United States Patent

Nakajima et al.

[15] **3,636,934**

[45] **Jan. 25, 1972**

[54] VEHICULAR AIR-POLLUTION PREVENTIVE SYSTEM

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[22] Filed: **Mar. 11, 1970**

[21] Appl. No.: **18,497**

[30] **Foreign Application Priority Data**

Mar. 22, 1969 Japan.....44/21282

[52] **U.S. Cl.** .....**123/119 A,** 180/105, 180/109

[51] **Int. Cl.**.....**F02m 25/06,** B60k 37/00

[58] **Field of Search**.....123/119 A, 107, 113, 116; 180/105–108, 109, 82

[56] **References Cited**

UNITED STATES PATENTS

1,506,166 8/1924 Durrant .....123/119 A

2,408,846 10/1946 Gulden et al.....123/119 A

2,722,927 11/1955 Cornelius.....123/119 A

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Attorney—Robert E. Burns and Emmanuel J. Lobato

[57] **ABSTRACT**

A vehicular air-pollution preventive system serious use with an internal combustion engine, which system is adapted to reduce the quantity of nitrogen oxides produced during acceleration or hill-climbing in such quantities as to cause a serious air-pollution problem especially when the vehicle is driven in urban areas, having switches closing when the vehicle is driven under predetermined conditions providing the acceleration or hill-climbing and a solenoid valve which is adapted to pass exhaust gases from the exhaust manifold to the intake manifold when the switches are closed concurrently. The conditions in which the switches are closed concurrently are represented by variables such as the combination of angular position of a carburetor throttle valve and engine speed or vehicle speed.

6 Claims, 6 Drawing Figures

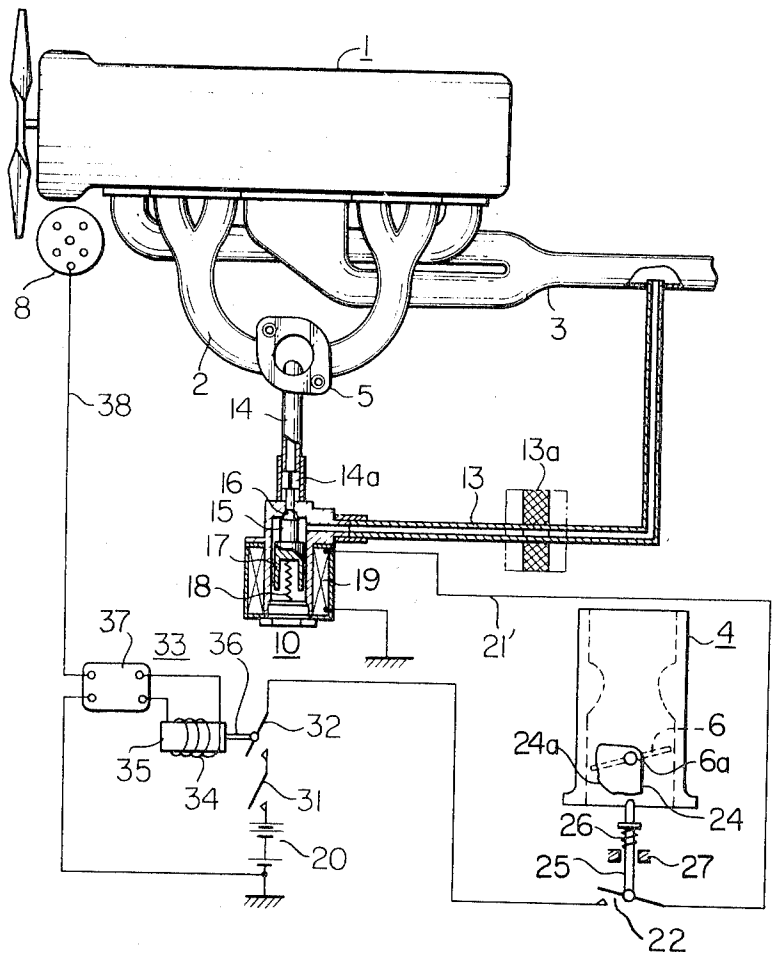

Fig. 1

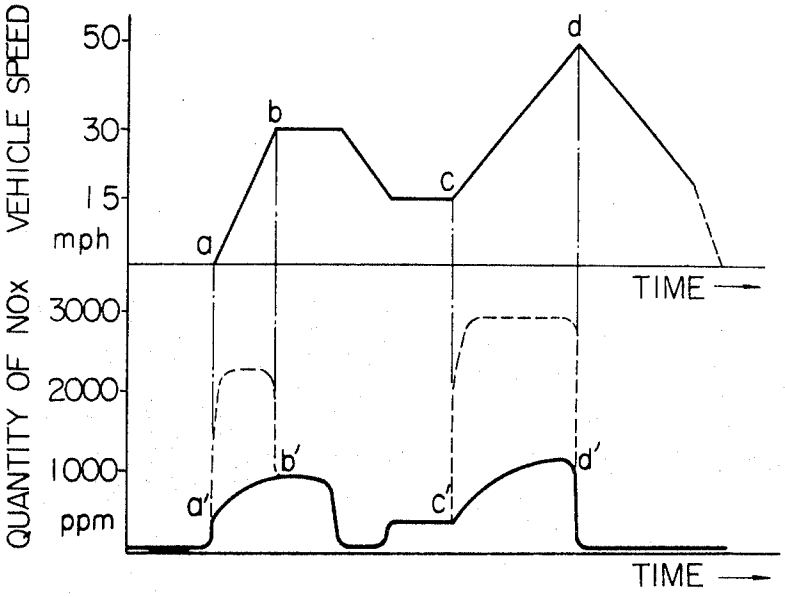
VEHICLE SPEED
50
30
15
mph
a
b
c
d
TIME
QUANTITY OF NOx
3000
2000
1000
ppm
a'
b'
c'
d'
TIME

Fig. 4

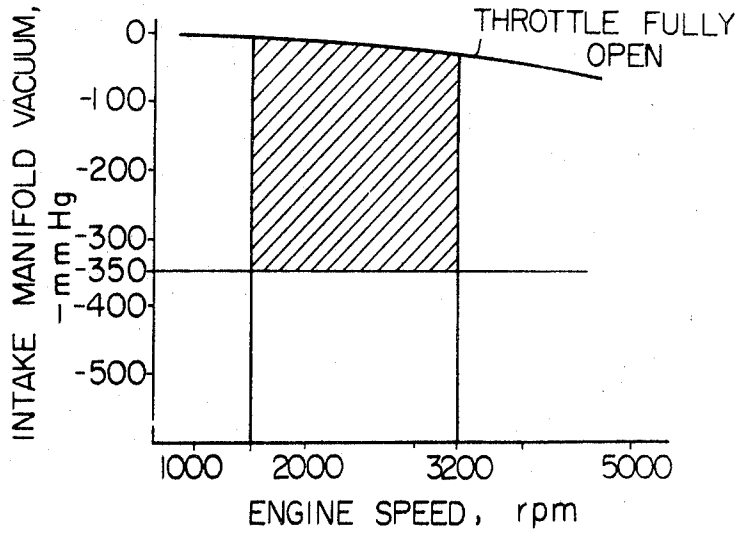
INTAKE MANIFOLD VACUUM, - mm Hg
0
-100
-200
-300
-350
-400
-500
THROTTLE FULLY OPEN
1000
2000
3200
5000
ENGINE SPEED, rpm

