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GOVERNOR APPARATUS FOR THE FUEL DELIVERY OF DIESEL AND OTHER INJECTION INTERNAL COMBUSTION ENGINES

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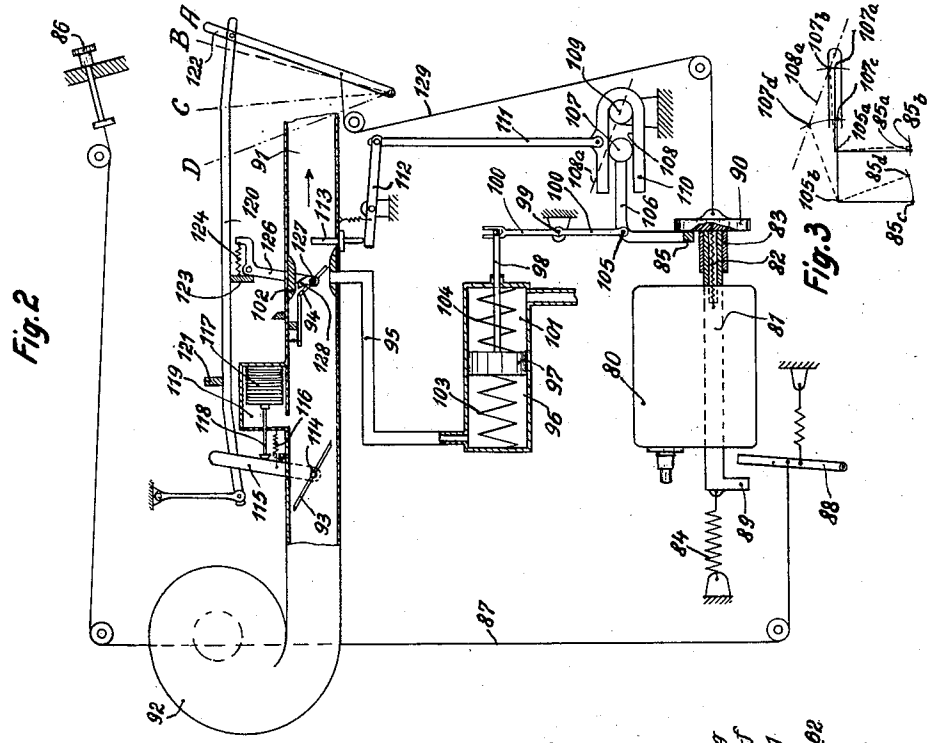

Fig. 2

Fig. 3

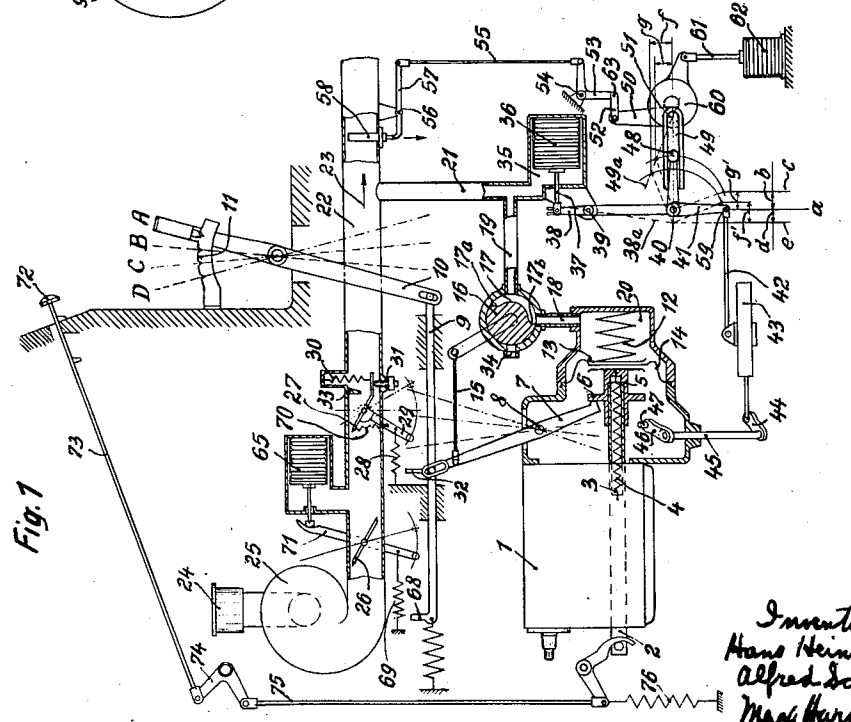

Fig. 1

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GOVERNOR APPARATUS FOR THE FUEL DELIVERY OF DIESEL AND OTHER INJECTION INTERNAL COMBUSTION ENGINES

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10 Claims. (Cl. 123—140)

The present invention relates to a governor apparatus for the fuel delivery of Diesel and other injection internal combustion engines wherein the movement of the fuel delivery control member of the injection apparatus in a direction producing an increase of fuel supply is limited by a stop, the position of which is automatically adjusted dependently upon the absolute pressure in the induction pipe of the internal combustion engine.

