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**Yokohama, Japan**  
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**1968**  
 [33] **Japan**  
 [31] **43-20781, 43-20782 and 43-20783**

[56]

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[54] **APPARATUS FOR REDUCING HYDROCARBON  
 CONTENT OF ENGINE EXHAUST GASES DURING  
 DECELERATION OF AUTOMOBILE**  
**13 Claims, 10 Drawing Figs.**

[52] U.S. Cl..... **123/119,**  
**123/97, 261/41**  
 [51] Int. Cl..... **F02m 7/04**  
 [50] Field of Search..... **123/97B,**  
**97, 119; 261/41.4, (Inquired)**

**ABSTRACT:** Apparatus for reducing the engine exhaust gas hydrocarbon content during deceleration of an automobile through the enrichment of the air fuel mixture in the slow running mixture supply flow path of a carburetor, the mixture being enriched by increasing the fuel content in response to the rapid increase in the intake manifold vacuum when decelerating.

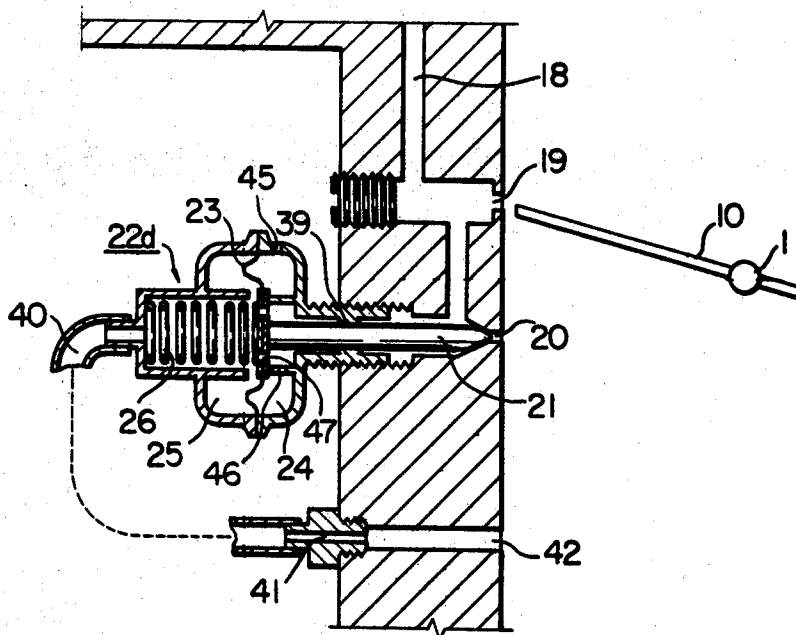


Fig. 1

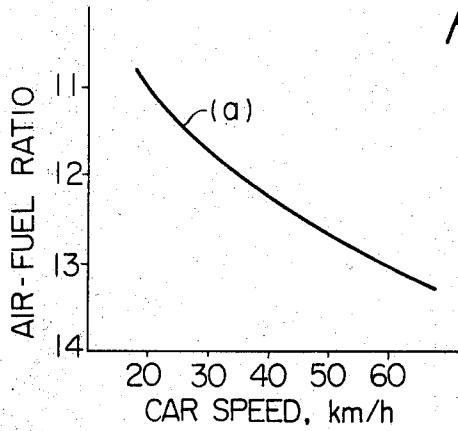


Fig. 2

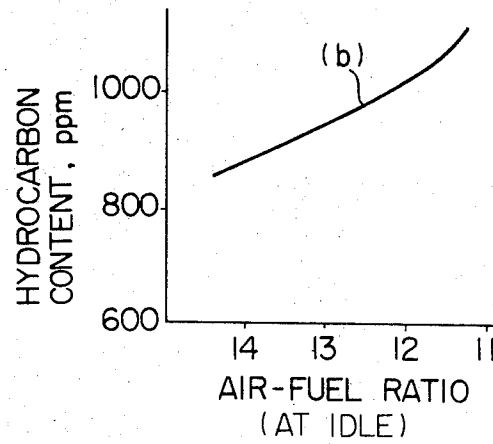
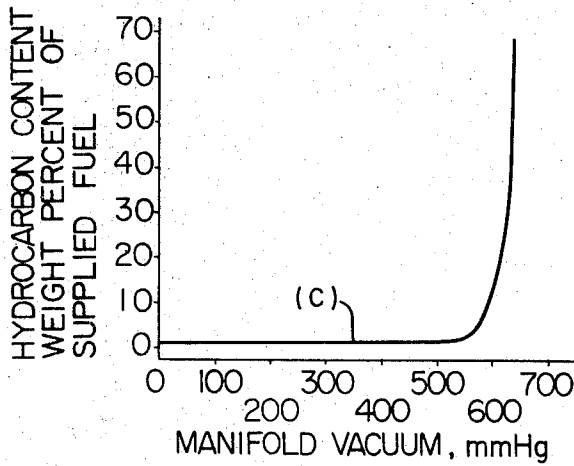


Fig. 3



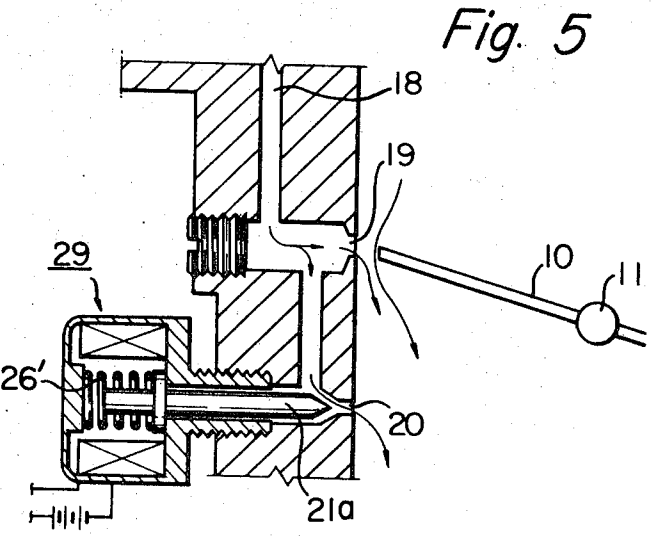
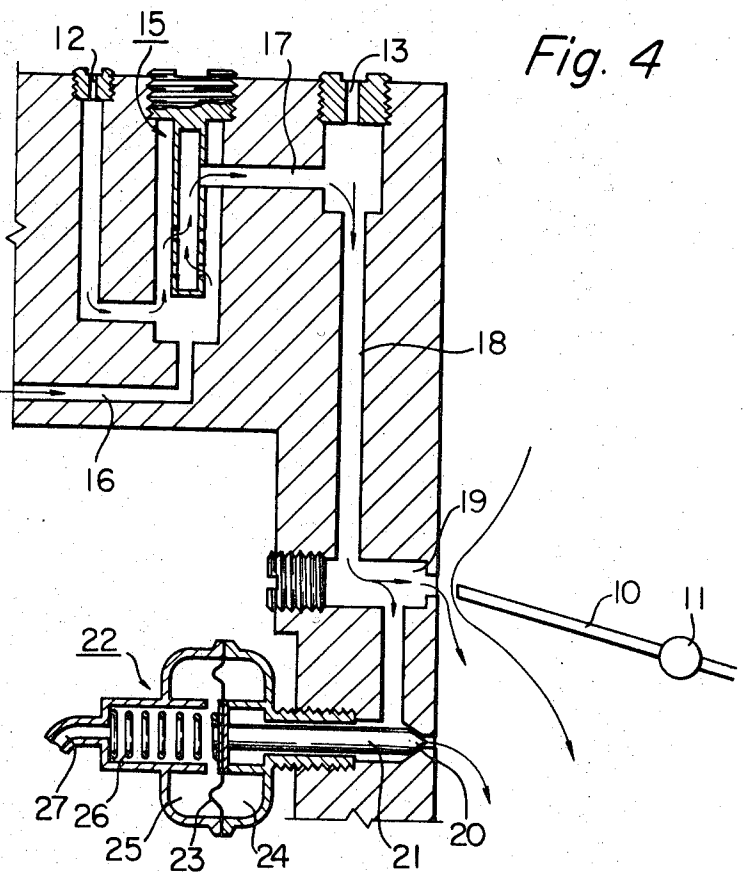


Fig. 6

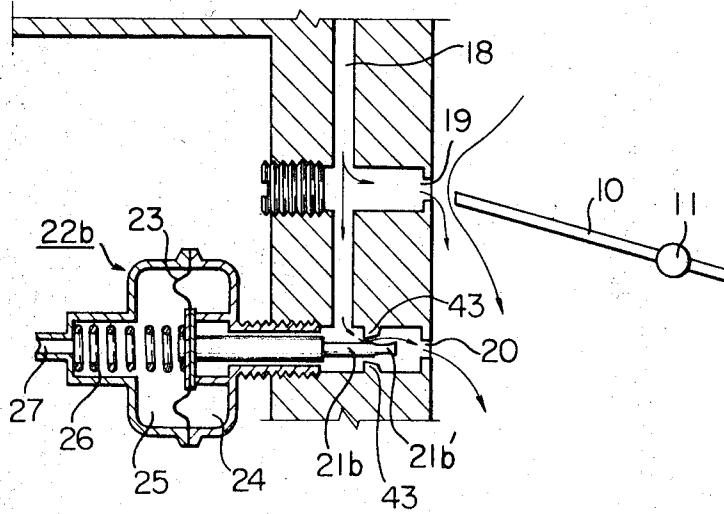


Fig. 7

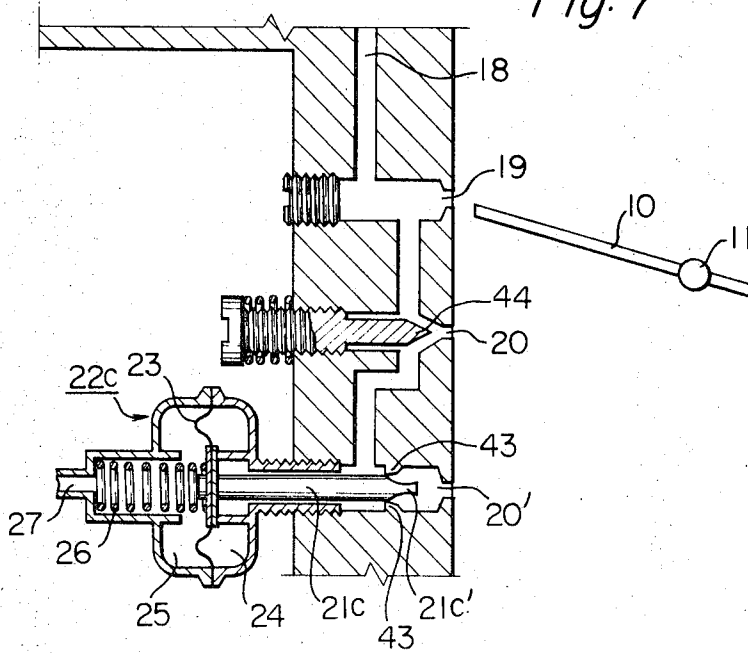


*Fig. 8*

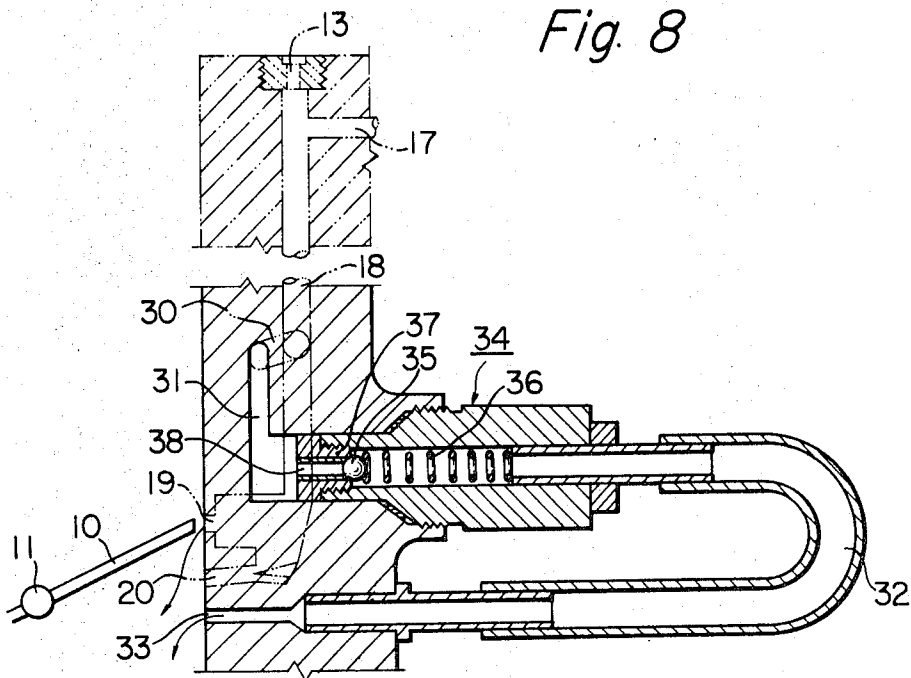


*Fig. 9*

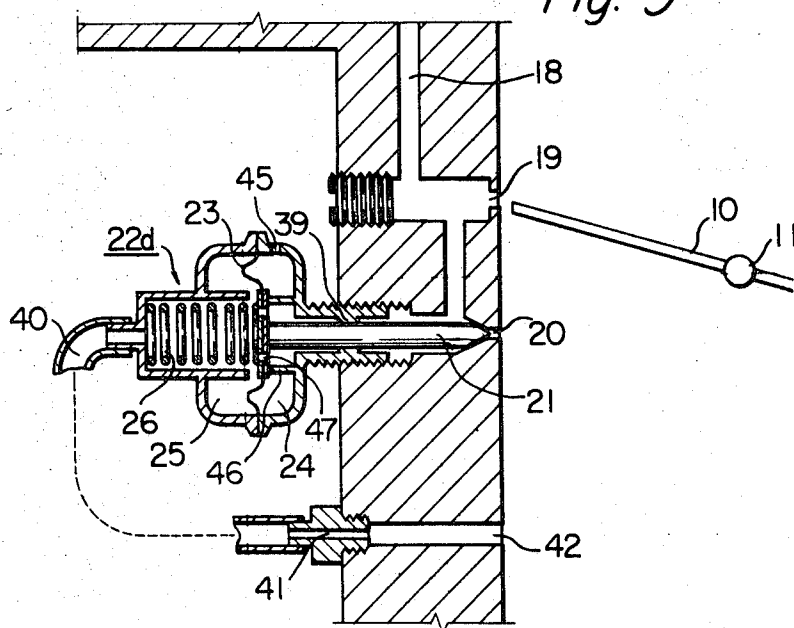
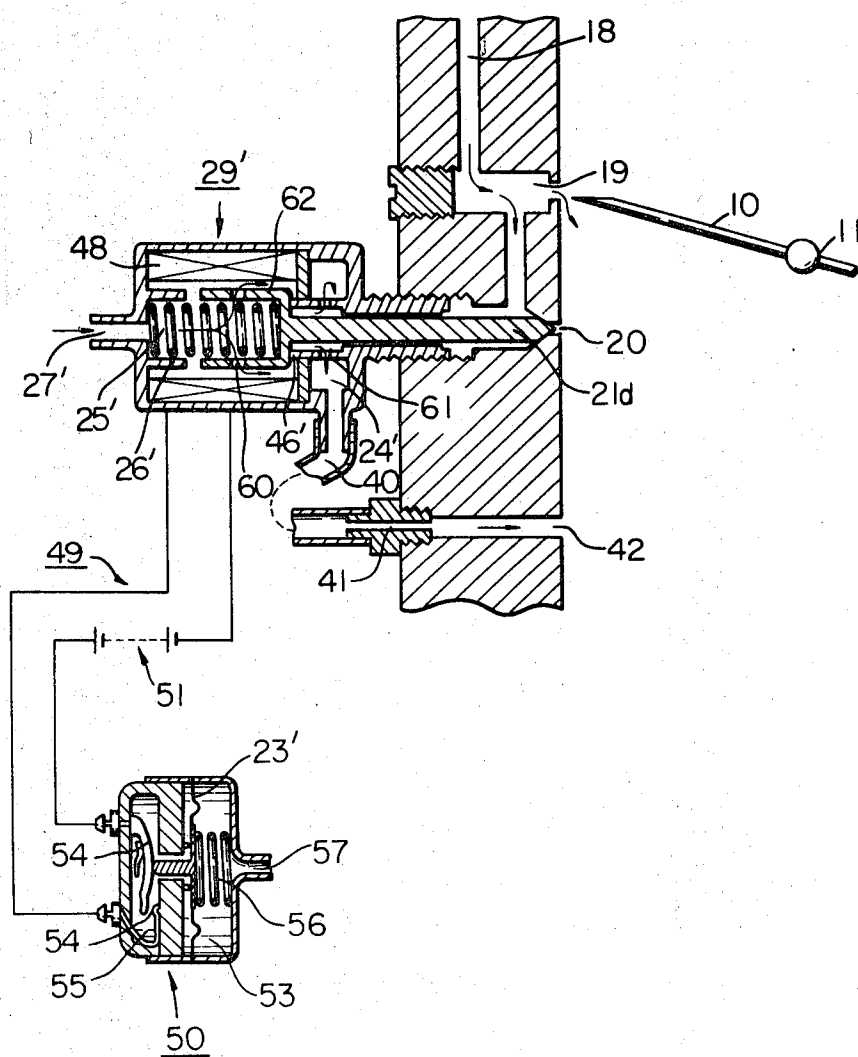


Fig. 10



# APPARATUS FOR REDUCING HYDROCARBON CONTENT OF ENGINE EXHAUST GASES DURING DECELERATION OF AUTOMOBILE

The present invention relates to a system for reducing the hydrocarbon content of exhaust gases of an automotive gasoline-powered internal combustion engine, and more particularly to a system for controlling the air-fuel ratio of an air-fuel mixture to be drawn into the engine by way of the slow running mixture supply flow path of a carburetor during deceleration of the automobile.

The presence of hydrocarbons in engine exhaust gases is of keen interest to the automotive industry for two major reasons—air pollution and fuel economy. To solve problems concomitant with these two factors, numerous attempts have heretofore been made, involving an effort to improve the performance characteristics of the carburetor in such a manner as to control the air-fuel ratio of the air-fuel mixture during operations of the automobile. Difficulties have, however, been encountered by the prior art methods and systems in maintaining the air-fuel ratio of the engine air-fuel mixture at a proper level invariably under the widely varying driving conditions and without impairing the driveability of the automobile.

Automobile operation is usually divided into four different driving conditions; idle, acceleration, normal cruising and deceleration. The range of hydrocarbon content of engine exhaust gases varies markedly according to the mode of automobile operation, and experiments thus far conducted on various engine exhaust gases emitted under different modes of automobile operation have revealed that the hydrocarbon content of exhaust gases peaks up during deceleration. This is due partly to the inability of the carburetor to supply the engine with an air-fuel mixture having an air-fuel ratio which is appropriate to provide for a satisfactory combustion of the mixture, and partly to the unsatisfactory combustion and misfiring of the air-fuel mixture in the combustion chamber that are invited by the increase in the intake manifold vacuum during deceleration. In order to accomplish satisfactory combustion of the air-fuel mixture during deceleration, therefore, it is important that the carburetor is capable of supplying the engine with a mixture having an air-fuel ratio best for each mode to eliminate the presence of partially burned or unburned hydrocarbons in the engine exhaust gases, and further to increase the amount of the mixture to be supplied to the engine thereby to prevent an excess increase of the intake manifold vacuum during deceleration. The fact is however that, during deceleration of the automobile, the air-fuel ratio of the mixture produced by the carburetor remains substantially unchanged from that which is produced during the idle operation in spite of the engine speed and intake manifold vacuum changing as the automobile speed changes. Thus, it is necessary for reducing the hydrocarbon content of engine exhaust gases during deceleration either to have the air-fuel ratio of the air-fuel mixture for the idle operation fixedly determined at a value which is adequate for effecting the satisfactory combustion of the mixture under all the driving conditions or to install in the carburetor such a device that is capable of controlling the air-fuel ratio within a predetermined range during deceleration.

It is therefore a prime object of the invention to provide a system which is capable of reducing the hydrocarbon content of engine exhaust gases produced during deceleration of an automotive engine independently of the remaining modes of operation.

It is another prime object of the invention to provide a system adapted to maintain the air-fuel ratio of an engine fuel mixture at an optimum level exclusively during deceleration of the automobile.

It is another prime object of the invention to provide a system for maintaining the air-fuel ratio of the engine fuel mixture at a proper level during deceleration and at the same time reducing the intake manifold vacuum that increases remarkably as soon as the automobile slows down, whereby the total hydrocarbon content of engine exhaust gases emitted

throughout the different modes of automobile operation is reduced to a minimum.

It is another prime object of the invention to provide a system adapted to enrich, during deceleration, the air-fuel mixture by limiting the amount of air to be mixed with the liquid fuel through the provision of special valve and orifice arrangement to the slow running fuel supply flow path of a carburetor.

It is another prime object of the invention to provide a system which is capable of continuously controlling the air-fuel ratio of the air-fuel mixture to an optimum level in close relation to the decrease in the automobile speed during deceleration.

It is another prime object of the invention to prevent air pollution caused by the presence of an unburned air-fuel mixture or hydrocarbons in engine exhaust gases and at the same time to significantly save the engine fuel consumption of an automobile driven by a gasoline-powered internal combustion engine.

Further and other objects of the present invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings in which like characters of reference designate corresponding parts in all figures and in which:

FIG. 1 is a graph showing an example of a desired relationship between the air-fuel ratio of an air-fuel mixture and the automobile speed during the decelerating operation;

FIG. 2 is a graph showing the relationship between the air-fuel ratio determined under the idling conditions of the engine and the total engine exhaust gas hydrocarbon content under the idling, accelerating and normal cruising operations, viz, under the operations excepting deceleration;

FIG. 3 is a graph showing the effect of the intake manifold vacuum on the exhaust gas hydrocarbon content;

FIG. 4 is a partial vertical sectional view of a carburetor incorporating a system embodying the present invention, in which the amount of the air-fuel mixture is controlled during deceleration of the automobile by a combination valve and diaphragm assembly which is responsive to the fluctuations in the intake manifold vacuum;

FIG. 5 is similar to FIG. 4, but shows a modification of the system shown in FIG. 4, in which the amount of the air-fuel mixture is controlled by the cooperation of a solenoid valve assembly and a diaphragm switch assembly (not shown);

FIG. 6 is also similar to FIG. 4, but shows another modification, in which the amount of the air-fuel mixture is controlled to a proper level continuously by means of a valve member having an enlarged tip;

FIG. 7 is similar to FIG. 6, but shows a further modification, in which the valve member having an enlarged tip is provided at a third port opening into the main mixture supply flow path of the carburetor;

FIG. 8 is a partial vertical sectional view of a further modified form of the system according to the present invention, in which necessary amount of air-fuel mixture is drawn through a check valve assembly into the main mixture supply flow path downstream of the butterfly valve;

FIG. 9 is a partial vertical sectional view of a further modified embodiment of the system according to the invention, in which the suction chamber of the diaphragm assembly is made to communicate with the main mixture supply flow path downstream of the butterfly valve so as to lower the vacuum thereat which is otherwise maintained at an extremely high level during deceleration; and

FIG. 10 is a modification of the embodiment of FIG. 9.

In a carburetor of the conventional type operating at the air-fuel ratio determined specifically for idle operation although the engine speed and intake manifold vacuum change as the automobile speed changes during deceleration, the engine fuel mixture fails to attain an optimum air-fuel ratio assuring satisfactory combustion of the mixture during deceleration.

The hydrocarbon content of engine exhaust gases produced during deceleration will be reduced to a minimum by con-

trolling the air-fuel ratio of the mixture in such a manner as to meet with the curve *a* of FIG. 1 which illustrates an example of a desired relationship between the automobile speed and the air-fuel ratio. One simple and economical expedient of approximately realizing the curve *a* in a usual carburetor may be to restrict the air-fuel ratio fixedly within a certain range, say, anywhere between 12:1 and 13:1 in consideration of the air-fuel ratio at idle of the existing automobiles. This will be achieved by regulating the air-fuel ratio by the use of the usual idle adjusting screw; the air-fuel ratio determined for idling remains substantially unchanged during deceleration, too, as previously noted. Such a restriction of the air-fuel ratio within a relatively low range, however, results in an increased amount of the hydrocarbon content during the idle, acceleration and normal cruising operations, as observed from the curve *b* of FIG. 2, so that it is advantageous to maintain the air-fuel ratio at a higher level throughout the different automobile operations excepting the deceleration, preferably by the use of a carburetor which is operable with a lean air-fuel mixture during deceleration. Thus, controlling the air-fuel ratio for the deceleration (during which a particularly large amount of hydrocarbons are contained in the engine exhaust gases) independently of the other modes of operation is necessitated to reduce the total hydrocarbon content of engine exhaust gases produced under all the driving modes of automobile operation.

In the slow running mixture supply flow path of the conventional carburetors, however, it is extremely difficult to maintain the air-fuel ratio of the air-fuel mixture at an optimum level in the course of the deceleration in view of the particular performance characteristics of the carburetor without use of a suitable control device, though the air-fuel ratio during the idle operation can be regulated as desired. In controlling the air-fuel ratio for the idle operation, moreover, problems are experienced from the difficulty of eliminating the individual errors ranging generally from 9:1 to 15:1, in the air-fuel ratio weight by weight, which is usually regulated by rule of thumb.

The present invention therefore contemplates, before everything else, to improve the slow running mixture supply flow path of a carburetor with a view to maintaining the air-fuel ratio at a relatively high level, preferably within the range 14:1 to 15:1 during the idle operation at a relatively low level, preferably within the range of 12:1 to 13:1, during the deceleration, thereby significantly reducing the total amount of the engine exhaust gas hydrocarbons under the widely varying driving conditions of the automobile.

As is apparent from the curve *b* of FIG. 2, moreover, it will be advantageous for minimizing the aggregated hydrocarbon content of engine exhaust gases emitted during the idling, accelerating and normal cruising operations (namely under all the modes of automobile operations excepting the deceleration) to use a carburetor of the type which is operable with a relatively lean air-fuel mixture, that is, with a mixture having a relatively high air-fuel ratio. The carburetor of this type will have the flow characteristics dictated by the lean side of the flow band in the established carburetor flow curve. Thus, using the system according to the invention in a carburetor having said flow characteristics will be conducive to the reduction of the total amount of hydrocarbons in engine exhaust gases emitted during the different operations of the automobile.

One embodiment of the present invention to achieve such an end is shown in FIG. 4, wherein the carburetor is illustrated with the engine idling and the butterfly valve substantially fully closed. The butterfly valve 10 may be of the type which is usually used in the conventional carburetor and is rotatable with the shaft 11. Represented by 12 and 13 are a first and a second slow running air bleeds, respectively, which are vented to the atmosphere and which are so sized in diameter as to admit a suitable amount of air to the slow running fuel supply flow path of the carburetor. The first and second air bleeds 12 and 13, respectively, are intervened by a slow running jet 15 at which the fuel fed from the liquid fuel supply passage 16 is me-

tered and mixed with air introduced from the first air bleed 12. The mixture of air and fuel is then spurted from the slow running jet 15 into a slow running economizer 17 and further mixed with air introduced from the second air bleed 13. The resultant mixture is fed by way of the air-fuel mixture flow passage 18 to the slow running port 19 and the idling port 20, from both of which the mixture is allowed into the carburetor downstream of the butterfly valve 10 while in the idle operation of the automobile.

According to the present invention, as previously noted, the amount of the air-fuel mixture to be supplied to the engine during the idle and decelerating operations is controlled through the special construction arrangements of a valve and diaphragm mechanism working in response to the fluctuations in the intake manifold vacuum. For this purpose, a needle valve 21 is provided in the idling port 20, with its pointed tip directed toward the outlet of the port 20. Behind the needle valve member 21 is provided a diaphragm assembly 22 which is divided by a diaphragm member 23 into an atmospheric chamber 24 vented from the open air and a suction chamber 25 which communicates with the intake manifold (not shown) of the carburetor by way of a conduit 27. The diaphragm member 23 is connected on its atmospheric chamber side with the needle valve member 21 and on the suction chamber side with a coil spring 26. The coil spring 26 forces the diaphragm member 23 and accordingly the valve member 21 toward the outlet of the idling port 20 while the vacuum in the suction chamber 26 yields to the bias of the spring 26, so that the idling port 20 is closed during the idle operation.

During the idle operation of the automobile when the intake manifold vacuum remains at a relatively low level, the diaphragm member 23 is forced toward the idling port 20 by the action of the spring 26 so that the pointed tip of the needle valve 21 assumes a position to minimize the amount of the air-fuel mixture flowing through the port 20. The fuel mixture to be supplied to the engine through the slow running mixture supply flow path of the carburetor is thus afforded with an optimum air-fuel ratio for the idle operation. The amount of air to be mixed with the fuel may be set at an adequate level by properly determining the apertures of the first and second air bleeds 12 and 13.

When, now, the automobile running at a normal cruising speed starts to decelerate with the butterfly valve 10 substantially closed similarly to the case of the idle operation but with the engine operating at a speed decreasing in accordance with the automobile speed, the intake manifold vacuum to augment abruptly. It therefore follows that the pressure in the suction chamber 25, which communicates with the intake manifold by way of the conduit 27 as previously described, decreases sharply so that the diaphragm member 23 is forced toward the suction side against the action of the coil springs 26. As the diaphragm member 23 thus moves leftwardly of the drawing, the needle valve member 21 connected with the diaphragm member 23 is also moved leftwardly, namely, away from the idling port 20, permitting an increased amount of the air-fuel mixture to flow through the port 20 into the main mixture supply flow path of the carburetor.

The needle valve 21 is arranged in the above described embodiment of the present invention in such a manner as to be relocated directly by the motion of the diaphragm member 23. As an alternative and to enable the valve member to operate with improved stability, however, the needle valve member 21 may be controlled electrically, say, by the cooperation of a solenoid valve assembly and a diaphragm switch assembly.

An example of such construction arrangements is illustrated in FIG. 5, wherein a solenoid valve assembly 29 is mounted behind the idling port 20 and is electrically wired to a diaphragm switch assembly (not shown). The construction of the diaphragm switch assembly is such that it incorporates a set of electric contacts which are kept disconnected from each other while a diaphragm member is subjected to the influence of the vacuum developed during idling in the intake manifold but which are connected through the displacement of the

diaphragm member in response to the rapid increase in the intake manifold vacuum and deceleration. Operating essentially on the same principles as the diaphragm assembly used in the first embodiment of the invention, the diaphragm switch assembly utilized from this second embodiment is removed in FIG. 5 for clarity of illustration.

The solenoid valve assembly 29 used in this embodiment of the present invention may be of the known type and has mounted therein a needle valve member 21a which is similar in shape and effect to that shown in FIG. 4 and a coil spring 26' which is connected with the needle valve member 21a.

Whereas, during the idling operation of the automobile when the intake manifold vacuum remains at a relatively low level, the electric contacts of the diaphragm switch assembly are kept released from each other and the solenoid valve assembly 29 deenergized, holding the needle valve member 21a in a position to restrict the flow of the air-fuel mixture through the idling port 20 by the very action of the coil spring 26'. Thus, a limited amount of the air-fuel mixture is allowed out of the idling port 20 while in the idling operation of the automobile.

When, however, the automobile running at a normal cruising speed starts to decelerate, the intake manifold vacuum increases at an extremely high rate as aforementioned, the electric contacts of the diaphragm assembly are connected together so that the solenoid valve assembly 29 which is electrically wired to the diaphragm assembly causes the valve member 21a to withdraw from the idling port 20, permitting an increased amount of the fuel mixture to spurt into the main mixture supply flow path of the carburetor during deceleration.

It will be understood that the diaphragm assembly 22 used in the first embodiment and the solenoid valve assembly 29 in the second embodiment may be located otherwise, say, anywhere between the economizer 17 and the idling port 20, whereby similar performance and effect to those achieved in the arrangements of FIGS. 4 and 5 will be attained.

It is now apparent that the systems described in the foregoing are specially suited for controlling the amount of the air-fuel mixture to be drawn to the engine so as to maintain the air-fuel ratio of the mixture at predetermined values within predetermined ranges, for example, between 14:1 and 15:1 for the idling operation and between 12:1 and 13:1 for the deceleration. The design concept of the two embodiments resides in that the desired curve *a* of FIG. 1 is approximately realized in a fixed range. It is, furthermore, more advantageous for minimizing the hydrocarbon content of engine exhaust gases to control the air-fuel ratio exactly in agreement with the curve *a*, namely, to have air-fuel ratio reduced continuously as the automobile speed decreases during the deceleration. For this purpose, it is necessary that the amount of the air-fuel mixture introduced through the idling port be increased continuously in proportion to the decrement of the automobile speed in such a manner as to follow exactly the characteristics of the curve *a* of FIG. 1.

In order to accomplish this purpose, as shown in FIG. 6, a curved valve head 21b' with an enlarged tip is attached to the leading end of the straight valve member 21b combined with the diaphragm assembly 22b, while a constriction 43 is provided on the internal wall of the passage to the idling idle port.

During the idle operation of the automobile when the intake manifold vacuum remains at a relatively low level, the diaphragm member 23 is held in its rightmost position as illustrated in the drawing by the action of the coil spring 26 mounted in the suction chamber 25 of the diaphragm assembly 22b so that the valve member 21b fixedly connected with the diaphragm member 23 is also held in its rightmost position on the drawing, thereby restricting the flow rate of the air-fuel mixture through the idling port 20.

During deceleration when the intake manifold vacuum increases abruptly and the diaphragm member 23 is accordingly forced away from the chamber 24, the valve member 21b moves toward the suction chamber 25 against the action of the

spring 26. As the valve member 21b moves toward the chamber 25 and away from the idling port 20, the air-fuel mixture fed from the passage 18, is permitted to spurt into the idling port 20 with a volume gradually decreasing as the curved valve head 21b' passes through the constriction 43. Since, now, the amount of the air-fuel mixture flowing past the valve head 21b' and the constriction 43 is increased, the air-fuel ratio of the engine air-fuel mixture may be relatively low during the deceleration from low speed cruising and relatively high during the deceleration from high speed cruising to low speed cruising, and may be so determined as to exactly agree to the characteristics of the curve *a* of FIG. 1 through the proper selection of the shape and dimensions of the valve head 21b' of the valve member 21b. The clearance between the valve head 21b' and the constriction 43 may be determined by properly determining the length of the screw thread of the diaphragm assembly 22b which is screwed into the carburetor wall.

Illustrated in FIG. 7 is a modification of the system shown in FIG. 6, wherein a third port or a decelerating port 20' is provided in the carburetor wall downstream of the idling port 20. In this embodiment of the present invention, the amount of the air-fuel mixture to be supplied to the engine is controlled during deceleration of the automobile by varying the clearance between the constriction 43 and the valve head 21c' of the mixture shutoff valve member 21c in a manner substantially similar to that used in the embodiment described in connection with FIG. 6. The amount of the air-fuel mixture flowing through the idling port 20 during the idle and decelerating operations may be determined by properly determining the length at which the idle adjusting screw 44 is screwed into the carburetor wall.

FIG. 8 shows a further modified form of the air-fuel ratio control system according to the invention, wherein the air-fuel mixture delivered from the economizer 17 is further mixed with air introduced from the second air bleed 13, and the resultant engine air-fuel mixture flows through the passages 30 and 31 that are branched from the air-fuel mixture passage 18. The passage 31 communicates by way of a bypass passage 32 with the deceleration port 33 which opens into the main mixture supply flow path of the carburetor. The passage 31 and the bypass passage 32 are connected through a check valve assembly 34 having a ball valve member 35, a coil spring 36 and a valve seat 37. The ball valve member 35 is normally forced against the valve seat 37 by the action of the coil spring 36, shutting off the air-fuel mixture from the bypass passage 32. During deceleration of the automobile when the intake manifold vacuum increases swiftly, the ball valve member 35 is released from the valve seat 37 against the action of the spring 36 so that the air-fuel mixture is allowed out of the passage 31 into the main mixture supply flow path by way of the bypass passage 32 and the deceleration port 33. The inlet 38 of the check valve assembly 34 is so arranged as to serve as an orifice which is adapted to meter the engine air-fuel mixture. Thus, the check valve 34 remains open during the deceleration only so as to permit the air-fuel mixture to flow into the main mixture supply flow path by way of the bypass passage 32, with the consequent enrichment of the air-fuel mixture to be fed to the engine.

Now, as previously noted, the intake manifold vacuum increases sharply during deceleration, say, in excess of about 650 mm. of Hg. while it remains of the order of 500 mm. of Hg. during the idle operation. This is entirely due to the fact that the butterfly valve of the carburetor remains substantially closed during deceleration so as to shut off the flow of the air-fuel mixture in the main mixture supply flow path although the engine operates at a relatively high speed which is proportioned to the running speed of the automobile. The intake manifold vacuum that has increased to such a high level inevitably leads to unsatisfactory combustion and misfiring of the air-fuel mixture in the combustion chamber of the engine, thereby giving rise to an increase in the hydrocarbon content of the engine exhaust gases emitted during deceleration.

Such a trend in the hydrocarbon content is evident from the curve *c* of FIG. 3 which indicates a typical example of the relationship between the engine exhaust gas hydrocarbon content and the engine intake manifold vacuum. As shown, the hydrocarbon content is suppressed to a low level independently of the intake manifold vacuum below approximately 530 mm. of Hg. while at higher vacuums it increases very rapidly.

To reduce the hydrocarbon content of engine exhaust gases in a more effective fashion, therefore, it will be advantageous to have the amount of engine air-fuel mixture increased with the resultant reduction in the intake manifold vacuum during deceleration. Ideally, it will be the best approach to the reduction of the hydrocarbon content of the engine exhaust gases during deceleration to have the amount of the engine air-fuel mixture increased to such an extent as to lower the intake manifold vacuum during deceleration to the vicinity of 530 mm. of Hg. On account of the braking effect of the engine, however, reduction on the intake manifold vacuum to such an extent turns out rather detrimental to the driveability of the automobile and hence, is not suited for practical purposes. The intake manifold vacuum should therefore be decreased to a point where the driveability of the automobile is not considerably impaired. In this sense, the level to which the intake manifold vacuum should be reduced is generally considered to lie in the neighborhood of 600 mm. of Hg. As illustrated by the curve *c* of FIG. 3, reducing the intake manifold vacuum to approximately 600 mm. of Hg. is apparently conducive to the reduction of the hydrocarbon content of the engine exhaust gases.

Referring to FIG. 9 which illustrates a preferred embodiment implementing such a concept, a combination diaphragm and valve assembly 22*d* is mounted behind the idling port 20. The assembly 22*d* is divided by a diaphragm member 23 into an atmospheric chamber 24 vented from the open air and a suction chamber 25 communicates with a third port 42 by way of a conduit 40 and an orifice 41. The diaphragm member 23 is connected on one side thereof with a coil spring 26 and on the other with a needle valve member 21. The chamber 24 of the assembly 22*d* is vented to the atmosphere, as mentioned, through inlet 45. The clearance between the valve member 21 and the internal wall of the passage to the idling port 20 is substantially sealed off by the constriction 39. The diaphragm member 23 is provided therein with holes 47 through which the chambers 24 and 25 are permitted to communicate with each other.

During the idle operation of the automobile when the intake manifold vacuum is not kept at such a low level as to overcome the bias of the coil spring 26, the diaphragm member 23 is forced against a stopper 46 (which serves as a valve seat) so that air introduced from the inlet 45 is prevented from entering the chamber 25. The diaphragm member 23 being held in this position, the needle valve member 21 is held in its rightmost position on the drawing, namely, in the position nearest to the idling port 20 with the result that the amount of the air-fuel mixture flowing through the idling port is reduced to a minimum.

During deceleration, on the other hand, the intake manifold vacuum and therefore the vacuum at the port 42 downstream of the butterfly valve increases abruptly to a level (650 mm. of Hg. or higher) which is enough to pull the diaphragm member 23 toward the suction chamber 25 against the action of the spring 26, the chambers 24 and 25 are allowed to communicate with each other while the needle valve member 21 is forced to move away from the idling port 20. It therefore follows that air introduced from the inlet 45 is fed through the holes 47, conduit 40 and orifice 41, in this sequence, into the deceleration port 42 and that the clearance between the needle valve member 21 and the internal wall of the idling port 20 increases concurrently. Thus, the intake manifold vacuum is reduced to a reasonable extent, preferably to about 600 mm. of Hg. with air being delivered from the deceleration port 42 on the one hand and the air-fuel mixture delivered from the

idle port being increased on the other hand. The combined effects of the reduced manifold vacuum and the increased amount of the fuel mixture will afford such an air-fuel ratio that is satisfactory in view of the characteristics of the curve *a* of FIG. 1.

The amount of air to be supplied to the deceleration port 42 may be suitably adjusted by properly determining the diameter of the orifice 41.

A modification of the embodiment of FIG. 9 is shown in FIG. 10, wherein the valve member for regulating the flows of air-fuel mixture and air through the ports 20 and 42, respectively, is controlled electrically by a solenoid valve assembly which is actuated by a diaphragm switch assembly. The solenoid valve assembly, as generally indicated by 29', largely comprises a solenoid device 48, a valve member 21*d*, a stopper or valve seat 46' and a coil spring 26'. The spring 26' acts to normally hold the valve member 21*d* in a position to keep the idling port 20 closed so as not to allow the air-fuel mixture into the main mixture supply flow path except during deceleration. The assembly 29' has chambers 24' and 25' that are normally isolated from each other by an enlarged portion of the valve member 21*d*. The suction chamber 24' communicates with the main mixture supply flow path downstream of the butterfly valve by way of a conduit 40 which debouches thereto through the orifice 41 and the deceleration port 42. The atmospheric chamber 25' is vented from the atmosphere and has provided therein the solenoid device 48 and the coil spring 26'. The solenoid device 48 is connected by an electric circuit 49 with a diaphragm switch assembly 50 by way of a power source 51. The diaphragm switch assembly 50 is divided by a diaphragm member 23' into atmospheric and suction chambers 52 and 53, respectively as in the case of the solenoid valve assembly 29'. The atmospheric chamber 52 has provided therein a set of moving and stationary contacts 54 and 55, respectively, the moving contact 54 being connected with the diaphragm member 23'. The suction chamber 53 has accommodated therein a coil spring 56 connected with the diaphragm member 23' and communicates with the intake manifold of the engine through a conduit 57. The spring 56 acts to normally bias the diaphragm member 23' in a direction to keep the moving contact 54 released from the stationary contact 55, thus further keeping the solenoid device 48 deenergized with the valve member 21*d* held in a position to close the deceleration port 42.

During the decelerating operation of the automobile when the intake manifold vacuum is maintained at a relatively high level, the diaphragm member 23' is displaced by the vacuum exerted thereon and against the action of the coil spring 56 so as to cause the moving contact 54 to abut against the stationary contact 55 so that the solenoid device 48 of the solenoid valve assembly 29' becomes energized. The result is, on the one hand, that the valve member 21*d* is forced to withdraw from the port 20 against the action of the spring 26' and, on the other, that the air introduced from the air vent 27' is admitted to the conduit 40 by way of the holes 60 and 61 provided in the enlarged portion 62 of the valve member 21*d* and the stopper or valve seat 46', respectively.

It will be understood that the combination diaphragm and valve assembly 22*d* utilized in the embodiment of FIG. 9 may be replaced with a suitable form of other control mechanism such as for example the solenoid valve assembly and the diaphragm switch assembly used in the second embodiment of the present invention.

In the last embodiment of the invention, as is apparent from the foregoing description, the air-fuel mixture fed from the passage 18 is augmented as soon as the automobile decelerates and the manifold vacuum increases rapidly and simultaneously air introduced from the atmosphere is supplied at a predetermined flow rate to the main mixture supply flow path so as to reduce the manifold vacuum to a level such that will afford an optimum air-fuel ratio of the mixture ranging from 12:1 to 13:1. Addition of air to the air-fuel mixture causes the intake manifold vacuum to be diminished to a

predetermined level (600 mm. of Hg., for example). Thus, both the air-fuel ratio of the mixture and the intake manifold vacuum can be controlled simultaneously by supplying the mixture with additional air in the main mixture supply flow path downstream of the butterfly valve, thereby satisfying the requirements dictated by the curves *a* and *c* of FIGS. 1 and 3, respectively.

According to a feature of the present invention, the hydrocarbon content of engine exhaust gases is diminished during deceleration through the effective utilization of the abrupt increase in the intake manifold vacuum at the engine or the carburetor downstream of the butterfly valve without major constructional modification to the carburetor in its entirety. This is particularly important in this invention in that the concentration of the hydrocarbons in engine exhaust gases is sufficiently stabilized by improving the combustion in the combustion chamber especially during deceleration of the automobile.

According to another feature of the invention, the air-fuel ratio of the mixture during the deceleration can be controlled independently of the other modes of the automobile operation so that it will permit reduction in the hydrocarbon content of engine exhaust gases produced under the idling accelerating and normal cruising operations by keeping the fuel mixture lean during the idling operation.

If, furthermore, the system according to the invention forms part of a carburetor operating on the lean side of the flow band of the carburetor flow curve, it will lend itself to the reduction of the hydrocarbon content of engine exhaust gases under all the modes of the automobile operation.

Since the system according to the invention is operable with a relatively lean air-fuel mixture during idling, accelerating and normal cruising operations, it will prove advantageous in the reduction of carbon monoxide content of engine exhaust gases as well as in the saving of engine fuel consumption.

While a few embodiments of the invention have been shown and described in detail, it will be apparent to those skilled in the art that such is by way of illustration only and numerous changes may be made thereto without departing the spirit and scope of the present invention which is defined by the appended claims.

We claim:

1. In a carburetor for an automotive gasoline-powered engine and having a main mixture supply flow path leading to the intake manifold of said internal combustion engine and kept substantially closed by a butterfly valve mounted therein during the idle and decelerating operations of the automobile and a slow running mixture supply flow path which is adapted to supply said engine with an air-fuel mixture having a predetermined air-fuel ratio during said operations and which includes first and second air bleeds which are vented to the atmosphere, a liquid fuel passage leading from a fuel source and communicating with said first and second air bleeds, a mixture passage for passing air delivered from said first and second air bleeds and fuel delivered from said fuel passage, a slow running port communicating with said mixture passage and opening into said main mixture supply path at a position where said butterfly valve substantially closes the last named path during the idling and decelerating operations and an idling port communicating with said slow running port and opening into said main mixture supply flow path downstream of said butterfly valve, a system for reducing the quantity of unburned hydrocarbons in the exhaust gases emitted from said engine during the decelerating operation of the automobile, said system comprising a diaphragm valve assembly which is divided by a diaphragm member into atmospheric and suction chambers, of which the atmospheric chamber is vented to the atmosphere and has accommodated therein a valve member secured to said diaphragm member and inserted operatively into said idling port and of which the suction chamber communicates with the intake manifold of said engine by way of a suction conduit and has accommodated therein a coil spring which normally acts to hold said valve member in a position to

close said idling port during the idle operation, wherein, as an increased vacuum develops at the intake manifold of the engine during the deceleration operation, said diaphragm member is displaced by the increased vacuum exercised thereto through said suction conduit and against the action of said coil spring in a direction to cause said valve member to withdraw from said idle port, whereby an increased amount of the air-fuel mixture is allowed into said main mixture supply flow path during the decelerating operation.

2. The system as set forth in claim 1, wherein said valve member has its end tapered and said idle port has provided at the inner wall thereof with a constriction, whereby the amount of said mixture to be delivered into said main mixture supply flow path during the decelerating operation is increased continuously as the tapered end of said valve member passes through said constriction.

3. In a carburetor for an automotive gasoline-powered internal combustion engine and having a main mixture supply flow path leading to the intake manifold of said engine and kept substantially closed by a butterfly valve mounted therein during the idle and decelerating operations of the automobile and a slow running mixture supply flow path which is adapted to supply said engine with an air-fuel mixture having a predetermined air-fuel ratio during said operations and which includes first and second air bleeds which are vented to the atmosphere, a liquid fuel passage leading from a fuel source and communicating with said first and second air bleeds, a mixture passage for passing the air delivered from said first and second air bleeds and fuel delivered from said fuel passage, a slow running port communicating with said mixture passage and opening into said main mixture supply path at a position where said butterfly valve substantially closes the last named path during the idling and decelerating operations and an idling port communicating with said slow running port and opening into said main mixture supply flow path downstream of said butterfly valve, a system for reducing the quantity of unburned hydrocarbons in the exhaust gases emitted from said engine during the decelerating operation of the automobile, said system comprising a diaphragm valve assembly which is divided by a diaphragm member into atmospheric and suction chambers, of which the atmospheric chamber is vented to the atmosphere and has accommodated therein a valve member secured to said diaphragm member and inserted operatively into said idling port and of which the suction chamber communicates with the intake manifold of said engine by way of a suction conduit and has accommodated therein a coil spring which acts to normally hold said valve member in a position to close said idling port during the idling operation, said diaphragm member being provided therein with an opening permitting said atmospheric chamber to communicate with said suction chamber, said atmospheric chamber being provided therein with a stopper for restricting the displacement of said valve member and serving to isolate said atmospheric chamber from the atmosphere while said valve member remains in a position to close said idling port for thereby blocking communication between said suction chamber and the atmosphere during the idling operation, wherein, as an increased vacuum develops at the intake manifold of the engine during the decelerating operation, said diaphragm member is displaced by the increased vacuum exercised thereto through said suction conduit and against the action of said coil spring in a direction to cause said valve member to withdraw from said idling port and to permit the atmospheric chamber to communicate with the suction chamber, whereby an increased amount of the air-fuel mixture is delivered into said main mixture supply flow path and simultaneously atmospheric air is introduced into the intake manifold of the engine by way of said atmospheric chamber, suction chamber and suction conduit.

4. The system as set forth in claim 3, wherein said suction conduit is provided at a suitable location thereof with an orifice for metering the amount of air to be introduced into the intake manifold of the engine.

5. In a carburetor for an automotive gasoline-powered internal combustion engine and having a main mixture supply flow path leading to the intake manifold of said engine and kept substantially closed by a butterfly valve mounted therein during the idling and decelerating operations of the automobile and a slow running mixture supply flow path which is adapted to supply said engine with an air-fuel mixture having a predetermined air-fuel ratio during said operations and which includes first and second air bleeds which are vented to the atmosphere, a liquid fuel passage leading from a fuel source and communicating with said first and second air bleeds, a mixture passage for passing air delivered from said first and second air bleeds and fuel delivered from said fuel passage, a slow running port communicating with said mixture passage and opening into said main mixture supply path at a position where said butterfly valve substantially closes the last named path during the idling and decelerating operations and an idling port communicating with said slow running port and opening into said main mixture supply flow path downstream of said butterfly valve, a system for reducing the quantity of unburned hydrocarbons in the exhaust gases emitted from said engine during the decelerating operation of the automobile, said system comprising a deceleration port communicating with said idling port and opening into said main mixture supply flow path downstream of said butterfly valve and a diaphragm valve assembly which is divided by a diaphragm member into atmospheric and suction chambers, of which the atmospheric chamber is vented to the atmosphere and has accommodated therein a valve member secured to said diaphragm member and inserted operatively into said deceleration port and of which the suction chamber communicates with the intake manifold of the engine by way of a suction conduit and has accommodated therein a coil spring which normally acts to hold said valve member in a position to close said deceleration port during the idling operation, wherein, as an increased vacuum develops at the intake manifold of the engine during the decelerating operation, said diaphragm member is displaced with the increased vacuum exercised thereto through said suction conduit and against the action of said coil spring in a direction to cause said valve member to withdraw from said deceleration port, whereby an increased amount of the air-fuel mixture is allowed into said main mixture supply flow path through said deceleration port during the decelerating operation.

6. The system as set forth in claim 5, wherein said valve member has its end tapered and said idle port has provided at the inner wall thereof with a constriction, whereby the amount of said mixture to be delivered into said main mixture supply flow path during the decelerating operation is increased continuously as the tapered end of said valve member passes said constriction.

7. In a carburetor for an automotive gasoline-powered internal combustion engine and having a main mixture supply flow path leading to the intake manifold of said engine and kept substantially closed by a butterfly valve mounted therein during the idling and decelerating operations of the automobile and a slow running mixture supply flow path which is adapted to supply said engine with an air-fuel mixture having a predetermined air-fuel ratio during said operations and which includes first and second air bleeds which are vented to the atmosphere, a liquid fuel passage leading from a fuel source and communicating with said first and second air bleeds, a mixture passage for passing air delivered from said first and second air bleeds and fuel delivered from said fuel passage, a slow running port communicating with said mixture passage and opening into said main mixture supply path at a position where said butterfly valve substantially closes the last named path during the idling and decelerating operations and an idling port communicating with said slow running port and opening into said main mixture supply flow path downstream of said butterfly valve, a system for reducing the quantity of unburned hydrocarbons in the exhaust gases emitted from said engine during the decelerating operation of the automobile, said

system comprising a deceleration port communication with said idling port and opening into said main mixture supply flow path downstream of said butterfly valve and a diaphragm valve assembly which is divided by a diaphragm member into atmospheric and suction chambers of which the atmospheric chamber is vented to the atmosphere and has accommodated therein a valve member secured to said diaphragm member and inserted operatively into said deceleration port and of which the suction chamber communicates with the intake manifold of the engine by way of a suction conduit and has accommodated therein a coil spring which acts to normally hold said valve member in a position to close said deceleration port during the idling operation, said diaphragm member being provided therein with an opening permitting said atmospheric chamber to communicate with said suction chamber, said atmospheric chamber being provided therein with a stopper for restricting the displacement of said valve member and serving to isolate said atmospheric chamber from the atmosphere while said valve member remains in a position to close said deceleration port for thereby blocking communication between said suction chamber and the atmosphere during the idling operation, wherein, as an increased vacuum develops at the intake manifold of the engine during the decelerating operation, said diaphragm member is displaced with the increased vacuum exercised thereto through said suction conduit and against the action of said coil spring in a direction to cause said valve member to withdraw from said deceleration port and to permit said atmospheric chamber to communicate with said suction chamber, whereby an increased amount of air-fuel mixture is delivered into said main mixture supply flow path and simultaneously atmospheric air is introduced into the intake manifold of the engine by way of said atmospheric chamber, suction chamber and suction conduit.

8. The system as set forth in claim 7, wherein said suction conduit is provided at a suitable location thereof with an orifice for metering the amount of air to be introduced into the intake manifold of the engine.

9. In a carburetor for an automotive gasoline-powered internal combustion engine and having a main mixture supply flow path leading to the intake manifold of said engine and kept substantially closed by a butterfly valve mounted therein during the idling and decelerating operations of the automobile and a slow running mixture supply flow path which is adapted to supply said engine with an air-fuel mixture having a predetermined air-fuel ratio during said operations and which includes first and second air bleeds which are vented to the atmosphere, a liquid fuel passage leading from a fuel source and communicating with said first and second air bleeds, a mixture passage for passing air delivered from said first and second air bleeds and fuel delivered from said fuel passage, a slow running port communicating with said mixture passage and opening into said main mixture supply path at a position where said butterfly valve substantially closes the last named path during the idling and decelerating operations and an idling port communicating with said slow running port and opening into said main mixture supply flow path downstream of said butterfly valve, a system for reducing the quantity of unburned hydrocarbons in the exhaust gases emitted from said engine during the decelerating operation of the automobile, said system comprising: a solenoid valve assembly having a valve member which is operatively inserted into said idling port and a coil spring which acts to normally hold said valve member in a position to close said idling port; and a diaphragm switch assembly which is linked through a wire circuit with said solenoid valve assembly and which is adapted to cause the same to be energized in response to an increase in the vacuum at the intake manifold of the engine, wherein, as an increased vacuum develops at the intake manifold during the decelerating operation said diaphragm switch assembly is actuated to cause said solenoid valve assembly be energized to force said valve member to withdraw from said idling port against the action of said coil spring, whereby an increased amount of the air-fuel mixture is allowed into said main mixture supply flow path during the decelerating operation.

10. The system as set forth in claim 9, wherein the interior of said solenoid valve assembly is opened to the atmosphere through an air vent and communicates with the intake manifold of the engine by way of a conduit, said air vent being isolated from the intake manifold while said valve member is held in a position to close said idling port, viz, during the idling operation, wherein, as said valve member is moved in a direction to open said idling port in response to the increase in the vacuum at the intake manifold during the decelerating operation, said air vent is permitted to communicate with the intake manifold through said conduit, whereby atmospheric air is introduced into the intake manifold during the decelerating operation.

11. The system as set forth in claim 10 wherein said conduit is provided at a suitable location thereof with an orifice for metering the flow rate of air to be allowed into the intake manifold of the engine.

12. In a carburetor for an automotive gasoline-powered internal combustion engine and having a main mixture supply flow path leading to the intake manifold of said engine and kept substantially closed by a butterfly valve mounted therein during the idling and decelerating operations of the automobile and a slow running mixture supply flow path which is adapted to supply said engine with an air-fuel mixture having a predetermined air-fuel ratio during said operations and which

includes first and second air bleeds which are vented to the atmosphere, a liquid fuel passage leading from a fuel source and communicating with said first and second air bleeds, a mixture passage for passing to said main mixture supply flow path air delivered from said first and second air bleeds and fuel delivered from said fuel passage, a system for reducing the quantity of unburned hydrocarbons emitted from said engine during the decelerating operation said system comprising a bypass passage branched from said mixture passage and communicating with said main mixture supply flow path downstream of said butterfly valve, a valve assembly having a valve member, a coil spring and a valve seat, said valve seat being normally forced against said valve member by means of said coil spring for closing said bypass passage during the idling operation, wherein, as an increased vacuum develops at the intake manifold of said engine during the decelerating operation, said valve member is pulled by said increased vacuum against the action of said coil spring for thereby opening said passage, whereby the air-fuel mixture fed via said bypass passage is prohibited and permitted to enter said main mixture supply flow path during the idling and decelerating operations, respectively.

13. The system as set forth in claim 12, wherein said valve member is a ball check valve member.

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