

April 21, 1936.

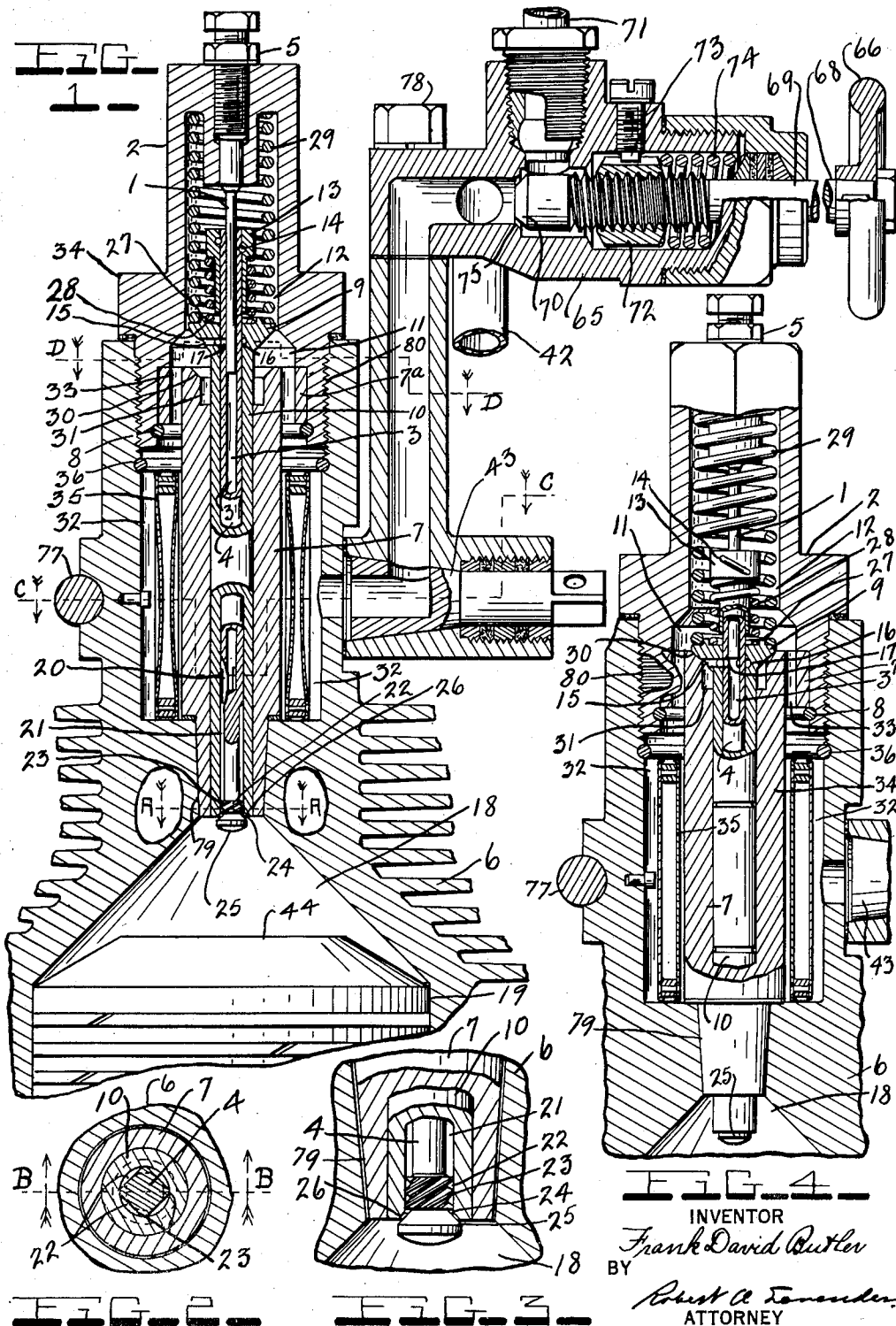
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Filed Nov. 4, 1931

2 Sheets-Sheet 1



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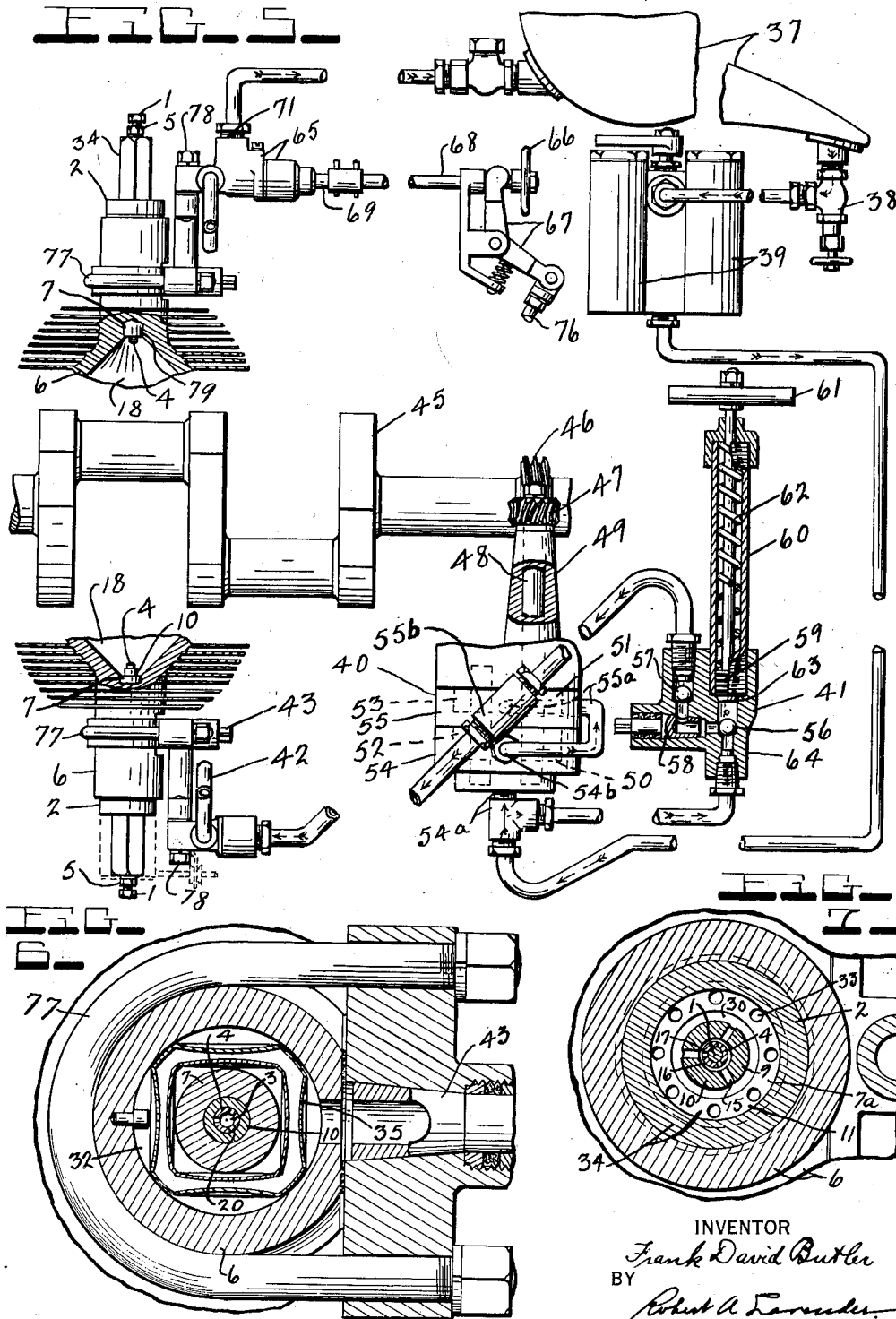
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2 Sheets-Sheet 2



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FUEL ATOMIZING AND INJECTING ASSEMBLY FOR INTERNAL COMBUSTION ENGINES

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12 Claims. (Cl. 123—139)

(Granted under the act of March 3, 1883, as
amended April 30, 1928; 370 O. G. 757)

While my invention relates generally to improvements in fuel atomizing and injecting assemblies for internal combustion engines, it relates more particularly to automatic fuel atomizing and injecting systems for solid fuel injection engines of the type mentioned and has the following objects in view; first, to provide a suitable combined atomizing and injecting unit means for each one of the cylinders of such an engine for the purpose of automatically and simultaneously atomizing and injecting the liquid fuel charges into their respective cylinder units by the internal compression and combustion forces therein and in proper timing relation to the travel of the respective pistons thereof; second, to provide means whereby said atomizing and injecting units may be removed from their respective cylinder units one at a time and replaced with spare units without necessitating the stopping of the engine; third, to provide means whereby the stroke and period of operation of the individual fuel atomizing and injecting units of the several cylinders may be varied and controlled collectively, externally and remotely from their respective cylinders, in such a manner as to form a unit control of the entire engine; and finally, to produce a fuel atomizing and injecting assembly design of the type mentioned which is exceedingly simple in construction, efficient in operation, durable in use, and which may be readily and conveniently applied, removed or replaced in various designs of the type of engines mentioned.

To the accomplishment of the foregoing and such other objects as may hereinafter appear, my invention consists in the combination, arrangement and construction of parts hereinafter described, pointed out in the appended claims and illustrated in the accompanying drawings forming a part hereof, it being understood that various changes may be made in practice within the scope of the claims, without digressing from my inventive idea or sacrificing any of the advantages disclosed.

With reference to the drawings; Fig. 1 is a vertical section of a combined automatic fuel atomizing and injecting unit, as per my invention, installed in the cylinder assembly of a two-stroke cycle, radial, solid fuel injection aviation engine, the assembly of the unit being illustrated in the atomizing and injecting position of travel; Fig. 2 is an enlarged fragmentary view of the fuel atomizer as it would appear on the dotted line A—A of Fig. 1; Fig. 3 is a view as would appear on the dotted line B—B of Fig. 2; Fig. 4

is a fragmentary view of similar parts illustrated in Fig. 1 except showing the assembly of the atomizing and injecting unit in its closed position of travel; Fig. 5 is a diagrammatic view of the liquid fuel supply and the engine control systems; Fig. 6 is a fragmentary horizontal section of the combined fuel atomizing and injecting unit as it would appear on the dotted line C—C of Fig. 1; and Fig. 7 is a similar view to that illustrated in Fig. 6 with the exception that the former illustrates the unit as it would appear on the dotted line D—D of Fig. 1.

With reference to the symbols of the drawings, similar numerals represent and indicate similar parts in the several views;—The numeral 1 indicates the fuel injection plunger member which is secured by a threaded and gasketed fit to the valve bonnet 2. Plunger 1 is provided with a sliding fit within the cylindrical fuel injection chamber 3 of the fuel atomizing valve member 4, and adjustable longitudinally in the latter by varying the adjustment position of the jam nut 5. The bonnet 2 is secured by a threaded and gasketed fit to the upper end of the engine cylinder body 6, Fig. 4, and having at its lower end a cylindrical and shouldered fit with the actuating plunger cylinder body member 7 whose upper end is provided with an integral enlarged head 7a removably secured within the lower part of said bonnet 2 by a cylindrical groove fitted with the spring snap retainer member 8. The upper end of plunger member 7 is provided with a seat 30 for the valve disc 9 of the actuating plunger member 10. Surrounding the actuating plunger 7 is a space forming the annular shaped fuel feed supply chamber 11. The interior of the valve bonnet 2 is provided with the cylindrical shaped dash pot and spring housing chamber 12. The fuel atomizing tubular valve member 4 is provided with a longitudinally sliding fit inside of the actuating plunger member 10, longitudinally within which member 4 extends the injection plunger member 1. The spring retainer collar 13 is secured by the retainer wire 14 to the top of said member 4 which member controls fuel supply communication between the fuel discharge chamber 3 (within the body of member 4 unoccupied by plunger 1) and the fuel feed chamber 11 via, the radial fuel feed holes 15 and annular shaped fuel feed groove 16 in the disc 9 of the actuating plunger member 10, and the radial fuel feed holes 17 in said member 4, Fig. 1. The fuel discharge chamber 3 is provided with communication with the combustion chamber 18 of the cylinder 19 via the radial

fuel discharge slots 20, the annular shaped fuel discharge passage 21, the spiral fuel whirling grooves 22 of the multi-threaded portion 23 adjoining passage 21, the fuel whirling chamber 24 adjoining the ends of the grooves 22, and the atomizing valve disc 25 adjoining the whirling chamber 24 and said combustion chamber 18. The actuating plunger member 10 is similar in appearance to a poppet valve as shown by the illustrations Figs. 1 and 4 and is provided with a sliding fit in the inside of its cylindrical body member 7 and surrounds the fuel atomizing valve member 4. The lower or inner end of plunger 10 is exposed within the compression space of its cylinder where said plunger 10 is provided with a seat 26 for the atomizer valve disc 25 on the lower or inner end of fuel atomizer valve member 4. The top surface of valve disk 9 of member 10 is provided with a retainer shoulder 27 for laterally retaining the ends of the atomizer valve spring 28 and its own retainer spring 29, each disposed within chamber 12 of bonnet 2. The remaining ends of springs 27 and 29 respectively bear against said collar 14 and the bonnet 2. The actuating plunger cylinder body member 7 is provided with a tapered and gasketed fit with the engine cylinder body 6, a slidable fit about the member 10 and a cylindrical and shouldered fit comprising the seat 30 and disk 9. Annular shaped feed supply pressure release chamber 31 is formed in member 7 below the lower edge of seat 30 which seat normally forms its upper rim communication between the annular shaped fuel feed heating and pressure cushioning chamber 32 (surrounding member 7) and the fuel feed supply chamber 11 is maintained via the fuel transfer holes 33 (Figs. 1 and 7) extending through head 7a of member 7. The assembly of the combined fuel atomizing and injecting unit is indicated by the numeral 34 and includes all the parts and items indicated by the numerals from 1 to 33 (illustrated in Fig. 4) with the exception of items represented by numerals 6, 18, 19 and 32, said unit 34 being installed in the cylinder body 6 in such a manner that it may be removed and exchanged with a spare without necessitating (in multi-cylinder engines) stopping the engine. The fuel pressure stabilizer bellows 35 (which will be described more in detail later) is retained in place, during the removal of the unit 34 from the cylinder body 6, by the snap spring retainer ring 36 which latter is provided with a snap fit in the groove within which it is mounted in said cylinder body 6.

With reference to all the figures in general, the operation of the automatic combined fuel atomizing and injecting assembly unit 34 is as follows:—Liquid fuel under a medium pressure is supplied to the fuel feed supply chamber 11 (each of the units 34) from the fuel supply tank 37 via the fuel cut out valve 38, (Fig. 5) the fuel strainers 39, the mechanically operated fuel pump assembly 40 or the manually operated fuel pump assembly 41, the fuel manifold 42, the fuel cut out valve 43 individually for each cylinder, the fuel feed heating and pressure stabilizing chamber 32, and the fuel transfer holes 33. The pressure of the liquid fuel (delivered to the chamber 11 as described) plus the tension of the resilient retainer spring 29 tends to retain the disc 9 of the actuating plunger member 10 in contact with its seat 30, similar to the position in which it is illustrated in Fig. 4. The plunger member 10 remains in the position last mentioned until such time as the pressure of the air charge being compressed in the cylinder 19 by the piston 44 (through the rotation of the crank shaft 45) and acting against the area of the stem end of said plunger member 10 plus the area of the head of disc 25 of the atomizing valve member 4, is such as to overcome the mentioned combined pressure of the liquid fuel and the retainer spring 29 retaining said plunger in contact with the seat 30, at which latter time said plunger member 10 travels upward or outward from its closed position to its open or spray position of travel which former position is illustrated in Fig. 4 and which latter position is illustrated in Fig. 1. Assuming (for example) that the fuel injection chamber 3, adjoining the fuel injection plunger member 1, was (by rotating the engine) filled with liquid fuel from the fuel feed supply chamber 11 via the radial holes 15, the annular groove 16 and radial holes 17, on the previous closing stroke of the actuating plunger 10, that the tension of the spring 29 is negligible, that the area of the head of the disc 9 minus the area of the small end of plunger 1 is four times an area of equal diameter to the stem end of the member 10, that the pressure of the fuel in chamber 11 is 115 pounds per square inch and that the air charge in the cylinder combustion chamber 18 has been compressed above the piston 44 to a trifle over 460 lbs. per square inch. Under the foregoing assumed conditions, the actuating plunger 10 with the atomizing valve member 4 would, by said pressure exerted on their ends exposed thereto, be caused to travel from the position in which they are illustrated in Fig. 4 to the position in which they are illustrated in Fig. 1. This movement would cause the liquid fuel in the fuel injection chamber 3 to be injected into the cylinder combustion chamber 18, (by the relatively stationary injection plunger 1), in a whirling minutely atomized and highly agitated spray and under an extremely high pressure and velocity via, the radial slots 20, the annular passage 21, the spiral fuel whirling grooves 22 of the threaded portion 23, the fuel whirling chamber 24, and between the yieldingly mounted atomizing disc 25 and its seat 26. As soon as the disc 9 leaves its seat 30 (during the foregoing operation) the pressure of the fuel in the fuel feed chamber 11 is equalized on both sides of the said disc, and the area of the stem end of member 10 minus the area of the head of disc 25 must oppose a similar area (at the disc end of said member 10) equal to the area of the stem end of said member 10 minus the area of the small end of plunger 1, the smaller area and higher pressure at the stem end of said member 10 prevails and forces said plunger 10 to continue to travel away from seat 30 until such time as the increasing tension of spring 29 plus the accumulating fuel pressure in the dash pot chamber 12 outward of disc 9, is such as to stop the outward travel of said member 10. Simultaneously with the foregoing described outward travel of the actuating plunger member 10, the larger area of the head of disc 25 as compared with the smaller area of the small end of the fuel injection plunger 1 (which ratio we will assume is 1 to 8) causing the former to force the atomizing valve member 4 to follow closely behind the actuating plunger member 10 in its outward travel, in the meantime the end of the fuel injection plunger 1 cuts off communication between the fuel injection chamber 3 and the fuel feed supply chamber 11 by passing over the radial fuel feed holes 17, the latter operation

