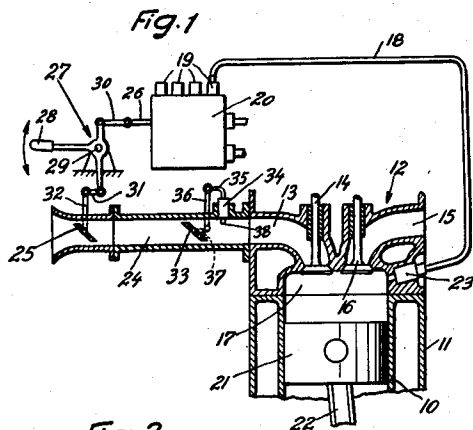
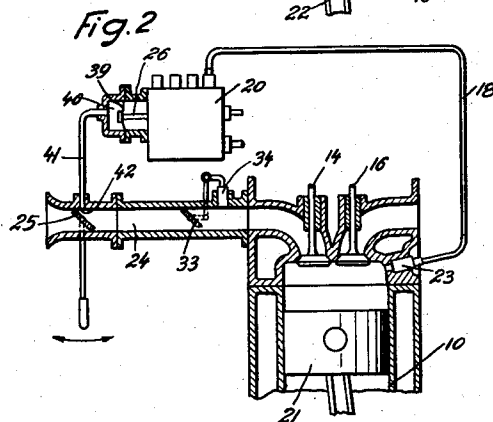
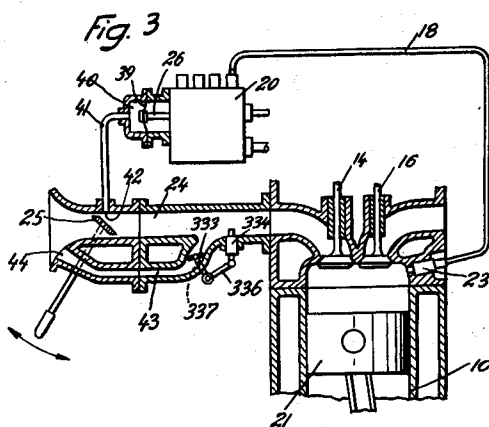
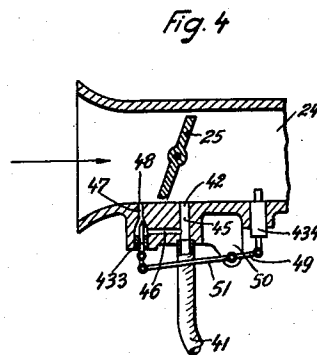
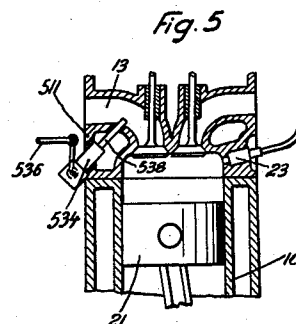


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INTERNAL COMBUSTION PISTON ENGINE

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INTERNAL COMBUSTION PISTON ENGINE

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Our invention relates to an internal combustion piston engine of the type in which the fuel is injected into the cylinder, preferably during the compression stroke of the piston for compression and subsequent ignition by a spark plug. More specifically, the present invention is concerned with the means for controlling the admission of air and fuel to the cylinder.

In engines of this type, the temperature has a considerable influence on the ratio measured by weight of the air charge to the quantity of fuel injected into and mixed with such air at the instant of ignition.

This influence is of a dual nature: On the one hand, the specific weight of the air charge and thus the number of oxygen molecules per space unit varies as the temperature changes so that cold air will result in a more meager mixture than warm air if the pressure of the air charge and the quantity of the fuel injected per ignition remain constant. On the other hand, the temperature of the walls contacted by the combustion air is of controlling influence, because it will influence the temperature of the air charge prior to the ignition and it may cause a smaller or larger proportion of the quantity of fuel injected to condense on the walls and to be thus absent in an ignitable form within the air charge at the instant of ignition.

In piston engine of the type to which the present invention relates, there are provided an adjustable control member coordinated to the fuel pump and adapted to variably determine the quantities of fuel intermittently injected into the cylinder and a main throttle valve in the air intake duct. Moreover, there are means responsive to the adjustment of the main throttle valve and adapted to adjust the pump control member. Consequently, when the adjustment of the main throttle is altered to thereby vary the pressure and consequent weight of the air charge, the quantity of fuel injected is varied accordingly so as to keep the ratio of mixture at an optimum value.

