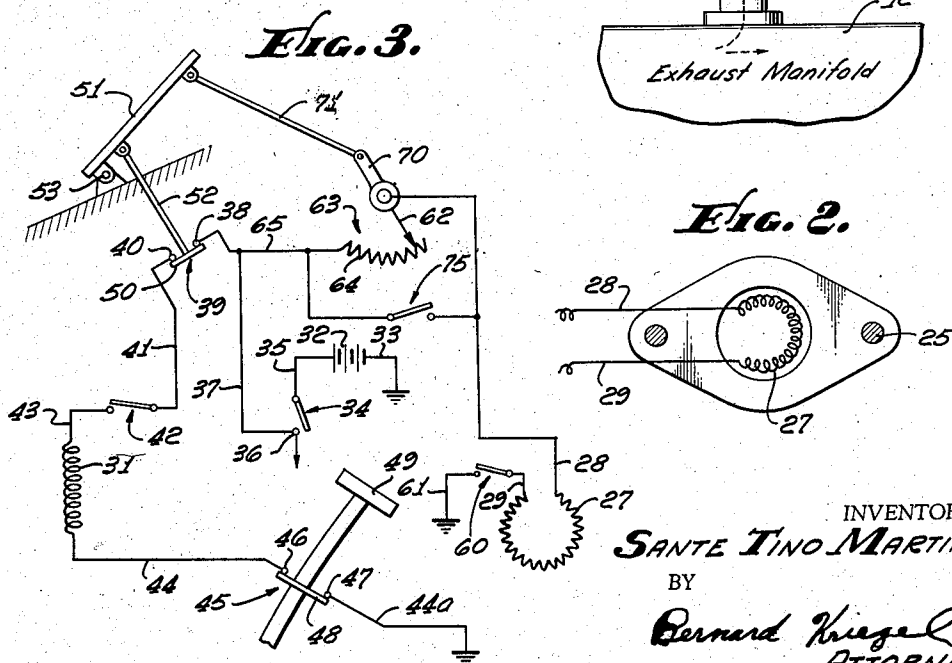


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APPARATUS FOR INCREASING EFFICIENCY OF
INTERNAL COMBUSTION ENGINES
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APPARATUS FOR INCREASING EFFICIENCY OF INTERNAL COMBUSTION ENGINES

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The present invention relates to internal combustion engines, and more particularly to apparatus for substantially reducing the amount of incompletely burned fuel discharged to the atmosphere.

Air pollution in many geographical regions is attributed largely to the unburned hydrocarbons from automobile and other internal combustion engines exhausted to the atmosphere. In the case of automotive engines, the amount of unburned hydrocarbons discharged to the atmosphere is increased considerably during conditions of coasting of the vehicles. The presence of unburned hydrocarbons in the exhaust gases is also attributable to the relatively low temperature of the fuel and air mixture entering the engine intake manifold. Not only does the unburned and partially burned fuels in the exhaust gases represent a menace to the health and comfort of the community by polluting the atmosphere, but it is also a manifestation of relative inefficiency in the operation of the internal combustion engine, representing a serious economic loss.

Accordingly, it is an object of the present invention to provide an improved apparatus for substantially minimizing the quantity of unburned hydrocarbons discharged into the atmosphere, particularly under conditions of coasting of automobiles and the like.

Another object of the invention is to provide improved apparatus for returning exhaust gases containing unburned hydrocarbons to an internal combustion engine under conditions insuring appropriate combustion of such unburned hydrocarbons, thereby increasing engine efficiency and diminishing the quantity of unburned fuel discharged into the atmosphere.

A further object of the invention is to provide an apparatus for returning exhaust gases containing incompletely burned hydrocarbons to the engine under the control of the accelerator mechanism, such as the accelerator pedal manipulated by the driver of the vehicle. More specifically, exhaust gases are also returnable to the engine under the control of the vehicle brake mechanism.

An additional object of the invention is to provide an improved apparatus for insuring appropriate preheating of the combustible fuel-air mixture prior to its introduction into the engine cylinders, the heat applied to the mixture being proportionate to the quantity of the mixture.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a somewhat diagrammatic view of a mechanical apparatus embodying the invention;

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Figure 2 is a section taken along the line 2—2 on Fig. 1;

Fig. 3 is a diagrammatic view illustrating an electric circuit forming part of the apparatus disclosed in Figs. 1 and 2 for controlling the latter.

