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Maeda

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[54] VAPOR POWER PLANT

[72] Inventor: Riichi Maeda, Yokohama, Japan

[73] Assignee: Nissan Motor Company Limited, Yokohama, Japan

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Primary Examiner—Martin P. Schwadron
Assistant Examiner—Allen M. Ostrager
Attorney—McCarthy, Depaoli, O'Brien & Price

[57] ABSTRACT

A vapor power plant driven with a working fluid vaporized from a liquid having a relatively freezing point such as trichloromonofluoromethane, comprising a working fluid circuit and a cooling fluid circuit both of which share limited common a passage with each other so that the same liquid can be used both as a working medium for driving a prime mover of the power plant and as a cooling medium for cooling an exhaust from the prime mover.

2 Claims, 2 Drawing Figures

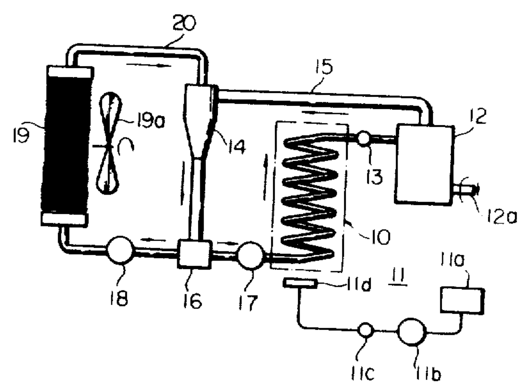


Fig. 1

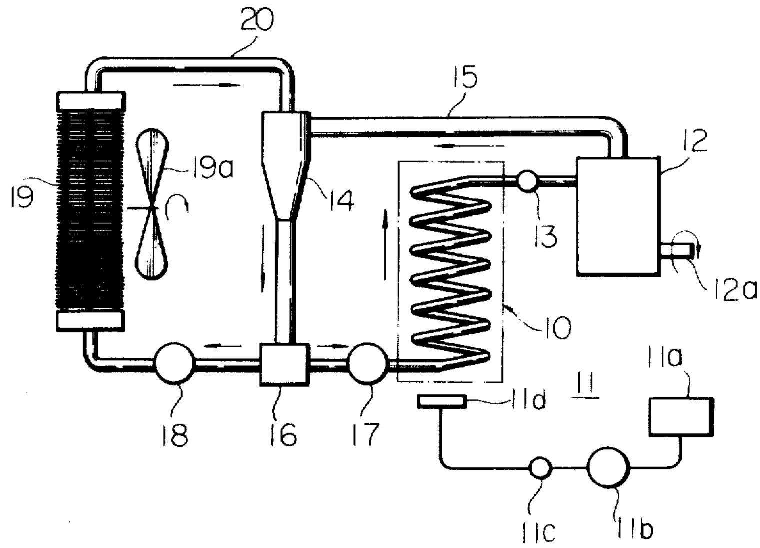
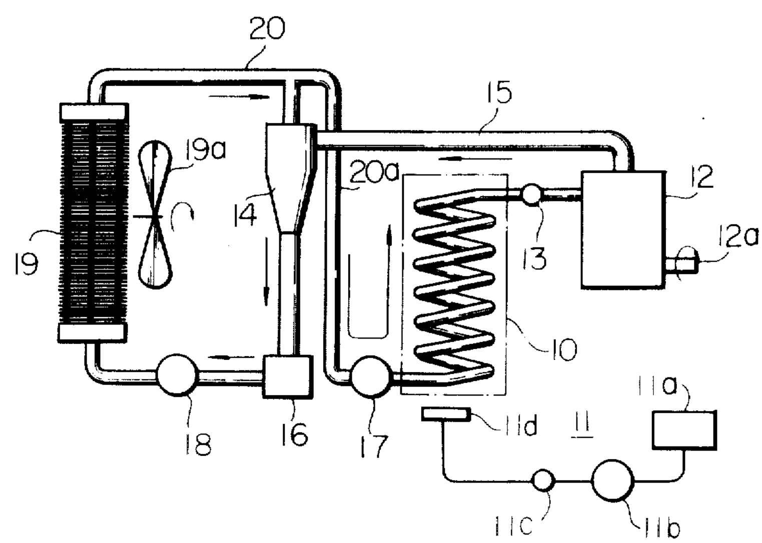


Fig. 2



INVENTOR
RIICHI MAEDA
BY McCarthy, Depaoli & O'Brien
ATTORNEYS

VAPOR POWER PLANT

This invention relates to a vapor power plant driven with vaporized working fluid and more particularly to a method and apparatus therefore of cooling from a prime mover of such power plant.

A vapor power plant has been proposed and put into limited practice so as to supersede conventional internal combustion engines from which noxious compounds such as carbon monoxides, hydrocarbons and nitrogen oxides are emitted to the atmosphere causing serious air pollution problems where the internal combustion engines are used in motor vehicles. The vapor power plant, which is a variant of external combustion engines, is driven with a working fluid which is vaporized from a cool liquid. If, in this instance, it is not desired for economical reasons to have an exhaust from the prime mover discharged into the open air, the exhaust should be repeatedly cooled and recycled in a closed circuit to drive the prime mover continuously. Where water vapor is to be utilized as such a working fluid, difficulties are encountered in that the water tends to freeze in chilly weather to eventually destroy the working circuit of the power plant and in that, where the exhaust is forcedly air cooled, a large-sized, space-taking cooling unit should be used to compensate for the low thermal conductivity between the water vapor and air.

An object of the invention is therefore to provide an improved method of cooling exhaust from a vapor power plant in which the exhaust is free from freezing even in chilly weathers.

Another object of the invention is to provide an improved method of cooling exhaust from a prime mover of a vapor power plant with an increased performance efficiency and with use of a compact and effective cooling unit.

Still another object is to provide a vapor power plant having means to cool and liquefy exhaust discharged from a prime mover of a power plant for repeated use or recycling of a working plant which, on the other hand, is utilized as a medium for cooling the exhaust recycled.

According to one aspect of the invention, it is herein proposed to use as a working fluid for the vapor power plant those chemical compounds which have a freezing point lower than minus 30° C at an atmospheric pressure. The working fluid may preferably have a boiling point lower than 95° C.

According to another important aspect of the invention, the same liquid is utilized, on one hand, as a working fluid and, on the other hand, as a cooling medium.

The method proposed by this invention as advantageous for cooling the exhaust from the prime mover of the power plant consists of the continuously repeated cycles each of which comprises contacting the exhaust with forcedly cooled fluid for cooling down and liquefying the exhaust into a liquid which is mixed with the cooled liquid serving as a cooling medium, vaporizing a portion of the resultant cool liquid into a working fluid for driving the prime mover, and forcedly cooling the remaining portion of the cool liquid for contact with the exhaust discharged successively from the prime mover, wherein the liquid used for both driving the prime mover and cooling the exhaust from the prime mover has a freezing point lower than minus 30° C. Thus, it will be readily appreciated that, since the cooling medium used to carry out the method according to the invention is of a liquid phase, a relatively high thermal conductivity between the exhaust and the cooling medium is available without use of a large-sized, space-taking cooling unit. The use of a liquid with a relatively low freezing point, the liquid is practically free from freezing when cooled down even in unusually chilly weathers.

The method according to the invention is advantageously carried out through provision of a vapor power plant comprising a working fluid circuit including an evaporator for vaporizing a cool liquid into a vaporized working fluid and a prime mover receiving the vaporized working fluid from the evaporator and driven therewith, and a cooling fluid circuit including a cooling means, the working fluid and cooling fluid circuits sharing a common chamber communicating with the outlet port of the prime mover and the cooling means and a

common liquid reservoir communicating with the inlet ports of the evaporator and the cooling. Pumps, valves and other regulating means may be provided between any of the components of the thus constructed power plant.

