March 31, 1936. J. H. VANDER VEER 2,035,775

GAS AND FUME ELIMINATOR FOR INTERNAL COMBUSTION ENGINES

Filed March 18, 1933 3 Sheets-Sheet 1

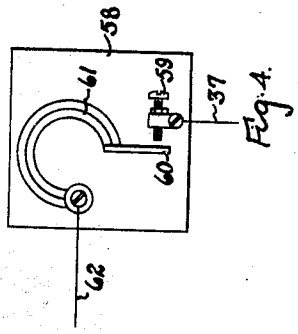


Fig. 4.

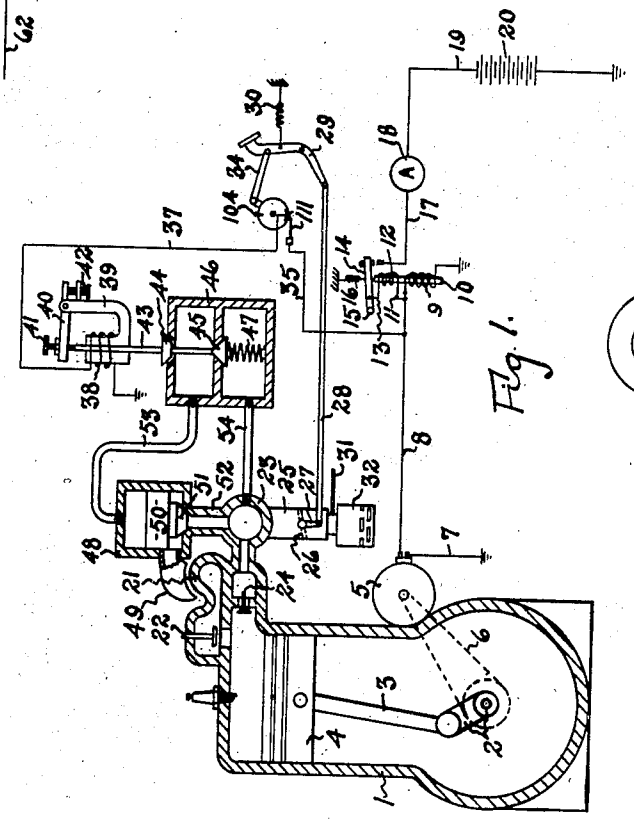


Fig. 1.

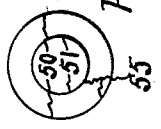


Fig. 2.

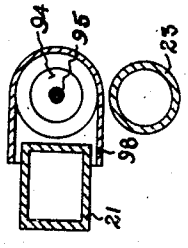


Fig. 8.

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GAS AND FUME ELIMINATOR FOR INTERNAL COMBUSTION ENGINES

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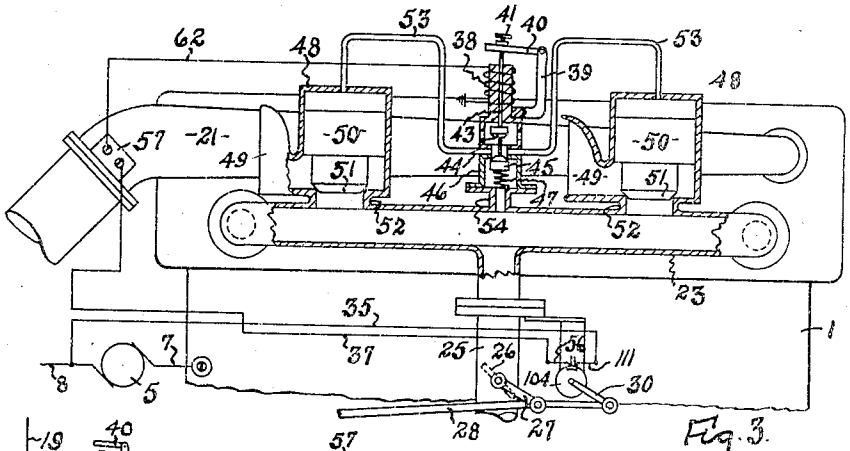


Fig. 3.

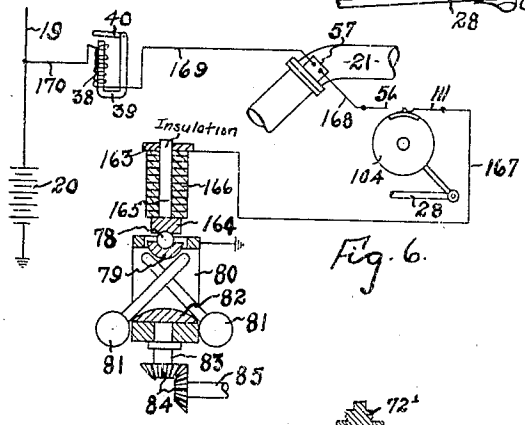


Fig. 6.

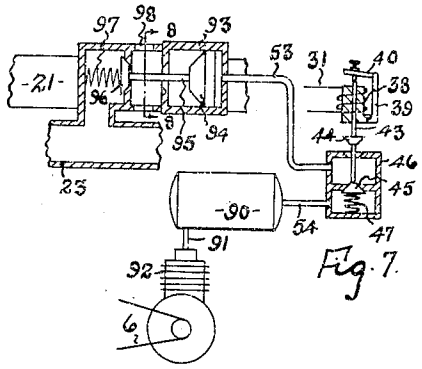


Fig. 7.

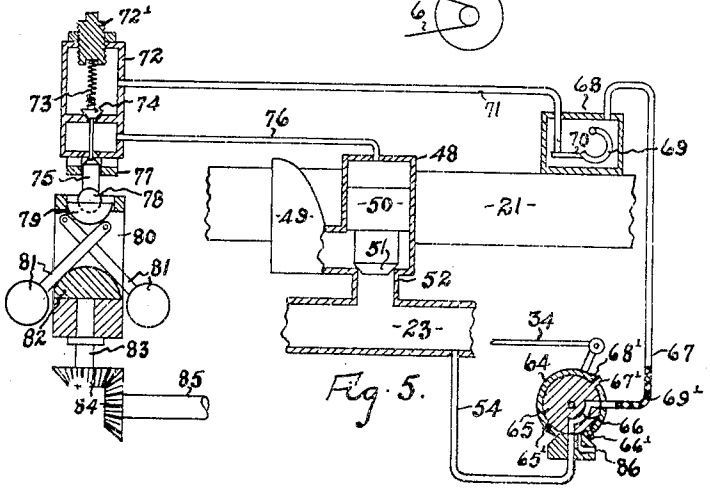


Fig. 5.

