# United States Patent [19]

**Inoue et al.**

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[54] **EXHAUST EMISSION CONTROL DEVICE**


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[51] **Int. Cl.** ..... **F01n 3/14**

[58] **Field of Search** ..... 60/286, 303; 23/277 C



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[57] **ABSTRACT**

This invention relates to an exhaust emission control device. A vortical combustion chamber extends into an oxidation reaction chamber so that the exhaust gases introduced into the oxidation reaction chamber through the exhaust manifold may be brought into direct contact with the outer wall surfaces of the vortical combustion chamber.


**5 Claims, 3 Drawing Figures**

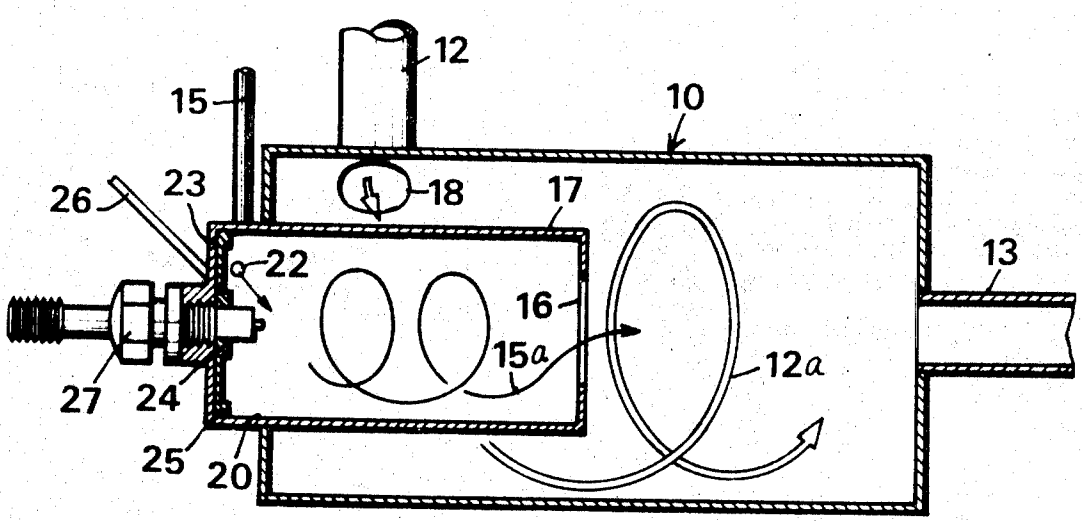

FIG. 1

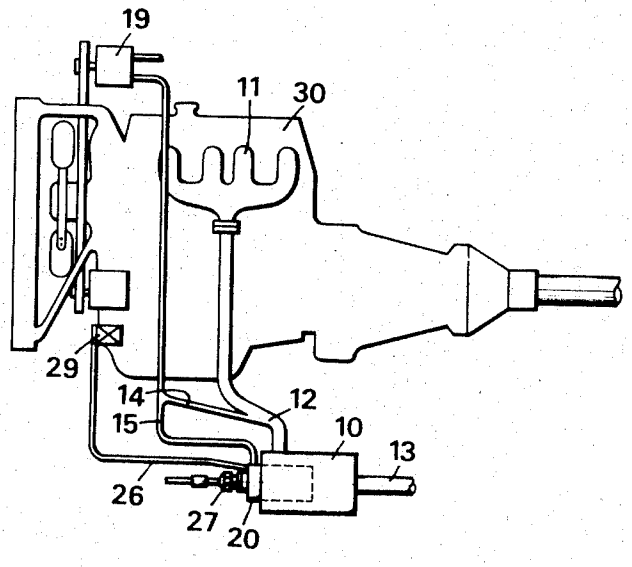
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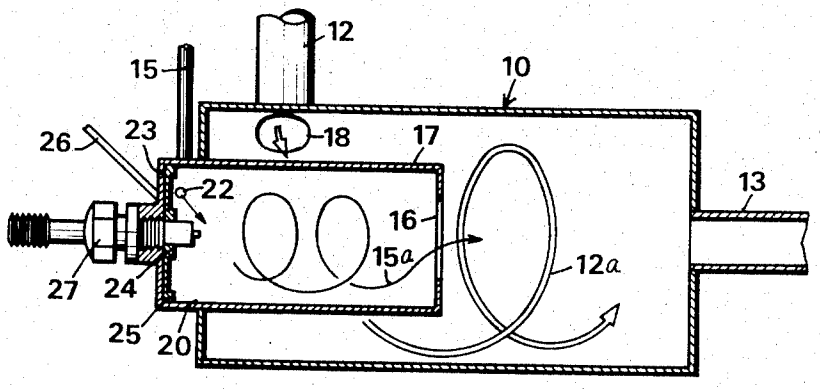
FIG. 2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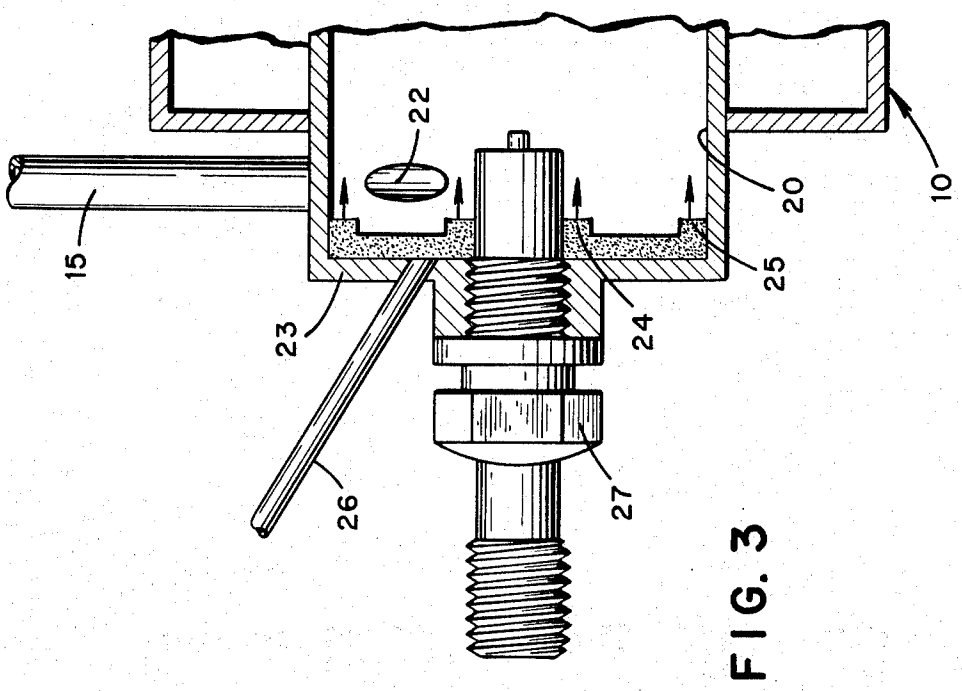


FIG. 3

# EXHAUST EMISSION CONTROL DEVICE

This invention relates to an exhaust emission control device for internal combustion engines for motor vehicles or the like designed to subject unburned noxious components of exhaust gases of such engines to recombustion to remove such noxious components from the exhaust gases.

In one type of exhaust emission control device known in the art in which exhaust gases of an internal combustion engine are subjected to recombustion in an oxidation reaction chamber, a supply of secondary fuel is delivered to a cylindrical combustion chamber disposed