Fig. 2

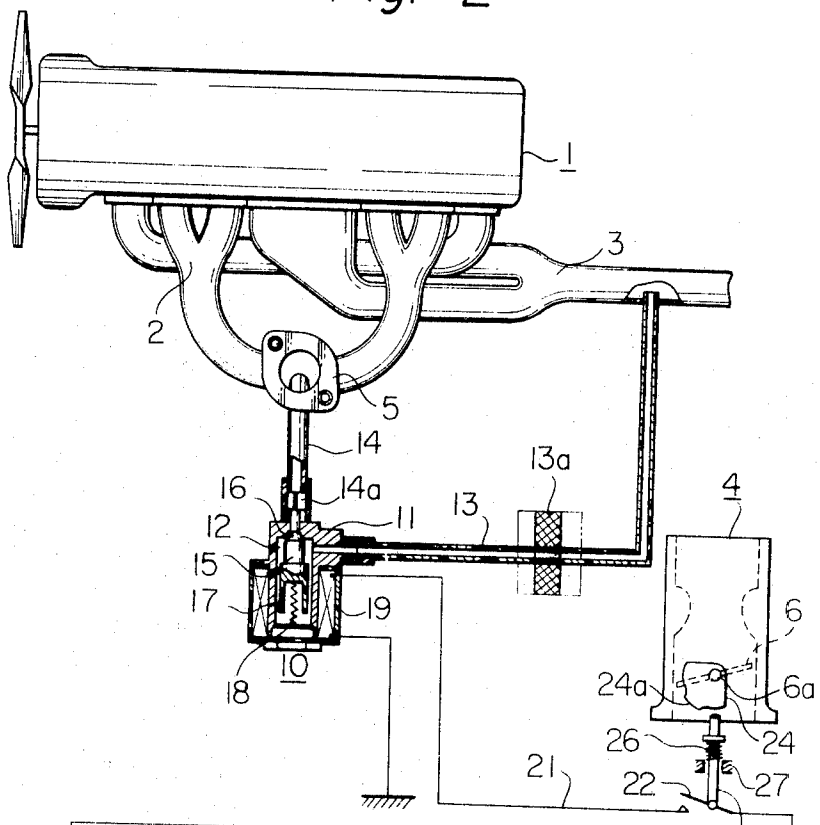

Fig. 3

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Fig. 5

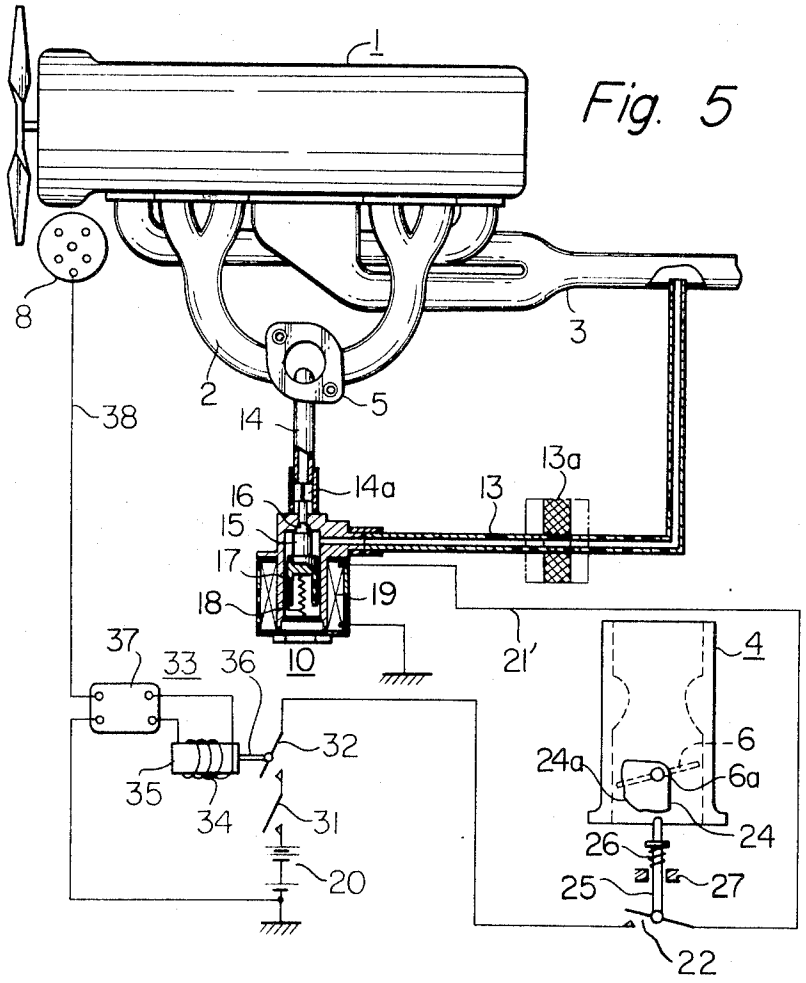
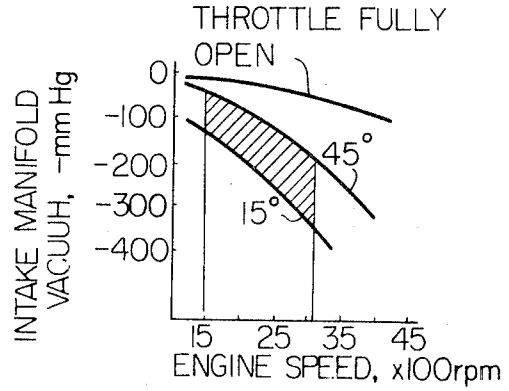


