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(54) Method of reforming fuel, fuel-reforming apparatus and thermal engine

(57) Primal object of the invention is to drastically decrease volume of carbon monoxide, hydrocarbon, nitrogen oxide and carbon dioxide (total volume) exhausted from conventional thermal engines such as internal-combustion engines and from boilers in particular as a result of combustion of fuel therein, and yet, enable them to significantly save fuel and promote output power. To achieve the above object, the invention provides a novel method of reforming fuel, an improved fuel-reforming apparatus and an improved thermal engine.

Concretely, a plurality of ceramics balls (16) mainly composed of silicon are disposed in a liquid-fuel tank (10) and a fuel-reforming apparatus (38) so that they can be immersed in fuel (28). If deemed necessary, the fuel tank (10) is internally provided with a microbe addition means (26) for adding microbial additive (24) to fuel (28) stored in the fuel tank (10), or the fuel tank (10) is internally provided with a stirring means (20 and 22) for stirring fuel (28), or the internal surface of a fuel tank (12) is coated with ceramics (14) mainly composed of silicon, or the fuel tank (12) is internally provided with ceramics balls (18) at least containing radioactive material so that they can be immersed in fuel (28).

At least part or whole of internal and external surfaces of fuel-supply system for supplying liquid fuel or vaporized fuel to a thermal engine (46) and part or whole of internal and external surfaces of air-intake system (50) and exhaust system (52) thereof is covered with ceramics (16) mainly comprising silicon, or part of said sytems is respectively filled with said ceramics (16).

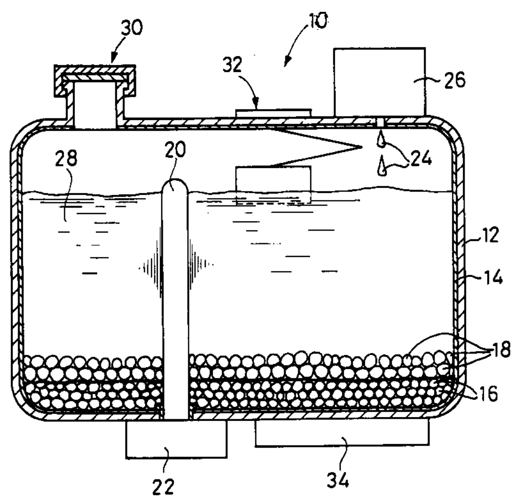

Fig.1

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Description

The present invention relates to a method of reforming fuel, a fuel-reforming apparatus, and a thermal engine. More particularly, the invention relates to thermal engines including internal combustion engines such as an automotive gasoline or diesel engine, combustion apparatuses such as a boiler or a burner, for example, and yet, the invention relates to a novel method of reforming fuel for driving said thermal engines and a fuel-reforming apparatus.

In order to improve fuel-combustion effect and decrease volume of hydrocarbon HC and nitrogen oxide NOx in exhaust gas in the course of operating conventional engines, such a method for radiating far-infrared rays or radioactive rays or magnetism solely against fuel or such a method for compulsorily discharging exhaust gas is conventionally known. The former method for radiating far-infrared rays or radioactive rays or magnetism against fuel improves fuel-combustion efficiency. Actually, emission of black smoke decreases from diesel engines to result in the decreased volume of SOx, raw HC and CO.Nevertheless, volume of exhausted NOx under critical issue inevitably increases. This is because volume of exhausted raw HC increases or decreases in inverse proportion to volume of exhausted NOx. The latter method for compulsorily discharging exhaust gas via a turbo fan results in the decreased volume of black smoke and enhanced output power. On the other hand, the latter method causes volume of NOx to increase, and yet, since output power can be raised by a significant rate, fine adjustment of output power involves difficulty to easily lead to occurrence of uncontrollable run.

In order to save consumption of fuel, there is such a method for radiating far-infrared rays or radioactive rays or magnetism solely against fuel or such a method for radiating far-infrared rays emitted by alumina-composed ceramics from the exterior of pipes for conducting absorbed air therethrough. While an ordinary automobile or an unloaded truck using either of the above methods runs on a high-way, fuel consumption decreases, but fuel consumption can not lower under loaded condition. It is presumably because, when only fuel has been reformed, fuel is easily combustible, however, when a truck is excessively loaded, volume of absorbed air and exhaust gas cannot increase or decrease in the mutual follow-up to result in the shortage or excessive supply of oxygen in the fuel-combustion chambers.

Accordingly, it is the primal object of the invention to drastically decrease volume of carbon dioxide, carbon monoxide, hydrocarbon, and nitrogen oxide exhausted via combustion of fuel inside of internal-combustion engines, and yet, drastically decrease fuel consumption and increase output power. To achieve the above object, the invention provides a novel method of reforming fuel, an improved fuel reforming apparatus, and an improved thermal engine.

A fundamental of the inventive method for reforming fuel is to bring liquid fuel into contact with ceramics mainly comprising silicon. The inventive fuel-reforming method is effected by adding either or both of microbial additive and enzyme to liquid fuel or by stirring liquid fuel at a super high speed.

A fundamental of the inventive fuel-reforming apparatus is that ceramics balls mainly comprising silicon are disposed in one or more than one internal portions selected from a liquid-fuel tank, a fuel-supply pipe, or a fuel filter, so that ceramics balls can be immersed in fuel. The inventive fuel-reforming apparatus is characterized by providing the liquid-fuel tank with a microbial addition means for adding either or both of microbial additive and enzyme to liquid fuel or a stirring means for stirring liquid fuel. The inventive fuel-reforming apparatus is characterized by coating one or more than one internal surfaces selected from the liquid-fuel tank, the fuel pipe, or the fuel filter, with ceramics mainly comprising silicon. The inventive fuel-reforming apparatus is further characterized by disposing ceramics balls at least containing radioactive material in one or more than one internal portions selected from the liquid-fuel tank, the fuel-supply pipe, or the fuel-filter, so that the ceramics balls can respectively be immersed in fuel. The liquid-fuel according to the inventive art is subject to heating at a temperature below ignition point thereof.

A fundamental of the inventive thermal engine is to effect coating at least part or whole of internal and external surfaces of pipes distributed for supplying liquefied or vaporized fuel in the fuel supply system with ceramics mainly comprising silicon. Another fundamental of the inventive thermal engine is characterized by filling at least part of internal portion of the pipes for distributing liquefied or vaporized fuel in the fuel supply system with ceramics balls mainly comprising silicon, or by covering part or whole of external surface of the pipe for distributing liquefied or vaporized fuel in the fuel supply system with ceramics balls mainly comprising silicon, or by coating part or whole of internal surface of either or both of air-absorption system and exhaust system, or by coating part or whole of external surface of either or both of air-absorption system and exhaust system with ceramics mainly comprising zirconium oxide containing titanium dioxide, or by coating internal surface of bent portion of pipes distributed in either or both of the air-absorption system and exhaust system with ceramics mainly comprising silicon. Furthermore, a still further fundamental of the inventive thermal engine is characterized by coating part or whole of internal and external surfaces of the fuel supply system for supplying liquefied or vaporized fuel, or the air-absorption system, or the exhaust system with ceramics mainly comprising silicon, or by filling part of internal surface of any of said systems with ceramics balls, or by coating either or both of internal and external surfaces of the fuel combustion chambers with ceramics mainly comprising zirconium oxide containing titanium dioxide.

Fuel-reforming and fuel-combustion systems as well as fuel combustion theory in regard to the inventive fuel-reforming method, fuel reforming apparatus, and the thermal engine, have not yet been elucidated, and thus, further study is expected. Accordingly, based on facts, the inventive art is described below. It was already confirmed that, as a result of causing liquefied fuel to come into contact with ceramics mainly comprising silicon, volume of carbon monoxide, hydrocarbon, nitrogen oxide, and carbon dioxide (total volume) contained in exhaust gas generated from combustion of liquefied fuel respectively decreased.

It was also confirmed via addition of either or both of microbial additive and enzyme to liquefied fuel that volume of carbon monoxide and hydrocarbon in exhaust gas generated from combustion of liquefied fuel respectively decreased. In this case, volume of carbon dioxide generated from exhaust gas indicated a slight increase, and thus, it is conceived that combustion was fully facilitated. It was also confirmed as a result of adding microbial additive or enzyme to liquefied full in contact with ceramics mainly comprising silicon that volume of carbon monoxide, hydrocarbon, nitrogen oxide, and carbon dioxide in exhaust gas generated from combustion of liquefied gas drastically decreased. Although the above effect was presumedly caused by interaction between them, concrete reason has not yet been clarified.

By effect of stirring liquefied fuel at a super high speed, effect of contact between ceramics and liquefied fuel further promoted to facilitate interaction between microbial additive or enzyme and liquefied fuel to enhance the above effect. When causing the liquefied fuel mixed with microbial additive to come into contact with ceramics or ceramics film containing radioactive material or implementing the above processes, practical effect can be enhanced by way of heating fuel to a temperature below ignition point thereof.

In the course of operating the inventive thermal engine, by effect of covering part or whole of internal and external surfaces of pipes of liquefied or vaporized fuel supply system with ceramics mainly comprising silicon or by effect of filling part or whole of pipes of the fuel-supply system with ceramics balls mainly comprising silicon, fuel can be supplied while being reformed in the course of supplying liquefied or vaporized fuel.

In addition, while operating the inventive thermal engine, by effect of covering part or whole of internal and external surfaces of either or both of air-absorption system and exhaust system thereof with ceramics mainly comprising silicon or by effect of providing an air-absorption promoting means for activating absorbed air in part of the air-absorption system, fuel can be subject to complete combustion and emission of detrimental material can be restrained to a minimum degree.