In known governor apparatus of this type it is not possible always to adjust the stop automatically under all running conditions, so as to produce smokeless combustion at all engine speeds and with a minimum quantity of superfluous air, so as to maintain the engine constantly at its highest efficiency. This is particularly true in the case of supercharged Diesel engines in aircraft or vehicles which are operated at a variety of altitudes and under a variety of air temperature conditions.

The object of the present invention is to provide a means for adjusting the fuel supply so as to produce a substantially smokeless combustion under all running conditions.

According to this invention, in a fuel injection apparatus of the type set forth, governing means, including a plurality of members respectively movable in response to changes of atmospheric pressure and of pressure and temperature obtaining in the induction pipe, is adapted to displace the stop in the direction of increased injection in accordance with a decrease of the atmospheric pressure and/or in accordance with an increase of the pressure obtaining in the induction pipe and decrease of the temperature therein in such a manner that equal changes of pressure in the said induction pipe cause displacements of the stop which increase progressively with reduction of the temperature in the induction pipe.

The invention will be more particularly described and ascertained with reference to the accompanying drawing in which—

Figs. 1 and 2 respectively represent two examples of construction of the invention.

Fig. 3 shows a detail of Fig. 2 in various positions.

An injection pump 1 is driven by an internal combustion engine (which is not shown) and supplies to the combustion engine in known manner various quantities of fuel according to the position of its fuel delivery control member 2. A movement of the fuel delivery control member 2, which can also be briefly described as a governor rod, towards the right, results in a reduction of fuel supply, and vice versa.

One end of an expansion spring 4 is secured in a bore 3 of the governor rod 2, whilst its other end is attached to the inner end face of a sleeve 5. The sleeve 5 has a collar 6 which abuts against one end of a lever 7. The lever 7 is pivotally mounted on a pin 8 attached to the housing and is pivotally connected by means of an axially displaceable rod 9 with a second lever 10. The levers 10 and 7 can be operated by the operator and can be adjusted into the positions A, B, C, D shown in the drawing or into intermediate positions. The operating lever is secured against accidental displacement by a latch 11 of known type.

The position A shown in full lines in the drawing is the stop position, in which the lower end of the lever 7 holds the collar 6 and the governor rod 2 connected therewith in the right hand end position. Under these conditions the collar 6 is forced against the lever 7 by means of a spring 12 which acts upon stiffening plates 13 of a diaphragm 14 and tends to force the sleeve 5 towards the left. When the operating levers are moved into the idling position B, the full load position C or the starting position D, the lower end of the lever 7 moves towards the left. The governor rod follows this movement of the end of the lever, under the pressure of the spring 12 so long as such movement is not prevented by certain opposed forces, the influence of which is more fully described below.

A three-way cock designed as an oscillating cylindrical valve 16 is connected to the lever by means of a connecting rod 15. The oscillating cylindrical valve 16 is provided with a groove 17 which in the stop position, as shown in the drawing, allows communication between two ducts 18 and 19. The duct 18 leads into a sealed chamber 20, one wall of which is formed by the movable diaphragm 14. The other duct 19 leads into a duct 21 which opens into the induction pipe 22 of the internal combustion engine. The induction pipe 22 is provided with combustion air by means of a supercharger 25 which draws in air through a filter 24. From the compression side of the supercharger the air flows past two throttle valves 26, 27 and past the opening of the duct 21 in the direction of the arrow 23 to the cylinders of the engine.

By the movement of the operating lever 10 into the stop position A, the injection pump is adjusted to the no supply position, so that the internal combustion engine is stopped. In this

stop position the throttle valve 27 has no connection with the operating lever, but is drawn back against the stop 31 by means of a spring 28 which is attached to a lever 29 which is mounted on the pivot of the throttle valve, and which is more strongly initially tensioned than a spring 30 which is attached to the throttle valve and which exerts a force in the opposite direction.

In the idling position B of the operating lever 10, the lower end of the lever 7 has a position which allows a movement of the collar 6 and the governor rod 2 from the stop position towards the left, under the action of a spring 12. Moreover a projection 32 at the upper end of the lever 7 comes into contact with the lever 29 without displacing it from the position shown in the drawing. Therefore when the engine is idling, the throttle valve 27 which is connected to the lever 29, remains in the position shown in the drawing, in which position the air supply to the engine is reduced. The reduction of air supply is such that at the low idling speed of the engine, the supercharger 25 does not produce any pressure above atmospheric pressure within the part of the induction pipe 22 lying between the throttle valve 27 and the cylinders of the engine. On the contrary, under idling conditions a subatmospheric pressure is produced in this part of the induction pipe.

