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[54] **CATALYTIC GAS CONVERTER**

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[51] **Int. Cl.²** **F23D 13/12**
[58] **Field of Search** .... 431/115, 328, 329, 10; 23/277 C

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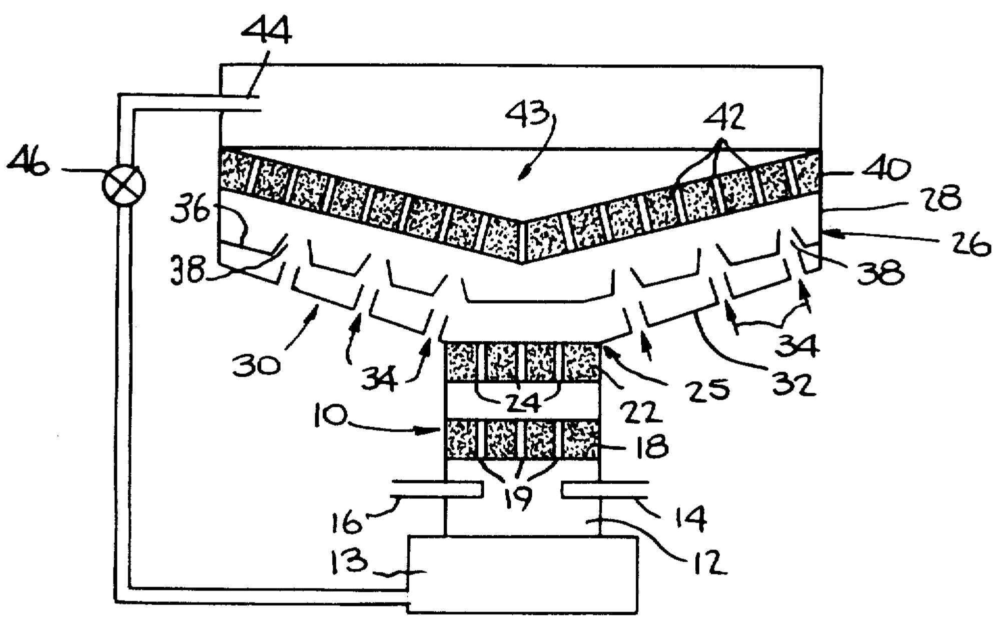
[57] **ABSTRACT**

The invention concerns an arrangement for the complete combustion of a liquid fuel. According to the invention, this arrangement comprises a catalytic gas converter (reformed-gas generator) suitable also for heavy hydrocarbons, a radiation plate system and a mixing arrangement for mixing the fuel gas generated by the converter with secondary air and for directing said mixture through said radiation plate for conversion to thermal energy.