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GAS AND FUME ELIMINATOR FOR INTERNAL COMBUSTION ENGINES

Filed March 18, 1933 3 Sheets-Sheet 3

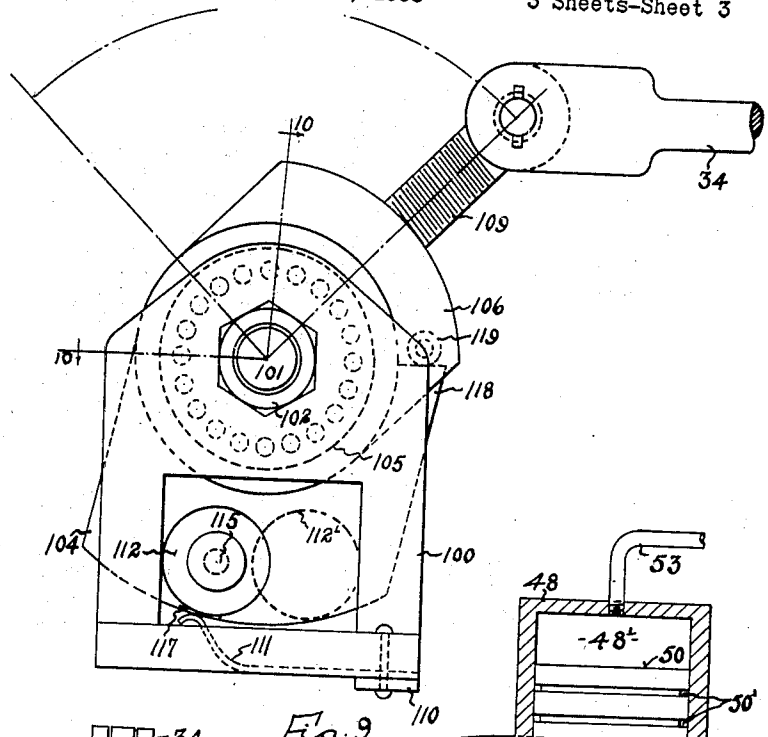


Fig. 9.

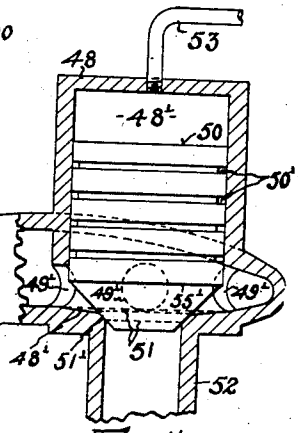


Fig. 11.

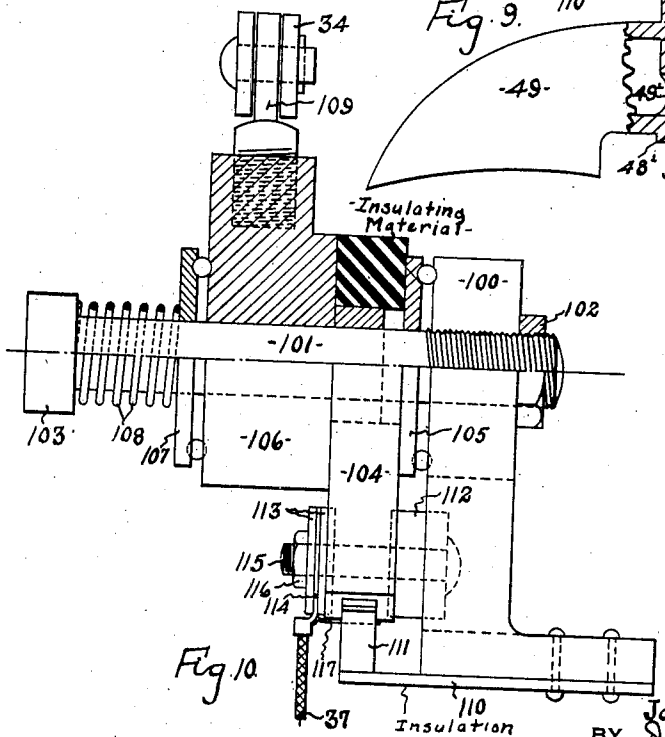


Fig. 10.

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2,035,775

GAS AND FUME ELIMINATOR FOR INTERNAL COMBUSTION ENGINES

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Application March 18, 1933, Serial No. 661,514

28 Claims. (Cl. 123—124)

This invention relates to apparatus associated with the intake manifold of an internal combustion engine as applied particularly to motor vehicles for automatic operation, with a view to eliminating the formation of gas and fumes and their ejection from the exhaust manifold of such vehicles during periods of deceleration thereof when the engine is idling.

A particular object of the invention is to eliminate the production of obnoxious gases and fumes during the deceleration of motor vehicles and to effect economy in the operation of such vehicles by saving in both gasoline and oil.

Another object of this invention is to provide an apparatus for automatically introducing fresh air into the intake manifold of internal combustion engines of motor vehicles during periods of deceleration of the engine with the throttle in idling position.

These and many other objects, as will appear from the following disclosure, are secured by means of the apparatus disclosed in detail in the following specification and defined in the appended claims.

This invention resides substantially in the combination, construction, arrangement and relative location of parts, as will be more fully described hereinafter.

Referring to the drawings—

Figure 1 is a diagrammatic view with some parts in cross section of the apparatus of this invention;

Fig. 2 is a diagrammatic view showing the relative areas involved in the relief valve;

Fig. 3 is a diagrammatic view, with some parts in cross section, of a modified form of the invention employing a plurality of relief valves in the intake manifold;

Fig. 4 is a plan view of a thermostatic switch employed with the invention;

Fig. 5 is a diagrammatic view, with some parts in cross section, of a still further modified form of the invention which is entirely pneumatic;

Fig. 6 is a still further modification, diagrammatically illustrated, of a full electrical form of the device;

Fig. 7 is a diagrammatic view, with some parts in cross section, of a portion of the apparatus in modified form employing superatmospheric pressure;

Fig. 8 is a cross sectional view taken on the line 8—8 of Fig. 7;

Fig. 9 is an elevational view of the accelerator pedal operated switch;

Fig. 10 is an edge elevational view of this switch with the upper portion in cross section on the line 10—10 of Fig. 9; and

Fig. 11 is a vertical cross sectional view through a modified form of poppet valve.

In the operation of large motor vehicles propelled by internal combustion engines employing gasoline or a similar fluid fuel, smoke and obnoxious fumes are ejected from the engine exhaust during periods of engine deceleration and/or during periods of engine overrunning where the engine is propelled at higher than idling speeds by the vehicle.

The quantity of fumes and smoke produced under these conditions is of such proportions that their elimination is highly desirable, especially where the vehicle operates in congested urban districts. These fumes and smoke are ejected from engines in good condition. In other words, even though the engine itself be in good working condition the production of large quantities of smoke and fumes, under the above noted condition, is an inherent result. Smoke and less obnoxious fumes may be ejected from the exhaust of an internal combustion engine because of worn piston rings or poor carbureter adjustment but these are readily controlled, whereas the smoke and fumes which are ejected from engines and carbureters in good condition can only be eliminated successfully by the invention herein described.