When the operating lever 10 is at the idling position B, the rod 15 and the oscillating cylindrical valve 16 have also a somewhat different position. The right hand end 17*a* of the slot 17 is moved slightly downwards without however sealing the duct 19, whilst the left hand end 17*b* now stands further towards the left. In this new position, the ducts 18 and 19 remain in communication with one another, so that the suction in the induction pipe 22 is able to draw the diaphragm 14 within the chamber 20 towards the right, against the force of the initially tensioned spring 12, when, with the lever 10 in the idling position B, the engine speed increases and consequently the suction in the induction pipe increases. In this manner the idling speed is governed. On the over-run that is, when the vehicle on which the engine is mounted goes downhill, for example, and causes the engine to rotate at a speed higher than maximum admissible speed, and with the governor rod in its idling position, the suction in the induction pipe 22 becomes so great that the governor rod 2 is drawn into a position in which no fuel whatever is supplied by the injection pump to the injection nozzles.

When the operating levers 7 and 10 are moved into the full load position C, the valve 16 is rotated by the lever 15, with the result that the duct 19 is closed and that the duct 18 communicates through the slot 17 with a duct 34 leading to atmosphere. In this case, the same air pressure prevails on both sides of the diaphragm 14. Moreover in the full load position the throttle valve 27 is brought into a horizontal position by the projection 32 of the lever 7, in which position it rests against the projection 33 in the induction pipe 22. When the throttle valve 27 is open, and with the engine working at full load, the supercharger 25 produces a pressure above atmospheric pressure in the induction pipe 22. This pressure is now unable to penetrate into the chamber 20 and influence the diaphragm 14, as under idling conditions; however it influences the fuel delivery control member of the injection pump, but in a different manner, which is to be explained below.

The duct 21 opening into the induction pipe 22 is in communication with a chamber 35, in which is disposed a diaphragm box 36 which responds to changes of pressure. The right hand end of the diaphragm box 36 is attached to an end face of the chamber 35, whilst the other movable end is connected by a rod 37 to a lever 38. The lever 38 is mounted on a pivot 39, and its lower arm carries a pin 40 which forms the fulcrum of a cranked lever 41. One arm of the cranked lever is connected by means of a connecting rod 42 with the operating member of a servomotor 43, which is shown only diagrammatically in the drawing, and which is connected with a stop 47 by means of a crank arm or lever 44, spindle 45, which is mounted in the governor housing, and a lever 46. According to the position of the stop 47, the collar or complementary stop 6, or the governor rod 2 can be moved varying distances towards the left by the force of the spring 12.

That arm of the cranked lever 41 which is shown in a horizontal position in Fig. 1 is guided by a pin 48 in a slot 49. Increase of loading pressure in the induction pipe 22 and in the chamber 35 results in a contraction of the diaphragm box 36, and consequently causes the lever 38 to be rotated in a clockwise direction. As a result of the guidance of the pin 48 in the slot 49, the cranked lever 41 is displaced in a direction towards the left and carries with it the connecting rod 42. It should be understood that when the connecting rod 42 is displaced towards the left, the servomotor 43 causes the stop 47 to be displaced also towards the left, whilst if the connecting rod 42 is displaced in the opposite direction as a result of a decrease of pressure in the induction pipe 22, the stop 47 is moved towards the right. The further the stop 47 is displaced towards the left as the loading pressure rises and with the engine adjusted for full load, the further can the spring 12 displace the collar 6 of the governor rod 2 towards the left, with consequent increase of fuel supply and vice versa.

A cranked lever 50, which is rotatable about a pivot 51, is provided with a slot 49. The cranked lever 50 is connected by means of a connecting rod 52 to another cranked lever 53, which lever is rotatable about a pivot 54 and is connected to a connecting rod 55, which in turn is connected with a two-armed lever 57, which is rotatable about a fulcrum 56. The two-armed lever 57 is actuated by a thermostat 58, which responds to the temperature of the air in the induction pipe 22. When the temperature rises, the thermostat 58 displaces the two-armed lever 57 and the cranked lever 53 in an anti-clockwise direction, whilst the cranked lever 50 is displaced in a clockwise direction. Consequently the slot 49 is directed upwards at an angle which increases with increase of temperature in the induction pipe 22. The position of the slot 49 which is shown in full lines in the drawing, corresponds to the lowest temperature provided for, e. g. —30° C.

With the lever 38 in the position shown in the drawing and provided that the loading pressure remains constant, if the temperature increases for example from the minimum temperature —30° C. to +40° C., then the slot 49 moves into the diagonal position 49*a* shown in dotted lines in the drawing. As a result the cranked lever 41 is rotated by the pin 48 so that the connecting pin 59 which connects the cranked

lever 41 to the connecting rod 42 is displaced from the position *a* by the amount *b* towards the right into the position *c*. The stop 47 also is carried towards the right and the fuel supply is reduced by an amount corresponding to the reduction of the weight of inducted air resulting from the temperature increase, whilst the loading pressure remains constant.

