PATENT SPECIFICATION 945,252

DRAWINGS ATTACHED.

945,252

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International Classification :—F 25 b.

COMPLETE SPECIFICATION.

Improvements in or relating to Method and Apparatus for Cooling Utilizing a Vortex Tube.

I, KEN-ITI MUNAKATA, a Japanese Subject, of 85 1-chome, Kamikoshien, Nishinomiya, Hyogo-Ken, Japan, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the method of cooling effectively, utilizing a Ranque Hilsch tube, comprising a long tube with two end walls, into which a jet-like stream of gas, for example air, is blown from outside through a nozzle provided tangentially to the inner surface of the tube near one of the two end walls in a direction substantially perpendicular to the axis of the tube, and from which a stream of gas colder than that blown in through the said nozzle emerges through an exhaust orifice at the end of the tube near the said nozzle, while another hot stream emerges through another exhaust orifice at the other end of the tube.

In a method of cooling, according to one aspect of the present invention, utilizing a Ranque Hilsch tube having an inlet nozzle and hot and cold exhaust orifices, the cold exhaust orifice is connected through a heat exchanger to the suction inlet of an internal combustion engine.

According to another aspect of the present invention, apparatus for cooling or refrigerating comprises a Ranque Hilsch tube having an inlet nozzle and hot and cold exhaust orifices, an internal combustion engine, a heat exchanger connected by one pass between the cold exhaust orifice of the Ranque Hilsch tube and the inlet pipe of the internal combustion engine, means for withdrawing hot air from the hot exhaust orifice of the Ranque Hilsch tube and means for flowing refrigerant through another pass of the heat exchanger.

The invention will be further described by way of example with reference to the accompanying drawings, in which:—

Figs. 1 and 2 show in block schematic form flow diagrams of two embodiments of internal combustion engines utilizing a Ranque Hilsch tube according to the present invention;

Fig. 3 is a graph illustrating conditions obtaining when the Ranque Hilsch tube is operated at super-atmospheric and sub-atmospheric pressures;

Fig. 4 and Fig. 5 are diagrammatic plan and side elevational views of an automobile in which the present invention is applied for interior cooling; and

Fig. 6 is a schematic flow diagram of the arrangement by which hot air is sucked out of a Ranque Hilsch tube by a suction equipment coupled with an internal combustion engine and cold air is sucked out of the said tube by the manifold of the internal combustion engine.

Referring initially to Fig. 3, if the pressure of gas blown into the tube is denoted by Po, and the temperature by To, and the pressure of gas at the instant of its passage through the cold exhaust orifice is denoted by P and its temperature by T, then if a graph is drawn with log Po/P as abscissa and T/To as the ordinate, I have discovered that the graph drawn when gas, under pressure, is blown in through the nozzle, pressure at the orifice at the ends of the tube being maintained the same as atmospheric pressure lies above that drawn when the pressure at the nozzle is maintained the

same as atmospheric pressure and the pressure at the exhaust orifices is lower than atmospheric pressure.

I found from the above fact that in utilizing a Ranque Hilsch tube effectiveness of refrigeration is more efficient if the gas enters through the nozzle substantially at atmospheric pressure and gas emerges from the exhaust orifices at a pressure lower than atmospheric pressure rather than when gas under pressure, that is to say precompressed gas, is blown in through the nozzle and emerges through the exhaust orifices at a pressure reduced substantially to atmospheric pressure.

Consequently, it becomes clear that cooling efficiency in a Ranque Hilsch tube is better when the gas within the tube is sucked out through the orifices rather than when compressed gas is blown into the tube.

The present invention is based on an application of the abovementioned principle to internal combustion engines.

For example, as shown in Fig. 1 the Ranque Hilsch tube (vortex tube) can be associated with an internal combustion engine operating with a carburettor. In such arrangement the suction pipe of the engine 20 is divided into two branches 22, 23. One branch 22 is connected to the cold exhaust orifice 24 of the Ranque Hilsch tube 25 through a heat exchanger 26, while the other branch 23 is connected to the outlet of the carburettor 27. The inlet of the carburettor is connected to the hot exhaust orifice 28 of the Ranque Hilsch tube and also through a valve 29 to an outlet of an air cleaner 50, whilst the nozzle 30 of the Ranque Hilsch tube is connected through a valve 31 to the outlet of the air cleaner 50.

Fig. 2 shows an arrangement wherein the Ranque Hilsch tube is associated with a Diesel-engine 32. The suction pipe of the engine is divided into three branches, 33, 34, 35. One branch 33 is connected to the cold exhaust orifice 24 of the Ranque Hilsch tube 25 (vortex tube) through the heat exchanger 26, the second branch 34 to the hot exhaust orifice 28, and the third branch 35 to the outlet of the air cleaner 50 through valve 36 and the nozzle 30 of the Ranque Hilsch tube is connected with the outlet of the air cleaner through a valve 36.

In the arrangements of Fig. 1 and Fig. 2 negative pressure obtaining in the manifold and suction pipe of the engine causes the flow of air through the Ranque Hilsch tube and the cold air which emerges from the cold exhaust orifice cools a refrigerant in the form of a separate flow of air by being passed through the heat exchanger in heat exchange with such separate flow.

The described cooling method has a number of advantages; for example a cheap cooling equipment can be installed in an automobile since the air is not under great pressure. Moreover mechanical losses, due to friction, can be reduced by reason of the Ranque Hilsch tube operating at sub-atmospheric pressure.

As a matter of fact, rather better efficiency in refrigeration is obtainable, if the air from the hot exhaust orifice of the Ranque Hilsch tube is supplied to the suction manifold of the engine after being cooled down nearly to atmospheric temperature. Still, it is believed that a high efficiency of engine can be expected as a result of supplying to the suction manifold of the engine the cold air which flows through the heat exchanger before warming it up to atmospheric temperature.

As illustrated in Fig. 6, either of the following two methods will do. One is to suck hot air out of the Ranque Hilsch tube 25 by means of suction equipment 44 coupled with an internal combustion engine 45 and to suck cold air out of the said tube by means of the inlet manifold of the said engine. The other is to cause the manifold of the internal combustion engine to suck cold air out of the Ranque Hilsch tube 25 and to cause other equipment to suck hot air out of the said tube. In these cases cooling is effected by making good use of the suction of the internal combustion engine which has a limit to its sucking capacity.

Referring now to Figs. 4 and 5 which illustrate an application of the invention to an automobile, 1 indicates a carburettor, 2 indicates an adjustable valve which is associated with a Ranque Hilsch tube 5 and which, by means of a wire 14, can be manipulated by a person sitting in the driver's seat to select the ratio of the quantities of air coming out of the exhaust orifice of the Ranque Hilsch tube 5 and out of an air-cleaner 7.

Air sucked in through the air-cleaner 7 enters the Ranque Hilsch tube 5 at nozzle 6 and is differentiated by the Ranque Hilsch tube 5 into cold air and hot air. The former flows out of the cold exhaust orifice of the Ranque Hilsch tube 5 into a pipe 8 and through a heat exchanger 12 and at the engine suction pipe 3 joins with the hot air which emerges from the hot exhaust orifice into a pipe 4, and then flows into the carburettor 1.

An independent supply of air sucked in through an air suction inlet 15 is cooled down in heat exchanger 12 and, by a motor 10 and a fan 11, is directed into the automobile body from a diffusing mouth 9.

In this way, suction of air is fully utilized in order for operating the Ranque Hilsch tube and cooled air is used to cool down the air to be supplied into the automobile body, thus the interior of the body itself may be comfortably air-conditioned.

WHAT I CLAIM IS:—

1. A method of cooling utilizing a Ranque Hilsch tube having an inlet nozzle and hot and cold exhaust orifices, wherein the cold exhaust orifice is connected through a heat exchanger to the suction inlet of an internal combustion engine.

2. The method as claimed in Claim 1, in which the hot exhaust orifice is connected to separate suction equipment.

3. The method as claimed in Claim 2, wherein said suction equipment is driven by the internal combustion engine.

4. The method as claimed in Claim 1, in which the hot exhaust orifice is also connected to said suction inlet of the engine.

5. A method as claimed in any of Claims 1 to 4, as applied to cooling the interior of an automobile in which the engine is installed.

6. Apparatus for cooling or refrigerating comprising a Ranque Hilsch tube having an inlet nozzle and hot and cold exhaust orifices, an internal combustion engine, a heat exchanger connected by one pass between the cold exhaust orifice of the Ranque Hilsch tube and the inlet pipe of the internal combustion engine, means for withdrawing hot air from the hot exhaust orifice of the Ranque Hilsch tube and means for flowing refrigerant through another pass of the heat exchanger.

7. Apparatus as claimed in Claim 6, in which said hot air withdrawing means comprises a pipe connected between the hot exhaust orifice and the engine inlet pipe.

8. Apparatus as claimed in Claim 7, in which the engine has two inlet pipe branches, one of which contains a carburettor, and in which the hot exhaust orifice is connected to the suction pipe branch containing the carburettor whilst the cold exhaust orifice is connected through said heat exchanger to the other suction pipe branch.

9. Apparatus as claimed in Claim 7, in which said engine is a diesel engine and in which the hot exhaust orifice is connected directly to the suction pipe of the engine and the cold exhaust orifice is connected to the suction pipe through said heat exchanger.

10. Apparatus as claimed in Claim 6, in which said hot air withdrawing means comprises suction equipment connected to said hot exhaust orifice.

11. Apparatus as claimed in Claim 10, in which said suction equipment is coupled to be driven by said internal combustion engine.

12. Apparatus as claimed in any of Claims 6 to 11, when installed in an automobile.

13. Methods of cooling utilizing a Ranque Hilsch tube and an internal combustion engine substantially as hereinbefore described with reference to the accompanying drawings.

14. Apparatus for cooling utilizing a Ranque Hilsch tube and an internal combustion engine constructed, arranged and adapted to be operated substantially as hereinbefore described with reference to and as illustrated in Fig. 1 of the accompanying drawings.

15. Apparatus for cooling utilizing a Ranque Hilsch tube and an internal combustion engine constructed, arranged and adapted to be operated substantially as hereinbefore described with reference to and as illustrated in Fig. 2 of the accompanying drawings.

16. Apparatus for cooling utilizing a Ranque Hilsch tube and an internal combustion engine constructed, arranged and adapted to be operated substantially as hereinbefore described with reference to and as illustrated in Figs. 4 and 5 of the accompanying drawings.

17. Apparatus for cooling utilizing a Ranque Hilsch tube and an internal combustion engine constructed, arranged and adapted to be operated substantially as hereinbefore described with reference to and as illustrated in Fig. 6 of the accompanying drawings.

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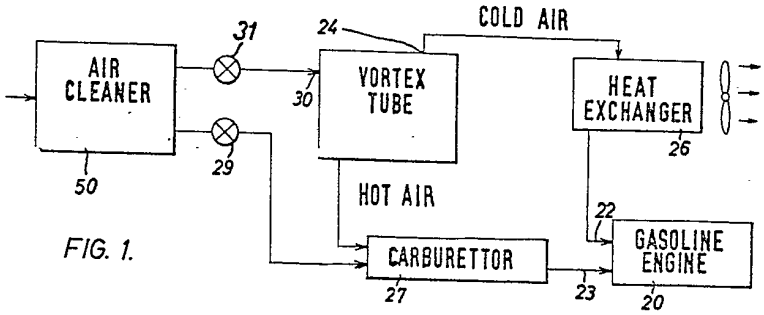

FIG. 1.

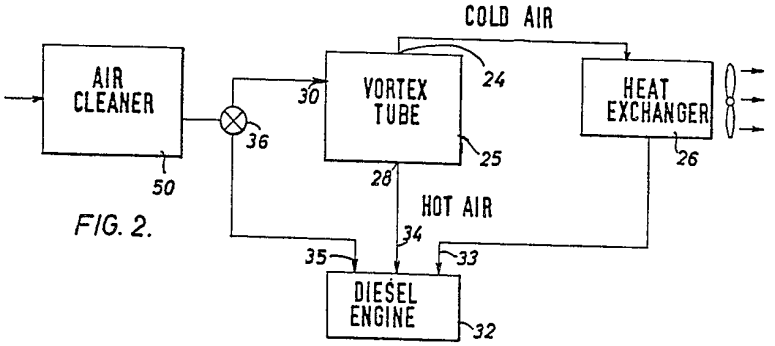

FIG. 2.

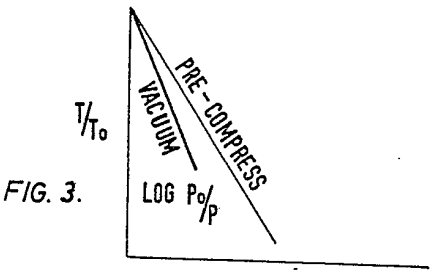

FIG. 3.

945252 COMPLETE SPECIFICATION

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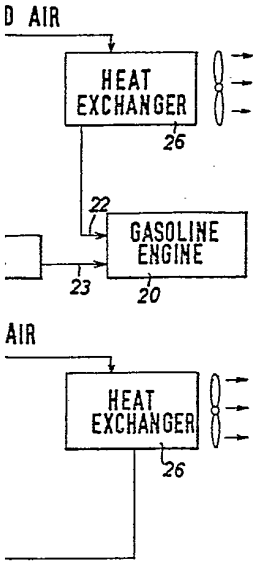
Sheets 1 & 2



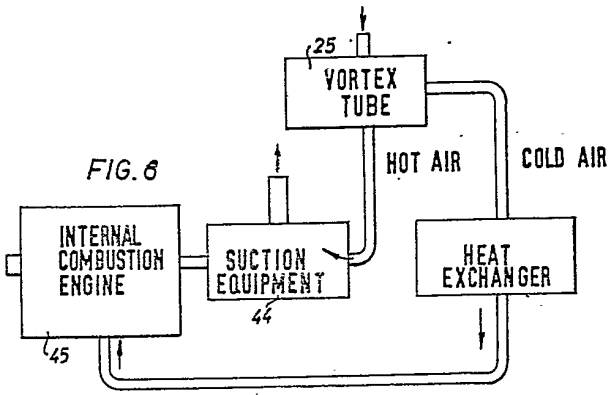


FIG. 6

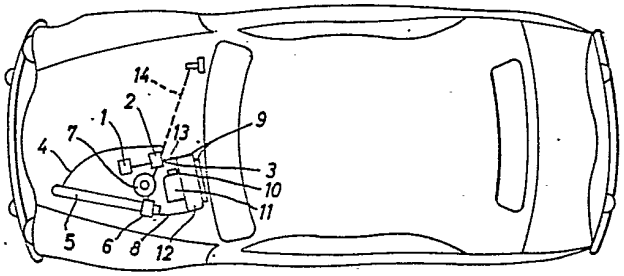


FIG. 4.

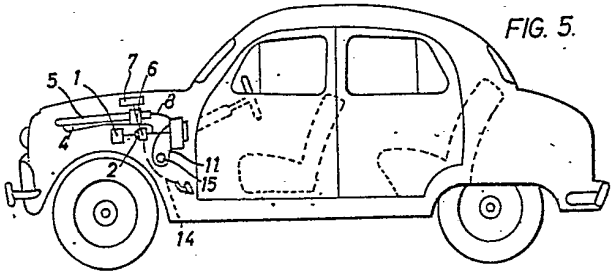


FIG. 5.

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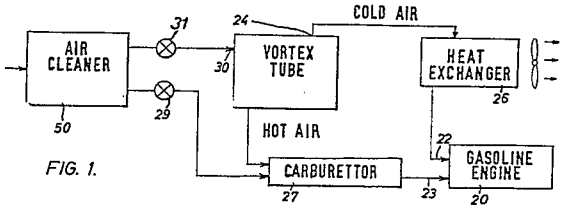

FIG. 1.

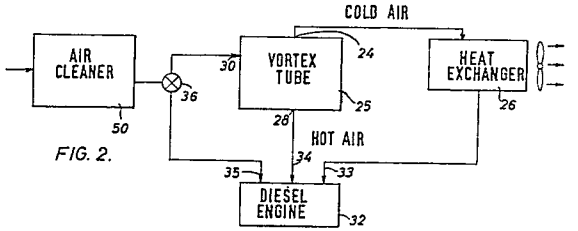

FIG. 2.

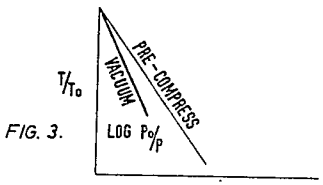

FIG. 3.

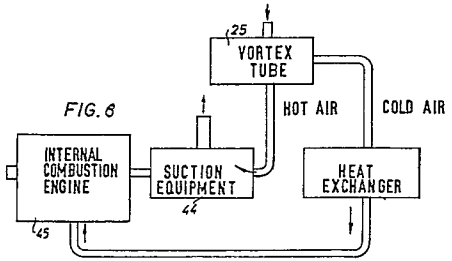

FIG. 6

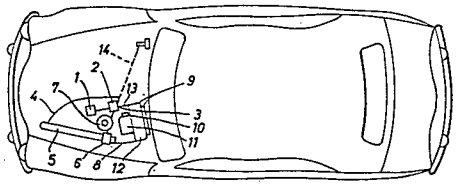

FIG.4.

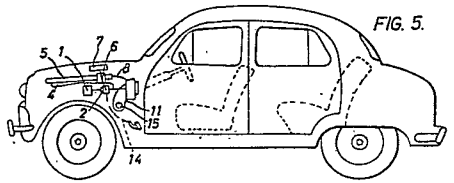

FIG. 5.