More particularly, the means responsive to the adjustment of the main throttle valve includes a linkage connecting the main throttle valve to the control member. Alternatively, the means responsive to the adjustment of the main throttle valve may comprise a vacuum-responsive diaphragm or piston connected to the adjustable pump control member and subjected to the vacuum prevailing in the intake duct, such vacuum depending on the position of the main throttle valve. In other words, the pump control member varying the quantity of fuel injected is either directly mechanically connected with the linkage of the main throttle valve, if desired through the intermediary of cams or the like. Or, alternatively, the pump control member is adjusted by means of a diaphragm subjected to the vacuum prevailing in the intake duct, such vacuum depending on the position of the main throttle valve which, as a rule, is formed by a butterfly valve.

It is the object of the present invention to provide improved means for controlling the air charge in relation to the quantity of fuel injected into the cylinder preparatory to any ignition, such control to be effected in de-

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pendence on the temperature so as to avoid any undesired influence of the temperature on the ratio of the air-fuel-mixture.

More specifically, it is an object of the present invention to provide an auxiliary air throttle valve controlled by temperature-responsive means so as to automatically adjust the desired ratio of the air-fuel-mixture when the temperature of the combustion air and/or of the walls contacted thereby changes.

Further objects of the invention are to provide an auxiliary air throttle valve for easy adjustment by the temperature-responsive means so that the latter must produce a slight force only for effecting the adjustment, as distinguished from an arrangement in which the temperature-responsive means are effective to adjust the fuel pump and, therefore, must produce a powerful adjusting force. Expressed in other words, it is the object of the present invention to effectuate a temperature control by means of a simple thermostat of the bi-metal type.

Further objects of the invention are to minimize the reaction of the auxiliary throttle valve on the vacuum tap connected with the pump-adjusting diaphragm chamber, and to minimize the dimensions of the auxiliary throttle valve.

Further objects of the present invention will appear from a detailed description following hereinafter of a number of embodiments of the present invention, and the features of novelty will be pointed out in the claims. It is to be understood, however, that such detailed description serves the purpose of illustrating the invention rather than that of limiting the same. In the drawings,

Fig. 1 shows a more or less diagrammatic axial section through a cylinder of an internal combustion piston engine provided with a fuel injection pump and a main throttle valve in the intake duct, means being provided to control the quantity of fuel injected at any time in direct dependence of the position of the main throttle valve,

Fig. 2 is a sectional view similar to that of Fig. 1 of an internal combustion piston engine differing from that shown in Fig. 1 in that the quantity of fuel injected at any time is controlled in indirect dependence of the position of the main throttle valve, both examples of the invention shown in Figs. 1 and 2 being characterized by the disposition of a thermostat-controlled auxiliary throttle valve in the intake duct,

Fig. 3 is a view similar to that of Figs. 1 and 2 of an internal combustion piston engine differing from that shown in Fig. 2 by the disposition of the thermostat-controlled auxiliary throttle valve in a bypass duct communicating with the main intake duct,

Fig. 4 is an axial section taken through the outer end of the intake duct provided with the main throttle valve and with an auxiliary throttle valve in form of a needle valve disposed in a bypass duct, and

Fig. 5 is a view similar to that of Figs. 1 and 2 of an internal combustion piston engine in which the thermostat controlling the auxiliary throttle valve is responsive to the temperature of both the combustion air and the cooling liquid.

The internal combustion piston engine comprises a cylinder block 10 including four cylinders provided with a cooling jacket 11 and with a cylinder head 12 which has intake ducts 13 controlled by intake valves 14 and outlet ducts 15 controlled by outlet valves 16. The cylinder head is provided with a lateral bore located adjacent to the compression space 17 and adapted to accommodate a fuel injection device 23 of any suitable type which is connected by a fuel pipe 18 to one of the four outlets 19 of a fuel pump 20, one outlet being provided for each cylinder of the engine. The pump 20 is geared to the customary cam shaft controlling the

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valves 14 and 16, the cam shaft being geared in its turn to the crankshaft actuated by the piston 21 through the intermediary of a connecting rod 22. The fuel pump feeds intermittently quantities of fuel to the injection device 23 of each cylinder and is so timed that the injection of the fuel takes place while the intake valve 14 is open and the piston 21 sucks air into the cylinder 10 through the intake duct 13.

