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[33] **Japan**
[31] **43 20785**

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[54] **APPARATUS FOR REDUCING HYDROCARBON
CONTENT OF ENGINE EXHAUST GASES DURING
DECELERATION OF AUTOMOBILE**
4 Claims, 6 Drawing Figs.
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123/119, 123/124, 261/41
[51] Int. Cl. F02m 3/02
[50] Field of Search 123/97 B,
97, 119, 124; 261/41.4, DIG. 19

ABSTRACT: A system for reducing the hydrocarbon content of engine exhaust gases emitted during deceleration of an automobile by controlling both the air-fuel ratio of the engine fuel mixture and the intake manifold vacuum which increases rapidly as soon as the automobile starts to slow down, said air-fuel ratio and intake manifold vacuum being controlled by supplying air to the intake manifold of the engine by way of the step mixture supply flow path of the secondary side of a carburetor of compound-type, which path is kept substantially inoperative during the deceleration of the automobile.

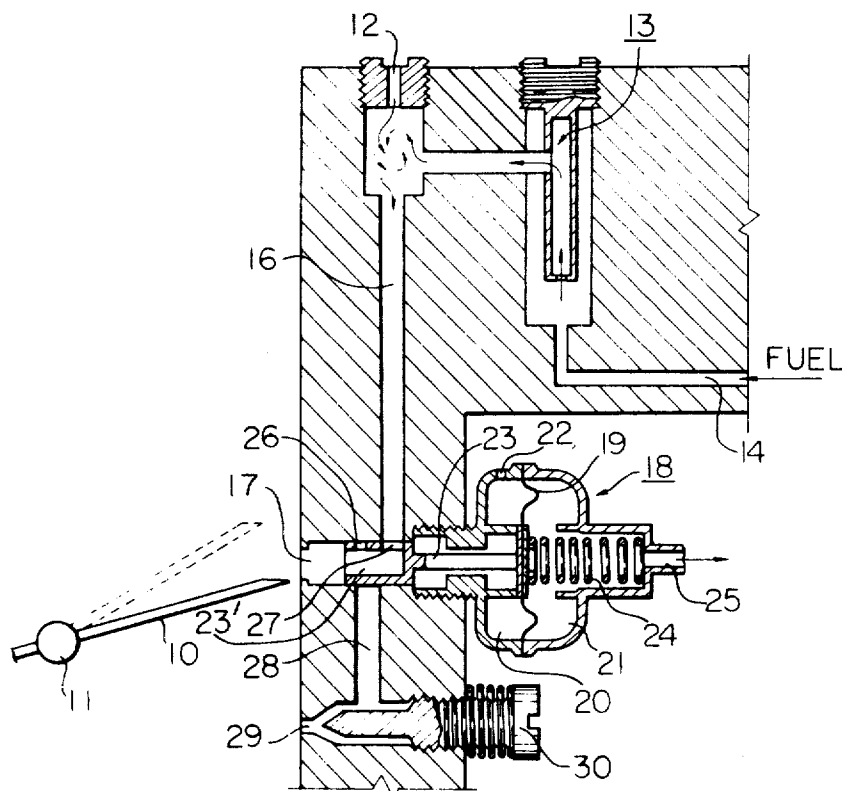


Fig. 1

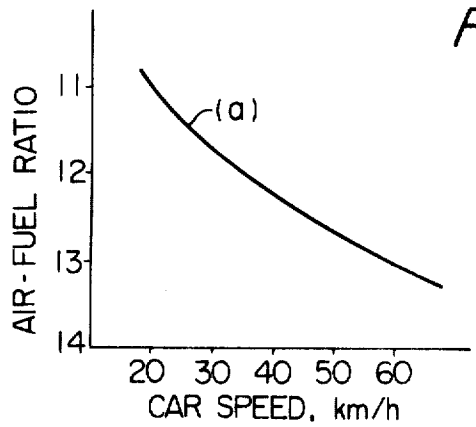


Fig. 2

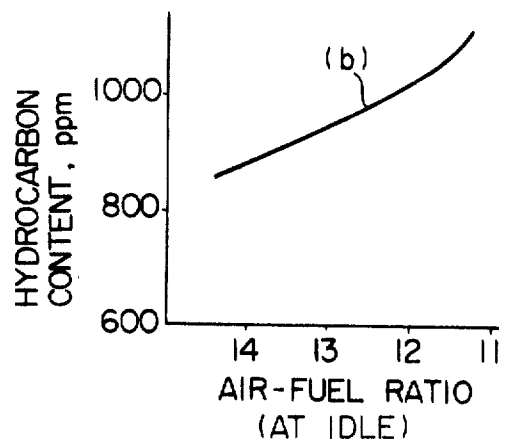


Fig. 3

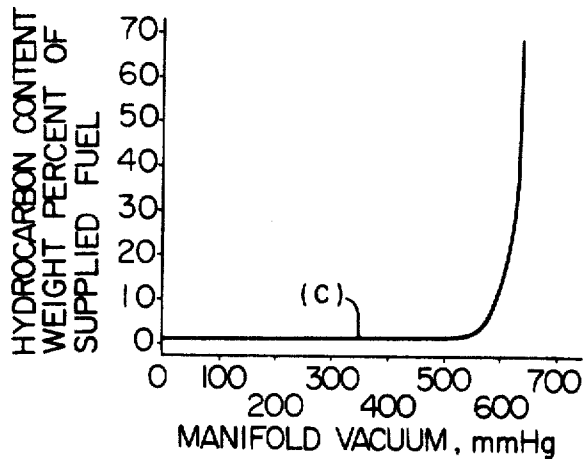


Fig. 4

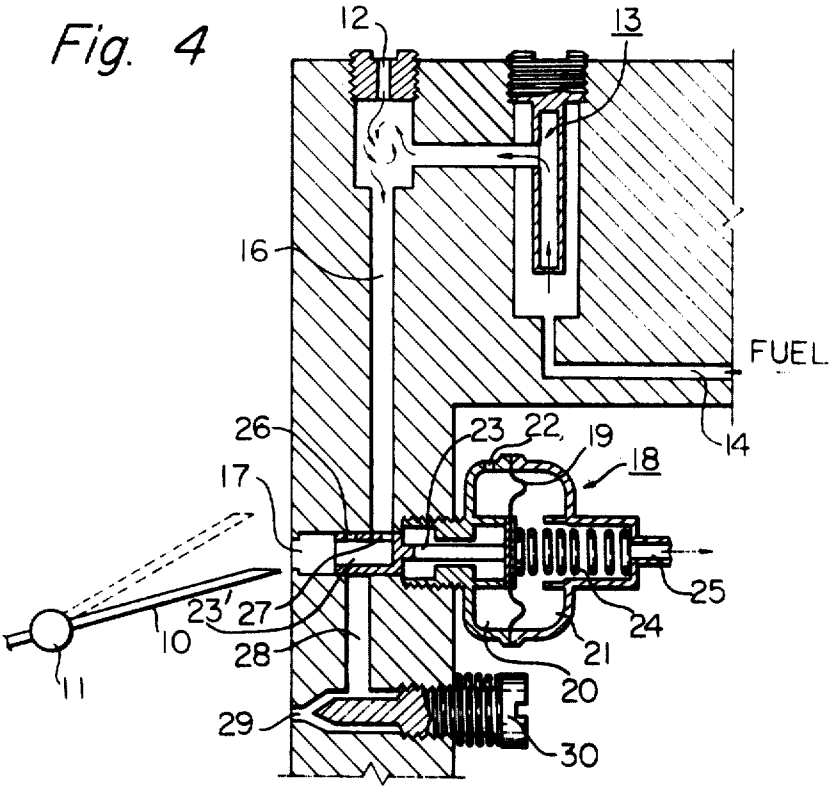


Fig. 5

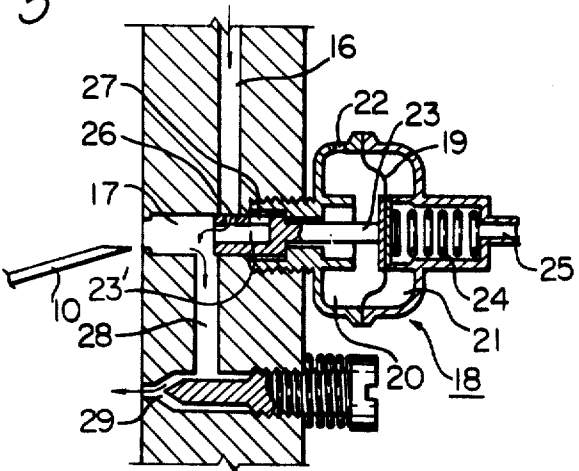
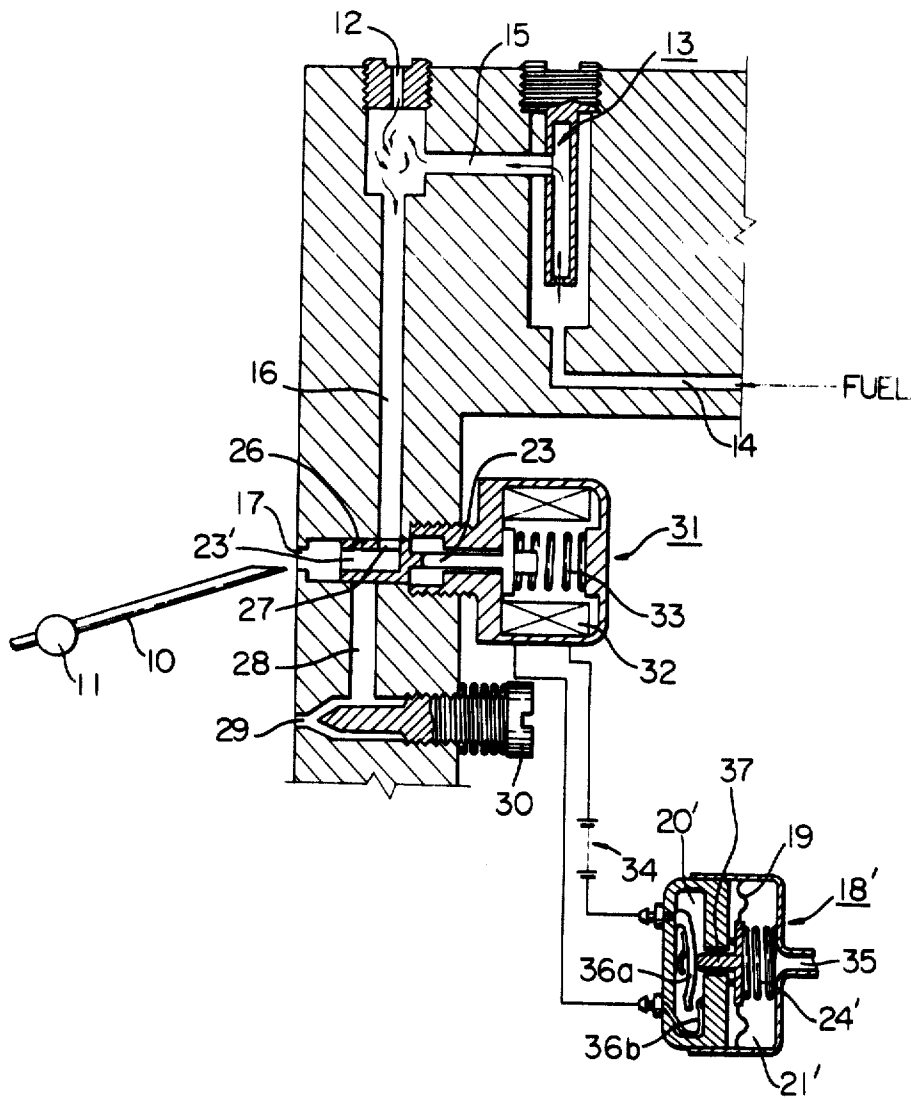