At the minimum temperature −30°, if the lever 38 is displaced into the position 38*a*, which is shown in dotted lines and which represents a greater loading pressure, then the pin 48 is displaced in a direction towards the left within the horizontally disposed slot 49, and the point of connection 59 moves from the position *a*, by the amount *d*, towards the left, into the position *e*. In this case the stop 47 is displaced in a direction towards the left sufficiently to allow an increase of the fuel supply corresponding to the increase in loading pressure, while the temperature remains constant.

If at the high loading pressure required by the position 38*a* the temperature rises to +40° in the induction pipe 22, then, with the slot 49 in the position 49*a*, shown in dotted lines, the pin 48 comes into a position which is located by the amount *f* above that position which it has at the same loading pressure and at the minimum temperature −30°, whilst at an equally high temperature +40° and with the lever 38 in the position shown in full lines in the drawing and representing a lower loading pressure, the pin 48 has a position which stands above its position at the lowest temperature only by the amount *g*.

Just as the distance *f* is greater than *g* so are the corresponding distances marked *f'* and *g'* of different dimensions, distances by which the point of connection 59 is displaced at the said high temperature +40° and at the different loading pressures. In this case *f'* is to *g'* as the weight of air at high loading pressure and at the high temperature of +40° is to the smaller weight of air at a lower loading pressure and at the same time high temperature of +40°. The adjustment paths of the stop 47 vary on the same principle, so that the fuel supply also varies with variations of loading pressure, in the same proportion as the respective charge weights.

At an intermediate loading pressure, an increase of temperature from −30° to +40° resulted in one case in an adjustment of the connecting point 59, which is connected with the stop 47, by a distance *g'*, whilst in the other case, at a high loading pressure, the same increase of temperature from −30° to +40° produced a displacement of the connecting point 59 by the larger amount *f'*. In the same way, according to the construction as set forth, still smaller loading pressures result in displacements which are even less than the distance *g* and in fact the amount of adjustment decreases proportionately to the amount of decrease of loading pressure, and of the weight of air which is proportional thereto, at constant temperature. The amount of adjustment is reduced to zero when the air weight is zero, in which case the pin 48 and the fulcrum 51 coincide, while the stop 47 adjusts the injection pump to the stop or no supply position. This position scarcely ever arises when the operating lever is adjusted to the full load position. It is merely important for the arrangement of the pin 51 which lies in the position which would be occupied by the pin 48 if the loading pressure fell to zero.

If in the manner set forth, the stop 47 is adjusted so that, in spite of alternation of pressure and of the temperature of the loading air, the amount of fuel injected is always proportional to the weight of loading air, then a good smokeless combustion could be attained in conjunction with high efficiency of the engine, if it were not for the fact that in the engines of vehicles, and particularly of aircraft, another important factor must be taken into account, which also influences the weight of loading air passing into the cylinders of the engine and which consequently must not be ignored when arranging the fuel supply, if the greatest possible efficiency of the engine is to be attained in conjunction with smokeless combustion. This factor which must be taken into account is the so called exhaust resistance. It has been discovered that when the loading pressure of an internal combustion engine remains constant while exhaust resistance decreases, as for example at high altitudes, the engine requires a rather larger fuel supply because the cylinders are discharging their exhaust into a thinner atmosphere, and consequently a better emptying and refilling of the cylinders with fresh air is possible. This influence is compensated by means of the device described below.

In Fig. 1, the pin 51 which forms the fulcrum of the cranked lever 50 is not locally fixed, but is secured to an eccentric 60, which can be angularly displaced by a diaphragm box 62 acting through a rod 61. The diaphragm box 62 responds to varying atmospheric pressure occurring, for example, at various altitudes in the case of aircraft, and which is equal to the exhaust resistance. A reduction of exhaust resistance causes the pin 51 to be turned in a downward direction. In this case (provided that the loading pressure and the temperature of the loading air do not produce any displacement of the lever 38 and of the cranked lever 53) the pin 40 and the connecting pin 63, which connects the cranked lever 53 to the connecting piece 52, remain at rest. Since the cranked lever 41 can turn about the pin 40, whilst the connecting piece 52 can turn about the pin 63, the cranked lever 50 is displaced substantially vertically in a downward direction on the downward displacement of the pin 51. The cranked lever 41 is angularly displaced in an anti-clockwise direction whilst the connecting pin 59 moves towards the left and, in accordance with the reduced exhaust resistance, adjusts the stop 47 in a direction corresponding to an increase of fuel supply. When the slot 49 is disposed diagonally as a result of a temperature of loading air which is higher than −30° C., the cranked lever 50 is displaced in a direction practically parallel thereto.

When the operating levers 7 and 10 are adjusted to the full load position C, the collar 6, under pressure of the spring 12, is enabled to move further towards the left towards the lower end of the lever 7 as the stop 47 moves further towards the left, dependently upon a higher loading pressure, a low temperature of the air load, and a low exhaust resistance.

The throttle valve 26, which is housed in the induction pipe 22, is designed to aid the throttle valve 27 in governing the loading pressure. If the amount of air supplied by the supercharger 25 is reduced with increasing altitude, so that the necessary loading pressure is no longer obtained, a diaphragm box 65 which responds to the loading pressure opens the throttle valve 27 by means of a two-armed lever 71 in order to in-

crease, in known manner, the amount of air derived from the supercharger.