The intake duct 13 communicates with an inlet duct 24 in which a main throttle valve in form of a butterfly valve 25 is inserted.

The pump 20 is provided with an adjustable control member in form of a control rod 26 which, for the purpose of varying the quantities of fuel, is shiftably mounted in the pump 20 in the direction of its axis.

The power produced by the engine may be controlled by a three-armed lever 27 having one arm provided with a handle 28 and adapted to be rocked about a stationary fulcrum 29. Another arm of lever 27 is connected by a link 30 to the control rod 26, and a third arm of the lever 27 is connected by a link 31 to an arm 32 fixed to the outer end of the shaft of the butterfly valve 25. If desired, lever 27 may be connected with a governor.

When the handle 28 is depressed to reduce the power output of the internal combustion piston engine, the throttle 25 is moved towards its closed position, whereby the weight of the air charge admitted into the cylinder 10 is reduced. By the same adjustment of the three-armed lever 27 control rod 26 is moved to the left, whereby the fuel quantities intermittently fed by pump 20 through pipe 18 to the injection device 23 are reduced accordingly to thereby keep the ratio of mixture of air and fuel constant irrespective of the power output.

Thus, it will appear that the linkage 31, 27, 30 connecting the main throttle valve 25 to the control member 26 constitutes, in effect, a means which is responsive to the adjustment of the main throttle valve 25 and is adapted to adjust the control member 26.

For the purposes of the present invention we have provided an auxiliary throttle valve which may take the form of a butterfly valve 33 mounted in the inlet duct 24, and we have furthermore provided temperature-responsive means in form of a thermostat 34 of the bi-metal type, the movable arm 35 of the latter being connected by a link 36 to an arm 37 fixed to the outer end of the shaft of the butterfly valve 33, the latter being so adjusted that it is adapted to unthrottle the flow of air through the inlet duct 24 and the intake 13 into the cylinder 10 when the temperature of the thermostat 34 increases. In the embodiment shown the thermostat member 34 is mounted in a bore provided in the wall of duct 24, and its temperature-sensitive element 38 projects into the duct 24 to be subjected to the flow of air therethrough.

Hence, the temperature-responsive means is mounted to respond to the temperature of the air sucked into the inlet duct 24.

The operation of the controlling system is as follows:

A predetermined position of the main throttle valve 25 and of the adjustable control member 26 is allotted to any position of lever 27. In this manner, such quantity of fuel will be injected into the cylinder 10 for any ignition as corresponds to the weight of the air charge determined by the position of the main throttle valve 25. Should the temperature of the air drop, the auxiliary throttle 33 will be so turned as to increase its throttling effect upon the flow of air through the inlet duct 24. As a result, the volume of the air charge supplied to the cylinder 10 will be somewhat reduced without affecting the quantity of fuel injected. Under normal conditions, the throttling effect produced by the auxiliary throttle valve 33 can be so selected that the weight of the air charge supplied to the cylinder 10 for any ignition will remain constant, thus ensuring an invariable ratio of mixture of fuel and air. Should the temperature of the air flowing through inlet duct 24 rise, the auxiliary

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throttle valve 33 will be so adjusted by the temperature-responsive means 34 as to unthrottle the flow of air.

The embodiment of the present invention illustrated in Fig. 2 is identical with that shown in Fig. 1 in many respects, and, therefore, the same reference numerals have been applied to the corresponding elements. This embodiment, however, differs from that shown in Fig. 1 by the absence of the lever 27, the control member 26 being connected to a movable wall member, such as a diaphragm 39, of a vacuum chamber 40 connected by a tapping pipe 41 with the inlet duct 24 at a point 42 where the vacuum prevailing in the duct 24 depends on the position of the main throttle valve 25. Therefore, the vacuum prevailing at the point 42 depending on the position of the throttle valve 25 will be transferred to the vacuum chamber 40. Depending on the degree of such vacuum, the diaphragm 39 will be bent thereby adjusting control member 26 accordingly. In this manner, the quantity of fuel injected will increase when the absolute amount of the pressure prevailing in the inlet duct 24 at the point 42 increases. Thus, the diaphragm 39 constitutes a means responsive to the adjustment of the main throttle valve 25 and adapted to adjust the control member 26.