In accordance with this invention in order to successfully eliminate the ejection of obnoxious fumes and smoke it is necessary—

(*a*) To introduce into the cylinders of the engine during periods of deceleration and/or overrunning of the engine approximately the maximum amount of atmospheric air or its equivelent permitted by the limiting sectional area of the intake manifold,

(*b*) That this introduction of air be made close to the engine cylinder, and particularly between the carbureter riser and the cylinders,

(*c*) That this introduction of air be made on any appreciable deceleration of the engine, even though such deceleration is produced by only a partial movement of the engine throttle towards its idling position, and

(*d*) That this introduction of air also be made whenever, with the engine throttle in idling position, the speed of the engine is materially higher than idling speed.

In meeting the above conditions in the application of the present invention the following additional considerations must be met:

(*a*) There must be no flow or leakage of air into the engine cylinders as a result of the use

of this invention, except the air deliberately introduced during periods of deceleration and/or overrunning, for such flow or leakage with the adjustment of the carbureter idling jet made necessary thereby, results in a higher idling speed of the engine, making gear shifting difficult and increasing engine fuel consumption.

(*b*) The atmospheric air or its equivalent which is introduced into the intake manifold or cylinders must be heated, for if it is not heated whatever tendency the engine has to backfire through the curbureter is increased with consequent injury to the carbureter.

(*c*) The introduction of atmospheric air or its equivalent into the intake manifold by the cylinders must stop when the speed of the engine falls to a speed slightly higher than idling speed, for if it did not stop it would be impossible to idle the engine.

In order that air may be introduced into the intake manifold as close to the engine cylinders as possible, this invention provides that the introduction of air be made at or as near as possible to each point where the intake manifold enters the valve structure of the engine.

The foregoing requirements are met by the provision of one or more valves so connected to the intake manifold that when they are open they admit the maximum amount of atmospheric air or its equivalent to the manifold as is permitted by the limited sectional area of the manifold, and when closed these valves tightly seal the manifold against admission of air. The air inlet ports of the valves are so constructed that the air which passes through these ports is first warmed by the exhaust manifold of the engine. Pneumatic means are provided for the operation of the valves by fluid pressure below or above atmospheric pressure. Electromagnetic means are also provided for the control of the fluid pressure. The electromagnetic means is automatically controlled by

(*a*) The generated electromotive force of the engine driven generator when the generator is disconnected from the vehicle storage battery by the usual generator cutout,

(*b*) A switch operable by the engine throttle and responsive to any appreciable movement of the throttle towards its idling position to establish a connection between the engine driven generator and the electropneumatic means whereby that means will be operated to open the air valve, provided the generated electromotive force of the engine driven generator is sufficiently above that of idling speed to operate said electromagnetic means and also responsive to any appreciable movement of the throttle towards full open throttle to interrupt the circuit with the electromagnetic means, and

(*c*) A thermo switch operable by the heat of the exhaust manifold to hold interrupted the circuit to the electromagnetic means until the exhaust manifold has warmed up.

Means is also provided for adjusting the electropneumatic means so that operation thereof to close the air valves may be made to take place at those values of the engine driven generator's electromotive force which have been predetermined by adjustment.

Since the generated electromotive force of the engine driven generator, when the generator is disconnected from the vehicle storage battery by the usual generator cutout, is a function of the engine's speed, it is apparent that the portion of the electropneumatic control means, which is dependent upon the engine driven generator's electromotive force, is dependent upon the engine's speed.

This invention is also of such nature that a plurality of air valves for controlling the admission of air to the intake manifold of the engine may be simultaneously operated or controlled by a single electropneumatic control means.

A detailed description of several forms of the invention will now be given in connection with the attached drawings. At **1** is diagrammatically illustrated an internal combustion engine of the usual type employing a crank shaft **2** which is connected by the piston rod **3** to the piston **4**, only one of which is illustrated. At **5** is diagrammatically illustrated the generator which is driven by the engine by means of the belt or chain **6**. One terminal of the generator is grounded on the engine frame by means of the wire **7**, as is usual. The other terminal of this generator is connected to one terminal of the solenoid winding **9** of the generator cutout, the other terminal of which is grounded.

At **10** is the core of this solenoid upon which is mounted a second solenoid winding **12** connected by wire **11** to wire **8** and by wire **13** to the lever arm **14** which is pivotally mounted at **15**. A coiled spring **16** normally holds the arm **14** against the stop and out of engagement with a fixed contact which is connected by wire **17** to one terminal of the ammeter **18**. The other terminal of this ammeter is connected by wire **19** to the storage batery **20** which is grounded. This mechanism comprises the usual generator cutout which normally completes the circuit from the generator to the battery by the energization of winding **9**. However when the back electromotive force of the storage battery equals the generated electromotive force of the generator **5** the flux produced by coil **12** sufficiently neutralizes the flux of coil **9** so that spring **16** may retract arm **14** and break the circuit to the storage battery.

At **21** is the exhaust manifold of the engine and at **22** is one of the exhaust valves. The intake manifold of the engine is shown at **23** and one of the intake valves is shown at **24**. The carbureter riser **25** is connected to the intake manifold and at **26** is shown the throttle valve of the carbureter. A short lever **27** operatively connects the throttle valve to the link **28**, which in turn is pivotally connected to the accelerator pedal **29** held normally in throttle closed position by means of the spring **30**.

At **31** is the fuel feed pipe of the carbureter which, of course, connects to the usual fuel tank not shown. At **32** is an air filter through which the air passing to the carbureter travels.

At **104** is diagrammatically disclosed a switch which is operated by the accelerator pedal through the agency of the connecting link **34**. A fixed spring finger **111** is positioned to engage a movable contact mounted on the switch. This spring finger is connected by wire **35** to wire **8**. The contact on the movable disc is connected by wire **37** to one terminal of the solenoid winding **38** which is grounded. At **39** is a magnetizable core for the solenoid which has pivotally mounted thereon a lever or armature **40**. Passing through the core is a rod for plunger **43** which has secured thereon the opposed valve discs **44** and **45** which cooperate with seats formed in the walls of a valve casing **46**. This casing is divided into two compartments by means of a transverse wall which provides the seat for valve disc **45**. A

spring 47 is interposed between valve disc 45 and the casing and normally holds valve disc 45 seated and valve disc 44 unseated. At 41 and 42 are adjustable thumb screws by means of which the air gap between the magnetizable core 39 and the armature 40 may be adjusted so as to predetermine by this adjustment the strength of current flowing through the solenoid and thus the electromotive force thereon, at which spring 47 will overcome the pull of core 39 upon armature 40 to cause valve disc 45 to seat and valve disc 44 to unseat.

