United States Patent [19]

Koch

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[54] **LIQUID VAPORIZER**

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[30] **Foreign Application Priority Data**

Apr. 4, 1972 Germany 2216196

[52] **U.S. Cl.** **261/131**, 261/99

[51] **Int. Cl.** **F02m 17/28**

[58] **Field of Search** ..... 261/95, 99, 100; 48/180 R, 48/180 H, 180 C, 144; 123/133, 134, 135, 119 E, 122 F, 122 A, 122 AA, 122 AB, 123

[56] **References Cited**

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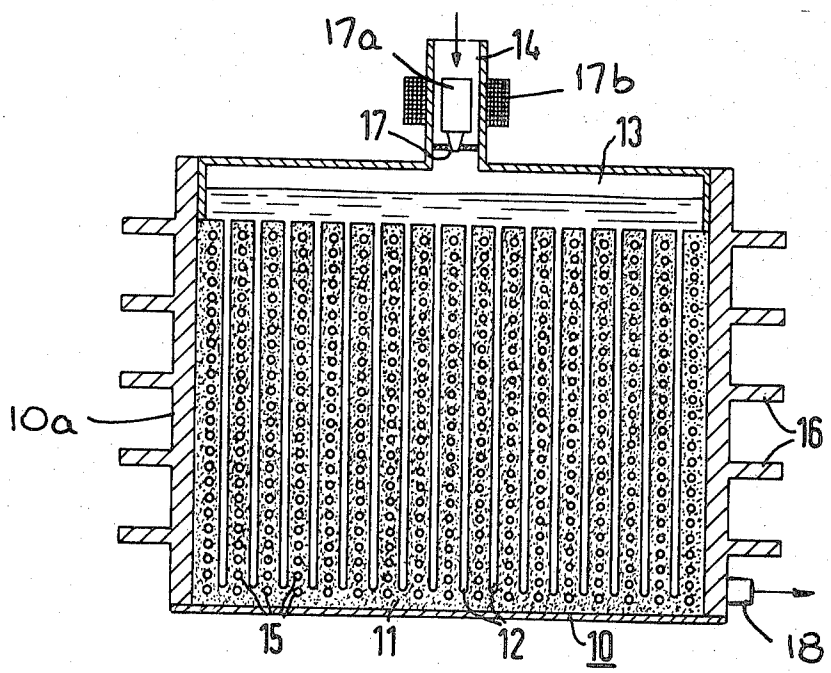
[57] **ABSTRACT**

A liquid vaporizer includes a porous body throughout which liquid can move in all directions, a supply of the liquid to be vaporized keeping the body impregnated with the liquid, and the body having a large number of relatively small diameter, interspaced holes formed transversely through it so that when a gas under pressure is applied to the passages at one end, the gas is split into a correspondingly large number of gas streams which pass through the holes and are ejected at the other end carrying along the liquid in vapor and/or small droplet form. This provides a flow having throughout its extent a uniform density of the vapor and/or small droplets uniformly proportioned relative to the gas.

12 Claims, 2 Drawing Figures



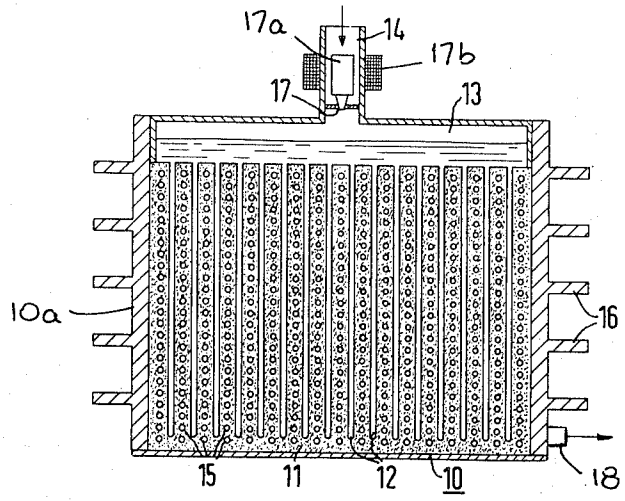


Fig.1

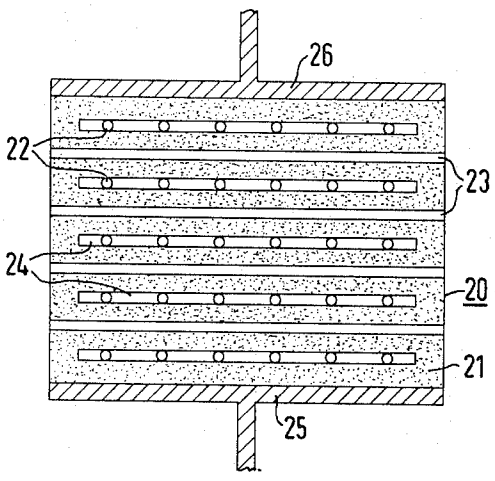


Fig.2

LIQUID VAPORIZER

BACKGROUND OF THE INVENTION

The production of a flow of vaporized liquid and/or liquid in the form of small droplets, can be obtained by ejecting a liquid under pressure through a nozzle having a small jet orifice, the ejected liquid expanding and providing the flow. Gas under pressure can be added to the flow.

However, when liquid is ejected as a relatively high velocity jet, relying on expansion of the liquid to convert it to its vapor phase and/or small droplets of the liquid, and the resulting flow impinges a flat surface normal to the flow, it is generally found that the surface receives localized concentrations instead of being covered uniformly. If the liquid is ejected from a carefully designed jet orifice arranged at a rather precisely fixed distance from the surface to be covered, a more uniform coverage may be achieved but at the expense of having to maintain this fixed distance. If gas under pressure is added to the flow, it is difficult to obtain a predetermined proportioning of the vapor and/or small droplets and the gas.

Such disadvantages are particularly objectionable in some instances. One example is provided by miniaturized converters used to convert a flow of hydrocarbon liquid fuel, such as gasoline, in vaporized and/or small droplet form and mixed with an oxygen-containing gas, into reformed gas containing carbon monoxide, methane and possibly hydrogen, this reformed gas, with air added, being used as fuel for automotive vehicle internal combustion engines, such as an automobile engine, in the interest of air pollution control. Such a converter may be made small enough for practical installation in automobiles, trucks, etc.

The above kind of converter comprises a relatively small catalyzer chamber containing at least one porous plate provided with a multiplicity of small diameter, uniformly distributed holes which extend through the plate, the latter being made of sintered particles carrying a catalyst. It is necessary to feed the upstream side of this plate with the fuel in vapor and/or small droplet form and mixed with an oxygen-containing gas such as air or the engine exhaust gases, or a mixture of both. As the mixture passes through the plate, it converts to the reformed gas which is mixed with air and supplied to the engine. Converters of this type are proposed in German patent applications Nos. 21 03 008 and 21 35 650 or U.S. application Ser. No. 270,923, filed July 12, 1972 by Henkel et al.

In the operation of such a converter it is desirable that the flow, including the hydrocarbon fuel vapor and/or small droplets, has a uniform density when contacting the catalytic plate of the converter. This plate may have a generally rectangular contour defining a surface area of 96 mm by 66 mm, for example, and this surface should preferably be uniformly covered by the fuel vapor or droplets. The flow rate may be high considering the horse power potential of an automotive engine and the relatively small dimensions of the catalytic plate through which the fuel must flow.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a liquid vaporizer capable of reliably producing a gaseous flow of vaporized liquid, or with the liquid in the form of small particles, of uniform density throughout, and when the flow is to impinge a surface normal to the flow, to produce a uniform density application to this surface without the requirement for observing a precise or critical distance adjustment between the vaporizer and such a surface.

According to the present invention, such objects are attained by a vaporizer comprising a body, such as a block or flat plate, made of porous material, such as sintered ceramic or metallic particles, and through which a multiplicity of holes are formed transversely so that when one side of the plate is supplied with a gas under pressure higher than the pressure on the other side, the gas flows through the small holes. The porous plate is supplied with means for maintaining it impregnated with the liquid to be vaporized. The liquid may at times fill the holes and at other times provide them with surface coatings of the liquid. As the gas goes through the multiplicity of small holes it picks up the liquid while converting it to vapor or very small particles. The holes are uniformly distributed throughout the body and are of small diameter and large in number, and the porosity of the body is such that it is uniformly liquid permeable in all directions, so the resulting vapor or fine droplet flow is of uniform density throughout. The body's pores are of a size causing the liquid to flow therethrough by capillary action.

In the case of the converter which is supplied with engine exhaust or with air, or a mixture of both, such gases which contain oxygen are applied to the upstream or inlet side of the body. The vaporizer may be in the shape of a plate and positioned parallel to the first converter catalytic body or plate, and because the separation distance between the two is not critical, the design of a more compact converter is made possible while providing for covering the first catalytic plate uniformly throughout with the gasoline vapor of fine droplets, the liquid being supplied to the porous vaporizer body to keep the latter impregnated. The supply of liquid fuel and the gaseous components may be controlled to provide the desired proportioning for the catalytic conversion and to meet the engine demand.

The output of the vaporizer may be conducted to the first upstream catalytic body via a duct and there may be an igniter or other element interposed between the vaporizer and the first catalyzing element, but in all cases the flow supplied should comprise the fuel and gaseous components in a form providing uniform density and properly proportioned components. Reference is made to the first catalytic body because the converter may include a series of such bodies.

Preferably the new vaporizer is in the form of a plate or block having mutually parallel front and back sides and with liquid passages formed through it parallel to these front and back sides and extending between and free from the gas passage holes, the latter extending normal to these passages from the back to the front sides of the vaporizer. These passages may terminate short of the opposite edge of the vaporizer, and at their open ends may be provided with a manifold chamber constantly supplied with the liquid component. The liquid should be in the form of an impregnating flow extending uniformly throughout the vaporizer body.

In some instances, such as in the catalytic converter application, it may be desirable to use heat in connection with the operation of this new vaporizer. If its porous plate is made of non-metallic material, it may be

contacted by a metallic member or members provided with heat conducting fins which can be enclosed or formed as ducts and exposed to the exhaust flow of the engine involved. On the other hand, if such heating is desired, the porous vaporizer plate may be made of sintered metallic particles and heated by electric resistance or induction heating.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the new vaporizer are illustrated schematically by the accompanying drawings in which:

FIG. 1 is a cross section showing an embodiment of the vaporizer as it might be used in plate form in conjunction with the catalytic converter application, this figure being a cross section in a plane cutting between the front and back surfaces of the vaporizer plate; and

FIG. 2 shows an application of the invention as it would be used in the case of a relatively long block of porous material as contrasted to a relatively thin plate, this view being a cross section taken on a plane which is parallel to the gas passages.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 the vaporizer **10** is shown in a form suitable for use in the catalytic converter application. In this case the porous body is a flat vertical plate **11** which is permeable to liquid in all directions. It may be formed of sintered ceramic particles providing voids small enough to exert a capillary attraction effect on the liquid. The liquid fuel, or gasoline passages **12**, extend from the top edge of the plate **11** downwardly so as to terminate close to the bottom edge of the plate **11**, or in other words, the passages **12** are long blind holes. These passages **12** are parallel to each other, and are uniformly interspaced, and there is a large multiplicity of these passages extending throughout the width of the plate **11**. The passages are small in diameter but large enough for free liquid flow. The top edge of the plate **11** is enclosed by a manifold or header **13** to which gasoline is fed through an inlet duct **14**.

Between each of the passages **12**, vertically extending rows of gas holes **15** are formed. Both the passages **12** and the holes **15** are uniformly distributed throughout the entire plate **11**. The holes **15**, of course, go transversely completely through the plate **11**. The side and bottom edges of the plate **11** are enclosed by a casing structure **10a**, the side walls of this casing, for the purpose of showing the existence of heating means, being shown as having fins **16** over which all or a portion of the engine exhaust gases may be passed for heating the vaporizer plate **11** and which may also be used for the vaporizer supply. Control of the gasoline flow to the manifold or header **13** may be by a needle valve **17** having an actuating armature **17*a*** within the field of an electric solenoid **17*b***. A temperature sensor **18**, for illustration only, is shown fixed to one of the side walls to sense the operating temperature of the vaporizer and produce a signal which may be used to control the flow of exhaust gases through the fins **16**, for example.

In this specific example of a preferred embodiment shown by FIG. **1**, the plate **11** is made of sintered aluminum oxide, or magnesium-aluminum silicate particles, and has a surface area of 96 mm by 66 mm and a thickness of **14** mm and a porosity from about 20 to about 60 percent by volume, but preferably being from 40 to 50 percent by volume. Twenty-six rows of the holes **15** are provided, with each row having 26 holes, all of which are, of course, interspaced. The diameter of these holes is about 1.1 mm, and it is through these holes that the oxygen-containing gas, either exhaust gas from the engine or air, or a mixture of both, is flowed. Flow is obtained by the pressure differential existing through atmospheric or higher pressure being on one side of the plate and the other side of the plate being at a lower pressure, such as by being connected to the engine via the catalytic reactor (not shown). The holes **15** are normal with the parallel front and back faces of the plate **11**, the fuel passages **12** are parallel to these surfaces, the passages **12** and the holes **15** are normal with respect to each other, and the holes **15** are mutually parallel and the passages **12** are mutually parallel, the latter extending between the rows of holes **15** so that there is always the porous plate material between the passages and the holes. The fuel passages **12** have diameters of about 1.2 mm, are located in the center between the front and back surfaces of the plate **11**, and their bottoms terminate about 10 mm from the bottom edge of the plate. The manifold or header **13** may have an inside dimension of 96 mm × 14 mm × 14 mm. Although a gravity fuel feed is suggestively illustrated, the fuel may be fed under pressure via the needle valve **17**. When pressure is applied to the fuel, the pressure may be about 10.5 N/cm^2.

With this specific example of the invention, with the heating via the exemplifying fins **16** controlled by the signal from the temperature sensor **18**, with the upstream side of the plate **11** fed by a mixture of 10 Nm^3 air and 10 Nm^3 exhaust gas from an internal combustion engine, and with the needle valve **17** under adequate control, 7.5 liters of gasoline are vaporized per hour. This produces an obviously relatively high velocity flow of vaporized gasoline and oxygen-containing gas which is fed to a converter catalytic plate (not shown) with an input dimension of 96 to 66 mm and converted into reformed gas, the latter being suitable to power an internal combustion engine with the consequent pollution control advantages obtained from using the reformed gas as a fuel. Of course, air is mixed with the reformed gas to support combustion in the engine.

FIG. 2 shows a second embodiment. In this case the vaporizer **20** has the liquid permeable or porous body with the characteristics previously described, but in the form of a block **21** having the vertical vaporizable liquid passages **22** extending vertically, as the device is shown in FIG. **2**, and being relatively thick in the direction of the gas passages **23**, the liquid passages **22** being interconnected by horizontal branch passages **24**, these passages terminating at both ends adjacent to the opposite surfaces, or front and back, of the body **21**.

In this case the porous material is made of sintered metallic particles so that electrodes **25** and **26** may be applied to the transverse sides of the block **21** and permit electric heating, either through resistance or by induction, of the body or block **21**.

For each row of liquid passages **22** there may be a number of the branch passages **24** positioned between the holes **23** and in the form of interspaced holes extending as shown by FIG. **2** but at differing levels with respect to the viewing plane of FIG. **2**, this permitting interconnection of the passages **22** at a plurality of lev-

els as to each row of the passages 22 with the various branch passages of that row parallel with respect to the other passages 24 of that row. Such branch passages may be formed by drilling holes through the body 21 from end-to-end between the easily drilled holes 23, so as to bisect the holes 22 of each row, with the holes 22 and the holes forming the branch passages 24 of equal diameters. Thereafter, the ends of the branch passage holes 24 may be filled or plugged adjacent to the opposite working surfaces of the body 21. The passages 22 may be drilled until near the bottom edge of the body, or drilled completely through and plugged. With the multiplicity of levels of branch passages, there is a uniform network of interconnecting liquid passages throughout the porous block or body 21.

Although the present invention has particular value when incorporated in a catalytic fuel converter to produce reformed gas for use as a fuel for an internal combustion engine, the invention has other uses. It may be used whenever a liquid is to be converted to its vapor phase or to atomized form. Depending on the liquid involved, it is converted to a flow of either vapor or finely atomized particles or both. For example, water may be ejected as atomized particles for absorption by the atmosphere in connection with humidifying purposes. With heating of the porous body used, the water may be more easily converted to its vapor phase. The present invention may also be applied in connection with the vaporization or atomization of oil supplying domestic and industrial burners, and the invention may also be used in connection with gas turbines.

However, the application of the present invention to pollution control in connection with the operation of automotive vehicles using internal combustion engines is of particular merit. In the hydrocarbon fuel, or gasoline, converters previously mentioned, and which are capable of miniaturization for automobile use, the present invention provides for extremely satisfactory impingement of the first catalytic plate or body of such a converter by a flow of oxygen-containing gas and fuel, such as gasoline, as vapor or a dispersion of extremely minute particles of fuel, with the flow of uniform density in all directions and providing very uniform density application to the upstream or entrance side of the catalytic plate or body. The distance of separation between the catalytic element and the new vaporizer is not critical in the sense of the criticality of the spacing of a nozzle or other jet dispersion device. Satisfactory engine operation is obtained by controlling the flow rate of the liquid fuel to the porous body in conjunction with controlling the temperature of this body and the rate of flow of the gas through the gas holes of the vaporizer body. During operation the liquid fuel may completely fill the gas holes throughout all or a portion of their lengths or it may be present as liquid films on the side walls of the holes. The liquid fuel is constantly fed to the holes by capillary action, possibly aided by pressure on the liquid as it is supplied to the vaporizer.

As previously suggested, the porous body of this invention should be liquid permeable in all directions. It may be made of ceramic particles sintered together to provide a porosity of preferably from 40 percent to 50 percent by volume with its pores sized to exert a capillary action on the liquid to be vaporized. Suitable bodies are disclosed by German Pat. applications (Offenlegungsschrift) Nos. 1,939,535 and 1,808,623. However, the body may be made entirely or to partly include metal particles.

Further, it is to be understood that the gas flow holes and the liquid passages are all straight or linear. Their diameters ordinarily range in the area of 1 to 2 mm, and in any event should provide for free fluid flow through them without being unreasonably large.

What is claimed is:

1. A liquid vaporizer comprising:
   a. a porous body with a porosity in the range of 20 to 60 percent having essentially flat parallel front and rear sides and essentially flat parallel top and bottom sides;
   b. a plurality of evenly distributed spaced gas passages extending through said body from said front to said rear side; and
   c. a plurality of spaced liquid passages extending from said top side to at least near said bottom side, essentially normal to said gas passages and arranged so that each gas passage has a liquid passage in close proximity thereto.

2. The vaporizer of claim 1 in which said liquid passages are transversely interconnected by branch passages formed through said body.

3. The vaporizer of claim 1 and further including a manifold interconnecting said liquid passages opening through said top side and valve controlled means for supplying said manifold with said liquid.

4. The vaporizer of claim 1 and further including means for heating said body.

5. The vaporizer of claim 1 and further including means for sensing the temperature of said body.

6. The vaporizer of claim 1 in which said body is in the form of a flat plate having edges forming said top and bottom sides and front and back faces forming said front and back sides.

7. The vaporizer of claim 1 wherein said porosity is in the range of 40 to 50 percent.

8. The vaporizer of claim 1 wherein said liquid passages extend from said top to only near said bottom.

9. The vaporizer of claim 1 in which said porous body comprises ceramic material.

10. The vaporizer of claim 9 with heat conducting means being provided for heating said body.

11. The vaporizer of claim 1 in which said porous body comprises at least partially metallic material.

12. The vaporizer of claim 11 with electrodes being applied to said porous body for heating said body.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,855,372

DATED : December 17, 1974

INVENTOR(S) : Christian Koch

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Change Assignee from "Sumens Aktiengesellschaft" to

--Siemens Aktiengesellschaft--

Signed and sealed this 15th day of April 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks