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[56]

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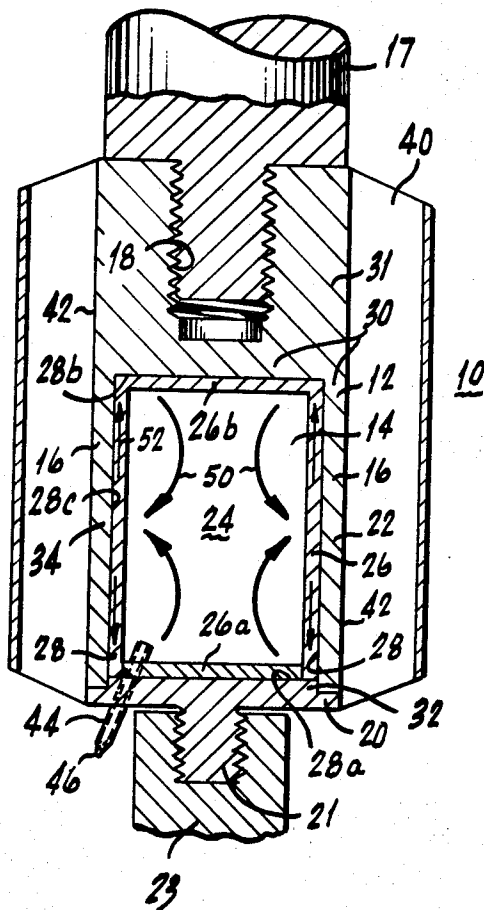
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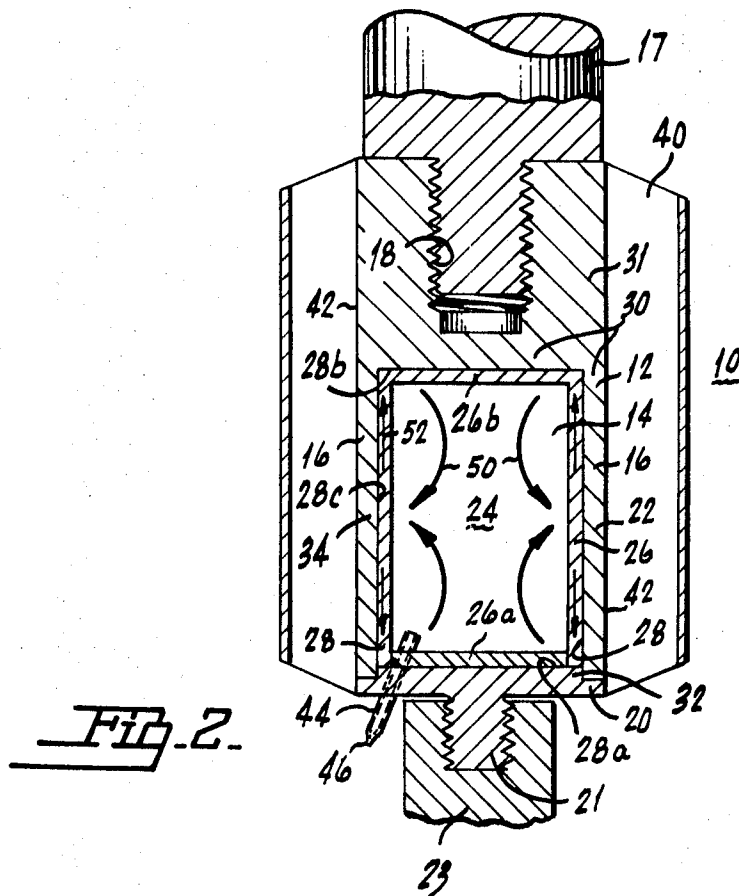
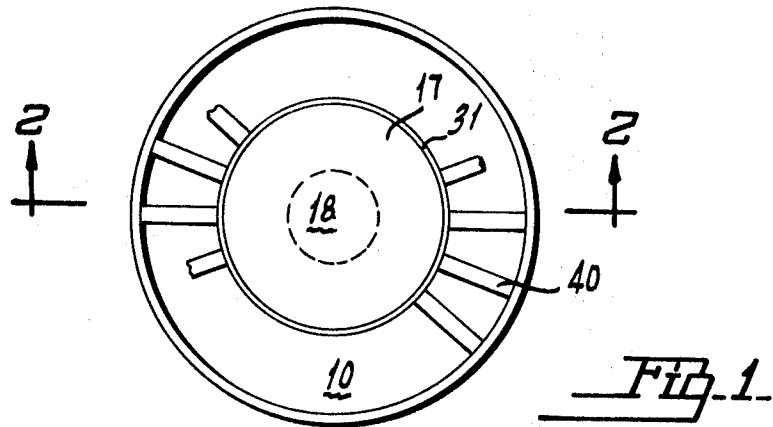
[54] ELECTRICAL CONNECTOR ASSEMBLY HAVING COOLING CAPABILITY

8 Claims, 2 Drawing Figs.

[52] U.S. Cl. 339/112,
 313/12, 313/34
 [51] Int. Cl. H01r 13/00
 [50] Field of Search 313/12, 34;
 339/112

ABSTRACT: An electrical connector assembly having cooling capability and adapted to electrically couple an electrical device with a voltage source. The connector assembly includes a hermetically sealed hollow envelope of electrically conducting material, a capillary wick lining the inner surface of the envelope, and a vaporizable heat-transfer medium disposed within the envelope. The assembly further includes a first means for electrically connecting the envelope with the voltage source and a second means for electrically connecting the electrical device to the envelope, both the first and second means being in heat transfer relationship with the envelope, and heat dissipation means in heat-transfer relationship with the envelope.





ELECTRICAL CONNECTOR ASSEMBLY HAVING COOLING CAPABILITY

BACKGROUND OF THE INVENTION

This invention relates to electrical connectors for devices and particularly to electrical connectors with cooling capability.

In the operation of many electrical devices, (e.g., power tubes, klystrons, etc.) heat is generated by the operation of the device itself and by electric current flowing through the connectors linking such devices with a voltage source, the latter commonly referred to as I²R heating. Previously, where relatively large amounts of heat are generated by either or both of the above modes, relatively large solid blocks of heat-conducting material were used as a heat sink. In many cases, it is necessary to provide large surface areas and, by means of mechanical apparatus, relatively large airflows (e.g., several hundred cubic feet per minute) to remove such heat from the heat sink. The above-described heat sink and mechanical apparatus are relatively heavy, relatively bulky, and are quite expensive.

SUMMARY OF THE INVENTION

The novel electrical connector assembly has a cooling capability and is adapted for electrically coupling an electrical device with a voltage source. The connector assembly includes a hermetically sealed envelope of electrically conducting material having a heat input region and a heat output region. A capillary structure is disposed at the inner surface of the envelope, one part of such capillary structure being located at the heat input region and another part being located at the heat output region. A vaporizable heat-transfer medium is disposed within the envelope and heat-dissipating means are disposed on the envelope outer surface at the heat output region. The assembly further includes a first means for electrically connecting the envelope to a voltage source and a second means for electrically connecting the above electrical device to the envelope, both such means being in heat transfer relationship with the envelope and the second means providing a thermal path between the electrical device and the envelope.

The novel electrical connector assembly provides a more efficient cooling of an electrical device without the use of a relatively large size heat sink and with a significant reduction in the required airflow for cooling the heat-accepting body of the device. Because of the reduced air requirement, the mechanical apparatus for pumping the air can be made considerably smaller and, in some cases, completely eliminated. This results in a space savings and a cost and weight reduction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view of an electrical connector device having cooling ability, which device is made according to the present invention.

FIG. 2 is a fragmentary, sectional elevation view along axis 2—2 of the electrical connector device shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 1 and 2 show an electrical connector assembly 10 which is comprised of a unitary body 12 of electrically conducting material (e.g., stainless steel, aluminum, or copper). The body 12 includes a cavity 14 which is defined by a cylindrical wall structure 16 and means for electrically and thermally coupling the connector assembly 10 to an electrical device 17, such as the threaded bore 18. The electrical device 17 with which the connector assembly 10 can be used may be a power tube of the RCA 8807 variety, for example. A cover member 20 of electrically conducting material is hermetically sealed (by brazing, for example) to the wall structure 16, thereby providing an envelope 22 which contains a chamber 24, the outer surface of the envelope substantially correspond-

ing with the inner surface thereof. The cover member 20 carries a threaded shank 21 or other means by which the connector assembly 10 can be coupled to a voltage source 23 (e.g., an electrical socket) to provide electrical energy to the device 17 used with the connector assembly 10. A capillary wick structure 26 is disposed at the inner surface 28 of the envelope 22 in heat-transfer relationship therewith, the wick structure 26 preferably covering substantially all of the inner surface 28. The capillary structure serves to transfer a liquid heat-transfer medium from one region of the envelope 22 to another region thereof, as described below, such transfer being achieved by capillary action, or capillary pumping. The capillary structure 26, may be, for example, a porous sponge of metal (e.g., copper) made by conventional powder metallurgical techniques. The capillary structure 26 can be made in two parts 26a and 26b, one part 26a being disposed on the cover member 20. Alternatively, the capillary structure may be a wire mesh. Within the chamber 24, there is a heat-transfer medium (not shown) which is vaporizable at the operating temperature of the electrical device 17 with which the connector is to be used. The heat-transfer medium may be, for example, water or acetone. The heat-transfer medium should be liquid at or below the operating temperature mentioned above in order for capillary pumping to take place. The quantity of heat-transfer medium in the chamber 24 should be at least sufficient to substantially saturate the capillary wick structure 26. The shape of the chamber 24 can be, for example, cylindrical or some other configuration. The preference that the capillary structure 26 cover substantially all of the inner surface 28 is to allow capillary pumping of the heat-transfer medium regardless of the orientation of the connector assembly 10. Each part 26a, 26b of the capillary wick structure 26 is in physical contact with the other part thereof so as to provide facile transfer of liquid heat-transfer medium from one such part (e.g., 26b) to the other (26a).

The portion 30 of the envelope 22 located in the vicinity of the bore 18 and the portion 32 thereof (including the cover member 20) located in the vicinity of the threaded shank 21 are the "heat input" regions of the envelope 22. Some of the heat from the electrical device 17 moves through the heat input region toward the chamber 24 while the rest of the heat is dissipated through the sidewall 31 of the bore 18. The I²R heat moves through both heat input regions toward the chamber 24. At least part of the capillary structure 26 is, for reasons given below, disposed at those portions 28a and 28b of the inner surface 28 corresponding with the respective heat input regions so as to provide liquid heat-transfer medium thereto. Those portions 34 of the envelope 22 which are more removed from the heat input region and lie between the heat input regions constitute the "heat output" region of the envelope 22. At least another part of the capillary structure 26 is disposed at the portion 28c of the inner surface 28 corresponding to the heat output region for reasons given below. Heat-radiating fins 40 or other suitable heat dissipation means are located at that portion of the envelope outer surface 42 corresponding to the heat output region, such fins 40 preferably extending beyond the heat output region, to the sidewall 31 of the bore 18 so as to dissipate heat more readily from the bore 18. A tubular member 44 which is sealed to the cover member 20 serves as a passageway for the evacuation of air from the chamber 24. This evacuation is done after the cover 20 is sealed to the wall structure 16 and, preferably, before the heat-transfer medium is supplied to the cavity 14, heat-transfer medium being suppliable through the tubular member 44 by known techniques. The tubular member 44 has a sealed end 46 which is produced, by methods known in the art, after the complete evacuation of air from the chamber 24.

In the employment of the connector assembly 10, electrical energy is applied to the threaded shank 21 from the voltage source 23 and is conducted, via the envelope 12 and the wall 31 of the bore 18, to the electrical device 17. This results in the generation of heat by the passage of current through the threaded shank 21 and by the internal heating of the electrical

device 17. Such heat is conducted to the heat input regions of the envelope 12 where it causes liquid heat-transfer medium to be evaporated. The evaporated heat-transfer medium moves (as indicated by the arrows 50 in FIG. 2) to the cooler heat output region, where it condenses, surrendering its heat to the capillary structure located thereat. The heat is conducted from the capillary structure 26 through the walls of the envelope 22 to the heat radiating fins 40 where it is dissipated to the ambience. The condensed heat-transfer medium is meanwhile absorbed by the capillary structure 26 and transferred by capillary pumping toward the heat input regions, as shown by the arrows 52. This cycle continues while heat is being generated by either or both of the above modes, cooling of the device 17 being achieved by this cyclic operation. While the envelope 22 with the threaded bore 18, and the cover member 20 with the threaded shank 21 are respectively illustrated as comprising singular structures, such is not necessary. Instead, the envelope and the threaded bore, as well as the cover member and the threaded shank, can be made as physically separate elements and subsequently joined together (e.g., by brazing) to provide a singular connector assembly. Also, it is not necessary for the heat output region to be located between two heat input regions. Instead, for example, threaded bore (not shown) can be located proximate with a threaded shank (not shown) both being located in the same general vicinity on an envelope (e.g., 22 in FIG. 2) and both sharing the same general heat input region. The heat output region in this case can be located at a portion of the envelope removed from the above-mentioned vicinity on the envelope so that the heat output region does not lie between two heat output regions.

By using the novel electrical connector assembly disclosed herein, more efficient cooling of an electrical device can be achieved, this with the use of a heat-accepting body which is smaller in size than the block-type sinks of the prior art. There also results a significant reduction in the airflow required for cooling the heat-accepting body, thereby allowing the use of smaller mechanical cooling apparatus and consequent weight and cost reduction and space savings.

We claim:

1. An electrical connector assembly having cooling capability and adapted for electrically coupling an electrical device with a voltage source, said assembly comprising:

- a. a hermetically sealed envelope of electrically conducting material, said envelope having an inner surface and a substantially corresponding outer surface, said envelope including a heat input region and a heat output region, at least a first portion of said inner surface corresponding with said heat input region and at least a second portion thereof corresponding with said heat output region, and at least a portion of said outer surface corresponding with said heat output region;
 - b. capillary means disposed at said inner surface, a first part of said capillary means being located at said heat input region and a second part thereof being located at said heat output region;
 - c. a vaporizable heat-transfer medium disposed within said envelope;
 - d. means for dissipating heat from said envelope;
 - e. a first means for electrically connecting said envelope to said voltage source, said first means being in heat-transfer relationship with said envelope; and
 - f. a second means for electrically connecting said electrical device to said envelope, said second means providing a thermal path between said electrical device and said envelope.
2. The connector assembly as defined in claim 1 wherein said first means is comprised of a threaded shank.
 3. The connector assembly as defined in claim 1 wherein said second means is comprised of a threaded bore.
 4. The connector assembly as defined in claim 1 wherein said heat-dissipating means is comprised of at least one heat-radiating fin disposed on said outer surface of said envelope at said heat output region.
 5. The connector assembly as defined in claim 1 wherein said electrically conducting material is selected from the group consisting essentially of copper, aluminum, and stainless steel.
 6. The connector assembly as defined in claim 1 wherein said capillary means is comprised of a sintered metal powder.
 7. The connector assembly as defined in claim 1 wherein said capillary means is comprised of a metal mesh.
 8. The connector assembly as defined in claim 1 wherein said working medium is selected from the group consisting essentially of water and acetone.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,605,074 Dated September 14, 1971

Inventor(s) Robert Alfred Freggens et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 3, "corresponding" should read --coextensive--. Column 4, lines 5 to 6, 7 and 8, each occurrence, "corresponding with" should read --being part of--.

Signed and sealed this 14th day of March 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents