March 7, 1939. M. MENNESSON 2,150,075

REGULATING DEVICE FOR INTERNAL COMBUSTION ENGINES SUPPLIED BY FUEL INJECTION

Filed June 28, 1937

Fig. 1.

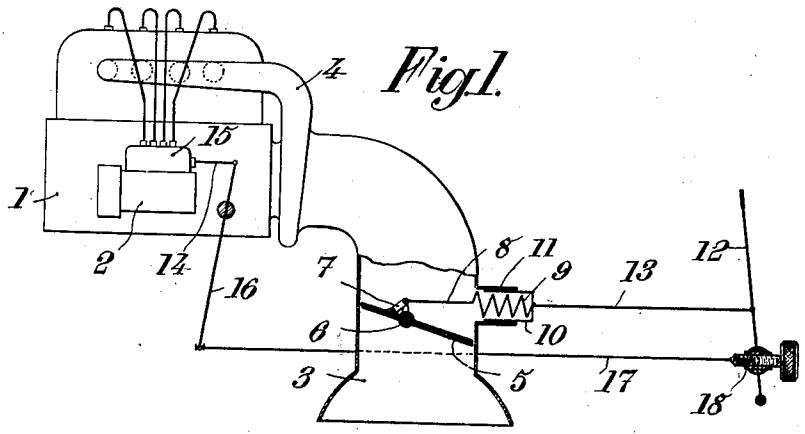


Fig. 2.

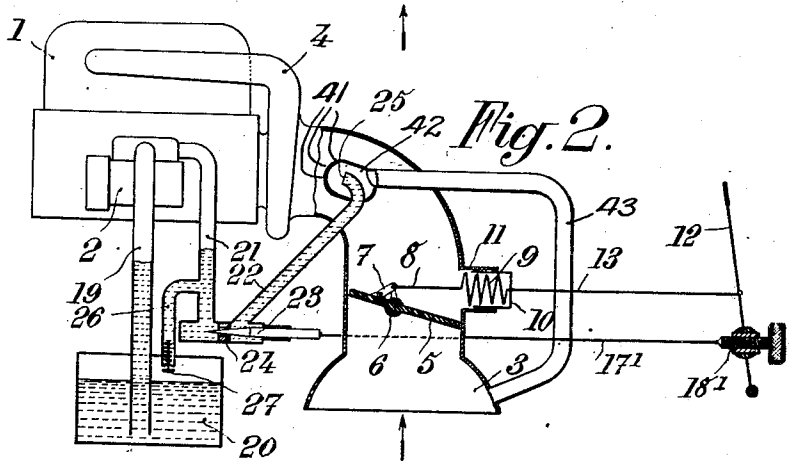
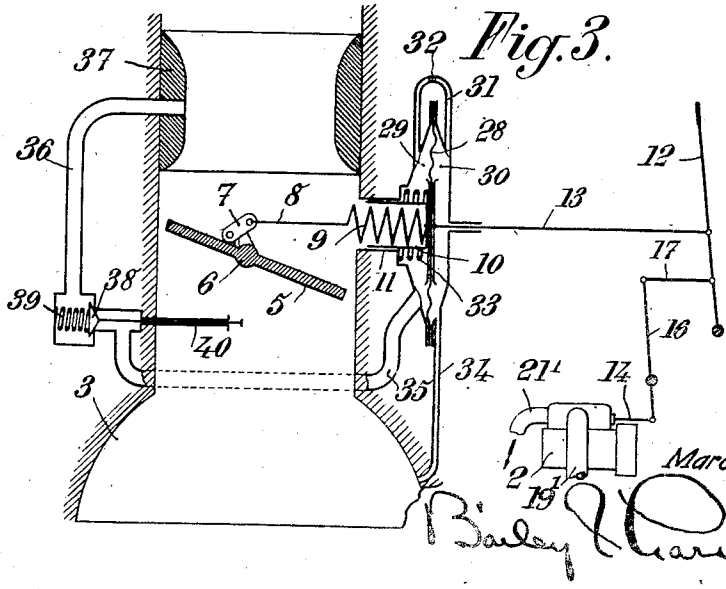


Fig. 3.