A third embodiment of the present invention is illustrated in Fig. 3 which in many respects is identical with that shown in Fig. 2, as indicated by the use of the same reference numerals for the corresponding elements. Thus, the control member 26 is adjusted by a diaphragm 39 of a vacuum chamber 40 connected to a point 42 of inlet duct 24 by a pipe 41. However, this embodiment differs from that shown in Fig. 2 by the disposition of the auxiliary throttle valve. This auxiliary throttle valve 333 is contained in an auxiliary duct 43 which bypasses the main throttle valve 25 and preferably branches off the inlet duct 24 at a point 44 located outside the main throttle valve 25. Alternatively, however, duct 43 may open into the atmosphere at any desired point. The exterior end of the shaft of the throttle valve 333 has an arm 337 which is connected by a link 336 to the movable end of the thermostat 334, the arrangement being such that a contraction of the temperature-responsive element 334 caused by a drop of the temperature of the air passing through duct 24 will throttle duct 43 thereby reducing the total volume of air sucked into cylinder 10 through both of the ducts 24 and 43.

The embodiment illustrated in Fig. 4 is similar in many respects to that shown in Fig. 2 differing therefrom, however, by the absence of the butterfly valve 33 and by the provision of the following means: The pipe 41 leading to the diaphragm chamber 40 communicates with a radial bore 45 provided in the wall of the inlet duct 24 leading to point 42 which, as stated above, is located between the main throttle valve 25 and the intake 13 of the engine. Bore 45 has a branch 46 which bypasses the main throttle valve 25 leading to a bore 47 communicating with the atmosphere, for instance at a point 48 of duct 24 outside of main throttle valve 25. The bore 47 is provided with a valve seat cooperating with a needle valve 433 whereby the flow of air through the bores 47 and 46 may be throttled. A two-armed lever fulcrumed on a bracket 50 rigid with the wall of duct 24 has one arm 49 connected to the movable end of a bi-metal thermostat 434 which is mounted to respond to the temperature of the air flowing through duct 24, whereas the other longer arm 51 is connected by an intermediate link to the needle valve 433.

The operation is as follows: When the main throttle valve 25 is partly closed to reduce the power output of the engine, the vacuum transferred through pipe 41 to the diaphragm chamber 40 has an absolute pressure intermediate those pressures which prevail at the points 42 and 48. Therefore, the vacuum in pipe 41 is less powerful than that prevailing at the point 42. When the temperature of the air passing through duct 24 drops, the thermo-

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stat 434 will contract rocking lever 49, 51 anti-clockwise, whereby bore 47 will be unthrottled thereby further reducing the vacuum in pipe 41. As a result, the control member 26 is shifted to the right thereby increasing the quantity of fuel injected in proportion to the increase of the weight of the air charge, the latter increase being due to the drop of the temperature of the air. Hence, it appears that the bores 46 and 47 constitute an auxiliary duct which bypasses the main throttle valve 25 and contains the auxiliary throttle valve 433.

Fig. 5 shows an alternative disposition of the temperature-responsive element, the same being formed by a bi-metal thermostat 534 mounted in the cooling jacket 511 of the cylinder head, its temperature-responsive member 538 extending through a bore in the lower wall of the intake 13 so as to be responsive to both the temperature of the cooling medium circulating through the jacket 511 and to the temperature of the air flowing through inlet duct 24 and the intake 13. Otherwise, the embodiment shown in Fig. 5 may be similar to any one of those described with reference to Figs. 1, 2, 3 and 4, a suitable linkage 536 being provided to connect the movable element of thermostat 534 to the auxiliary throttle valve 33 or 333 or 433.

While we have described our invention with reference to a number of specific embodiments thereof, we wish it to be clearly understood that the same is capable of numerous modifications within the scope of the appended claims and is in no way restricted to the details shown. Thus, the injection device 23 need not be located at the point illustrated.

