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(54) Thermoelectric Air Conditioner

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ABSTRACT

An air-conditioner is provided especially for use in an automobile. The air conditioner includes a thermoelectic device having a hot side and a cold side, a cooler attached to the cold side, a heat dissipator attached to the hot side, and a drier for drying the air before the air meets the cooler to thereby limit the cooler to sensible heat removal to lower the air temperature. The drier includes means to rejuvenate material contained in the drier by removing moisture received from the air and contained in the drier.

This invention relates to a structure for reducing the latent and sensible heats of warm, humid air to more acceptable levels in an environment such as the interior of an automobile.

The structure will be described with reference to its use as an air conditioner in an automobile but it will be evident that the structure lends itself to other uses.

Conventionally air conditioners in automobiles consist of a refrigeration cycle applied to air fed into the automobile and using mechanical work provided by a take off from the motor. This mechanical work is conventionally a pump used to compress a refrigerant and the normal refrigeration cycle is applied to the air in a heat exchanger where vapourisation of the coolant removes heat from the air. In the process, the dew point of the air is usually reached because air conditioning is most beneficial in environments where the ambient air is both hot and humid. Consequently the air is subject to an initial drop in temperature to the dew point and then a large amount of heat has to be removed to reduce the temperature of the air further because most of the heat is being used to provide latent heat of condensation as the water is condensed from the air. The resulting cooled air is at 100% relative humidity and consequently it is necessary to expend more energy to reduce the temperature of the air to a point below the temperature required in the automobile so that the air has an opportunity to warm to return the relative humidity to an acceptable level.

A further disadvantage of conventional air conditioners is that the mechanical work is drawn directly from the running motor: there is no buffer to store energy. As a result the motor must be tuned and adjusted to run when idling with the extra load of the pump. Also these tend to be sensitive moving parts and the structure requires a refrigerant which quite often has to be replaced.

The conventional air conditioners are capable of cooling quite large volumes of air and are in wide use. However, where smaller cooling effects are required, thermoelectric devices have found a use. These devices are very simple and consist essentially of hot and cold sides resulting from an input of electrical power. The cool side is used to cool for instance a small wine cooler whereas the hot side is radiated to the external surroundings. The devices have found acceptance in such uses as portable refrigerators, electronic equipment coolers, aquarium coolers, cream dispensers, medical intrument uses and military uses. However the thermoelectical device has been limited to these kind of smaller devices and has not found a use in cooling large volumes such as that found inside an automobile.

In theory, thermoelectric devices have many advantages over a conventional refrigeration system. Most importantly they are small and have no moving parts whereas refrigeration systems include a mechanical compressor, they are noisy and they are quite bulky. It would therefore be desireable to implement the advantages of thermoelectric devices in an air conditioning unit capable of cooling an automobile for instance. Simple control, quick response and even the possibility of using the system without the need to operate the vehicles motor would result from the use of such a device.

It is therefore an object of the present invention to provide a structure which is capable of controlling the air temperature in a limited environment such as that found in an automobile interior and to implement the advantages of thermoelectric devices.

Accordingly in one of its aspects, the invention provides an air-conditioner for use in an automobile in which the air conditioner includes a thermoelectic device having a hot side and a cold side. A cooler is attached to the cold side, a heat dissipator is attached to the hot side, and a drier is provided to dehumidify the air before the air meets the cooler to thereby limit the cooler to sensible heat removal to lower the air temperature.

According to another of its aspects, the invention provides a method of conditioning air in an automobile to reduce the sensible and latent heats of intake air. Humid and warm air is directed into the automobile and passed through a dehumidifying means to remove the moisture from the humid air isothermally until the relative humidity is such that the air has a dew point below the temperature required for the cooled air in the automobile. Next the air is passed through a cooler coupled to the cold side of a thermoelectric device to cool the air before passing the cold air into the interior of the automobile.

The invention will be better understood with reference to the following description taken in combination with the drawing in which:

Fig. 1 is a schematic sectional view of a preferred embodiment of the invention and showing also parts of a control circuit necessary to operate the structure.

Reference is made to Fig. 1 which shows a preferred embodiment of structure according the invention. Warm, humid air is received at an inlet 20 of a drier designated generally by the numeral 22 and then, having had moisture removed, the air is passed through a connector 24 to a cooler 26 where sensible heat is removed before the air leaves through an outlet 28. The cooler 26 is at the cold side of a thermoelectric device 30, and on the hot side of the device, a heat sink reservoir 32 forms part of a heat dissipater 34 which also includes a radiator 36. This radiator is connected hydraulically by pipes 38 and water or other coolant is pumped through the reservoir and radiator by a small electric pump 40.

The thermoelectric device 30 (preferably model CP-5-31-06L made by Materials Electronic Products Corporation) is sandwiched between a pair of electrical insulators 42, 44 of a material having good thermal conductivity. Preferably the material used is a quaternary alloy of bismuth, tellurium, selenium and antimony with small amounts of dopant added oriented in a polychrystalline ingot with good anistropic thermal electric properties. These layers are also respectively in surface-to-surface contact with a bottom plate 45 having upstanding parallel fins 47 in the cooler 26, and with a wall 46 of the reservoir 32. Ends of the thermoelectric device are sealed at 48, 50 to prevent moisture transfer in and out of the device and the device and reservoir are surrounded at their vertical extremities (as drawn) and at the bottom of the reservoir by insulation 52. Preferably a silicone insulation is used.

A base 54 supports the structure and a housing 56 sits on the base and provides openings to receive grommets 58 and 60 surrounding pipes 38 where they enter and leave to carry coolant to and from the reservoir 32. The housing also defines an inlet opening 62 and outlet opening 64 to receive air from the connector 24 and to feed air to outlet 28.

The thermoelectric device 30 can be made up of a number of individual devices and in this instance, three are shown in the drawing. The number will depend upon the capacity of the device and the cooling required. The devices are connected in an electrical circuit by two connectors 66, 68 which terminate at a controller 70. The arrangement will be described more fully later.

Turning now to the drier 22, this consists of a cylindrical outer casing 72 containing a cylindrical inner casing 74 which can rotate on stub axles 76, 78 provided centrally at the ends of the inner casing and rotating in suitable mountings in the outer casing. The axle 78 terminates in a pinion 80 coupled to a motor 82 which can be operated through a timer 84 by the controller 70.

The inner casing defines two cavities separated by a central wall 86 which extends diametrically across the casing. This wall separates the casing into a first cavity 88 and a second cavity 90 both of which contain silica gel. Ends of the cavities are open to the passage of air with the ends nearer the cooler having respective activated carbon filters 92, 94 to retain particulate silica gel and prevent it being carried by the air stream out of the housing.

The outer casing of the drier 22 defines a first inlet 96 and a second inlet 98 as well as a first outlet 100 and a second outlet 102. In the position shown in Fig. 1, air entering the inlet 96 passes through the first cavity 88 and leaves by outlet 100. Similarly, air entering via the inlet 98 will pass through the cavity 90 and leave by the outlet 102.

The first cavity is subject to warm humid air entering the inlet 20 and removes moisture from this air to a point where the air leaving by the outlet 100 has a dew point lower or equal to the temperature of the air leaving the outlet 28 from the cooler 26. The silica gel in the first cavity 88 will eventually carry sufficient moisture that it is no longer efficient and because of this, the silica gel will have to be rejuvenated. In practice, a timing cycle is used which on average allows moisture to accumulate in the silica gel until it has reached about 70% of its capacity for removing moisture. At this point a timer 84 activates the motor 82 to rotate the inner casing 74 through 180° thereby reversing the positions of the first and second cavities. Hot air is led from the motor of the automobile through the inlet 98 and then through the silica gel where it removes moisture and delivers it to the outlet 102 from which it is fed to atmosphere outside the automobile. This flow of hot air continues to dry the gel, thereby rejuvenating the gel ready for the next cycle when this cavity is returned to the position shown in Fig. 1 to again remove moisture from the warm humid air.

It will be evident that the drier 22 operates on energy which is otherwise wasted by the vehicle. The silica gel removes moisture from the air in an essentially isothermic manner and this moisture is then removed from the silica gel using hot air. Because the hot air is essentially outside air raised to an elevated temperature, its relative humidity has dropped to the point where more moisture can be removed from the gel. Consequently, the drier operates on waste energy which adds to the efficiency of the structure.

In operation, because the heat dissipator 34 is self-contained, the structure can be switched on prior to engine use or while the vehicle is parked. Obviously, it would be possible for the cooler to get to a temperature which is too low and similarly for the reservoir to reach a temperature which is too high and such extreme temperatures could create unacceptable stresses in the thermoelectric device 30. This is why a sensor 104 is provided on the pipe 38 to carry an analogue signal to the controller 70 indicating the temperature of the water leaving the reservoir 32 and also why a sensor 106 is provided on the outlet 28 to indicate the temperature of air leaving that outlet. Should extremes be reached, then the controller can switch off and wait for the temperatures to change to more acceptable levels.