Fig. 6



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VEHICULAR AIR-POLLUTION PREVENTIVE SYSTEM

This invention relates to a vehicular air-pollution preventive system and, more particularly, to a system adapted to reduce the quantity of toxic nitrogen oxides contained in engine exhaust gases.

Air-pollution resulting from the emission of nitrogen oxides is one of serious public nuisances particularly in urban areas of today and it is during acceleration and hill-climbing of a motor vehicle that nitrogen oxides are discharged to the open air in such quantities as to cause a serious air-pollution problem in the urban areas. This will mean that the air-pollution problem could be alleviated significantly if the quantity of nitrogen oxides is reduced during acceleration and hill-climbing that occur frequently when the motor vehicle is driven in urban areas.

In order to reduce the quantity of nitrogen oxides in the engine exhaust gases, various attempts have been made including a scheme of continuously recirculating the engine exhaust gases to the intake manifold of the engine. In this known practice, the engine exhaust gases are partially recirculated in a continuous fashion to the intake manifold where a regulated amount of inert gases are added to the recirculated exhaust gases to lower the temperature at which the exhaust gases are burned for a second time. This reduction in the flame temperature prevents reaction that would otherwise take place between nitrogen and oxygen in the exhaust gases. Thus, the quantity of nitrogen oxides contained in the finally discharged exhaust gases can be reduced significantly without detriment to the performance quality of the engine.

In spite of the prominent reduction in the quantity of nitrogen oxides in the exhaust gases, continuous recirculation of the exhaust gases without respect of the operating conditions of the engine, as has thus far been the practice, results in unstable engine operation, decreased engine output and contamination within the engine and, as such, is considered unsuitable for practical purposes.

The invention was thus completed under the recognition that the drawbacks which result from the continuous recirculation of the exhaust gases can be effectively eliminated be selectively recirculating the exhaust gases only when the engine is driven under predetermined conditions in which the motor vehicle accelerates or climbs up a hill as frequently experienced in the driving in urban areas.

Such conditions of the engine providing the acceleration or hill-climbing of the motor vehicle are represented, as preferable according to the invention, by the combination of the speed of the engine or vehicle and the angular position of the throttle valve in the carburetor.

A primary object of the invention is therefore to provide a system for reducing the quantity of nitrogen oxides emitted from the engine when the motor vehicle is driven in urban areas.

Another primary object of the invention is to provide a system which is adapted to reduce the quantity of nitrogen oxides in the engine exhaust gases without detriment to the operation stability and power output of the engine and without contamination of the engine components.

Still another primary object of the invention is to provide a system which is constructed and arranged to have the exhaust gases recirculated into the intake manifold only when the engine is driven under predetermined conditions in which the motor vehicle is accelerated or climbs up a hill.

Still another primary object of the invention is to provide a system whereby the engine exhaust gases containing nitrogen oxides are recirculated into the intake manifold only when the engine or vehicle is driven at a speed in a predetermined range and concurrently the carburetor throttle valve is open at predetermined angles.

In the drawings:

FIG. 1 is a graphical representation of a typical example of the relationships between the vehicle speed of a motor vehicle running on city roads and the quantity of nitrogen oxides in the then emitted exhaust gases;

FIG. 2 is a schematical view showing a preferred embodiment of the air-pollution preventive system according to the invention as combined with a usual automotive internal combustion engine which is shown in a schematical and view;

FIG. 3 is a section on line I—I of FIG. 2;

FIG. 4 is a graphical representation exemplifying a region in which the system shown in FIGS. 2 and 3 is operable;

FIG. 5 is similar to FIG. 2 but shows a modification of the system shown therein; and

FIG. 6 is similar to FIG. 4 but shows a region in which the modified system of FIG. 5 is operable.

The quantity of nitrogen oxides contained in the engine exhaust gases is intimately related to the vehicle speed. The investigations conducted by the inventors have revealed that it is during acceleration and hill-climbing that the quantity of nitrogen oxides increases to such an extent as to cause a serious air-pollution problem in urban areas. This will be ascertained by reference to FIG. 1, which shows that as the vehicle speed is increased from *a* to *b* for acceleration or *c* to *d* for hill-climbing, the quantity of nitrogen oxides increases abruptly as indicated by the broken curve *a'–b'* or *c'–d'*, respectively. Thus, the emission of nitrogen oxides could be reduced effectively throughout the varying modes of vehicular operations if the emission is minimized during acceleration and hill-climbing.

In order to realize such scheme, the invention proposes, as preferable, to have the ranges *a–b* and *c–d* of the driving conditions of the vehicle represented by the combination of the angular position of the throttle valve and the speed of vehicle or engine.

A preferred embodiment to accomplish such an end is shown in FIGS. 2 and 3.

As best seen in FIG. 2, the system according to the invention is used in combination with a usual automotive internal combustion engine which is generally designated by reference numeral 1. The engine 1 has, as customary, an intake manifold 2 and exhaust manifold 3 and is combined with a carburetor 4 for simplicity of illustration. The carburetor 4 is anyway mounted on the intake manifold 2 by a mounting flange 5 and, as illustrated in FIG. 3, has a throttle valve 6 which is mounted on and rotatable with a rotary shaft 6*a*, as customary.

The air-pollution preventive system of the invention essentially comprises an exhaust recirculation control valve assembly 10, which is actually a solenoid valve device. The valve assembly 10 has a casing 11 having formed therein a chamber 12 which communicates on one side with the exhaust manifold 3 through an exhaust recirculation conduit 13 and on the other with the carburetor 4 downstream of the throttle valve 6 through an exhaust recirculation nozzle 14. If preferred, the nozzle 14 may be opened into the intake manifold 2, though not so illustrated. An orifice 14*a* may be provided in the passage 14 thereby to control the flow of air therethrough.

A valve element 15 is operatively mounted in the chamber 12 and is positioned relative to a valve seat 16 forming part of the inner wall of the chamber 12. The valve element 15 is integrally combined with a hollow cylinder 17 which is axially movably mounted in the chamber 12. The hollow cylinder 17 has accommodated therein a compression spring 18 so that the hollow cylinder 17 is forced in a direction in which the valve element 15 is seated on the valve seat 16 to block the communication between the conduit 13 and nozzle 14. The hollow cylinder 17 also serves as a moving core which is actuated into motion by a solenoid coil 19 and is powered by a suitable source 20 of electric energy through a line 21.

The exhaust recirculation control valve assembly 10 thus constructed is operated by control means which is responsive to the driving conditions of the motor vehicle so that the valve element 15 is moved to and seated on the valve seat 16 when predetermined driving conditions are responded to by the control means.

The driving conditions of the vehicle may be represented by numerous variables and, in the particular embodiment of FIGS. 4 and 5, the control means is arranged to be responsive

to the angular position of a carburetor throttle valve **6** and the vehicle speed selected by a transmission system which is generally designated by numeral **7**.

The control means may be, as illustrated in FIG. **2**, comprises essentially of a throttle valve switch **22** and vehicle speed switch **23**, which are connected in series with the solenoid coil **19** of the control valve assembly **10** through a line **21**.

The throttle valve switch **22** is operated by means of a cam arrangement which detects the angular position of throttle valve **6** of the carburetor **4**, namely, the effective throttle area in the carburetor, which angular position or effective throttle area varies with the driving conditions of the motor vehicle.

As illustrated in FIG. **2**, the cam arrangement essentially comprises a cam element **24** having a partially protruded peripheral edge **24***a*. The cam element **24** is securely mounted on and rotated with the shaft **6***a* supporting the throttle valve **6**. An actuating rod **25** is rigidly connected at one end with the throttle valve switch **22** and positioned at the other relative to the cam element **24**. The rod **25** is normally forced toward the cam element **24** by the action of a compression spring **26** which is mounted on a fixed support **27**. When the cam element **24** rotates with the rotation of the throttle valve shaft **6***a*, the protruded peripheral edge **24***a* abuts against the leading end of the actuating rod **24**, which is consequently retracted from the initial position against the action of the compression spring **26**, causing the switch **22** to close. The relative position of the protruded peripheral edge **24***a* and/or actuating rod **24** may be determined in such a manner that the switch **22** is closed when the motor vehicle is driven under conditions corresponding to the lines *a–b* and *c–d* in FIG. **1** and preferably when the throttle valve **24** is open at 15° to 45°.

The vehicle speed switch **23**, on the other hand, is operated by a vehicle speed detector **28** which is driven by the output shaft (not identified) of the transmission system **7** through a driving shaft **29** so as to detect the revolution speed of the output shaft of the transmission system. The vehicle speed detector **28** delivers voltages proportional to the vehicle speeds detected thereby and energizes the switch **23**. The switch **23** may be constructed as a normally open relay switch which is arranged to close when it is energized with a voltage corresponding to a vehicle speed ranging from 20 to 80 km./hr., by way of example.

The vehicle speed detector **28** is herein shown as connected with a speed meter **30** which visibly indicates the vehicle speed selected in the transmission system from time to time. Denoted by **31** is an ignition switch which may be interposed, if desired, between the vehicle speed switch **23** and power source **20**.

When, in operation, the engine is driven under conditions in which the quantity of nitrogen oxides contained in the engine exhaust gases is not such that will cause a serious air-pollution problem as during deceleration or normal cruising, then the vehicle speed and/or angular position of the throttle valve **6** will be outside the range within which the throttle valve switch **22** and/or vehicle speed switch **23** are to be closed. In this particular condition, the solenoid coil **19** of the control valve assembly **10** is kept disconnected from the source **20** of power and thus remains unexcited. As the consequence, the valve element **15** remains seated on the valve seat **16** by the action of the compression spring **18**, isolating the intake manifold **2** from the exhaust manifold **3**. The exhaust gases are in this manner prohibited from entering the nozzle **14** through the chamber **12**.

When, however, the engine power output is increased to such an extent as to cause a serious air-pollution problem, then the vehicle speed will fall within a predetermined range of, for instance, 20 to 80 km./hr. (12 to 50 mile/hr.) and the carburetor throttle valve will be open at an angle falling within a predetermined range of, for instance, 15° to 45°, as illustrated in FIG. **4**. In this condition, the partially protruded peripheral edge **24***a* abuts against the leading end of the actuating rod **25** and depress the same against the action of the compression spring **26** to a position in which the switch **22** is closed. At the same time, the relay switch **23** is energized with a voltage supplied from the detector **28** and closed consequently. The two switches **22** and **23** thus closed concurrently, the solenoid coil **19** of the control valve assembly **10** is now energized to cause the valve element **15** to be unseated from the valve seat **16** against the action of the spring **18**, thereby passing the exhaust gases from the conduit **13** to nozzle **14**. The exhaust gases are thus recirculated into the intake manifold so that the nitrogen oxides contained in the finally discharged exhaust gases are reduced from the level indicated by the broken curve *a'–b'* or *c'–d'* down to the level indicated by the solid curve *a'–b'* or *c'–d'*, respectively, as shown in FIG. **1**.

In order to prevent the intake manifold and engine from being contaminated with the exhaust gases recirculated, a filter **13***a* may be provided in the recirculation conduit so as to remove carbons from the exhaust gases.

FIG. **5** illustrates a modification of the air-pollution preventive system of this invention, the modification being arranged to be operable on the angular position of the throttle valve and the engine speed.

The modified system illustrated herein also uses an exhaust recirculation control valve assembly which is similar to the counterpart in the embodiment previously described and shown. The same reference numerals are, therefore, employed in FIG. **5** to designate corresponding parts.

The control valve assembly **10** in this modification is operated by control means essentially comprising a throttle valve switch **22** and an engine speed switch which is designated by **32**. The switches **22** and **33** are connected in series with the solenoid coil **19** of the control valve assembly **10** through a line **21'** and with a power source **20**.

The throttle valve switch **22** is operated by a cam arrangement of the same construction as that used in the embodiment of FIG. **2** and, hence, description thereof will entirely apply to the corresponding arrangement shown in FIG. **5**.

The engine speed switch **32**, on the other hand, is controlled by a solenoid device **33** having a solenoid coil **34** and moving core **35**. The moving core **35** is connected with the switch **32** through a connecting rod **36** and is positioned to normally keep the switch **32** to open and to be moved to a position to close the switch **32** when the solenoid coil **34** is excited. The solenoid coil **34** is connected to and excited by the output terminal of a pulse counter **37** of known construction. The input terminal of the pulse counter **37**, in turn, is connected to an ignition distributor **8** of the engine **1**. The pulse counter **37** thus detects the number of pulses fed from the primary winding of the ignition coil (not identified) of the ignition distributor **8**. The pulse counter **37** may be of such type as to excite the solenoid coil **34** when it detects pulses in a number proportional to an engine speed within a predetermined range. The switch **32** is thus closed only when the engine is driven at a speed falling within a predetermined range of, for instance, 1,500 to 3,200 r.p.m.

When, in operation, the vehicle is being driven with the carburetor throttle valve **6** kept open at an angle falling outside a predetermined range of, for instance, 15° to 45°, then the switch **22** remains open with the protruded peripheral edge **24***a* releases from the leading end of the actuating rod **26**. Similarly, when the engine is being driven at a speed higher or lower than a predetermined range of, for instance, 1,500 to 3,200 r.p.m., then the switch **32** remains open. With at least one of the switches **22** and **32** kept open, the solenoid coil **19** of the exhaust recirculation control valve assembly **10** is disconnected from the power source **20** so that the valve element **15** is kept seated on the valve seat **16** so as to block the air communication between the intake manifold **2** and the atmosphere.

When, however, the engine is driven at a speed falling within a predetermined range of, for instance, 1,500 to 3,200 r.p.m. and with the carburetor throttle valve open at an angle falling within a predetermined range of, for instance, 15° to

45°, then the switches 22 and 32 are closed concurrently to cause the solenoid coil 19 of the control valve assembly 10 to be energized. The valve element 15 is consequently unseated and the exhaust gases passed through the chamber 12 into the intake manifold 2.

FIG. 6 illustrates an example of the range in which the two switches 22 and 32 are closed concurrently in the air-pollution preventive system of FIG. 5.

