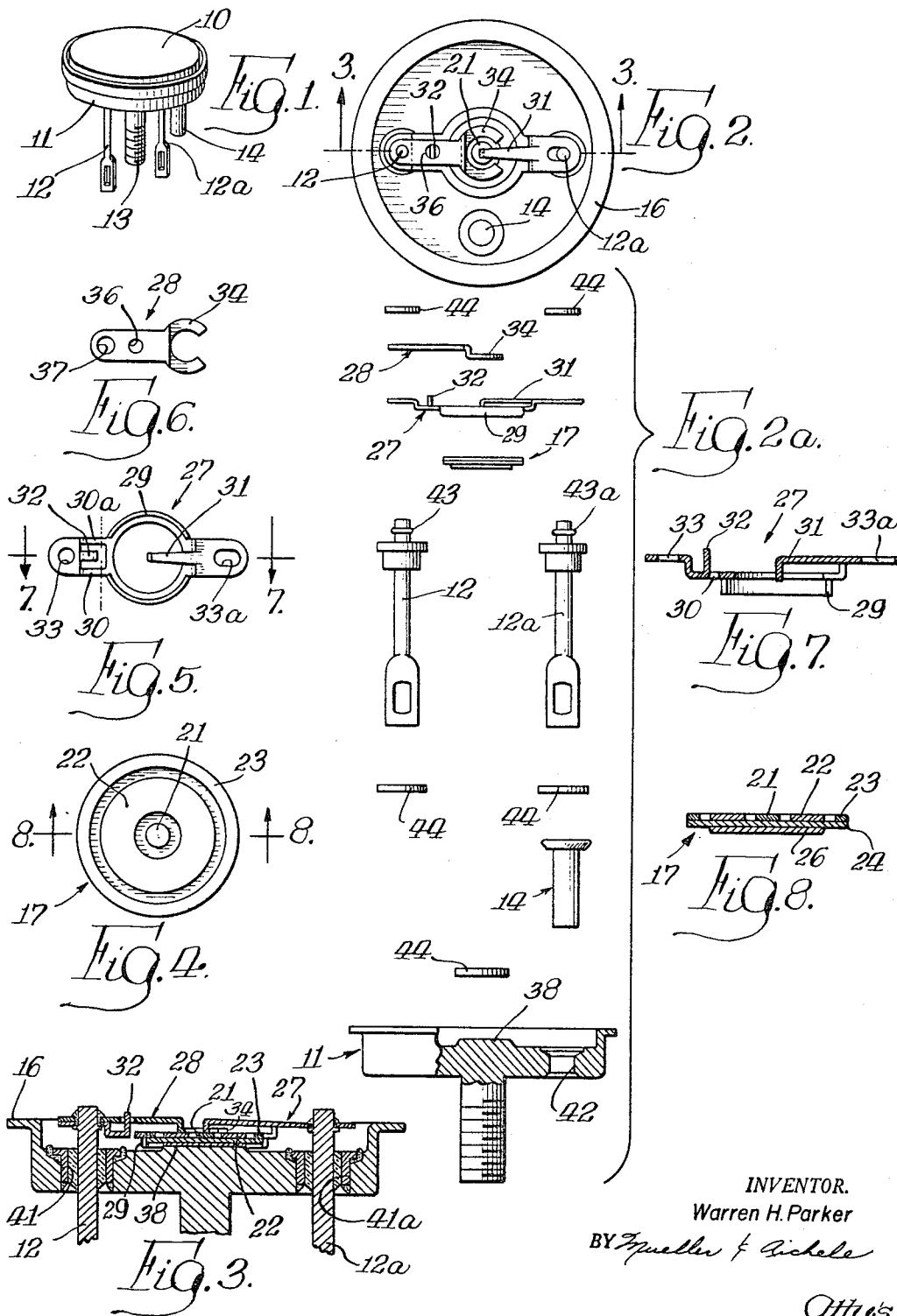


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SEMICONDUCTOR DEVICE
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SEMICONDUCTOR DEVICE

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This invention relates in general to power transistors of the alloyed junction type, and particularly to such a transistor with the semiconductor unit portion of the device mounted intermediate the emitter and base contact conductor posts for the transistor and in a substantially straight line position within the device.

The present invention is related to the structure and method of assembly of Kelley applications Serial No. 847,718, and 847,735 now Patent No. 3,061,766, which were filed October 21, 1959, and October 21, 1959, respectively, and is also related to Ackerman applications Serial No. 83,794 and 83,795, now Patents Nos. 3,153,275 and 3,153,750 and filed January 19, 1961, and January 19, 1961, respectively. It provides an improvement in structure and method of assembly over prior devices employing a base with a threaded mounting stud centrally thereof, and serving as one electrical connection from the semiconductor unit, while emitter and base connections are spaced away from the unit and disposed respectively on opposite sides thereof. In the present invention the semiconductor unit is mounted on a pedestal portion aligned with the stud, and connections are made to the base and emitter contact or electrode portions on the semiconductor unit by two interconnected pre-stamped metal connectors. The latter are dropped in place for such connections without independent jiggling, but are positioned accurately relative to the contact portions on the semiconductor unit by conductor or post portions extending upwardly from the base and comprising emitter and base connections for the device. Interlocking structure of the connectors when placed on the post portions and unit originally positions them in a straight line across such semiconductor unit, and then permits the pieces to settle into a final assembled position during heating and soldering of the assembly without any change of position thereof relative to these points lying in the straight line.

With this interconnected and articulated connecting means for the semiconductor unit and conductors or posts, there is assurance that the pieces are in the proper position without any jiggling independent of the power transistor structure itself, and high speed of assembly with uniformity and ruggedness of the finished product is assured.

Referring to the drawings:

FIG. 1 is a general perspective view of the power transistor;

FIG. 2 is an enlarged plan view of the power transistor without its cover and with the elements in assembled position but not soldered;

FIG. 2a shows the elements of this subassembly in an exploded view, with the base member turned counterclockwise 90° from the position of FIG. 2;

FIG. 3 is an enlarged cross-sectional view of the power transistor subassembly taken along line 3-3 of FIG. 2, except that the assembly in this figure has been soldered or fused together and is ready for encapsulation;

FIG. 4 shows an enlarged plan view of the top of the semiconductor unit;

FIG. 5 is an enlarged bottom view of the largest electrical connector member;

FIG. 6 is an enlarged top view of the smallest of the two interconnected electric connector members;

FIG. 7 is a cross-sectional view of the first electrical connector member taken along line 7-7 of FIG. 5, and in enlarged size; and

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FIG. 8 is a cross-sectional view of the semiconductor unit taken along line 8-8 of FIG. 4.

Referring more particularly to the drawings, the device is shown in FIG. 1 substantially in actual commercial size with a cover 10 and a base 11. Two conductor or post portions 12 and 12a, a threaded mounting stud 13, and an orientation post 14 project downwardly from the base. The cover 10 is cold welded to the base 11 at the annular flange 16 (FIG. 3).

The semiconductor unit 17 is the heart of the power transistor, and is shown in the enlarged plan view of FIG. 4, and in section in FIG. 8. Its top face contains a central, circular base electrode 21. Completely surrounding the base electrode 21 is an annular ring emitter electrode 22, and completely surrounding the latter electrode is an annular ring base electrode 23. The electrodes 21, 22 and 23 are concentric. The semiconductor die 24 (FIG. 8) is germanium in a commercial embodiment of the invention. The collector electrode 26 appears on the bottom face of the complete unit.

The remaining elements of the assembly of FIG. 2, and as shown in detail in FIG. 2a, will be referred to before describing the method of assembling the device, and such elements include the connector 27 (FIG. 5) which will ultimately electrically interconnect the base electrodes 21 and 23 on the semiconductor unit and a corresponding post 12a. The second connector identified by the reference character 28 (FIG. 6) will extend between the ring emitter electrode 22 and the post or conductor 12.

Although the spacing between the concentric electrodes on the face of the semiconductor die 24 is minute, relatively speaking, an insulating separation must be maintained, and this is accomplished in the connectors by a stepped configuration shown particularly in FIGS 2a, and 7. The base connector 27 comprises a central enlarged portion with an annular right-angled flange 29 serving the double function of assisting in the positioning and maintaining of the semiconductor unit 17 on the base 11 during assembly, and being ultimately soldered or fused to the ring base electrode 23 for the electrical connection. An integral horizontal tongue 31 extending from one end portion of the elongated connector is ultimately fused to the center base electrode 21. As is shown in FIG. 3 this is out of contact with the ring emitter electrode 22. The one-piece connector 27 is interlocked during assembly through an upstanding tongue 32 with the connector 28, as will be described, and end portions with apertures 33 and 33a complete this element. The apertures 33 and 33a fit over conductors 12 and 12a.

The second one-piece connector 28 has a C-shaped prong 34 to engage the ring emitter electrode 22, and an aperture 36 to receive the tongue 32 on the first connector to interlock them during assembly. The connector is positioned in assembly with the aperture 37 receiving the post 12.

The full assembly function for the structure of the connectors will be subsequently explained, but we will first complete the description of the remaining elements. The base 11 comprises the integral stud portion 13 which also can be separable if desired, and a pedestal 38 in alignment with the stud portion. Apertures 41 and 41a receive the feedthroughs 12 and 12a or posts or conductors, as they are also called herein, and the aperture 42 (the base in FIG. 2a is rotated so it shows this aperture in the sectional portion) receives the orientation post 14. The feedthroughs each have a flange 43 and 43a, respectively, which determines the position to which the connectors settle in the final assembly and heating, and the soldering of the feedthroughs, base, and connectors together is accomplished with soldering rings 44 placed as will be explained.

In the assembly process, the base 11 (FIG. 2a) is

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placed on a moving conveyor belt in an upright position. A solder ring 44 is placed above and concentric with hole 42, and orientation post 14 is dropped through that solder ring and into the hole 42. Solder rings 44 are placed above and concentric with holes 41 and 41a, and the posts or feedthroughs 12 and 12a are dropped into these holes (FIG. 2). The semiconductor unit 17 is placed on and concentric with pedestal 38, with the ring electrodes facing upwards (FIG. 3), and with the collector electrode 26 on the pedestal top surface. The first connector member 27 is dropped down over the posts 12 and 12a and the unit 17. The posts 12 and 12a project upwards through the corresponding apertures 33 and 33a in the first connector member 27 (FIG. 2), and the central portion with the flanged rim 29 surrounds and further locates the unit 17 on the pedestal 38. The second connector member 28 is then dropped over the post 12 (on the left in FIG. 2), and in this placing and positioning it interconnects with the prong 32 at the aperture 36. In this manner the second connector member is aligned along a straight line that joins the posts or conductors 12 and 12a and the semiconductor unit 17.

Thus, the unit 17 is positioned concentrically with the pedestal 34, lies on a straight line between the two pins 12 and 12a, and is contained by the circular flange or rim 29 of the first connector member 27.

FIG. 3 is a sectional view through the entire subassembly and shows clearly the manner in which the parts readily fit together, and are ultimately secured in position. Here the unit 17 can be seen located at the center of the structure and resting on pedestal 38. The first connector 27 runs between posts 12 and 12a, and the prong 32, which is part of the first connector 27, projects upward through the smaller aperture 36 in the second connector member 28 thereby providing alignment for the two connector members and with the posts 12 and 12a.

Following the assembly of the various parts, the entire subassembly of FIG. 2 is run through a high temperature firing furnace to melt the solder, and the posts 12 and 12a, and the orientation post 14 are soldered to the base 11. At the same time the unit 17 is fused to the pedestal 38 at the collector electrode 26, the ring base electrode 23 (FIG. 4) is fused to the flanged portion 29, and the prong portion 34 of the second connector 28 is fused to the emitter electrode 22. The tongue 31 on the connector 27 is fused to the center base electrode. Both connector members are soldered to the posts 12 and 12a on which they rest. The firing step causes the solder as well as the electrode material to melt, and fusion or soldering of the elements is accomplished.

Meanwhile, the conveyor belt on which the assembly has been moving all of the time, carries the assembly in the condition shown in FIG. 3 out of the furnace, all of the parts cool, and the meltable material secures the connector members, the unit and the base together by means of soldered or fused joints, and establishes the desired electrical connections.

The steps of placing the various parts on the base 11 without the need for independent locating fixtures are straightforward and can be done quickly. The connector members 27 and 28 readily drop into place over the posts and the semiconductor unit. The interlocking feature between the connectors provides positive alignment of the connectors intermediate the posts 12 and 12a, and the connectors maintain the unit 17 in the desired position on the pedestal 38 and in line with the posts. This structure and arrangement prevents vibratory or other dislocating effects during the firing or melting run. The connectors settle at the flanges 43 and 43a on the posts, and the collector electrode fully fuses to the pedestal.

Prior to assembling the first connector member 27, the webbing is severed (FIG. 5) at the dotted line and the reference character 30 on one side of the extension, using a small tool. Enough rigidity remains in the member 27 to permit it to be properly assembled into the

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structure. After the entire subassembly has been put through the firing furnace and all the solder connections have cooled and are fixed (as for FIG. 3), a current is passed between the posts 12 and 12a. This current flows through the unsevered side 30a of the web and enough heat is generated to cause that side to burn open. This removal of the webs 30 and 30a eliminates any emitter-to-base short between the posts 12 and 12a.

Thereafter, the assembly of FIG. 3 is cleaned and the cover 10 is secured to the base at the flange 16. This latter securing is not a part of the present invention.

The round-style power transistor package such as shown in FIG. 1 is a desirable type of package and is used commonly in industry. By locating the stud 13 at the center of the device package, excellent thermal and electrical contact to the surface on which the transistor is mounted can be obtained. As can be seen in FIG. 3, the pedestal portion 38 is located centrally with respect to the base 11 and this pedestal is aligned and is concentric with the threaded stud 13. With the unit 17 soldered directly to the top face of the pedestal, heat generated in the semiconductor unit during operation of the transistor, can be very efficiently conducted into the base 11 and out through the device to which the transistor is mounted.

The over-all height of the transistor can be kept to a minimum because of the limited space which the first and second connector members require. This efficient use of vertical space can be seen in FIG. 3. The stepped portion of the left end of the first connector member 27 provides a vertical space or separation between the first such connector member and the second connector member 28, so that there is no short circuit to the electrodes on the unit 17. When the final web portion 30a is severed by the current, then, even though the left end portion, as viewed in FIG. 3, of connector 27 remains on the post 12, and the connector 28 connects the post 12 and the emitter electrode, there is no short circuit between the different electrodes on the semiconductor unit.

The secure and compact manner in which the connector members, the semiconductor unit, and the base member are joined, provides a very rugged, and mechanically reliable structure. Because of the configuration of the two connector members as previously described, the soldered connections between the ends of the connector members and the posts 12 and 12a are at the same height above the surface of the base 11, and this permits the posts to be of exactly the same configuration and dimensions.

In solving the problem of devising highly efficient assembly methods for a power transistor package where the unit assembly and the emitter and base posts are in one straight line, the first and second connector members of the present invention allow straightforward, rapid assembly steps with self-jigging features which are well suited to mass production conveyor-belt assembling, and all of the soldered connections can be formed at one time. The firing operation and subsequent cooling provides a semiconductor assembly with a compact group of parts strongly bonded together.

I claim:

1. In a semiconductor device having a base support structure with a pair of conductor members protruding from one side of said structure, and a semiconductor die unit supported by said structure and positioned between said conductor members, the combination including a first connector member making a connection to the semiconductor die unit and electrically connected to one of said conductor members, a connector part derived from said first connector member and secured to the other of said conductor members, said first connector member and said connector part being physically and electrically separate from each other in the final device but extending in a straight line between said conductor members and initially being one piece to facilitate the alignment of said first connector member relative to said semiconductor die unit and said base support structure in the manufacture of

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said device, a second connector member electrically connected to said other conductor member and to said semiconductor die unit, said second connector member and said connector part having portions in overlapping relationship relative to each other with means interlocking the same to facilitate the alignment of said second connector member relative to said semiconductor die unit and said base support structure in the manufacture of said device, and solder joints connecting said first and second connector members to the respective conductor member.

2. In the semiconductor device of claim 1, said first connector member comprising a longitudinally extending element having an annular portion engaging and fused to a corresponding annular portion of the semiconductor die unit, and having an extension from said annular portion connected to said one conductor member, said extension having a tongue connected to said semiconductor die unit within said annular portion, and said connector part being in line with said extension portion but on the opposite side of said annular portion.

3. A semiconductor device including in combination, a base support structure having a pair of conductor members projecting from one surface thereof and a semiconductor die unit supporting area on said surface spaced from each conductor member and located centrally between said conductor members with said conductor members and said area representing three points in a substantially straight line, a semiconductor die unit on said supporting area having an electrode portion on one side thereof in contact with said base support structure at said area and said die unit having a pair of concentric ring electrodes on the other side thereof and a center electrode within the innermost of said ring electrodes, a first connector member having an

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apertured portion fitting over a corresponding conductor member and having an enlarged portion in contact with the outer ring electrode of said die unit and a pronged portion in contact with the center electrode of said die unit, a connector part derived from said first connector member and having an apertured portion fitting over the other of said conductor members, said first connector member and said connector part being physically and electrically separate from each other in the final device but extending in a straight line between said conductor members and initially being in one piece to facilitate the alignment of said first connector member relative to said semiconductor die unit and said base support structure in the manufacture of said device, a second connector member having an apertured portion fitting over said other conductor member and having an extension in contact with the inner ring electrode of said semiconductor die unit, said second connector member and said connector part having portions in overlapping relationship relative to each other with means interlocking the same to facilitate the alignment of said second connector member relative to said semiconductor die unit and said base support structure in the manufacture of said device, and solder joints connecting said connector members and said connector part to the corresponding conductor members.

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