The controller 70 is also connected to the pump 40 (by wiring which has been omitted for clarity) so that provided an air fan is moving air through the system, the structure can operate independent of the automobile's motor.

In normal operation the vehicle will be moving and the radiator 36 will dissipate heat to enhance the efficiency of the unit. Prior to movement however, there will be some radiation and of course there is in effect a buffer because of the volume of coolant in the system. Nevertheless, use of the structure when the vehicle is standing stationary will be limited because unacceptable temperatures levels will be reached.

As a vehicle moves along, the radiator 36 dissipates heat from the reservoir, thereby maintaining the hot side of the thermoelectric device at an acceptable level. Similarly, the coolant takes up heat from the air, thereby reducing the air to the required level as it leaves the outlet 28.

It is also possible to use the device as a heater. By simply reversing the polarity of the DC supply to the thermoelectric device, the cooler becomes a heater and outside air can be heated for improving the ambient temperature in the vehicle. Such a system would benefit from the use of more chambers in the drier 22. For instance, one could be provided without silica gel so that air would have free flow in the heating mode. Similarly, more chambers of gel would permit cycling more often with greater time for rejuvenation of the gel in each chamber.

Further modifications within the scope of the invention would include enhancing the heat sink capability for use prior to moving the vehicle. For instance, an intermediate structure could be provided between the thermoelectric device and the base 42 carrying the fins 44. This intermediate structure would include material with a high heat accumulating ability such as an aerated gel. The gel would drop in temperature significantly and as soon as the vehicle is started up there would be a boost of cold air.

These and other modifications are within the scope of the invention as described and claimed.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. Structure for reducing the sensible and latent heat of humid and warm air in an automobile and the like, the structure comprising:

intake means for directing the humid and warm air;

a drier for removing moisture from the air received from the intake means to reduce the dew point of the air below that of the required cooled air temperature, the drier including dehumidifying means for removing the moisture from the air and drying means for removing moisture trapped in the dehumidifying means to thereby revitalise the dehumidifying means for use to remove more moisture from the humid and warm air;

a cooler coupled to the drier to receive the air leaving the drier for reducing the sensible heat of this air to provide the required cooled air in the automobile;

a thermoelectric device coupled to the cooler for reducing the temperature of the cooler; and

cycle means for alternately permitting the humid and warm air to pass through the dehumidifying means and then to subject the dehumidifying means to the drying means to thereby rejuvenate the dehumidifying means.

2. Structure as claimed in claim 1 in which there is a second dehumidifying means so that the first mentioned dehumidifying means is receiving the air while the second dehumidifying means is being treated by the drying means and

vice versa.

3. Structure as claimed in claims 1 or 2 in which the dehumidifying means is silica gel.

4. Structure as claimed in claims 1 or 2 in which the dehumidifying means is silica gel, and in which an activated carbon filter is placed downstream of the dehumidifying means to contain particulate silica gel.

5. Structure as claimed in claim 1 in which the cooler includes fins in the path of the warm air for better heat transfer from the air to the cooler and hence to the dielectric device.

6. Structure as claimed in claim 1 and further including a cooling system having a reservoir coupled to the thermoelectric device to receive heat from the device and a radiator coupled hydraulically to the reservoir for cooling by heat loss at the radiator.

7. A method of conditioning air in an automobile to reduce the sensible and latent heats of intake air, the method comprising the steps:

directing outside humid and warm air into the automobile;

passing the air through a dehumidifying means to remove the moisture from the humid air isothermally until the relative humidity is such that the air has a dew point below the temperature required for the cooled air in the automobile;

passing the dehumidified warm air through a cooler coupled to the cold side of a thermoelectric device to cool the air; and

feeding the cold air into the interior of the automobile.

8. Structure for reducing the sensible and latent heat of humid and warm air in an automobile and the like, the structure comprising:

intake means for directing the humid and warm air;

a drier comprising a cylindrical outer casing and a cylindrical inner casing contained in the outer casing for rotation about the longitudinal axis of the inner casing, the outer casing defining at opposite ends of the casing a first inlet and a first outlet and a second inlet and a second outlet, the inner casing having a central wall extending diametrically to separate the casing into first and second cavities containing an air permeable and moisture absorbent material and open ends to these cavities positioned to be in registration with respective first and second inlets and outlets to permit flow of the warm and humid air from the intake means to pass through the first inlet, the first cavity, and the first outlet to thereby remove moisture from the air as the air passes over the moisture absorbent material and to permit hot air to be directed through the second inlet, through the second cavity and out of the second outlet to remove moisture contained in the moisture absorbent material in the second cavity to rejuvenate this material for use to again remove moisture;

9. In an air-conditioner for an automobile the improvement in which the air conditioner includes a thermoelectic device having a hot side and a cold side, a cooler attached to the cold side, a heat dissipator attached to the hot side, and a drier for drying the air before the air meets the cooler to thereby limit the cooler to sensible heat removal to lower the air temperature.

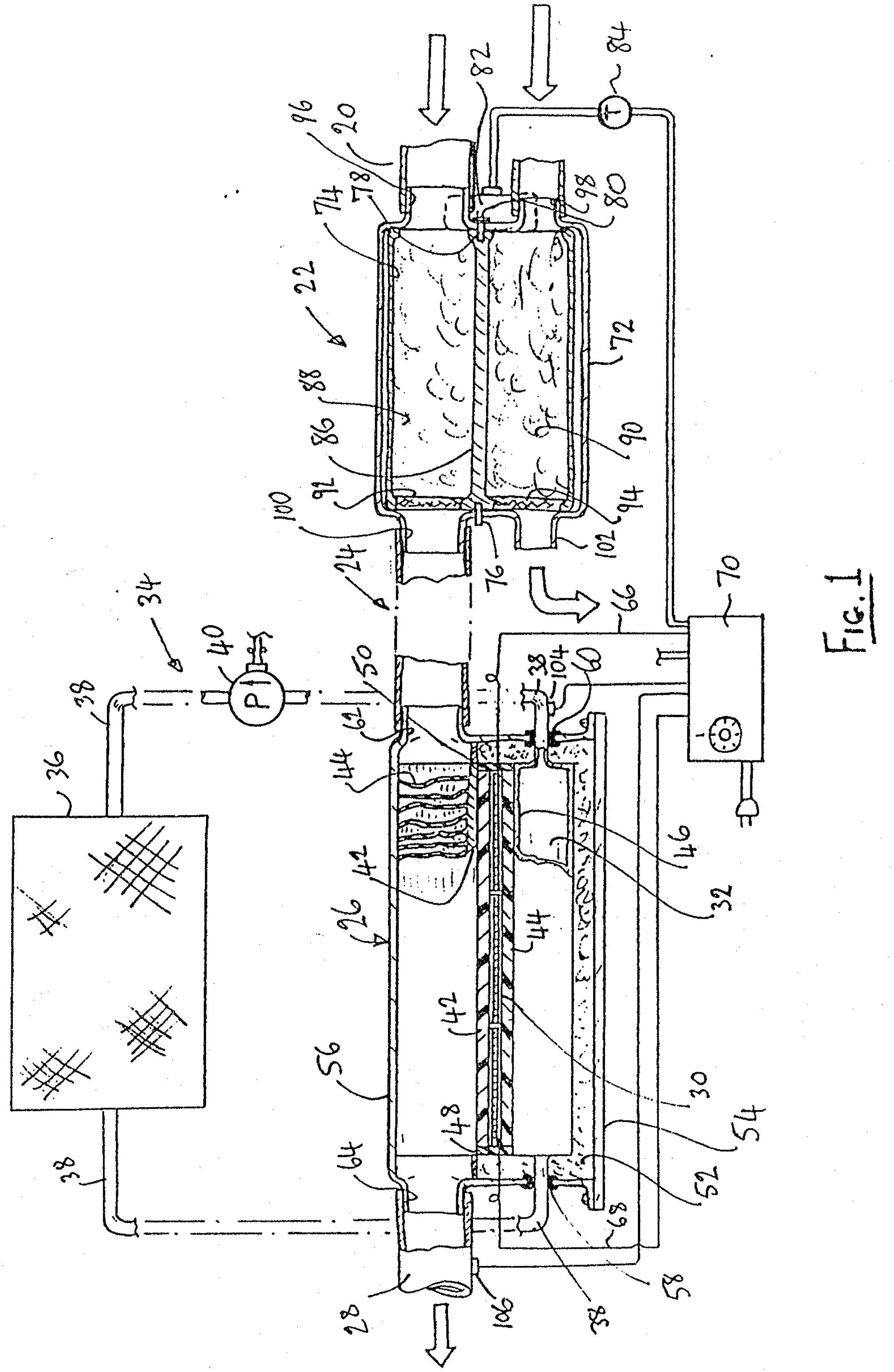

Fig. 1

Agents for the Applicants