As disclosed in Fig. 1, the fuel-air mixture from a carburetor 10 is drawn into an intake manifold 11 for distribution to the engine cylinders (not shown). The exhaust gases from the engine pass into the usual exhaust manifold or exhaust pipe 12 for discharge to the atmosphere. Such exhaust gases usually contain a substantial proportion of unburned or incompletely burned hydrocarbons, which the present invention seeks to return to the engine for appropriate combustion. To accomplish this objective, a return line 13 is connected to the exhaust manifold or exhaust pipe, this line opening into a valve housing 14 that has a valve seat 15 therein adapted to be engaged by a valve element or ball 16 under the influence of a helical compression spring 17 bearing against the ball and against an end 18 of the housing. When the spring 17 is permitted to engage the ball 16 with its companion seat 15, the exhaust gases cannot pass around the ball. The exhaust gases in the valve housing 14 on the inlet side thereof are adapted to mix with air entering the housing through a suitable inlet line 19, and such air and exhaust gas mixture is adapted to pass through the valve seat 15 and around the valve element 16 when the latter is removed from the valve seat, and through an outlet line 20 connected to the housing and which is attached to and opens into an intermediate pipe section 21 placed between the carburetor flange 22 and the manifold flange 23. This intermediate pipe section 21 is suitably clamped to the carburetor flange 22, as by means of bolts 24, and it is also clamped to the intake manifold flange 23 by means of bolts 25, there being an intervening gasket 26 made of insulating material between the flange 23 and pipe 21, to prevent leakage therebetween and also to electrically insulate a heating element 27 in the form of a resistance wire or coil having a pair of leads 28, 29 extending outwardly of the gasket 26.

The open and closed conditions of the control valve 15, 16 for the exhaust return line 13 and the auxiliary air entering through the inlet 19 is dependent upon a solenoid 30 of any suitable type, the solenoid coil 31 being carried by the housing 14 and the solenoid plunger 32a being adapted to be drawn in a direction toward the valve element 16 when current passes through the solenoid coil, in order to disengage the valve element 16 from its companion seat 15 against the resisting force of the spring 17. In the absence of current passing through the solenoid coil 31, the spring 17 will return the valve element 16 to a closed position in engagement with its companion valve seat 15.

The passage of current through the solenoid coil 31 is determined by the position of the throttle control mechanism of the engine. The battery 32 of the automobile engine has one side connected to ground through a suitable lead 33, the other side being connected to the ignition switch 34 through a suitable lead 35. A contact 36 of the ignition switch is connected through a suitable lead 37 to a contact 38 of an accelerator pedal operated switch 39, this switch including another contact 40 that is connected through a lead 41 to a manual switch 42 which is connected through a lead 43 to one end of the solenoid coil 31. The other end of the solenoid coil may be connected to a suitable lead 44 back to ground, to complete the circuit, or to ground through a brake pedal operated switch 45. When this latter switch is used, a lead 44 from the solenoid coil 31 is connected to a switch contact 46, the other contact 47 of the switch 45 being con-

nected through a lead 44a to ground. These contacts 46, 47 are adapted to be interconnected by a conductive bridge element 48 suitably secured to a brake pedal 49, or to any convenient portion of a brake mechanism, so as to bridge the contacts 46, 47 and close the brake pedal operated switch 45 when the vehicle brakes are not being applied.

The accelerator pedal operated switch 39 is closed by means of a conductive bridge piece 50 that may be connected to any part of the linkage between the accelerator pedal 51 and the engine throttle, or directly to the accelerator pedal itself, as desired. For purposes of simplicity in illustration, the switch piece 50 is disclosed in Fig. 3 as being secured to a rod 52 connected to the accelerator pedal 51, which is pivotally mounted upon a fulcrum 53 on the floor of the vehicle. When the accelerator pedal 51 is in the engine idling position, the bridge piece 50 is moved into engagement with the switch contacts 38, 40.

It is apparent that the solenoid coil 31 is connected to the source of electrical energy 32, namely, the battery, in series with the ignition switch 34, the accelerator pedal operated switch 39, the manual switch 42, which is placed in any location convenient to the operator of the vehicle, and the brake pedal operated switch 45. If the solenoid coil 31 is to be rendered ineffective under all conditions, in order to retain the valve 15, 16 in its closed position at all times, the manual switch 42 is opened. Normally this manual switch 42 will be closed, and when the engine is running, the ignition switch 34 is also closed. Accordingly, the solenoid coil 31 will be energized whenever the accelerator pedal 51 is in its uppermost or engine idling position, and when the brake pedal 49 is in its ineffective or uppermost position. Under such conditions, the vehicle is coasting, which causes the engine to force a large proportion of incompletely burned and unburned hydrocarbons into the exhaust system of the engine.

