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(54) IMPROVEMENTS IN AND RELATING TO FLUID COOLING SYSTEMS FOR ELECTRICAL COMPONENTS

(71) We, AMP INCORPORATED, a corporation organised and existing under the Laws of the State of New Jersey, United States of America, of Eisenhower Boulevard, Harrisburg, Pennsylvania, U.S.A., do hereby declare the invention, for which we pray that a Patent may be granted to us, 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 a closed fluid cooling system for electronic apparatus and in particular to electrical connector assemblies in or for a closed fluid cooling system for electronic apparatus.

According to the present invention, an electrical connector assembly in or for a closed fluid cooling system for electronic apparatus, comprises first and second releasably matable electrical connectors each including a housing of insulating material, at least one electrical contact mounted in a passageway of the housing and adapted to electrically engage the corresponding electrical contact of the other electrical connector, and a conduit passage in which is mounted a coupling for co-operating engagement with a substantially identical coupling in the other electrical connector when the connectors are mated to permit the passage through the mated electrical connectors of a cooling fluid.

An embodiment of the invention will now be described, by way of example, reference being made to the Figures of the accompanying diagrammatic drawings in which:—

Figure 1 is an exploded perspective view of an electronic system having a closed fluid cooling system;

Figure 2 is an exploded perspective view of a fluid header and an integrated circuit device forming part of the system of Figure 1;

Figure 3 is a transverse cross-section on the line 3—3 of Figure 1;

Figures 4, 5 and 6 are details in cross-section of a coupling in three stages from disengagement to engagement, the coupling forming part of the fluid cooling system of Figure 1, Figure 6 being in cross-section on line 6—6 of Figure 1.

Figure 7 is an exploded perspective view of a modified fluid header for an integrated circuit device; and

Figure 8 is a transverse cross-section through the header of Figure 7 assembled with an integrated circuit device.

As shown in Figure 1, an electronic apparatus for example, a portion of a computer includes a pair of spaced, parallel side walls 10, 12, a front panel 70, a rear panel (not shown) and a base 22 extending between the side walls. The side walls 10, 12 are formed with grooves 14, 16 dimensioned to receive a plurality of printed circuit boards 18. Supported on the base 22 are a plurality of edge connectors 20, each edge connector being connected to an edge of a printed circuit board 18. At its upper edge (as shown) each board 18 has locking means 24 which secures the board 18 in position in its respective edge connector 20.

Each board 18 carries a plurality of integrated circuit devices which are cooled by a closed fluid cooling system including fluid headers 26 interconnected by conduits 36. The first and last headers 26 are connected respectively by conduits 60, 62 to a connector 64 mounted on the board 18 adjacent the edge connector 20. The connector 64 is adapted to make both electrical and fluid tight connection with the edge connector 20.

A fluid and electrical distribution cable 66 connects individual connectors 20 to a connector 68 mounted on the panel 70. The connector 68 is similarly connected to a main fluid cooling system by a fluid and

electrical distribution cable 72.

Referring also to Figures 2 and 3, each header 26 includes a base 28 having a passageway interconnecting an inlet 32 and an outlet 34 at opposite ends each connectable to a conduit 36. A portion of the passageway is in the form of a central flow chamber 30. A groove 38 is formed in the base 28 and is spaced from but surrounds the chamber 30. Opposite sides edges of the base 28 have flanges 56. The upper external surface (as shown) of the base 28 has a recess 58 arranged adjacent to and communicating with the central flow chamber 30 and two opposed rows of electrical contacts 40 are mounted in the base with contact surfaces in the recess 58. The contacts 40 extend through the base 28 as shown in Figure 3.

A sealing member 42 is received in the groove 38 and makes sealing contact between the base 28 and the lower surface (as shown) of a substrate 44 received in the recess 58. The substrate 44 includes a plurality of contact pads 46 along opposite side edges, each pad being electrically connected to an integrated circuit chip 48. Each pad 46 electrically engages a respective contact surface of an electrical contact 40 when the substrate 44 is received in the recess 58.

A cover 50 is releasably latched to the base 28 by first and second parallel spaced flanges 52, 54, which are adapted to engage resiliently over the flanges 56. The cover 50 holds the substrate 44 in the recess 58 and in electrical engagement with the contacts 40. Cooling fluid flows from the inlet 32 to the outlet 34 through the central flow chamber 30 and extracts heat from the substrate 44 in the recess 58.

At each of the interconnect position in the fluid cooling system, namely, between the connectors 20 and 64 and in the mating halves of the connector 68, each fluid line is provided with a coupling 74 shown in detail in Figures 4 to 6 in association with the connectors 20 and 64. Each coupling 74 comprises means in the form of a fitting 76 one end of which engages the appropriate associated conduit (not shown). The other end of fitting 76 is joined to a body 78 by annular ridges 80. The body 78 has an axial bore which communicates with a narrow opening 82 at the opposite end from fitting 76. A resilient sealing member 84 is mounted in the narrow opening 82 and has an annular flange 86 inside the body and an enlarged profiled head outside the body. The sealing member 84 also has an axial bore 90 coaxial with the bore in the body 78 which bore 90 communicates with a shallow conical entrance 92. A valve member 94 is mounted in the body 78 with an integral stem 96 extending from a head 98 and

passing through the bore 90. The head 98 of the valve member 94 is biased against the flange 86 of sealing member 84 by a spring 100. A stop 102 projects from the head 98 of the valve member 94 in the opposite direction from the stem 96. The end of the spring 100 opposite that which engages the head 98 abuts against an end of the fitting 76.

The couplings 74 associated with the connectors 20 and 64 are identical. The coupling 74 on the left of Figures 4 to 6 has been mounted on the connector 64 as a plug member projecting from the connector 64, while the coupling 74 on the right is recessed as a receptacle in its associated connector 20. The same conditions would apply for the mating halves of connector 68.

The steps of engaging the couplings 74 are shown in Figures 4 to 6. Figure 4 shows the separated or fully disconnected position of the couplings. In this position the heads 98 of both valve members 94 are biased against flanges 86 of sealing members 84 by springs 100 to prevent fluid flow through the couplings. When the couplings are initially engaged, as shown in Figure 5, the free ends of the sealing members 84 engage and are compressed against each other to form a leak proof passageway through the aligned axial bores 90. As the relative movement of the coupling towards one another continues, the free ends of the valve stems 96 engage and begin to open the valve members 94 against the biasing force of springs 100 to establish fluid flow therethrough. The stops 102 on the end of each valve member 94 eliminate the possibility of only one valve member opening while the other valve members stays closed. If one valve member sticks in the closed position the stop 102 of the other valve member will abut its related fitting 76 so that all the force bringing the couplings together will be applied against the stuck valve member.

Full fluid communication between the mated couplings 74 is shown in Figure 6. Disengagement of the couplings 74 produces a reverse action to that described above. As the valve members 94 are closed by springs 100 the sealing members 84 prevent undue leakage of the fluid from the system.

The connectors 20, 64 are releasably matable together and are latched in the mating position by latching means (not shown).

Each connector 20, 64 comprises an insulating housing which has a plurality of passageways in each of which is mounted an electrical contact (not shown) for electrically engaging a co-operating electrical contact of the mating connector.

A modified header, known as a cold plate header, is shown in Figures 7 and 8. The

cold plate header functions substantially the same as the header described above with reference to Figures 2 and 3. There may however, be times when it is desirable to have the fluid cooling system completely sealed so that individual substrates 44 can be replaced without removing the associated board 18 from the frame. In such cases a cold plate header as shown in Figures 7 and 8 would be used.

The header base 104 is similar to base 28 in that it has a central chamber 106 communicating with an inlet 108 and an outlet 110. However, instead of a groove 38 surrounding the chamber, there is a step 112 extending around the upper edge of the chamber. A cold plate 114 is mounted with its peripheral edge sealed in the step 112 to provide a permanent closure of the central chamber. The cold plate 114 can be made of any fluid tight material, such as an elastomer, a thin metal film or aluminium filled rubber, and sealed in the step by ultrasonic welding or by known adhesives. The cold plate 114, in effect covers one side of the chamber 106 and forms a base portion of the recess receiving the substrate 44. The cold plate header also includes contacts 116 fixed along opposite sides thereof and shoulders 116, 118 adapted to receive flanges 122, 124 of a cover 126.

The coolant is pumped through the chamber of the cold plate header. The substrate 44 lays against the cold plate 114 and heat is transferred from the substrate to the coolant *via* the cold plate.

The closed fluid cooling system described above, the fluid header 26 and the modified header known as a cold plate header are each described and claimed in our co-pending application number 42882/1975 (Serial No. 1,491,569).

WHAT WE CLAIM IS:—

1. An electrical connector assembly in or for a closed fluid cooling system for electronic apparatus, comprising first and second releasably matable electrical connectors each including a housing of insulating material, at least one electrical contact mounted in a passageway of the housing and adapted to electrically engage the corresponding electrical contact of the other electrical connector, and a conduit passage in which is mounted a coupling for

co-operating engagement with a substantially identical coupling in the other electrical connector when the connectors are mated to permit the passage through the mated electrical connectors of a cooling fluid.

2. An electrical assembly as claimed in Claim 1, in which each coupling includes a body with an axial bore for the passage therethrough of cooling fluid, means joined to one end of the body for connection to a conduit, a resilient sealing member mounted on the opposite end of the body and having a bore co-axial with the bore in the body, a valve member having a head and a stem, the valve member being mounted for movement in the axial bore of the body between a first position at which the head engages the sealing member to prevent the flow of fluid through the axial bore of the body and a second position at which the head is spaced from the sealing member, a spring for biasing the valve member to the first position, the stem extending through the bore in the sealing member so that when the electrical connectors are mated the stems of the two opposed couplings engage to move the valve members towards their second positions against the bias of their respective springs.

3. An electrical assembly as claimed in Claim 2, in which a stop extends from each valve head in the opposite direction to the stem.

4. An electrical connector assembly as claimed in any one Claims 1 to 3, in which one electrical connector has its coupling mounted within the conduit passage to define a receptacle and the other electrical connector has its coupling mounted in the corresponding conduit passage with a portion of the coupling extending outwardly of the connector to define a plug.

5. An electrical connector assembly in or for a closed fluid cooling system for electronic apparatus constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figures 1 and 4 to 6 of the accompanying drawings.

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