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C. A. WEBBER ET AL
METHOD FOR IMPROVING ASSEMBLY OF HEAT
EXCHANGER FOR SEMICONDUCTORS

3,086,283

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2 Sheets-Sheet 1

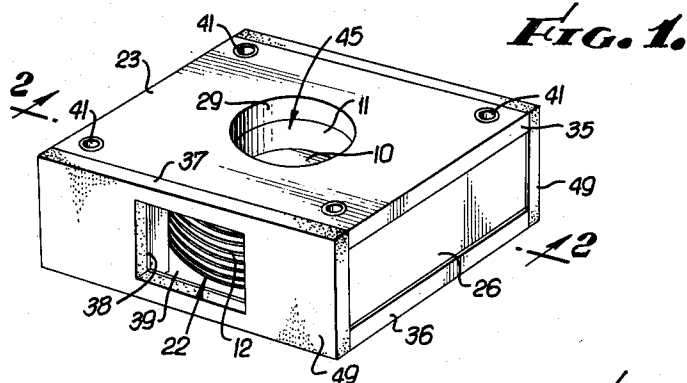


FIG. 1.

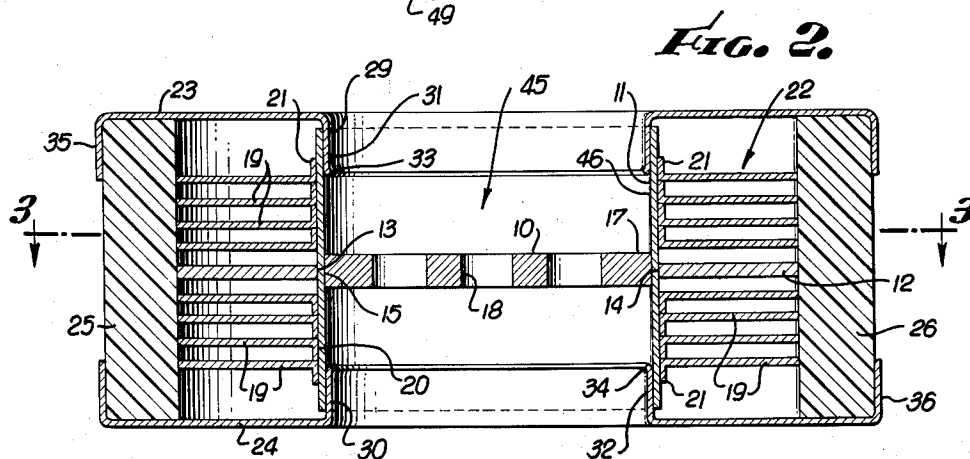


FIG. 2.

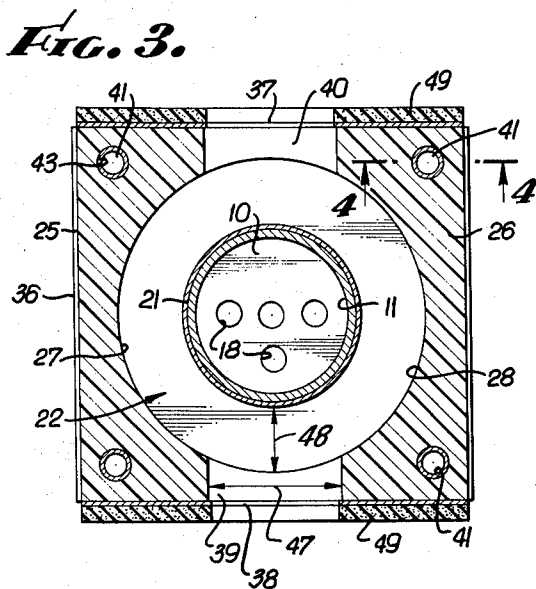


FIG. 3.

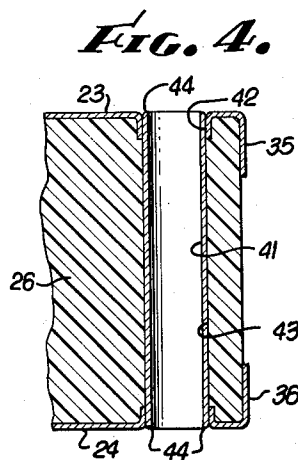


FIG. 4.

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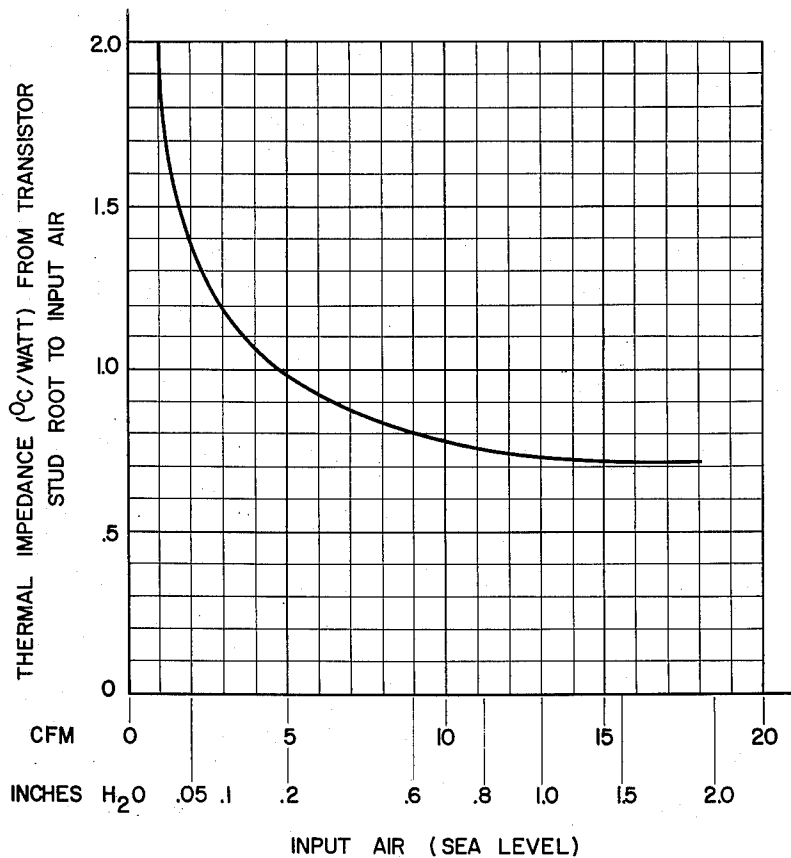
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Fig. 5.



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METHOD FOR IMPROVING ASSEMBLY OF HEAT EXCHANGER FOR SEMICONDUCTORS

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Original application Aug. 24, 1959, Ser. No. 835,519. Divided and this application May 27, 1960, Ser. No. 38,089

1 Claim. (Cl. 29—157.3)

This invention relates to a method for improving assembly of heat exchangers for semiconductors, particularly heat exchangers using a forced gaseous coolant for transistors capable of large internal power dissipation. The application which resulted in the issuance of this patent is a division of U.S. patent application Serial Number 835,519, filed on August 24, 1959, and pending at the time of filing of this divisional application, and with the same persons named as inventors. Such semiconductors generate large amounts of heat, which limits their practical application. Accordingly, removal of this heat is a major consideration in the operation of such semiconductors. Existing designs of such heat exchangers for removal of heat generated by semiconductors are costly to manufacture and are relatively ineffective heat transfer devices due to low overall thermal impedance obtainable by their use.

It is, therefore, an object of our invention to provide a method of making a heat transfer unit designed to remove the heat generated by semiconductors with a minimum of gaseous coolant and with a coolant which may be at ambient temperatures such as 25 degrees centigrade, or less than the maximum allowable junction temperature of the semiconductor used.

Another object of our invention is to provide a method of making a complete segment of the overall air conditioning system for semiconductors by our design of the fin assembly and enclosing ductwork used in our heat exchanger unit.

A further object of our invention is to provide a method of making a heat exchanger unit designed to permit the semiconductor to be assembled with the unit in direct metal to metal contact as an integral part for maximum efficiency in heat transfer and heat removal, while at the same time achieve electrical insulation of the semiconductor.

A still further object of our invention is to provide a method of making a heat exchanger unit with a capability for removing large amounts of heat internally dissipated in commercial power semiconductors having large power outputs.

A still further object of our invention is the design of a heat exchanger unit which is relatively inexpensive to manufacture and permits the use of a novel method of assembly which facilitates assembly of large quantities of units by mass production techniques utilizing punched metal parts assembled by force fitting and high pressure deformation or coining.

A still further object of our invention is a method of assembly of heat exchanger units dispensing with the need for the usual operations of brazing, welding, or casting of parts in the manufacture and assembly of heat exchanger units in mass production.

These and other objects will be more readily understood by reference to the following description and claims, taken in conjunction with the accompanying drawing forming a part hereof, in which

FIGURE 1 is a perspective view of the assembled heat exchanger unit.

FIGURE 2 is a cross section of FIGURE 1 taken along line 2—2 of FIGURE 1.

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FIGURE 3 is a section taken along line 3—3 of FIGURE 2.

FIGURE 4 is a detail section taken along line 4—4 of FIGURE 3.

FIGURE 5 is a graph illustrating the characteristics of an embodiment of the invention.

The heat exchanger unit is assembled by inserting the center slug 10 into retaining tube 11 while at the same time placing the center circular cooling fin 12, having a center opening 13 therethrough, around the middle of the outside circumference of the retaining tube 11 at 14. This assembly is performed in one operation in an assembly jig having dies which coin the center slug 10 in the retaining tube 11 by expanding and locking the slug 10 in the approximate center of retaining tube 11 at 15. This operation simultaneously locks the center cooling fin 12 into position at 14, which is in the same plane as center slug 10. The center slug 10 has a slight concavity 17 at its outer edge due to high pressure deformation produced by the coining operation which expands the slug into a tight fit with the tube 11. Holes 18 in the center slug 10 are adapted to receive connections of commercial power semiconductors. The hole pattern illustrated in the drawing is for a configuration typified by the Delco 2N174 transistor.

A further operational step of force fitting occurs when a series of cooling fins 19, circular in shape and having central openings 20 of a size suitable to fit around the outside circumference of retaining tube 11, are force fitted into position above and below the center cooling fin 12 as shown in FIGURE 2. These cooling fins are from .010 to .040 inch thick, and have flanges 21 around their central openings 20 oriented as shown in FIGURE 2. When the cooling fins 19 are force fitted into position on the retaining tube 11, they form the fin assembly 22 in conjunction with center slug 10, retaining tube 11, and center cooling fin 12.

The fin assembly 22 is then placed on one of identical rectangular cover plates 23 and 24, which serve as a bottom. Filler blocks 25 and 26 are then inserted around the fin assembly. The filler blocks are shaped to fit the area between the fin assembly and the cover plates 23 and 24, thus channeling the coolant flow through the heat exchanger. The concavities 27 and 28 of the filler blocks are adapted to duct the coolant flow in either direction through the assembled heat exchanger. The filler blocks may be made of any suitable plastic material, such as foam polystyrene, or a polyurethane or an epoxy plastic material.

Then, the other cover plate is placed over the top of the filler blocks and the assembled whole is squeezed together in a press. Retaining tube 11 fits into the orifices 29 and 30 of the cover plates. Mounting flanges 31 and 32 around orifices 29 and 30 secure the fin assembly 22 in position as a result of their force fit with retaining tube 11. The edges 33 and 34 of the mounting flanges 31 and 32 have a slight roll out to prevent scraping against retaining tube 11 so that the cover plates will not lose their insulating character as described later.

To secure the filler blocks 25 and 26 in position around the fin assembly 22, the cover plates 23 and 24 have holding lips 35 and 36. Notches 37 and 38 in the holding lips 35 and 36 form inlet and outlet openings 39 and 40 for coolant flow in and out of the heat exchanger. Since the heat exchanger is symmetrical in design, the coolant flow may be in either direction through openings 39 and 40.

To keep the assembled heat exchanger firmly united, eyelets 41 are placed in holes 42 in the cover plates and pass through cylindrical holes 43 in the filler blocks. The ends 44 of the eyelets 41 are rolled over to provide better holding together of the assembled heat exchanger

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unit and to remove any sharp edges which may interfere with the insulating character of the cover plates.

Most of the metal parts of the heat exchanger unit are of punched metal. None of the metal parts requires brazing, welding, or casting. While we prefer to use copper for the center slug 10 and retaining tube 11 as well as for the center cooling fin 12, the other cooling fins 19 are preferably of aluminum, which performs as well as copper in this particular application and in the thicknesses employed here. The cover plates are aluminum also but have an insulating surface throughout of deep anodized aluminum which serves to electrically insulate the semiconductor while at the same time being no barrier to heat transfer.

In the operation of the heat exchanger, a semiconductor such as the Delco 2N174 is placed in the cup shaped area 45 formed by the center slug 10 and the wall 46 of the retaining tube 11. This produces a metal to metal contact of the center slug 10 with the semiconductor for maximum heat transfer from the semiconductor to the heat exchanger. The heat exchanger unit is now ready for use with the semiconductor as an integral part.

The forced coolant flow may be in either direction through the openings 39 and 40. The lateral dimension 47 of openings 39 and 40 is approximately twice the annular diameter 48 of the cooling fins 19. We have found experimentally that this ratio increases cooling efficiency of the heat exchanger by reducing turbulence in the coolant flow through the heat exchanger. Our design of the heat exchanger unit permits the use of forced air as well as other gaseous coolants at ambient temperatures such as 25 degrees centigrade. For maximum cooling efficiency, the coolant flow is channeled by filler blocks 31 and 32 in a semi-circular direction as shown in FIGURE 3 around the cooling fins 19.

The heat exchanger unit may be employed in multiple

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units arranged in series or parallel flow. When used in multiple units, gaskets 49 will seal the coolant flow through the units.

The following graph illustrates the characteristics of an embodiment of our invention as illustrated in the drawing, having outside dimensions $1\frac{1}{8}$ inches high, $2\frac{7}{8}$ inches wide, and $3\frac{1}{8}$ inches long. In the graph, the vertical axis represents thermal impedance, while the horizontal axis represents cubic feet per minute of coolant, air in this instance, and air pressure.

While we have described our invention in detail with reference to the accompanying drawing illustrating the preferred form of our invention and with reference to a preferred method of assembly, it is understood that numerous changes in the details of construction and arrangement of parts and variations in the method of assembly may be made without departing from the spirit and scope of the invention as described and hereinafter claimed.

We claim:

In a method for assembly of a heat exchanger for semiconductors, said heat exchanger having a slug member, a retaining tube, and a central cooling fin, the step of coining the slug member inside the tube by expanding and locking the slug member inside the tube while simultaneously locking the fin around the outer circumference of the tube.

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