What we claim is:

1. In an internal combustion piston engine, the combination comprising a cylinder, a fuel injection device mounted to inject fuel into said cylinder, inlet and outlet valves mounted on said cylinder, an inlet duct controlled by said inlet valve, a fuel pump geared to the engine and connected with said injection device and adapted to intermittently feed quantities of fuel to said injection device, a main throttle valve in said inlet duct, an adjustable control member operatively connected to said pump and adapted to variably determine said quantities of fuel, means responsive to the adjustment of said main throttle valve for adjusting said control member, means in said engine responsive only to temperature changes within said engine that are proportional to the temperature of the air fed to the cylinder, an auxiliary throttle valve controlled by said temperature-responsive means to vary the air charge admitted to the cylinder through said duct in relation to said quantity of fuel when said temperature changes.

2. The combination claimed in claim 1 in which said means responsive to the adjustment of said main throttle valve includes a linkage connecting said main throttle valve to said control member.

3. The combination claimed in claim 1 in which said means responsive to the adjustment of said main throttle valve comprises a chamber having a movable wall member connected to said adjustable control member and a conduit connecting said chamber to said inlet duct at a point where the vacuum prevailing in said duct depends on the position of said main throttle valve.

4. In an internal combustion piston engine, the combination comprising a cylinder, a fuel injection device mounted to inject fuel into said cylinder, inlet and outlet valves mounted on said cylinder, an inlet duct controlled by said inlet valve, a fuel pump geared to the engine and connected with said injection device and adapted to intermittently feed quantities of fuel to said injection device, a main throttle valve in said inlet duct, an adjustable control member operatively connected to said pump and adapted to variably determine said quantities of fuel, means responsive to the adjustment of said main throttle valve for adjusting said control member, means in said engine responsive only to temperature changes

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within said engine, an auxiliary throttle valve controlled by said temperature-responsive means and adapted to vary the air charge admitted to the cylinder through said duct in relation to said quantity of fuel when said temperature changes, said temperature-responsive means being mounted in said engine to respond to the temperature of the air sucked into said inlet duct.

5. The combination claimed in claim 1 in which said means responsive to the adjustment of said main throttle valve comprises a chamber having a movable wall member connected to said adjustable control member and a conduit connecting said chamber to said inlet duct at a point where the vacuum prevailing in said duct depends on the position of said main throttle valve, said auxiliary throttle valve being disposed in said inlet duct between said point and said inlet valve.

6. The combination claimed in claim 1 in which said inlet duct communicates with an auxiliary duct bypassing said main throttle valve and containing said auxiliary throttle valve.

7. The combination claimed in claim 1 in which said means responsive to the adjustment of said main throttle valve comprises a chamber having a movable wall member connected to said adjustable control member and a conduit connecting said chamber to said inlet duct at a point where the vacuum prevailing in said duct depends on the position of said main throttle valve, and in which said inlet duct between said point and said inlet valve communicates with an auxiliary duct bypassing said main throttle valve and containing said auxiliary throttle valve.

8. The combination claimed in claim 1 in which said means responsive to the adjustment of said main throttle valve comprises a chamber having a movable wall member connected to said adjustable control member and a conduit connecting said chamber to said inlet duct at a point where the vacuum prevailing in said duct depends on the position of said main throttle valve, and in which said inlet duct between said point and said inlet valve communicates with an auxiliary duct which bypasses said main throttle valve and contains said auxiliary throttle valve and branches off said inlet duct at a point outside of said main throttle valve.

9. In an internal combustion piston engine, a cylinder, a fuel injection device for injecting fuel into said cylinder, inlet and outlet valves mounted on said cylinder, an air inlet duct controlled by said inlet valve, a fuel pump geared to the engine and connected with said injection device and adapted to intermittently feed quantities of fuel to said injection device, a main throttle valve in said inlet duct, an adjustable control member operatively connected with said pump to variably determine said quantities of fuel, vacuum-responsive means connected to said control member for the adjustment thereof, a conduit connecting said vacuum-responsive means to a point of said inlet duct, said conduit being provided with an inlet port, a control valve controlling said inlet port, and temperature-responsive means in said engine responsive only to temperature changes within said engine that are proportional to the temperature of the air fed to the cylinder and connected with said control valve to throttle said inlet port when the temperature increases.

10. In an internal combustion piston engine, a cylinder, a fuel injection device for injecting fuel into said cylinder, inlet and outlet valves mounted on said cylinder, an air inlet duct controlled by said inlet valve, a fuel pump geared to the engine and connected with said injection device to intermittently feed quantities of fuel to said injection device, a main throttle valve in said inlet duct, an adjustable control member operatively connected with said pump to variably determine said quantities of fuel, vacuum-responsive means connected to said control member for the adjustment thereof, a duct connecting said vacuum-responsive means to a point of said inlet duct located downstream of said main control valve, said duct being provided with an inlet port terminating

in said duct upstream of said main control valve, a further control valve controlling said inlet port, and temperature-responsive means in said engine connected with said further control valve to throttle said inlet port upon increases in temperature within said engine that are proportional to the temperature of the air fed to the cylinder.

11. In an internal combustion piston engine, the combination comprising a cylinder, a fuel injection device mounted to inject fuel into said cylinder, inlet and outlet valves mounted on said cylinder, an inlet duct controlled by said inlet valve, a fuel pump geared to the engine and connected with said injection device and adapted to intermittently feed quantities of fuel to said injection device, a main throttle valve in said inlet duct, an adjustable control member operatively connected to said pump and adapted to variably determine said quantities of fuel, means responsive to the adjustment of said main throttle valve for adjusting said control member, means in said engine responsive only to temperature changes within said engine, an auxiliary throttle valve controlled by said temperature-responsive means and adapted to vary the air charge admitted to the cylinder through said duct in relation to said quantity of fuel when said temperature changes, said temperature-responsive means being mounted in said engine to respond to the temperature of the wall of said inlet duct.

12. In an internal combustion piston engine having a cooling jacket through which a cooling medium circulates, the combination comprising a cylinder, a fuel injection device mounted to inject fuel into said cylinder, inlet and outlet valves mounted on said cylinder, an inlet duct controlled by said inlet valve, a fuel pump geared to the engine and connected with said injection device and adapted to intermittently feed quantities of fuel to said injection device, a main throttle valve in said inlet duct, an adjustable control member operatively connected to said pump and adapted to variably determine said quantities of fuel, means responsive to the adjustment of said main throttle valve for adjusting said control member, means in said engine responsive only to temperature changes within said engine, an auxiliary throttle valve controlled by said temperature-responsive means and adapted to vary the air charge admitted to the cylinder through said duct in relation to said quantity of fuel when said temperature changes, said temperature-responsive means being mounted to respond to the temperature of said cooling medium.

13. In an internal combustion piston engine, the combination comprising a cylinder, a fuel injection device mounted to inject fuel into said cylinder, inlet and out-

let valves mounted on said cylinder, an inlet duct controlled by said inlet valve, a fuel pump geared to the engine and connected with said injection device and adapted to intermittently feed quantities of fuel to said injection device, a main throttle valve in said inlet duct, an adjustable control member operatively connected to said pump and adapted to variably determine said quantities of fuel, means responsive to the adjustment of said main throttle valve for adjusting said control member, means in said engine responsive only to temperature changes within said engine, an auxiliary throttle valve controlled by said temperature-responsive means and adapted to vary the air charge admitted to the cylinder through said duct in relation to said quantity of fuel when said temperature changes, said temperature-responsive means being a thermostatic element responsive to temperature changes only and exposed to the air flowing in said inlet duct.

14. In an internal combustion piston engine having a cooling jacket through which a cooling medium circulates, the combination comprising a cylinder, a fuel injection device mounted to inject fuel into said cylinder, inlet and outlet valves mounted on said cylinder, an inlet duct controlled by said inlet valve, a fuel pump geared to the engine and connected with said injection device and adapted to intermittently feed quantities of fuel to said injection device, a main throttle valve in said inlet duct, an adjustable control member operatively connected to said pump and adapted to variably determine said quantities of fuel, means responsive to the adjustment of said main throttle valve for adjusting said control member, means in said engine responsive only to temperature changes within said engine, an auxiliary throttle valve controlled by said temperature-responsive means and adapted to vary the air charge admitted to the cylinder through said duct in relation to said quantity of fuel when said temperature changes, said temperature-responsive means being mounted to respond to the temperature of both said cooling medium and the air flowing through said inlet duct.

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