

[54] **DEVICE FOR REGULATING THE RATE OF FLOW OF THE AIR BLOWN INTO THE EXHAUST DUCT OF AN INTERNAL COMBUSTION ENGINE**

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[56] **References Cited**

UNITED STATES PATENTS

2,991,160 7/1961 Claussen..... 60/288

3,197,287 7/1965 Innes..... 60/288

3,360,927 1/1968 Cornelius..... 60/289

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[57]

ABSTRACT

In an internal combustion engine equipped with means adapted to blow air into the exhaust duct of the engine so as to achieve the postcombustion of unburned fractions, the improvement consisting in providing a first member which senses the difference between the pressure in the delivery duct of the air pump and the pressure obtaining in the exhaust duct and acts so as to decrease the rate of flow of the blown in air as the pressure differential is decreased, and a second means which is sensitive to the difference between the pressure in the exhaust duct and the delivery duct of the pump on the one hand, and the atmospheric pressure on the other hand so as to diminish the delivery of the air pump as said second named difference is increased.

5 Claims, 3 Drawing Figures

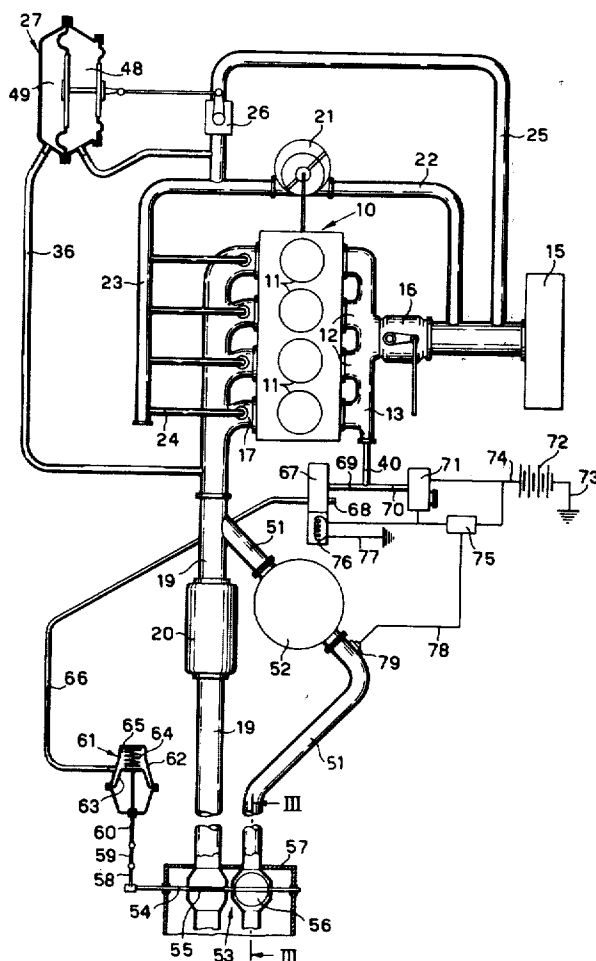


Fig. 1

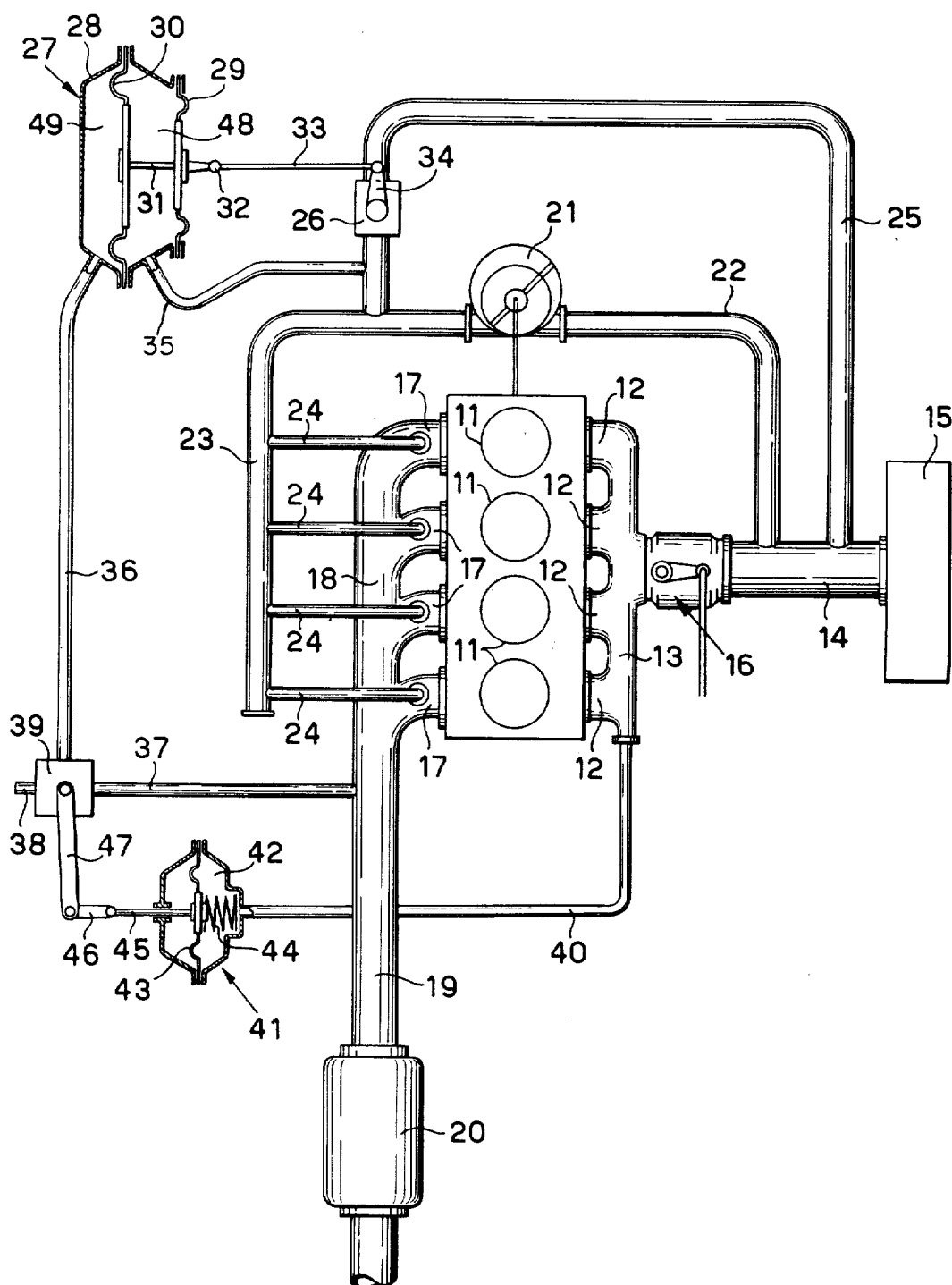


Fig. 2

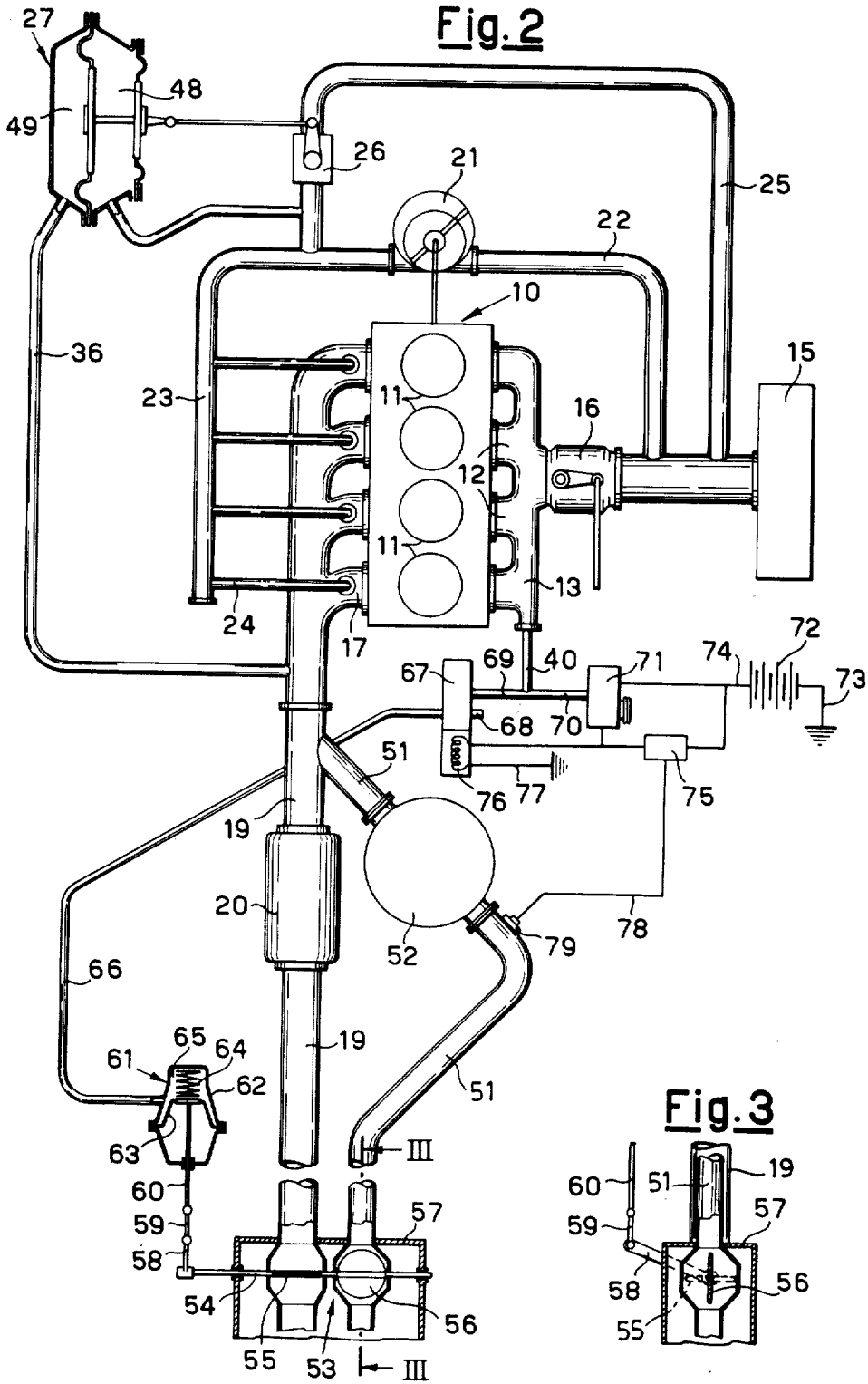
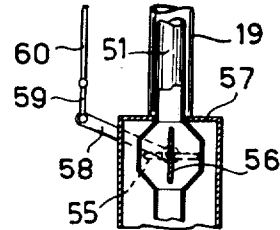


Fig. 3



DEVICE FOR REGULATING THE RATE OF FLOW OF THE AIR BLOWN INTO THE EXHAUST DUCT OF AN INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

