United States Patent

[11] 3,599,426

[72] Inventor **Paul E. Oberdorfer, Jr.**
Devon Township, Wilmington, Del.

[21] Appl. No. **38,176**
[22] Filed **May 18, 1970**
[45] Patented **Aug. 17, 1971**
[73] Assignee **Sun Oil Company**
Philadelphia, Pa.
Continuation-in-part of application Ser. No. 6,832, Jan. 29, 1970.

[54] **MOTOR VEHICLE EMISSION CONTROL SYSTEM**
9 Claims, 2 Drawing Figs.

[52] U.S. Cl. ..... **60/29,** 60/30, 123/97 B, 123/119 D, 123/124
[51] Int. Cl. **F02b 75/10,** F02m 23/00, F02m 23/04
[50] Field of Search ..... 123/124 B, 119 D, 97 B; 60/29, 30

[56] **References Cited**
UNITED STATES PATENTS

1,324,436	12/1919	Singelyn	123/124 (B)
1,503,555	8/1924	Raule	123/124 (B)
1,513,142	10/1924	Webb	123/124 (B)
3,413,803	12/1968	Rosenlund et al.	60/30

Primary Examiner—Wendell E. Burns
Attorneys—George L. Church, Donald R. Johnson, Wilmer E. McCorquodale, Jr. and Frank A. Rechif

ABSTRACT: Emission from motor vehicle exhausts of oxides of nitrogen, carbon monoxide, hydrocarbons, and aldehydes is reduced by a combination of enrichment, under off-idle operating conditions, of the fuel-air mixture fed to the engine, and an exhaust converter, e.g., a thermal exhaust reactor. The enrichment is brought about by a mechanical modification of the carburetor, and a selective carburetor control arrangement responsive to engine speed is utilized for enleanment of the fuel-air mixture at higher engine speeds.

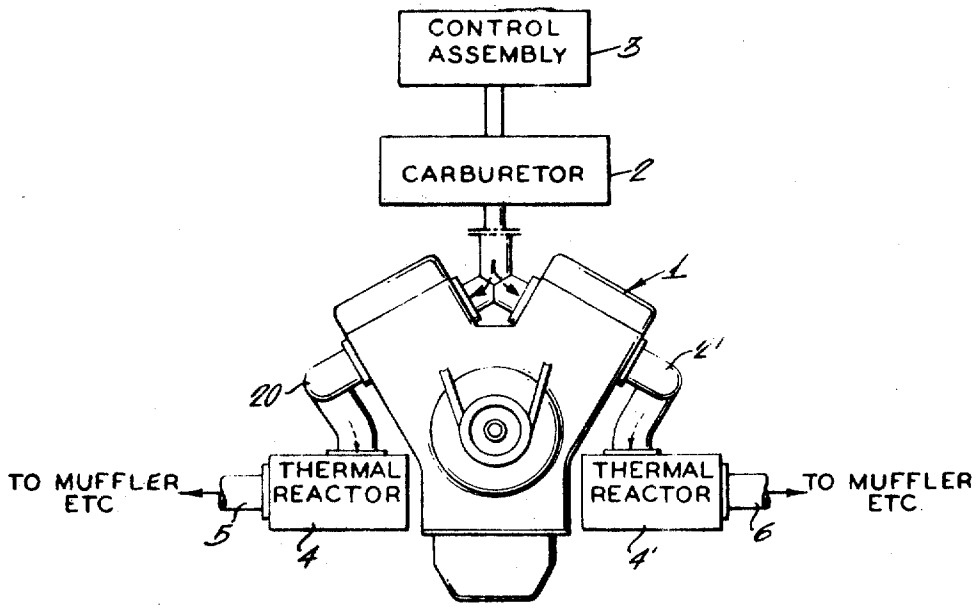


FIG. 1.

