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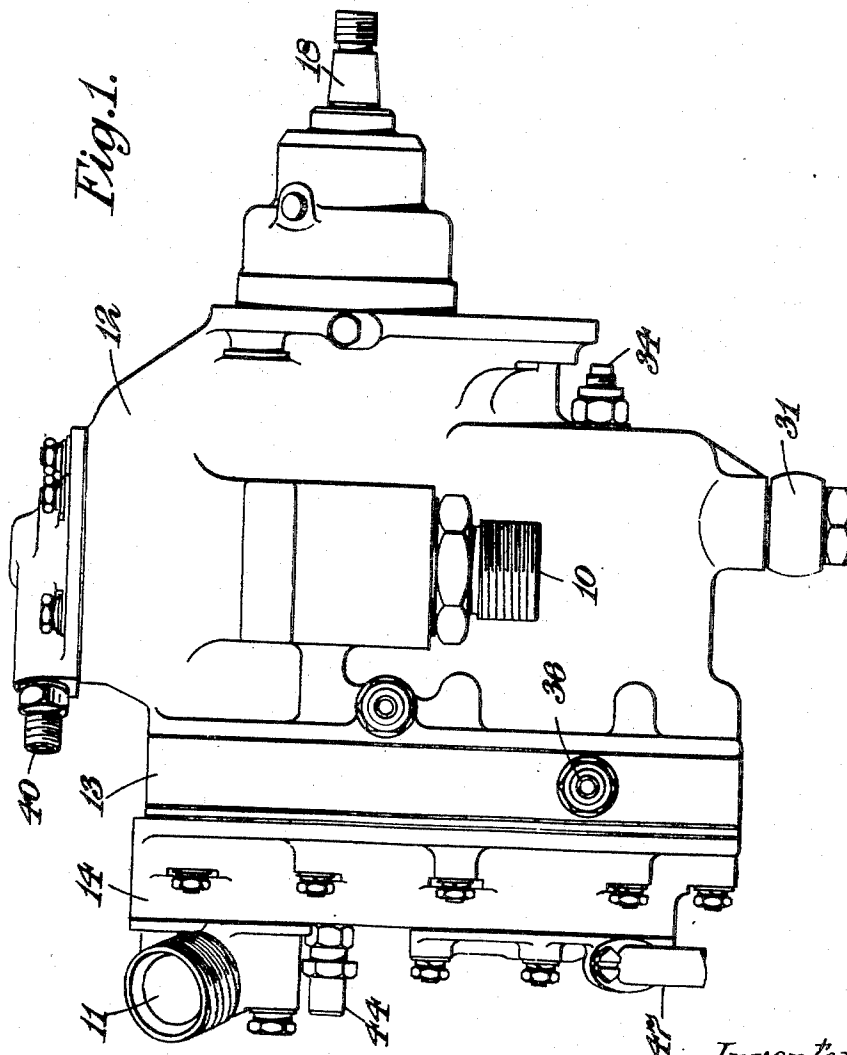
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FUEL INJECTION DEVICE FOR INTERNAL-COMBUSTION ENGINES

Filed Nov. 30, 1945

3 Sheets-Sheet 1



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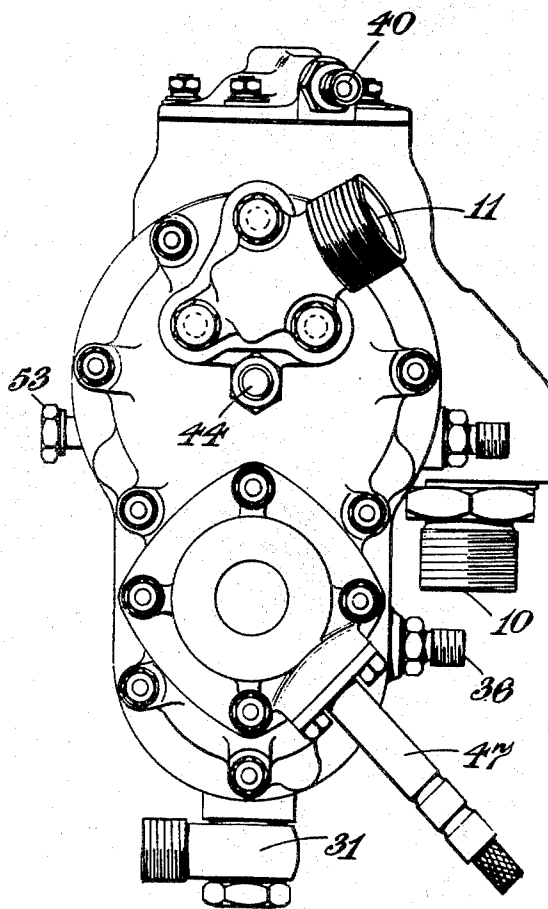
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3 Sheets-Sheet 2