At 48 is the valve casing of the relief valve through which air at atmospheric pressure is introduced into the intake manifold. This casing is connected by a pipe or conduit 52 to the intake manifold 23. Within the valve casing 48 is a plunger or piston 50 which has formed thereon a central extension of reduced diameter which is provided with a valve disc 51 cooperating with a seat in the casing. The valve is shown closed in Fig. 1. An air inlet port for the casing is provided with a hooded pipe 49 positioned with its air intake end adjacent to the exhaust manifold so that the air entering the valve casing will be drawn over the heated exhaust manifold to heat it. The inlet port into the casing opens, at least in part, as will be apparent from Fig. 1, below the plunger or piston 50. In other words, the lower face of the plunger 50 is exposed to atmospheric pressure. Casing 48 is connected by pipe 53 to casing 46 above valve disc 45. The intake manifold 23 is connected by pipe 54 to casing 46 below valve disc 45.

Before describing the operation of this apparatus reference is made to Figs. 9 and 10 in which is disclosed in full detail the accelerator pedal operated switch which controls the circuit to the electromagnet valve. This switch comprises a bracket 100 constructed so that it may be attached to some suitable support. Mounted on this bracket is a bolt 101 which threadedly engages the bracket and may be locked in longitudinal adjusted position by means of the lock nut 102. Freely and rotatively mounted on the bolt are the driving and driven members 106 and 104, respectively. The driving member 106 may be of metal but the driven member 104 is made of some suitable insulating material, such as fibre for example. Interposed between the member 104 and the bracket 100 is a ball race 105. A small ball race 107 is mounted on the outside of the driving member 106 and a compression spring 108 lies between it and the head 103 of the bolt. The driving member is connected by the adjustable rod 109 to the link 34 which, in turn, is connected to the accelerator pedal 29. The driven member 104 is operated solely by the frictional forces between it and the driving member. These forces may be varied by axially adjusting the bolt 101 to vary the pressure on spring 108. The bracket 100 is provided with an opening, as shown in Fig. 9, between the sides of which oscillates the lug 112 secured to the driven member by a bolt and nut 115 and 116. The lug 112 limits the swinging movement of the driven member. Mounted on the bracket is an arm 110 of insulating material which supports the spring contact finger 111 opposite the lower face of the driven member. A cooperating contact 117 is mounted on the driven member so as to be in the path of the contact finger 111. The contact 117 is electrically connected to the metal washer 114 held in place by bolt 115 and nut 116. Mounted on one face of the driving member, as shown in Fig. 9, is a lug 119 positioned to engage the shoulder 118 formed on the driven member.

When the accelerator pedal is in released position, as shown in Fig. 1, the parts of this switch will be in the position shown in Fig. 9. As soon as the accelerator pedal is depressed the driving member moves in a counterclockwise direction and moves with it the driven member through the frictional engagement therebetween. This moves contact 117 out of engagement with contact finger 111 and breaks the circuit to the magnet valve. Continued and further depression of the accelerator pedal will cause the driven member to swing until the lug 112 assumes the dotted position 112', Fig. 9. The driven member can then move no further but the driving member may move as far as necessary to accomplish the open position of the throttle. As soon as the accelerator pedal is released the initial movement of the driving member back to normal position will cause the driven member to move to the full line position shown in Fig. 9, thereby closing the circuit to the magnet valve. The parts are so adjusted that when the throttle is in idling position lug 119 will engage the shoulder 118 of the driven member insuring that the switch parts will be held in the position shown in Fig. 9 with contact 117 in engagement with spring finger 111.

It will be noted from Fig. 2 that the plunger 50 and valve 51 provide three different areas. Area 50 represents the total area of the piston, as for example the area of its upper surface. The area 51 represents the area of the valve disc and area 55 represents the difference between areas 50 and 51. These areas are so proportioned that the operation of the entire valve is governed by the relative pressures on the areas 50, 51 and 55. When the valve is seated it is subjected to the pressure below atmospheric pressure on the area 51. This is apparent because of course a vacuum condition exists in the intake manifold with the engine running. Area 50 is exposed to atmospheric pressure through pipe 53 since valve disc 44 is unseated. The differential area 55 is likewise exposed to atmospheric pressure. Under operating conditions obviously the valve will be firmly seated since the pressure on its upper surface is greater than the total pressure on its lower surface. Of course when the engine is not running the valve will remain seated by its own weight, though in those applications where it is necessary to mount this valve on its side, or upside down, a light spring may be used to urge the valve towards its seat when the engine is not running. In the form of valve shown in Fig. 11 the valve is drawn to its seat by the suction of the intake manifold when the plunger has partially reduced the area of the inlet ports.

When the engine is operating and the vehicle is in motion, and the operator partially or wholly releases the accelerator pedal the first movement of it will cause the driving member of the accelerator operated switch to move the driven member sufficiently to make the circuit in which it is included. In other words, a small movement of the accelerator pedal towards idling position will complete the circuit to the magnet valve. This, of course, reduces the supply of fuel to the carbureter and the engine tends to slow down to idling speed, but if the vehicle is on the down grade, for example, the engine will be over driven thereby. If the speed of the engine is above a predetermined speed sufficient current will flow from the generator 5 through wires 8 and 35, spring finger 111, the contact of

the switch, wire 37, solenoid winding 38, and through ground back to the generator. This will cause the downward movement of armature 40, the movement of which seats valve disc 44 and unseats valve disc 45. The upper part of valve casing 48 will then be directly connected to the intake manifold 23 and the vacuum condition therein, acting through pipes 54 and 53, will reduce the pressure on the upper surface of plunger 50 in valve casing 48 below atmospheric pressure, with the result that atmospheric pressure operating on area 55 on the under surface of the plunger 50 will raise it, unseating valve disc 51.

Air at atmospheric pressure will then be drawn into the intake manifold through the funnel shaped conduit 49. This air will be heated as it is forced to flow over the exhaust manifold in reaching the funnel 49. Thus heated, air enters the intake manifold 23 in quantities limited only by the cross sectional area of the passage leading to the intake manifold which, in best practice, should not be of more constricted cross sectional area than that of the intake manifold. The cylinders of the engine will, therefore, be supplied with large quantities of fresh air and the proportion of fuel, if any, which is mixed with this air will be so small that an explosive mixture will not form. The result is that the engine, in effect, will be pumping substantially fresh air and no fumes or smoke will form and be discharged.

The predetermined speed above which these operations will occur, will in part depend upon the adjustable air gap between the magnetizable core 39 and the armature 40. This air gap may be adjusted by means of the screws 41 and 42 so that the magnet valve will not be operated unless the engine is operating above a predetermined speed and, as a result, the generator is supplying a current thereto above a corresponding predetermined value. This adjustment will of course take in the relationship between the various pressures on valve discs 44 and 45, and the pressure exerted by spring 47.

These various forces are so proportioned in relationship to the air gap adjustment that with the circuit to the magnet valve completed the magnet valve will only seat valve 44 and unseat valve 45 if the engine is operating at a speed above a predetermined value. If the speed of the engine is below this value the magnet valve will not operate and the relief valve 51 will not open.

