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SEMICONDUCTOR DEVICES

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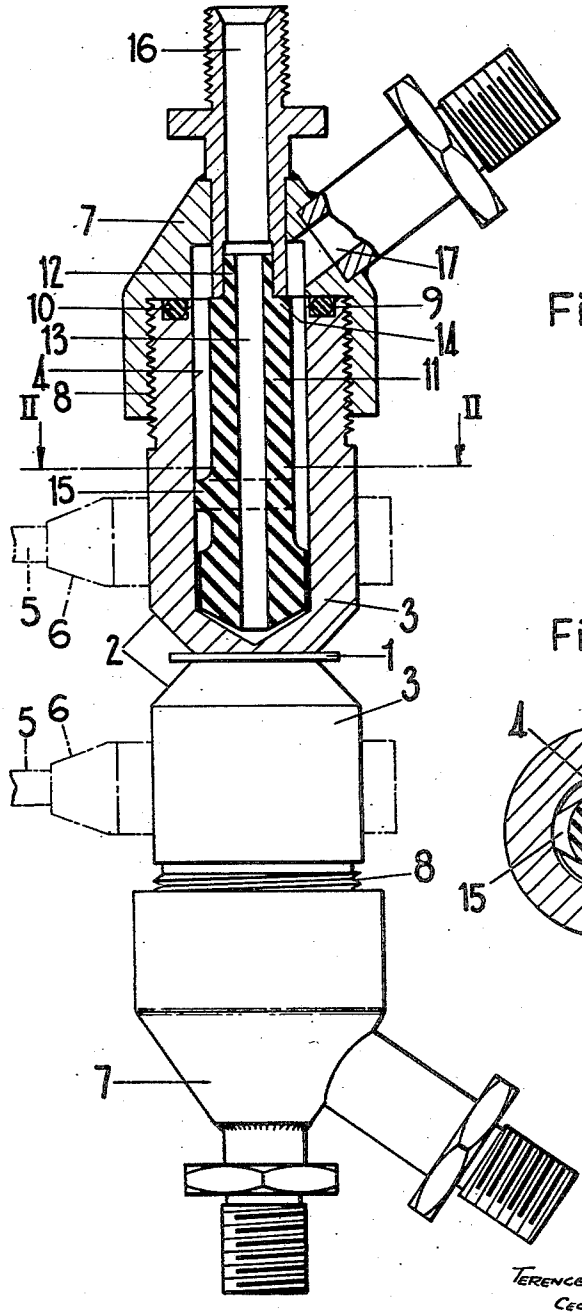
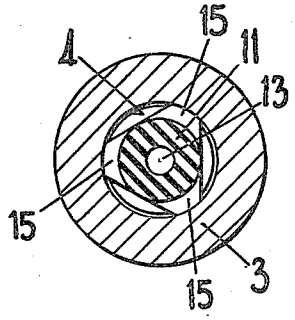


Fig. 1.

Fig. 2.



INVENTORS

TERENCE ALEXANDER KETTERINGHAM

CECIL FRANCIS MACHIN

BY

ATTORNEY

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SEMICONDUCTOR DEVICES

Terence Alexander Ketteringham, Wembley, and Cecil Francis Machin, Harrow, England, assignors to The General Electric Company Limited, London, England

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This invention relates to semiconductor devices.

Where such a device is designed for operation at a very high power level, it is necessary to provide some form of cooling system for the device in order to prevent its attaining a temperature at which its operation is impaired, and to provide suitable electrode arrangements for conducting high currents flowing through the device.

It is an object of the present invention to provide a semiconductor device which meets these requirements.

According to the invention, in a semiconductor device at least one of the electrodes is constituted by a hollow metal block of high thermal and electrical conductivity closed at one end and having the outer surface of the closed end secured directly or indirectly to the semiconductor, the device being provided with a cooling system including a tubular member projecting up inside the block and having an open end spaced from the inner surface of the closed end of the block, the arrangement being such that a cooling liquid may be passed through the tubular member towards the closed end of the block and back through the space between the tubular member and the block or vice versa.