Furthermore, while operating the inventive thermal engine, operating efficiency of the whole fuel-combustion system can be promoted by effect of covering or filling part or whole of pipes distributed in the fuel-supply system for supplying liquefied or vaporized fuel, or the air-absorption system, or the exhaust system, with ceramics balls or ceramics mainly comprising silicon, thus making it possible for the thermal engine to burn fuel at a high efficiency. Likewise, by effect of covering internal and external surfaces of the fuel combustion chambers with ceramics mainly comprising zirconium oxide containing titanium dioxide, the inventive thermal engine can burn fuel at a high efficiency.

According to the invention, it was confirmed that fuel could be burnt to full extent, and yet, carbon monoxide and hydrocarbon contained in exhaust gas generated by the inventive thermal engine were respectively below measurable threshold value, and in addition, carbon dioxide drastically decreased as well. Furthermore, it was also confirmed that substantial volume of water vapor or water drops was emitted from exhaust port of the thermal engine by such a scope beyond that was discharged from conventional thermal engines.

Fig. 1 is a cross-sectional view of the inventive fuel tank representing an embodiment of the fuel-reforming method and the fuel-reforming apparatus related to the invention;

Fig. 2 is a front view of fundamental portions of the fuel-reforming apparatus representing an embodiment of the fuel-reforming method and the fuel-reforming apparatus related to the invention;

Fig. 3 is a cross-sectional view of fundamental portions representing another embodiment of a heating apparatus for embodying the fuel-reforming method and the fuel-reforming apparatus related to the invention;

Fig. 4 is explanatory of structural concept of an internal combustion engine for exemplifying the thermal engine related to the invention;

Fig. 5 is explanatory of an example of the air-absorbing manifold making up part of the thermal engine related to the invention, in which Fig. 5(a) designates a carburetor-mounted engine and Fig. 5(b) a fuel-jetting engine;

Fig. 6 is explanatory of an example of air-absorption promoting means making up part of the thermal engine related to the invention, in which Fig. 6(a) is explanatory of side surfaces and Fig. 6(b) being explanatory of cross-section thereof;

Fig. 7 is explanatory of fundamental components by way of illustrating an exhaust manifold and a catalyzer unit making up part of the thermal engine related to the invention; and

Fig. 8 is a plan representing a table-top gas-cooking stove being another example of the thermal engine related to the invention.

Referring now to the accompanying drawings, embodiments of the invention are described below. As shown in Fig. 1, a ceramics-coated layer 14 mainly comprising silicon is formed on internal surface of a steel-made air-tightly closed main tank body 12 of a fuel tank 10 according to an embodiment of the invention. A plurality of ceramics balls 16 mainly comprising silicon and the other ceramics balls 18 each containing radioactive elements are respectively disposed on bottom surface of the main tank body 12 via stratification. A stirring rod 20 is projectively erected on internal surface of the main tank body 12 of the fuel tank 10, where the stirring rod 20 is rotated at a very fast speed by a super high-speed motor 22 functioning as a stirring means which is secured to external surface of the main tank body 12. An addition device 26 for adding microbial additive 24, a fuel inlet port 30 for injecting fuel into the main tank body 12, and a liquid-surface level meter 32 for detecting actual surface level of fuel 28, are respectively provided on the top surface of the main tank body 12. A heating apparatus 34 is disposed below the main tank body 12 in order to heat fuel 28 to a predetermined temperature degree for a predetermined duration.

The above-referred ceramics balls 16 mainly comprising silicon individually consist of about 68% to 73% of silicon dioxide, about 12% to 17% of magnesium oxide, about 6% to 9% of aluminium oxide, about 0.5% to 2.0% of titanium dioxide, and other negligible ingredients such as calcium oxide, potassium oxide, ferric oxide, and sodium oxide, thus conjunctionally forming ceramics (hereinafter specifically being referred to as "ceramics mainly comprising silicon"). In order to expand contactable area with fuel 28, it is desired that the ceramics balls 16 be formed in poriferous condition. A ceramics-coated layer 14 mainly comprising silicon is formed on internal surface of the main tank body 12 via an initial step of grinding the ceramics balls 16 into pulverized particles followed by a step of adhering them onto internal surface of the main tank body 12. It was proven via immersion of the ceramics balls 16 in fuel followed by combustion of fuel that volume of carbon monoxide, hydrocarbon, nitrogen oxide, and carbon dioxide (total volume) in exhaust gas decreased.

On the other hand, the above-referred ceramics balls 18 containing radioactive elements are respectively composed of aluminium oxide, silicon dioxide, zirconium oxide, Rb_2, O, La_2O_3, Pr_6O_2, and Kr. However, it is not yet certain which one of these elements and compound actually contributes to reformation of fuel, and thus, further study is expected. According to test run of an automotive engine via combustion of gasoline immersed in the ceramics balls 18 composed of the above constituents, it was confirmed that the number of idling revolution increased by about 50rpm through 100rpm compared to the case of using conventional gasoline, thus resulting in the decreased volume of hydrocarbon and carbon dioxide emitted from exhaust gas.

The above-referred super high speed motor 22 used for embodying the invention is capable of rotating itself at a minimum of 4000rpm, preferably at a minimum of 10000rpm, more particularly at 20000rpm through 40000rpm. This is because the greater the number of the rotation, the higher the stirring effect so that fuel particles can become finer and more homogeneous. The above-referred stirring rod 20 is rotated by the super high speed motor 22 at an ultra high speed in fuel 28 to stir fuel 28 to cause impurities in fuel such as water and sulfur oxide to become finer so that constituents of fuel 28 can be homogenized. Simultaneously, mutual contact and reaction between the ceramics balls 16 mainly comprising silicon and the other ceramics balls 18 containing radioactive elements can be promoted to yield substantial effect. It was reported that calorific value of fuel was raised by effect of agitation via the super high speed motor 22.

Simultaneous with injection of fuel 28, the microbial additive 24 is added to fuel 28 via the addition device 26 by an optimal amount in correspondence with volume of injected fuel. Concretely, the microbial additive 24 is added to fuel 28 at a rate of 0.1cc through 2.0cc per liter of fuel 28. It should be understood however that actual amount or rate of addition is variable according to proportion and kind of microbes contained in the microbial additive 24 without being limited to the above-exemplified value. The microbial additive 24 is activated in fuel. Use of enzyme is preferred because of own function to cut off molecular chains of hydrogen and carbon into short length. Not only enzyme, but such a fuel-reforming agent using any available microbe may also be used without specific limit.

The above-referred heating apparatus 34 set to bottom of the main tank body 12 promotes reaction between the ceramics balls 16 and 18, the microbial additive 24, and fuel 28. After heating fuel 28 to a predetermined temperature degree in a range from 50 °C to 70 °C for an hour through 8 hours for example, heating is discontinued so that fuel 28 can remain at normal temperature.

Following injection of fuel 28 into the fuel tank 10 featuring the above-described structure, the above processes are executed to reform fuel 28. It was confirmed from combustion of the reformed fuel 28 that volume of carbon monoxide and carbon dioxide in exhaust gas decreased by one half. In the course of belching flame via a grass-burner, in contrast with conventional fuel causing reddish flame to be blown out of the burner, combustion of the reformed fuel 28 generated bluish white flame by a substantial length from the outlet of the burner, and yet, length of flame was extended on the whole. Based on this result, it was conceived that the reformed fuel was fully burnt to cause flame temperature to be raised by a great extent. An embodiment of the fuel-reforming method and the fuel-reforming apparatus related to the invention has thus been described. It should be understood however that the scope of the invention is by no means limited to the above-exemplified embodiment.

Concretely, at least by causing fuel 28 to remain in contact with the ceramics balls 16 mainly comprising silicon for more than a predetermined duration, the fuel-reforming method and the fuel-reforming apparatus embodied by the invention can yield substantial effect. It was confirmed that emitted volume of carbon monoxide and carbon dioxide was decreased solely by implementing the inventive fuel-reforming art. Accordingly, as shown in Fig. 2 for example, it is also possible to provide a circular cylindrical member 38 filled with the ceramics balls 16 mainly comprising silicon in part of a pipe 36 for supplying fuel 28 so that fuel 28 processed by the ceramics balls 16 can immediately be supplied to a combustion chamber. When implementing this embodiment, it is recommended that air-vent be provided between the circular cylindrical member 38 and the combustion chamber. It is also recommended that a ceramics-coated layer 14 mainly comprising silicon be formed on internal surface of the circular cylindrical member 38.

As was described above, predetermined effect can be generated by provision of the ceramics balls 16 and the ceramics-coated layer in respectively comprising silicon as the main constituent. It was also confirmed that volume of carbon monoxide and carbon dioxide generated in exhaust gas could be decreased by a great extent by virtue of combined use of the microbial additive 24, and thus, combined use of the both components is most recommended when executing the inventive art.

It is also recommended to stir fuel 28 at an ultra high speed instead of using or in conjunction with the microbial additive 24 so that fuel-processing time can be contracted. Not only the super high speed motor 22 and the stirring rod 20, but ultrasonic waves may also be used for radiating fuel 28 stored in the main tank body 12 as a means for stirring fuel 28 at an ultra high speed to cause the stored fuel 28 to be oscillated at an ultra high speed. However, available stirring means is not specifically limited.

It is also recommended to use the ceramics balls 18 containing radioactive elements in combination with any of the above-exemplified embodiments. Likewise, it is also recommended to coat internal surface of the circular cylindrical member 38 shown in Fig. 2 with pulverized particles of the ceramics balls 18 containing radioactive elements by applying binder.