Fig. 2.



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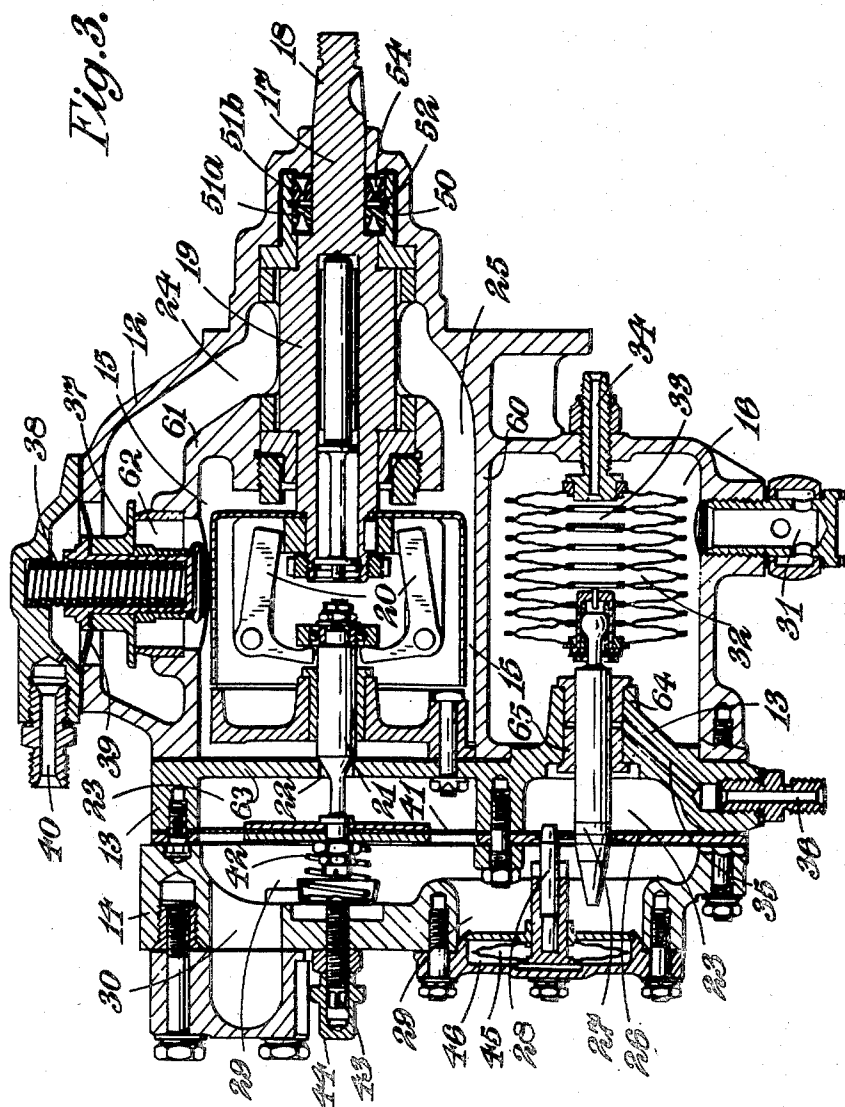
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FUEL INJECTION DEVICE FOR INTERNAL-COMBUSTION ENGINES

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1

This invention relates to fuel-injection devices for internal-combustion engines used on aircraft. Such engines are required to operate throughout a wide range of varying conditions, both natural and operational, and in order that the rate of fuel-supply shall always be suited to the prevailing conditions at any time, many automatic controls and adjustments are required. The complete device therefore is a complex mechanism and tends to be bulky and inconvenient to accommodate on an engine, and the object of this invention is to provide a construction which is compact, neat and as simple as possible in its manufacture, assembly, operation and maintenance.

The invention therefore comprises the general construction of fuel-injection device as herein-after described and illustrated, the essential features of such construction being set out in the claims appended to this specification.

In the accompanying drawings:

Figure 1 is a side elevation of the complete device,

Figure 2 is an end elevation looking from the left in Figure 1 and

Figure 3 is a central sectional elevation corresponding to Figure 1.

The principal conditions which are required to be satisfied by a fuel-injection device for an internal combustion engine on an aircraft are that the fuel shall be delivered under pressure to the engine, conveniently to the inlet eye of the supercharger, and that the rate of fuel supply, whilst in general being under the control of the pilot according to his operational requirements, shall be controlled automatically in accordance with the ambient atmospheric pressure, or back pressure on the engine, the boost pressure as determined by the supercharger, the temperature in the induction pipe, and the engine speed. The construction of device now about to be described provides for all these controls in a very compact arrangement.

Referring to the drawings, the complete device comprises a casing which is divided into a number of chambers with a fuel inlet 10 communicating with the first chamber and a fuel outlet 11 to the engine from the last chamber.

The casing or body of the apparatus is conveniently made in three separate parts shown in Figures 1 and 3 as 12, 13 and 14 respectively and suitable valve-controlled orifices are provided between the different chambers. The first body-portion 12 is divided by a partition 60 into two chambers 15, 16 respectively. A driving shaft 17

2

is mounted in the compartment 15 with its end 18 projecting therefrom to receive a drive by any suitable connection from the engine. This shaft carries a rotary pump 19 which is of the vane type, and at its inner end it has mounted on it a centrifugal governor whereof the bob weights are shown at 20. These weights are operative according to the engine-speed on a needle valve 21, and this valve controls an orifice 22 which provides communication between the fuel-pressure chamber 15 and the space 23 within the second body portion 13. This space 23 is termed the governed fuel chamber. It will be seen therefore that fuel entering by the inlet 10 (see Figures 1 and 2) passes to the fuel-inlet chamber 24 adjacent the fuel pump 19 and is delivered therefrom by the passage 25 to the fuel-pressure chamber 15 containing the centrifugal governor, and passes from this chamber 15 by way of the valve-controlled orifice 22 to the governed fuel chamber 23. A septum 61 divides the fuel-inlet and fuel-pressure chambers 24 and 15 respectively.

It will be observed from Figure 3 that the driving shaft 17 of pump 19 is mounted in a bearing in the casing of the apparatus and that a seal 50 is provided for said shaft. The seal comprises a pair of cup-shaped synthetic rubber members 51 disposed back-to-back with a circlip 52 located therebetween. The backing washers of the members 51 engage the circlip 52 and transmit the axial thrust of the seals thereto. Oil at a pressure higher than the maximum fuel pump pressure enters the casing of the apparatus through connection 53 (Figure 2) and is applied to space 54 so that seal 51b engages the shaft 17 and the casing and prevents oil passing into the fuel pump or fuel leaking into the engine crankcase. The purpose of seal 51a is to prevent leakage of fuel into the engine crankcase in the event that a gravity fuel tank is associated with the fuel pump 19 and the fuel cocks are left open whilst the engine is inoperative.