Preferably the closed end of the block is shaped so that when an electric current flows through the block the current density is substantially uniform over the whole of this part of the block; preferably also the inner surface of the closed end of the block and the adjacent end surface of the tubular member are so shaped and spaced that the surface velocity of the cooling liquid as it flows past said inner surface is substantially uniform over the whole of this surface.

In one convenient embodiment of the invention the block and the tubular member are separately and detachably mounted in a liquid-tight manner at their ends remote from the closed end of the block in a socket provided with channels which communicate respectively with the interior of the tubular member and the space between the tubular member and the block.

In order that the invention may be more fully understood one arrangement according to the present invention, as applied to a germanium rectifier, will now be described by way of example with reference to the accompanying drawing, in which Figure 1 is a side elevation, partly in section, of the device, and Figure 2 is an end section on line II—II in Figure 1.

Referring to the drawing, the rectifier includes a plate of germanium 1, partly P-type and partly N-type, the P–N junction lying in a plane parallel to the main faces of the plate. The P-type and N-type regions of the plate are respectively provided with electrodes 2 each consisting of a hollow circular cylindrical copper block 3 provided with an axial hole 4 of circular cross-section extending from one end of the block almost to the other end, the outer surfaces of the closed ends of the two blocks being soldered to opposite main faces of the germanium plate 1. Each electrode is provided with a current lead 5 which terminates in a clamp 6 encircling the cylindrical surface of the appropriate block.

Each copper block 3 is mounted at its open end in a brass socket 7, this end of the block being provided with an external screw thread 8 and screwing into a correspondingly threaded hole in the socket; the end surface of the block is provided with an annular groove 9 in which is disposed a rubber ring 10 which is compressed against the base of the hole in the socket 7 to form a liquid-tight seal when the block is screwed into the hole in the socket. Also mounted in each socket is a tubular member 11 of synthetic resin bonded paper which extends axially through the interior of the copper block 3, being spaced from the block with one end surface disposed close to the inner surface of the closed end of the block. The mounted end 12 of the tubular member is of reduced external diameter and is a sliding fit in a hole 16 which extends axially into the socket from the base of the main hole in the socket, the tubular member being accurately located in an axial direction by the abutment of the shoulder 14 formed at the end of the portion of reduced diameter with the base of the main hole in the socket. It will be appreciated that each copper block is also located accurately in an axial direction by being screwed tightly into the socket so that its end surface abuts against the base of the main hole of the socket, so that the block 3, and the tubular member 11 are accurately located with respect to each other in an axial direction. Each tubular member is located radially with respect to the corresponding block by means of three ribs 15 projecting radially from the tubular member which abut against the internal surface of the block.

Each socket is provided with two channels 16 and 17 which communicate respectively with the interior of the tubular member and the space between the tubular member and the block, and in operation of the rectifier cooling water is passed through the first channel 16 into the interior of the tubular member 11 so that it flows towards the closed end of the block 3, the water then flowing past the inner surface of the closed end of the block and back through the space between the tubular member and the block and being finally drained away through the second channel 17 in the socket. It will be appreciated that the insulating nature of the tubular member 11 prevents any appreciable heat exchange between the outgoing and incoming water. When the water is passed through the system each tubular member 11 is held firmly seated against the base of the main hole in the socket 7 by the pressure developed at the closed end of the copper block.

In order to ensure that excessive heat is not developed in the closed ends of the blocks 3, these parts of the blocks are shaped so that when current flows through the rectifier the current density is substantially uniform over the whole of the closed end of the block. For this purpose the inner surface of the closed end of each block, which is constituted by the end of the axial hole 4 in the block, is made of conical shape, the apex of the cone being disposed closest to the outer surface of the block and being disposed as close to the outer surface of the block as is mechanically possible.

In order to ensure efficient cooling, the inner surface of the closed end of each block 3 and the adjacent end surface of each tubular member 11 are so shaped and disposed that the surface velocity of the cooling water as it flows past the inner surface of the closed end of each block is substantially uniform over the whole of this surface. For this purpose, the end surface of each tubular member is given a conical shape, the angle of the cone being greater than that of the cone constituting the end of the hole in the block. By this means the effective cross-section of the passage formed between the inner surface of the closed end of the block and the adjacent end surface of the tubular member is made con-

stant throughout this passage, this cross-section being chosen to be equal to the cross-section of the hole extending through the tubular member; the external diameter of the tubular member adjacent the conical end surface is chosen so that the cross-section of the annular passage formed at the end of the tubular member 11 between it and the copper block 3 has the same value.

It will be appreciated that in the arrangement described above the electrode arrangements and cooling system are of relatively simple form, while the whole assembly is readily demountable for the purpose of replacement of the rectifier.

We claim:

1. A semiconductor device comprising a first electrode constituted by a hollow block of high thermal and electrical conductivity closed at one end, a rectifier element secured to the outer surface of the closed end of said block, a second electrode arranged to make electrical contact with said rectifier element, and a tubular member projecting up inside said block, said tubular member having an open end spaced from the closed end of the block and providing a passage for cooling liquid through the tubular member, through the space between the closed end of the block and the end of the tubular member in the block and then through the space between the sides of the tubular member and the walls defining the hollow of the block.

2. A semiconductor device according to claim 1, wherein the inner surface of said block is of conical shape at its closed end, the apex of the cone being disposed closest to the outer surface of the block.

3. A semiconductor device comprising a first electrode constituted by a hollow block of high thermal and electrical conductivity closed at one end, the inner surface of said block being of conical shape at its closed end and the apex of the cone being disposed closest to the outer surface of the block, a rectifier element secured to the outer surface of the closed end of said block, a second electrode arranged to make electrical contact with said rectifier element, and a tubular member projecting up inside said block, said tubular member having an end surface of conical shape spaced from the closed end of the block, the angle of cone being greater than that of the conical surface constituting the closed end of the block, and providing a passage of uniform cross-section through the tubular member and through the space between the tubular member and the block for cooling liquid.

4. A semiconductor device comprising a first electrode constituted by a hollow block of high thermal and electrical conductivity closed at one end, a rectifier element secured to the outer surface of the closed end of said block, a second electrode arranged to make electrical contact with said rectifier element, a socket attached at the end of said block remote from said rectifier element, a sealing ring mounted in an annular groove in said block and providing a liquid-tight seal between said block and said socket, and a tubular member mounted in said socket and projecting up inside said block, said tubular member having an open end spaced from the closed end of the block and providing a passage through the tubular member and through the space between the tubular member and the block for cooling liquid.

5. A semiconductor device comprising a first electrode constituted by a hollow block of high thermal and electrical conductivity closed at one end, a rectifier element secured to the outer surface of the closed end of said block, a second electrode arranged to make electrical contact with said rectifier element, and a tubular member of heat insulating material projecting up inside said block, said tubular member having an open end spaced from the closed end of the block and providing a passage through the tubular member and through the space between the tubular member and the block for cooling liquid.

6. A semiconductor device comprising a first electrode constituted by a hollow block of high thermal and electrical conductivity closed at one end, the inner surface of said block being of conical shape at its closed end and the apex of the cone being disposed closest to the outer surface of the block, a rectifier element secured to the outer surface of the closed end of said block, a second electrode arranged to make electrical contact with said rectifier element, a socket attached at the end of said block remote from said rectifier element, a sealing ring mounted in an annular groove in said block and providing a liquid-tight seal between said block and said socket, and a tubular member mounted in said socket and projecting up inside said block, said tubular member having an open end spaced from the closed end of the block and providing a passage through the tubular member and through the space between the tubular member and the block for cooling liquid.

7. A semiconductor device according to claim 5 wherein the inner surface of said block is of conical shape at its closed end, the apex of the cone being disposed closest to the outer surface of the block.

8. A semiconductor device comprising a first electrode constituted by a hollow block of high thermal and electrical conductivity closed at one end, the inner surface of said block being of conical shape at its closed end and the apex of the cone being disposed closest to the outer surface of the closed end of said block, a rectifier element secured to the outer surfaces of the closed end of said block, a second electrode arranged to make electrical contact with said rectifier element, a socket attached at the end of said block remote from said rectifier element, a sealing ring mounted in an annular groove in said block and providing a liquid tight seal between said block and said socket, and a tubular member mounted in said socket and projecting up inside said block, said tubular member having an end surface of conical shape spaced from the closed end of the block, the angle of the cone being greater than that of the conical surface constituting the closed end of the block, and providing a passage of uniform cross-section through the tubular member and through the space between the tubular member and the block for cooling liquid.

9. A semiconductor device comprising a first electrode constituted by a hollow block of high thermal and electrical conductivity closed at one end, the inner surface of said block being of conical shape at its closed end and the apex of the cone being disposed closest to the outer surface of the block, a rectifier element secured to the outer surface of the closed end of said block, a second electrode arranged to make electrical contact with said rectifier element, and a tubular member of heat insulating material projecting up inside said block, said tubular member having an end surface of conical shape spaced from the closed end of the block, the angle of cone being greater than that of the conical surface constituting the closed end of the block, and providing a passage of uniform cross-section through the tubular member and through the space between the tubular member and the block for cooling liquid.

10. A semiconductor device comprising a first electrode constituted by a hollow block of high thermal and electrical conductivity closed at one end, a rectifier element secured to the outer surface of the closed end of said block, a second electrode arranged to make electrical contact with said rectifier element, a socket attached at the end of said block remote from said rectifier element, a sealing ring mounted in an annular groove in said block and providing a liquid-tight seal between said block and said socket, and a tubular member of heat insulating material mounted in said socket and projecting up inside said block, said tubular member having an open end spaced from the closed end of the block and providing a passage through the tubular member and through the space between the tubular member and the block for cooling liquid.

11. A semiconductor device comprising a first electrode

constituted by a hollow block of high thermal and electrical conductivity closed at one end, the inner surface of said block being of conical shape at its closed end and the apex of the cone being disposed closest to the outer surface of the block, a rectifier element secured to the outer surface of the closed end of said block, a second electrode arranged to make electrical contact with said rectifier element, a socket attached at the end of said block remote from said rectifier element, a sealing ring mounted in an annular groove in said block and providing a liquid-tight seal between said block and said socket, and a tubular member of heat insulating material mounted in said socket and projecting up inside said block, said tubular member having an open end spaced from the closed end of the block and providing a passage through the tubular member and through the space between the tubular member and the block for cooling liquid.

12. A semiconductor device comprising a first electrode constituted by a hollow block of high thermal and electrical conductivity closed at one end, the inner surface of said block being of conical shape at its closed end and the apex of the cone being disposed closest to the outer surface of the closed end of said block, a rectifier element secured to the outer surfaces of the closed end of said block, a second electrode arranged to make electrical contact with said rectifier element, a socket attached at the end of said block remote from said rectifier element, a sealing ring mounted in an annular groove in said block and providing a liquid tight seal between said block and said socket, and a tubular member of heat insulating material mounted in said socket and projecting up inside said block, said tubular member having an end surface of conical shape spaced from the closed end of the block,

the angle of the cone being greater than that of the conical surface constituting the closed end of the block, and providing a passage of uniform cross-section through the tubular member and through the space between the tubular member and the block for cooling liquid.

13. A semiconductor device comprising a pair of opposed electrodes each electrode being constituted by a hollow cylindrical block of high thermal and electrical conductivity having a closed end, the inner surface of each block being of conical shape at its closed end and the apex of the cone being disposed closest to the outer surface of the closed end of the block, a rectifier element secured between said blocks and soldered to the outer surface of the closed end thereof, a socket attached at the end of each block remote from said rectifier element, a sealing ring mounted in an annular groove in each of said blocks and providing a liquid-tight seal between the block and the socket attached thereto, and a tubular member of heat insulating material mounted in each socket and projecting axially up inside each block, each of said tubular members having radially projecting ribs adapted to locate the member axially in one of said blocks, and having an end surface of conical shape spaced from the closed end of a block, the angle of the cone being greater than that of the conical surface constituting the closed end of the block, and providing a passage of uniform cross section through the tubular member and through the space between the tubular member and the block for cooling liquid.

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