said casing.

5. In a fuel control valve, the combination with a casing having a chamber and an outlet passage, of a valve mounted therein and controlling the passage of fuel through said outlet passage, a pair of oppositely disposed flexible, metal diaphragms closing off a part of said chamber, a member abutting against the interior central portions of said diaphragms, an exteriorly disposed clamp engageable with said diaphragms and clamping them to said member, and means operatively connecting said member with said valve to open the same when the diaphragms are flexed.

6. In a fuel control valve, the combination with a casing having an outlet passage, of a valve working in said casing and controlling the passage of fuel through said outlet passage, means for operating said valve, and means for limiting the lift of said valve comprising a stop member within said casing, a diaphragm, and an exteriorly disposed micrometrically adjustable member for flexing said diaphragm.

7. In a fuel control valve, the combination with a casing having an outlet passage, of a valve working in said casing and controlling the passage of fuel through said outlet passage, a pair of statically balanced diaphragms operatively connected to said valve, means outside said casing for flexing said diaphragms to lift said valve, and means for limiting the lift of said valve comprising a stop member within said casing, a diaphragm, and an exteriorly disposed adjust-

able member for flexing said last named diaphragm.

8. In a fuel control valve, the combination with a casing having an outlet passage, of a valve working in said casing and controlling the passage of fuel through said outlet passage, a lever within said casing associated with said valve, a pair of oppositely disposed diaphragms associated with said lever, means for flexing said diaphragms to move said lever to open said valve, means to move said lever to a clearance position, and adjustable stop means to determine the clearance position of said lever.

In testimony whereof, I affix my signature.

LOUIS O. FRENCH.