Not only the heating apparatus 34 provided for heating fuel 28 below the main tank body 12 as shown in Fig. 1, but as shown in Fig. 3 for example, such a heating apparatus 44 may also be provided, wherein the heating apparatus 44 incorporates a heating unit 42 in the center of a pipe 40 extending itself in the upper and lower directions from the main tank body 12 and having both ends being open to the interior of the main tank body 12. According to the heating apparatus 44, heated fuel 28 generates convection so that temperature of fuel 28 stored in the main tank body 12 can be raised evenly, and yet, fuel temperature can substantially be held constant without involving difficulty.

The fuel-reforming method and the fuel-reforming apparatus according to the invention have thus been described. Next, by way of exemplifying an automotive engine, thermal engine embodied by the invention is described below.

As being illustrated in Fig. 4, an automotive engine 46 comprises a fuel-supply system 48 for supplying fuel for driving the engine 46, an air-absorption system 50 for supplying fresh air needed for burning fuel, and an exhaust system 52 for externally discharging exhaust gas from the engine 46. In order to restrain emissive volume of detrimental constituents contained in exhaust gas, adequate measures are effected in appropriate portions inside of the engine 46, fuel-supply system 48, air-absorption system 50, and the exhaust system 52, respectively.

It is desired that the above-referred fuel tank 10 shown in Fig. 1, Fig. 4, and in other embodiments be used for the fuel tank 54 of the fuel-supply system 48 shown in Fig. 4, and yet, the fuel tank 54 be so structured that fully reformed fuel can be supplied thereto. It is also possible for this embodiment to provide a fuel-reforming device 60 in part of a fuel-supply pipe 58 disposed between the fuel tank 54 and a fuel filter 56. Better effect can be generated by operating the fuel-reforming device 60 in conjunction with the fuel tank 10 which is structured to have fuel reformed. It is also effective that the interior of the fuel filter 56 be filled with ceramics so that the fuel-reforming device 60 can be formed. Alternatively, it is also possible to provide the fuel-reforming device 60 only in the case of using any conventional fuel tank. Normally, in order to eliminate foam generated in the fuel-reforming device 60, it is necessary to dispose the fuel filter 56 between the engine 46 and the fuel-reforming device 60.

The fuel-reforming device 60 has such a structure substantially being identical to that of the circular cylindrical member 38 shown in Fig. 2. When using gasoline, it is more preferred that internal surface of the circular cylindrical member 38 be processed by means of coating 14 with ceramics containing radioactive elements, and yet, it is further preferred that the internal portion of the circular cylindrical member 38 be filled with ceramics mainly comprising silicon by about 70% and ceramics containing radio-active elements by about 30% in terms of share. When using light oil as fuel, it is more preferred that internal surface of the circular cylindrical member 38 be processed by means of coating 14 with ceramics containing radioactive elements, and yet, it is further preferred that the internal portion of the circular cylindrical member 38 be filled with ceramics mainly comprising silicon. When using light oil, it is more preferred that a heating unit 62 be disposed at a portion immediately before a specific point at which fuel is led to the fuel-reforming device 60 so that light oil heated in a range of 50 °C through 70 °C . can be delivered to the fuel-reforming device 60. This is because the heating promotes reformation of light oil.

As shown in Fig. 5, the reformed fuel is delivered to a carburetor 64 or an electronically-controlled fuel-jetting system 66 respectively being operated for mixing gasoline or light oil with fresh air as of misty or liquefied condition, and then air-mixed reformed fuel is delivered to the engine 46 via an air-absorption manifold 68. It is recommended that, as shown in Fig. 5(a), in the case of the air-absorption manifold 68, external surface of a pipe 70 inter-linking the carburetor 64 and the engine 46 as well as external surface of the fuel-jetting system 66 shown in Fig. 5(b) be respectively coated with ceramics mainly comprising silicon. It is also allowable that, instead of executing the coating, using a bag containing pulverized particles of ceramics mainly comprising silicon, external surface of the pipe 70 may be covered with it. Since ceramics cannot be brought into direct contact with fuel when being disposed on external surface of the pipe 70, it is conceived that far-infrared rays emitted from ceramics could act on misty or liquefied fuel.

According to the experimental result, effect of far-infrared rays significantly varies when being radiated against a rubber pipe 70 and a metalic pipe 70, and thus, it is recommended to implement such a method for coating internal and external surfaces of the pipe 70 with ceramics or such a method for covering external surface of the pipe 70 with ceramics balls or appropriately shift applicable amount of ceramics.

On the other hand, when treating an air-cleaner 72 provided for the air-absorption system 50 shown in Fig. 4, it is desired that internal surface of an external cylinder and external surface of an air-filter respectively being component of the air-cleaner 72 be coated with ceramics. Since ceramics mainly comprising silicon is used for the coating to generate proper action of infrared rays, it is probable that fresh air can be activated in the air-cleaner 72. Concretely, the fuel-supply system 48 is treated with the above processes for driving the engine 46 with reformed fuel. However, when no treatment was effected against the air-absorption system 50, the engine 46 incurred such a symptom being short of oxygen to result in the increased volume of carbon monoxide and hydrogen emitted therefrom. After treating the fuel-supply system 48 with the above processes, symptom indicating oxygen shortage disappeared, thus resulting in the decreased volume of carbon monoxide emitted from the engine 46. Based on the above fact, it was conceived that the coating with ceramics promoted activation or absorption of incoming air.

It is recommended that activation or absorption of fresh air in the air-absorption system 50 be promoted inside of the air-cleaner 72, bent portion, air-inlet port, and peripheral portions of the air-absorbing pipe, as well as internal portion and internal bent portion of the air-absorbing manifold 68. The air-cleaner 72 has angular or circular form. Since the angular-form air-cleaner 72 has substantial inner capacity and enables substantial volume of fresh air to pass therethrough, it is recommended that internal air passage be properly filled with ceramics balls mainly comprising silicon or the internal surface forming air-passage be coated with ceramics mainly comprising silicon. On the other hand, since the circular air-cleaner 72 has in-substantial inner capacity and permits less volume of fresh air to pass therethrough, it is recommended that internal surface forming air-passage be coated with ceramics mainly comprising silicon. It is also possible to fix pulverized particles of ceramics on the surface of air-filter of the air-cleaner 72 so that the ceramics particles can be brought into contact with incoming fresh air. It was confirmed that execution of the above processes resulted in generation of substantial effect.

It is recommended that ceramics-coating be effected on internal surface of air-absorbing pipe 73 disposed in the front and on the back of the air-cleaner 72, more particularly, ceramics-coating be effected on internal surfaces of bent portion and air-intake port of the air-absorbing pipe 73 being exposed to substantial fluid resistance by applying ceramics mainly comprising silicon. It is also possible to provide an air-absorption promoting means 74 between the air-cleaner 72 and air-intake port of the air-absorbing pipe 73. The air-absorption promoting means 74 has such a structure incorporating a cylindrical container being filled with ceramics balls mainly comprising silicon so that fluid resistance caused by absorbed fresh air cannot be raised while preserving such a dimension of sectional area of the container enough to secure sufficient volume of incoming fresh air. It was confirmed that absorbed air can be further activated and accelerated by enabling absorbed fresh air to pass through ceramics balls mainly comprising silicon. It is also recommended that coating be effected with ceramics mainly comprising silicon on a predetermined internal surface of the air-absorbing pipe 73 in a range from about 10cm to about 20cm from the air-intake port, for example. It was confirmed that such phenomenon causing absorbable volume of fresh air to be increased was generated by effect of the above processes.

As shown in Fig. 6, air-absorption promoting means 76 may be of such a device capable of conducting absorbed fresh air in the form of helicoid flow. Concretely, as shown in Fig. 6, a plurality of helically formed helicoid plates 78 are set to air-intake port. Ceramics balls 80 are secured to internal surface of a circular cylindrical member 79 with a meshed member 81 to internally hold a plurality of helicoid plates 82. Accordingly, after passing through the air intake port, absorbed air is helically led by the helicoid plates 78 and then flows through internal surface of the circular cylindrical member 79 via centrifugal force. Absorbed fresh air is brought into contact with the ceramics balls 80. Then, the absorbed fresh air is and simultaneously converted into helicoid flow by the helicoid plates 82, and finally, activated and accelerated fresh air is delivered to the air-absorbing manifold 68.

Next, fuel is burnt inside of the engine 46, thus generating exhaust gas externally dischargeable. In order to accelerate flow of exhaust gas externally being discharged, it is recommended that internal and external surfaces of exhaust manifold 84 be coated with ceramics. Concretely, as shown in Fig. 7, exhaust gas emitted from pistons of the engine 46 is externally discharged via the exhaust manifold 84, and yet, it is essential that exhaust gas passing through the exhaust manifold 84 be discharged as quickly as possible. Accordingly, it is recommended that internal and external surfaces of the exhaust manifold 84 be coated with ceramics. In particular, in order to coat internal surface of the exhaust manifold 84, it is most preferred to use ceramics mainly comprising silicon. On the other hand, in order to coat external surface thereof, use of zirconium oxide containing titanium dioxide is most preferred.

In the same way as was done for the exhaust manifold 84, it is recommended that internal and external surfaces of catalyzer unit 86 provided for any gasoline-combustion automobile be coated with ceramics. It is most preferred to coat internal surface of the catalyzer unit 86 with ceramics mainly comprising silicon, whereas it is most preferred that external surface be coated with zirconium oxide containing titanium dioxide. Likewise, it is desired that sub-muffler 88 and main muffler 90 shown in Fig. 4 be also coated with ceramics.

The above-referred ceramics-coating may be implemented by way of coating the objective surface for coverage with pulverized particles of ceramics via binder or with plasma-molten ceramics, and yet, no limitation is applied to the coating method. Alternatively, instead of executing or in conjunction with the ceramics-coating, it is also allowable for the invention to dispose ceramics balls on internal and external surfaces of the exhaust manifold 86 and then fully cover the disposed ceramics balls with heat-resistant sheets.