It is known that one of the ways for diminishing the percentage of unburned hydrocarbons and carbon monoxide which are present in the exhaust gases of internal combustion engines consists in promoting a post-combustion of these pollutants in an area of the exhaust system prior to discharging the exhaust gases into the atmosphere. Post-combustion can be encouraged by temperature only, or also by the presence of a gas-swept catalyst mass: in both cases, however, postcombustion requires the presence of oxygen. If, as it generally occurs, oxygen is not already contained in the necessary amount in the exhaust gases emerging from the engine explosion chamber, it will become necessary to introduce it into the exhaust duct. To this purpose, it is known to equip the engine with a specially provided metering pump which, driven by the engine itself, draws air from the outside and injects it into the exhaust duct, generally through nozzles which are placed immediately downstream of the exhaust valves of the individual cylinders. It is obvious that the amount of air which is thus introduced should be regulated in order to be adequate to the necessity: it is known that usually a certain excess of air, with respect to the stoichiometric value, is required to encourage combustion, but too high an amount of air makes the temperature of the exhaust gases too low so that postcombustion is slowed down.

If the air pump is of the metering type, its rate of flow can be regarded, as a rough average, to be proportional to the rate of revolution of the pump and thus of the engine. On account of the high ratio of the maximum to the minimum rate of revolution of the engine (for example approximately 6), and since the resistances on the delivery side of the pump generate a back pressure which is increased correspondingly to the square power of the rate of flow, starting from a value of the delivery pressure which is considered necessary to the minimum rate of revolution, said pressure would be increased too much (for example 36 times) at the maximum rate of revolution. It is known that, to prevent such a drawback, there is usually on the delivery side of the pump, an automatic valve for discharging or recycling the opening which is counteracted by a preloaded and rather stiff spring.

The exceedingly high increase of the delivery pressure as the rate of revolution is increased, is thus avoided since an ever increasing amount of air is progressively exhausted into the atmosphere without passing through the nozzles of the exhaust manifold.

A regulation of this kind is not adequate to the ever increasing demand of minimizing the amount of pollutants in the engine exhausts. As a matter of fact, on the basis of what has been said above, with the regulation mentioned above, the rate of flow of the pump is essentially and only a function of its piston displacement and the rate of revolution. This means that at a certain determined rate of revolution, the rate of flow of the air injected into the manifold is constant whereas, obviously, the rate of flow of the exhaust gases when the engine rate of revolution is constant, is considerably variable as a function of the throttle angle (and thus of the engine feeding pressure). Generally, the rate of flow of

the exhaust gases when the rate of revolution of the engine is constant can vary from 1 to 6 when passing from the closed throttle to the wide open throttle configuration. The result is that, in correspondence therewith, the value of the ratio of the rate of flow of the air injected for the postcombustion to the rate of flow of the exhaust gases, is varied from 1 to 1/6.

OBJECTS AND SUMMARY OF THE INVENTION

An object of the present invention is to obtain a substantially constant ratio between the rate of flow of the exhaust gases and the rate of flow of the air injected therein for postcombustion, at least within a preselected rate of revolution field of the engine.

An additional object of the invention is to enable such a ratio to be varied, more particularly in the sense of reducing the rate of flow of the blown in air when the engine is driven so as to deliver a high power and postcombustion is regarded as being either unnecessary or unadvisable.

According to the present invention, an internal combustion engine comprises an intake piping, an exhaust piping, a pump driven by the engine itself and which draws air from the atmosphere to discharge through a delivery piping the air compressed in said exhaust piping, means adapted to vary the rate of flow which is passed through said delivery pipings, and is characterized in that a first member is responsive to the differential between the pressure in the delivery piping of the pump and the pressure obtaining in the exhaust piping, said first member being connected to said means in the sense of diminishing said rate of flow as said differential is increased, a second member being sensitive to the differential between at least one of said pressures in the exhaust piping and in the delivery piping and the pressure of the outside atmosphere, with said second member being connected to said rate of flow varying means in the sense of diminishing the rate of delivery of the pump as said differential is increased.