With the engine in the coasting condition, the solenoid coil 31 is energized, to cause the plunger 32a to shift to the left, as seen in Fig. 1, disengaging the ball 16 from the seat 15, whereupon a substantial portion of the exhaust gases will pass through the return line 13 into the valve housing 14, comingling with the auxiliary air which the intake manifold draws through the auxiliary air inlet 19, this exhaust gas and air mixture passing through the outlet line 20 into the intermediate pipe section 21 and then back into the intake manifold 11, for the purpose of effecting combustion of the incompletely burned hydrocarbons in the engine cylinder. When the accelerator pedal 51 is depressed, its companion switch 39 is opened, which interrupts the circuit to the solenoid coil 31, causing the spring 17 to shift the valve element 16 back against its seat 15, and thereby preventing any of the exhaust gases from returning to the engine cylinders. Similarly, if the brake pedal switch 45 is used, the application of the vehicle brakes will cause the brake pedal 45 to open the circuit through the solenoid coil 31, causing the exhaust return valve 15, 16 to close, preventing a large portion of the exhaust gases in the manifold or exhaust pipe 12 from passing back into the engine cylinders admixed with a suitable quantity of air passing into the valve housing 14 through the air inlet 19.

Whenever the accelerator pedal 51 is in its uppermost position, in which only a minimum of fuel is being fed to the engine cylinders, with the vehicle coasting or standing idle with the brakes not applied, a large percentage of the exhaust gases are returned to the engine. During the braking of the vehicle, or during the feeding of fuel from the carburetor to the intake manifold 11 above the engine idling quantity, the circuit to the solenoid coil 31 is interrupted, and the return or by-pass valve 15, 16 is maintained in its closed condition.

The foregoing arrangement is found highly effective in increasing fuel economy, as by providing more miles per gallon of gasoline or other fuel consumed, and also

in reducing substantially the quantity of pollutants discharged into the atmosphere through the exhaust pipe 12. Greater increases in efficiency are secured by preheating the exhaust gas and auxiliary air mixture prior to its passage into the intake manifold. To accomplish this purpose, the resistance or vaporizer coil 27 is mounted in the gasket 26, which is clamped between the intermediate pipe section 21 and the manifold flange 23. Current from a suitable source, such as the battery 32, passes through the resistance coil 27 to preheat the exhaust gas and auxiliary air mixture. More complete combustion of the unburned and partially burned hydrocarbons in the exhaust gases is secured under the preheating action. In fact, the preheater coil 27 is also effective to preheat the usual fuel-air mixture passing from the carburetor 10 to the intake manifold 11. It is quite evident that such mixture will flow from the carburetor 10, through the intermediate pipe section 21, and past the electric resistance wire 27, for passage to the intake manifold 11 and the engine cylinders.

The current passing through the vaporizer coil 27 is made to vary in dependence upon the quantity of fuel being fed to the engine under the control of the throttle mechanism operated by the accelerator pedal 51. Thus, the greater the quantity of fuel fed to the engine, the more current is caused to pass through the vaporizer coil 27, to increase the heat available for heating the fuel-air mixture from the carburetor 10. As the quantity of fuel-air mixture drawn into the cylinders increases, the current passing through the vaporizer coil increases, to elevate the temperature of the fuel-air mixture to the same extent with large quantities passing into the engine as with small quantities passing into the engine. Such proportionate change in the current passing through the vaporizer coil 27 is determined by the position of the accelerator pedal 51, or the throttle linkage connected thereto.

As disclosed in Fig. 3, one end of the vaporizer coil 27 is connected through the lead 29 to a manually operated switch 60, which is connected through a suitable lead 61 to ground. The other end of the coil is connected through the lead 28 to the movable arm 62 of a variable rheostat 63, that is adapted to be shifted over a resistance coil 64, contacting the resistance coil at various distances therealong. An end of the resistance coil 64 is connected through a suitable lead 65 to the lead 37 running to the ignition switch 34, which, as has been described above, is connected to one side of the battery 32, the battery being connected to ground. Thus, the circuit through the vaporizer coil 27 is closed whenever the manual switch 60 and ignition switch 34 are closed. If the vaporizer coil 27 is to be ineffective, then the operator will open the manual switch 60. However, the manual switch is normally closed, so that the vaporizer coil 27 has current passing through it so long as the ignition switch 34 is closed, the quantity of current being dependent upon the position of the potentiometer arm 62 along the resistance coil 64. This position is determined by the position of the throttle control mechanism, such as the accelerator pedal 51.