As was described above, it is desired that coating be effected against appropriate portions of the fuel-supply system 48, the air-absorption system 50, and the exhaust system 52, with ceramics balls or ceramics aside from the engine 46. However, it is also desired that even the engine 46 itself be also coated with ceramics balls or ceramics. Concretely, it is recommended that external surface of the engine 46 be coated with such ceramics mainly comprising zirconium containing titanium dioxide or with ceramics balls having the composition identical to said ceramics. It is also recommended that surface of the crankcase inside of the engine 46 be coated with ceramics as well.

The inventive thermal engine has thus been described by exemplifying an automotive engine. It should be understood however that it is not always necessary to treat all the above-referred components with ceramics, but treatment with ceramics may be executed against properly selected portions thereof. In the case of the inventive thermal engine, using fuel reformed by the invention, the engine 46 is driven, and yet, by properly covering or coating internal and external surfaces of appropriate portions of the air-absorption system 50 and the exhaust system 52 with ceramics. Test result proved that volume of emitted carbon monoxide, carbon dioxide, nitrogen oxide, and hydrocarbon, drastically decreased. Furthermore, it was also confirmed that the muffler 90 emitted increased volume of water vapor or water drops compared to the volume emitted via conventional cases, and yet, it was confirmed that volume of emitted nitrogen oxide decreased to less than one half the conventional cases.

It was also confirmed that, as a result of the introduction of the above-described inventive thermal-engine structure, operating noise and oscillation of the engine drastically decreased. Decreased noise and oscillation of the engine was noticeably proved when the engine was covered with the ceramics balls or coated with ceramics. Furthermore, as a result of running tests carried out under a daily routine, it was also confirmed that fuel cost economy as well as accelerating performance were respectively improved by a great extent.

As was described above, operative theory of the inventive art has not yet been established. However, according to the inventive art, fuel is more easily combustible by causing ceramics mainly comprising silicon to come into contact with hydrocarbon in fuel. In addition, as a result of causing ceramics mainly comprising silicon to come into contact with fresh air being absorbed, absorbed air is reformed, and yet, flow speed of absorbed air is accelerated, thus resulting in the increased volume of absorbed fresh air. Furthermore, by causing ceramics mainly comprising silicon to come into contact with exhaust gas being discharged, it is conceived that exhaust can be reformed, and yet, flow speed of exhaust gas is accelerated to result in the increased volume of exhaust gas being discharged. More particularly, flow volume of absorbed fresh air becomes more equivalent to the flow volume of exhaust gas to drastically promote fuel consumption efficiency of the engine in the high-rotational range while driving a truck under loaded condition, thus drastically promoting output power and fuel cost economy, and yet, drastically purifying exhaust gas as well.

Concretely, as a result of causing ceramics mainly comprising silicon to come into contact with absorbed fresh air and also by effect of coating internal surface of the exhaust manifold with ceramic mainly comprising silicon and coating external surface of the exhaust manifold with zirconium oxide containing titanium dioxide to cause incoming fresh air to be brought into contact with the ceramics-coated surfaces, such a presumable phenomenon can be generated. Concretely, as a result of treating the air-absorption system with the above processes, flow speed of absorbed fresh air is accelerated, thus activating oxygen volume and contracting clusters of hydrous particles in the absorbed fresh air to result in the enhanced combustion efficiency. On the other hand, as a result of treating the exhaust system with the above processes, expansive rate of exhaust gas is promoted to result in the accelerated flow speed of exhaust gas and promoted thermal radiation. It is thus conceived that combustion efficiency can be enhanced by a great extent because of proportionate flow speed of absorbed fresh air and exhaust gas. It is further conceived that, by virtue of the above-described physical performance characteristics, combined rate of fresh air and hydrocarbon is improved to result in the enhanced combustion efficiency and exhaust efficiency, thus making it possible to drastically improve output power and fuel economy simultaneous with purification of exhaust gas.

Fundamental components of the inventive thermal engine have thus been described by exemplifying an automotive engine. Needless to mention that the scope of the invention is by no means limited to the above embodiments thus far exemplified.

For instance, the fuel-reforming device 60 and the heating device 62 of the fuel-supply system 48 can integrally be structured. Furthermore, it is possible for the invention to compose the fuel-supply system 48 based on such a structure in which a heater is disposed in the periphery of a zigzag-formed fuel-supply pipe 58, and then, after heating fuel to a predetermined temperature degree, heated fuel is delivered to a fuel-reforming device filled with ceramics balls by way of passing therethrough via zigzag form so that fuel can eventually be reformed. Available heater may be electrically heated via a battery or it may be heated by way of conducting heat from exhaust gas or the radiator. No restriction is applied to available heater.

Applicable scope of the invention is not merely limited to the above embodiments, but the inventive scope is properly variable in correspondence with automotive engine manufacturers and kind of automobiles.

Applicable scope of the invention is not only limited to liquefied fuel, but the scope of the invention can properly be applied to vaporized fuel as well. As shown in Fig. 8, taking a commercially available table-top gas-cooking stove 92 for example, zirconium oxide was applied to surface-coating of a gas-generator 96 for generating vaporized gas from liquefied butane gas fed from a gas cylinder 94, a gas-supply pipe 98, and a nozzle 100. It was confirmed from test result that the surface-coated nozzle 100 blew out flame by such a length longer than that was thus far measured from a conventional nozzle 100, and yet, flame temperature was raised. This is presumedly because gas was reformed by effect of far-infrared rays emitted from zirconium oxide.

In the case of coating surface of such a grass burner and a boiler burner, by effect of coating surfaces of these burners with zirconium oxide, it was also confirmed that longer flame was blown out and flame temperature also rose. Accordingly, the inventive art is effectively applicable not only to internal combustion engines such as automotive engines, but it can also be applied to thermal engines using every available fuel such as gasoline, light oil, kerosene, or crude petroleum, independent of liquefied form or vaporized form.

It should be understood that the inventive method of reforming fuel, absorbed fresh air, and exhaust gas, the inventive fuel-reforming apparatus, and the inventive thermal engines, are not merely limited to the above-exemplified embodiments, but the invention is also practicable by way of implementing a variety of improvements, modifications, and variations, based on knowledges of those skilled in the art without deviating from the fundamental scope of the invention.

EXAMPLE 1:

Initially, 0.1cc of bio-fuel reforming agent (a product of Sun Life Chemical Laboratory) was added to 1 liter of kerosene by ten thousandth (1/10000th) of blend ratio, and then the blended kerosene was stirred for 30 seconds in a high-speed agitator (GP-25A, a product of Hitachi, Ltd.) at 30000rpm. Next, 20 pieces of poriferous circular ceramics balls each mainly comprising silicon being fired into black shade and having about 1cm of diameter (a product of Nishio Co., Ltd., Aki-gun, Mie Prefecture) and 3 pieces of circular cylindrical ceramics each containing a negligible amount of radioactive element and having about 1cm of diameter and 5cm of length (a product of Kohsho Co., Ltd.), were respectively added to the kerosene, and then, the blended kerosene was heated until reaching 65 °C before being maintained at 65 °C for 24 consecutive hours.

The black ceramics balls mainly comprising silicon added to kerosene were chemically composed of the following: about 68% to 73% of silicon oxide, about 12% to 17% of magnesium oxide, about 6% to 9% of aluminium oxide, about 2% to 4% of calcium oxide, about 2% of titanium dioxide, about 2% of potassium oxide, and a certain amount of ferric oxide and sodium oxide. The above-referred ceramics containing a negligible amount of radioactive element was composed of aluminium oxide, silicon dioxide, zirconium oxide, Rb_2O, La_2O_3, Pr_6O_2, and Kr. However, blend ratio of respective constituents was not certainly known. Of those elements and compound added to kerosene, it was not known which one of them possibly contributed to reformation of fuel, and thus, further study is expected.

Next, the reformed kerosene was burnt in a kerosene-combustion heating apparatus (OKA27C, a product of Sharp Corporation). In the meanwhile, detecting device of a CO2 tester (ETT00836, a product of Bosche) was disposed above the combustion chamber of the heating apparatus after disengaging the front cover therefrom, and then, density of CO, CO_2, HC, and O_2 contained in exhaust gas was checked. On the other hand, constituents of exhaust gas was also measured at the hot-air blowing portion without disengaging the front cover from the heating apparatus. Results of analyzing density of exhaust gas are shown in Table 1.

TABLE 1

		CO(%)	HC ppm	CO_2 (%)	O_2 (%)
COVERING	EXAMPLE 1	0.002	N • D	2.9	16.8
	COMPARATIVE EXAM. 1	0.004	N • D	6.0	13.1
NO COVERING	EXAMPLE 1	0.001	3	0.3~0.2	20.3
	COMPARATIVE EXAM. 1	0.002	6~7	0.5	20.3

COMPARATIVE EXAMPLE 1:

Using the above-cited heating apparatus without previously applying any preparatory process to kerosene stored therein, density of CO, CO_2, HC, and O_2, was measured from exhaust gas under the condition identical to that was applied to Example 1. Test results are also shown in Table 1. As is apparent from Table 1, by virtue of combustion of the reformed kerosene, density of CO and CO_2 measured from exhaust gas respectively decreased by one half.