7 Claims, 3 Drawing Figures



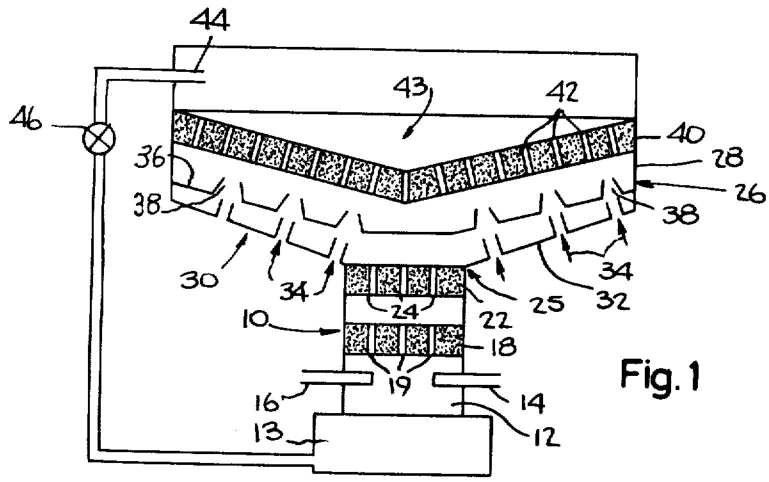


Fig. 1

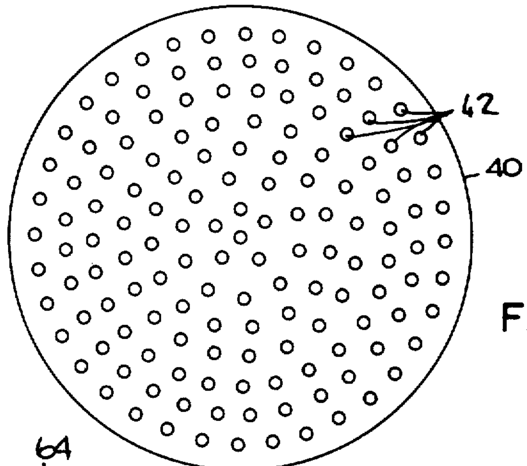


Fig. 2

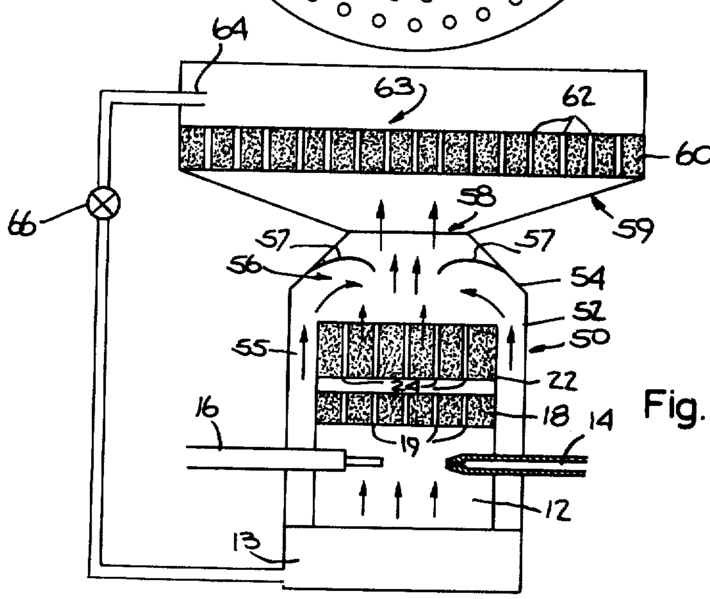


Fig. 3

CATALYTIC GAS CONVERTER

BACKGROUND OF THE INVENTION

The present invention concerns an arrangement for the complete combustion of a liquid fuel but, particularly, an arrangement utilizing catalytic gas converters.

The increasing pollution of the air leads to a steadily increasing danger to the health of the population, particularly in densely populated areas. Exhaust gases of motor vehicles with internal-combustion engines and of heat generators contribute to this to a considerable extent. Incomplete combustion results from non-uniform evaporation and mixing of the hydrocarbons with the combustion air. As a consequence, unburned or partially burned hydrocarbons, carbon monoxide, condensed products, benzpyrene, tar, soot and aldehydes are found in the exhaust gas, which are given off to the ambient air. Of grave importance is the simultaneous emission of hydrocarbons and nitrogen oxides, as strongly toxic compounds are formed from these, particularly under the influence of sun light.

These harmful secondary effects due to the exhaust gases of motor vehicles with internal-combustion engines can be reduced very substantially by the use of a so-called catalytic gas converter (reformed-gas generator). In the German Offenlegungsschrift 2,103,008 and the not previously published German Offenlegungsschrift 2,135,650 the principle of such a catalytic gas converter is described. The fuel containing liquid hydrocarbons, such as gasoline, is first evaporated, gasified or atomized and the gaseous or vaporous fuel is conducted over a catalyst disposed on a catalyst carrier for conversion into a gas mixture (so-called reformed gas). This mixture contains essentially carbon monoxide, carbon dioxide, methane and/or hydrogen. To provide a substantially soot-free conversion, the gaseous or vaporous fuel is combined with fed-back exhaust gas of the internal combustion engine and/or other gases serving as oxygen carriers. Prior to its introduction into the combustion chambers of the internal-combustion engine, an oxygen carrier, such as air, is mixed with the reformed gas. The catalyst carrier can advantageously be in the form of highly porous sintered blocks with a large number of passage openings for the gas, which are arranged approximately parallel to each other.