A relief-valve 37 governing port 62 in the septum 61 permits excess fuel to pass from the fuel-pressure chamber 15 back to the inlet chamber 24 of the pump, this valve being controlled jointly by a spring 38 and a flexible diaphragm 39 which is subject to the air-intake pressure through a connection 40. The relief valve 37 is designed so that it is capable of passing the pump delivery at high engine (and hence pump) speeds without the pressure at which the valve is selected to operate being exceeded. The diaphragm 39 has an effective area equal to the seat area of the

relief valve and being subject to the air-intake pressure ensures that the relief valve is not affected by variations in the intake pressure. With this arrangement moreover external leakage of fuel is avoided in the event that diaphragm 39 becomes punctured. The fuel-pressure chamber 15 and boost-pressure chamber 16 both open through the inner end of the first body 12 and are closed by a wall 63 of the second body 13. The wall 63 contains the orifice 22 and a bearing 64 for the capsule valve 27.

The governed fuel chamber 23 is contained between the wall 63 and a diaphragm 26 having an upper flexible and lower rigid portions. The lower rigid portion 26 contains two orifices controlled respectively by needle-valves 27, 28 to permit the flow of fuel to a chamber 29 hereinafter termed the metered fuel chamber, whence it passes by the port 30 to the outlet 11 (see Figure 1) and thence to the engine.

The needle-valve 27 controlling one of the outlet orifices from the governed fuel chamber 23 is controlled by an assemblage of capsules mounted in the compartment 16. This compartment is subjected to the boost-pressure (as determined by the supercharger) through a connection 31 therefrom. The capsules, which are responsive to variations in boost pressure, are in two groups comprising a set of, say, six evacuated capsules and another group of, say, two capsules 33 which are open through a connection 34 to the ambient atmosphere, which is the back-pressure against which the engine is working. The needle-valve 27 extends through a suitable bush 65 in the bearing 64 in the wall 63 of the second body-portion 13, this bush being provided with a connection 35, 36 to drain off any small leakage of fuel, this being preferably led to the eye of the supercharger.

The flexible portion 41 of the diaphragm is coupled to the needle-valve 21 so that the setting thereof is in part determined by the pressure existing in the metered fuel chamber 29, and the pressure existing in the governed fuel chamber 23. An adjustable controlling spring 42 is also operative on the flexible diaphragm 41 for the purpose of determining the slow running setting of the valve 21, this adjustment being effected by means of a setscrew 43 which is accessible from outside the casing but is normally covered and locked by a cap 44 after the desired adjustment has been made.

The rate of fuel-supply further requires adjustment in accordance with the temperature existing in the induction pipe, and this adjustment is effected by the needle-valve 28 above-mentioned. This valve is controlled by a temperature capsule 45 of any convenient type which is responsive to temperature variations in the induction pipe. As illustrated it is a capsule situated in a chamber 46 which chamber communicates by means of a pipe connection 47 (see Figures 1 and 2) with a bulb in the induction pipe. Chamber 46, pipe 47 and the bulb associated therewith are filled with a non-volatile liquid and the inside of capsule 45 is vented to chamber 29 by a groove (not shown) which extends along the holder for needle 28. With this arrangement an increase of temperature in the induction pipe results in the expansion of the non-volatile liquid and causes an increase in pressure in the chamber 46 so that the capsule 45 is compressed and moves the valve 28 in an opening direction.

It is to be understood that no claim is made

herein to the individual controlling means in respect of their mechanism or their functions, and that this invention is concerned only with the general construction and arrangement whereby the various individual controls are grouped together in a compact assembly.

We claim:

