

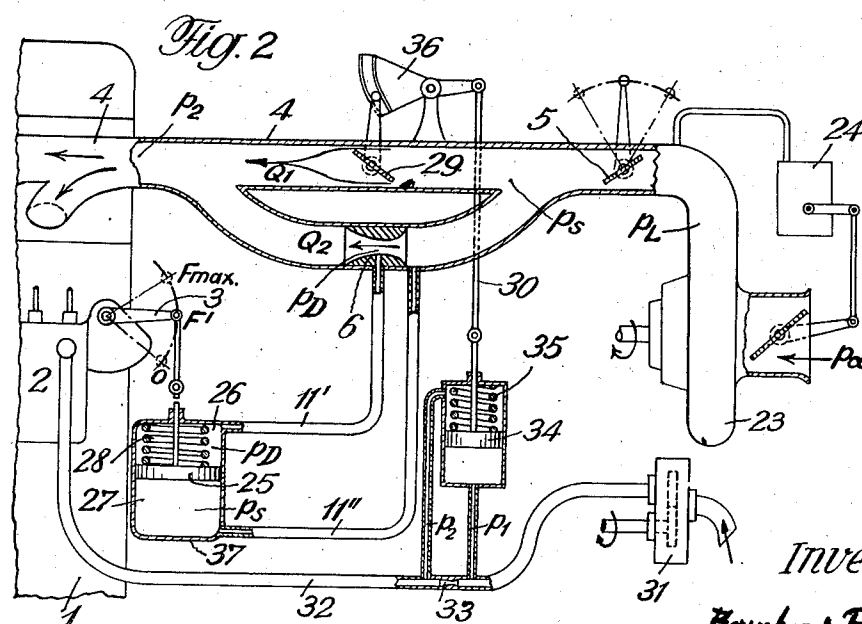
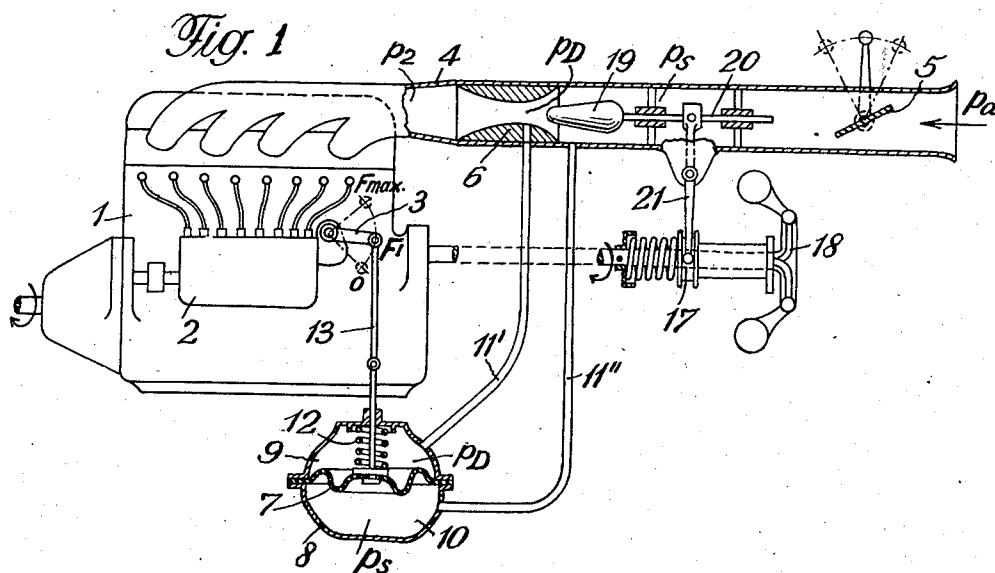
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FUEL INJECTION CONTROL DEVICE

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FUEL INJECTION CONTROL DEVICE

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This invention relates to internal combustion engines and more especially to means for controlling fuel injection in engines operating with spark-ignition, for instance aircraft engines, in which a fuel pump injects fuel into a space closely adjoining the working cylinder, or directly into the latter.

Fuel injection controls of this type are designed to supply to the weight of combustion air enclosed within the cylinder the required quantity of fuel. They operate as a rule in dependence upon the density of the charging air in front of the inlet valves.

Known control devices of this type ascertain the air density by its pressure and temperature by means of complicated transmission devices. Alternatively gas filled aneroid cells are used, whose volume changes in dependence on the pressure and temperature of the gas. The slow reaction of these cells on changes of temperature render them unreliable in practical use.

According to the present invention a venturi is used in a novel manner for ascertaining the density of the charging air. In a venturi through which the charging air flows, a drop in pressure $p_s - p_D$ occurs according to the formula

$$p_s - p_D = \frac{\gamma}{2g} \cdot C^2$$

wherein p_s is the pressure in front of and p_D the pressure in the narrowest part of the venturi, while γ is the air density, g the acceleration of gravity and C the highest speed of air flow. The difference in pressure $p_s - p_D$ is thus proportional to the density of the charging air as long as the speed of flow C does not change, and it may be used as a controlling agent for actuating the member that controls the quantity of fuel injected by the fuel pump.