Fig. 6



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 both the air-fuel ratio of an air-fuel mixture to be drawn into the engine by way of the step mixture supply flow path of a carburetor and the level of intake manifold vacuum 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 engine 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 a satisfactory combustion of the mixture in the combustion chamber of the engine and partly to the occurrence of an unsatisfactory combustion and misfiring of the air-fuel mixture 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 suited 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 decreased to 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 under a predetermined level.

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 emitted 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 both the air-fuel ratio of an engine fuel mixture and the intake manifold vacuum under predetermined limits 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 for lowering the intake manifold vacuum that increases remarkably as soon as

the automobile slows down, whereby a total of the hydrocarbon content of engine exhaust gases emitted throughout all the modes of automobile operation is ultimately reduced to a minimum.

It is another prime object of the invention to provide a system which is adapted to supply air to the carburetor downstream of the butterfly valve, viz., to the intake manifold of the engine by way of the step mixture supply flow path of the secondary side of a carburetor of compound-type so that the engine fuel mixture is made optimum in both amount and air-fuel ratio for the satisfactory combustion of the mixture in the combustion chamber of the engine and that the intake manifold vacuum, which abruptly increases as soon as the automobile starts to slow down, is lowered to a level that will minimize the emission of unburned gases from the engine.

It is another prime object of the invention to prevent an 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 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 a desired example of the relationship between the air-fuel ratio of an air-fuel mixture and the automobile speed during 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 invention which is under the idle operation of the automobile;

FIG. 5 shows the system of FIG. 4 under deceleration of the automobile; and

FIG. 6 shows a modified form of the system of FIGS. 4 and 5.

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 controlling 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 to a predetermined 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 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 deceleration (during which time a particularly large amount of hydrocarbons are present 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 deceleration in view of the 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.

Another important factor in reducing the hydrocarbon content of engine exhaust gases is the influence of the high intake manifold vacuum which develops abruptly at the initial stage of the deceleration. The intake manifold vacuum increases sharply as soon as the automobile starts to slow down during deceleration, say, in excess of 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 misfire of the air-fuel mixture in the combustion chamber of the engine, thereby remarkably 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 reduced to a low level substantially 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 the engine 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 fuel mixture increases to such an extent as to lower the intake manifold vacuum to the vicinity of 530 mm. of Hg. On account of the braking effect of the engine, however, reduction of 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 in no way impaired. In this sense, the reasonable level to which the intake manifold vacuum should be reduced is generally considered to be 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 600 mm. is apparently conducive to the minimization of the hydrocarbon content of the engine exhaust gases.

As is apparent from the curve (b) of FIG. 2, moreover, it will be advantageous for minimizing the aggregated amount 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 carbu-

retor 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 secondary butterfly valve substantially fully closed and with the secondary side of the carburetor kept inoperative. The butterfly valve 10 may be of the type which is usually used in the conventional carburetors and is rotatable with the shaft 11. Represented by 12 is a step air bleed, which is vented from the atmosphere and which is so sized in diameter as to admit a suitable amount of air to the step fuel supply flow path of the carburetor. The air bleed 12 communicates upstream with a step jet 13 by way of a passage 15. At the step jet 13, the fuel fed from the liquid fuel passage 14 leading to the fuel source (not shown) is metered and mixed with air introduced from the air bleed 12. The resultant mixture of air and fuel is then introduced into a step fuel mixture passage 16.

According to the present invention, a combination valve and diaphragm fuel control assembly 18 is provided behind the step port 17, whereby the air-fuel mixture flowing in the fuel mixture passage 16, is allowed into the carburetor downstream of the secondary butterfly valve 10 during deceleration of the automobile when the intake manifold vacuum increases abruptly while, in the idling operation, the step fuel supply flow path of the carburetor remains inoperative with the secondary butterfly valve fully closed.

The construction of the fuel control assembly 18 is such that it is divided by a diaphragm member 19 into atmospheric and suction chambers 20 and 21 of which the suction chamber 21 communicates with the intake manifold (not shown) of the engine by way of a suction conduit 25 and the atmospheric chamber 20 has provided therein a valve member 23 which is fixedly connected with the diaphragm member 19. The diaphragm member 19 and accordingly the valve member 23 are normally held in their leftmost positions, namely, in positions remotest from the suction conduit 25 by the action of a coil spring 24, as illustrated in FIG. 4.

The valve member 23 has a hollow, cylindrical and open-ended portion 23', in which are provided two different holes 26 and 27 of which the former is shown to be smaller in diameter than the latter. The hole 27 is located in such a manner as to let the air-fuel mixture passage 16 communicate with the step port 17 and be isolated from the passage 28 leading to the decelerating port 29 during the idling operation of the automobile when the valve member 23 is held in a position remotest from the suction conduit 25 as shown in FIG. 4, while the hole 26 is located in such a manner as to let the air-fuel mixture passage 16 communicate not only with the step port 17 but with the passage 28 when the valve member 23 is held in its rightmost position, viz., when in deceleration, as shown in FIG. 5.

During the idle operation of the automobile, as previously described, the engine intake manifold vacuum is kept at a relatively low level and, as a consequence, the diaphragm member 19 of the fuel control assembly 18 is held in the leftmost position on the drawing by the action of the coil spring 24. The result is that the air-fuel mixture passage 16 is permitted to communicate with the step port 17 through the hole 27 of the cylindrical portion 23' and is prohibited from communicating with the passage 28 leading to the decelerating port 29 which opens into the secondary main mixture supply flow path of the carburetor downstream of the secondary butterfly valve 10. The secondary butterfly valve 10 being in a substantially fully closed position, however, there takes place no flow of air between the secondary side of the carburetor the secondary main mixture supply flow path and the step fuel supply flow path so that the atomized air-fuel mixture is not generated.

According to the invention, however, the air-fuel mixture in the fuel mixture passage 16 is introduced into the main mixture supply flow path downstream of the butterfly valve 10

through the decelerating port 29 during deceleration of the automobile, thereby eliminating the possibility of an unburned fuel remaining in the engine exhaust gases, which would otherwise lead to the presence of hydrocarbon content therein.

As soon as the automobile running at a normal cruising speed starts to decelerate, the intake manifold vacuum increases rapidly with the result that the diaphragm member 19 of the fuel control assembly 18 is forcedly drawn toward the suction conduit 25 against the spring action and accordingly the valve member 23 retracts away from the step port 17, viz., moves rightwardly of the drawing. It therefore follows that the fuel mixture passage 16 communicates through the hole 26 with the step port 17 and the passage 28 leading to the decelerating port 29 which opens into the secondary main mixture supply flow path. With the relationship between the passages 16 and 28 and the step port 17 thus maintained, air is permitted to spurt from upstream to downstream of the secondary butterfly valve 10 by way of the step port 17 and at the same time the air-fuel mixture flowing through the fuel mixture passage 16 is introduced into the passage 28 by way of the hole 26, due to the extremely high vacuum present downstream of the butterfly valve. The hole 26 is so sized in diameter as to serve as an orifice adapted to properly determine the flow rate of the air-fuel mixture which debouches into the step port 17.

Thus, the air-fuel mixture to be drawn into the decelerating port 29 through the passage 28 is mixed with air supplied from the step port 17 so that the air-fuel ratio of the air-fuel mixture is controlled to a satisfactory level for the operation of the engine during deceleration.

It may be mentioned that the inlet slit of the step port 17 is usually shaped, sized and located in such a manner as to provide for the best performance of the secondary side of the carburetor. The size of the said inlet slit being optimum for compensating for the extreme deficiency of air in the fuel mixture during deceleration, the slit used in the conventional carburetor can be utilized without making any modification thereto. The secondary butterfly valve may be of the type which is usually used in the conventional carburetors of compound type and there is, again, no need of making a major modification thereto in respect of the dimensions. For utilizing the slit of the step port 17 in an effective fashion, it will be advantageous to make the tip of the butterfly valve 10 thinner toward the peripheral edge thereof so that, when the butterfly valve is held in a substantially fully closed position as in the idling and deceleration, the upper surface of the butterfly valve becomes substantially flush with the lower periphery of the slit of the step port 17.

The rate of the coil spring 24 is so determined that it overcomes the force of the intake manifold vacuum occurring during the idling operation, so that the fuel control assembly 18 remains inoperative under the automobile operation excepting deceleration.

Represented by 30 is a decelerating port adjusting screw, which is adapted to control the amount of the air-fuel mixture to be debouched out of the decelerating port 29, which screw may be removed if desired, however.

Although the fuel control assembly 18 is described and shown to use a diaphragm member, it will be understood that the assembly may be operated by the use of a solenoid device which is actuated by a diaphragm switch assembly of suitable construction arrangement.

In this embodiment of the invention, as is apparent from the foregoing description, the air-fuel mixture fed from the passage 16 is substantially shut off from the engine combustion chamber while in the idling operation, but, as soon as the automobile slows down on deceleration and the manifold vacuum decreases rapidly, the air-fuel mixture from the passage 16 is supplied with additional air from the step port 17 and is introduced to the engine combustion chamber during deceleration.

FIG. 6 shows a modified form of the system according to the present invention, wherein the valve for regulating the flow of

air-fuel mixture in the step mixture supply flow path is constructed basically similarly to the counterpart of the first embodiment and is controlled by means of an electrically powered solenoid device actuated by a diaphragm switch assembly is constructed basically similarly to the counterpart in the first embodiment.

The valve 23 is connected with a solenoid valve assembly 31 incorporating a solenoid device 32 and a coil spring 33 which normally holds the valve member 23 in a position to close the passage 28 from the step port 17 and the passage 16. The solenoid valve assembly 31 is linked by a wire circuit to a diaphragm switch assembly 18' via a power source 34. The assembly 18' is divided by a diaphragm member 19 into atmospheric and suction chambers 20' and 21'. The suction chamber 21' communicates with the intake manifold (not shown) of the engine by way of a conduit 35, while the other atmospheric chamber 20' has mounted therein a moving contact 36a and a stationary contact 36b. A coil spring 24' is mounted in the chamber 21' and normally forces the diaphragm member 19 toward the moving contact 36a in a normal state so that the moving contact, which is connected by a rod 37 with the diaphragm member 19, is kept released from the stationary contact 36b as illustrated in the drawing. Both of the contacts 36a and 36b are wired to the solenoid valve assembly 31.

During the idling operation of the automobile when the intake manifold vacuum remains at a relatively low level, the diaphragm member 19 is forced toward the atmospheric chamber 20' by the action of the spring 24' as shown in the drawing so that the moving contact 36a remains released from the stationary contact 36b, disconnecting the circuit connecting the diaphragm switch assembly 18' and the solenoid valve assembly 31. While the solenoid valve assembly 31 remains deenergized, the valve member 23 rests at its leftmost position on the drawing by the action of the spring 33 so that the step port 17 is isolated from the passage 28, prohibiting the mixture to spurt from the passage 16 into the secondary main mixture supply flow path downstream of the butterfly valve 10 during the idle operation.

When, now, an automobile running at a normal cruising speed starts to decelerate, the pressure in the suction chamber 21', which communicates with the intake manifold by way of the conduit 35 as previously described, decreases sharply so that the diaphragm member 19 is forced toward the suction side against the action of the coil spring 24'. When the diaphragm member 19 moves rightwardly of the drawing, the moving contact 36a is made to abut against the stationary contact 36b and the diaphragm switch 18' becomes electrically connected with the solenoid valve assembly 31, which consequently is initiated into action. The actuation of the solenoid valve assembly 31 urges the valve member 23 to move leftwardly of the drawing, permitting the passages 16 and 28 to communicate with each other by way of the hole 26. As the result, air introduced from the inlet 25 of the port 17 and the fuel from the passage 16 is allowed into the secondary main mixture supply flow path downstream of the butterfly valve 10 through the passage 28 and the port 29.

According to a feature of the present invention, the hydrocarbon content of engine exhaust gases produced during deceleration is diminished through the effective utilization of the abrupt increase in the intake manifold vacuum of the engine without major dimensional 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 quality of combustion in the combustion chamber especially during deceleration of the automobile.

According to another feature of the invention, not only the amount but also the air-fuel ratio of the engine air-fuel mixture can be controlled during deceleration of the automobile independently of the other modes of the automobile operation in such a manner as to keep the engine air-fuel mixture richer during deceleration than during the idling, accelerating and normal cruising operations of the automobile.

According to a further feature of the invention, the intake manifold vacuum which increases abruptly at the initial stage of deceleration of the automobile is rendered low, say, reduced to about 600 mm. of Hg. which is considered a level appropriate for minimizing the presence of hydrocarbons in the engine exhaust gases without impairing the driveability of the automobile, as is previously noted with reference to the curve (c) of FIG. 3.

If, furthermore, the system according to the invention is placed on use with 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 during every mode of the automobile operation.

Since the system according to the invention is operable with a relatively lean air-fuel mixture during the 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 two 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.

What I claim is:

1. In a carburetor of compound-type used 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 secondary butterfly valve mounted therein during the decelerating operation of the automobile and a step mixture supply flow path which includes means defining an air bleed vented from the atmosphere, a liquid fuel passage leading from a fuel source and communicating with said air bleed, a mixture passage for passing the mixture of air delivered from said air bleed and fuel delivered from said liquid fuel passage and step port communicating with said mixture passage and opening into said main mixture supply flow path at a position where said secondary butterfly valve substantially closes the last named path during deceleration, a system for supplying said engine with an air-fuel mixture through said step mixture supply flow path during the decelerating operation, said system comprising means defining a deceleration port communicating with said step port and opening into said main mixture supply flow path downstream of said secondary butterfly

valve and a valve assembly comprising a valve member and a coil spring, said valve member being operatively inserted into said step port and normally held in a position to permit said mixture passage to communicate with said step port by the action of said coil spring and held, during the decelerating operation, in a position to permit said mixture passage to communicate not only with said step port but with said deceleration port against the action of said coil spring and in response to the increase in the vacuum at the intake manifold of the engine said valve member having provided therein means defining two different holes, one permitting said mixture passage to communicate with said main mixture supply flow path when said valve member is held in a position to close a passage leading to said deceleration port and the other permitting said mixture passage to communicate with said main mixture supply flow path when said valve member is held in a position to open a passage leading to said deceleration port.

2. The system as set forth in claim 1, wherein said valve assembly further comprises a solenoid device which becomes energized in response to the increase in the vacuum at the intake manifold of the engine for thereby causing said valve member to move to a position to permit said mixture passage to communicate with said deceleration port.

3. The system as set forth in claim 2, wherein said solenoid device is connected by an electrical circuit to a diaphragm switch assembly by way of a power source, said diaphragm switch assembly being divided by a diaphragm member into atmospheric and suction chambers, of which the atmospheric chamber has accommodated therein a set of moving and stationary contacts both connected with said electrical circuit and of which the suction chamber communicates with the intake manifold of the engine and has accommodated therein a coil spring acting to normally keep said moving contact releases from said stationary contact, 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 exerted thereon and against the action of the last named coil spring in a direction to cause said moving contact to abut against said stationary contact for causing said solenoid device be energized from said power source during the decelerating operation.

4. The system as set forth in claim 3, wherein said secondary butterfly valve is made thinner toward the peripheral edge thereof.

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