EXAMPLE 2:

Using a 4-metric-ton payload truck "FUSO Fighter" (a product of Mitsubishi Motor Corporation), density of gas constituents in exhaust gas was measured. Ceramics balls mainly comprising silicon shown in Fig. 4 were loaded in the fuel-reforming device 60, and then density of gas constituents in exhaust gas was measured. Likewise, by securing the fuel-reforming device 60 and the absorbed-air activating means 74 loaded with ceramics balls mainly comprising silicon and by securing the air-absorption promoting means 74 to a predetermined portion, and yet, by securing ceramics balls mainly comprising silicon to external surface of the exhaust manifold 84 by way of covering it, density of exhaust gas constituents was measured.

A sum of 790 grams of black-fired ceramics balls mainly comprising silicon (a product of Nishio Co., Ltd.) were loaded in the fuel-reforming device 60 made of stainless steel sheets by way of forming a cylindrical container having 354mm of total length and 50mm of external diameter. Each ceramics ball had about 10mm of diameter. The air-absorption promoting means 74 was made of stainless steel sheets formed into porously punched metals, with which 3 of box-form containers each having 12mm of height, 250mm of total length, and 51mm of width were fabricated. The box-form containers were then loaded with said ceramics balls, and then secured inside of the air-cleaner 72 of the air-absorption system. Ceramics balls for covering external surface of the exhaust manifold 84 were secured to external surface thereof with wire nets made of stainless steel.

After completing the above setup, the truck engine was ignited, and then density of nitrogen oxide, oxygen, and hydrocarbon was measured from exhaust gas. Density of nitrogen oxide was measured in accordance with JIS B-7982 (1988) prescribing chemi-luminescence method based on mobile form. Density of oxygen was measured in accordance with JIS B-7983 (1979) prescribing electrochemical method using zirconia. Density of hydrocarbon was measured in accordance with JIS D-1030 (1976) prescribing analysis via ionization of hydrogen flame. The above analytical survey was carried out by Environmental Engineering Division of Chugai Technos Co., Ltd. Results of the above analytical survey are shown in Table 2, which represents mean values of density of the above exhaust-gas constituents measured in the course of running the above truck per hour.

TABLE 2

	NOx (ppm)	HC (ppm)	O_2 (%)
MOUNTING ONLY ON FUEL-REFORMING PART	206.0	78.0	18.0
MOUNTING ON 3 POSITIONS	130.5	4.5	18.3
IMPROVED RATE	37 %	94 %	0.16 %

EXAMPLE 3:

Using an automobile "HONDA" E-AH equipped with a gasoline-combustion engine EW, ceramics balls of the above-referred two kinds were loaded in the fuel-reforming device 60, the air-cleaner 72, the fuel-injection pump 66, exhaust manifold 84, and the catalyzer unit 86 shown in Fig. 4. After igniting the engine, density of carbon dioxide and carbon monoxide contained in exhaust gas was measured in accordance with JIS K-0301 (1989) prescribing Orsat method. The above analytical survey was carried out by Environmental Engineering Division of Natsuhara Industrial Co., Ltd. The analytical survey evidenced that mean value of density of carbon dioxide was 3.2%, whereas mean value of density of carbon monoxide was less than 0.2%. Since measurable threshold value of carbon monoxide is less than 0.2%, it is conceived that actual density of carbon monoxide contained in the analyzed exhaust gas was extremely low.

EXAMPLE 4:

Using an automobile "TOYOTA" Corolla SE Limited, Model E-AE91, equipped with a 1500cc engine Model 5A, fuel reforming treatment was effected for the fuel-reforming device 60, the air-cleaner 72, the absorbed-air manifold 68, and the exhaust manifold 84 shown in Fig.4. Concretely, about 570 grams of ceramics balls mainly comprising silicon were loaded in a pipe having 50mm of diameter and 250mm of total length serving as the fuel-reforming device 60. In addition, 110 pieces of ceramics balls mainly comprising silicon were loaded in the angular air-cleaner 72, and yet, internal bent portions of the air-cleaner 72 and a duct hose were respectively coated with ceramics mainly comprising silicon.

In addition, internal surfaces of the absorbed-air manifold 68 and the exhaust manifold 84 were also coated with ceramics mainly comprising silicon, whereas external surfaces of the absorbed-air manifold 68 and the exhaust manifold 84 were respectively coated with ceramics mainly comprising zirconium oxide containing titanium dioxide.

After starting up the engine, the test car was driven forward. The time spent for running the car in a range of 400 meters was counted for 3 rounds, and then mean value was counted to be 20.79 seconds. Next, using a densitometer (MEXA324G, a product of Horiba Seisakusho, Co., Ltd.), density of carbon monoxide and hydrocarbon was measured in presence of a third party. Analyzed values were below measurable threshold value. In addition, using an output power tester (a product of Bosche) and a digital revolution meter (PET-2100, a product of Oppama Industrial Co. ,Ltd.), output power (PS) and the number of maximum revolution (rpm) were measured. Then, in order to check fuel economy, a test-run road with the least number of signal lamps permitting repeated reproduction of identical test condition therethrough was selected. After driving the test car by 132 kilometers, consumed volume of fuel was measured to be 9.49 liters. The test-car ran the road at a rate of 13.91km per liter of gasoline. Test results are shown in Table 3.

TABLE 3

	COMPARATIVE EXAM.			EXAMPLE			DEFFERENCE
TRAVELING TIME (400m)	1 st	2 nd	3 rd	1 st	2 nd	3 rd	
	22.08	21.99	21.92	20.85	20.75	20.73	
	Average	21.99 S		Average	20.79 S		1.20 S
CO CONCENTRATION	1.6 ppm			N・D≒0			-1.6ppm
HC COCENTRATION	4.9 ppm			N・D≒0			-4.9ppm
FUEL CONSUMPTION	10.8km/l			13.91km/l			28.8 %
HORSEPOWER TEST	73PS			84PS			+11PS
MAX NUMBER OF REVOLUTION	6070rpm			6490rpm			420rpm

COMPARATIVE EXAMPLE 2:

Using the test-car ran for Example 4 without loading and coating with the inventive ceramics balls, a test run was executed under the condition identical to that was applied to Example 4. Test results are also shown in Table 3.

As is apparent from Table 3, as a result of setting the inventive ceramics balls to fundamental components of the test-car, density of carbon monoxide and hydrocarbon drastically lowered, and yet, fuel economy was sharply promoted.

EXAMPLE 5:

Using a 2-cycle motor-bicycle "SUZUKI" Cepia having 50cc of displacement, inventive treatment was effected for the fuel tank, air-absorption system , and the exhaust system. Concretely, 30 pieces of ceramics balls each having 1cm of diameter and mainly comprising silicon and 5 pieces of rod-shaped ceramics each having 1cm of diameter and 5cm of length and containing a negligible amount of radioactive element, were respectively loaded in the above components. In addition, whole internal surfaces of fly-wheel in the air-absorption system were coated with ceramics mainly comprising silicon, and yet, internal surface of the air-cleaner was also coated with ceramics mainly comprising silicon, and in addition, 30 pieces of ceramics balls mainly comprising silicon were loaded in the air-cleaner. To implement treatment of the exhaust system, internal surface of the exhaust manifold ranging up to about 20cm from the engine was coated with ceramics mainly comprising silicon, and in addition, external surface of the exhaust manifold ranging up to 30cm from the engine was coated with zirconium oxide containing titanium dioxide.

After starting up the engine, the test-motorbicycle was driven forward, and then, time spent for running 200 meters of distance was counted for 3 rounds. As a result of checking mean value, it was found to be 15.86 seconds. Next, using a digital revolution meter (PET-2100, a product of Oppama Industrial Co., Ltd.) and a densitometer (MEXA324J, a product of Horiba Seisakusho, Ltd.), the number of maximum revolution (rpm) and density of hydrocarbon were measured. Results of analysis are shown in Table 4.

TABLE 4

	COMPARATIVE EXAM.			EXAMPLE			DEFFERENCE
TRAVELING TIME (200m)	1st	2nd	3rd	1st	2nd	3rd	
	17.43	17.54	16.79	16.01	15.87	15.69	
	Average	17.25 S		Average	15.86 S		1.39 S
MAX NUMBER OF REVOLUTION	5820rpm			12110rpm			6290rpm
HC CONCENTRATION	14.688ppm			8.563ppm			-6.125ppm

COMPARATIVE EXAMPLE 3:

Using the test-motorbicycle ran for Example 5, an experiment was carried out without effecting the treatment with the inventive ceramics. Results of the experiment carried out under the condition identical to that was applied to Example 5 are also shown in Table 4. As is apparent from Table 4, as a result of setting the inventive ceramics balls, density of hydrocarbon drastically lowered, and conversely, the number of maximum revolution drastically increased.

Claims

1. A method of reforming fuel comprising a step of causing liquefied fuel to be brought into contact with ceramics mainly being composed of silicon.

2. The method of reforming fuel set forth in Claim 1, wherein either or both of microbial additive and enzyme are added to said liquefied fuel.

3. The method of reforming fuel set forth in Claim 1 or 2, wherein said liquefied fuel is stirred at a super high speed.

4. An apparatus for reforming fuel, which is disposed by way of enabling ceramics balls mainly comprising silicon to be immersed in fuel inside of one portion or more than one portions selected from a liquefied-fuel tank, or a fuel pipe, or a fuel filter.

5. The fuel-reforming apparatus set forth in Claim 4, wherein said liquefied-fuel tank is provided with a microbial addition means for adding either or both of microbial additive and enzyme to said fuel.

6. The fuel-reforming apparatus set forth in Claim 4 or 5, wherein stirring means for stirring fuel is provided inside of one portion or more than one portions selected from said liquefied-fuel tank, or said fuel pipe, or said fuel filter.

7. The fuel-reforming apparatus set forth in any of Claims 4 through 6, wherein one or more than one internal surfaces selected from said liquefied-fuel tank, or said fuel pipe, or said fuel filter is (are) coated with ceramics mainly comprising silicon.