It is now an object of the invention to describe also for heat generators an arrangement which makes possible complete combustion of the liquid fuel fed to them, with negligible emission of harmful substances.

SUMMARY OF THE INVENTION

For solving this problem, it is proposed that the arrangement comprise a catalytic gas converter suitable also for heavy hydrocarbons, a radiation plate system and a mixing arrangement for mixing the fuel gas (reformed gas) generated by the catalytic converter with secondary air.

The catalytic gas converter is preferably designed so that the reformed gas generated in it has overpressure.

The mixing arrangement in one embodiment comprises mixing nozzles which are arranged between the catalytic converter and the radiation plate system advantageously in the form of a ring. In another embodiment the mixing arrangement comprises a mixing chamber arranged between the catalytic converter and the radiation plate system.

The catalytic gas converter is preferably connected with the radiation plate system in such a manner that part of the exhaust gases is fed to it periodically or continuously.

The invention will be explained in detail in the following specification with reference to the figures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**, a schematic overall view of one arrangement according to the invention;

FIG. **2**, a plan view of the radiation plate system; and,

FIG. **3**, a cross section elevation view of another embodiment of the arrangement.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **1** is a schematic representation of an embodiment of this invention. Catalytic gas converting chamber **10** includes a fuel mixing chamber **12** which is positioned above and axially aligned with blower **13**. Fuel is introduced into the fuel mixing chamber **12** via fuel feed line **14**. An ignition device **16**, is also suitably positioned in the fuel mixing chamber **12**.

Axially displaced from the blower **13**, and bounding the opposite end of the fuel mixing chamber **12**, is a fuel distributor or carburetor **18**. The carburetor **18** includes a multiplicity of parallel openings **19** which tend to insure uniform distribution of the fuel as it proceeds axially along the length of the converting chamber **10**.

At the one end of the converting chamber **10** there is located the catalytic gas converter comprising one or several catalytic or non-catalytic perforated sintered blocks **22**. These include a plurality of openings **24** which have their axes essentially parallel to each other and to the centerline of the chamber **10**.

Positioned at the end **25** of the catalytic gas converting chamber **10**, is a mixing chamber **26**. This includes a cylindrical shaped portion **28** and a truncated conical section **30** interposed between the cylindrically shaped portion **28** and the gas converting chamber **10**. On the side walls **32** of the truncated section **30**, there is located a plurality of intake orifices **34**. These orifices **34** are connected to an oxygen bearing gas supply which generally would be the air.

Interior to the mixing chamber **26** and axially displaced from end **25** of the gas converting chamber is a truncated conical ring plate **36**. This ring plate **36** includes a plurality of mixing nozzles **38**, the center line of which preferably is coaxially aligned substantially, with the center line of intake orifices **34**.

Secured in a continuous fashion with the sidewalls of the cylindrical shaped portion **28** is a radiation plate **40**. A plan view of radiation plate **40** is shown in FIG. **2**. The plate **40** may be constructed from either a low thermal conductivity, highly porous, non-catalytic material or, alternately, it may be constructed from a high thermal conductivity material with a finely-distributed, suitable catalyst disposed in the porous material. The plate **40** includes a plurality of essentially parallel openings **42** which communicate between the mixing chamber **26** and the exhaust side **43**, of plate **40**.

In a preferable variation of this embodiment there is inserted into the sidewall of cylindrical portion **28** on the exhaust side of plate **40**, an exhaust gas feed line **44**, which is connected therefrom back to the mixing chamber **12** via blower **13** through a valve arrangement **46**. This arrangement permits intermittent or continuous feedback of the exhaust gases to thereby provide an additional burning of the exhaust gases resulting in a still further reduction of pollutants.