In order that the objects and the features of the invention may become clearer, two exemplary embodiments thereof will now be described in the accompanying drawings, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a diagrammatical overall view of a first embodiment of the invention,

FIG. 2 shows a diagrammatical overall view of a second embodiment, and

FIG. 3 is a cross-sectional view taken along the line III—III of FIG. 2, the view looking in the direction of the arrows.

DETAILED DESCRIPTION OF THE EMBODIMENTS

As diagrammatically shown in FIG. 1, an internal combustion engine generally shown at 10 comprises a set of cylinders 11, fed by intake ducts 12 which open into a manifold 13. A duct 14 is in communication with the atmosphere through a filter 15 and feeds the manifold 13 through throttling means known per se and generally shown at 16, which can be controlled so as to vary the feeding and thus the power delivered by the engine. In addition, each cylinder 11 is equipped with an exhaust duct 17 and the ducts 17 merge into a manifold 18 which is extended into an exhaust pipe 19 for which a muffler 20 is provided. The engine 10 and its

accessories as indicated above, are not described in detail herein since they are known and can be manufactured according to techniques which are known to those skilled in the art. Other parts which have not been shown, such as, for example, the fuel feeding means, the regulation and control members, could take any form as appropriately selected among the conventional ones.

A conventional rotary metering pump 21 is mechanically connected to the engine 10, so as to be driven to rotation therewith at a proportional speed and is fed by the intake piping 22 which branches off from the duct 14.

A delivery pipe 23 of the same pump 21 branches off into small tubes 24 which inject air in the ducts 17. A recycling pipe 25 connects the pipe 23 to the duct 14 and is cut off by a valve 26 which is controlled as will be explained hereinafter. A pressure sensing device, generally shown at 27, is composed by a stiff outer wall 28 closed by a resiliently deformable diaphragm 29 and, wherein, a second deformable diaphragm 30 defines two chambers 48 and 49.

The diaphragms 29 and 30 are centrally connected to a stem 31, to a projecting end 32 of which a link 33 is linked which, in turn, is connected to a control lever 34 of the valve 26. In the chamber 48 opens a small tube 35 which connects the chamber to the pipe 25 and the chamber 49 is connected in turn to a small tube 36 which is alternately placed in communication either with a duct 37, opening into the pipe 19, or with an outside exhaust 38, under the control of a valve 39. From the intake manifold 13 branches off a duct 40 which feeds a pressure sensing device generally shown at 41 and consisting of an outer rigid casing 42 to which is circumferentially connected a diaphragm 43 which rests against a spring 44 which works under compression and has, centrally affixed thereto, a stem 45 which is linkably connected, by a link 46, to a control lever 47 of the valve 39.

The operation of the assembly shown in FIG. 1 is described in the following: as the throttling means 16 of the intake to the engine 10 are partially closed, a negative pressure obtains in the manifold 13 so that the diaphragm 43 is drawn against the bias of a spring 44 and this movement of the diaphragm controls the valve 39 to connect the ducts 36 and 37: in such a case, in the chamber 49, the pressure p_e of the pipe 19 obtains, and in the chamber 48 there obtains the pressure p_a of the pipe 23.

The valve 26 of a conventional make, for example a butterfly valve, is mounted so as to become opened when the stem 31 is shifted towards the left of FIG. 1 and to become closed as the stem 31 is shifted towards the right. Thus, when the pressure in the chamber 48 is increased, as compared with that of the chamber 49, the valve 26 is controlled so as to increase the rate of flow of air in the duct 25. The mode of operation of the device 27 will become clearer in the light of the following considerations: by indicating with A the area of the diaphragm 29, with B the area of the diaphragm 30 and with p_e the outside pressure, the equation of the equilibrium of the forces acting upon the stem 31, when considering the force required to actuate the valve 26 negligible, is:

$$a. (p_a - p_e) A = (p_a - p_g) B$$

Considering then that the specific gravity of the ex-

haust gas is γ and S the area of the restricted section capable of giving a pressure drop equal to the one the exhaust gas undergoes when passing through the pipes 17, the manifold 18, the duct 19 and the relevant muffler 20, the following equation can be written:

$$b) \quad p_a - p_e = \frac{\gamma_a}{2g} \left(\frac{Q}{S} \right)^2$$

wherein g is the acceleration of gravity and Q the rate of flow.