The liquid which is advantageously operable in the method and apparatus according to the invention is trichloromonofluoromethane, butyl acetate, diethyl carbonate, butyl ether, O-dichlorobenzene, monobromobenzene, hexafluorobenzene, trichlorotrifluoroethane, or a mixture of two or more of these, but other fluoro- or hydrocarbons may also be used, if desired.

Preferred embodiments of apparatus carrying out the method described above are illustrated in the accompanying drawings in which:

FIG. 1 is a schematic diagram showing an embodiment of a vapor power plant incorporating the improvements according to the invention; and

FIG. 2 is a view showing a modification of the power plant illustrated in FIG. 1.

First referring to FIG. 1, the vapor driven power plant incorporating the improvements according to the invention comprises an evaporator **10** which is heated by an associated burning means **11** and which vaporizes a cool liquid supplied thereto. The evaporator communicates at its outlet port with an inlet port of a prime mover **12** to which the working fluid vaporized in the evaporator **10** is delivered. A regulator valve **13** may be interposed between the outlet port of the evaporator **10** and the inlet port of the prime mover **12**, whereby the flow rate of the vapor is adjusted as desired. The prime mover **12** communicates at its outlet port with an inlet of a vapor condenser **14** through an exhaust passage **15**, whereby the exhaust discharged from the outlet port of the prime mover **12** is fed into the condenser **14** in which the vapor is cooled and liquefied as explained later. The condenser **14**, in turn, communicates at its outlet port with an inlet port of a liquid reservoir **16** and the cool liquid in the condenser **14** is passed over to the reservoir **16** for temporary storage. The reservoir **16** communicates at its outlet port with an inlet port of the boiler **10** through a feed pump **17** so that a portion of the cool liquid in the reservoir is pumped by the feed pump **17** into the evaporator **10** for vaporization into a working fluid. A closed working fluid circuit is thus formed by the evaporator **10**, prime mover **12**, exhaust passage **15**, condenser **14** and liquid reservoir **16**.

The burning means which is generally represented by reference numeral **11** is made up, by way of example, of a fuel storage tank **11***a* containing fuel therein, a fuel pump **11***b* communicating with the fuel storage tank **11***a* for pumping out the fuel therefrom, a fuel flow regulator **11***c* adapted to regulate the flow rate of the fuel to be passed therethrough, and a burner **11***d* which receives the fuel from the regulator **11***c* and burns the fuel to heat the evaporator **10**. The burning means **11** may be arranged otherwise insofar as the purpose of heating the boiler **10** in a selected manner is achieved.

The power plant shown in FIG. 1 includes another closed circuit for the circulation and forced cooling of the liquid to cool and liquefy the exhaust introduced into the condenser **14** from the prime mover **12**. This cooling fluid circuit comprises a circulating pump **18** which communicates with a second outlet of the liquid reservoir **16** for pumping out a portion of the cool liquid therefrom. The pump **18** communicates with an inlet port of a cooling means or radiator **19** so that the cool liquid is pumped into the cooling means or radiator **19** and is therein forcedly cooled down. The cooling means or radiator **19**, in turn, communicates at its outlet port with a second inlet of the condenser **14** through a cooling liquid passage **20** whereby the liquid which has been forcedly cooled down in the cooling means or radiator **19** is drawn into the condenser chamber **14**. The cooling fluid circuit is thus formed by the reservoir **16**, pump **18**, cooling means or radiator **19** and condenser **14**. In other words, the drive fluid circuit and the cooling fluid loop share the condenser **14** and the reservoir **16** with each other so that both of the media for driving the prime mover 12 and cooling the exhaust from the prime mover issue from or originate in a common source of liquid which, in this instance, is the liquid reservoir.

When, in operation, the exhaust is discharged from the outlet port of the prime mover 12 and introduced into the condenser 14, the exhaust is brought into contact with the cooled liquid supplied from the cooling means or radiator 19 and is thereby cooled down and liquefied into the cool liquid. The thus cooled liquid is mixed with the exhaust which therefore exchanges heat with the cooled liquid.

The resultant cool liquid is passed over to the reservoir 16. A portion of the cool liquid drawn into the reservoir is then pumped into the evaporator 10 in which the cool liquid is converted into a hot vapor. The major portion of the cool liquid in the reservoir 16 is drawn into the cooling means or radiator 19 by means of the circulating pump 18 and is therein cooled and fed into the condenser 14 for contact with the exhaust from the prime mover 12. The cooling and drive media are in this manner recycled in the cooling and working fluid circuits continuously, joining together in the condenser 14 and reservoir 16 which are shared by the two circuits.

The power produced by the prime mover 12 is carried to a suitable driven member (not shown) through an output shaft 12*a*. Designated by reference numeral 19*a* is a fan which forcedly air cools the cooling means or radiator 19.

The constructions and operations of the components of the power plant may be changed and modified in any desired manners as long as the basic concept of the invention is maintained. For instance, instruments for adjusting and/or regulating the performances of the individual components of the power plant may be incorporated where desired. Also, the circuit connections may be modified in a desired manner, an example being shown in FIG. 2.

As illustrated in FIG. 2, a modification is made to the power plant of FIG. 1 so that the evaporator 10 receives the cool liquid directly from the cooling means or radiator 19 through a branch passage 20*a* which is branched from the cooling liquid passage 20.

Now, the fuel to be used to heat the evaporator 10 may be gaseous, liquid or solid and, moreover, the cooling means or radiator 19, which has been described as cooled with atmospheric air, may be cooled in any desired manner.

It may be herein noted that emission of toxic compounds resulting from the combustion of a fuel to vapourize the working liquid in the power plant of the invention can be minimized to a negligible extent because the arrangement for heating the evaporator can be selected desiredly and because the combustion of the fuel takes place at an atmospheric pressure. The power plant according to the invention is, therefore, expected to contribute to the solution of the vehicular air pollution problems.

What is claimed is:

1. A vapour power plant driven with a working fluid vapourized from cool liquid including trichromonofluoromethane having a freezing point lower than minus 30° C and a boiling point lower than 95° C, comprising a working fluid circuit including an evaporator for vapourizing said cool liquid into a vapourized working fluid, a regulator valve disposed between said evaporator and a prime mover for adjusting the flow of said vapourized working fluid to be fed to said prime mover, a cooling fluid circuit including a cooling means, said working fluid and cooling fluid circuits sharing a common condenser communicating with the outlet ports of said prime mover and said cooling means and a common liquid reservoir communicating with the inlet ports of said evaporator and said cooling means, said working fluid circuit having a first pump interposed between said reservoir and said evaporator, and said cooling fluid circuit having a second pump interposed between said reservoir and said cooling means, whereby said cool liquid in said reservoir is passed by said first and second pumps over to said evaporator and to said cooling means, respectively.

2. A vapour power plant driven with a working fluid vapourized from cool liquid including trichromonofluoromethane having a freezing point lower than minus 30° C and a boiling point lower than 95° C, comprising an evaporator delivering a vapourized working fluid, a prime mover communicating at its inlet port with said evaporator for receiving the vapourized working fluid therefrom, a regulator valve disposed between said evaporator and said prime mover for adjusting the flow of said vapourized working lfuid to be delivered to said prime mover a vapour condenser communicating at its inlet port with an outlet port of said prime mover for receiving and liquefying an exhaust discharged therefrom, a liquid reservoir communicating at its inlet with said condenser for temporarily storing a cool liquid fed therefrom and communicating at outlet port with an inlet port of said evaporator through a first pump interposed between said reservoir and said boiler and a cooling means communicating at its inlet port with a second outlet port of said reservoir through a second pump and at its outlet port with a second inlet port of said condenser, said first and second pump feeding said cool liquid in said reservoir to said evaporator and said cooling means, respectively, the liquid forcedly cooled in said cooling means being fed into said condenser for cooling and liquefying the exhaust discharged from said prime mover in the succeeding cycle.

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