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Patented Mar. 7, 1939

2,150,075

UNITED STATES PATENT OFFICE

2,150,075

REGULATING DEVICE FOR INTERNAL COMBUSTION ENGINES SUPPLIED BY FUEL INJECTION

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Application June 28, 1937, Serial No. 150,837
In France November 4, 1936

11 Claims. (Cl. 123—139)

The invention relates to regulating devices for internal combustion engines, particularly wherein an obturating member automatically regulates the quantity of air admitted to the engine by the action of the suction of the engine on the said member and concerns more especially such devices associated with engines supplied by fuel injection.

It is obvious, to regulate the quantity of fuel admitted in pump-fed engines, it is necessary to act on the delivery of the pump and to provide a device permitting this delivery to vary according to the power it is desired to obtain. This variation can be obtained by acting on the stroke of the movable member (piston or diaphragm) of the pump, on the section of an orifice delivering fuel or by any other means.

Where the engine is of the type in which the charge of air and fuel is ignited in the cylinders, to vary the power it is necessary to act both on the quantity of air admitted and on the quantity of fuel introduced. Moreover, if the engine is provided with a compressor, as is the case for example for certain aircraft engines, it is advantageous and even sometimes necessary to provide the compressor with a pressure-regulating device limiting, at the desire of the pilot, the quantity of air admitted to the engine.

The present invention has for its object automatically to proportion, whatever may be the power required from the engine and whatever may be the exterior pressure and temperature conditions, the quantity of aspired air and the quantity of fuel introduced into the engine.

It consists, principally (for such devices particularly although not exclusively for engines for vehicles or aircraft) in connecting the means regulating the delivery of fuel with those by which the driver can act on an obturator automatically regulating the delivery of air in order to vary, as desired, the charge of air admitted to the engine, in such a way as thus to obtain, for each setting of the engine, the best proportion of air and fuel.

It consists, apart from this principal arrangement, in certain other arrangements, which are preferably utilized at the same time and which will be more explicitly mentioned hereafter.

According to these latter it comprises a second arrangement, which further is a simple example of the principal arrangement and consists in connecting a device automatically regulating the charge of air admitted to the engine per unit of time—this charge moreover being variable at the desire of the driver—with a device regulating the charge of fuel supplied to the engine per unit of time, this charge being a function of the corresponding charge of air.

It also comprises a third arrangement consisting in utilizing a device automatically regulating the charge of air admitted to the engine per engine turn, this charge being variable at the desire of the driver, connected with a device regulating the charge of the fuel supplied to the engine per engine turn, this charge per engine turn being a function of the corresponding charge of air.

Further, it comprises a fourth arrangement consisting in utilizing an obturating member which automatically regulates the delivery of air by the effect of the pressure which the current of air exerts thereon in opposition to a spring the tension of which is independent of the speed of the said current of air, and in connecting the tension-regulating members of the said spring with the device which causes the variation of the delivery of fuel supplied to the engine.

Additionally it includes a fifth arrangement, consisting in associating with the connection of the members, acting on the tension of the spring regulating the quantity of air, with the device controlling the variation of delivery of the pump delivering the fuel, a regulating device, at the disposal of the driver, adapted if necessary to vary the quantity of fuel whilst the quantity of air remains unchanged and vice versa in such a way that the driver can modify the proportion of air and fuel introduced into the engine.

It still further comprises a sixth arrangement consisting in utilizing, when the arrangement for regulating the feed of air can no longer operate because the density of the air has fallen too low, the tension of the spring of the mechanism in order to cause to vary directly, or through a servo-motor, the quantity of fuel introduced into the engine.

In order that the invention may be better understood, it will now be described with reference to the accompanying drawing, which is given by way of example and in which:

Fig. 1 shows, diagrammatically, an engine provided with a device constructed according to a first embodiment of the invention and for which it has been supposed that the air is supplied to the engine by a turbo-compressor whilst the fuel is injected directly into the cylinders.

Fig. 2 shows, similarly, a device constructed according to a second embodiment of the inven-

tion and for which it has been supposed that the fuel is injected into the turbo-compressor.