Then be γ_a the specific gravity of air and s the equivalent area, that is, the area of the restricted cross section which is capable of giving the same pressure drop as that the air undergoes when passing through the tubes 24 and the relative terminals not shown: in addition, be "q" the rate of flow of the air sent from the pipe to the pipes 24, or the delivery rate of the pump 21, less the rate of flow which is recycled through the piping 25. The following relationship can be written:

$$c) \quad p_a - p_e = \frac{\gamma_a}{2g} \left(\frac{q}{s} \right)^2$$

From the relationship a), b) and c) one obtains, subsequently:

$$d) \quad \frac{p_a - p_e}{p_e - p_e} = \frac{\gamma_a}{\gamma_g} \left(\frac{q}{Q} \right)^2 \left(\frac{S}{s} \right)^2$$

$$(p_a - p_e) = \frac{B - A}{A} (p_a - p_e)$$

$$\left(\frac{q}{Q} \right)^2 = \frac{\gamma_g}{\gamma_a} \left(\frac{s}{S} \right)^2 \frac{A}{B - A}$$

From the final relationship d) it can be concluded that the ratio between the rate of flow of the exhaust gases and the rate of flow of air blown therein by the pump 21 is maintained at a substantially constant level by the tendency of the diaphragms 29 and 30 to place themselves in an equilibrium position, drawing therewith the stem 31 which is integral therewith.

Let it be assumed, for example, that the feeding to the running engine is abruptly closed at 16, and the engine, by the inertia of its own or of the vehicle is kept, at least for a while, running at a substantially constant rate of rotation: in this case, the delivery of the exhaust gas is decreased although the delivery of the pump 21 remains virtually unaltered. In this case, the pressure in the chamber 48 is high as compared with the pressure in the chamber 49 and the stem 31 is moved towards the left, opening the valve 26 and thus recycling the excess fraction of the pump delivery. Without examining in detail other operative conditions, it is obvious that, in any case, the device 27 places itself in an equilibrium position, which corresponds to a preselected ratio, which is constant, between the rates of flow of the exhaust gases and the post-combustion air added thereto, consistently with the objects of the present invention.

When the throttling means 16 of the engine intake is open beyond a preselected position, the pressure in the manifold 13 is increased until, at a threshold value, the conventional device 41 is controlled so as to move the valve 39 to connect the ducts 36 and 38, so that the pressure in the chamber 49 is abruptly decreased and

the device 27 opens the valve 26 to minimize the air injected by the ducts 24 into the tubes 17.

In the embodiment shown in FIG. 1, the postcombustion of the unburned fractions which are contained in the exhaust gases can be considered as spontaneously occurring, or to be encouraged by suitable catalysts placed in the exhaust duct. In both cases, the minimization of the postcombustion air as introduced when the engine delivers high powers prevents unacceptable overheating.

FIGS. 2 and 3 show a modification of the embodiment shown in FIG. 1, and like parts are indicated by like symbols.