The lower arm of the two-armed lever 71 is located in the proximity of a hook 68 attached to the rod 9. When the operating levers 7 and 10 are brought into the starting position D, the upper arm of lever 71 is carried towards the left by the hook 68 and the throttle valve is opened against the pressure of the closing spring 69, in order to facilitate as far as possible the supply of air to the cylinders in starting. In this case the upper arm of the two-armed lever 71 is raised from the diaphragm box 65. The other throttle valve 27 which was already fully opened in the full load position C, allows the rod 9 to move into the starting position, because it is not fixedly connected to the operating lever 29 but is connected thereto by means of a spring 70. In the starting position, the valve 16 with the groove 17 has a position somewhat different from that which it occupies at full load, but the effect of which is similar.

When starting the internal combustion engine it is desirable for the injection pump to be adjustable so as to give a particularly large fuel supply. This is effected in spite of the stop 47 and the lower end of the lever 7, both of which lie in the path of the collar or complementary stop 6 of the governor rod 2, in that, when the collar 6 abuts against the lever 7 or against the stop 47, the governor rod 2 can be adjusted so as to give an excess of fuel, against action of the springs 76 and 4, by means of a knob 72 connected by a cable 73 to the parts 74, 75.

In Fig. 2 an injection pump 80 driven by an internal combustion engine which is not shown has a governor rod 81, which is connected by means of an expansion spring 82 to a sleeve 83. The spring 82 is more strongly initially tensioned than a spring 84 which is attached to the opposite end of the governor rod 81, and its length generally remains unaltered when the spring 84 forces a collar 90 arranged on the sleeve 83 to follow a movable stop 85, which is adjusted in a manner explained hereinafter.

A movement of the governor rod 81 in a direction towards the right results in reduction of the amount of fuel delivered by the injection pump, whilst displacement of the governor rod in the opposite direction causes an increase of the fuel supply. The spring 82 merely serves to allow the governor rod 81 to be drawn towards the left by means of a knob 86 acting through a cable 87, a lever 88 and a hook 89, in the event of it being necessary to adjust the injection pump to give a particularly large fuel supply for the purpose of starting the engine independently of the position of the stop 85.

91 is the induction pipe through which combustion air passes from the supercharger 92, past two throttle valves 93 and 94, to the engine. Within the induction pipe 91 is a Venturi valve 102, into the narrowest part of which opens a duct 95 which leads to a governor chamber 96. The governor chamber is sealed on the right hand side by means of a displaceable piston 97, which is connected by means of a rod 98 to a two-armed lever 100 which is pivoted at 99. On the right hand side of the piston 97 is a second governor chamber 101 in which atmospheric pressure prevails, or in the case of engines having a waste gas turbine, the pressure existing at the inlet side of the waste gas turbine. Within the chamber 96 is a spring 103, whilst the chamber 101 houses a spring 104. The lower arm of the lever 100 is provided with a pin 105 on which is pivoted a cranked lever 106. The lower arm of the cranked lever 106 is provided with a stop 85, whilst its other arm slides within a slot 108 formed in a lever 110 which is pivoted at 109. To the lever 110 is attached one end of a connecting rod 111, the other end of which is attached to a two-armed lever 112, which in turn is connected to a thermostat 113 which responds to the temperature of the air in the induction pipe 91.

To a spindle 114 of the throttle valve 93 is fixed a lever 115 which, in the position shown in the drawing, abuts under the pressure of a spring 116 against a rod 118 leading to a diaphragm box 117. So long as, for example, in the case of aircraft flying at a moderate altitude, sufficient air is supplied by the supercharger 92 to produce the desired loading pressure behind the throttle valve 93 in the direction of the air stream, the pressure in a chamber 119 housing the diaphragm box 117 remains sufficiently high to prevent the throttle valve 93 from changing its position. At a predetermined altitude, where the supercharger can no longer produce the desired pressure behind the throttle valve 93, on account of the thinner atmosphere, the diaphragm box 117 expands and opens the throttle 93.

The upper end of the arm 115 lies in the path of a stop 121 attached to a connecting rod 120. The connecting rod 120 is pivotally connected to an operating lever 122 which can be adjusted to the positions A, B, C, D and to intermediate positions. In the position D which is the starting position for the vehicle, the lever 115 is moved towards the left by the stop 121 until the throttle valve 93 is operated independently of the diaphragm box 117.

A second projection 123 on the connecting rod 120 is subjected to the force of a spring 124 and abuts against a lever 126 which is pivotally mounted on a spindle 127 of the other throttle valve 94, and which when displaced towards the left turns the throttle valve 94 by means of a projection 128 out of the closed position shown in the drawing. When the operating lever 122 stands in the stop position A, represented in full lines in the drawing, the governor rod is adjusted by a cable 129, which is attached to the collar 90 and to the operating lever 122 into the stop or no supply position. When the operating lever 122 is adjusted to the idling position B, the spring 84 is able to draw the collar 90 and the governor rod 81 towards the left by an amount dependent upon the adjustment of the stop 85. The manner in which the stop 85 is adjusted will now be explained.

