Dec. 4, 1956 R. L. JONES 2,773,225

SEMICONDUCTOR DEVICE

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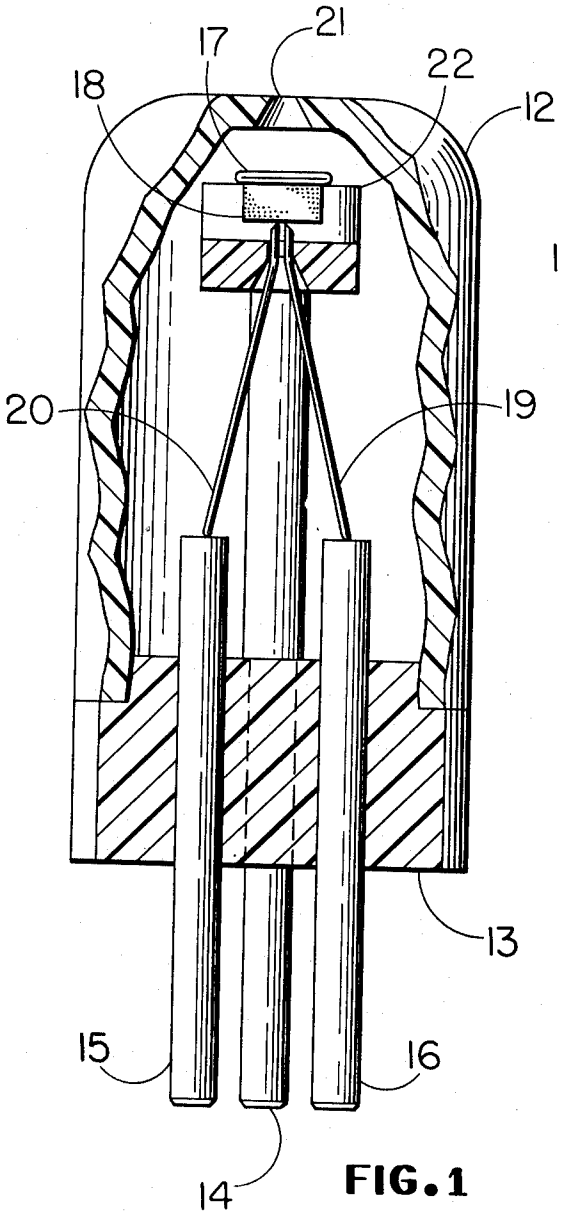


FIG. 1

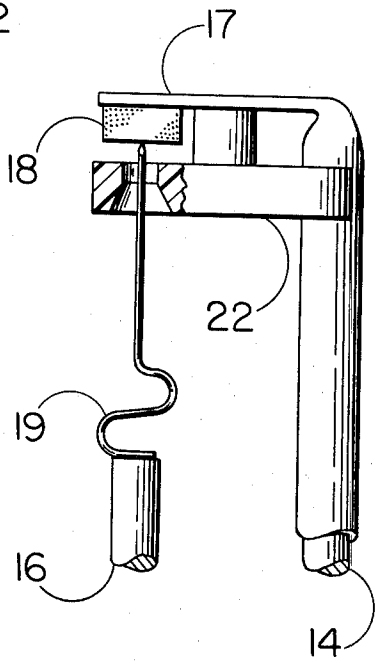


FIG. 2

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SEMICONDUCTOR DEVICE

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4 Claims. (Cl. 317—235)

This invention relates in general to semiconductors and in particular to point-contact semiconductor devices.

Point-contact transistors are presently finding wide acceptance in various areas previously reserved to vacuum tubes. It is necessary, however, that the characteristics of such transistors be substantial equivalents of the tubes which are to be replaced. Numerous factors determine the operating characteristics of point-contact transistors, but it has been shown in theory and by experimentation that the main determining factors are the resistivity of the germanium used as the crystal, the materials used for the point-contacts, the electrical forming process and, finally, the spacing of the point-contacts. Of these factors, perhaps the most difficult to control has been the spacing of the point-contacts. Numerous difficulties are encountered in maintaining a desired spacing primarily because the spacing is normally required to be of an order of magnitude of thousandths or fractions of thousandths of an inch. This difficulty in maintaining spacing is emphasized by the fact that it is the one main factor which must be contended with during the actual assembly of the transistor. Obviously, the materials for the point-contacts and the resistivity of the germanium may be predetermined before assembly. Electrical forming, on the other hand, is usually accomplished after assembly. Proper point spacing, however, can only be accomplished during assembly.

Therefore, it is an object of the present invention to provide a transistor of a structure which determines and maintains a desired spacing of point-contacts.

It is a further object to provide a transistor of a rugged and shock resistant design.

It is a still further object to facilitate the assembly of point-contact transistors.

In general, the invention consists in a body member which may be cylindrical in shape and from one end of which three leads extend. One of these leads is welded within the body to an L-shaped member. This L-shaped member is generally made of larger stock than the lead. On the portion of the L-shaped member facing the end from which the leads extend, there is mounted a germanium crystal. From the other two leads, there extend two cat whiskers which are designed to contact the crystal. There is also provided a spacer of insulating material which is held in position within the body member by attachment to the L-shaped member. The attachment is made at one point adjacent the crystal and, at a second point, nearer the end of the cartridge through which the leads extend. The spacer is designed to determine and retain a predetermined spacing of the whiskers on the surface of the crystal. For a better understanding of the invention, together with other and further objects, features, and advantages, reference should be made to the following description which is to be read in connection with the accompanying drawing in which:

Fig. 1 is an elevation view, partly cut away, of a point-contact transistor embodying the principles of the invention; and

Fig. 2 is an elevation view, partly in section, of the internal structure of the transistor of Fig. 1.

Referring now to Fig. 1 of the drawing, there is shown a molded, cylindrical plastic cartridge **12** having one open end. A mount is made up for insertion in the open end of cartridge **12**. It consists of a disk-shaped plastic plug **13** through which there are sealed three leads **14**, **15**, and **16**. Lead **14** extends a substantial distance beyond plug **13** into the interior of cartridge **12**. Mounted on lead **14** is a tubular L-shaped member which may, as shown, be slipped over lead **14** at one end thereof, the other end beng flattened to provide a flat surface for attachment of a crystal of germanium **18**. Crystal **18** is preferably soldered to member **17**, but may be attached thereto by other means which permit electrical conduction. On lead **15**, there is welded a cat whisker **20**. A similar cat whisker **19** is welded on lead **16**. Cat whiskers **19** and **20** may be made of tungsten, Phosphor bronze, beryllium copper, or other metals having similar properties. However, Phosphor bronze is used for the collector and beryllium copper for the emitter electrode in the present embodiment. Each of these whiskers has an **S** bend formed in a portion of its length. The **S** bend is made near the point of attachment to the lead because locating the **S** bend at that point, a stronger weld may be achieved than would be the case if the ends of the whiskers were to be butt welded against the ends of the leads. The purpose of the **S** bend in each of the leads is to add to the resilience of the whiskers in order that a constant pressure may be maintained by the whiskers against crystal **18**. Whiskers **19** and **20** are arranged, by proper shaping and mounting thereof, to have a tendency to spring apart. A locating disk **22** is attached to the L-shaped member **17** at two points, one on the flat surface adjacent the crystal, and the other near the bend in member **17**. The locating disk **22** has an opening therethrough which is chamfered at the surface facing the open end of cartridge **12**. At the surface adjacent crystal **18**, the opening in disk **22** is maintained to close tolerances at a predetermined dimension for a portion of its length. Whiskers **19** and **20** have chisel points formed at the ends which bear upon crystal **18**. As may be seen from the drawing, the furthest extensions of the points are at the edges of the whiskers which are most closely adjacent. This permits closer whisker spacing than could otherwise be achieved. Whiskers **19** and **20** are mounted, as noted above, in such a fashion as to cause them to spring apart and bear against the periphery of the opening in disk **22**. As a result, the spacing between point contacts on crystal **18** may be determined with a fine degree of accuracy by maintaining close tolerances on the opening and on whiskers **19** and **20**.