1. In a fuel-injection device for aircraft internal combustion engines, a hollow first body, a septum in said first body dividing the same into fuel inlet and fuel pressure chambers with the latter chamber opening through an end of the first body, a pump in said first body communicating at its inlet with the fuel inlet chamber and at its outlet with the fuel pressure chamber, an engine-driven centrifugal governor in said fuel pressure chamber, a needle valve entrained to move with said governor, a partition in said first body separating the fuel-pressure chamber from a boost-pressure chamber opening through the same end of the first body as the fuel-pressure chamber, a pressure-responsive capsule in the boost-pressure chamber, a valve movable with said capsule, a second body secured on said first body and comprising a wall for closing the ends of said fuel-pressure and boost-pressure chambers, and a diaphragm spaced from said wall to provide a governed fuel chamber therebetween, said diaphragm having a flexible portion opposite the fuel-pressure chamber connected to said needle valve and a rigid portion opposite the boost-pressure chamber, said wall having a fuel orifice receiving said governor-controlled needle valve and establishing communication between the fuel-pressure and governed-fuel chambers, a third body secured to the second body having an internal hollow space constituting a metered fuel chamber exposed to said diaphragm and having a port adapted to be connected to the engine induction system, said rigid portion of said diaphragm having a port setting up communication between said governed-fuel and metered-fuel chambers and controlled by said capsule valve.

2. A fuel-injection device as claimed in claim 1 characterized by the fact that the rigid portion of the diaphragm has a second port setting up communication between the governed-fuel and metered-fuel chambers, a valve controlling said second port, and a temperature-responsive capsule in the third body connected to said last-named valve.

3. A fuel-injection device according to claim 1 comprising in addition a spring adapted to move the flexible portion of the diaphragm in needle-valve opening direction, and adjustable means on the third body connected to vary the load of said spring.

4. A fuel-injection device according to claim 1 wherein said pressure-responsive capsule comprises an evacuated unit and a second unit internally connected to atmosphere, both units subject externally to the boost pressure in said boost-pressure chamber and connected to jointly operate said capsule valve.

5. A fuel-injection device according to claim 1 comprising in addition a driving shaft extending into said first body, and having said pump, governor and governor-operated valve all coaxial with and driven by it.

6. In a fuel-injection device for aircraft internal combustion engines, a hollow casing, a wall internally of said casing dividing the interior into fuel-pressure and governed-fuel chambers, said wall having an orifice, a fuel valve mov-

5

able in the orifice, means for supplying fuel under pressure to the fuel-pressure chamber, an engine-driven governor coupled to open and close said fuel valve, a diaphragm in said casing dividing the governed-fuel chamber from a metered-fuel chamber having connection to the engine induction system, said diaphragm having a port therein, a temperature capsule in said casing, and a valve coupled for movement to said temperature capsule and movable through the port. 10

7. In a fuel-injection device for aircraft internal combustion engines, a hollow casing, a wall internally of said casing dividing the interior into fuel-pressure and governed-fuel chambers, said wall having an orifice, a fuel valve movable in the orifice, means for supplying fuel under pressure to the fuel-pressure chamber, a diaphragm in said casing dividing the governed-fuel chamber from a metered-fuel chamber connected to the engine induction system, said diaphragm having a port therein, a valve for controlling said port, means for opening and closing said valve, said diaphragm having a flexible portion coupled to said fuel valve. 20

8. In a fuel-injection device for aircraft internal combustion engines comprising a hollow casing, a wall internally of said casing dividing the interior into fuel-pressure and governed-fuel chambers, said wall having an orifice, a fuel valve movable in the orifice, a diaphragm in said casing spaced from said wall and dividing the governed-fuel chamber from a metered-fuel chamber connected to the engine induction system, said diaphragm having a flexible portion coupled to said fuel valve, said diaphragm also having a port therein, a valve for controlling said port, 25

6

and means for opening and closing said last-named valve.

9. A fuel-injection device for aircraft internal combustion engines as claimed in claim 8 characterized by the fact that said last-named means is a temperature responsive capsule subject to engine induction heat. 5

10. A fuel-injection device for aircraft internal combustion engines as claimed in claim 8 characterized by the fact that said last-named means is a capsule subject to boost pressure of the engine induction system. 10

11. A fuel-injection device for aircraft internal combustion engines as claimed in claim 8 characterized by the fact that said last-named means is a capsule subject to the differential between atmospheric and boost pressure. 15

12. A fuel-injection device for aircraft internal combustion engines as claimed in claim 8 characterized by the fact that adjustable spring means is imposed on the flexible portion of said diaphragm acting in a direction to open the fuel valve. 20

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