The movement of the operating lever 122 from position A into position B (the idling position) is sufficient to allow the stop 128 to come into contact with the throttle valve 94 without displacing it, so that the throttle valve 94 remains in the closed position as shown in the drawing. When the engine is idling, a vacuum or negative pressure is formed in the induction pipe between the throttle valve 94 and the engine, which vacuum, when a predetermined maximum idling speed is attained, is sufficient to draw the piston 97 towards the left against the force of the spring 103. As a result, the lever 100 is turned in an anti-clockwise direction, whilst the pin 107 is displaced in the slot 108 and the stop 85 is adjusted in the stop direction, so that the spring 84 can allow only a small idling fuel supply.

When the operating lever 122 is adjusted to

the full load position C, the projection 123 draws the lever 126 towards the left by means of the spring 124, while the projection 128 opens the throttle valve 94. The engine and the supercharger are now running more quickly. Consequently a super-atmospheric pressure arises in the induction pipe and is transmitted to the chamber 96, where it forces the piston 97 towards the right, so that the piston is withdrawn from the spring 103 which operates under idling conditions. The adjustment towards the right is directly proportionate to the loading pressure and is inversely proportionate to the opposed exhaust resistance prevailing in the other chamber 101. The difference between the loading pressure and the exhaust resistance, which determines the loading of the cylinder with combustion air, adjusts in this case the piston 97 and consequently also the pin 107 in the slot 108, and also the stop 85. The adjustment is dependent upon the volume of air supplied to the cylinders. If the difference of pressure is great and a large volume of air is supplied to the cylinders, the pin 107 is displaced further towards the left in the slot 108, and consequently the stop 85 is adjusted so as to give a greater fuel supply than is the case for small volumes of air.

This adjustment of the stop 85 dependent upon the volume of combustion air is co-ordinated with its adjustment dependently upon the temperature of the combustion air, in such a manner that the combined adjustment of the stop 85 and the variation of the fuel supply is always proportional to the variation of weight of air supplied to the cylinders. This is achieved in the following manner:

At the lowest temperature allowed for, for example −30°, the slot 108 has the position shown in the drawing, and when the temperature of the loading air rises, the slot is raised by the thermostat 113, acting through the rods 112 and 111. At +40° the slot 108 might lie in the position 108*a* shown in dotted lines in the drawing. When a high degree of vacuum arises in the induction pipe 91, on the maximum engine speed being attained, for example, on the over-run at high altitudes, the pin 107 is displaced towards the right within the slot 108 until its axis is concentric with the axis of the pin 109. In this case the stop 85 is drawn towards the right, against the force of the spring 84, until the injection pump is set at the no supply position. The position of the stop 85 is the same in this case whether the temperature is high or low, because when the axes of the two pins are concentric the diagonal position of the slot 108 has no effect on the stop 85.

When the engine is idling on the other hand and a low degree of vacuum prevails within the chamber 96, in contrast to the high degree of vacuum prevailing at the maximum engine speed when the pin 105 has reached a position 105*a*, the pin 107 stands, at −30° C., in the position 107*a*, and at +40° in the position 107*b*, whilst under the same conditions, the stop 85 occupies the positions 85*a* and 85*b*. It will be seen then that within the idling range of the engine, when the air supply is reduced as a result of a fall of pressure in the induction pipe, the stop 85 occupies slightly different positions at different temperatures.

When the operating lever 122 is adjusted to the full load position and the throttle valve 94 is at the fully open position, whilst the maximum loading pressure prevails in the induction pipe 91, the pin 105 occupies the position 105*b*, and with it the cranked lever 106 is moved towards the left, until the pin almost reaches the left hand end of the slot 108. At the minimum temperature −30°, the pin 107 has the position 107*c*, whilst at +40° it reaches the position 107*d*. At −30° the stop 85 stands in the position 85*c* whilst at +40° it occupies the position 85*d*, the position 85*c* being very different from the position 85*d*. At full load, when the air supply, being at high pressure, is comparatively great, with the result that variations of temperature in the large amount of air being supplied to the engine have considerable influence upon the weight of air entering the cylinders, the temperature change from −30° to +40° has a correspondingly great effect on the adjustment of the stop 85 and on the alteration of the amount of fuel injected which, within the full load range must always be proportional to the air supply. At partial load and within the idling range on the other hand, the temperature influence is comparatively slight.

Provided that, as in the present case, under all variations of the air supply arising in the induction pipe 91 dependently upon loading pressure, exhaust resistance and temperature (which factors govern the weight of air supplied to the cylinders), it is possible to keep the fuel supply always proportional to the air supply, then at the full load position it is possible to maintain the highest efficiency of the engine in combination with a good smokeless combustion, at all engine speeds.