Referring now to Fig. 2, the internal structure of the embodiment of the invention shown in Fig. 1 may be more clearly seen. In this plane, the **S** bend of whisker **19**, which is identical to whisker **20** and its attachment to lead **16**, is clearly visible. The upwardly extending protrusion on disk **22** is also clearly visible. Disk **22** is maintained in position by means of a plastic cement at the point where the protrusion contacts the flattened portion of member **17** and, also, at the point of contact with the tubular section of member **17**. At this latter point, disk **22** has a matching semi-circular opening cut to provide a greater amount of surface contacting the tubular section of member **17**.

The device lends itself to convenient assembly techniques. One process used is begun by assembling plug **13** with leads **14**, **15**, and **16** tightly sealed therethrough. L-shaped member **17** is then formed and crystal **18** is soldered in position adjacent the end of the flattened portion. Locating disk **22** is then cemented to member **17** at the two points mentioned above, that is, to the flat

portion and to the tubular portion of member **17**. The protrusion on disk **22** is of a height sufficient that the disk surface nearer crystal **18** will clear crystal **18** by a relatively small amount, of the order of ten thousandths of an inch. Whiskers **19** and **20** are formed and are welded to leads **16** and **15** respectively. The assembly on plug **13** is then joined to that on member **17**, lead **14** being inserted in the tubular portion of member **17**. The two assemblies are brought together with a predetermined amount of force being exerted on plug **13** to bring whiskers **19** and **20** into firm contact with crystal **18**. The opening in disk **22** guides the two whiskers into a closely spaced disposition as explained hereinabove. The tubular portion of member **17** is then welded to lead **14** at several points to give a rigid union of the two assemblies. After the joining of the two assemblies, plug **13** is fitted into cartridge **12** and securely cemented thereto. An opening **21** is provided in the closed end of cartridge **12** for the introduction of an impregnating solution which fills the entire enclosure. Finally, opening **21** is cemented closed and the unit is physically complete.

While what has been disclosed is a preferred embodiment of the present invention, numerous modifications thereof will suggest themselves to those skilled in the art. Such modifications, however, are believed to be within the present invention which should be limited only by the spirit and scope of the appended claims.

What is claimed is:

1. A transistor comprising, a semiconducting body, a a base connection to said semiconducting body, a pair of leads having pointed ends, said pointed ends bearing against said semiconducting body, means for mounting said leads in normally diverging relationship, and a collar surrounding said leads adjacent the pointed ends thereof to restrain divergence therebetween and maintain close spacing between said points in the area of contact with said semiconducting body.

2. A transistor comprising, a semiconducting body, a base member connected to a surface of said body, a pair of leads each having a pointed end, a locating disk attached to said base member, said disk having an aperture formed therein, said leads being fixedly mounted at separate points remote from said body and being resiliently urged apart, said leads passing through said aperture at a point adjacent said body and being restrained from divergence thereby, and means for causing the pointed end of said leads to exert a predetermined force against said body.

3. A transistor comprising, a cylindrical plastic housing having one open end and an opening formed in the other end thereof, a plug inserted and sealed into said open end, three conducting leads sealed through said plug and insulated from one another, a whisker of beryllium copper mounted on one of said leads within said housing, a whisker of Phosphor bronze mounted on a second of said leads within said housing, said whiskers being mounted on said leads in normally diverging relationship, an L-shaped member mounted on the third of said leads within said housing, one leg of said L-shaped member being parallel to the axis of said cylindrical housing, the other leg being perpendicular thereto, a cube of germanium being mounted on said other leg and facing said open end, and a disk-shaped locating member having an aperture formed therein attached to said L-shaped member and being disposed adjacent said cube, said aperture being larger than the total diameters of said whiskers by a predetermined amount, said whiskers passing through said aperture and being restrained from divergence beyond said predetermined amount, said whiskers each having an S-shaped bend formed therein to cause them to bear upon said cube of germanium with a predetermined pressure, and said opening in said housing permitting the introduction of an impregnating compound.

4. A semiconductor device comprising, a semiconducting body, at least a pair of leads having ends thereof in contact with said semiconducting body, common support apparatus for said leads and said semiconducting body, said apparatus including a plug, three conductor pins sealed through said plug in fixed relationship to each other, said semiconducting body being supported by one of said conductor pins, each of said leads being supported by another of said conductor pins, the spacing between said conductor pins being such that said leads trace converging paths to said semiconducting body, and means adjacent said semiconducting body for maintaining said leads in said converging paths.

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