Aug. 17, 1965

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3,201,207

MUFFLER

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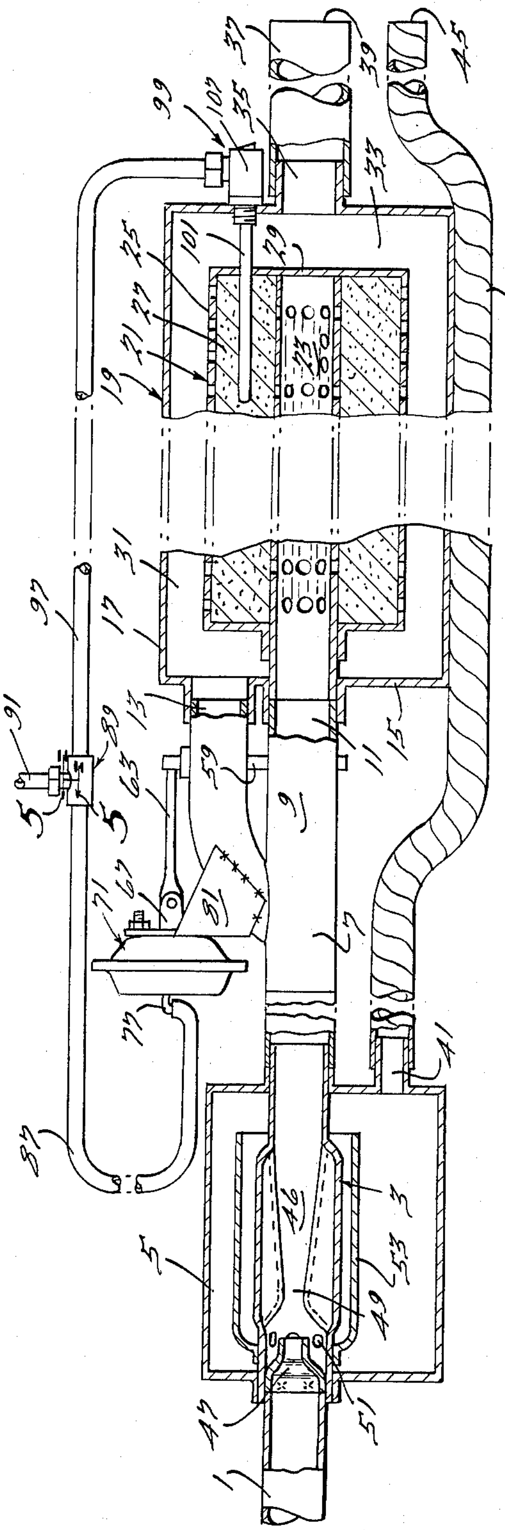

FIG. 1.

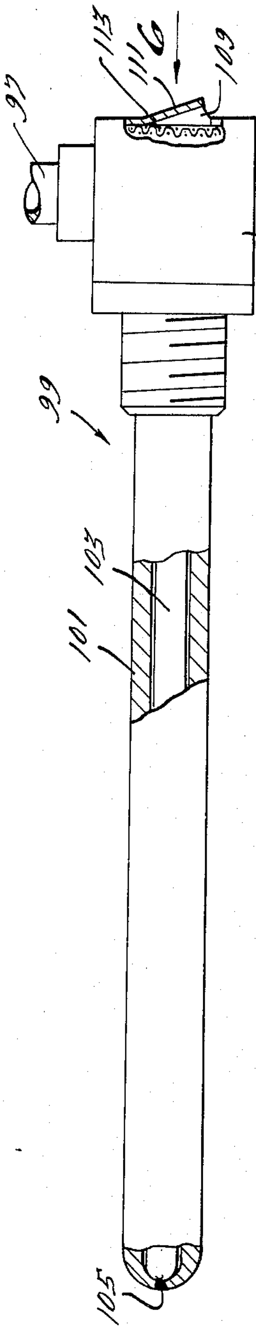

FIG. 4.

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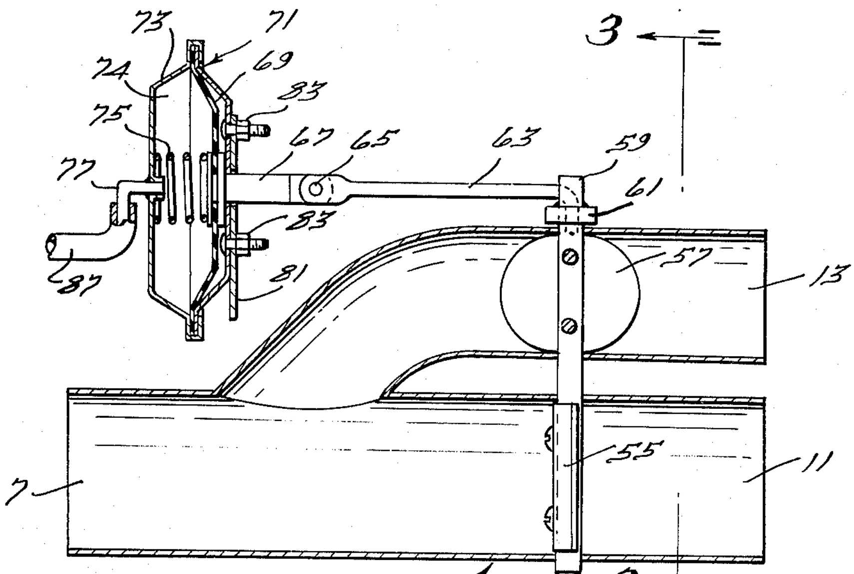

FIG. 2.

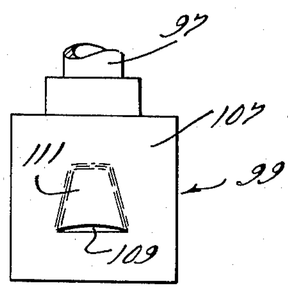

FIG. 6.

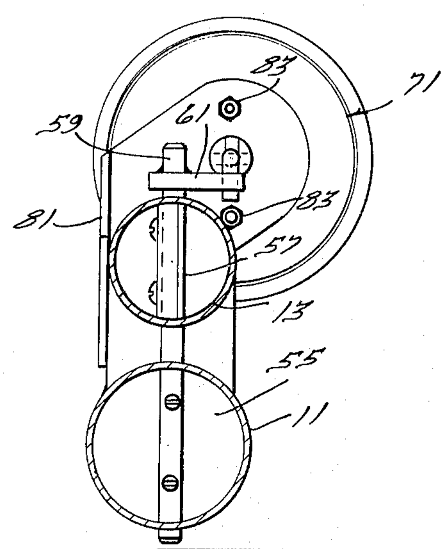

FIG. 3.

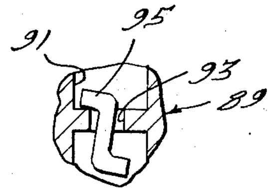

FIG. 5.

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This invention relates to the treatment of exhaust gases from internal combustion engines in order to remove unburned constituents.

In the combustion of the unburned constituents in exhaust gases a substantial amount of heat is liberated. If uncontrolled, this heat can destroy the conversion unit and, in the case of anti-smog systems for motor vehicles, become a serious danger to the vehicle and passengers.

Accordingly, it is an object of the present invention to provide means that will prevent overheating of a conversion device in a motor vehicle exhaust system.

It is a further purpose of the invention to provide an over temperature control means, useful especially in catalytic conversion units, which is positive acting and relatively simple and inexpensive.

Other objects and features of the invention will become apparent upon consideration of the accompanying drawings in which:

FIGURE 1 is a somewhat schematic view in cross-section of the pertinent portion of an automotive exhaust system embodying the invention;

FIG. 2 is an enlarged detailed view of the by-pass and valve device;

FIG. 3 is an end view taken from the right of FIG. 2;

FIG. 4 is an enlarged view of a two-way thermo valve;

FIG. 5 is a sectional view showing the air inlet louver to the valve of FIG. 4; and

FIG. 6 is a view taken along the arrow 6 in FIG. 4.

Referring first to FIG. 1, the conduit section 1 receives exhaust gases from the exhaust manifold of an internal combustion engine. It delivers gases to a conduit section 3 which extends through a plenum chamber 5. The conduit section 3 feeds the gases to the inlet end 7 of the Y-joint 9. The joint 9 has a leg 11 which is a straight continuation of the conduit 3 and it has a by-pass leg 13 which is in parallel with the leg section 11. The legs 11 and 13 open into a pair of inlets formed in the inlet header 15 of a casing 17 for the catalytic converter 19. There is an annular catalyst bed 21 supported inside of the converter casing 17 and arranged to be directly in the path of flow of the gases coming through the inlet leg 11 of the by-pass joint 9. The catalyst bed 21 has an inner perforated tube 23 and an outer perforated shell 25 and between them is the catalytic material 27 in the form of suitable granules or particles of catalyst. The end of inner tube 23 is closed, as seen at 29. Consequently, gas entering tube 23 from conduit 11 must pass radially through the catalyst bed and into an annular space 31 surrounding the shell 25 from which it can flow to the space 33 at the end of a shell 25 and then into the outlet 35 of the casing and thence into the tailpipe 37 to flow to atmosphere at the outlet end 39 of the tailpipe.

In order to insure complete combustion of the unburned constituents as they pass through the catalyst bed 21, it is necessary to introduce a supply of auxiliary or secondary air. While it is within the broad purview of the invention to use various other methods to introduce secondary air, there is shown in FIG. 1 the use of the plenum chamber 5 having a secondary air inlet 41 to which is attached a flexible secondary air inlet hose 43. In order to provide for preheating of the air, the flexible metal hose 43 is supported as close as possible to the converter 19 and the tailpipe 37 but spaced from the upstream parts of the exhaust system. The inlet end 45 to the hose 43 is

preferably located close to the outlet 39 to the tailpipe 37 and therefore at the rear of the motor vehicle as this will tend to drown out and minimize any objectionable noise in the secondary air system. It also eliminates the need for a check valve since any back flow in the secondary air system will be evacuated at the rear of the car adjacent the outlet to the tailpipe.

Air is drawn into the hose 43 by a simple venturi 46 in the conduit section 3 within the plenum chamber 5 which will provide an aspirating action that will tend to induct air from the plenum chamber and hose 43 into the exhaust gases flowing through section 7. The venturi is formed by a nozzle 47 which is supported in the tube 3 and may be spotwelded to it as well as to the inlet neck of the plenum chamber 5. The tube 3 is reduced in diameter by squeezing the sides of the metal as indicated in the drawings to provide a diffuser 49 that is spaced downstream from the nozzle 47. A plurality of holes providing a relatively large inlet area to the throat of the venturi are provided in the tubing as indicated at 51. Spaced around the venturi is a flow-through tuning shell 53 as indicated in the drawings, and this is tuned along with the chamber 5 to attenuate sound in the secondary air as well as in the exhaust gases when they flow either through the catalyst bed or by-pass it. Thus, the plenum chamber 5 acts as an aspirating and as a silencing means in the exhaust system.

If desired, a small and inexpensive automotive heater type fan may be attached in the secondary air system to assist the aspirating action of the venturi, such fan not interfering with the ability of the venturi to induct air but serving to supplement the action of the venturi. Using a catalyst bed temperature responsive switch element to shut off the fan at excessive temperatures will furnish a means for over temperature control. It is also within the broad scope of the invention to eliminate the venturi and use only a forced air source, such as a fan or compressor, to supply the secondary air. Another alternative is to use air from the radiator fan to furnish a forced air assist to the venturi. It is also possible to utilize a suitable temperature controlled valve in the secondary air supply, such as in the inlet 41 to the plenum chamber, and arrange it to shut off the secondary air supply when the temperature in bed 21 is too high.

As indicated, each of the legs 11 and 13 of the Y-joint 9 has a butterfly valve in it. Thus, the leg 11 has the butterfly valve 55 and the leg 13 has the valve 57. These are mounted on and rotated by a shaft 59 which extends through both legs 11 and 13. The valves are mounted so that they are 90° out of phase. Thus, when the valve in one leg blocks flow through that leg, the valve in the other leg will be disposed so as to provide minimum interference to flow. It will be observed in FIG. 3 that the valve 55 in leg 11 is mounted to pivot along an axis that is off center whereas the valve 57 is mounted on center. With this arrangement the gas pressure on the valve 55 is unbalanced and will tend to close it whereas gas pressure on 57 is equalized. This provides a fail-safe feature so that if the linkage to be described should break the pressure of the exhaust gases themselves will cause the valves to operate in such a way that the gases will be by-passed around the catalyst bed 21.

A crank arm 61 is attached to the shaft 59 and is moved by the link or rod 63 that is secured at 65 to the arm 67 that projects from a diaphragm assembly 69 inside the vacuum actuator 71. The actuator 71 may be purchased on the open market and comprises a suitably vented housing 73 in which the diaphragm assembly 69 is mounted and a spring 75 that urges the diaphragm assembly to the expanded position shown in the drawings wherein the by-pass 13 is open. Thus, the spring urges the mechanism to a fail-safe position wherein the gases will by-pass the catalyst bed 21.

There is a vacuum inlet 77 to the chamber 74 inside of the housing 73 which contains the spring 75. It is apparent that when vacuum is connected to the inlet 77, the diaphragm assembly 69 will move toward the left-hand side of the actuator housing to compress the spring 75 and thus move the crank 61 and pivot the shaft 59 so as to close the by-pass valve 57 and open the through passage valve 55 and permit mixed exhaust gas and secondary air to flow through the catalyst bed 21. The vacuum system for operating the actuator 71 is arranged (as by sizing of the vent behind diaphragm 69 and the strength of spring 75) so that it takes about four seconds or so for the by-pass valve 57 to open after an over temperature condition is sensed. This delay will prevent operation of the system in response to mere transitory conditions such as a rapid temporary acceleration which may only briefly produce more unburned constituents in the exhaust system. When the engine is turned off and there is no more vacuum the spring 75 will force the diaphragm assembly to the right and switch the valves so that the by-pass 13 is open and the straight through leg 11 is closed.

The actuator 71 may be conveniently mounted on the Y-joint 9 as by bolting to a bracket 81 which has its leg welded to the Y-joint. The actuator housing may be secured by suitable bolts 83 to the bracket 81. In the event that there is too much heat transferred through the Y-joint to the actuator, a suitable gasket material may be inserted between the actuator and the bracket to keep the actuator below the desired temperature level.

The actuator inlet 77 receives vacuum through a conduit 87. This is connected to one side of a T-joint 89. The T-joint receives vacuum through a line 91 which is connected to the intake manifold of the internal combustion engine (not shown). An orifice 93 (FIG. 5) around jiggle wire 95 in the T-joint 89 gives a greater pressure drop between the T-joint and line 91 than between the T-joint and the other two lines. The line 97 leads from the T-joint to a thermovalve 99 which is a two-way valve responsive to temperature for controlling the admission of air to line 97 and thus to the vacuum circuit. Briefly, it comprises a metal outer tube 101 which has a relatively large coefficient of thermal expansion and an inner rod 103 of metal having a lower thermal coefficient of expansion which is welded at one end 105 to the tube. When the temperature of the assembly is raised, the tube 101 expands more than the rod 103 and therefore results in movement of the rod that actuates suitable internal linkage to unseat a valve in body 107 and permit air to flow from inlet 109 into line 97. The orifice 93 is sized smaller than the open area of the valve seat in body 107 and also to provide the desired delay in operation of actuator 71. The inlet 109 is shown as formed by a pressed-out louver 111 and a screen 113 through which air enters the valve 99 with a change in direction to help keep out foreign matter.

In normal operation, exhaust gases from the engine pass along the conduit 1 through the conduit 3 to the inlet end 7 of the Y-joint 9. Secondary air flows into the exhaust gases in the conduit 3 from the plenum chamber 5 through openings 51, having reached the plenum chamber 5 in preheated condition from the flexible metal hose 43. The tuning shell 53 around the opening 51 is tuned to silence the secondary air flow through conduit 43 as well as the exhaust gas when it flows through either the leg 11 or the leg 13 of the Y-joint 9. Other noise in the secondary air system is lost because the opening 45 is at the rear of the vehicle. It will be noted that any outflow of exhaust gases through openings 51 on the pressure pulses will not be harmful since if in sufficient quantity it will flow out of opening 45 at the end of the hose 43.

Assuming that the catalyst bed 21 is functioning at a safe temperature, the valve 55 will be opened to permit straight-through flow into the tube 23 and conversion of the unburned constituents by radial passage through the catalyst 27 into the annular passage 31 and from there into the tailpipe 37. When this flow occurs, there is vacuum in the circuit and the diaphragm assembly 69 is at the left side in FIG. 2 to compress and overcome the spring 75. The vacuum reaches the system from the line 91 which is attached to the intake manifold and flows through conduit 87 to the inlet 77 on the vacuum actuator 71. Should there by any failure in the system, the vacuum will be lost and the spring 75 will push the diaphragm 69 to the right to put the Y-joint 9 in the by-pass condition.

The by-pass condition of FIG. 2 is also obtained if the temperature of the bed 21 rises above a predetermined degree. When this happens the differential expansion between the tube 101 and the rod 103 opens the valve inside the thermovalve 99 to admit air through inlet 109. Since the air inlet opening is larger than opening 93 in the T-joint 89, the pressure in the spring chamber 74 of actuator 71 will go to atmospheric after a short delay of sufficient duration to prevent operation under transitory conditions.

When the valve 55 is closed and the valve 57 is open, by-pass flow occurs and gas is deviated out of the straight-through path into the by-pass leg 13 from which it flows into the annular passage 31 and along the full length of the converter 19 in contact with the full outer surface of the catalyst bed 21. Secondary air is preferably being admitted during by-pass operation and consequently some conversion will occur during gas flow along the length of the catalyst bed. However, the temperature of the bed will drop since the heat will be liberated on the outside of the bed. It will be noted also that the porous bed 21 will act as a relatively large area and large volume sound absorber. By-pass gas that has flowed through the catalyst bed 21 will flow into the tailpipe 37.

It will be noted that the arrangement of the flow paths for conversion flow and by-pass flow are such as to provide minimum back pressure in each case.

The temperature sensing portion 101 of the thermovalve 99 preferably extends into the catalyst bed at the downstream end as shown so as to provide for optimum sensing and control conditions.

In the event that the linkage connecting the actuator 71 through the shaft 59 is broken, the pressure of the exhaust gases in the leg 11 will be unbalanced on the valve 55 due to its off-center mounting. Consequently, the valve 55 will be rotated to turn the shaft 59 and open the by-pass 57 and shut off leg 11. It will also be noted that under some conditions both valves will be partially open as the circuit seeks to adjust the relative amounts of by-pass and conversion flow to limit the maximum temperature, thus, in effect, modulating the flow to prevent overheating.

Modifications may be made in the structure shown without departing from the spirit and scope of the invention.

I claim:

1. A conversion system for the combustion of unburned constituents in the exhaust gases of an internal combustion engine comprising a catalytic converter having a catalyst bed arranged for the flow of exhaust gases therethrough whereby combustion of unburned constituents in the gases occurs in the vicinity of the bed with the release of heat, said bed having an inlet side and an outlet side, flow control means for directing the path of gas flow through the converter including valve means having a flow-through position wherein gas flows through the bed from the inlet side to the outlet side thereof and a by-pass position wherein gas flows directly to the outlet

side of the bed and by-passes the inlet side and does not flow through the bed, and valve means operating mechanism for moving the valve means to the flow-through position and to the by-pass position, said mechanism including a vacuum actuator containing a movable diaphragm operatively connected to said valve means, a spring in said actuator on one side of said diaphragm and urging it to move said valve means to said by-pass position, said actuator having an air vent communicating with the side of said diaphragm opposite to the spring, a vacuum conduit connected to said actuator to apply vacuum to the spring side of said diaphragm in opposition to said spring force and to thereby cause said diaphragm to move said valve means to said flow-through position, said vacuum conduit having a vacuum inlet for connection to a source of vacuum, said vacuum conduit having an air inlet for atmospheric air, said air inlet including a valve and a differential expansion temperature sensing probe projected into said bed and controlling said valve and opening said valve to admit air to said vacuum conduit when the bed temperature exceeds a predetermined maximum and closing said valve when said temperature falls below a predetermined value, said vacuum inlet having orifice means providing greater resistance to air flow to said vacuum source than to said vacuum actuator, flow of air to said vacuum actuator breaking vacuum on said diaphragm whereby said spring acting on said diaphragm moves said valve means to by-pass position.

2. The invention set forth in claim 1 wherein said spring, air vent, and orifice means are sized to provide a delay of about four seconds in moving said valve means to said by-pass position when said bed temperature exceeds said predetermined maximum.

3. A conversion system for the combustion of unburned constituents in the exhaust gases of an internal combustion engine comprising a catalytic converter having an inlet for attachment to an exhaust pipe and a catalyst bed having an inlet side and an outlet side, valve means in the path of gas flow to said bed for selectively directing the gas to the inlet side or to the outlet side of said bed, valve operating mechanism for operating said valve means, said mechanism including bed temperature responsive means whereby said valve means is operated in response to changes in bed temperature, said valve means including a pressure responsive surface exposed to the pressure of incoming exhaust gas and arranged to urge said valve means toward a position wherein it directs gas to the outlet side of said bed whereby said valve means will fail-safe in the event of malfunction of said valve operating mechanism.

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