An operating arm 70 is secured to the potentiometer arm 62, being connected through a link 71 to the accelerator pedal 51. When the accelerator pedal is in its uppermost position, then the operating arm 70 is disposed in the position disclosed in Fig. 3, in which the potentiometer arm 62 engages the rheostat coil 64 at the greatest distance from its end connected to the lead 65, thereby placing a maximum amount of resistance in the circuit through the vaporizer coil 27. In other words, a minimum amount of current is passing through the vaporizer coil when the accelerator pedal 51 is in the engine idling condition, to cause a minimum quantity of fuel-air mixture to pass from the carburetor 10 to the intake manifold 11 of the engine. As a greater quantity of fuel-air mixture is caused to flow from the carburetor to the

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intake manifold, due to a depression of the accelerator pedal, such depression will cause the accelerator pedal 51 to act through the link 71 and the operating arm 70 to swing the potentiometer arm 62 closer toward the left end of the rheostat coil 64, reducing the effective resistance of the coil and causing an increase in the current flowing to the vaporizer coil 27, which is then emanating a greater quantity of heat per unit of time, in order to heat the greater quantity of combustible mixture passing from the carburetor 10 to the intake manifold 11. Thus, the current passing to the vaporizer coil 27 is increased in proportion to the increase in the fuel-air mixture passing around the coil, in order to preheat such mixture to the proper extent, regardless of the quantity of mixture passing to the intake manifold 11. As the accelerator pedal 51 returns toward its uppermost position, then the resistance in the circuit to the vaporizer coil is correspondingly increased, to reduce the current passing through the latter and its heating effect.

In the event the engine is cold and it is desired to facilitate its starting, a by-pass switch 75 around the potentiometer 63 is provided, this switch being connected across the lead 65 running from one end of the potentiometer 63 and the lead 28 extending from the potentiometer arm 62. The closing of this switch 75 will obviously by-pass or short circuit the potentiometer 63, and will cause a maximum amount of current to pass through the vaporizer or preheater coil 27, insuring the proper heating of the relatively cold fuel-air mixture passing from the carburetor 10 to the intake manifold 11, and insuring more complete combustion of this mixture in the engine cylinders.

It is evident that the vaporizer 27 is effective to preheat the fuel-air mixture passing from the carburetor 10 to the intake manifold 11, and also in preheating the exhaust gas and auxiliary air mixture passing thereby when the ball is disengaged from its seat 15. In both instances, proper and complete combustion of the mixture is assured by virtue of the effectiveness of the vaporizer coil, which is delivering adequate heat under conditions in which a low demand for a combustible mixture in the engine is present, as well as under conditions in which a high or much greater demand is present.

It is, accordingly, apparent that an apparatus has been provided which considerably reduces the unburned and incompletely burned hydrocarbons discharged from the engine exhaust system to the atmosphere, and which insures a more complete combustion of the fuel-air mixture being fed to the engine cylinders.

The inventor claims:

1. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; and air inlet opening into said return means to enable air to mix with the exhaust gases in said return means; throttle means for controlling the quantity of fuel passing to the intake line; and valve means operable in response to movement of said throttle means for controlling the passage of the air and exhaust gases to said fuel feeding means.

2. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; throttle means for controlling the quantity of fuel passing to the intake line; valve means for controlling the return of the exhaust gases to said fuel feeding means; and means interconnecting said throttle means and valve means, whereby said valve means is open when said throttle means is in a substantially minimum

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fuel control position and said valve means is closed when said throttle means is shifted from said substantially minimum fuel control position, said valve means remaining closed as said throttle means increases the quantity of fuel passing to the intake line.

3. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; an air inlet opening into said return means to enable air to mix with the exhaust gases in said return means; throttle means for controlling the quantity of fuel passing to the intake line; valve means for controlling the passage of the air and exhaust gases to said fuel feeding means; and means interconnecting said throttle means and valve means, whereby said valve means is open when said throttle means is in a substantially minimum fuel control position and said valve means is closed when said throttle means is shifted from said substantially minimum fuel control position.

4. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; throttle means for controlling the quantity of fuel passing to the intake line; valve means operable in response to movement of said throttle means for controlling the return of the exhaust gases to said fuel feeding means; vehicle brake means; and means interconnecting said vehicle brake means and valve means, whereby said valve means is closed when said vehicle brake means are applied.

5. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; throttle means for controlling the quantity of fuel passing to the intake line; a valve in said return means for controlling the return of the exhaust gases to said fuel feeding means; electromagnetic means for opening said valve; an electric circuit for said electromagnetic means; and means for opening said circuit in response to shifting of said throttle means from a substantially minimum fuel control position.

6. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; throttle means for controlling the quantity of fuel passing to the intake line; a valve in said return means for controlling the return of the exhaust gases to said fuel feeding means; electromagnetic means for opening said valve; an electric circuit for said electromagnetic means; means for opening said circuit in response to shifting of said throttle means from a substantially minimum fuel control position; vehicle brake means; and means for opening said circuit upon operation of said vehicle brake means to apply the vehicle brakes.

7. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; an air inlet opening into said return means to enable air to mix with the exhaust gases in said return means; throttle means for controlling the quantity of fuel passing to the intake line; a valve in said return means for controlling the passage of the air and exhaust gases to said fuel feeding means; electromagnetic means for opening said valve; an electric circuit for said electromagnetic means; and means for opening said circuit in

response to shifting of said throttle means from a substantially minimum fuel control position.

8. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; an air inlet opening into said return means to enable air to mix with the exhaust gases in said return means; throttle means for controlling the quantity of fuel passing to the intake line; a valve in said return means for controlling the passage of the air and exhaust gases to said fuel feeding means; electromagnetic means for opening said valve; an electric circuit for said electromagnetic means; means for opening said circuit in response to shifting of said throttle means from a substantially minimum fuel control position; vehicle brake means; and means for opening said circuit upon operation of said vehicle brake means to apply the vehicle brakes.

9. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; valve means in said return means for controlling the return of the exhaust gases to said fuel feeding means; and means for preheating the exhaust gases returning from the exhaust line to said fuel feeding means.

10. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; throttle means for controlling the quantity of fuel passing to the intake line; valve means operable in response to movement of said throttle means for controlling the return of the exhaust gases to said fuel feeding means; means for preheating the exhaust gases returning from the exhaust line to said fuel feeding means; and means operated by said throttle means for controlling the heat output of said preheating means.

11. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; an air inlet opening into said return means to enable air to mix with the exhaust gases in said return means; throttle means for controlling the quantity of fuel passing to the intake line; valve means for controlling the passage of the air and exhaust gases to said fuel feeding means; means interconnecting said throttle means and valve means, whereby said valve means is open when said throttle means is in a substantially minimum fuel control position and said valve means is closed when said throttle means is shifted from said substantially minimum fuel control position; means for preheating the air and exhaust gases passing from the exhaust line and air inlet to said fuel feeding means; and means operated by said throttle means for increasing the heat output of said preheating means as said throttle means is opened wider.

12. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; throttle means for controlling the quantity of fuel passing to the intake line; a valve in said return means for

controlling the return of the exhaust gases to said fuel feeding means; electromagnetic means for opening said valve; an electric circuit for said electromagnetic means; means for opening said circuit in response to shifting of said throttle means from a substantially minimum fuel control position; an electric heater for preheating the exhaust gases returning from the exhaust line to said fuel feeding means; an electric circuit for said heater including a variable resistance; and means connecting said variable resistance to said throttle means, whereby the effective resistance of said variable resistance is decreased as said throttle means is opened wider.

13. In an internal combustion engine having an intake line: means for feeding fuel to said intake line; throttle means for controlling the quantity of fuel passing to said fuel feeding means; an electric heater in said fuel feeding means for preheating the fuel passing therethrough; an electric circuit for said heater including a variable resistance; and means connecting said variable resistance to said throttle means, whereby the effective resistance of said variable resistance is decreased as said throttle means is opened wider.

14. In an internal combustion engine having an intake line: means for feeding fuel to said intake line; throttle means for controlling the quantity of fuel passing to said fuel feeding means; an electric heater in said fuel feeding means for preheating the fuel passing there-through; an electric circuit for said heater including a variable resistance; means connecting said variable resistance to said throttle means, whereby the effective resistance of said variable resistance is decreased as said throttle means is opened wider; and by-pass switch means for short circuiting said variable resistance.

15. In an internal combustion engine having an intake line and an exhaust line: means for feeding fuel to the intake line; return means interconnecting the exhaust line and fuel feeding means to return at least part of the exhaust gases from the exhaust line to said fuel feeding means; throttle means for controlling the quantity of fuel passing to the intake line; valve means for controlling the return of the exhaust gases to said fuel feeding means; and means interconnecting said throttle means and valve means, whereby said valve means is open when said throttle means is in an engine idling fuel control position and said valve means is closed when said throttle means is shifted from said engine idling fuel control position, said valve means remaining closed as said throttle means increases the quantity of fuel passing to the intake line.

16. In an internal combustion engine having an intake line: means for feeding fuel to said intake line; throttle means for controlling the quantity of fuel passing to said fuel feeding means; an electric heater in said fuel feeding means for preheating the fuel passing there-through; an electric circuit for said heater including a variable resistance; and means for varying said resistance in response to movement of said throttle means.

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