The quantity of air passing through an internal combustion engine is dependent on the engine speed. The speed of flow inside the charging pipe is thus directly and in a linear degree dependent on the engine speed. Further, according to the invention, the speed of flow in the charging pipe and likewise in the venturi is maintained constant at varying speeds by means of a speed-responsive control member actuating a device arranged in the air current, which varies the cross-sectional area of the passage in such manner that the quantity of air passing per unit of time through the cross-sectional area of the venturi, i. e. the speed C , is not, or only slightly, varied throughout the entire range of engine speed.

In the drawing affixed to this specification and forming part thereof the invention is illustrated diagrammatically by way of example,

Fig. 1 being a side elevation, partly in axial section, of one embodiment in which the device for varying the cross-sectional area of the passage is located within the venturi, while

Fig. 2 is a similar view of a second embodiment, in which this device is inserted in a branch conduit arranged in parallel to the venturi.

Referring to the drawing and first to Fig. 1, 1 is the internal combustion engine, 2 the fuel injection pump, 3 a lever for adjusting the fuel delivery. Combustion air from the atmosphere enters the air supply conduit 4 at a pressure p_a . In order to vary the engine output, the suction pressure p_s can be lowered to the desired degree below atmospheric pressure by means of the throttle valve 5. The air flows through the venturi 6 arranged within the air conduit 4. The suction pressure p_s acts through the pipe 11' on one side of a diaphragm (piston) 7, the pressure p_D in the venturi acts on the other side of the diaphragm through pipe 11'. The two halves 8 and 9 of the diaphragm casing form pressure chambers 9 and 10 on opposite sides of the diaphragm. The latter is thus displaced in dependence upon the pressure drop $p_s - p_D$ produced in the venturi, which drop, according to this invention, is proportional to the density. The displacement of the diaphragm is transmitted by the rod 13 to the lever 3 varying the quantity of injected fuel in such manner that with an increasing drop in pressure $p_s - p_D$ of the venturi, i. e. with increasing density of the charging air, the quantity of fuel delivered rises. The spring 12 returns the rod 13 and the diaphragm 7 when the pressure difference drops.

The device for varying the cross-sectional area of passage in dependence upon the engine speed, according to the second feature of this invention, consists of a centrifugal governor 18 of a well known type driven by the engine and which, by means of a lever 21 engaging the governor sleeve 17, displaces the rod 20 and the control member 19 relative to the entrance of the venturi. This displacement occurs in such a manner that the control member 19 is moved into the venturi 6 when the engine speed drops, and is moved in the opposite direction, when the engine speed rises. The manner, in which the control member 19 is moved, and its shape, preferably as a profiled valve body, should be so chosen that with a constant density γ_s in the suction pipe and at any engine speed the drop in pressure $p_s - p_D$, i. e. the

velocity of flow in the throttling portion, is, at least approximately, constant.

In the embodiment shown in Fig. 2 the combustion air is supplied to the pipe 4 by the charging blower 23, which is driven by the engine or by an exhaust gas turbine. The compressed air regulator 24 keeps the blower pressure p_1 constant. The suction pressure p_s may be lowered at will by means of a throttle 5.

The control member adapted to be adjusted in dependence upon the engine speed, here shown as a flap valve 29, and the venturi 6 are arranged in two parallel branches of the air conduit. The pressure drop produced in the nozzle 6 acts on a piston 25, which divides the cylinder 37 into the pressure spaces 26 and 27, and supplies the force for actuating the lever 3 for controlling the quantity of fuel injected.

Here the adjusting movements dependent on the engine speed are brought about by a supply pump 31 driven by the engine, which aspires the fuel from a storage tank and delivers it through a conduit 32 to the fuel pump 2. In the conduit 32 a choke member 33 creates a pressure drop $p_1 - p_2$ in dependence upon the quantity of fuel passing therethrough. The delivery of the supply pump 31 and the pressure difference $p_1 - p_2$ are directly dependent on the engine speed. The pressure difference acts on the piston 34 urging it together with the linkage 30 and the cam member 36 against the action of the return spring 35. The shape of the cam 36 determines the adjustment of the throttle 29, so that this throttle occupies a predetermined position for every speed.

Instead of the supply pump, the lubricating pump, the cooling-water pump, the air pump or the like might be used.

The flap 29 and cam member 36 might be replaced by a profiled valve.

I wish it to be understood that I do not desire to be limited to the exact details above described and shown in the drawing, for obvious modifications will occur to a person skilled in the art.

I claim:

1. An internal combustion engine comprising in combination, an engine cylinder, a fuel injection pump, means operatively connected with said pump for controlling the quantity of fuel injected into said cylinder per working cycle, an air conduit communicating with said cylinder, an engine output regulating means, means responsive to changes in air density comprising a venturi arranged in said air conduit between said regulating means and said engine, means for adjusting the total cross sectional area of flow of air between said output regulating means and said engine, an engine-driven mechanism acting on said air flow adjusting means to reduce said cross sectional area in proportion, as the engine speed drops, in such manner as to render the speed of air flow in the narrowest portion of the venturi constant and independent of the engine speed, a casing, a piston-member in said casing dividing the casing in two chambers, one communicating with the narrowest part of said venturi, the other with the air conduit in front of the Venturi entrance and means arranged to transmit the movement of said piston to said fuel-control means to adjust the quantity of fuel delivered by the pump per working cycle in dependence upon the density of the air admitted.

2. The engine of claim 1, in which the air flow adjusting means is arranged inside the venturi.

3. The engine of claim 1, in which the air flow adjusting means is arranged in a branch air conduit connected in parallel to the venturi.

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