The operation of the configuration of FIG. 1 would be as follows. A suitable fuel containing liquid hydrocarbons, such as gasoline, is supplied to the fuel mixing chamber **12** via fuel feed line **14.** Blower **13** forces air into the mixing chamber and the resultant mixture of air and fuel through the fuel distributor **18** and then across the catalytic, perforated sintered blocks **22.** Passage of the fuel-air mixture as it comes from the fuel distributor **18** over the appropriately selected catalytic sintered blocks **22** produces a gas (so-called reformed gas) which contains essentially carbon monoxide, carbon dioxide, methane and/or hydrogen.

The reformed gas exits end **25** and enters the mixing chamber **26** at a velocity which is determined by the blower rate and diameter of openings **19** and **24.** Because of the forcing of the fuel-air mixture and then the reformed gas through the gas converting chamber **10** by blower **13,** a pressure differential is created between the interior of the mixing chamber **26** and the exterior thereof which results in the oxygen bearing gas being sucked in through intake orifices **34** and mixed with the reformed gas by way of nozzles **38.** The design of the system is such that the pressure of the gas-air mixture as it exits from the nozzles **38** is suitable to overcome the subsequent flow resistance of the radiation plate.

The combined reformed gas-air mixture is next forced through the radiation plate **40.** When the radiation plate **40** is constructed from the high thermally conductive, catalytic material, the reaction of the reformed gas and air as assisted by the material causes substantially higher temperatures than when the plate is made from the low thermally conductive, noncatalytic material. The exhaust gases which exit from the radiating side of plate **40,** although generally low in recognized pollutant content can be fed back to the mixing chamber **12** via the optional exhaust feedback line **44.** Upon suitable actuation of valve **46** exhaust gases can be drawn back through the line **44** and sucked into the mixing chamber in much the same fashion as the air was drawn into the mixing chamber as described above. Valve **46** can be adapted such that it continuously feeds back the exhaust gases or only periodically.

FIG. **3** describes an alternate embodiment within the scope of the present invention. The catalytic gas converting chamber **10** contains essentially the same elements as its corresponding number in FIG. **1,** such member being identified with like numerals. Here, however, instead of the air to be mixed with the reformed gas being introduced through orifices such as **34** in FIG. **1,** the air is provided directly by blower **13.**

The chamber **10** is surrounded by an outer shell **50.** The shell includes a portion **52** which is contoured to the shape of chamber **10** and a truncated cone section **54.** A passageway **55** is formed between the chamber and the outer shell. This connects the blower **13** directly to a mixing chamber **56** formed by the truncated cone section **54.**

Integral with the sidewalls of the truncated cone section **54** is a mixing vane plate **57** which forms an opening coaxial with the center line of chamber **10** through which the gas exiting from the gas converting chamber **10** must pass.

Positioned at the truncated end **58** of the shell **50** is a radiation plate system **59** which communicates therewith. It generally has an inverted truncated cone shape as depicted. Positioned axially away from end **58** is the radiation plate **60.** Like its counterpart in FIG. **1** this radiation plate is constructed of either a low thermal conductivity, highly porous material without catalyst or a high thermally conductive material including a finely distributed catalyst disposed therein. It further includes a plurality of openings **62** necessary to maintain the proper gas flow through the device.

As with the embodiment of FIG. **1,** the sidewall to which the radiation plate **60** is affixed may be extended a distance beyond the exhaust side **63** of the radiation plate. Exhaust gas feed line **64** may be positioned therethrough. Upon actuation of the control valve **66** the exhaust gases emanating from the radiation plate may be fed back through the valve into the mixing chamber **12,** preferably via blower **13.** The operation of this device is as follows. The oxygen bearing gas or air drawn in from outside the device by the blower **13** is divided into two gas streams. One of the gas streams is led to the fuel distributor **18,** the other one which is provided for mixture with the reformed gas passes through the passageway **55.** The mixing vanes direct this second gas stream into the exhaust area from the gas converter **10,** in which the vaporized fuel and the first gas stream are reacted to form the reformed gas. The restricting orifice formed by the vanes forces the mixture of the air with this reformed gas. The air-gas mixture is thrust into the radiation plate system **59** at a pressure suitable to overcome the subsequent flow resistance of the radiation plate. It thereafter dissiminates through the porous material of the plate **60** causing a high speed reaction at high temperatures which results in intensive radiation heat and the conversion of the gas-air mixture to a low pollutant form.

Additional refinement of the exhaust gas can be provided through the feedback of the exhaust gas, either on an intermittent or continuous basis through exhaust feed lines **64** and control valve **66.**

The conversion of the liquid fuels into gases and the thorough mixing of these gases with air prior to the combustion by the arrangement according to the invention thus make possible complete combustion with negligible emission of harmful substances. The heat transfer conditions and the efficiency are improved by the high combustion temperatures. By using a flameless burner, the heat transfer conditions are improved still further over the flame because of the higher radiation coefficient of the radiation plates.

Other variations of the scheme above will be evident to those skilled in the art and the descriptions herein are not intended to restrict the scope of the claims as hereinafter appended.

What is claimed is:

1. An apparatus for the complete combustion of a liquid fuel which comprises:

a. means for converting said liquid fuel to a reformed gas containing carbon monoxide, carbon dioxide, and at least one of the group consisting of methane and hydrogen;

b. means for producing a mixture of said reformed gas and oxygen bearing gas; and

c. a radiation plate having a plurality of essentially parallel openings therethrough, one side of said openings being coupled to said means for producing a mixture so as to conduct said mixture from said means for producing through said parallel openings to the other side of said radiation plate said radiation plate adapted to react with said mixture as it passes through openings to produce substantially complete combustion of said liquid fuel.

2. The apparatus of claim 1 wherein said means for producing a mixture of said reformed gas and said oxygen bearing gas include:

a. a first mixing chamber located between said converting means and said radiation plate means;

b. means for blowing said liquid fuel through said converting means such that said reformed gas exits from said converting means into said first mixing chamber at a predetermined velocity;

c. means for directing said oxygen bearing gas into the path of said exiting reformed gas to provide a prescribed mixture of both.

3. The apparatus of claim 2 where said means for converting said liquid fuel to said reformed gas is adapted to convert liquid fuel composed of heavy hydrocarbons.

4. An apparatus for the complete combustion of a liquid fuel which comprises:

a. means for converting the liquid fuel to a reformed gas;

b. a first mixing chamber coupled to the outlet of said means for converting;

c. means for blowing said liquid fuel through said converting means such that said reformed gas exits from said converting means into the said first mixing chamber at a predetermined velocity;

d. a plurality of orifices communicating between an oxygen bearing gas and said first mixing chamber;

e. a ring plate having a plurality of mixing nozzles positioned thereon said nozzles bearing a predetermined relationship to said orifices and the exhaust orifice of said converting means to thereby mix said oxygen bearing gas with said reformed gas in a prescribed mixture of both;

f. a radiation plate containing a plurality of essentially parallel openings having inputs coupled to the output of said first mixing chamber and adapted to react with said mixture to produce substantially

completed combustion of said liquid fuel as said mixture passes through said openings.

5. The apparatus of claim 4 further including means for feeding back the exhaust gases produced by said radiation plate means to a second mixing chamber located between said blower means and said converting means to be mixed therein with fuel and oxygen bearing gas.

6. An apparatus for the complete combustion of a liquid fuel which comprises:

a. means for converting the liquid fuel to a reformed gas;

b. a first mixing chamber coupled to the outlet of said means for converting;

c. means for blowing said liquid fuel through said converting means such that said reformed gas exits from said converting means into said first mixing chamber at a predetermined velocity;

d. passageway means communicating between said blower means and said first mixing chamber, said blower means forcing an oxygen bearing gas into said passageway; and

e. mixing vane means secured to the walls of said first mixing chamber and adapted to direct the oxygen bearing gas exiting from said passageway into the path of said exiting reformed gas;

f. a radiation plate containing a plurality of essentially parallel openings having inputs coupled to the output of said first mixing chamber and adapted to react with said mixture to produce substantially complete combustion of said liquid fuel as said mixture passes through said openings.

7. The apparatus of claim 6 further including means for feeding back the exhaust gases produced by said radiation plate means to a second mixing chamber located between said blower means and said converting means to be mixed therein with fuel and oxygen bearing gas.

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