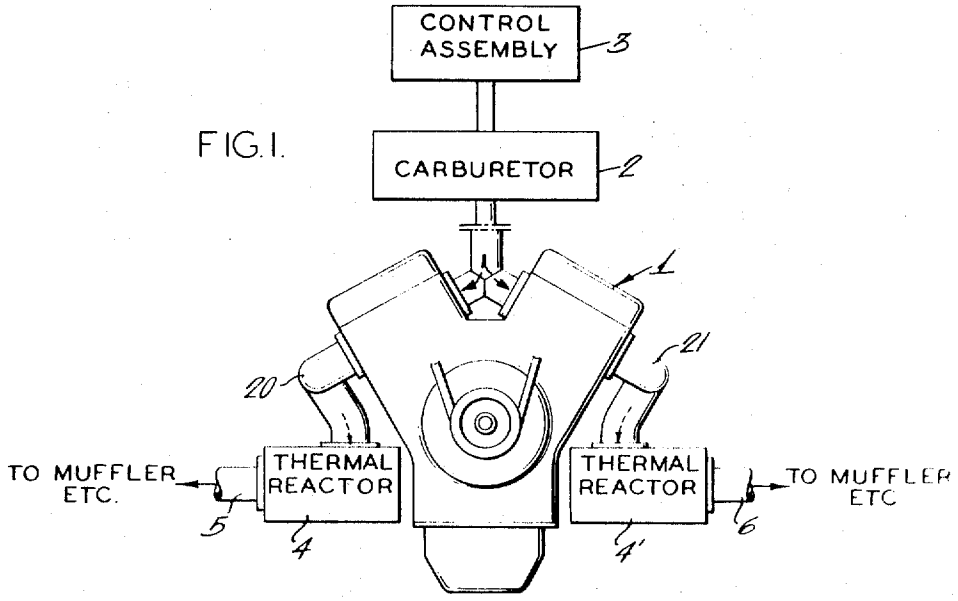
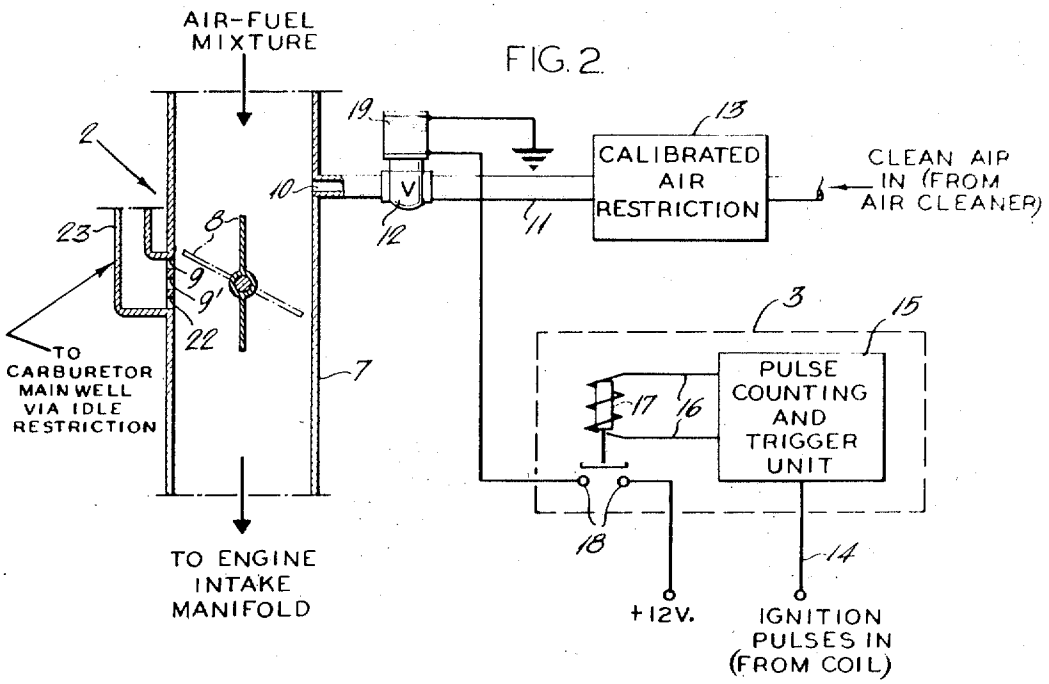


FIG. 2.