8. The fuel-reforming apparatus set forth in any of Claims 4 through 7, wherein ceramics balls at least containing radioactive material are immersed in fuel inside of one portion or more than one portions selected from said liquefied-fuel tank, or said fuel pipe, or said fuel filter.

9. The fuel-reforming apparatus set forth in any of Claims 4 through 8, wherein said liquefied fuel is heated below ignition point thereof.

10. A thermal engine having a pipe distributed for own fuel-supply system for supplying liquefied or vaporized fuel, in which at least part or whole of internal and external surfaces of said pipe is coated with ceramics mainly comprising silicon.

11. A thermal engine having a pipe distributed for own fuel-supply system for supplying liquefied or vaporized fuel, in which at least part of the interior of said pipe is filled with ceramics mainly comprising silicon.

12. A thermal engine having a pipe distributed for own fuel-supply system for supplying liquefied or vaporized fuel, in which part or whole of surface of said pipe is covered with ceramics mainly comprising silicon.

13. A thermal engine having part or whole of internal surface of either or both of air-absorption system and exhaust system being coated with ceramics mainly comprising silicon.

14. A thermal engine having part or whole of external surface of either or both of air-absorption system and exhaust system being coated with ceramics mainly comprising zirconium oxide containing titanium dioxide.

15. A thermal engine having internal surface of bent portion of a pipe of either or both of air-absorption system and exhaust system being coated with ceramics mainly comprising silicon.

16. A thermal engine having part or whole of internal and external surfaces of own fuel-supply system for supplying liquefied or vaporized fuel or own air-absorption system or exhaust system being coated with ceramics mainly comprising silicon or part of the interior of any of said systems is filled with said ceramics.

17. A thermal engine having either or both of internal surface or external surface of fuel-combustion component being coated with ceramics mainly comprising zirconium oxide containing titanium dioxide.

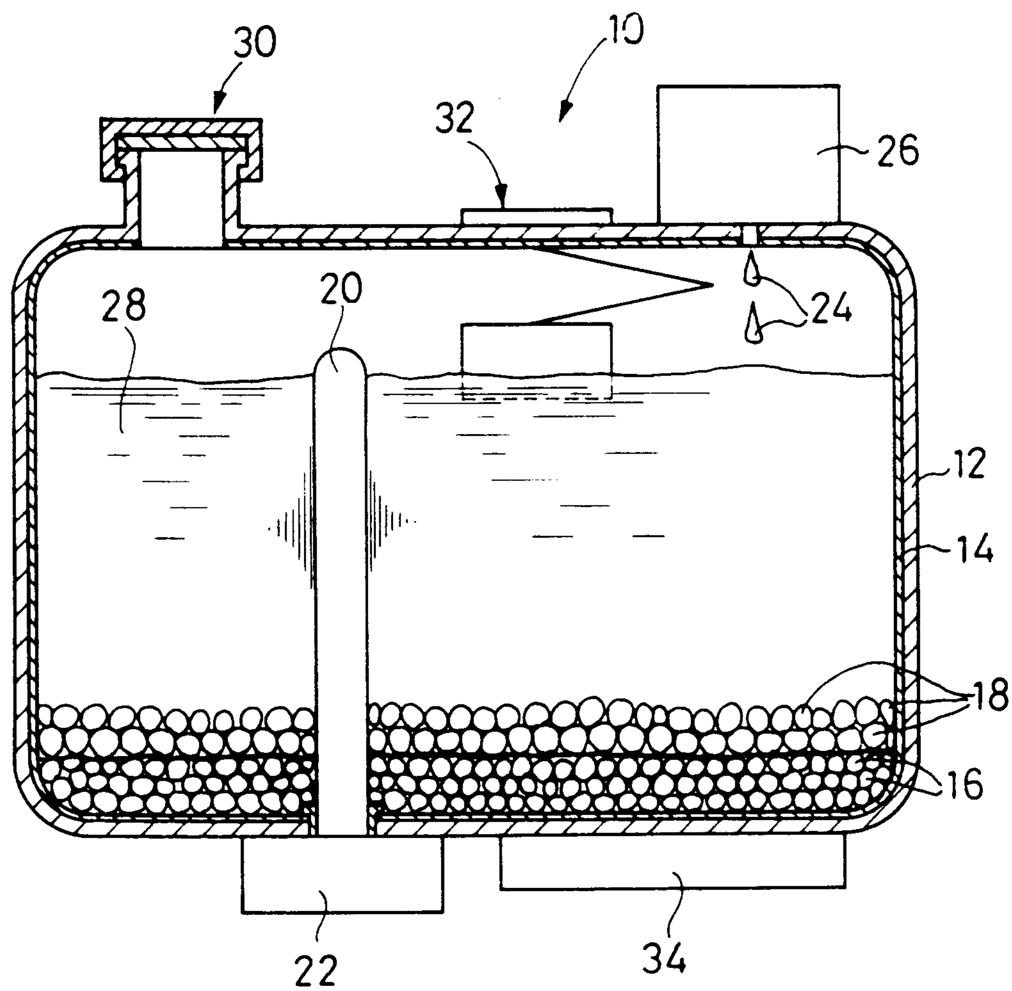

Fig.1

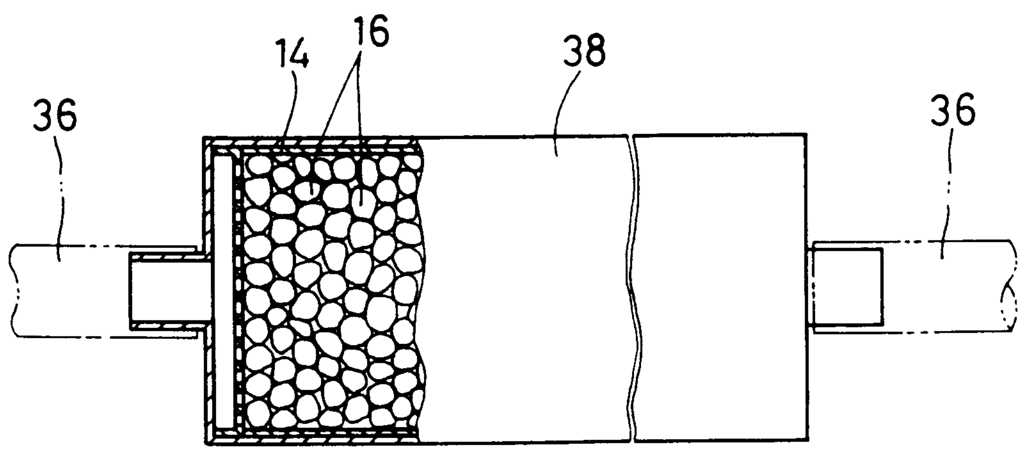

Fig. 2

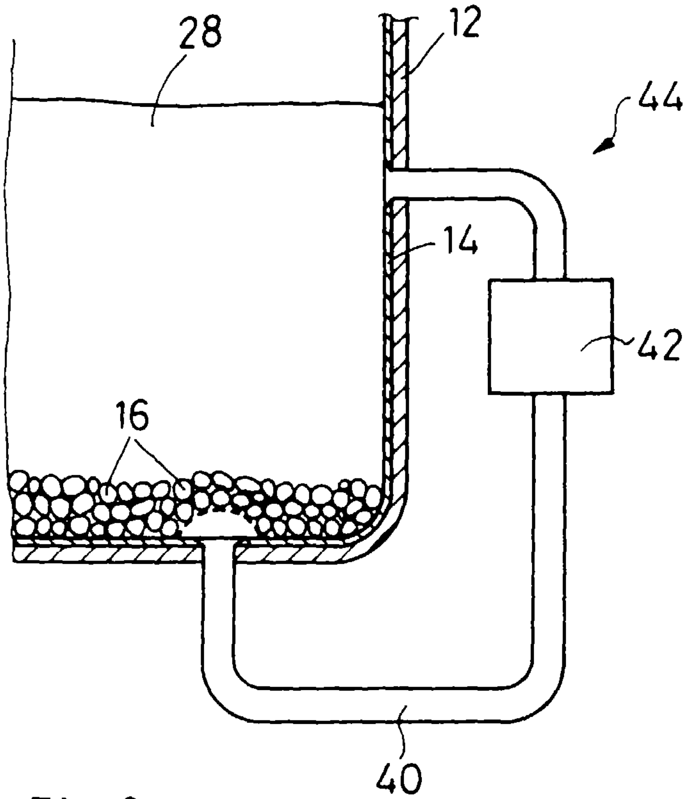

Fig.3

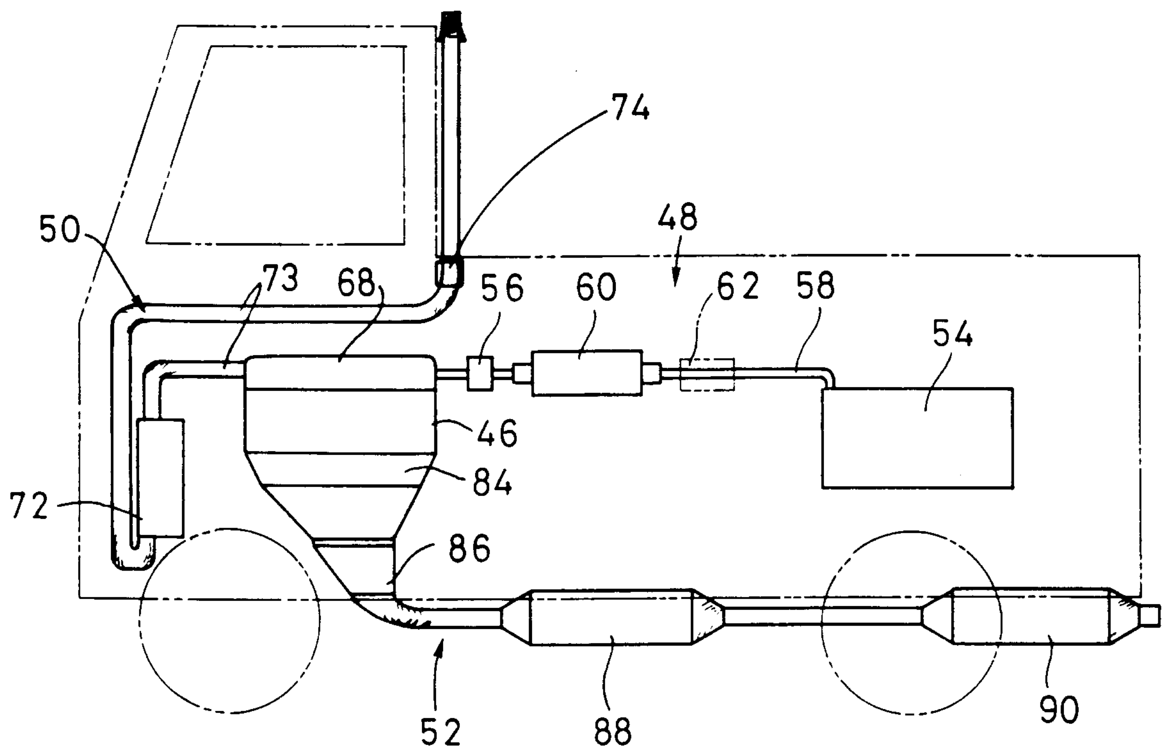

Fig. 4

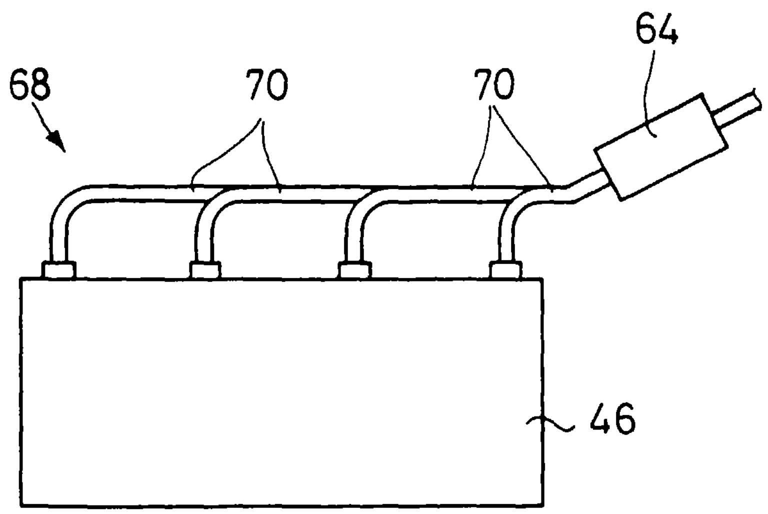

Fig.5(a)

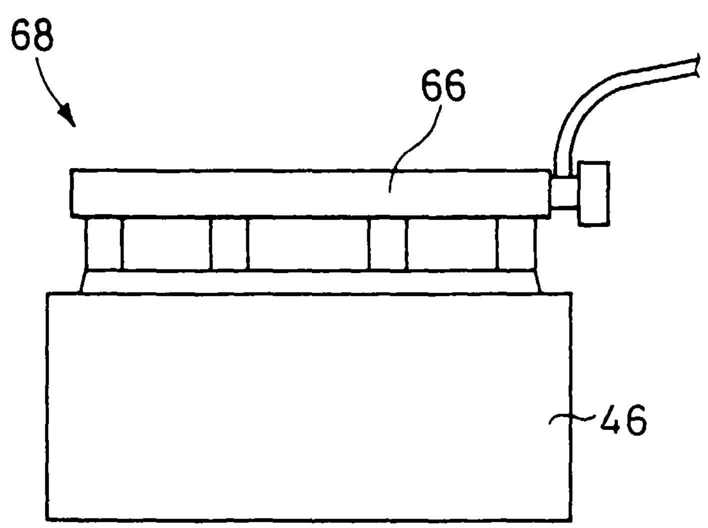

Fig.5(b)

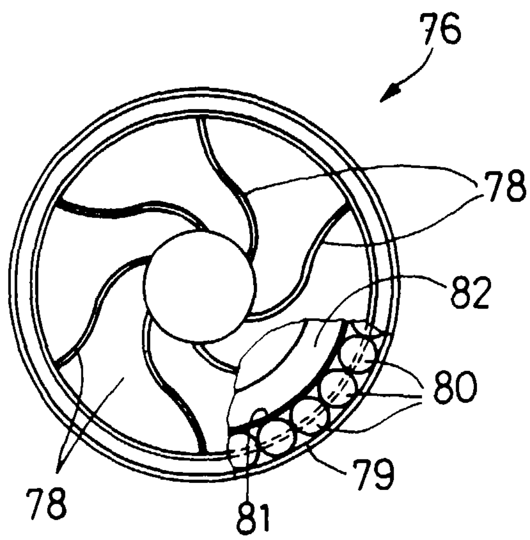

Fig.6(a)

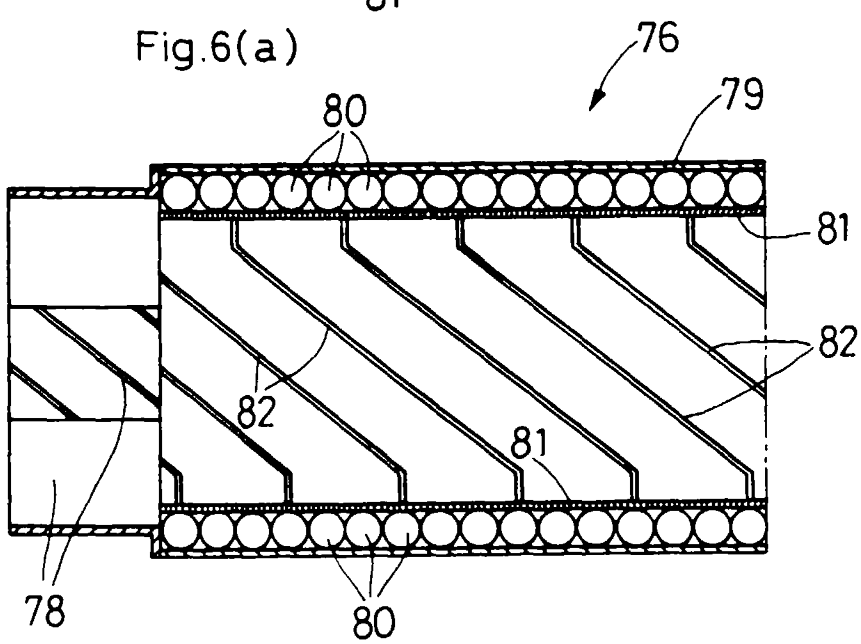

Fig. 6(b)

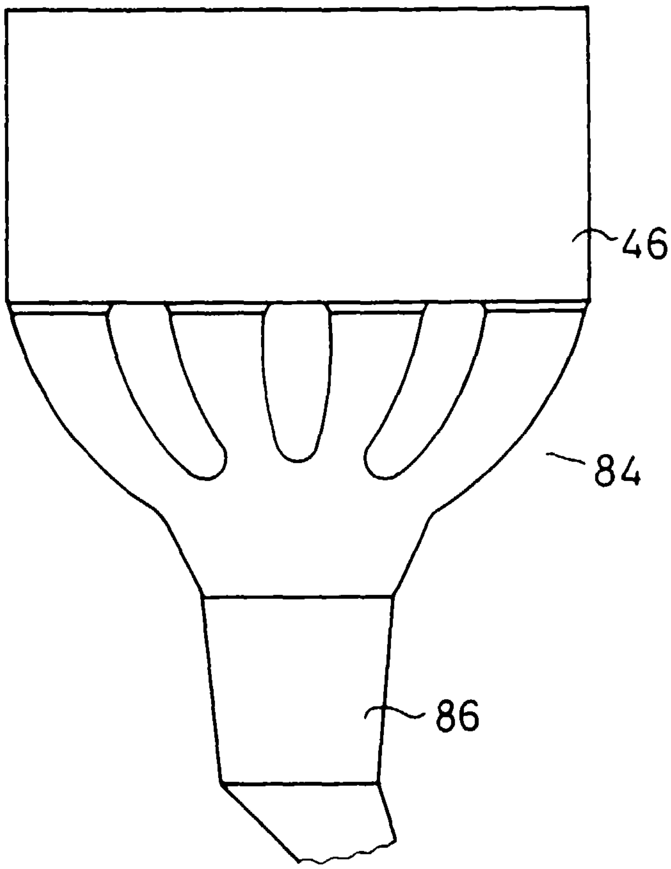

Fig. 7

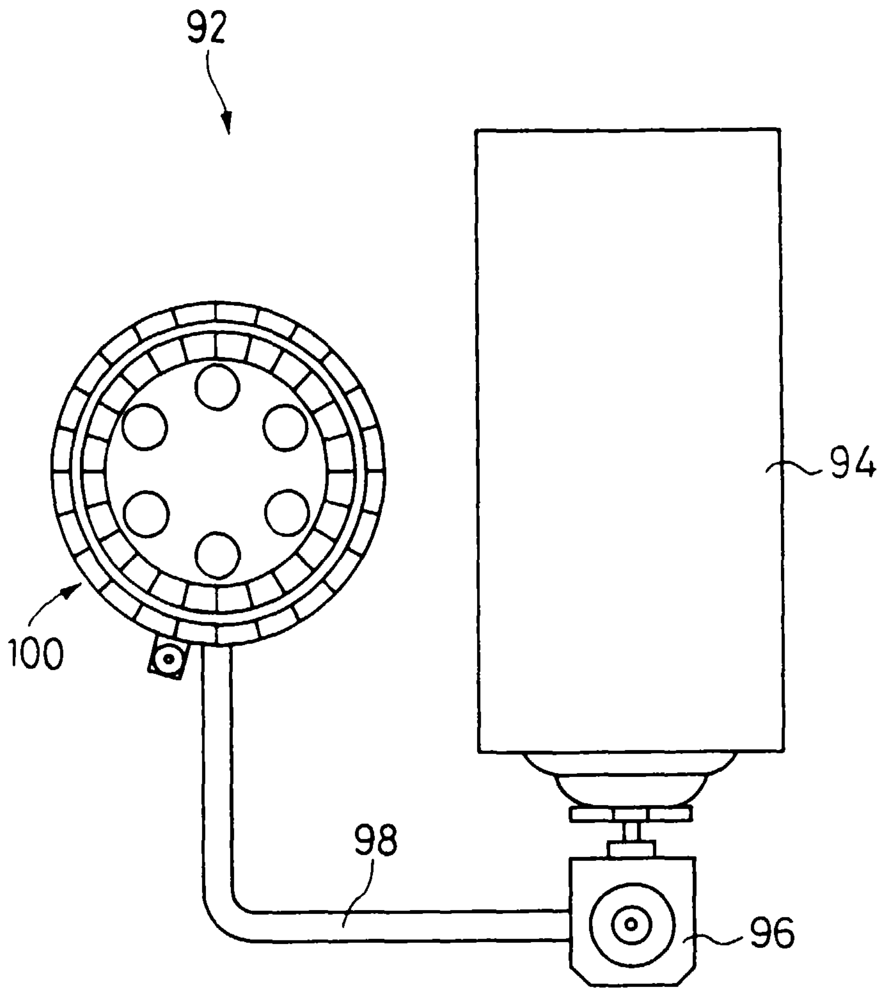

Fig.8

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EUROPEAN SEARCH REPORT

Application Number
EP 96 10 2728

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	WO-A-95 27849 (IBE)	1,3,4,6, 11,12,16	F02M27/00
Y	* abstract; figures 1-7 * & EP-A-0 708 237 (IBE)	8	
X	FR-A-2 174 958 (SIEMENS) * page 1, line 1 - line 4 * * page 2, line 25 - line 36 * * page 5, line 8 - line 13 *	16	
Y	* page 5, line 30 - line 37 *	8	
X	PATENT ABSTRACTS OF JAPAN vol. 13, no. 340 (M-857), 31 July 1989 & JP-A-01 116275 (YAKURA KENJI), 9 May 1989, * abstract *	1,4,11, 12,16	
X	CH-A-208 617 (MARTINI) * page 1, right-hand column, paragraph 1 - page 2, left-hand column, line 2 * * page 2, left-hand column, paragraph 6 * * page 2, right-hand column, paragraph 2 *	1,4,11, 16	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F02M F01N
A	EP-A-0 597 173 (AMOS) * abstract * * page 1, line 15 - line 31 * * claims 1,11,20 *	1	
X	EP-A-0 149 688 (OPTIMIZER) * page 5, line 11 - line 32 * * page 6, line 15 - line 19 * * page 8, line 29 - line 32 * * page 9, line 18 - line 30 * * page 11, line 23 - page 12, line 11 *	1,4,9, 11,16	

-/--

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 January 1997	Joris, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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EUROPEAN SEARCH REPORT

Application Number
EP 96 10 2728

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US-A-4 170 200 (TAKEUCHI) * column 2, line 50 - line 67 * * column 3, line 65 - line 68 * * column 9, line 14 - line 24 * * column 9, line 30 - line 39 * ---	1,4,9, 11,13,16	
X	EP-A-0 597 173 (AMOS) * abstract * * column 1, line 15 - line 31; claims 1,11,20 * ---	13	
X	PATENT ABSTRACTS OF JAPAN vol. 17, no. 342 (C-1076), 29 June 1993 & JP-A-05 043363 (ISUZU CERAMICS), 23 February 1993, * abstract * ---	13,15	
X	PATENT ABSTRACTS OF JAPAN vol. 8, no. 96 (M-294), 4 May 1984 & JP-A-59 012116 (SUZUKI), 21 January 1984, * abstract * ---	13	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 17, no. 206 (M-1400), 22 April 1993 & JP-A-04 347322 (ISUZU), 2 December 1992,	13,15	
Y	* abstract * ---	16	
X	DE-A-24 11 222 (NIPPONDENSO) * page 4, line 6 - line 14 * * page 4, line 21 - page 5, line 3 *	13	
Y	* page 7, paragraph 6 - page 8, paragraph 2; figures 3,6,13 * --- -/--	16	

The present search report has been drawn up for all claims

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EPO FORM 1503 03.82 (P04C01)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 10 2728

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US-A-5 024 289 (MERRY) * abstract * * column 3, line 49 - line 62; figures 1,2 * -----	16	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 January 1997	Joris, J

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L : document cited for other reasons

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filling more than ten claims

☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the claims fees have been paid within the prescibed time limit. The present European search report has been drawn up for the first ten claims and those claims for which fees have been

namely claims:

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of the unity of the invention and relates to several inventions or groups of inventions, namely:

See sheet B

☐ All further search fees haven been paid within the fixed time limit. The present European search report has been drawn up for all claims

☐ Only part of the further claims fees have been paid within the prescibed time limit. The present European search report has been drawn up for for those parts of the European patent application which relate to the inventions in respects of which search fees have been paid,

namely claims: 1-12,16 (partially), 13-15,16 (partially)

☐ None of the further claims fees have been paid within the prescibed time limit. The present European search report has been drawn up for for those parts of the European patent application which relate to the invention first mentioned in the claims,

namely claims:

European Patent Office

EP 96 10 2728 -B-

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims 1-12,16 (partially) : Method for reforming fuel, fuel reforming apparatus and fuel pipe for an engine with internal and external surfaces of said pipe coated or filled with ceramics mainly comprising silicon (CSi) or surface of said pipe is covered with CSi or filled with ceramics.

2. Claims 13-15,16 (partially): Air intake and/or exhaust system having internal surface coated with CSi or external surface coated with ceramics comprising zirconium oxide containing titanium dioxide or filled with CSi.

3. Claim 17: Internal surface of combustion component of a thermal engine coated with ceramics mainly comprising zirconium oxide containing titanium dioxide.

WO-A- 95 027849 (which corresponds to EP 0 708 237 published 24-04-1996) discloses a method for reforming fuel comprising the step of causing fuel to be brought into contact with ceramics mainly comprising silicon (see EP doc. page 2, lines 26-30, line 33, page 3, lines 1,2,14-17,34-38, claims 1,2,6). Therefore claim 1 is not new.
Said WO doc. also discloses an apparatus for reforming fuel comprising ceramics balls mainly comprising silicon to be immersed in the fuel inside a portion of a fuel pipe; therefore also independent claim 4 is not new.
These 2 claims (claims 1 and 4) therefore do not have a special technical feature (STF) as defined in Rule 30 EPC.
The STF of the invention defined in independent claim 10 is a fuel pipe for a thermal engine with internal and external surfaces of said pipe coated with ceramics mainly comprising silicon (CSi).
The STF of the invention defined in claim 11 is nihil since said WO documents also thermal engine having a fuel pipe filled with CSi (see page 4, lines 26-29).
The STF of the invention defined in claim 12 is nihil since according to figure 7 in said WO document; the internal surface of part of the fuel pipe is covered with CSi.

The STF of the invention defined in claim 13 is an air intake and/or exhaust system for a thermal engine with internal surface coated with CSi.
The STF of the invention defined in claim 14 is an air intake and/or exhaust system for a thermal engine with external surface coated with ceramics comprising zirconium oxide containing titanium dioxide.
The STF of the invention defined in claim 15 is a bent portion of a pipe of the air intake and/or exhaust system for a thermal engine is coated with CSi.
The STF of the invention defined in claim 16 is internal and external surfaces of fuel

supply system or of air intake or of exhaust system for a thermal engine coated with CSi. That part of this claim relating to a thermal engine with part of a fuel supply system being filled with ceramics is known from said WO document; that part therefore is not a STF). The STF of the invention defined in claim 17 is the internal or external surface of a fuel combustion component for a thermal engine being coated with ceramics mainly comprising zirconium oxide containing titanium dioxide.

The technical relationship (as defined in said Rule 30 EPC) between the inventions defined in claims 10 and 16 (partially) is a fuel pipe (as part of the fuel supply system of claim 16) with internal and external surfaces coated with CSi.

There is no technical relationship between the inventions defined in claims 10,16 (partially) and in claim 11 since claims 10,16 (partially) relate to a fuel pipe coated with CSi and claim 11 relates to a fuel pipe filled with CSi.

There is no technical relationship between the inventions defined in claims 10,16 (partially) on the one hand and in claims 13,14,15,16 (partially) on the other hand since claims 10,16 (partially) relate to a fuel pipe and claims 13,14,15,16 (partially) relate to air intake and/or exhaust systems.

There is also no technical relationship between the inventions defined in claims 10,16 (partially) and claim 17 on the other hand since claims 10,16 (partially) relate to a fuel pipe and claim 17 relates to a combustion component. Therefore the inventions defined in claims 10,16 (partially), in claims 13,14,15,16 (partially) and in claim 17 do not meet the requirements of unity of invention.