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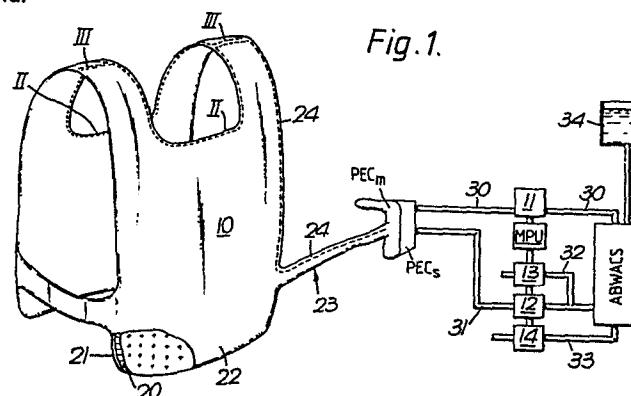
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54 Improvements in or relating to heat pipes.

57 A heat pipe assembly having a heat pump arranged in association with a heat sink. The heat pipe is principally a conformable garment, and the assembly may include dismantable connection means and pump means for evacuating the heat pipe interior and/or pumping the fluid.



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IMPROVEMENTS IN HEAT PIPES

The present invention relates to heat pipes, especially those constituted as thermal conditioning garment assemblies for personnel use in hot environments. It is concerned with the provision of thermal conditioning in circumstances where some power, but not necessarily a lower temperature environment, is available for heat sink purposes.

In UK Patent Specification 8106782 there is described a flexible or conformable heat pipe assembly in sheet form and suitable for use as a thermal conditioning garment, the assembly having a reticulated structure including wicking and void continua, an impermeable plastics film envelope surrounding the structure, and means by which the assembly may be outgassed and evacuated and liquid introduced thereinto.

According to the present invention a heat pipe assembly comprises a heat receiver of heat pipe construction for providing thermal conditioning to a person or apparatus, a compressor and a heat sink constituting a heat pump, non-return valve means for preventing liquid return into the heat sink, a vapour duct connecting the heat receiver and the compressor, and a liquid duct connecting the heat sink with the heat receiver. The assembly may also include an evacuator for evacuating and maintaining evacuated the interior of the assembly, and connector means for establishing and dis-establishing communication between the heat receiver and the compressor as described in co-pending UK Patent Application

8129022. The evacuator may be that described in co-pending UK Patent Application. The connector means, if employed, may include valves which isolate the interior of the assembly from the environment when disconnected.

By the present invention is conferred upon traditional heat pipes the facility of affording cooling even though the heat sink is required to operate at a temperature about the same as or perhaps higher than that of the surface to be cooled. The compressor raises the temperature of the vapour from the heat pipe, which in then condensing in the heat sink and reverting to the pressure of the heat pipe interior returns to the heat pipe as liquid at a temperature below that of the surface to be cooled.

This facility in turn enables heat pipes to be employed in apparatus for space heating and environmental conditioning, solar energy collection, recovering energy in various forms, and vehicle interior heating and fuel pre-heating using heat from engine exhaust manifolds.

A principal embodiment of the invention however is an assembly for personal thermal conditioning, in which the heat receiver element is a garment perhaps as described in UK Patent Specification 8106782. The garment, for use by personnel such as aircrewmen or metal or glass foundry workers, may thus be in poncho form for lining a clothing assembly. The receiver element may, particularly where it is to be remote from or somewhat above the heat sink, incorporate the liquid distribution means described in co-pending UK Patent Application 8129014 which means comprises an elongate perforate tube contacting the wicking throughout its perforate length. The perforation which may comprise holes or a continuous slit, is preferably sited so that in use it, and the distribution means a whole, is in an uppermost location with respect to the wicking.

The non-return valve may, according to a feature of the invention, be a liquid pump, as described in co-pending UK Patent Application 8129025, and adapted to supply the above described distribution means where the said means are fitted.

The heat sink element of the heat pump may be the air blown wick assisted condenser sink (ABWACS) described in co-pending UK Patent Application 8129027.

The compressor, and where fitted the evacuator, liquid pump and heat sink air blower may be commonly powered by a motor, and the motor may be thermostatically controlled.

A heat pipe assembly in accordance with the present invention will now be described by way of example, with reference to the accompanying drawings, of which:

Figure 1 illustrates schematically a thermal conditioning garment assembly,

Figure 2 is a section at station II in Figure 1,

Figure 3 is a section at station III in Figure 1, and

Figure 4 is a part sectional isometric view of a heat pump heat sink.

The heat pipe assembly shown in the drawings comprises a heat receiver element in the form of a conformal thermal conditioning poncho 10, a connector PEC, a heat sink ABWACS, a liquid pump 11, a motor MPU, a compressor 12, an evacuator 13 and an air blower pump 14.

The poncho 10 comprises a flexible reticulated woven plastics structure 20 having at its working face a perforated wick 21 and surrounded by an impermeable plastics envelope 22. The structure 20 provides a continuum behind the wick 21 and throughout the garment. The garment carries an umbilical heat transfer lead 23 leading to the connector PEC. The garment is therefore substantially similar in

construction to that described in UK Patent Specification 8106782.

5 The umbilical lead 23 is arranged for the conveyance of cool liquid to and vapour from the garment. Thus the poncho 10 and lead 23 contain liquid distribution means in the form of a flexible plastics tube 24 leading from the lead 23 up one side of the garment, across the shoulders and around the neck of the garment. Across the neck front and back, ie in the region II, and across the shoulders, 10 ie in region III, the tube 24 is slit in a substantially uppermost location. Edges 25 of the wick 21 are held in the slits by thread 26 sewn through the felts and passed around the tube 24.

15 At the connector PEC the liquid and vapour ducts are separated, a liquid duct 30 being connected via the liquid pump 11, with the heat sink ABWACS, and a vapour duct 31 being connected via a compressor 12 with the heat sink ABWACS. A tee 32 from the duct 31 leads to the evacuator 13 while an air duct 33 connects the blower with the heat sink ABWACS. 20 The heat sink ABWACS has an associated water reservoir 34.

The heat sink ABWACS comprises, as shown in Figure 4, a condenser of extensive surface 40, longitudinal furrows 41 whereof lead to a collector trough 42, an evaporator comprising a furrowed wick 43, a liquid distributor 44 for 25 feeding liquid to the wick 43, and a thermally conductive screen 45 isolating the wick 43 from the condenser. A housing 46 encloses the condenser and the evaporator, providing a guide for air blown over the wick 43.

30 The motor MPU is arranged for driving the pump 11, the compressor 12, the blower 14 and the evacuator 13 intermittently. The pump 11 is a peristaltic pump to preserve ducting integrity, and serves as a non-return valve to the heat sink ABWACS. The compressor 12 serves partially to condense and to raise the temperature of the

vapour to facilitate operation of the heat sink ABWACS. The evacuator 13 serves to maintain a low pressure regime within the assembly, and is particularly described in co-pending Patent UK Application 8129028. The air blower 14
5 and the reservoir 34 associated with the heat sink ABWACS are more particularly described in co-pending UK Patent Application 8129027.

The connector PEC includes valves by which the garment 10 is isolatable, so that it can be supplied for use already
10 outgassed and perhaps partially evacuated.

The assembly is prepared for use by being connected as described and shewn, when the connector PEC automatically establishes communication between ducts 24 and 30 etc, the poncho donned by someone about to enter a hot environment,
15 and the heat sink ABWACS and the reservoir 34 charged with water. The motor MPU is switched on when the environment to the garment wearer has become hot. Then the pump 11 pumps water from the sink ABWACS via the ducts 30 and 24 into the garment 10 and the compressor 12, by compressing the vapour
20 it receives from the garment via the duct 31, raises the temperature thereof while passing it to the sink ABWACS. The evacuator 13, operative initially, evacuates the assembly to a required vacuum. Then it is switched off and only cuts in occasionally thereafter, either on a time basis
25 or due to a pressure transducer. In the sink ABWACS the vapour is condensed and the water so formed cooled. This is principally effected by means of thermal contact over an extensive area between the working fluid and a felt in the sink moistened with water from the reservoir 34 and dried by
30 airflow from the blower 14 and duct 33.

The vapour in the condenser condenses and the water runs along the furrows 41, into the trough 42 and the pipe 30. The pump 11 additionally acts as a non-return valve between

the sink ABWACS and the garment. The general low pressure of the assembly is maintained by the evacuator 32.

5 Garments in accordance with the invention may be worn by personnel working in hot environments, such as military personnel, particularly tank crew and aircrew, and furnace operatives. They may be particularly useful in the aircrew context, for in the event of emergency egress over sea the connector PEC, which may be part of an ejector seat mounted personal equipment connector, may be arranged both to
10 isolate the interior of the garment and to minimise the extent to which it and the lead 23 can act as a heat sink per se.

CLAIMS

1. A heat pipe assembly comprising a heat receiver of heat pipe construction for providing thermal conditioning to a person or apparatus, a compressor and a heat sink constituting a heat pump, non-return valve means for preventing liquid return into the heat sink, a vapour duct connecting the heat receiver and the compressor, and a liquid duct connecting the heat sink with the heat receiver.
2. A heat pipe assembly as claimed in claim 1 and incorporating an evacuator for evacuating and maintaining evacuated the interior of the assembly.
3. A heat pipe assembly as claimed in claim 1 and having connector means for establishing and disestablishing communication between the heat receiver and the compressor.
4. A heat pipe assembly as claimed in claim 3 and wherein the connector means comprises valves which isolate the interior of the assembly from the environment when disconnected.
5. A heat pipe assembly as claimed in claim 1 and wherein the heat receiver is in sheet form.
6. A heat pipe assembly as claimed in claim 5 and wherein the heat receiver is conformable.
7. A heat pipe assembly as claimed in claim 6 and wherein the heat receiver is in garment form.
8. A heat pipe assembly as claimed in claim 1 and wherein the non-return valve is a liquid pump.
9. A heat pipe assembly as claimed in claim 1 and wherein the heat sink element is an air blown wick assisted condenser sink.

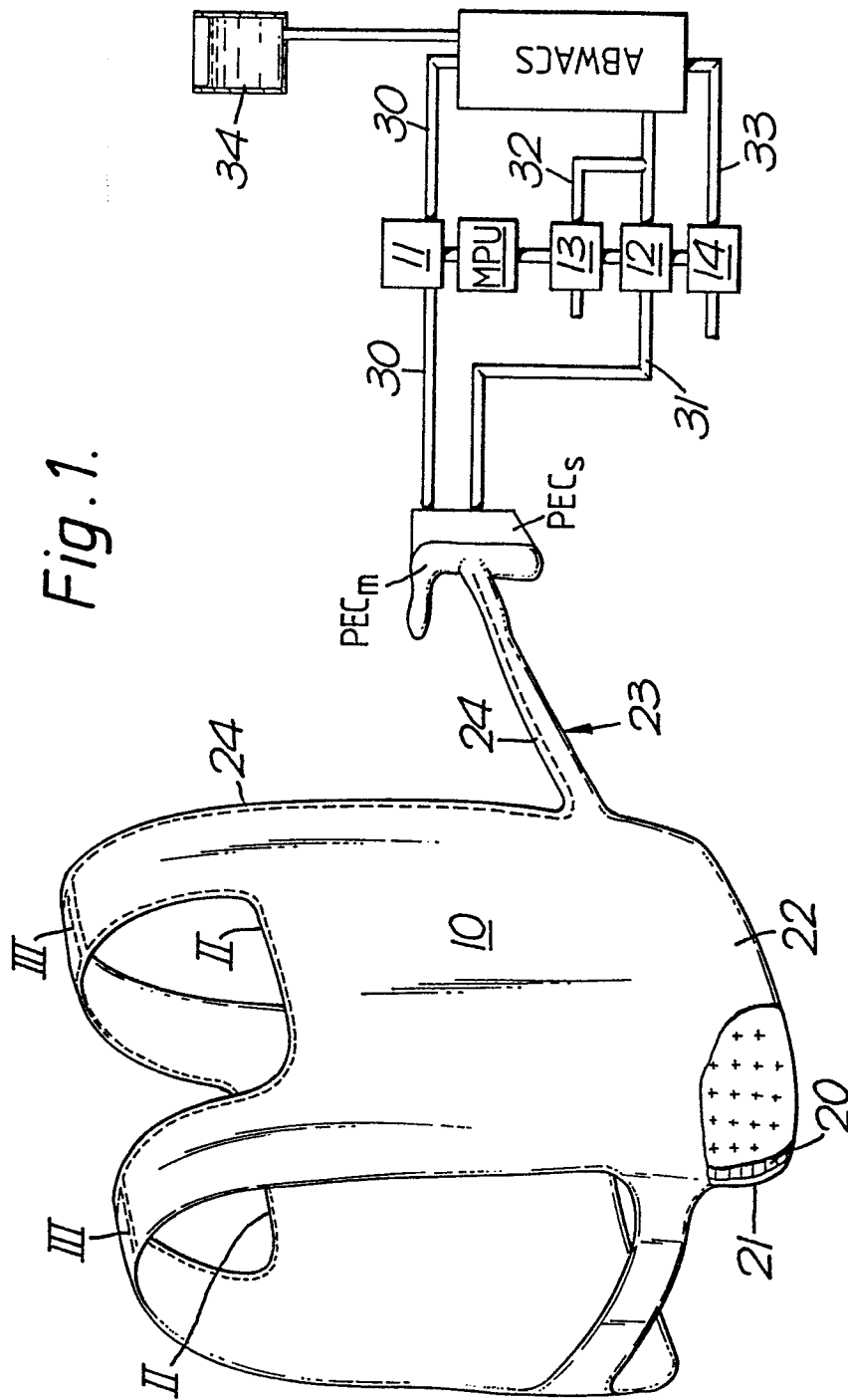


Fig. 3.

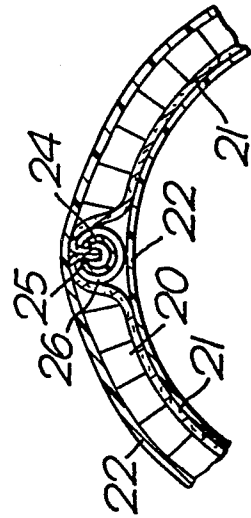


Fig. 2.

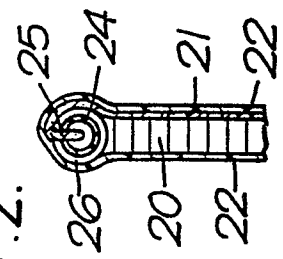


Fig. 4.