What is claimed is:

1. An air-pollution preventive system for a motor vehicle having an internal combustion engine provided with an intake manifold, exhaust manifold and carburetor having a throttle valve comprising: a solenoid valve assembly having means therein defining a valve chamber having an inlet opening and an outlet opening, a movable valve element disposed within said valve chamber movable to an open position providing communication between said inlet and outlet openings and to a closed position preventing communication between said inlet and outlet openings, a movable core integral with said valve element, a solenoid coil effective when energized to effect movement of said valve element to said open position, and spring means urging said valve element into said closed position; means providing communication between said inlet opening and said exhaust manifold and between said outlet opening and said intake manifold; and control means for providing an electrical output signal to said solenoid valve assembly to energize said solenoid coil and effect movement of said valve element to said open position in response to acceleration of hill-climbing operating conditions of the motor vehicle.

2. A system according to claim 1, wherein said operating conditions are defined by a predetermined combination of the angular position of the carburetor throttle valve and the motor vehicle speed selected in the transmission system.

3. A system according to claim 1, wherein said operating conditions are defined by a predetermined combination of the angular position of the carburetor throttle valve and engine speed.

4. A system according to claim 1, wherein said control means comprises a throttle valve switch operated by a cam arrangement cooperating with the throttle valve and a vehicle speed switch connected with an operated by a vehicle speed detector, means connecting said throttle valve and vehicle speed switches in series with an electrical power source and said solenoid coil, said cam arrangement comprising a cam element having a partially protruded peripheral edge, means mounting said cam element for angular movement integrally with said throttle valve, an actuating rod rigidly connected with said throttle valve switch and positioned relative to said cam element, and a compression spring forcing said actuating rod toward said cam element to keep said throttle valve switch open, said protruded edge being shaped and sized to bring said actuating rod into a position to close said throttle valve switch when said cam element is angularly moved with said throttle valve to contact and depress said actuating rod toward said throttle valve switch, and said vehicle speed detector having means operative to close said vehicle speed switch when the detector detects a predetermined range of vehicle speeds and for delivering a voltage proportional to the detected vehicle speed; whereby said solenoid coil is energized and said valve element moved to said open position when both the throttle valve and vehicle speed switches are concurrently closed.

5. A system according to claim 1, wherein said control means comprises a throttle valve switch operated by a cam arrangement cooperating with the throttle valve and an engine speed switch connected with and operated by a solenoid device, means connecting said throttle valve and engine speed switches in series with an electrical power source and said solenoid coil, said cam arrangement comprising a cam element having a partially protruded peripheral edge, means mounting said cam element for angular movement integrally with said throttle valve, an actuating rod rigidly connected with said throttle valve switch and positioned relative to said cam element, and a compression spring forcing said actuating rod toward said cam element to keep said throttle valve switch open, said protruded peripheral edge being shaped and sized to bring said actuating rod into a position to close said throttle valve switch when said cam element is angularly moved with said throttle valve to contact and depress said actuating rod toward said throttle valve switch, and said solenoid device comprising a pulse counter having an input terminal connected to an ignition distributor of the engine for detecting the number of pulses supplied therefrom, a solenoid coil connected with the output terminal of said pulse counter and energized thereby when said number of pulses falls within a range corresponding to a predetermined range of engine speeds, a moving core cooperating with said solenoid coil of the solenoid device and normally held in a position to keep said engine speed switch open when the associated solenoid coil remains deenergized, and a connecting rod rigidly connecting said moving core of the solenoid device and said engine speed switch, said moving core of the solenoid device being moved to a position in which said engine speed switch is closed through the associated connecting rod when said solenoid coil of the solenoid device is energized; whereby said solenoid coil of said control valve assembly is energized and said valve element moved to said open position when both said throttle valve and engine speed switches are concurrently closed.

6. A system according to claim 5, wherein a filter is provided in said means providing communication between said inlet opening and said exhaust manifold.

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