

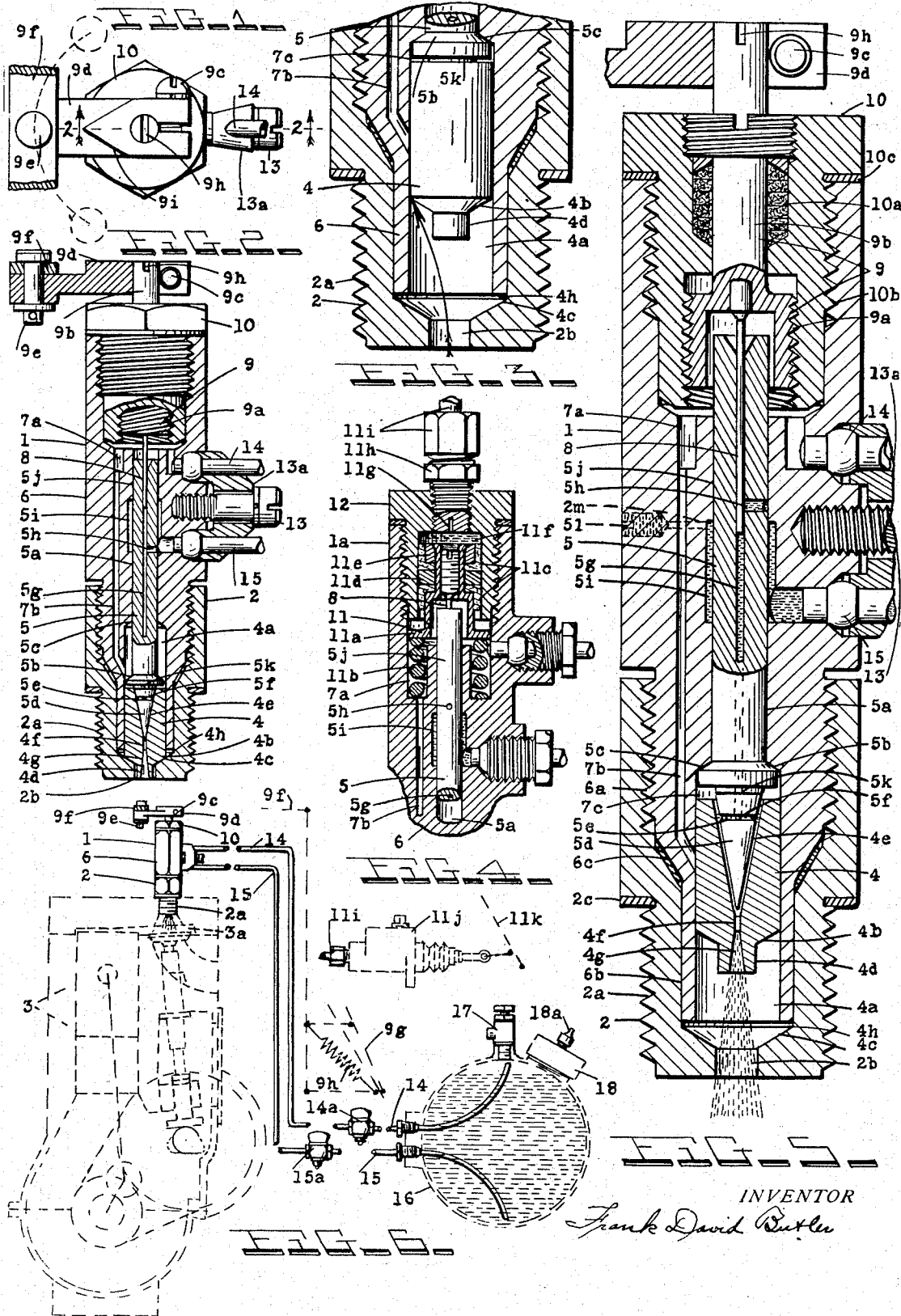
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INTERNAL COMBUSTION ENGINE CHARGE-FORMING DEVICE

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INTERNAL COMBUSTION ENGINE CHARGE-
FORMING DEVICE

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2 Claims. (Cl. 299—107.2)

(Granted under the act of March 3, 1883, as
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My present invention relates to charge-forming devices for internal combustion engines, more particularly of the type wherein the fuel used in such engine is atomized, and injected into the combustion chamber of such engine automatically by the compression and combustion pressures present in such combustion chamber, and wherein such fuel is ignited during such injection by the intense heat generated in said combustion chamber as the supply air charge is highly compressed therein by the engine piston as the latter nears the completion of its compression cycle period of operation. The solution of the major problem of burning oil fuel efficiently (especially in relatively small piston displacement engines), with its many minor resulting problems, has been long and vainly sought by many in this art.

The major concept of my present invention is the solution of said problem and the provision of a simple, durable, efficient and relatively inexpensive means for its practical and commercial accomplishment.

More specific concepts of my invention in combination with an internal combustion engine and as an article of manufacture, contemplate; (a) the provision of relatively inexpensive and efficient means for minutely atomizing, highly agitating and injecting the fuel charge into the combustion chamber of each cylinder of such engine automatically and pneumatically by and through the compression and combustion pressures within such combustion chamber or chambers; (b) the provision of means for bleeding off sufficient compressed air or combustion gas from said combustion chambers via said fuel injecting unit necessary for the pneumatic operation of the latter; (c) the provision of means for cushioning the automatically operated moving elements of said fuel injecting unit as they near the ends of their reciprocating travel; (d) the provision of mechanical means for remotely regulating the quantity of fuel per injection charge of said fuel injecting unit, and remotely and collectively regulating the quantity of fuel injection charges when more than one unit is used (as when used in multi-cylindrical engines); (e) the provision of hydraulic means (especially adapted to radial aviation engines) for remotely and collectively regulating the quantity of fuel per injection charge per cylinder; (f) the provision of means combining provisions a, b and c with either d or e into a single fuel atomizing and injecting unit; and (g), the provision of means comprising minor new and useful entities which practically, com-

mercially, efficiently, and economically practice, in the manner found by me thus far in the development of my invention to be most advantageous in each of the foregoing, and other respects which will more clearly appear, and be understood by those skilled in this art, from the accompanying drawing and the following description, and appended claims.

It will be readily appreciated by those skilled in this art, after understanding my invention, that various changes may be made in the means disclosed herein which will produce the same results in practically the same manner without digressing substantially from my inventive concept or sacrificing any of its outstanding inherent advantages.

With reference to the drawing—

Fig. 1 is a plan view of Fig. 2.

Fig. 2 is a longitudinal section (as would appear on the dotted line 2—2 of Fig. 1) of my automatically and pneumatically operated, mechanically remotely regulated fuel atomizing and injecting unit and illustrates the automatically operated moving elements of such unit in their closed or normal position of travel, and the mechanically remotely regulated elements of such unit in their half fuel charge position of regulation.

Fig. 3 is an enlarged portion of the lower end of Fig. 2 except illustrating the automatically operated moving elements of the fuel injecting unit in the position they would occupy at the completion of the fuel injection period and prior to their return to their closed or normal position of travel.

Fig. 4 is a portion of a longitudinal section of my automatically and pneumatically operated, hydraulically remotely regulated fuel atomizing and injecting unit and illustrates the automatically operated moving elements of such unit in their open position of travel, and the hydraulically remotely regulated elements of such unit in their half fuel charge position of regulation.

Fig. 5 is an enlargement of Fig. 2 except illustrating the automatically operated moving elements of the fuel injecting unit in their full open position of travel.

Fig. 6 is a diagrammatic sketch illustrating one of the fuel atomizing and injecting units as it would appear if mounted in a marine or automobile type of internal combustion oil fuel engine, and further illustrates the general arrangement of the auxiliary equipment of such unit.

In the accompanying drawing, similar numerals and letters represent and indicate similar parts in the several views, the numeral 1 indicates one of the mechanically regulated fuel atomizing and injecting units, while the combined numeral and letter 1a indicates one of the hydraulically regulated fuel atomizing and injecting units. Each of said units (when manufactured to be used in a marine or automobile type of internal combustion oil fuel engine) may be equipped, near its lower end, with a suitable threaded portion 2a (similar to that of the present day common spark plug) which may be adapted to secure said unit, to the engine cylinder, so that its extreme lower end will be constantly exposed to the variable pressures and temperatures within the combustion chamber 3a of such engine. Each of said units 1 or 1a consists of a differential area actuating piston 4 which is adapted to fit snugly to and reciprocate within a cylindrically shaped chamber 4a and to normally seat with its disc 4b in contact with the conically shaped seat 4c (the latter being located in the lower body portion 2, of the unit 1 or 1a, adjoining the combustion chamber 3a) and to have a cylindrically shaped projecting reduced tip portion 4d adjoining the lower end of said disc 4b and adapted to be constantly exposed to said combustion chamber and to be appreciably smaller than and thus to fit within the cylindrically shaped throat opening 2b of said body portion 2; said piston 4 having an elongated conically shaped internal seat portion 4e (which latter extends downward from the upper end of said piston) and terminates at its lower end in a minute cylindrically shaped orifice 4f which latter in turn terminates at its lower end in a conically shaped nozzle 4g which latter extends through tip 4d.

The elongated cylindrically shaped fuel atomizing and injecting piston valve 5 is adapted to fit snugly to and reciprocate within the cylindrically shaped chamber 5a (which latter is located in the intermediate body portion 6 of the unit 1 or 1a) and is equipped at its extreme lower end with an elongated conically shaped valve disc 5d (corresponding with and adapted to seat against seat 4e) having in the intermediate portion thereof a minute annular shaped fuel atomizing groove 5e which latter is connected to the minute cylindrically shaped elongated fuel injection chamber 5g (which latter extends lengthwise through-out the greater portion of and internal to valve 5) by and through the fuel diffuser ports 5f (which latter extend radially through said valve 5), and in its upper portion with a suitable radially extending fuel supply port 5h (which latter intermittently offers communication between the annular shaped fuel supply chamber 5i and the fuel injection chamber 5g); the cylindrically shaped upper portion 5j of valve 5 terminates at its lower end in a conically shaped disc 5b (which latter is adapted to intermittently contact the seat 5c located in body 6 between chambers 4a and 5a; the largest diameter of said disc 5b being appreciably smaller than and thus to fit within the chamber 4a, said valve 5 having intermediate said largest diameter and the upper end of disc 5d, a relatively short cylindrically shaped relieved portion 5k, which latter is of the same outside diameter as the largest portion of disc 5d and a predetermined amount smaller than the diameter of portion 5j of 5.

Extending between the annular shaped pneu-

matic air supply chamber 7a (located in the upper end of 6) and the chamber 4a (and terminating at a predetermined location in the wall of the latter) is the pneumatic air communication port 7b which latter is adapted to intermittently (being controlled by the movement of piston 4 in 4a) form communication between said chambers.

In the upper end of fuel supply chamber 5i and extending through body portion 6 to the outside atmosphere is the air vent port 2m which latter is equipped with a regulating needle valve 5l which is for the purpose of venting off any quantity of air that might collect in chambers 5g or 5i under adverse operating conditions.

Extending down into and adapted to fit snugly within the fuel injection chamber 5g (of the valve 5) is the fuel injection plunger 8 which latter (due to movement of the piston valve 5 as will be explained later) is adapted to intermittently pass beyond port 5h (in chamber 5a) and thus to cut-off communication (through said port 5h) between chambers 5g and 5i and thereby to trap (at such times) the fuel in the former chamber.

In the mechanically regulated fuel atomizing and injecting unit 1, the fuel injection plunger 8 is rigidly secured (at its upper end) within the regulating spindle 9 which latter is rotatably mounted within the upper body portion 10 of the unit 1 and is equipped, at its lower end, with an enlarged, hollow, externally multiple right threaded portion 9a (which latter is adapted to be telescoped internally by the piston valve 5 and to fit snugly externally within a suitable threaded portion in body 10) and, at its upper end, with a cylindrically shaped journal portion 9b (which latter extends upward through a suitable stuffing box 10a in the body 10 and projects above the upper end of the latter); the projecting portion of 9b having clamped thereto, by the bolt 9c, the crank arm 9d which latter has pinned to the opposite end thereof, with the pin 9e, the multiple unit coupling strip 9f which latter is adapted to couple a series of such unit 1 crank arms 9d and to be operated remotely by a manually foot operated regulating pedal 9g (which latter is diagrammatically illustrated in Fig. 6); when several units 1 are to be coupled together with the coupling strip 9f (in a multi-cylindered engine), the individual units 1 may be adjusted while the engine is operating by loosening clamp bolt 9c and rotating 9b clockwise to increase the amount of fuel injection and vice versa, and after such individual adjustments are made, the series of units 1 may be regulated collectively through movement of said strip 9f clockwise (Fig. 1) to increase the fuel injection of all the cylinders of the engine and vice versa.

In the hydraulically regulated fuel atomizing and injecting unit 1a, the fuel injection plunger 8 is adjustably secured (being threaded at its upper end) within the hydraulically operated plunger 11 which latter is reciprocatably mounted within the upper body portion 12 of the unit 1a and is equipped, at its lower end, with an enlarged flanged portion 11a (which latter is adapted to bear against the resilient spring 11b) and, at its upper end, with a packed plunger portion which is a snug fit within the cylindrically shaped chamber 11f and consists of a pair of opposed leather packing cups 11c, a collar 11d (which the latter is located between said cups) and a retainer washer 11e which latter is located above the upper of said cups and secures them

to said plunger portion. The upper end of said cylinder 11f is connected with the master hydraulic cylinder 11j by and through the fitting 11h (the latter having the minute restriction orifice 11g at its lower end), and the tubing connections 11i; and said master cylinder 11j is operatable by the manually operated foot pedal 11k. When several units 1a are to be regulated together simultaneously, each individual unit 1a (of such units) is adjusted separately by adjusting the combined fuel metering and injection plunger 8 in plunger 11, and then regulating all of said units 1a collectively and simultaneously by and through movement of the plunger of said master hydraulic cylinder in to increase and out to decrease the quantity of fuel injection of said units. Any supply of fluid into chamber 11f from 11j will tend to close spring 11b and will force plunger 11 and 8 to a lower level in cylinder 11f and fuel injection chamber 5g respectively and vice versa and will increase or decrease respectively the quantity of fuel injection of all units, likewise connected with 11j, simultaneously.

It is understood and is obvious that the connecting regulating strip 9f of the unit 1, or the plunger of the hydraulic cylinder 11j of the regulating system of unit 1a, could be connected to a common ball or other type governor in place of the manually operated foot pedals previously mentioned.

Fig. 6 is a diagrammatic illustration of one of the units 1 mounted so as to have its lower end projecting into the combustion chamber 3a of the cylinder of the internal combustion engine 3, its intermediate body portion 6 connected with the fuel tank 16 through the pneumatic air tubing and connections 14 and the fuel supply tubing and connections 15, and its regulating crank arm 9d connected with the manually operated foot pedal 9g through the multiple connection regulating strip 9f and the linkage illustrated diagrammatically. The pneumatic air tubing 14 and fuel tubing 15 are both secured to the unit 1 by the bolt 13 and securing dog 13a, and have therebetween and the fuel tank 16, the pneumatic air cut-out valve 14a and fuel cut-out valve 15a (and also suitable air and fuel strainers, not illustrated), the former mentioned tubing extending inside of and to the top of said tank and the latter inside of and to the bottom of said tank. The top of said tank 16 having secured thereto and in communication with the inner portion thereof the adjustable relief valve 17 (which latter is normally set at 100 pounds pressure per square inch), and also the filler cap 18 which latter has secured thereto the outside source pneumatic air supply valve connection 18a.

As the units 1 and 1a function alike, except for their differences in remote means of regulation, I will endeavor to describe the construction and operation of one of the units 1, and for convenience of such description will assume that the moving elements of said unit are in the position in which they are illustrated in Fig. 2 (normal closed position), that there is a pneumatic air pressure of 100 pounds on tank 16 and on the oil fuel therein, that all air has been vented off from chamber 5i through needle valve 5l, that the fuel supply chamber 5i is filled with oil fuel at the same pressure as on tank 16, that the weight and friction of the moving elements of the unit are negligible, that there is pneumatic air under 100 pounds pressure in chambers

7a and 4a and in the communication passage 7b connecting them, and that said unit 1 is mounted, as illustrated in Fig. 6, in the engine 3. We will now further assume that we want fuel atomization and injection to start automatically when the pressure of the compressed air in combustion chamber 3a (compressed therein during the compression cycle of said engine) exceeds 400 pounds per square inch, that the threaded portion 2a of the unit 1 is the same size as a common $\frac{7}{8}$ inch spark plug, and that the other dimensions of said unit are of proportionate size therewith. We will then construct the unit 1 so that the cross-sectional area across the throat 2b is .025 of a square inch (known as area (A)), the cross-sectional area of the upper diameter of chamber 4a four times as large as area (A) or .1 of a square inch (known as area (B)), the cross-sectional area of the lower diameter of said chamber 4a (known as area (C)) the same as area (B); therefore 100 pounds pneumatic air pressure exerted against the upper ends of 4 and 5 (equal to area (B)) would prevent 400 pounds pneumatic air pressure in combustion chamber 3a and exerting itself against area (A) under actuating piston 4 from lifting the latter from its seat 4c until such time as the latter mentioned pressure is exceeded. We will now assume that the pneumatic pressure in combustion chamber 3a slightly exceeds 400 pounds (by and through the rotation of crank shaft of engine 3), the piston 4 will then be forced upward from its seat 4c and will travel from the position in which it is illustrated in Fig. 2 to the position it is illustrated in Fig. 5 and thence to the position illustrated in Fig. 3. During the first part of such movement of 4 and as the disc 4b of the latter leaves its seat 4c, the pneumatic air in combustion chamber 3a rushes into the chamber 4a (area (C)) beneath piston 4 and instantly accelerates the upward movement of the latter in chamber 4a, and as the upper edge of piston 4 passes beyond the communication port 7b (in the wall of chamber 4a) the pneumatic air above piston 4 (at approximately 100 pounds pressure) is trapped in the annular shaped chamber 7c (above piston 4 and surrounding the intermediate portion of piston valve 5 Fig. 5) and is compressed therein (by said upward movement of 4) to a pressure appreciably higher than the actuating pressure in combustion chamber 3a and exerting itself against the under side of 4 (area (C)). This relatively high pneumatic air pressure generated in chamber 7c is the result principally of the relation of various cross-sectional areas of the unit 1 to one another, and also to the accelerated upward movement (ram like) of piston 4 as previously described. We will assume that the cross-sectional area of the diameter of portion 5j (of 5) is .05 of a square inch (known as area (D)); then area (B) minus area (D) (known as area (B-D)) is likewise .05 of a square inch, and as the pneumatic air pressure above the upper end of 5 is (constantly) 100 pounds we have: $.05 \times 100$ equals 5 pounds (downward pressure on the upper end of 5 area (D)) and $.1 \times 400$ equals 40 pounds (upward pressure on under side of 4 area (C)); therefore 40 minus 5 equals 35 pounds (remaining available pounds) and 35 divided by $.05$ (area (B-D)) equals 700 pounds, which latter is the maximum pneumatic air pressure possible to generate in chamber 7c (providing the fuel in chamber 5g remained at 100 pounds per square inch pressure and discounting the upward ram motion of 4 75

previously mentioned). However, it is not desirable to generate 700 pounds per square inch pneumatic air pressure in chamber 7c (prior to commencement of combustion) so therefore, some means must be devised to release such pneumatic air from chamber 7c into chamber 3a at some pre-determined pressure ranging between 700 and 400 pounds per square inch, and some means must also be devised for separating the disc 5d (of 5) from its seat 4e (of 4). This release of said pneumatic air from 7c and separating of 5d and 4e is accomplished as follows; we will assume that we want to release said pneumatic air from chamber 7c when it exceeds 500 pounds per square inch, then resorting to calculation of areas we have; as previously mentioned the down pressure on area (D) equals 5 pounds, therefore, the latter divided by 500 pounds equals .01, which latter is the correct fractional part of a square inch area (known as area (E)) necessary to separate 5d and 5e under such pressure conditions and the difference of area (D) minus area (E) or .05 minus .01 equals .04 (known as area (D-E)) which then will be the cross-sectional area in square inches of diameter 5k or the largest diameter of disc 5d of 5. As the piston 4 travels upward in chamber 4a and nears the position of travel in which it is illustrated in Fig. 5, the pneumatic air pressure in chamber 7c slightly exceeds 500 pounds and as described above separates 5d from 4e and at approximately the same instant the lower edge of fuel supply port 5h passes upward beyond the lower edge of fuel injection plunger 8 and thus cuts off communication between fuel supply chamber 5i and fuel injection chamber 5g. As the piston 4 and piston valve 5 continue on their upward travel, the fuel injection plunger 8 displaces a minute quantity of oil fuel from chamber 5g via the radial defuser holes 5f into the annular shaped fuel atomizing groove 5e and thence into the minute separating space (between disc 5d and seat 4e as previously described) wherein it is picked up by the relatively high pressure pneumatic air (which latter is being ejected from chamber 7c via said space into chamber 3a) and is minutely atomized and carried with said air via said space thence the minute orifice 4f and thence the tapering nozzle 4g into said combustion chamber in an extremely fine mist status and thoroughly conditioned and prepared to become ignited instantly by and through contact with the high temperature of the relatively highly compressed combustion air charge in said combustion chamber. The length of duration of said fuel injection in degrees of rotation travel of the engine crank-shaft depending principally upon the size of the minute orifice 4f, the adjustment position of the fuel injection plunger as to the quantity of fuel being injected, the volume of pneumatic air ejected from 7c to 3a via said minute orifice 4f, and other minor details. The period of fuel injection normally continuing from approximately 7 degrees in advance of top dead center to approximately 30 degrees past such dead center.

After 5d is separated from 4e, and the lower edge of port 5h passes upward beyond lower edge of plunger 8, the disc 5b of 5 contacts its seat 5c in 6 and stops the further upward travel of piston valve 5; this stopping of 5 discontinues further displacement of fuel from 5a by plunger 8 and as the piston 4 closes in the space separating 5d and 4e the relatively high pressure pneumatic air continues to escape through said

space until 4e contacts 5d and thus blows said space clear of oil fuel and prevents dribbling at orifice 4f and nozzle 4g.

Due to the acceleration of the piston 4 in its upward travel (as previously described) and to the distance the piston valve 5 travels before port 5h passes beyond the end of plunger 8, said piston and piston valve gain considerable velocity before injection starts and the delivery of such injection is after a ram fashion which tends to further break up said oil fuel into a mist and this method of fuel atomization and injection will lead the way to burning crude oil for fuel in all oil fueled engines.

The clearance space in chamber 7c with piston 4 and piston valve 5 at the upper ends of their travel as in Fig. 3 should be kept to a minimum.

Compressed air is supplied to fuel tank 16 by and through slight leakage of either highly compressed air or combustion gas from combustion chamber 3a through chamber 4a (as diagrammatically illustrated in Fig. 3) through the small clearance space between piston 4 and the walls of its cylinder 4a and into the pneumatic air communication port 7b and thence via chamber 7a and tubing and fittings 14 to said fuel tank; any slight surplus amount of such compressed air being released out of said tank through relief valve 17. It being obvious that such relief valve could be set at a higher pressure than 100 pounds per square inch and that a manually operated pressure regulating means could be interposed between such units 1 or 1a and tank 16 to regulate such pneumatic air to various pressures below the setting of such relief valve and thus to furnish a means of varying the timing of the fuel injection in relation to the travel of the moving elements of the engine; a release or reduction in such pressure advancing the timing of said fuel injection and vice versa, and an abnormally high pressure stopping said engine.

As the pressure in the combustion chamber 3a drops during the exhaust cycle period of operation of said engine 3, the piston 4 and piston valve recede in their respective cylinders as such pressure bears relation to the pneumatic pressure above said piston and piston valve tending to force them downward, and as they near the bottom end of their travel the closeness of the fit of the tip 4d to the throat opening 2b causes a certain quantity of the expended gas escaping from cylinder 4a beneath piston disc 4b become trapped in said cylinder and to become compressed by such piston in said cylinder and thus to cushion the aforesaid piston and piston valve at the lower end of their downward travel. During such cushioning of said piston and piston valve a part of said compressed gas beneath said piston is displaced into the annular shaped cushion compression chamber 4h and assists in preventing pneumatic air leakage from chamber 4a and 7a to combustion chamber 3a by forming a pressure seal therebetween during the period said piston and said piston valve are at rest in their normal closed position of travel intermittent their stroke periods of operation. Likewise during the upward period of travel of said piston and piston valve members and as they near the outward end of their stroke travel they are cushioned by and through the closeness of the fit of the outside diameter of the disc 5b (of 5) to the wall of the cylinder 4a and the allowed clearance space therebetween for the escape of the pneumatic air being displaced above

disc 5b into the compression space 7c beneath said disc and above piston 4.

It is understood that in certain cases where trouble may be experienced (due to air leakage into the fuel supply chamber 5i) that the air vented from 5i through port 2m and needle valve 5l to the atmosphere could be lead through a suitable tubing connected with said valve (not illustrated) to a suitable small vent drain tank and a very small leak-off allowed to continue through said valve and drain connection into such tank.

The invention herein described may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment to me of any royalty thereon or therefor.

Having fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A fuel injection device for an oil engine comprising an elongated cylindrically shaped actuating piston member adapted to be floatably mounted adjacent the combustion chamber of such engine, a tapering seat located within said actuating piston member and terminating towards said combustion chamber in a minute cylindrical orifice, a tapering nozzle adjacent the combustion chamber end of said minute orifice, an elongated cylindrically shaped piston valve member of smaller diameter than and floatably mounted adjacent to said actuating piston member, a tapering disc integral with said piston valve member and corresponding to and fitting within said tapering seat, an elastic substance compression space adjacent the larger end of said tapering seat and disc, an annular shaped groove located in the periphery of the intermediate length of said tapering disc, a cylindrical fuel chamber located concentrically within said piston valve member and in constant communication with said annular shaped groove, a fuel supply port extending radially through said piston valve member into said fuel chamber, a fuel injection plunger member slidably extending into one end of said fuel chamber to adjacent said fuel supply port, an elastic substance supply space located adjacent the end of said piston valve member opposite the tapering disc end of the latter, means for remotely controlling the

location of said fuel injection plunger member relative to said fuel supply port, means for supplying liquid fuel under a slight pressure to said fuel supply port, means for supplying an elastic substance under a slight pressure to said elastic substance supply and compression spaces, means for actuating said actuating piston and piston valve member, means for compressing said elastic substance in said elastic substance compression space, means for separating said tapering disc and said tapering seat at a predetermined point in the travel of said actuating piston member, and means for displacing the compressed elastic substance from said elastic substance compression space and the liquid fuel from said fuel chamber and uniting and injecting them into said combustion chamber of such engine.

2. In a fuel injection device for an oil engine the combination of an elongated cylindrically shaped actuating piston member adapted to be floatably mounted adjacent the combustion chamber of such engine, a tapering seat located within said actuating piston member and terminating towards said combustion chamber in a minute orifice, an elastic substance compression space adjacent the end of said actuating piston member at the larger end of said tapering seat, an elongated cylindrically shaped piston valve member of smaller diameter than and floatably mounted adjacent to said actuating piston member, a tapering disc integral with said piston valve member and corresponding to and fitting within said tapering seat, an annular shaped groove located in the periphery of the intermediate length of said tapering disc, a cylindrically shaped fuel chamber located concentrically within said piston valve member and in constant communication with said annular shaped groove, a fuel injection plunger member slidably extending within said fuel chamber, a fuel supply port extending radially through said piston valve member into said fuel chamber, said port being located adjacent one end of said fuel injection plunger member, and means for simultaneously displacing liquid fuel from said fuel chamber and compressed elastic substance from said compression space into said combustion chamber of said engine by and through the actuation of said actuating piston and piston valve members.

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