Fig. 3 shows an arrangement similar to those in Figs. 1 and 2 and which causes the quantity of fuel fed to the motor to decrease automatically when the air-regulating arrangement can no longer maintain the quantity of air constant because the density of the air has dropped too low.

In Fig. 1 there has been shown, in a very diagrammatic manner, an explosion engine 1, the cylinders of which are supplied directly with fuel delivered by a pump 2 whilst the air is supplied separately to the said cylinders through a conduit 3 in which is provided a super-charging air compressor, such as a turbo-compressor 4.

In the air inlet 3 there is accommodated an obturating valve 5 in the axis 6 of which is eccentric with respect to that of the air inlet properly speaking. The said valve is connected by a link 7 and a rod 8 to a spring 9 fixed to a socket 10 which can slide in a housing 11. The socket 10 is connected to the control lever 12, placed at the disposal of the pilot, by a rod 13. The direction of eccentricity of the valve 5 is such that the current of aspired air tends to close this valve whilst the traction of the spring 9 tends to open it.

The delivery of the fuel pump 2 is regulatable by the sliding of a rod 14 which acts for example on the distributor 15 or on a pump-delivery regulator, this rod being connected, by a connecting rod 16 and a rod 17, to the control lever 12 mentioned above. A screw 18, with a milled head or the like, allows the relative position of the connection 16—17 to be modified with respect to the lever 12 and, in consequence, with respect to the connection 13 provided between this latter and the spring 9.

The device thus constituted operates as follows:

For the reasons indicated in my pending application S. N. 113,245 filed November 28, 1936, it is known that the quantity of air drawn in by the engine is a function of the position of the socket 10, that is to say of the position of the control lever 12.

Furthermore, according to the law of the tension of the spring 9 as a function of the opening of the valve 6, a law which varies with the system of connection of the spring to the valve and with the characteristics of the spring, it is possible to obtain at will for a fixed position of lever 12, and whatever be the density of the air, the admission to the motor of a constant weight of air, either per unit of time, or per revolution of the motor.

It is therefore sufficient to equip the engine, in the first case, with a pump and a device delivering a constant charge of fuel per unit of time, and in the second case a pump and a device delivering a constant charge of fuel per engine turn.

Consequently, by connecting the rod 14 which regulates the delivery of the pump 2 to the lever 12 the result is obtained that, for a constant quantity of air drawn in per engine turn, a substantially constant quantity of fuel is introduced into the engine per engine turn. It is consequently sufficient to regulate the relative displacements of the socket 10 and of the rod 14 as to have predetermined proportions of air and fuel and which correspond to the optimum working of the engine for its different conditions of operation.

On the other hand, if for any reason the pilot desires to modify the proportion of air and fuel admitted into his engine he can proceed in two ways:

Either, by leaving the control lever 12 at determined position and by acting on the screw 18, which has for effect to change the delivery of fuel delivered by the pump 2 without modifying the delivery of air since the socket 10 remains immovable;

Or, by moving the control lever which modifies the delivery of air admitted to the engine, and he can then act on the screw in order to modify the delivery of fuel which would normally correspond to the new air delivery.

The device is interesting in the following particular case:

If the density of the exterior air becomes very low to such a degree that the action of the spring 9 always overcomes the action of the current of air tending to close the valve 5, then this valve remains completely open when the density of the air continues to diminish, as is the case with aircraft engines if a too-high altitude is attained. At the moment there is the risk that the mixture introduced into the engine is no longer correct, the quantity of air drawn in being comparatively too small with respect to the quantity of fuel introduced into the engine. The pilot can then, by acting on the screw 18, restore the suitable proportion required for the correct operation of the engine.

Fig. 2 shows a similar arrangement as regards the regulation of the air admission. The fuel is supplied to the engine by a pump 2 which takes the fuel, through the intermediary of a conduit 19, from a reservoir 20. This fuel is forced by a conduit 21, on the one hand, into a channel 22 into which its delivery is regulated by a needle valve 23 which more or less closes a calibrated orifice 24. This channel 22 ends in an orifice 25 which delivers the fuel into the conduit 3 for the supply of air between the air-regulating device 5—13 and the turbo-compressor 4.