Assuming that the relief valve 51 has opened, as the engine slows down the generated electromotive force of the generator 5 falls off, so that when it approximates the back electromotive force of the storage battery 20 the generator cut out mechanism will operate to disconnect the battery from the generator. The important feature of this operation is that the generated electromotive force, which is then supplied to the magnet valve only, becomes substantially directly proportional to the engine speed, with the result that the magnet valve will be directly controlled by the generated electromotive force which is directly proportional to the engine speed. Hence, as the speed of the engine falls to a second predetermined value lower than the above discussed predetermined value, the magnet of the magnet valve will finally become so weakly magnetized with respect to the strength of spring 47 that the spring will seat valve disc 45 and unseat valve disc 44, disconnecting valve casing 48 from the intake manifold and connecting it to atmospheric pressure.

As a result, valve disc 51 will seat closing the fresh air supply connection to the intake manifold. The relief valve closes because when the upper area of the valve plunger is subjected to atmospheric pressure, the pressures on the valve plunger are balanced. Then the weight of the plunger will cause it to fall, in which it starts to close the inlet port, and the suction of the intake manifold upon the air drawn through this restricted port produces a reduced pressure under the valve plunger so that the higher pressure on the top of the valve plunger will cause the valve to quickly and firmly seat. The conditions under which the relief valve closes, or in other words the predetermined speed of the engine below which the magnet valve closes is preferably selected so that when the intake manifold is sealed the engine will be operating slightly above idling speed so that it can quickly pick up and again become operative without stalling.

If, when the accelerator pedal is released, the engine is operating below the first of the above discussed predetermined speeds the magnet valve will not operate and, of course, the relief valve will not open.

Best results are secured when the fresh air introduced into the cylinders is introduced as close as possible to the intake valves themselves. As shown, the relief valve is between the carbureter and the intake valves so that little or no fuel is drawn into the cylinders when the relief valve is open. This is important because otherwise the inrushing air would draw some fuel from the carbureter, plus that which it can pick up from the walls of the intake manifold or passage, thereby partially defeating the object of the invention. The most ideal position for the relief valve would be on the inlet valve casings, with one supplied for each inlet valve.

Fig. 3 shows an arrangement in which a plurality of relief valves are employed, or, as illustrated, two relief valves connected to the intake manifold, one on each side of the carbureter riser. This figure need not be described in detail since the parts corresponding to those in Fig. 1 have been given the same number and appear in substantially the same relationship and are of substantially the same construction. With regard to the accelerator operated switch, it will be noted that a second spring finger 56 is provided which is interconnected with the spring finger 111 by means of the contact on the switch, which is the same as the arrangement of Fig. 1, with the exception that wire 37 is not directly connected to the contact.

In circuit with wire 37 is shown a thermostatic switch 57, shown diagrammatically, but which is illustrated in detail in Fig. 4. This switch comprises support 58 having a fixed contact 59 mounted thereon by which the wire 37 is connected. At 61 is a suitable bimetal element comprising two metals of different coefficients of expansion secured together so that when their temperature is raised the free end thereof on which the contact 60 is mounted will move over to engage the fixed contact 59. The other end of the bimetal element is, of course, anchored to the support. This thermostatic switch is then connected by wire 62 to the solenoid winding 38 of the magnet valve which is grounded. The magnet valve is of substantially the same

construction as that shown in Fig. 1. In this case it is connected by two pipes 53 to the two valve casings 48. The operation of this mechanism is substantially the same as that previously given in detail in connection with Fig. 1. However, when the magnet valve operates in this case both valve casings 48 are connected to the intake manifold, with the result that both relief valves are raised off their seats to supply fresh heated air into the intake manifold at two points positioned on opposite sides of the carbureter riser. This insures a supply of fresh air to the cylinders in large quantities and at points more remote from the carbureter and nearer the cylinders themselves.

The thermostatic switch 57 is employed in the circuit to the solenoid so that even if the engine is operating above a predetermined speed and the circuit is completed through the accelerator switch the magnet valve will not be operated until the engine has been running sufficiently long to warm up to a point where the thermostatic switch is closed. It will be noted that this switch is associated with the exhaust manifold so as to be in heat exchange relation therewith. When the engine first starts to run it will, of course, be cold and under these conditions it is preferable not to supply fresh air to the cylinders even if the engine is overrunning. Hence the circuit to the magnet valve cannot be completed until the engine has warmed up. Just as the magnet valve cannot operate until the engine has attained a normal operating temperature, so it will be prevented from operating if the engine with the throttle at idling position cools below its normal operating temperature as it might easily do, for example in running down a long hill and being supplied with large quantities of fresh air. As its temperature drops below its normal operating temperature the thermostatic switch will open and the relief valves will close. It is of course apparent that the thermostatic switch may be associated with any other part of the engine, such as the engine block, the cooling water system, and the like, the essential requirement being that it control the magnet valve circuit so that the magnet valve cannot be operated until the engine reaches or approaches a normal operating temperature.

Fig. 5 illustrates a fully pneumatic system in which the electromagnet valve has been eliminated and a centrifugal governor operated valve is employed which is driven from the engine and is operated in proportion to the speed thereof. At 21 is the exhaust manifold and at 23 is the intake manifold. Mounted on the intake manifold, as before, is the relief valve casing 48 provided with the air inlet having the funnel shaped end 49 associated with the exhaust manifold. Instead of the accelerator pedal operated switch there is supplied a valve which comprises the driving member 64 operated by the link 34 which connects the accelerator pedal. The driving member frictionally engages a driven member 65 which has an air passage 66 therein. One end of the air passage is connected by means of a flexible hose or tube 69' with a pipe 67 which extends to the casing 68 of a thermostatic valve positioned in heat exchange relation with the exhaust manifold. The bimetal element 69 controls a valve disc or its equivalent 70 which is positioned to close the end of the pipe 71 projecting into the casing. Pipe 71 is in turn connected to that portion of casing 72 above valve disc 74. The driven member 65 cooperates with a seat having a passage 86 opening into the atmosphere. A pipe 54 connects the intake manifold 23 with a port in the seat position to cooperate with the passage 66. The driven member is provided with lugs 65' and 65'' which cooperate with the valve seat block to limit the movement thereof. The driven member 65 is also provided with a lug 67' positioned to engage a shoulder or lug 68' on the driving member. When the accelerator pedal is released the driving member 64 operates the driven member to the position shown in Fig. 5.