adjacent the oxidation reaction chamber, and a supply of secondary air is injected into the cylindrical combustion chamber tangentially thereto to produce a forced vortex flow of the air-fuel mixture in a central portion of the cylindrical combustion chamber and natural vortex flows of the air-fuel mixture in outer peripheral portions of the combustion chamber. Flames are produced in cylindrical form by igniting the air-fuel mixture in such forced vortex flows, and blown through an opening or pipe into the oxidation reaction chamber where a mixture of exhaust gases and excess air is ignited by such flames in cylindrical form to subject the exhaust gases to recombustion, thereby removing unburned noxious components of the exhaust gases before they are vented to the atmosphere.

Some disadvantages are associated with the exhaust emission control device of this type. In the conventional exhaust emission control device of the type described, the oxidation reaction chamber and the cylindrical combustion chamber are separated from each other, and the flames produced in the cylindrical combustion chamber are blown into the oxidation reaction chamber. Thus, wall surfaces of the reaction chamber remain cool for a while after the internal combustion engine is started, thereby delaying the ignition of the exhaust gases in the oxidation reaction chamber by the flames from the cylindrical combustion chamber. This may result in an incomplete oxidation reaction taking place in the exhaust gases, thereby achieving little or no result in removing noxious unburned components from the exhaust gases.