A bye-pass 26, provided with a suitably regulated discharge valve 27, allows a constant pressure for the fuel in the channel 21 to be obtained. This supply of fuel is therefore a constant-pressure supply of a well known type.

In order that the pressure existing in the air inlet 3, at the level of the orifice 25, shall not modify the delivery of fuel, the orifice 25 can be provided with a device forming the object of my pending application S. N. 53,682 filed December 9, 1935, and matured into Patent No. 2,121,506, dated June 21, 1938.

This arrangement comprises a chamber 42 provided with orifices 41 and communicating with the air entrance by a passage 43 the cross sectional area of which is relatively very great as compared to that of orifices 41. The fuel passage 22 has its outlet in this chamber 42. In this manner the suction which exists in the interior of the chamber 42 is only a small fraction of the suction which exists in the intake pipe.

The fuel delivery is therefore regulated by the displacement of the needle valve 23 which is connected by a rod 17^1 to a screw 18^1 with a milled head or the like and which is mounted on the control lever 12, at the disposal of the pilot.

For reasons similar to those indicated with reference to Fig. 1, it is seen that to any given position of the lever 12 there corresponds substantially a predetermined charge of air admitted to the engine and which is constant per unit of time. This position also corresponds to a predetermined charge of fuel and which is constant per unit of time since this charge of

fuel only depends upon the free section existing between the orifice 24 and the needle valve 23.

It is therefore possible, by giving a suitable form to the needle valve 23 and by adopting equally suitable relative positions for the connected controls 13 and 17^1, to obtain, for each position of the lever 12, a charge of air and a charge of fuel the proportion of which corresponds to the optimum working of the engine.

For the same reasons also, the pilot can modify this proportion if he considers it advantageous, either by acting through the screw 18^1 on the fuel delivery without modifying the quantity of air while leaving the lever 12 stationary or, conversely, change the quantity of air by displacing the lever 12 and modifying, subsequently, the delivery of fuel by acting on the screw 18 in such a way that this fuel delivery is no longer the delivery which corresponds to the new quantity of air admitted to the engine, determined by the new position of the lever 12.

Fig. 3 shows a similar arrangement to that of Fig. 1 and which brings into action, in addition, an automatic device in order to modify the proportions of air and fuel admitted to the engine when the density of the air falls below a certain value. To this end there can be mounted on the socket 10 a diaphragm 28 which separates two chambers 29 and 30 connected between themselves by a channel 31 provided with a calibrated orifice 32. A spring 33 tends constantly to stretch the spring 9, but is generally held in place by the lever 12.

The chamber 30 communicates, through a conduit 34, the section of which is definitely greater than that of the orifice 32, with the exterior air or with the general air inlet 3 of the engine.

The chamber 29 communicates, through a channel 35 and a channel 36, with a venturi 37 accommodated in the air conduit 3 between the valve 5 and the engine. The communication between the channels 35 and 36 can be interrupted by a valve 38 maintained on its seating by a spring 39. This valve 38 is provided with a push rod 40 on which the valve 5 acts when it is completely open. The spring 39 is such, when the valve 5 bears on this push-rod 40 by the mere action of the springs 9 and 33, that it easily compresses the spring 39 in diverting the valve 38 from its seat.

The lever 12 is also connected, by the connections 17, 16 and 14, to the fuel pump 2 which draws in the fuel through a conduit 19^1 and forces it through a conduit 21^1 into the cylinders of the engine (Fig. 1) or into the compressor (Fig. 2), the displacement of the rod 14 being capable of varying this delivery.

The operation of a device thus constituted is the following:

When the pilot acts on the lever 12 so as to admit a certain quantity of air into the engine, this quantity is determined by the position of equilibrium taken by the valve 5 influenced, on the one hand, by the spring 9 and, on the other hand but in the opposite direction, by the current of aspired air. The quantity of fuel is also determined by the position of the rod 14, as explained with reference to Figs. 1 and 2.

