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[54] **FUEL FEED DEVICES FOR INTERNAL COMBUSTION ENGINES**

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[58] **Field of Search**.123/139 AW, 140 MC, 139 AF, 123/119 R

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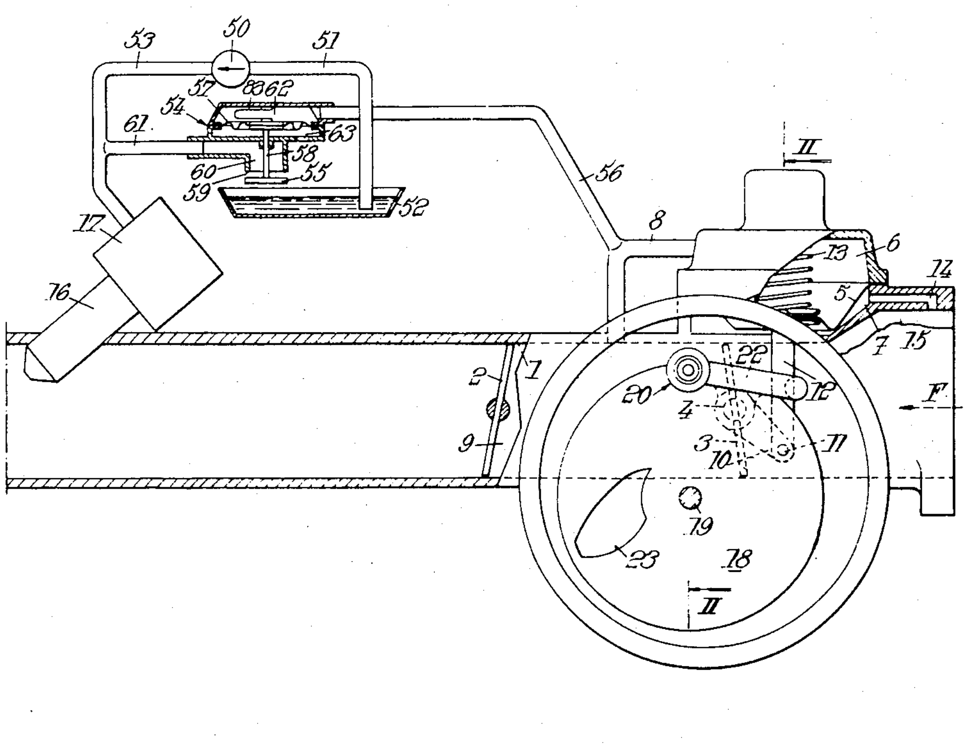
[57] **ABSTRACT**

Valves supplied from a source of fuel under pressure are each actuated by an electromagnet energized over a variable fraction of each revolution of a rotary member driven by the engine. The energizing current is governed by a light source which illuminates a photo-sensitive element according to the position of an intermediate rotary member. The fuel is fed to the valve by a fuel pump whose delivery circuit includes a pressure regulator comprising a discharge valve controlled by the suction in the intake pipe of the engine. Variation of richness of the air/fuel mixture through temperature changes is compensated by a bimetallic element coupled to the discharge valve.

2 Claims, 2 Drawing Figures



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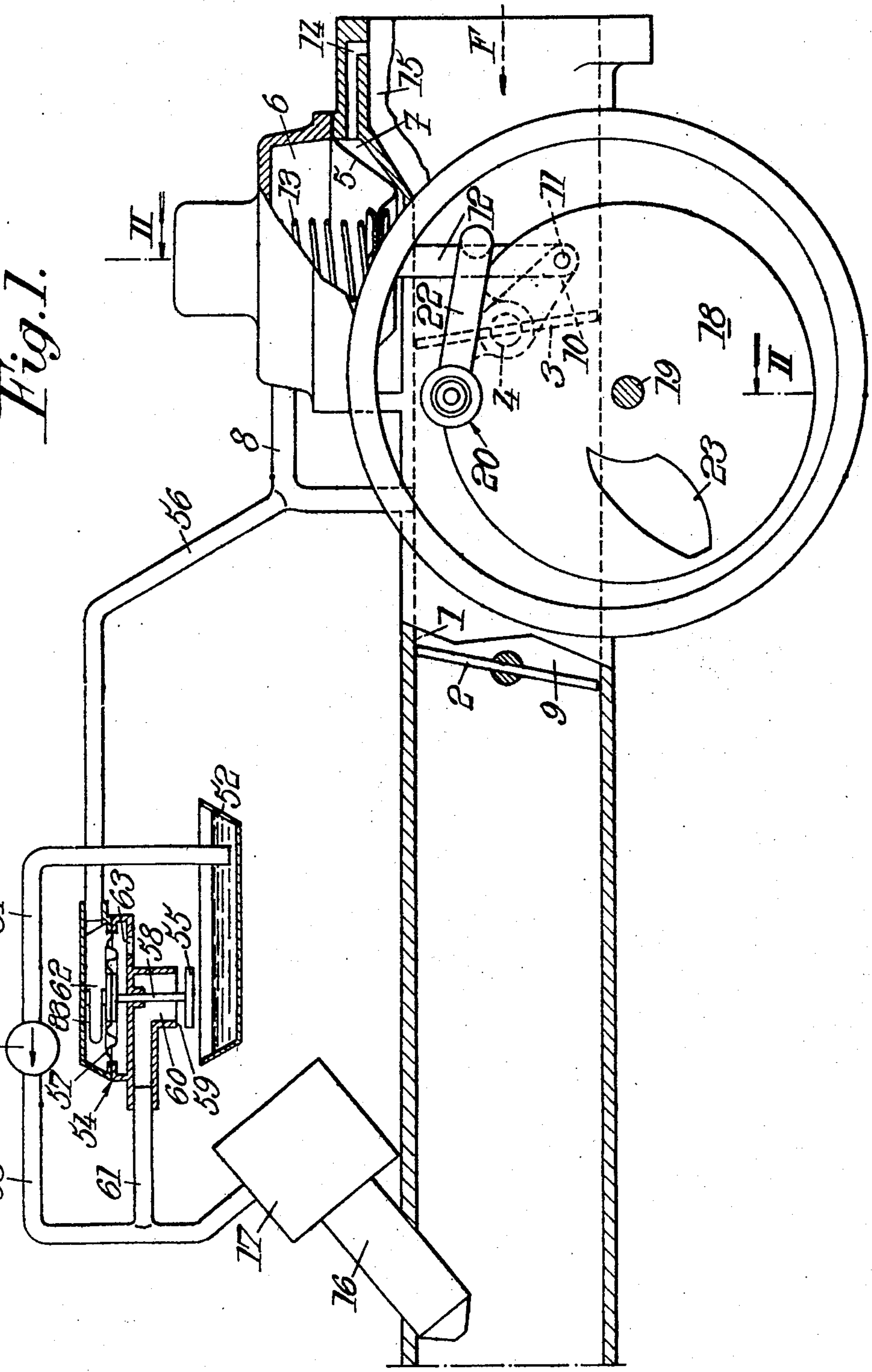
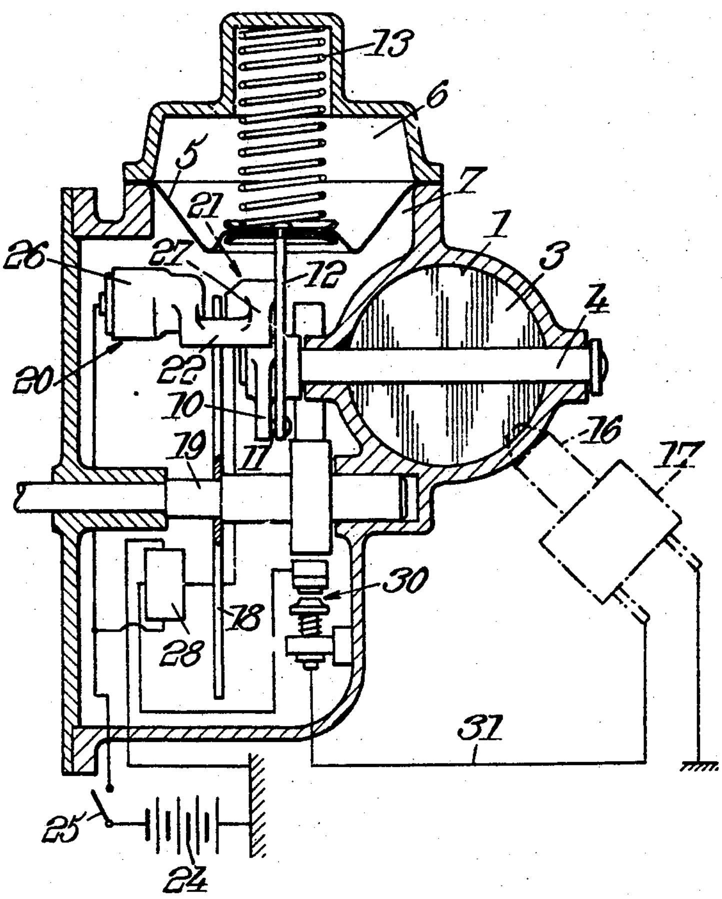


Fig.1.

Fig. 2.



FUEL FEED DEVICES FOR INTERNAL COMBUSTION ENGINES

The invention relates to fuel feed devices for internal combustion engines, of the type which comprise, on the one hand, in their inlet conduit, upstream of an principal throttle member actuated by the driver, an auxiliary throttle member which opens automatically and progressively in proportion as the air flow rate in the said conduit increases, on the other hand, means for injecting under pressure liquid fuel into the portion of this conduit situated downstream of the principal throttle member, and, on the other hand lastly, a metering system sensitive to the position of the auxiliary throttle member and adapted to regulate the flow-rate of the fuel injected in such a way that the richness of the air/fuel mixture passing into the inlet conduit is substantially constant, at least under certain conditions of operation of the engine, the abovesaid injection means being constituted by a source of fuel under pressure whose delivery circuit, opening into the above-said portion of the inlet conduit, is controlled by at least one valve actuated by an electromagnet.

The invention relates more particularly to those of the devices of the type concerned which have been described in applicant's Pat. No. 3,543,739 and of which the above-said metering system comprises a member driven in continuous rotary movement and capable, by acting on the energization of the electromagnet, of determining over a fraction only of each of its revolutions the opening of the valve, the system being arranged so that it increases the said fraction in proportion as the opening of the auxiliary throttle member increases and vice-versa.

The invention relates more particularly again to those devices of the type concerned of which the source of fuel under pressure is constituted by a fuel pump in the delivery pipe of which acts a pressure regulator which comprises a relief valve tending to open under the effect of the delivery pressure of the pump and to close under the effect of the suction existing in the section of the inlet conduit comprised between its two throttle members, which suction is transmitted by a connecting passage to a diaphragm to which is coupled the relief valve.

Of course the position of the auxiliary throttle member is characteristic of the flow-rate of the air passing from upstream to downstream of this member, provided that the density of the air is practically constant.

However, for large variations of temperature of the air, the variation of its density becomes important and the position of the auxiliary throttle member no longer gives accurate indication of the air flow-rate in terms of mass passing from upstream to downstream of this throttle member. In fact, for a given position of the latter and hence for an identical fuel flow-rate (provided that the temperature of the latter is constant), the air flow-rate in terms of mass passing from upstream to downstream of the auxiliary throttle member is all the greater as the air temperature is lower.

Additionally, the fuel flow-rate through a calibrated orifice tends to increase if the temperature of this fuel increases as a result of the decrease in its viscosity. An increase in ambient temperature, hence an increase in the temperature of the fuel, is manifested consequently, also, by an increase in fuel flow-rate.

As a result, at low ambient temperatures, the richness of the air/fuel mixture passing in the inlet conduit is too weak and, on the other hand, at high temperatures, the richness of the mixture is too strong.

With the object of overcoming this drawback, the fuel supply device of the type defined above is characterized by the fact that an elastic element, deformable under the effect of the temperature variation, exerts on the discharge valve of the above-said pressure regulator a force directed in the sense of its closing which increases (in algebraic value) in proportion as the temperature drops. The said element can be adjusted so that, for an average position of the discharge valve, the force that it exerts is null for an average temperature range and tends to close the valve or to open it according as its temperature is below or above this temperature range. In this latter case, the force directed in the sense of closing is considered by convention as a negative force.

The fuel flow-rate is thus modified by acting on the injection pressure, so that the richness of the air/fuel mixture passing in the inlet conduit remains substantially constant, even for considerable variations in the air temperature.

The invention will, in any case, be well understood by means of the following complementary description, as well as from the accompanying drawings, which complementary description and drawings relate to a preferred embodiment, given purely by way of illustrative and non-limiting example.

In these drawings,

FIG. **1** shows, in diagrammatic elevation with portions cut out, one embodiment of the fuel feed device constructed according to the invention ;

FIG. **2** shows a section along the line II—II of FIG. **1**.

According to the invention, and more particularly according to that of its methods of application, as well as according to those of its methods of production of the various parts, to which it would appear that preference should be given, in order to contruct a fuel feed device for automobile engines or the like, procedure is as follows.

As regards the device as the whole, it is constituted in any suitable manner so that it comprises :

— on the one hand, in its inlet conduit **1**, upstream of a principal throttle member **2** actuated by the driver, an auxiliary throttle member **3** which opens automatically and progressively in proportion as the air flowrate in the conduit **1** increases, the direction of flow being indicated by the arrow F in FIG. **1** ;

— on the other hand, means for injecting under pressure liquid fuel into the portion of the conduit **1** situated downstream of the principal throttle member **2** ;

— on the other hand, lastly, a metering system sensitive to the position of the auxiliary throttle member **3** and adapted to regulate the flow-rate of injected fuel in such a way that the richness of the air/fuel mixture passing in the conduit **1** is substantially constant, at least for certain conditions of operation of the engine.

In the embodiment shown, the auxiliary throttle member **3** is constituted by a butterfly-valve fixed on an axle **4**. This butterfly-valve is actuated by a pneumatic device comprising a diaphragm **5** separating two chambers **6** and **7** from one another. The chamber **6** is connected by a passage **8** to a chamber **9** constituted by the section of the conduit **1** which is comprised between the principal throttle member **2** and the valve **3**. The axle **4** is rigidly fixed to a lever **10** provided, at its free end, with a pin **11** which cooperates with the end of a rod **12**, which is connected to the diaphragm **5**. Spring **13** tends constantly to close the valve **3** against the effect of the suction transmitted in the chamber **6**. The chamber **7** is placed at atmospheric pressure by passage **14** starting preferably from the air intake **15** of the conduit **1**.

Of course the angular position adopted at any moment inside the conduit **1** by the valve **3** corresponds to the air flow-rate which circulates in this conduit, as long as the density of the air remains practically constant. The greater the air flow-rate , the more the valve **3** opens, a substantially constant suction (or varying according to the characteristics of the spring **13**) being established in the chamber **9** comprised between the two throttle members **2** and **3**. The valve **3** could be replaced by equivalent throttle members, of which examples have been described in the abovesaid patent and its first certificate of addition.

The above-said injection means is constituted by source of fuel under pressure which will be described in more detail below and which the delivery circuit, opening into the conduit **1** downstream of the principal throttle member **2**, is controlled by at least one valve **16** actuated by an electromagnet **17**.

The metering system comprises a flattened opaque disc **18** which is borne by a shaft **19**, connected preferably to the internal combustion engine (not shown) supplied by the device, so that the disc is driven in a continuous movement of rotation around an axis perpendicular to its plane. The disc **18** is interposed between a source of radiation, especially a light source **20** and a receiver such as a photodiode or a photoelectric cell **21**, borne by a common support **22** connected to the auxiliary throttle member **3** and it is pierced by at least one aperture **23** adapted to allow the beam coming from source **20** to arrive at cell **21**. Cell **21** is arranged to control the energization the electromagnet **17** according as it is irradiated or not and the assembly is such that the electromagnet is energized over a fraction of each of the revolutions of disc **18** which varies in the same sense as the degree of opening of the throttle member **3**.

The light source **20** may be constituted by a lamp which is adapted to be supplied by a battery **24** as soon as the ignition contact **25** of the engine is closed and which is arranged in a hollow boss **26** pierced by a hole. This hole is oriented in such a way as to direct a light beam onto the cell **21**, through a hole passing through a hollow boss **27** wherein the said cell is lodged. In the embodiment shown, the bosses **26** and **27** are made to be carried by the ends of the U-shaped support **22** which straddles the disc **18** so that the source **20** and the cell **21** occur on each of the disc and which is rigidly fixed to the axle **4**, the latter being parallel to the shaft **19** as well as to the light beam received by the cell **21**.

To apply the currents generated in the cell **21**, there is interposed between the latter and the electromagnet **17**, an amplifying relay **28**.

When the internal combustion engine has several cylinders supplied by a valve **16** actuated by an individual electromagnet **17**, all the electromagnets can be actuated simultaneously or a distributor **30** can be provided synchronized with the disc **18** to send successively intermittent energizing current into the various electromagnets, the disc possessing as many apertures **23** as cylinders to be supplied. The apertures are distributed regularly around the shaft **19** and have each a shape such that the fraction of the revolution during which it normally permits the cell **21** to be illuminated increases in proportion as the throttle member **3** opens, that is to say (in the embodiment shown) in proportion as the bosses **26**, **27** approach the shaft **19**.

Of course the fuel feed device which has just been described operates as follows.

In proportion as the air flow-rate in the conduit **1** increases, the throttle member **3** opens thereby driving the support **22** in the sense which brings closer together the shaft **19** and the bosses **26** and **27**. Each of the positions of the bosses corresponds to a different radius of the disc **18**.

Since the shape of each aperture **23** has been determined so that the fraction of a revolution, during which it allows to pass towards the cell **21** the light ray coming from the source **20** (creation of a current in the conductor **31**), increases in proportion as the latter elements approach the shaft **19**, it is insured that the fuel flow-rate delivered by each injection valve **16** varies in the same sense as the air flow-rate in conduit **1**.

This being so , the source of liquid fuel under pressure is constituted by a fuel p mp **50** of which the intake pipe **51** dips into a fuel reservoir **52** and on the delivery pipe **53** of which acts a pressure regulator **54**. The latter comprises a relief valve **55** tending to open under the effect of the delivery pressure of the pump and to close under the effect of the suction existing in the chamber **9**, which suction is transmitted by a connecting passage **56** to a diaphragm **57** to which is coupled the valve **55** by a rod **58**. The valve **55** cooperates with a seat **59** which constitutes the exit of a chamber **60** connected through a branch channel **61** to the delivery pipe **53**. The connecting passage **56** ends in a variable volume chamber **62** bounded by one surface of the diaphragm, the other surface being placed at atmospheric pressure for example through an orifice **63**. The whole is such that the valve **55** opens as soon as the pressure in the pipe **53** exceeds a value determined by the surface of the diaphragm **57** and by the suction exerting on the latter.

According to the invention, recourse is had to an element, elastic and deformable under the effect of temperature variation, such that a bimetallic strip **83**. One of the ends of this strip is fixed on the body of the regulator **54**, the other end is coupled to the rod **58**. Thus positioned, the strip **83** has a temperature which depends on that of the ambient air and of the fuel, due to the fact of thermal conduction in the regulator. It is arranged so that, on an increase in temperature, the bimetallic strip **83** has a tendency to open the valve **55**.

The operation of the regulator according to the present improvement is as follows :

As explained above, for a same position of the auxiliary throttle member **3**, the air flow-rate by weight passing in the inlet conduit **1** is greater or less according as the air temperature is higher or lower, and the fuel flow-rate is greater or less according as its temperature is higher or lower. To maintain an approximately constant air/fuel mixture richness, the bimetallic strip **83** serves to increase the fuel flow-rate if the temperature decreases and to reduce the fuel flow-rate if the temperature increases.

In fact, for a drop in temperature, the effort of the bimetallic strip **83** is added to that exerted by the diaphragm **57** under the effect of the suction in the chamber **62** and tends to close the valve **55** a little more, which causes an increase in fuel pressure upstream of the injection orifice actuated by the valve **16**, and consequently an increase in the flow-rate of the fuel in the inlet conduit **1**.

A reverse effect is obtained for an increase of temperature.

This correction in the richness of the air/fuel mixture is all more effective as the air flow-rate in the conduit **1** is less, but in practice, this correction is not generally necessary for high air flow-rates.

As is self-evident, and as emerges already from the foregoing, the invention is in no way limited to those of its methods of application, nor to those of its methods of production of its various parts, which have been more especially indicated ; it encompasses, on the contrary, all variations. In particular, the bimetallic strip **83** may be replaced by any other element, elastic and deformable under the effect of temperature variation.

I claim :

1. Fuel feed device, for an internal combustion engine, comprising in an inlet conduit, upstream of a principal throttle member adapted to be actuated by the operator, an auxiliary throttle member which opens automatically and progressively as the air-flow rate in said conduit increases, and means for injecting liquid fuel under pressure into the portion of this conduit situated downstream of the principal throttle member and, a metering system sensitive to the position of the auxiliary throttle member and adapted to regulate the flow-rate of the fuel injected in such a way that the richness of the air/fuel mixture passing in the inlet conduit is substantially constant, at least for certain conditions of operation of the engine, the above-said injection means being constituted by a source of fuel under pressure of which the delivery circuit opening into the said portion of the inlet conduit is controlled by at least one valve actuated by an electromagnet, the metering system comprising a member driven in a movement of continuous rotation and capable, by acting on the energization of the electromagnet, of determining over a fraction only of each of these revolutions, the opening of the valve, said system being arranged so that it increases the said fraction in proportion as the opening of the auxiliary throttle member increases and vice-versa, the said source of fuel under pressure being constituted by a fuel pump in whose delivery circuit acts a pressure regulator which comprises a relief valve tending to open under the action of the delivery pressure of the pump and to close under the action of the suction existing in the section of the inlet conduit comprised between its two throttle members, which suction is transmitted through a connecting passage to a diaphragm to which the relief valve is coupled, characterized by the fact that an elastic element which engages said relief valve and is deformable under the effect of the variation of temperature, is arranged to exert on said relief valve, a force directed in the sense of its closing which increases (in algebraic value) in proportion as the temperature decreases.

2. Fuel feed device according to claim **1**, wherein said elastic element is adjusted in such a way that, for an average position of the relief valve, the force that it exerts is nil for an average temperature range and tends to close the valve or to open it according as its temperature is respectively below or above said temperature range.

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