More particularly, the duct 18 is connected to the tube 19 in a direct fashion and from the tube 19, upstream of the muffler 20, a duct 51 is branched off in which a catalyst muffler 52 of conventional type is inserted, which contains a mass acting as a catalyst of the combustion of the unburned fractions contained in the exhaust gases. The two tubes 19 and 51 are controlled by a valve assembly generally shown at 53, which is formed by a rotatable pin 54 which passes through the two tubes placed side by side and carrying two ganged butterflies 55 and 56, each of which can be controlled to throttle either duct. The throttles are angularly staggered so that, when the butterfly 55 closes the duct 19, the butterfly 56 is arranged so as to leave the duct 51 open, as shown in the drawings, and vice versa. To the pin 54, which is diagrammatically shown as being rotatably supported by a supporting member 57 integral with the tubes, there is affixed a lever 58 which is connected, through a linking rod 59, to a stem 60 of a pressure sensing mechanism 61 of the kind in which to a rigid outer casing 62 there is circumferentially affixed a diaphragm 63 to whose center the stem 60 is affixed. The diaphragm 63 can be moved against the bias of a spring 64 so as to vary the volume of a space 65 into which a duct 66 opens: the duct 66 is connected by an electromagnetic valve 67 alternately with the outside at 68 or with a branch 69 of the duct 40. A further branch 70 of said duct drives a pressure-stat 71 of conventional make of the type in which a member sensitive to the driving pressure controls the closing and opening of an electric switch. A current generator 72, which can be, for example, the battery of the vehicle, is connected by a line 73 to a grounded pole: the other pole of the generator is connected by means of a line 74, having in parallel the pressure-stat 71 and a switch 75, to an end of a control coil 76 of the electromagnetic valve 67, whose other end is grounded at 77. The switch 75 is normally open and is driven to close, through a line 78, by a temperature-sensing device 79 mounted on the tube 51, when the exhaust gases exceed in the tube 51 a preselected temperature. Similarly, the pressure-stat 71 controls the closure of the relative switch when the pressure in the duct 70 exceeds a preselected value.

The operation of the device shown in FIGS. 2 and 3 will now be described in the following with particular reference to the already described operation of the embodiment shown in FIG. 1. It is fitting to observe that, as can be usually seen, the tube 51, also due to the presence of the catalyst muffler 52, offers a resistance to gas flow which is higher than that of the tube 19 with its dampening muffler 20.

When the engine is rotated at low values of delivered power or with the means 16 placed to throttle the intake stream, a highly negative pressure obtains in the

manifold 13: under these conditions, when also the temperature in the duct 51, to which the sensing device 79 is subjected, is below a preselected value, the valve assembly 53 is arranged as in FIG. 2 and FIG. 3 and the exhaust gases of the engine 10 pass through the tube 51.

The pressure sensing device 27 controls in this way the blowing of air into the ducts 17 in an appropriate and constant ratio with the exhaust gases, just as has been described to occur in the embodiment shown in FIG. 1, when the valve 39 connects the ducts 36 and 37. The exhaust gases, combined with the air fed by the ducts 24, complete the combustion in the muffler 52.

When the engine delivers high power values, the increase of the pressure in the manifold 13 due to the opening of the throttling device 16, drives the pressure stat 71 to connect the coil 76 with the battery 72 and the valve 67 places the duct 66 in communication with the exhaust 68. Then the spring 64 acts upon the diaphragm 63 and the valve unit 53 is driven so as to position the butterfly 56 to close the duct 51 and the butterfly 55 to open the duct 19: this occurs by a rotation of the shaft 54 through 90°: since the gases pass, under these conditions, through the duct 19 offering the less resistance, the pressure in the collector 18 is abruptly lowered and the device 27 consequently reduces to a minimum value the air blown by the ducts 24.

A similar action is impressed by the temperature-sensing device 79 when the gases which pass through the muffler 52 are heated above a preselected value: under these conditions, the switch 15 is closed and energizes the coil 76 thus moving the valve 67 so as to connect the duct 66 to the exhaust 68, with the effects being those described above on the unit 53.

The controlled interruption of the exhaust gas flow through the tube 51 and thus the muffler 52 prevents overheating of the catalyst mass contained in the muffler, with the possibly ensuing damages being thus prevented.

The embodiments illustrated above are, as outlined above, merely exemplary and suitable modifications can be introduced in the individual component parts, and to their arrangement without departing from the scope of the invention. For example, various configurations can be attributed to the pressure sensing members 27 and 41, as well as to the valves and the pump 21: according to the conventional art further ancillary apparatus known per se and not described in detail herein can be adopted.

What is claimed is:

1. An internal combustion engine comprising an intake piping, an exhaust piping, a pump driven by the engine for drawing air from the atmosphere and discharging through a delivery duct the compressed air into said exhaust piping, means for varying the rate of delivery through said delivery duct, the improvement including first means sensitive to the differential between the pressure in the delivery duct of the pump and the pressure in the exhaust piping, said first means being connected to said means for varying the rate of delivery in the sense of diminishing said rate of flow as the differential is increased, second means sensitive to the differential between one at least of said pressures in the exhaust piping and in the delivery duct and the outside atmosphere pressure; said second means being connected to said means for varying the rate of delivery of the pump in the sense of diminishing the rate of de-

livery of the pump as the differential is increased, said first and second sensitive means being formed by a casing having a surface consisting of a first deformable diaphragm and partitioned in two half spaces by a second deformable diaphragm which is substantially parallel to said first diaphragm, the half space comprised between the two diaphragms being connected to the delivery duct of the pump, the other half space being connected to the initial portion of the exhaust piping, the diaphragms being mechanically interlinked and connected with said means for varying the rate of flow delivered through the delivery duct.

2. The internal combustion engine according to claim 1, characterized in that said first diaphragm has an area which is less than the area of the second diaphragm.

3. An internal combustion engine comprising an intake piping, an exhaust piping, a pump driven by the engine for drawing air from the atmosphere and discharging through a delivery duct the compressed air into said exhaust piping, means for varying the rate of delivery through said delivery duct, the improvement including first means sensitive to the differential between the pressure in the delivery duct of the pump and the pressure in the exhaust piping, said first means being connected to said means for varying the rate of delivery in the sense of diminishing said rate of flow as said differential is increased, and second means sensitive to the differential between one at least of said pressures in the exhaust piping and in the delivery duct and the outside atmosphere pressure; said second means being connected to said means for varying the rate of delivery in the sense of diminishing the rate of delivery of the pump as said differential is increased; and a member sensitive to the power delivered by the engine to control said means for varying the rate of delivery in the sense of minimizing said rate of delivery when the delivered power of the engine exceeds a preselected value.

4. An internal combustion engine comprising an intake piping, an exhaust piping, a pump driven by the

engine for drawing air from the atmosphere and discharging through a delivery duct the compressed air into said exhaust piping, means for varying the rate of delivery through said delivery duct, the improvement including first means sensitive to the differential between the pressure in the delivery duct of the pump and the pressure in the exhaust piping, said first means being connected to said means for varying the rate of delivery in the sense of diminishing said rate of flow as the differential is increased, second means sensitive to the differential between one at least of said pressures in the exhaust piping and in the delivery duct and the outside atmosphere pressure; said second means being connected to said means for varying the rate of delivery of the pump in the sense of diminishing the rate of delivery of the pump as the differential is increased, a member sensitive to the power delivered by the engine to control said means for varying the rate of delivery in the sense of minimizing the rate of delivery when the delivered power of the engine exceeds a preselected value, said exhaust duct comprising a first duct at least partially parallel to a second duct in which a device is inserted which is a catalyst of the postcombustion of the exhaust gases, said second duct offering a resistance to gas flow which is greater than the resistance offered by said first duct, valve means to control the gas flow through said first and said second ducts, and a device sensitive to the power delivered by the engine controlling said valve means in the sense of sending the exhaust gases into said first duct when the power delivered by the engine exceeds a preselected value and into said second duct when the power is below said value.

5. The internal combustion engine according to claim 4 characterized in that means sensitive to the temperature of the gases are arranged in the second exhaust duct downstream of the catalyst device for controlling said valve means in the sense of sending the exhaust gases into the first duct when the temperature is above a preselected value.

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