It is also possible of course by a curved design of the slide 108 to vary the relation between the fuel supply and air supply, for example, at partial load, and within the idling range, so that at a reduced load, the engine can operate with a larger quantity of superfluous air.

The pressure conditions in the two chambers 96 and 101 can be varied, for example, by altering the diameter of the rod 98 or by supplying a diaphragm box which responds to pressure variations and which varies the adjustment of the piston 97 dependently upon changes of exhaust resistance. Moreover the piston 97 might be replaced by a diaphragm.

We declare that what we claim is:

1. In a fuel injection apparatus for a supercharged internal combustion engine the combination comprising an injection pump; a fuel delivery control member associated with said pump; resilient means urging said control member in a direction to increase the amount of fuel injected; a stop for limiting movement of said member in the direction corresponding to an increase of the amount of injected fuel; and governing means, including a plurality of members respectively movable in response to changes of atmospheric pressure and of pressure and temperature of the charging air, and variable coupling means connecting said members to said stop to displace the stop in said direction in accordance with a decrease of atmospheric pressure, and in accordance with an increase of the pressure of the charging air and decrease of the temperature of said charging air whereby equal changes of pressure of said charging air cause displacements of the stop which increase with decrease of the temperature of said charging air.

2. In a fuel injection apparatus for a supercharged internal combustion engine the combination comprising an injection pump; a fuel delivery control member associated with said

pump; a stop for limiting movement of said member in the direction corresponding to an increase of the amount of injected fuel; a complementary stop carried by said control member, resilient means urging said control member in a direction to increase the amount of fuel injected and urging said complementary stop into contact with said first-mentioned stop; and governing means, including a plurality of members respectively movable in response to changes of atmospheric pressure and of pressure and temperature of the charging air, and variable coupling means connecting said members to said first-mentioned stop to displace said first-mentioned stop in said direction in accordance with a decrease of atmospheric pressure and in accordance with an increase of the pressure of the charging air and decrease of the temperature of said charging air whereby equal changes of pressure of said charging air cause displacements of said first-mentioned stop which increase with decrease of the temperature of said charging air.

3. In a fuel injection apparatus for a supercharged internal combustion engine the combination comprising an injection pump; a fuel delivery control member associated with said pump; a stop for limiting movement of said member in the direction corresponding to an increase of the amount of injected fuel; a complementary stop carried by said control member, resilient means urging said control member in a direction to increase the amount of fuel injected and urging said complementary stop into contact with said first-mentioned stop; means for moving the said member in a direction away from the first-mentioned stop against the pressure of the resilient means, for the purpose of reducing the amount of fuel injected; and governing means, including a plurality of members respectively movable in response to changes of atmospheric pressure and of pressure and temperature of the charging air, and variable coupling means connecting said members to said first-mentioned stop to displace said first-mentioned stop in said direction in accordance with a decrease of atmospheric pressure and in accordance with an increase of the pressure of the charging air and decrease of the temperature of said charging air whereby equal changes of pressure of said charging air cause displacements of said first-mentioned stop which increase with decrease of the temperature of said charging air.

4. In a fuel injection apparatus for a supercharged internal combustion engine the combination comprising an injection pump; a fuel delivery control member associated with said pump; a stop for limiting movement of said member in the direction corresponding to an increase of the amount of injected fuel; a complementary stop carried by said control member, resilient means urging said control member in a direction to increase the amount of fuel injected and urging said complementary stop into contact with said first-mentioned stop; an operating lever for moving the said member in a direction away from the first-mentioned stop against the pressure of the spring means, for the purpose of reducing the amount of fuel injected; and governing means, including a plurality of members respectively movable in response to changes of atmospheric pressure and of pressure and temperature of the charging air, and variable coupling means connecting said members to said first-mentioned stop to displace said first-mentioned stop in said direction in accordance with a decrease of atmospheric pressure and in accordance with an increase of the pressure of the charging air and decrease of the temperature of said charging air whereby equal changes of pressure of said charging air cause displacements of said first-mentioned stop which increase with decrease of the temperature of said charging air.

5. In an internal combustion engine the combination comprising an induction pipe; a supercharger feeding into said pipe; an injection pump; a fuel delivery control member associated with said pump; a stop for limiting movement of said member in the direction of increased injection; governing means, including a plurality of members respectively movable in response to changes of atmospheric pressure and of pressure and temperature obtaining in the induction pipe, and variable coupling means connecting said members to said stop to displace the stop in the direction of increased injection in accordance with a decrease of atmospheric pressure and in accordance with an increase of the pressure obtaining in the induction pipe and decrease of the temperature therein whereby equal changes of pressure in the said induction pipe cause displacements of the stop which increase progressively with reduction of the temperature in the induction pipe; a resilient means for urging said control member in the direction of increased injection; a complementary stop resiliently connected with said fuel delivery control member; an operating lever engaging with said complementary stop independently of the first-mentioned stop for displacing said control member against the pressure of said resilient means; a pneumatic governor including a chamber adapted to communicate with said induction pipe and a movable member which displaces said fuel delivery control member in the direction of decreased injection due to a reduction of the pressure obtaining within said chamber; a valve actuated by the aforesaid operating lever which, when said lever is in the idling position, puts said chamber in communication with the induction pipe, said communication being interrupted when the lever is in a position corresponding to a higher load, whereby, in the higher load range, variations of pressure in the induction pipe cannot affect the fuel delivery control member directly through said pneumatic governor, but only by way of said first-mentioned stop and associated governing means aforesaid; an auxiliary throttle valve, housed in said induction pipe, and adapted when the said lever is in the idling position to reduce the supply of air to said engine in such a manner that the pressure in the induction pipe is then maintained at or below atmospheric pressure; and means associated with the operating lever for opening said auxiliary throttle valve when the operating lever is moved to the position it occupies when starting the engine.

6. An apparatus according to claim 4 in which said operating lever, independently of the first mentioned stop, abuts against the complementary stop, which is resiliently connected with the fuel delivery control member so that said member can be adjusted to give an excess of fuel independently of the position of the first-mentioned stop or the complementary stop.

7. An apparatus according to claim 4 including a throttle valve housed in said induction pipe and operable by said operating lever, which valve is adapted when said lever is in the idling posi-

tion, to reduce the air supplied to the engine in such a manner that the production of a pressure exceeding atmospheric pressure by means of the supercharger in that part of the induction pipe lying between said valve and the engine cylinders is prevented.

8. In an internal combustion engine the combination comprising an induction pipe; a supercharger feeding into said pipe; an injection pump; a fuel delivery control member associated with said pump; a stop for limiting movement of said member in the direction of increased injection; governing means, including a plurality of members respectively movable in response to changes of atmospheric pressure and of pressure and temperature obtaining in the induction pipe, and variable coupling means connecting said members to said stop to displace the stop in the direction of increased injection in accordance with a decrease of atmospheric pressure and in accordance with an increase of the pressure obtaining in the induction pipe and decrease of the temperature therein whereby equal changes of pressure in the said induction pipe cause displacements of the stop which increase progressively with reduction of the temperature in the induction pipe; a resilient means for urging said control member in the direction of increased injection; an operating lever adapted for displacing said control member against the pressure of said resilient means; a pneumatic governor including a chamber adapted to communicate with said induction pipe and a movable member which displaces said fuel delivery control member in the direction of decreased injection due to a reduction of the pressure obtaining within said chamber; and a valve actuated by the aforesaid operating lever which, when said lever is in the idling position, puts said chamber in communication with the induction pipe, said communication being interrupted when the lever is in a position corresponding to a higher load, whereby, in the higher load range, variations of pressure in the induction pipe cannot affect the fuel delivery control member directly through said pneumatic governor, but only by way of the stop and associated governing means aforesaid.

9. In a fuel injection apparatus for a supercharged internal combustion engine the combination comprising an injection pump; a fuel delivery control member associated with said pump; a stop for limiting movement of said member in the direction corresponding to an increase of the amount of injected fuel; and a governing means, including a plurality of members respectively movable in a response to changes of atmospheric pressure and of pressure and temperature of the charging air, and variable coupling means, including a lever, connecting said members to said stop to displace the stop in said direction of increased injection amount in accordance with a decrease of atmospheric pressure and an increase in the pressure of the charging air and a decrease in the temperature of said charging air, the member influenced by changes of pressure of the charging air being arranged to cause displacement of the stop by means of said lever whose effective leverage is so varied in response to movements of the member influenced by changes of temperature of said charging air that a given change of pressure of said charging air produces displacements of the stop which increase progressively throughout the pressure range with decrease of temperature of said charging air.

10. In a fuel injection apparatus for supercharged internal combustion engines of the self-ignition type in which the fuel is solidly injected and ignition is effected by the high compression of the air charge in the engine cylinders, the combination comprising a fuel injection pump; a fuel delivery control means associated with said pump; resilient means urging said control member in a direction to increase the amount of fuel injected; a stop for limiting the movement of said means in the direction corresponding to an increase of the amount of injected fuel; and governing means, including a plurality of members, one of which is movable in response to changes of the pressure of the atmosphere into which the engine cylinders exhaust, said member being connected to and acting on said stop in such a direction that with decreasing pressure of said atmosphere the stop is adjusted in positions corresponding to increasing delivery amount, a second of said members being movable in response to changes of pressure of the charging air and connected with said stop in such a manner that with increasing pressure of the charging air the stop is adjusted in positions corresponding to increasing delivery amounts, and a third of said members being movable in response to changes of the temperature of the charging air, disposed between the second member and the stop, and variable coupling means connecting said members and said stop whereby equal changes of pressure of said charging air cause displacements of the stop which increase with decrease of the temperature of said charging air, thus automatically adjusting the stop in positions corresponding to the maximum fuel amounts which at the different temperatures and pressures of the charging air and the different pressures of said atmosphere can be burned in the engine cylinders without producing smoke.

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