VEHICULAR AIR-POLLUTION PREVENTIVE SYSTEM

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5 Claims

ABSTRACT OF THE DISCLOSURE

A vehicular air-pollution preventive system for 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 two switches closing when the vehicle is driven at a speed falling within a predetermined range and with the intake manifold vacuum lower than a predetermined level providing acceleration or hill-climbing and an exhaust re-circulation control valve assembly which is adapted to pass the exhaust gases to the intake manifold when both of the two switches are closed concurrently.

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 the 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 by 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 vacuum in the intake manifold of the engine and the vehicle speed.

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 motor vehicle is accelerated or climbs up a hill at a speed within a predetermined range and with the intake manifold vacuum lower than a predetermined level.

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 schematic 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 schematic end 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 also similar to FIG. 2 but shows another modification.

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 intake manifold vacuum and vehicle speed.

A preferred embodiment to accomplish such an end is shown in FIGS. 2, 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 carburettor 4 which is removed from FIG.
for simplicity of illustration. The carburettor 4 is anyway mounted on the intake manifold 2 by a mounting flange 5 as illustrated in FIG. 3, has a throttle valve 6 which is mounted on and rotatable with a rotary shaft 6a, 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 carburettor 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 14a may be provided in the passage 14 thereby to control the flow of air flowing 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 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 control means is arranged according to the invention to be responsive to the vacuum in the intake manifold 2 of the engine 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. 4, comprising essentially of a vacuum switch 21 and a 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 vacuum switch 22 is connected with and controlled by a diaphragm device 24, which is intended to detect the vacuum in the intake manifold 2. The diaphragm device 24 has a chamber 25 and atmospheric chamber 26 which is separated from the former by a diaphragm member 27. The vacuum chamber 25 communicates with the intake manifold 2 of the engine 1 through a vacuum conduit 28, while the atmospheric chamber 26 is vented from the atmosphere. The diaphragm member 27 is connected with the vacuum switch 22 through a connecting rod 29 extending through the atmospheric chamber 26. In the vacuum chamber 27 is mounted a compression spring 30 whereby the diaphragm member 27 is forced toward the atmospheric chamber 25. Thus, when the intake manifold vacuum is at an elevated level, the diaphragm member 27 is forced toward the atmospheric chamber 25. When, in contrast, the intake manifold vacuum drops under a predetermined level of, for instance, —350 mm. of Hg, then the spring 30 overpowers the vacuum and the diaphragm member 27 is moved toward the atmospheric chamber 26 to permit the switch 22 to close. The spring 30 may be determined in a manner to yield to the vacuum at such predetermined level.

The vehicle speed switch 23, on the other hand, is operated by a vehicle speed detector 31 which is driven by the output shaft (not identified) of the transmission system 7 through a driving shaft 32 so as to detect the revolution speed of the output shaft of the transmission system. The vehicle speed detector 31 delivers a voltage 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.

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 intake manifold vacuum and/or vehicle speed will be outside the range within which the vacuum 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 a consequence, the valve element 15 remains seated on the valve seat 16 by the action between the 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, on the other hand, the engine output increases to such an extent as to produce nitrogen oxides in quantities to cause a serious pollution problem as represented by the dotted curves a’-b’ or c’-d’ in FIG. 1, then the intake manifold vacuum drops under the aforesaid predetermined level, for example, —350 mm. of Hg and the vehicle speed falls within the predetermined range of, for instance, 20 to 80 km./hr. In this condition, the spring 30 overpowers the vacuum in the vacuum chamber 25 to cause the diaphragm member 27 to move into 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 31 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 2 which is combined with the exhaust manifold 3 and atmospheric chamber 25.

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

The exhaust recirculation control valve assembly which has been shown as a solenoid valve device 10 may be constructed otherwise inasmuch as the intent of recirculating the exhaust gases only when the engine is driven at predetermined speeds and the intake manifold vacuum lowered under a predetermined level, one of such modifications being illustrated in FIG. 4.

The embodiment shown in FIG. 5 is adapted to protect the solenoid device from contamination with exhaust gases. As shown, the exhaust recirculation control valve is now constructed as a combination of a spool valve device 35 and a solenoid valve device 36 to control the former.

The spool valve device 36 has a casing 37 communicating on one side with the exhaust manifold 3 through a conduit 38 and on the other with the Intake manifold 2.
through a nozzle 39. The conduit 38 is shown to debouch into the casing 37 at an inlet port 38a and the nozzle 39 to lead from the casing at an outlet port 39a. An orifice 45 may be provided in the nozzle 39 to control the flow through the nozzle.

The casing 37 has accommodated therein a spool valve 41 having a land 42. A compression spring 43 is mounted in a chamber 44 formed between the end walls of the casing 37 and land 42 in such a manner that the spool valve 41 is forced toward a position in which the inlet port 38a is closed by the land 42, as shown.

The casing 37 further communicates with a casing 45 of the solenoid device 36 through a conduit 46. This casing 45 in the solenoid device 37 communicates on one side with the intake manifold 2 through a conduit 47 and on the other with the atmosphere, or with an cleaner if preferred, through a conduit 48. A moving core 49 is axially movably mounted in the casing 45 to act as a valve member and a compression spring 50 is mounted around this moving core or valve member 49 in a manner to force the valve member toward a position in which the conduit 47 is closed and the conduit 48 opened. In this condition, the casing 45 is prevented for communicating with the intake manifold 2 and is maintained at an atmospheric pressure.

The valve member 49 is operated by a solenoid coil 51 which is connected at one end with a power source 20 through a line 21a and at the other with a vacuum switch 26 and vehicle speed switch 24 through a line 21b similarly to the system illustrated in FIG. 2.

The switches 22 and 23 are controlled by a diaphragm device 24 and vehicle speed detector 31, respectively, which are entirely similar in construction and function to those shown in FIG. 2 so that the discussion previously given may be applied thereto.

During deceleration or normal cruising of the motor vehicle when the emission of nitrogen oxides from the engine is too low in concentration to cause a serious air pollution problem, the solenoid valve device 36 remains inoperative because the solenoid coil 51 thereof is kept de-energized with the switches 22 and 23 open.

When, on the other hand, the engine output increases and nitrogen oxides are produced from the engine in quantities that can not be neglected from the practical standpoint as indicated by the dotted curves a'--b' and c'--d' in FIG. 1, then the intake manifold vacuum decreases under a predetermined range to cause the compression of the spring 28 of the diaphragm device 24 and concurrently the vehicle is driven at a speed within a predetermined range to cause the vehicle speed switch 23 to be actuated. The switches 22 and 23 are now closed and the solenoid coil 51 of the solenoid device 36 energized. The valve member 49 is moved against the action of the spring 50 to a position to open the conduit 47 and close the conduit 48. The intake manifold vacuum that is now at a lower level is permitted to flow into the chamber 44 formed by the end walls of the casing 37 and land 42 of the spool valve 41.

The spring 43 being selected to yield to the thus lowered vacuum, the spool valve 41 is pulled by the vacuum over to a position in which the land 42 leaves and opens the inlet port 38a. The conduit 38 is permitted to communicate with the nozzle 39 to enable the exhaust gases to recirculate from the exhaust manifold 3 into the intake manifold 2.

As an alternative to the spool valve device 35 used in the above-described embodiment, a diaphragm valve device may be combined with the solenoid valve device to constitute an exhaust recirculation control assembly in the system according to the invention, example being shown in FIG. 5.

In FIG. 6, only the diaphragm valve device which is generally denoted by 52 and the solenoid valve device which is similar to the counterpart in FIG. 5 and is numbered accordingly are illustrated, because the remaining essential elements are the same as used in the system in FIG. 5.

Referring to FIG. 6, the diaphragm valve device 52 is constructed similarly to the diaphragm device 24 in FIG. 2, and has a vacuum chamber 53 defined by a diaphragm member 54 and the structural wall of the device 52, as shown. The vacuum chamber 53 communicates with the casing 45 of the solenoid valve device 36 through a conduit 46a. A valve element 55 is connected with the diaphragm member 54 on its side opposite to the vacuum chamber 53. A compression spring 56 is mounted in the vacuum chamber 53 in a manner to force the diaphragm member 54 and accordingly the valve element 55 away from the vacuum chamber 53. The valve element 55 in this protruded position projects into a port 57 between an exhaust recirculation conduit 38 and nozzle 39 thereby to isolate the conduit and nozzle from each other.

Now, as the engine output increases and the switches 22 and 23 are closed, then the solenoid valve device 36 becomes actuated to permit the vacuum to flow into the vacuum chamber 53. The compression spring 56 is selected so as to yield to the vacuum so that the diaphragm member 54 and accordingly the valve element 55 are moved toward the vacuum chamber 53 and away from the port 57. With valve element 55 thus retracted, the conduit 38 communicates with the nozzle 39 thereby to pass the exhaust gases from the exhaust manifold to the intake manifold, similarly to the previously described embodiments.

What is claimed is:

1. An air-pollution preventive system for a motor vehicle having an internal combustion engine with a carburetor, comprising control means responsive to the intake manifold vacuum and vehicle speeds at which the motor vehicle is driven for acceleration or hill-climbing and an exhaust recirculation control assembly having a chamber to provide communication between the intake manifold and the exhaust manifold of the engine and a valve element operatively mounted in said chamber and normally held by a spring action in a position to block said communication, said valve element being moved by said control means against said spring action to a position in which said chamber communicates with the intake manifold when said control means detects said intake manifold vacuums and vehicle speeds whereby the exhaust gases are recirculated from the exhaust manifold to the intake manifold.

2. A system according to claim 1, wherein said exhaust recirculation control valve assembly comprises a solenoid coil, a hollow moving core integral with said valve element and movably mounted in said chamber, a compression spring mounted within said hollow moving core and forcing the moving core to a position in which said valve element blocks said communication, an exhaust recirculation conduit communicating with the exhaust manifold and leading into said chamber, and an exhaust recirculation nozzle leading from said chamber downstream of said valve element to the intake manifold, said valve element being unseated when said solenoid coil is energized to cause said moving core to move to its retracted position whereby said conduit communicates with said nozzle.

3. A system according to claim 1, wherein said control valve assembly includes a spool valve device and a solenoid valve device, said spool valve device including a casing communicating on one side with the exhaust manifold through an exhaust recirculation conduit and on the other with the intake manifold through an exhaust recirculation nozzle, a solenoid valve axially movably mounted in said casing and having a land at one end, and compression to a position in which said land is moved to a position in which said conduit communicates with said nozzle when said solenoid coil of said solenoid valve device is excited by means of said control means.
4. A system according to claim 1, wherein said control valve assembly includes a diaphragm valve device and a solenoid valve device, said diaphragm valve device including a vacuum chamber, a diaphragm member separating said vacuum chamber from the atmosphere, a port communicating on one side with the exhaust manifold through an exhaust recirculation conduit and on the other with the intake manifold through an exhaust recirculation nozzle, a valve element connected with said diaphragm member and directed toward said port, and a compression spring mounted in said vacuum chamber to force said diaphragm member toward a position in which said valve element is closed; said port, the compression of said compression spring being determined to yield to the intake manifold vacuum lowered to a predetermined level at which the vehicle is accelerated or climbs up a hill, said solenoid valve device including a solenoid valve casing communicating spring mounted in said casing to force said spool valve toward a position in which said land isolates said nozzle from said conduit, the compression of said compression spring being determined to yield to the intake manifold vacuum lowered to a predetermined level, said solenoid valve device including a solenoid valve casing communicating with said casing of the spool valve device, said solenoid valve casing further communicating on one side with the intake manifold through a vacuum conduit and on the other with the atmosphere, a moving core axially movably mounted in said solenoid valve casing and acting at the same time as a valve member, said moving core being normally forced into a position to isolate said vacuum conduit from said casing of said spool valve device by a spring action, and a solenoid coil associated with said moving core and connected with a power source through said control means, said moving core being moved to a position to permit said vacuum conduit to communicate with said casing of said spool valve device to cause said diaphragm member to be moved against the action of said spring in said diaphragm valve device to a position in which said valve element is moved to a position to open said port whereby said exhaust recirculation nozzle is permitted to communicate with said conduit when said solenoid coil of said solenoid valve device is excited by means of said control means.

5. A system according to claim 1, wherein said control means comprises a vacuum switch connected with and controlled by a diaphragm device and a vehicle speed switch connected with and controlled by a vehicle speed detector which detects vehicle speeds selected by a transmission system and delivers voltages proportional to the vehicle speeds detected, said vacuum and engine speed switches being connected in series with a power source and said solenoid coil, said diaphragm device comprising a vacuum chamber communicating with the intake manifold of the engine, a diaphragm member separating said vacuum chamber from the atmosphere, a connecting rod rigidly connecting said diaphragm member and said vacuum switch, and a compression spring mounted in said vacuum chamber to force said diaphragm member to a position in which said connecting rod is moved to close said vacuum switch, the compression of said spring being determined to overpower the intake manifold vacuum lower than a predetermined level at which the vehicle is accelerated or climbs up a hill, and said vehicle speed detector being operative to cause said vehicle speed switch to close when the detector detects a predetermined range of vehicle speed in which the vehicle is accelerated or climbs up a hill and delivers a voltage proportional to the vehicle speed detected, whereby said solenoid coil of said control valve assembly is energized and said valve element unseated when both of said vacuum and vehicle speed switches are closed concurrently.

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