causing the pressure on the fuel charge in chamber 3 to accumulate to an assumed pressure of approximately eight times the compression and later combustion pressures in the engine combustion chamber 18, and the fuel charge in said fuel injection chamber 3 to be injected into said combustion chamber 18 by said injection plunger 1 as previously described. During the foregoing described outward travel of the members 4 and 10, a small quantity of fuel is displaced by said members from the fuel feed chamber 11 into the chamber 32 and is compensated for in the latter chamber by the contraction of the pressure stabilizing or pulsating bellows 35 which latter has the sides thereof constructed of a thin flexible metal so as to be capable of contracting as the members 4 and 10 travel outward and expanding as they travel inward, the pulsating movement of said bellows 35 being very slight due to the large volume displaced by a slight contracting or expanding movement of the large side areas thereof as compared with the volume of fuel displaced by said members 4 and 10 as previously mentioned. The bellows 35 and the holes 33 also moderate the shock liable to result from the intermittent flow of the fuel oil occurring during the periodic movement of members 4 and 10. During the inward travel of the members 4 and 10 the fuel injection chamber 3 is filled with a fresh fuel charge from the chambers 11 and 31 via, the radial holes 15, the annular groove 16 and the radial holes 17 due to the displacement of the plunger 1 in the chamber 3 as the member 4 moves away from the end of said plunger, and in the meantime the pressure on the fuel in the fuel release chamber 31 is completely removed due to the fuel suction taken therefrom by the displacement of plunger 1 during the period the disc 9 of the member 10 is closing off communication between chambers 11 and 31 by seating on seat 30.

From the foregoing description of the operation of the automatic combined atomizing and injecting assembly unit 34 it is evident that in order to advance or retard the starting of the fuel injection period thereof (and consequently increase or decrease the length of stroke of the members 4 and 10 and increase or decrease the quantity of fuel injected into the combustion chamber 18 per stroke of the member 4) it would only be necessary to respectively decrease or increase the pressure of the liquid fuel being supplied to chambers 11 of the units 34, and that by so doing, the power and speed of operation of the entire engine may be successfully controlled externally and remotely from said units 34. With the foregoing type of control in view, the fuel pump assembly 40 is designed to furnish a greater quantity of liquid fuel to the fuel manifold 42 than is necessary for fuel injection purposes and of sufficient pressure as to be about one fourth of that of the highest possible compression pressure obtainable in chambers 18. With reference to Fig. 5 the construction and operation of the pump assembly 40 is as follows: It being understood and apparent to those skilled in this art that any type of pump could be used that would furnish a sufficient quantity of liquid fuel at the required pressure to the manifold 42 to accomplish the purpose specified, however, in order to reduce fuel pressure pulsations and for convenience of illustrative purposes, a mechanical, compounded gear type of fuel pump assembly 40 is shown in which, the worm 45 mounted to ro-

tate with the crank shaft 45 is adapted to drive the worm wheel 47 which latter is secured to rotate with the pump drive shaft 48 which latter in turn is adapted to be mounted in the pump casing 49 and to have secured thereto a wide or first stage drive gear 50 and a narrow or second stage drive gear 51, said gears being adapted to drive the wide and narrow driven gears 52 and 53 respectively, and to be mounted in the gear housings 54 and 55 respectively. Liquid fuel supply and discharge connections respectively are supplied between, the fuel supply tank 37 and the suction side 54a of housing 54, between the discharge side 54b of housing 54 and the suction side 55a of housing 55, and between the discharge side 55b of housing 55 and the manifold 42. A manually operated plunger type pump assembly 41 adapted to furnish a fuel supply pressure to the manifold 42 for engine starting purposes is also illustrated in Fig. 5 in addition to pump 40, and consists of the following;—A suction check valve 56 having communication with the suction connection 54a of pump 40; a discharge check valve 57 having communication with the discharge connection 55b of pump 40; a plug type cut out valve member 58 used for hand pump 60 connecting purposes; a plunger member 59 adapted to take suction via the check valve 56 and to discharge via the check valve 57, to be manually operated upward in the pump barrel 60 by the pump handle 61 and to be operated downward in said barrel either manually or automatically by the said handle 61 or the coarse pitch resilient spring member 62 respectively, and to be seated on the seat 63 of the pump body member 64 when not in use.

With reference to Figs. 1 and 5 in particular, the object, construction and operation of the fuel pressure regulating valve assembly 65 is as follows;—The said valve assembly 65 is a means of varying the pressure of the liquid fuel in the fuel feed manifold 42 and consequently (as previously described) a means of remotely and conveniently controlling the power and speed of the engine while in operation. The liquid fuel supplied to the fuel feed manifold 42, from the fuel supply tank 37 (as previously described) by the pump 40, is controlled by the valve assembly 65 through remote control via, the throttle control wheel 66 and the spring loaded manually operable bell-crank 67, connections being made between the extension stem 68 of the wheel 66 and the threaded valve stem 69 of the control valve disc 70, and between the fuel return connection 71 and said fuel supply tank 37. The valve assembly 65 consists of a valve disc 70 integral with the threaded valve stem 69 and having a traveling adjustment nut 72 which latter is prevented from turning by the guide lock screw 73, is under tension of the resilient spring 74 and is adjustable by the rotation of the stem 69 which rotation increases or decreases the tension of said spring 74 against said nut 72 and consequently the tension of the valve disc 70 against its seat 75. To increase the pressure of the liquid fuel in the fuel feed manifold 42 and thereby decrease the power and speed of the engine, the valve stem 69 is screwed towards the valve seat 75, this operation causes the nut 72 to travel away from the seat 75 thereby increasing the tension on the spring 74, thus requiring more pressure on the small end of disc 70 to lift said disc from its seat 75. To decrease the pressure of the liquid fuel in the fuel feed manifold 42 and thereby increase

the power and speed of the engine, the valve stem 69 is screwed away from the valve seat 75, this operation causes the nut 72 to travel towards the seat 75, thereby requiring less pressure on the small end of disc 70 to lift said disc from its seat 75. In order to rapidly increase the speed of the engine, the wheel 66 is pulled out by hand or pushed out by the spring loaded bell-crank accelerating means 67 which latter may be connected up for foot operation via the rod 76. By screwing the stem 69 fairly well in or to about the engine idling control position, the engine may be controlled with the accelerating means 67 without any further adjustment of said stem by the wheel 66.

The body members of the individual valves 43 are secured to the cylinder body members 6 by their embracing U shaped bolts 77, and the valve assembly 65 and the manifold 42 are secured to said body members of valves 43 by the bolts 78.

A replacement of any one of the units 34 may be accomplished, during the period the engine is operating, by first closing the respective fuel cut out valve 43 to the unit 34 that is to be replaced with a spare unit and then slowly removing the defective unit 34 from the cylinder body 6, allowing sufficient time to elapse for the fuel in chamber 32 to pass into the cylinder 19 via the tapered portion 79 of the member 7 before said unit is finally removed. The threaded portion 80 of the member 2 should be considerably longer than the tapered portion 79 of the member 7 in order to facilitate removals and replacements of the units 34.

During the operation of the engine, the firing of any one of the cylinder units may be temporarily stopped for test purposes by screwing the respective fuel injection plunger member 1 thereof inward out of adjustment.

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 liquid fuel injecting assembly for cylinders of a combustion motor comprising a valve stem having a valve head thereon and a longitudinal opening therein adapted to supply fuel oil to said valve head, a first member surrounding and movably supporting said stem and having a seat for said valve head, a pin slidably fitting a portion of said longitudinal opening, means for supporting said pin, means for movably supporting the first member on the cylinder of a combustion motor with said valve head and an adjacent portion of the first member extending into and adapted to be moved by the force of compression in the interior of the compression chamber of said cylinder, a valve element on the first member removed from the seat for said valve head and adapted when open to admit fuel oil to said longitudinal opening, an element of the last stated means having a seat for said valve element, means for supplying fuel oil to said valve element, and means for opening said valve head and admitting its supplied fuel oil into the cylinder when the first member is moved by said compression.

2. The apparatus of claim 1 characterized by means for longitudinally, adjustably securing said pin to its supporting means.

3. The apparatus of claim 1 characterized by means for controlling larger or smaller the volume of fuel oil supplied through the valve head by respectively decreasing or increasing the pressure of the fuel oil supplied to the valve element.

4. The apparatus of claim 1 characterized by means for supplying fuel oil under pressure to the valve element, and means for varying low or high the fuel oil pressure supplied to the valve element for varying respectively greater or less the volume of fuel oil supplied through said valve head.

5. The apparatus of claim 1 further characterized by the means for supporting said pin being longitudinally adjustable, means for supplying fuel oil under pressure to the valve element, and manually adjustable means for varying low or high said fuel oil pressure to respectively increase or decrease the volume of fuel oil supplied through said valve head.

6. The apparatus of claim 1 further characterized by said fuel oil supplying means having associated therewith at each cylinder adjustable means for varying low or high the pressure of the supplied fuel oil, and respectively increasing or decreasing the volume of fuel oil admitted through the valve head.

7. In a fuel injecting assembly for association with the combustion chamber of an internal combustion engine, the combination of a plunger mounted to move longitudinally and provided with a head adapted to be exposed to and moved by pressure within said chamber, a valve member having an enlarged valve head mounted to be exposed to and longitudinally movable by pressure within said chamber and adapted to seat in the head of and to reciprocate with said plunger, a body portion provided with an inner end adapted to be removably attached to a wall of said chamber, said valve member being tubular and open at its end opposite its said head, a stationary plunger extending into the tubular part of and adapted to open said valve member when said movable plunger is moved, a valve and valve seat cooperably mounted respectively on said movable plunger and body portion, means for supplying fuel oil under pressure to the last stated valve, registerable oil supply ports in the movable plunger and valve member intermediate the last stated valve and the enlarged head of the valve member, said ports, when the last stated valve is open, communicate with the tubular bore of said valve member and feed fuel oil from the supply thereof to the last stated valve, means for closing said cooperable valve and seat and moving the movable plunger and valve member toward said combustion chamber.

8. The apparatus of claim 7 characterized by a spring between the valve member and the first plunger adapted to normally hold the valve head against its seat, a second spring adapted to normally hold the plunger valve head against its seat on the body portion, the valve head being adapted to open into the compression-combustion chamber, and the plunger valve being adapted to open outwardly and remote from said chamber.

9. The apparatus of claim 7 characterized by the consumption of the supplied fuel oil being intermittent, and the fuel oil supply means being provided adjacent the cooperable valve and seat with pressure yieldable means movable by the pressure of the fuel oil for stabilizing fluctuations, occasioned by said intermittent consumption of fuel oil.

10. The apparatus of claim 7 characterized by 75

the consumption of fuel oil being intermittent, which subjects said oil to fluctuations, and the fuel oil supplying means being provided with a fuel oil passage extending at least partly around said body portion, a pressure diaphragm in said passage and yieldable by the pressure of the fuel oil, and said diaphragm having inner and outer diaphragm walls spaced apart by and secured to an intervening edge member, there being a fuel oil space between said diaphragm walls and the wall of the last stated passage.

11. The apparatus of claim 7 characterized by said valve member being provided adjacent its head with helical grooves through which, when said head is off its seat, the fuel oil is adapted to helically pass into the combustion chamber.

12. The apparatus of claim 1 characterized by the fuel pressure supply means having a surplus fuel return means whose inlet is controlled by the valve comprising a casing, a valve seat therein which forms said inlet, a valve stem extending 5 through said casing and having a threaded portion and a valve head provided with a seating surface adapted to fit said valve seat and said head being exposed to the pressure of the fuel tending to pass through said seat, a nut on the threaded 10 portion of said valve stem, means for preventing the turning of the nut by rotation of said stem, and spring means between said nut and a portion of the casing.

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