In this figure both members are shown in the limit of position in one direction. When the accelerator pedal is depressed the driving member rotates in a counterclockwise direction and by its frictional engagement with the driven member rotates it therewith unless lug 65' engages the seat block and stops it, at which time pipe 67 is connected to the atmosphere through passages 66 and 86. The valve casing 72 is provided with opposed seats which are controlled by the valve discs 74 and 75. A compression spring 73 holds the valve disc 74 seated and valve disc 75 unseated. A longitudinally adjustable plug 72' is employed to vary the pressure exerted by the spring. In support 80 is mounted movable member 79 between which, and the valve disc 75, is mounted a ball bearing member 78. The member 79 has a substantially hemispherical lower surface positioned to rest between the weighted and pivotally mounted arms 81. When the device is at rest these arms rest upon a member 82. The support or casing 80 is rotatably supported in any suitable manner and is connected to shaft 83. This shaft is connected to shaft 85 by a pair of miter gears 84. The shaft 85 is rotatably connected to the engine so as to be rotated therewith. There are many ways in which this shaft can be connected to the engine, similar to the way for example the generator of Fig. 1 or the pump or distributor is connected in common practice. The lower part of casing 72 between the valve discs 74 and 75 is connected by pipe 76 to the valve casing 48. The thermostatic valve in this case is positioned so that it is normally closed.

In the operation of this apparatus when the accelerator pedal is partially or wholly released its first movement causes the driving member 64 to move the driven member 65 to the position shown in Fig. 5 so that pipes 54 and 67 are connected. This connects thermostatic valve casing 68 with the intake manifold, creating a vacuum condition therein. If the engine is at normal operating temperatures the thermostatic valve will have opened, with the result that these vacuum conditions are supplied to the upper part of valve casing 72, through pipe 71. If the engine is operating above a predetermined speed casing 80 will be revolving at such a speed that the weighted governor arms 81 will be in a raised position so as to have caused valve disc 75 to seat and valve disc 74 to unseat. The result is that valve casing 48 will then be exposed to the vacuum conditions in the intake manifold through pipe 76. As soon as the engine's speed falls below the predetermined speed for which the device is adjusted, the weighted governor arms 81 will have fallen to a position where spring 73 may seat valve disc 74 and unseat valve disc 75. Valve casing 48 will then be connected to the atmosphere and the relief valve 51 will close, cutting off the supply of fresh air to the intake manifold previously supplied thereto. As soon as the accelerator pedal is

again depressed the driven member 65 will be moved so that passage 66 is connected to passage 86 and atmospheric conditions will be present in the thermostatic valve casing 66. The driven member of the accelerator valve, like the driven member of the accelerator switch, is only given a limited movement without interfering with the necessary movement of the driving member to effect complete operation of the accelerator pedal and hence the carbureter.

Here, again, the pressures on the various areas, the pressure exerted by spring 73, and the speed of rotation of the governor arms and the supporting casing are all proportioned so that the relief valve will open and close when the engine is above or below a predetermined speed. These conditions are of course controlled by the thermostatic valve which opens and closes when the temperature of the engine is at or below a substantially normally operating temperature.

Fig. 6 discloses a combination electromechanical modification of the system. The manifold relief valve is not shown in Fig. 6 but armature 40 which operates the valves 44 and 45 is shown and it should be understood that the operation of the relief valve 51 from the armature 40 through valves 44 and 45 is as described with Fig. 1. The accelerator switch is employed as before, as well as the thermostatic switch 37. The magnet portion of the magnet valve is shown comprising a core 39 on which the valve operating armature 40 is pivotally mounted. The solenoid 38, which energizes the core, is connected by wire 170 to wire 19. The other terminal of the solenoid is connected by wire 169 to the thermostatic switch 57. Spring finger 111 is connected by wire 167 to ground through a variable resistance 166 which in this case comprises a plurality of carbon buttons mounted upon an insulating rod or support 165. At 164 is a member which bears on the lower surface of the carbon buttons and presses them against a fixed stop 163.

A rotatable casing or support 80 is supplied, as before, in which is mounted the bearing member 79 between which and member 164 is the ball bearing 78. The weighted governor arms 81 are pivotally mounted on the casing and rest on the member 82 when the casing is at rest. This casing is revolved through the agency of shaft 83, miter gears 84, and shaft 85, which is operatively connected to the engine. The casing is grounded as shown. In this case when the accelerator pedal is partially or wholly released the circuit to the solenoid 38 is completed through the thermostatic switch, if it is closed (under the conditions previously given), through the accelerator switch, and through the carbon button resistance 166 to ground. If the engine is operating above a predetermined speed the governor arms will have moved upwardly and exerted a pressure through the members 79, 78, and 164 on the carbon buttons 166, to reduce the resistance of the circuit to the point where sufficient current flows to operate the magnet valve. As the engine slows down the pressure on the carbon buttons is reduced to a point where the resistance increases so that the spring of the magnet valve, as before, will return the magnet valve and armature 40 to normal position. The magnet valve will control the relief valve or valves exactly as previously described.

The arrangement of Fig. 7 is given to illustrate the fact that this invention is not limited to the operation of the relief valve by the subatmospheric conditions in the intake manifold but may be used in a system employing fluid pressure to operate the relief valve, which is above atmospheric pressure. Thus in Fig. 7, the magnet valve is shown as in the arrangements of Figs. 1 and 2. It will be connected in circuit either with or without the thermostatic switch as previously described. In this case a suitable air compressor 92, which may be driven from the engine, is connected by pipe 91 to a fluid pressure storage tank 90. This tank is the equivalent of the intake manifold as employed in the before described systems. It is connected by pipe 54 to the magnet valve casing 46 below the valve disc 45. The upper portion of the casing is connected by pipe 53 to the relief valve casing 93. Within this casing is a piston 94 having a valve faced to cooperate with a seat formed at the left hand end of the casing. A second valve disc 96 seats on another seat formed in the casing and is connected by means of the rod 95 to the valve disc and piston 94. A compression spring 97 is positioned to normally hold the valve discs in the position shown with valve disc 96 seated. This spring is strong enough to prevent the unseating of valve disc 96 under the vacuum action of the intake manifold 23. Between the two chambers is provided a fresh air inlet which may be provided with a hood 98, as shown in Fig. 8.

In the operation of this apparatus when the current supplied to the magnet valve is sufficiently strong (it being remembered that the circuit to the magnet valve having been completed through the accelerator switch and the engine is running above a predetermined speed) valve disc 44 will be seated and valve disc 45 will be unseated. The fluid pressure source 90 is then connected to valve casing 93 to supply fluid pressure to the right hand face of the valve disc and piston 94. This will move the piston to the left until it seats. This seat is merely provided to prevent the leakage of the fluid pressure medium past the piston, and the movement of the piston 94 also causes the unseating of the valve disc 96, and as a result fresh air is drawn into the intake manifold past the hood or funnel 98 which is again positioned with respect to the exhaust manifold 21 so that the air will be heated as it enters the intake manifold. The operation of this device and the conditions under which it operates are the same as described in connection with the other modifications, but is illustrated for the main purpose of showing that the apparatus can be operated with a separate fluid pressure source which is preferably above atmospheric pressure, as well as by the vacuum conditions in the intake manifold. Here, again, the various valve areas and springs are proportioned with respect to the pressures involved and the solenoid air gap is adjusted so that the device will only operate with the engine running above predetermined speeds and after the throttle has been retarded.

Figure 11 shows a preferred form of the air inlet, or relief, valve 51 for operation by fluid pressures below atmospheric pressure. Conduit 52 connects casing 48 with the intake manifold 23 and the junction of conduit 52 and casing 48 is the outlet port 51' of the valve. A pipe 49 connected eccentrically to the lower portion of the cylindrical body of casing 48 admits air into this casing through the holes 49', 49', which holes constitute the air inlet ports of the valve. Within the casing 48 is the plunger or piston 50 which has formed on the lower end thereof a concentric extension in the form of a frustum of a cone, a given ring area of which serves as the

valve disc 51. The space above plunger 50 is the operating chamber 48' of the valve, this chamber being connected by pipe 53 with the operating means already described. In this Fig. 11 the area 55 is the projected area of the conical surface between the cylindrical portion of plunger 50 at ring 55' and the valve ring 51, said projection being on a plane at right angles to the axis of the plunger. Similarly area 51 is the plane area inside the valve ring 51. Annular grooves 50', 50' are cut into the cylindrical portion of the plunger 50 to provide for the alternate expansion and contraction of the air which passes from the inlet ports 49', around the limited clearance between plunger 50 and casing 48 into chamber 48'. This alternate expansion and contraction operates to reduce the leakage of air from the ports 49' into the chamber 48'. The lower portion of casing 48 from the outlet port 51' to the lower edges of the inlet ports 49' is also formed as a smooth surface such as the frustum of a cone tapered downward towards the outlet port 51'.

The operation of this valve is as described on page 3, particular attention being drawn at this point only to the functions of ring 55' and the conical surfaces of plunger 50 and casing 48. As plunger 50 and valve 51 move downward towards the closed position in which valve 51 seats on the outlet port 51', said movement resulting from an increased fluid pressure in chamber 48', the open area of inlet ports 49' is reduced as ring 55' and the cylindrical portion of plunger 50 move over these ports. This progressive reduction of the inlet port areas causes a progressive reduction in the pressures on areas 55 and 51 on the under side of the plunger, so that the force on these areas resisting the downward movement of the plunger is progressively reduced. The result is an accelerated downward movement of the plunger 50.

Also, as plunger 50 moves downward, its lower conical surface approaches the lower surface of the casing 48, the result being a gradual contraction of the smoothly converging passage for air between the open portion of the inlet ports 49' and the outlet port 51' which further reduces the pressure on area 55 and thus further accelerates the closing of valve 51.

This accelerated closing of valves 51 is very desirable in valve applications of this kind, for these valves are often closed at engine speeds only slightly above idling speed and while considerable quantities of atmospheric air are being drawn through the valves into the intake manifold, at which time atmospheric pressure operating to close the valves is only slightly higher than the pressure under the valves in the intake manifold.

It is pointed out that the poppet type of relief valve illustrated in the drawings is not the only form of valve which may be used with this invention since those skilled in the art will appreciate that a slide, rotary slide, or rotary type of valve, as well as the piston type, may be employed. It is also pointed out that the apparatus does not necessarily depend upon the vacuum condition within the intake manifold for the connection thereof since some other vacuum source can be employed, such as a vacuum pump driven by the engine.

From the above description it will be apparent that this invention resides in certain principles of construction and operation which may be readily embodied by those skilled in the art in many other physical forms without departure therefrom. I do not, therefore, desire to be strictly limited to the disclosure as given for purposes of illustration but rather to the appended claims.

What I seek to secure by United States Letters Patent is:

1. The combination with an internal combustion engine having an intake manifold, of a fuel throttle therefor, means for admitting air into the intake manifold and means connected to said throttle for operating said first means when the throttle is moved towards its idling position from any operating position and the engine is operating at speeds higher than idling speed.

2. The combination with an internal combustion engine having an intake manifold and a carbureter connected thereto, of a valve in the intake manifold, means influenced by the speed of the engine and the operation of the carbureter throttle for opening said valve and means operated with said throttle to actuate said first means when the carbureter throttle is moved from any operating position towards or is at idling position and the engine is operating above the speed corresponding to the throttle setting.

3. The combination with an internal combustion engine, an intake manifold for the engine, a carbureter connected to said manifold and carbureter control means, of means for admitting air into the intake manifold controlled by the carbureter control means, the engine speed, and the temperature of the engine.

4. The combination with an internal combustion engine, an intake manifold for the engine, a carbureter for supplying fuel to the engine and a control device for the carbureter of at least one fluid pressure operated air supply valve connected to the manifold, means for supplying fluid pressure to the valve to operate it, and means controlled by the carbureter control device and the engine speed for operating the fluid supply means to actuate the valve when the carbureter control means is partially or wholly moved to idling position from any operating position and the engine is operating above idling speed.

5. The combination with an internal combustion engine, an intake manifold for the engine, a carbureter and a control device therefor, of fluid pressure operated means for admitting air directly into the manifold, and means including a thermostat subject to the temperature of the engine for actuating said fluid pressure operated means when the carbureter is operated partially or wholly to idling position and the engine is operating above idling speed.

6. The combination with an internal combustion engine, an intake manifold for the engine, a carbureter and a control device therefor, of fluid pressure operated means for admitting air directly into the manifold, and means including a thermostat subject to the temperature of the engine for actuating said fluid pressure operated means when the carbureter is operated partially or wholly to idling position and the engine is operating above idling speed, said last mentioned means being operatively connected to the carbureter control device.

7. The combination with an internal combustion engine, an intake manifold for the engine, a carbureter and a control device therefor, of a fluid pressure operated valve for admitting air into the manifold, control means operated by the control device and an engine operated governor controlled device cooperating with said control

means for actuating said valve to open it if the engine is operating above idling speed and the carbureter control device is retarded from any operating position to a position corresponding to a lower speed.

8. In a mechanism as described, an internal combustion engine, valve controlled means for supplying air to the engine cylinders, electromagnetic means for operating the valve, a circuit therefor and an engine operated governor for controlling said circuit whereby said electromagnetic means is only operated when the engine is operating above a predetermined speed greater than that corresponding to the fuel supply to the engine, and thermostatic means subject to the engine temperature for finally completing said circuit when the engine temperature reaches normal.

9. The combination with an internal combustion engine and an accelerator controlled carbureter therefor, of means connected to and controlled by the accelerator and the engine speed for introducing air into the engine cylinders when the carbureter first moves toward or is in idling position from any to any operating position and the engine is operating above a predetermined speed.

10. The combination with an internal combustion engine having intake valves, a carbureter for said engine and carbureter control means, of means for admitting air to the intake valves, controlled by the carbureter control means, the engine speed and the engine temperature.

11. The combination with an internal combustion engine, an intake manifold for the engine, a carbureter connected to said manifold and carbureter control means, of means connected to and controlled by the carbureter control means for admitting air into the intake manifold when the carbureter control means is initially retarded from any operating position and the engine is operating above a predetermined speed.

12. The combination with an internal combustion engine having an intake manifold, a carbureter connected thereto and carbureter control means, of a plurality of valves in the intake manifold, and means influenced by the speed of the engine and directly by the operation of the carbureter control means for opening said valves when the carbureter control means is partially retarded from any operating position and the engine is operating above idling speed.

13. The combination with an internal combustion engine having intake valves, a carbureter for said engine and carbureter control means, of a plurality of valves operable to supply air to the intake valves, and electromagnetic means controlled by the engine speed and the carbureter control means for opening said valves to admit air to the intake valves when the carbureter control means is first retarded from any operating position and the engine is operating above idling speed.

14. The combination with an internal combustion engine having intake valves, a carbureter for said engine and carbureter control means, of at least one fluid pressure operated air supply valve operable to supply air to the intake valves, a source of fluid pressure, electromagnetic means for controlling the supply of fluid pressure to the valve, and means subject to the speed of the engine and controlled by the carbureter control means for operating the electromagnetic means when the engine is operating above a predetermined speed and the carbureter control is retarded from a position corresponding to the operating speed.

15. The combination with an internal combustion engine having intake valves, a carbureter for said engine and carbureter control means therefor, of fluid pressure operated means for admitting air to the intake valves, and means including a thermostat subject to the temperature of the engine for actuating said fluid pressure operated means when the carbureter control means is retarded and the engine is operating above idling speed.

16. The combination with an internal combustion engine having intake valves and a carbureter including a throttle for supplying fuel to the engine, of means for supplying heated air to the intake valves at at least one point between the carbureter and said valves, and means for delaying the admission of the air to the intake valves until after the engine has obtained normal operating temperature.

17. The combination with an internal combustion engine having intake valves, an intake manifold therefor, at least one fluid pressure operated valve operable to admit air to the intake manifold, air inlet ports in said valve, an outlet port in said valve leading to the intake manifold, an operating chamber for said valve, and means for reducing the areas of said inlet ports as fluid pressure in the operating chamber moves the valve towards the position in which it closes its outlet port, said valve being operationally influenced by the operating pressure therein, atmospheric pressure, and the pressure in the intake manifold.

18. The combination with an internal combustion engine having intake valves, an intake manifold, a carbureter and a throttle therefor, of at least one valve arranged to admit air at atmospheric pressure to the intake valves, said valve being operated by the pressure of the atmospheric and the fluid pressure in the intake manifold, and means for controlling application of said intake manifold pressure to the valve by and in accordance with the engine speed and any retarding of the carbureter throttle.

19. The combination with an internal combustion engine having an intake manifold, a carbureter and a throttle therefor, of at least one valve with a plunger, a casing therefor and ports therein, said valve being arranged to admit air at atmospheric pressure to the intake manifold, said valve being operated by the pressure of the atmospheric air and the fluid pressure in the intake manifold, the shape of the valve plunger and casing being such that as the valve closes, converging surfaces are provided between the air inlet ports and the restricting area between the valve and its seat, the application of intake manifold pressure to a portion of the valve being influenced by the partial retarding of the carbureter throttle.

20. The combination with an internal combustion engine having intake valves, an intake manifold, a carbureter and a throttle therefor, of at least one valve with a plunger, a casing therefor and ports therein, said valve being arranged to admit air at atmospheric pressure to the intake valves, said valve being operated by the pressure of the atmospheric air and the fluid pressure in the intake manifold, the shape of the valve plunger and casing being such that as the valve closes converging surfaces are provided between the air inlet ports and the restricting area between the valve and its seat, the application of in-

take manifold pressure to a portion of the valve being influenced by any retarding of the carbureter throttle.

21. The combination with the intake manifold of an internal combustion engine having a port therein, of a pressure fluid operated valve for opening and closing said port, a pressure fluid supply connection from the intake manifold to said valve, and an electro-magnet valve in said connection, and means for operating the electro-magnet valve when the engine throttle valve moves toward retarded position.

22. The combination with an internal combustion engine having an intake manifold and a fuel throttle therefor, of electro-magnetic means for admitting air into the intake manifold, a manual for operating said throttle and connected thereto, a switch operated by said manual, a current source, and circuits including said source, switch and magnet valve whereby the switch is closed upon reversal of movement of the manual from throttle advance to throttle retard from any position.

23. The combination with an internal combustion engine having an intake manifold and a fuel supply carbureter including a throttle, of valve means for supplying air into the intake manifold between the engine and the carbureter, means for operating the valve means to supply air into the intake manifold when the carubreter throttle is retarded and the engine is operating above a predetermined speed, and means for delaying the operation of said valve means until the engine has attained normal operating temperature.

24. The combination with an internal combustion engine having an intake manifold and a fuel supply carbureter throttle, of pressure fluid operated means for supplying air into said manifold, said means being operated by the conjoint action of the pressure in the manifold and atmospheric pressure, means for controlling the supply to and exhaust from said means of pressure fluid from the intake manifold, and means for operating said supply and exhaust means when the engine is operating above a predetermined speed and the carbureter throttle is retarded.

25. The combination with an internal combustion engine and an intake manifold having a port therein, of a pressure fluid operated valve for opening and closing said port, a pressure fluid connection between the intake manifold and said valve to supply an operating pressure therefor, an electro-magnet valve in said connection for controlling the supply to and exhaust from the valve of pressure fluid, a current source, a circuit from said source to said electro-magnet, a carbureter operating manual, and a switch in said circuit connected to said manual for completing said circuit when said manual is initially moved from any position to a retard position.

26. The combination with an internal combustion engine and an intake manifold having a port therein, of a pressure fluid operated valve for opening and closing said port, a pressure fluid connection between the intake manifold and said valve to supply an operating pressure therefor, an electro-magnet valve in said connection for controlling the supply to and exhaust from the valve of pressure fluid, a current source, a circuit from said source to said electro-magnet, a carbureter operating manual, a switch in said circuit connected to said manual for completing said circuit when said manual is initially moved from any position to a retard position, and means for interrupting said circuit when the potential of said source falls below a predetermined value.

27. The combination with an internal combustion engine and an intake manifold having a port therein, of a pressure fluid operated valve for opening and closing said port, a pressure fluid connection between the intake manifold and said valve to supply an operating pressure therefor, an electro-magnet valve in said connection for controlling the supply to and exhaust from the valve of pressure fluid, a generator driven by said engine and connected to said circuit, a throttle control manual, and a switch in said circuit conneted to said manual whereby said switch is operated to close said circuit when said manual is initially moved to retard from any position and said electro-magnet valve is operated to close said port when the engine speed and hence the generator potential falls below a predetermined value.

28. The combination with an internal combustion engine for propelling a vehicle, having intake valves, of a throttle for controlling the supply of fuel to the engine, means for admitting air to said intake valves, and means operated with said throttle for actuating said first means when the throttle is partially retarded from any operating position and the engine is operating at greater than the speed corresponding to the retarded throttle position.

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