If, for any reason, the density of the air commences to decrease, the regulating device continues to admit a substantially constant quantity of air in consequence of the progressive opening of the valve 5, the lever 12 always remaining immovable. When the valve is completely open and when the density of the air continues to diminish, it is obvious that the quantity of air admitted to the engine is also going to diminish. As, on the other hand, the rod 14 is immovable, it follows that the proportion of fuel is going to be larger and larger with respect to the quantity of air. In order to obviate this disadvantage, it is therefore necessary to diminish the fuel delivery. To this end, when the current of air which tends to close the valve 5 is no longer sufficient, this valve begins to act on the push-rod 40 in order to open the valve 38. At this moment the suction, which exists in the venturi 37, acts in the chamber 29 and deforms the diaphragm 28 by compressing the spring 33. The calibrated orifice 32 and the piping 35 as well as their respective sections then come into action in such a manner that this suction is not substantially exerted in the chamber 30.

It results therefrom that the socket 10 is displaced by compressing the spring 33 and relaxing the spring 9. This socket also influences the lever 12 through the intermediary of the rod 13, which has for effect to diminish the delivery of fuel since the rod 14 is also displaced in a direction for which a diminution of fuel delivery is obtained.

The displacement of the socket 10 is produced until the spring 9 is sufficiently relaxed and the effect of the current of air has again become sufficient for it to have a tendency to close the valve 5. At this moment, the action of the valve on the push-rod 40 is no longer sufficient to keep the valve 38 open. When this latter is applied on its seat, the chambers 29 and 30 are at the same pressure. Consequently, the spring 33 tends to displace the socket 10 in the contrary direction, which has for effect again to stretch the spring 9 and again to apply the valve 5 against the push-rod 40. It results therefrom that a position of equilibrium is set up for the socket 10, this position of equilibrium depending upon the density of the air drawn in.

This position of equilibrium also determines the delivery of fuel, which depends upon the position of the rod 14, and consequently upon the density of the air drawn in.

It is then sufficient to provide, between the socket 10 and the rod 14, connections such that the delivery of fuel is proportionate to the delivery of the air drawn in by the engine.

It is seen on the other hand that, as long as the valve is not completely open, the device does not come into action and the whole system operates exactly like those which have been described with reference to Figs. 1 and 2.

Instead of causing the diaphragm 28 to act on the fuel pump through the articulated assembly 13—17, there could be provided between this latter and the regulating member 14 of the pump, a suitable relay or servo-motor which moves this member under the same conditions as those indicated above.

In Figs. 1 and 2, it has been supposed that a compressor is placed after the regulating device. Naturally, this compressor might quite as well have been placed in front of this device or even completely eliminated. In effect, in the description of the operation, the compressor does not come into action and its presence is therefore not essential. It is the same for Fig. 3, in which the compressor could be placed in front of or after the regulating device or even be completely eliminated.

What I claim is:

1. A feed-regulating device for an internal

combustion engine comprising means for the injection of fuel in said engine, an element regulating the fuel delivery of said injection means, a conduit for the admission of air to said engine, a spring, an obturator in said conduit, the suction of said engine in said conduit acting in a direction tending to close said obturator, said spring acting in a direction to open said obturator, control means for displacing said element which regulates the fuel delivery, and connecting means between said control means and said spring, whereby movement of said control means varies the tension of said spring.

2. A feed-regulating device for an internal combustion engine comprising means for the injection of fuel in said engine, an element regulating the fuel delivery of said injection means, a conduit for the admission of air to said engine, a spring, an obturator in said conduit, the suction of said engine in said conduit acting in a direction tending to close said obturator, said spring acting in a direction to open said obturator, a control member, means operatively connected to said element which regulates the fuel delivery and to said control member, means to adjust said connecting means, and connecting means between said control member and said spring, whereby movement of said control member varies the tension of said spring.

3. In a device as claimed in claim 2, said adjusting means comprising interengaging threaded members.

4. A feed-regulating device for an internal combustion engine comprising a conduit for the admission of air to said engine, a spring, an obturator in said conduit, the suction of said engine in said conduit acting in a direction tending to close said obturator and said spring acting in a direction tending to open said obturator, means for feeding fuel to said engine, a needle valve for controlling the said fuel-feeding means, control means for displacing said needle valve, and connecting means between said control means and said spring, whereby movement of said control means varies the tension of said spring.

5. A feed-regulating device for an internal combustion engine comprising a conduit for the admission of air to said engine, a spring, an obturator in said conduit, the suction of said engine in said conduit acting in a direction tending to close said obturator and said spring acting in a direction tending to open said obturator, a fuel supply conduit opening in said air admission conduit between said obturator and said engine, an element movable to regulate the flow of fuel through said fuel supply conduit, control means for displacing said element, and connecting means between said control means and said spring, whereby movement of said control means varies the tension of said spring.

6. A feed-regulating device for an internal combustion engine comprising a conduit for the admission of air to said engine, a spring, an obturator in said conduit, the suction of said engine in said conduit acting in a direction tending to close said obturator and said spring acting in a direction tending to open said obturator, a fuel supply conduit opening in said air admission conduit between said obturator and said engine, a needle valve movable to regulate the flow of fuel through said fuel supply conduit, control means for displacing said element, and connecting means between said control means and said spring, whereby movement of said control means varies the tension of said spring.

7. A feed-regulating device for an internal combustion engine comprising a conduit for the admission of air to said engine, a spring, an obturator in said conduit, the suction of said engine in said conduit acting in a direction tending to close said obturator and said spring acting in a direction tending to open said obturator, fuel supply means for supplying fuel to said engine, a fuel feed conduit connected to said fuel supply means and opening into said air admission conduit, an element movable to regulate the flow of fuel through said fuel supply conduit, and an automatic discharge valve connected to said fuel supply conduit between said fuel supply means and said control element to maintain a constant pressure of fuel in said fuel supply conduit, control means for displacing said element, and connecting means between said control means and said spring, whereby movement of said control means varies the tension of said spring.

8. A feed-regulating device for an internal combustion engine comprising a conduit for the admission of air to said engine, an obturator in said conduit, the suction of said engine in said conduit acting in a direction tending to close said obturator, a spring connected to said obturator and tending to open the same, a diaphragm operatively connected to said spring, means enclosing said diaphragm and forming therewith two chambers, a passage connecting said chambers having a calibrated orifice therein, means connecting the chamber on the same side of the diaphragm as said spring to the said air supply conduit downstreamward of said obturator, means having a greater cross section than said calibrated orifice for connecting the other chamber to the atmosphere, fuel supply means for said engine, an element movable to control said fuel supply means, control means for displacing said element, and connecting means between said control means and said spring, whereby movement of said control means varies the tension of said spring.

9. A feed-regulating device for an internal combustion engine comprising a conduit for the admission of air to said engine, an obturator in said conduit, the suction of said engine in said conduit acting in a direction tending to close said obturator, a first spring connected to said obturator and tending to open the same, a diaphragm operatively connected to said spring, a second spring acting on said diaphragm in the same direction as said first spring acts on said obturator, means enclosing said diaphragm and forming therewith two chambers one of which contains said second spring, a passage connecting said chambers having a calibrated orifice therein, means connecting the chamber containing said second spring to the air supply conduit downstreamward of said obturator, means having a greater cross section than said orifice for connecting the other chamber to the atmosphere, fuel supply means for said engine, an element movable to control said fuel supply means, control means for displacing said element, and connecting means between said control means and said first spring, whereby movement of said control means varies the tension of said first spring.

10. A feed-regulating device for an internal combustion engine comprising a conduit for the admission of air to said engine, an obturator in said conduit, the suction of said engine in said conduit acting in a direction tending to close said obturator, a first spring connected to said obturator and tending to open the same, a dia-

phragm operatively connected to said spring, a second spring acting on said diaphragm in the same direction as said first spring acts on said obturator, means enclosing said diaphragm and forming therewith two chambers one of which contains said second spring, a passage connecting said chambers having a calibrated orifice therein, means connecting the chamber containing said second spring to the said air supply conduit downstreamward of said obturator, means having a greater cross section than said orifice connecting the other of said chambers with said air admission conduit upstreamward of said obturator, fuel supply means for said engine, an element movable to control said fuel supply means, countrol means for displacing said element, and connecting means between said control means and said first spring, whereby movement of said control means varies the tension of said first spring.

11. In a device as claimed in claim 10, means normaly closing said connecting means between the chamber containing the second spring and the air admission conduit, and means operable by the opening of said obturator to open said connecting means.

MARCEL MENNESSON.