Besides, after the exhaust gases are ignited, complete combustion of the exhaust gases may not be possible in the oxidation reaction chamber due to large variations in the quantities of exhaust gases, particularly of unburned components of the exhaust gases when the engine is in a transient condition as the time of rapid acceleration of the engine.

This invention has as its object the provision of a device which is capable of effecting perfect exhaust emission control even if quantities of exhaust gases, particularly of unburned noxious components of exhaust gases therein, undergo large fluctuations as when the internal combustion engine is started or accelerated rapidly.

This invention permits effecting exhaust emission control satisfactorily by obviating the aforementioned disadvantages of the prior art by the features as set forth in the claims appended hereto.

Other and additional objects are those inherent in the invention hereinafter shown, described and claimed, and will become evident as the description proceeds.

In the drawings:

FIG. 1 is a schematic side view of the exhaust emission control device according to this invention as incorporated in an internal combustion engine of a motor vehicle; and



FIG. 2 is a vertical sectional view, on an enlarged scale, of the oxidation reaction chamber of the device.

FIG. 3 is an enlarged sectional view of the fuel vaporizer of FIG. 2.

In FIG. 1, an exhaust manifold 12 connected at one end to exhaust ports 11 of an internal combustion engine 30 is connected at the other end to an oxidation reaction chamber 10 which is provided with an exhaust pipe 13 for venting purified exhaust gases to the atmosphere.

In FIG. 2, a vortical combustion chamber 20 is mounted at an end of oxidation reaction chamber 10 opposite to the end thereof at which exhaust pipe 13 is provided. Vortical combustion chamber 20 has a portion 17 which extends into the interior of oxidation reaction chamber 10 and which is formed with a flame ejection port 16 in a wall thereof with respect to the interior of oxidation reaction chamber 10. Exhaust manifold 12 opens at an opening 18 thereof in oxidation reaction chamber 10 which is disposed in a position such that the exhaust gases introduced into oxidation reaction chamber 10 through exhaust manifold 12 are brought into direct contact with the portion 17 of vortical combustion chamber 20.

As shown in FIG. 1, an air pump 19 operated by internal combustion engine 30 or an electric motor is connected to exhaust manifold 12 and vortical combustion chamber 20 by air lines 14 and 15 respectively, air line 15 being tangentially connected to a base of vortical combustion chamber 20 through an opening 22 thereof to supply secondary air tangentially to the base of vortical combustion chamber 20.

In FIG. 2 and 3, fuel vaporizers 24 and 25 made of a heat resisting porous material, such for example as sintered metal, are provided in a central portion and peripheral portion of a surface of a wall 23 of vortical combustion chamber 20 opposite to the wall in which flame ejection port 16 is formed, and connected through a fuel line 26 and a fuel pump 29 shown in FIG. 1 to a secondary fuel supply source (not shown). An ignition plug 27 is mounted in the central portion of wall 23.

In operation, air pump 19 and fuel pump 29 are operated when internal combustion engine 30 is started. Secondary air is tangentially supplied through the opening 22 of air line 15 into vortical combustion chamber 20 and formed into vortex flows in the vortical combustion chamber comprising forced vortex flows in a central portion of the chamber and natural vortex flows in peripheral portions of the chamber. At the same time, secondary air is supplied through fuel line 26 to fuel vaporizers 24 and 25 which are impregnated with the secondary fuel. The secondary fuel with which vaporizers 24 and 25 are impregnated is vaporized by the flows of the secondary air to produce an air-fuel mixture.

The air-fuel mixture is ignited by ignition plug 27 such that first the air-fuel mixture in forced vortex flows is ignited, and then the air-fuel mixture in natural vortex flows is ignited till all the air-fuel mixture in vortical combustion chamber 20 is ignited and burns. Thus, combustion of the air-fuel mixture takes place vigorously in vortical combustion chamber 20 and the outer wall surfaces of the chamber are rapidly heated.

On the other hand, exhaust gases are introduced through the opening **18** of exhaust manifold **12** into oxidation reaction chamber **10.** When necessary, secondary air supplied through air line **14** is introduced into oxidation reaction chamber **10** together with the exhaust gases. The exhaust gases with or without secondary air are brought into direct contact with the outer wall surfaces of vortical combustion chamber **20,** and unburned noxious components thereof at once undergo oxidation reaction and are readily burned by flames in cylindrical form ejected through flame ejection port **16** into oxidation reaction chamber **10.**

Unburned noxious components of exhaust gases, such for example as carbon monoxide, hydrocarbons and the like, are burned completely in this way so that the exhaust gases are rendered innocuous and vented to the atmosphere through exhaust pipe **13.**

In the aforementioned construction and operation of the device according to this invention, any shape as desired may be given to the vortex flows in vortical combustion chamber **20** by suitably selecting the shape of flame ejection port **16.** It is to be understood that the vortical combustion chamber may be of any form as desired so long as its outer wall surfaces can be maintained at elevated temperatures or in a red hot state.

In the aforementioned embodiment of this invention, the body of the vortical combustion chamber extends into the oxidation reaction chamber. This arrangement permits a high efficiency in exhaust emission control immediately after the internal combustion engine is started, in spite of the fact that the temperature of exhaust gases introduced into the exhaust emission control device is low because the internal combustion engine, exhaust manifold and oxidation reaction chamber are cool at the time the engine is started. The exhaust gases introduced into the oxidation reaction chamber are immediately warmed and ignited because they are brought into direct contact with the red hot outer wall surface of the vortical combustion chamber.

The aforementioned embodiment of this invention also permits complete combustion of unburned noxious components of exhaust gases to take place even in cases where the conventional exhaust emission control device is unable to maintain combustion of exhaust gases in the oxidation reaction chamber because a sudden increase in the quantity of exhaust gases cools off the exhaust gases and reduces the proportions of unburned noxious components in the exhaust gases as when engine speed is rapidly increased.

In the aforementioned embodiment of this invention, fuel vaporizers made of a heat resisting porous material are provided in a central and peripheral portion of one wall of the vortical combustion chamber. This arrangement is effective first to positively ignite the air-fuel mixture in forced flows in the central portion of the vortical combustion chamber and then to ignite the air-fuel mixture in natural vortex flows in the peripheral portions thereof. This makes it possible to heat the outer wall surfaces of the vortical combustion chamber to a red hot state in a short interval of time.

What is claimed is:

**1.** In an exhaust emission control device comprising an oxidation reaction chamber connected to an exhaust manifold of an internal combustion engine to receive exhaust gases therefrom, and a vortical combustion chamber receiving a supply of secondary air and secondary fuel to produce an air-fuel mixture therein which is ignited to burn in flames in vortical form, said flames in vortical form being blown from said vortical combustion chamber into said oxidation reaction chamber so as to subject unburned components of the exhaust gases in the oxidation reaction chamber to recombustion, the improvement in that at least a portion of said vortical combustion chamber extends into said oxidation reaction chamber so that the exhaust gases introduced into said oxidation reaction chamber through said exhaust manifold may be brought into direct contact with outer wall surfaces of the vortical combustion chamber, and wherein fuel vaporizers made of a heat resisting porous material comprise a central fuel exit portion and peripheral fuel exit portion of one wall of said vortical combustion chamber so as to facilitate vaporization of the secondary fuel in the vortical combustion chamber.

**2.** The exhaust emission control device of claim **1,** wherein said central fuel exit portion is disposed around an ignition means.

**3.** An exhaust emission control device comprising:

an oxidation reaction chamber for receiving exhaust gases from an internal combustion engine:

a cylindrical vortical combustion chamber having means for introducing secondary fuel thereto and means for introducing secondary air thereto tangentially to the inner surface of said cylindrical chamber, for producing an air-fuel mixture therein for burning in a vortical flame blown from said vortical chamber through an open end thereof into said oxidation reaction chamber for subjecting unburned components of said exhaust gases to recombustion,

said cylindrical vortical combustion chamber extending along the direction of its axis into said oxidation reaction chamber, and the outside surface of said vortical chamber being adjacent an exhaust gas inlet opening in said oxidation reaction chamber, for directly contacting exhaust gases entering said reaction chamber with said outside surface of said vortical chamber, and

a fuel vaporizer of heat resistant porous material at a closed end of said cylindrical vortical combustion chamber, said vaporizer comprising a central fuel exit portion near the axis of said cylindrical chamber and a peripheral fuel exit portion near the inner surface of said cylindrical chamber.

**4.** The exhaust emission control device of claim **3** wherein said oxidation reaction chamber is also cylindrical, and said cylindrical oxidation reaction chamber and said cylindrical vortical combustion chamber are substantially coaxial.

**5.** The exhaust emission control device of claim **3,** wherein said central fuel exit portion is disposed around an ignition means.

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