INVENTOR
PAUL E. OBERDORFER,
BY
ATTY.

MOTOR VEHICLE EMISSION CONTROL SYSTEM

This application is a continuation-in-part of my copending application, Ser. No. 6,832, filed Jan. 29, 1970.

This invention relates to controlling emissions from the exhausts of motor vehicles powered by gasoline-fueled internal combustion engines, and more particularly to controlling these emissions in such a way as to reduce certain air pollutants (e.g., smog-forming pollutants) commonly found in motor vehicle exhaust gases.

This application is related in a general way to my copending application, Ser. No. 889,252, filed Dec. 30, 1969.

It has been recognized that certain types of atmospheric pollutants which are commonly found in exhaust emissions from motor vehicles should be reduced; in fact, Federal standards have been set for maximum exhaust emissions of hydrocarbons and carbon monoxide, on a mass emission basis, and standards for emissions of oxides of nitrogen (denoted hereinafter by NO_x) are now under active consideration. It is also desirable to reduce exhaust emissions of aldehydes.

An object of this invention is to provide a novel motor vehicle emission control system.

Another object is to provide an emission control system for automobiles which does not adversely affect the driveability of the automobile.

A further object is to provide an automotive emission control system which gives results showing substantial improvement over factory-equipped automobiles.

The objects of this invention are accomplished, briefly, in the following manner: In the internal combustion engine of a motor vehicle which uses full-boiling gasoline as a fuel, the carburetor is modified mechanically to produce an enrichment of the fuel-air mixture fed to the engine under off-idle operating conditions, and a selective carburetor enleanment arrangement (which enleans the fuel-air mixture fed to the engine at higher engine or vehicle speeds) is utilized. One or more converters are utilized on the engine exhaust. The enrichment suppresses formation of NO_x and also reduces the emission of aldehydes, while the enleanment minimizes the drop in fuel economy. The downstream converters remove combustible gases such as hydrocarbons and carbon monoxide from the exhaust by conversion thereof to harmless substances.

A detailed description of the invention follows, taken in conjunction with the accompanying drawing, wherein:

FIG. 1 is a diagrammatic illustration showing the principal elements of a motor vehicle emission control system (exhaust pollutant reduction system) according to this invention; and

FIG. 2 is a schematic illustration of a selective carburetor control arrangement which may be utilized in the invention.

Refer first to FIG. 1. A V-type or V-design internal combustion engine, which uses full-boiling gasoline (a so-called fossil fuel, or a hydrocarbon fuel) as a fuel, is quite schematically represented by numeral 1. A carburetor 2, of somewhat conventional construction but modified as hereinafter described (to achieve an enrichment action plus a selective enleanment action), supplies a fuel-air mixture to the two cylinder banks of engine 1. The selective enleanment action of the carburetor 2 is effected by means of a control assembly 3, hereinafter described.

An exhaust converter, preferably a thermal reactor 4 of the type described more fully hereinafter, is mounted in the engine compartment of the motor vehicle (e.g., automobile) to receive the effluent (exhaust) from one bank of cylinders, and a duplicate unit 4', also mounted in the engine compartment, receives the effluent from the other cylinder bank. The outlet connections 5 and 6, respectively, of the converters 4 and 4' are connected to the conventional exhaust system of the automobile, including a muffler or mufflers, tailpipes, etc.

Refer now to FIG. 2, which shows, somewhat schematically, a portion of the carburetor 2, together with adjuncts including the control assembly 3. According to this invention, a reduction in NO_x emissions (perhaps more accurately, a lessening in the formation of NO_x in the combustion chambers of the engine) is brought about through enrichment of the air-fuel mixture fed to the engine intake during off-idle operating conditions (or, to state this another way, during urban-type, light-load accelerations involved in the driving cycle). In this connection, it has been determined that the bulk of urban NO_x emissions occurs during these light-load accelerations.

In FIG. 2, a portion of one of the main barrels or bores of a four-barrel carburetor is illustrated at 7, a throttle valve 8 of conventional type being pivotally mounted within this bore. The wide-open or full-throttle position of this valve is illustrated in solid lines, while the off-idle position of this valve is illustrated in dotted lines. In the latter position, main bore 7 is opened only very slightly. The lower end of main bore 7 leads to the intake manifold of the engine, while above the throttle valve 8 there are venturi passages (not shown) which feed gasoline from the carburetor bowl into the bore 7, to be mixed with air and fed (when the throttle valve 8 is opened sufficiently) into the engine intake manifold. An idle mixture needle hole 22, in which there is an adjustable needle valve (not shown) operated by an idle adjustment screw, opens into the main bore 7 some little distance below the dotted-line position of valve 8, such that an air-fuel mixture may be fed (by way of hole 22) into the bore 7 below the throttle valve 8 (and thus into the engine intake manifold) when the latter is in its fully closed or "idle" position. This fully closed or "idle" position of the throttle valve 8 is one wherein the valve closes off bore 7 somewhat more completely than it does in the dotted-line "off-idle" position illustrated.

A pair of vertically spaced idle discharge ports 9 and 9' open into the main bore 7 somewhat above the idle mixture needle hole 22, such that a fuel-air mixture can be fed by way of these ports into the bore 7 below the throttle valve 8 (and thus into the engine intake manifold) when the latter is in its dotted-line "off-idle" position. In some carburetors, a single idle discharge slot may be provided instead of the two separate idle discharge ports 9 and 9'. The fuel for this air-fuel mixture (as well as the fuel for the fuel-air mixture fed through hole 22) is originally derived from the carburetor bowl, and flows from the carburetor main well by way of idle tube 23 containing therein an idle tube restriction (not shown), mixing with air along the way, to ports 9 and 9'. All of the elements mentioned in connection with the carburetor, such as the bowl, the main well, the main bore, the throttle valve, the idle tube, etc., are contained in the body of the carburetor, as integral parts thereof.

In an embodiment of this invention which was actually built for experimental purposes and successfully tested, the original factory carburetor was mechanically modified by enlarging the idle tube restriction or restrictions (there may be more than one of these restrictions in the carburetor), by appropriate machining. (Of course, on a commercial or mass production basis, the original factory carburetor itself would be redesigned to effect these enlargements, so that no separate machining would be necessary.) The enlarging of the idle tube restriction (that is, the increasing of its diameter) permits an enriched idle with leaner idle adjustment screw turnout, which in turn creates a considerably enriched off-idle operating condition. This enrichment of the air-fuel mixture fed to the engine intake manifold during off-idle conditions (as a result of the "tailoring" of the idle tube restriction) brings about a reduction in NO_x emissions during the light-load accelerations involved in the driving cycle. Additional enrichment beyond (above) off-idle speeds can be obtained by enrichment of the main metering jets (e.g., by reduction of the primary metering rod diameter). This may or may not be necessary, depending on engine size, car application, etc.

Since enrichment of the air-fuel mixture fed to the intake manifold is made to occur in the above-described manner, and would tend to have an effect throughout all engine operating conditions (that is, throughout all positions of throttle valve 8, except perhaps the "idle" position), there would inherently tend to be an overall loss of fuel economy. In order to restore

fuel economy at higher speed cruise conditions (highway conditions), where exhaust emissions are less of a problem, the carburetor **2** is controlled to provide a selective enleanment action, which results in an enleanment of the air-fuel mixture going to the intake manifold at all vehicle speeds a above a chosen preset speed, for example approximately 35 m.p.h. This enleanment action is produced by the selective carburetor control arrangement **3**, in response to engine speed. It may be stated that the enleanment action is produced by speed-responsive (rpm-controlled) throttle bore air ports.

One or more air ports **10**, opening into the carburetor main bore **7** above the main throttle valve **8**, are provided. A line (tubing or hose) **11** extends from port or ports **10** to a source of clean air at atmospheric pressure, such as the downstream side of the carburetor air cleaner. A solenoid-operated valve **12** and a calibrated air restriction **13** (which may, in the alternative, be an adjustable needle valve) are located in line **11**. When valve **12** is open, clean air is drawn by manifold vacuum through air line **11** and restriction **13** into the carburetor main bore **7** (assuming throttle valve **8** is opened sufficiently), this additional flow of air causing an increase in the air-fuel ratio of the mixture going to the intake mainfold, and thus an enleanment of this mixture.

Pulses derived from the ignition coil of the engine, the repetition rate of which is of course directly proportional to the speed of the engine, are fed at **14** into the input of a pulse counting and trigger unit **15**, which rectifies these pulses and applies them to an internal trigger circuit set to produce a signal voltage across the output leads **16** of unit **15** when the input pulse repetition rate corresponds to a predetermined engine speed, say that corresponding to approximately 35 m.p.h. vehicle speed, though not limited thereto.

The unit **15** may comprise a commercially available tachometer-type solid-state circuit, such as are often used in racing, as over-speed indicators on engines. These units are responsive to engine speed and produce an output signal voltage when a certain engine speed is reached.

The output leads **16** are connected to the coil of a relay **17** having a pair of normally closed contacts **18** which when closed supply 12 volts (derived from the car battery) to a solenoid **19** which operates the valve **12** in the air line **11** for supplying air to the carburetor bore **7**. The arrangement is such that when solenoid **19** is deenergized valve **12** is open, supplying air to the bore **7**. It is here pointed out that elements **14**—**18** essentially make up the control assembly **3** of FIG. **1**.

At or above the preset engine speed corresponding (by way of example) to approximately 35 m.p.h. vehicle speed, which latter may be thought of as the "trigger speed," the repetition rate of the ignition pulses fed into unit **15** becomes high enough to actuate the trigger circuit of this unit, causing a signal voltage to appear on leads **16**. This energizes relay **17** to open its contacts **18**, deenergizing solenoid **19** and opening valve **12** to supply air to carburetor main bore **7**. These conditions are the ones illustrated in FIG. **2**. The opening of valve **12** causes clean air to be drawn through air line **11** into the bore **7**, increasing the air-fuel ratio and enleaning the air-fuel mixture going to the engine intake. As previously described, this selective embodiment, at higher speed conditions, tends to restore fuel economy under such conditions.

Below the "trigger speed," there is no signal voltage on leads **16**, relay **17** is unenergized, contacts **18** are closed, and solenoid **19** is energized, which closes the valve **12**, cutting off the supply of additional air to carburetor bore **7**. Therefore, no enleanment of the air-fuel mixture going to the engine intake occurs under these conditions.

It may be more expedient to utilize an alternative to the special air ports **10** in bore **7**. A vent plate which has an arrangement of transverse holes extending from the outside of the plate to the carburetor bore, may be utilized as a mounting for the carburetor, in the manner of a thick gasket. The outer ends or termini of the holes would be coupled to a source of clean air, by way of a valve such as **12** and a calibrated air restriction **13**.

Refer again to FIG. **1**. As previously stated, the emission control system of this invention includes a pair of exhaust converters (preferably thermal reactors) **4** and **4'** for acting upon the carbon monoxide and hydrocarbons (as well as other combustibles such as aldehydes) which appear in the effluent from the combustion chambers or cylinders of the engine. A thermal reactor **4** is connected to the four exhaust ports of one cylinder bank of the V-type engine **1**, and an exactly similar thermal reactor **4'** is connected to the four exhaust ports of the other cylinder bank of the engine. The thermal reactors **4** and **4'** will not be described in detail herein, since per se they form no part of the present invention; by way of example, they may be of the construction disclosed in the Rosenlund-Douthit U.S. Pat. No. 3,413,803. The patented reactor is of a double (concentric) hollow tubular construction, with no catalyst; the outer tube has relatively thin layers of heat-insulating material on its inner faces. Each reactor has four inlet connections, one for each of the four cylinders of the corresponding cylinder bank, and a single outlet connection; these reactors may therefore be termed thermal exhaust manifold reactors. For reactor **4**, one of the inlet connections is schematically indicated at **20** and the outlet connection is schematically indicated at **5**; this latter connection extends to the muffler, etc. of the dual exhaust system of the automobile. For reactor **4'**, an inlet connection is schematically indicated at **21** and the outlet connection at **6**; this latter connection extends to the muffler, etc. of the automobile's dual exhaust system.

Although not illustrated in the drawing, an air injection system (secondary air delivery system) is preferably used in conjunction with the thermal reactors **4** and **4'**. This system utilizes an air delivery pump belt-driven from the engine and having a filter and silencer on its intake. Air from this pump is fed continuously, by means of individual delivery tubes and channels, to a point just underneath each exhaust valve, outside each combustion chamber or cylinder, so that it is introduced at each exhaust valve but just beyond the combustion chambers or cylinders, on the way to the reactors **4** and **4'**.

As described in the above-identified patent, oxidation (i.e., combustion) of hydrocarbons and of carbon monoxide contained in the exhaust gases (effluent from the combustion chambers of the engine) takes place in the thermal reactors **4** and **4'**, the oxidation reaction being enhanced by various types of turbulence which are caused to occur in the reactors. In addition to the combustion of the carbon monoxide and hydrocarbons which takes place in the reactors, combustion or oxidation of aldehydes, which may be left over in the effluent from the combustion chambers of the engine, is postulated to also take place in the thermal reactors, since these aldehydes are combustible substances.

It may be noted here that the enrichment described in connection with FIG. **2**, and also the selective enleanment arrangement, operate on the induction system or intake of the engine, while the thermal reactors operate on the exhaust of the engine. However, there is an important interaction or interplay between the two, as will now be explained. The complete overall system includes two combustion devices which must work in harmony, the first being the engine itself and the second being the thermal reactors. First, the carburetor is optimized (by enrichment) to reduce to a minimum the NO_x (and also the aldehydes, which decrease with richer mixtures), in keeping with good engine performance, economy, and driveability and then the secondary air delivery system (air in effect injected into the thermal reactors) must be tailored to give the proper air-fuel ratio to the reactors, such that these latter will (a) completely burn the carbon monoxide and hydrocarbons; (b) at the same time, not be burned up themselves.

By way of example, in order to minimize the NO_x and the aldehydes in the combustion chamber (by way of carburetor enrichment) there might be 6 percent carbon monoxide produced (due in large part to the enrichment action, with

more fuel going into the cylinders). This means that more carbon monoxide is being sent as fuel to the thermal reactors. Without more air, the reactors would not burn this properly due to either improper chemical balance or improper combustion temperatures. The ratio of CO to air fed to the reactors is critical since an optimum combustion temperature is desired for emissions reduction; at the same time, the combustion must be limited so that the temperature does not get so high that the reactors burn up. So, the amount of air that is injected into the inlet of the reactors (by means of the secondary air delivery system) must be readjusted to compensate for the action that has been effected in the carburetor to produce a certain amount of carbon monoxide and at the same time the amount of CO produced by enrichment (and thus the level of enrichment) must be carefully balanced.

As has been described previously, the carburetor enrichment (at off-idle condition) employed in this invention requires the supplying of additional air to the reactors (by means of the secondary air delivery system described), over and above what would be supplied to the reactors absent any enrichment, in order to properly oxidize or burn the carbon monoxide and hydrocarbons in the combustion chamber effluent. This means that when the enrichment is in effect cut off by the cutting-in of the selective enleanment arrangement, there will be an excess-air condition which prevents the reactors 4 and 4' from overheating. That is, at higher speed conditions more air is supplied to the reactors than they need; they still function to reduce the hydrocarbons, carbon monoxide, and aldehydes to a low level, but the extra air prevents the reactor temperature from continuing to rise, thus relieving any tendency to burn out the reactors.

Because of the enrichment employed in the emission control system of this invention, the engine requires slightly more gasoline. That is to say, with the present system there is an inherent reduction in fuel economy. At 30 m.p.h., it was found that there was a loss of about 13 percent in fuel economy (miles per gallon), though in highway driving (60 m.p.h.) the fuel economy reduction is rather small (due primarily to the selective enleanment of the air-fuel mixture at higher speeds, which is characteristic of the carburetor control of FIG. 2). However, even this (about 13 percent) reduction or loss in fuel economy is small as compared to that encountered in other emission control systems.

Additional spark retard is commonly used with thermal or catalytic reactors, to obtain rapid warmup and additional reactor temperature, which is said to provide a reduced level of emissions (as compared to that obtained with no additional retard). However, this additional spark retard (if used indiscriminately) carries with it a severe drop in fuel economy, a drop in the car performance or driveability and an increase in underhood temperatures. It is pointed out that no additional spark retard is utilized in the present system; the standard ignition system is used, retaining the standard advance curve and initial timing. Thus, the disadvantages of additional spark retard can be obviated. Additional spark retard can be used with the present system to afford additional reduction of emissions (at the above described expense, however), and is not excluded from the scope of this invention.

In the past, exhaust gas recirculation has often been employed to reduce the emission of NO_x. However, this has a definite and substantial adverse effect on the car performance or driveability also, the control (valving, rerouting, or switching) of hot exhaust gas is extremely difficult and troublesome. It is pointed out that in the system of the present invention no exhaust gas recirculation is used, so that the problems associated with such recirculation are avoided. Again, however, if additional NO_x reduction were desired, some exhaust gas recirculation could be used, but only a much lesser amount would be required, so that performance or driveability would not be unduly compromised.

It is again pointed out, however, that spark retard and exhaust gas recirculation both result in an adverse effect on driveability In contrast, in the emission control system of the present invention (used without these alternative methods) the driveability in terms of acceleration as well as other criteria such as startability, warmup, throttle response, etc. has remained excellent.

As previously described, the selective carburetor enleanment arrangement of FIG. 2 is responsive to engine speed, since ignition pulses are fed at 14 into unit 15. It may be more desirable, in some instances, to base the carburetor control on vehicle speed, rather than on engine speed, such as in the case of a vehicle with an automatic transmission, wherein there is slippage and wherein some fuel economy may be otherwise lost due to that slippage. For vehicle speed, a small pulse generating device of some sort could be placed in the drive line, or in the transmission tail shaft which operates the speedometer, in order to generate pulses (proportional to vehicle speed) for application to the input of unit 15. Mechanical vehicle speed sensing (not employing pulses) could alternatively be used for controlling the selective carburetor enleanment arrangement. For this purpose, it is anticipated that switches of known type (responsive to transmission pressure, or to drive line r.p.m.) could be employed to suitably control the solenoid 19.

The following example, illustrating the novel motor vehicle emission control system of this invention and the results obtained therewith, is given without any intention that the invention be limited thereto. The sampling and analysis of emission components were carried out in the prescribed manner according to the Federal test procedure, using the seven-mode cycle. In the absence of regulations, the NO_x were determined by the H.E.W. recommended sampling and subsequent Saltzman determination. The automotive vehicle utilized was a 1967 Chevrolet Camaro, a sporty-type performance-oriented vehicle, with 350-cubic-inch-displacement engine and manual transmission. This car utilized a single Rochester 4MV-A.I.R. "Quadrajet" carburetor, with enlarged idle tube restrictions according to the invention and with slightly enlarged main metering orifices, and also modified in accordance with the principles set forth in FIG. 2 to provide r.p.m.-controlled (speed-controlled) throttle bore air ports. Two thermal exhaust reactors, of the type described in the aforementioned patent, were utilized.

Table I, following, gives hot cycle test data obtained with this vehicle.

Table I

	Factory Equipped	Modified Car	% Modified of Factory Equipped
NO_x, p.p.m.	1203	147	12
CO, %	1.0	0.21	21
HC, p.p.m.	217	45	21
Fuel Economy, mpg			
30 m.p.h.	22.1	19.1	87
50 m.p.h.	18.6	16.5	89
60 m.p.h.	15.8	15.0	96

As stated, table 1 displays only hot cycle test data. Table II, following, shows the data obtained running the composite cold start seven-mode cycle. It is interesting to note, in this latter table, that during the first cycle, with choke operation, the NO_x were extremely low, which would indicate a response to additional enrichment even compared to the low levels obtained throughout the test; unfortunately, this is offset by the increase in carbon monoxide and hydrocarbons during this first cycle.

Table II

Cycle	CO, %	HC, p.p.m.	NO_x, p.p.m.
1	0.93	100	78

Table II—Continued

Cycle	CO, %	HC, p.p.m.	NO_x, p.p.m.
2	0.40	76	163
3	0.26	78	165
4	0.27	80	157
5			
6	0.27	70	141
7	0.19	60	184
Composite	0.31	71	155

Although the emission control system of the invention has been described as including the thermal exhaust manifold reactors **4** and **4'**, this is merely the preferred embodiment. It is entirely possible to use, in place of these thermal reactors, catalytic converters of known type, and the use of such latter converters is not outside the scope of the present invention. Catalytic converters, when used in the system of the invention, will function effectively and efficiently in a manner similar to the thermal reactors previously described, which is to say that the former will also convert at least a part of the carbon monoxide and hydrocarbons contained in the combustion chamber effluent to harmless substances.

The use of catalytic converters in the system of the present invention may be quite feasible and practical in view of the fact that one of the main drawbacks, if not the main drawback, to their use (to wit, the poisoning of the catalyst by leaded fuels) will quite probably be removed by the increased availability of nonleaded fuels.

In connection with catalytic converters, it will be appreciated that the procedures of spark retard and of exhaust gas recirculation (both of which were commonly used in the past, in conjunction with catalytic converters, and both of which result in an adverse effect on driveability are not at all necessary with the system of the present invention, and are ordinarily, and preferably, not utilized in the latter system.

I claim:

1. A system for reducing the pollutants contained in the exhaust of a motor vehicle internal combustion engine using a fossil fuel comprising, in combination, means for enriching the fuel-air mixture fed to the intake of said engine during off-idle and low-flow main metering operating conditions, the enrichment being sufficient to reduce the emission from said engine of oxides of nitrogen; means responsive to engine or vehicle speed for automatically enleaning the fuel-air mixture fed to the engine intake at speeds at or above a preselected speed and under nonclosed throttle conditions, and means acting upon the effluent from the combustion chambers of said engine for converting at least a part of the carbon monoxide and hydrocarbons contained in said effluent to harmless substances.

2. System according to claim **1**, wherein the automatic enleaning means acts to increase the air-to-fuel ratio of said mixture at the speeds and under the throttle conditions stated.

3. System of claim **1**, wherein said engine utilizes a carburetor for feeding the fuel-air mixture to the engine intake, and wherein said enriching means and said enleaning means both operate upon said carburetor.

4. System defined in claim **3**, wherein said enleaning means comprises actuatable means, separate from the main engine intake air supply, for supplying air to the engine intake, and means responsive to the speed of said engine or vehicle for actuating said separate air supplying means.

5. System recited in claim **1**, wherein the last-mentioned means comprises a thermal reactor operating to burn at least a part of the carbon monoxide and hydrocarbons contained in said effluent.

6. System of claim **1**, wherein the last-mentioned means comprises a thermal reactor with inlet connections and an outlet connection, means connecting the combustion chambers of the engine to said inlet connections, and means for connecting an exhaust pipe to said outlet connection.

7. For a motor vehicle internal combustion engine using a fossil fuel, a method for controlling exhaust emissions which comprises enriching the fuel-air mixture fed to the intake of said engine under off-idle and low-flow main metering operating conditions, thereby to reduce the emission from said engine of oxides of nitrogen, selectively and automatically varying the composition of the mixture at engine or vehicle speeds at or above a preselected speed and under nonclosed throttle conditions, and burning combustible gases present in the exhaust of said engine.

8. Method of claim **7**, wherein the varying is effected selectively and automatically in response to the speed of said engine or vehicle.

9. Method of claim **7**, wherein the varying comprises enleaning the fuel-air mixture.