Jan. 13, 1959 W. A. SCHAPER 2,869,053

TRANSISTOR UNIT

Filed May 22, 1953

2 Sheets-Sheet 1

Fig. 1.

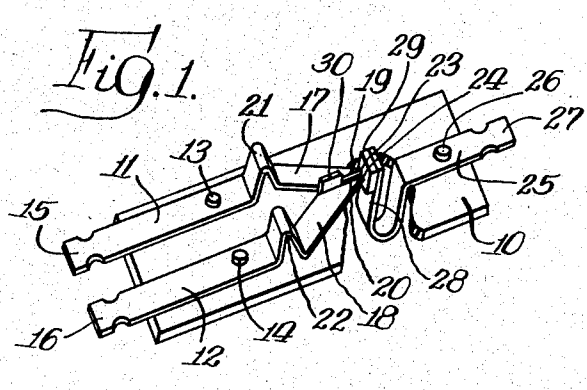


Fig. 2.

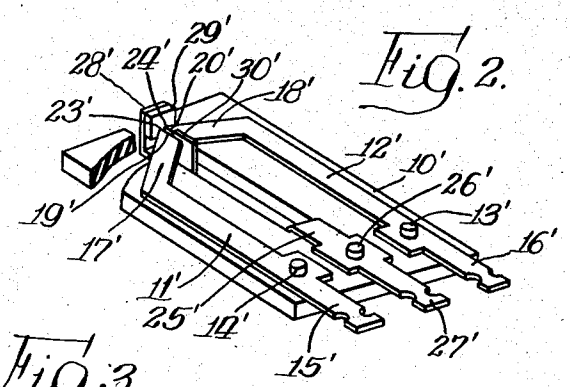


Fig. 3.

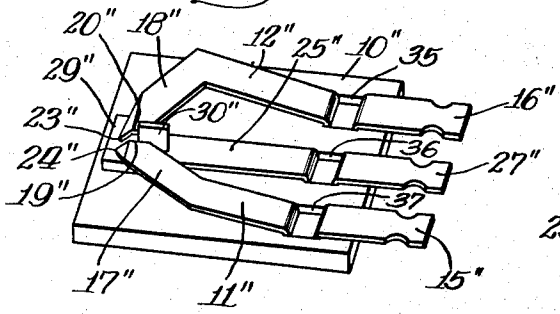


Fig. 5.

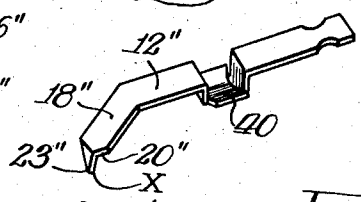


Fig. 4.

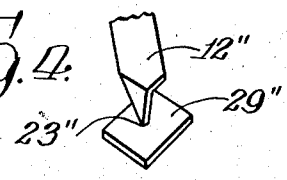


Fig. 6.

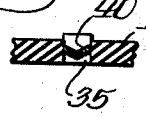
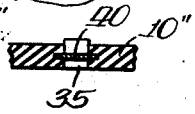


Fig. 7.



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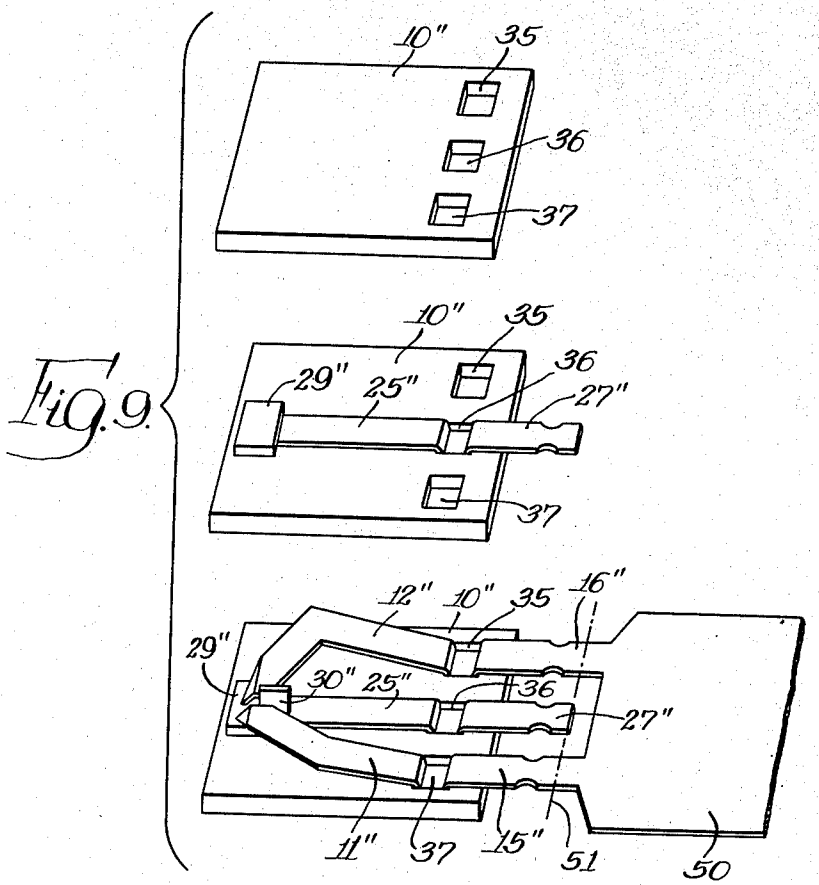
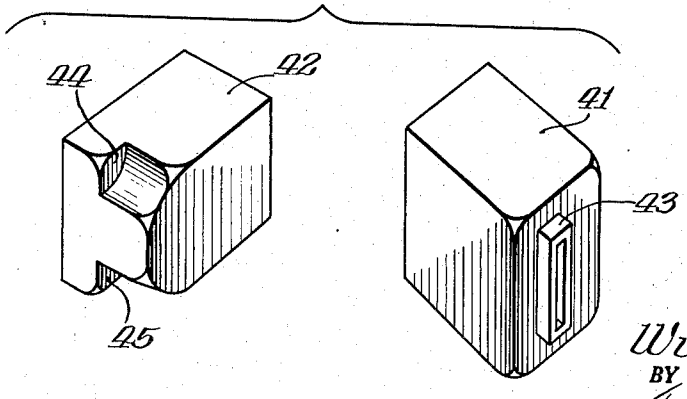


Fig. 9.

Fig. 8.



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TRANSISTOR UNIT

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Application May 22, 1953, Serial No. 356,637

12 Claims. (Cl. 317—235)

The present invention relates to circuit elements and more particularly to an improved point contact transistor unit and to an improved and simplified method for fabricating such a transistor.

The usual known type of point contact transistor comprises a semi-conductive block on crystal composed, for example, of germanium, and the transistor also includes a pair of pointed fine wire or ribbon electrodes supported to extend in spaced parallel relation from one face of the germanium block. These electrodes constitute respectively the emitter and collector for the transistor. The transistor also includes a base electrode which usually takes the form of a metal tab soldered to an opposite face of the germanium block.

The cubical dimension of the germanium block is of the order of .032" on a side, and the fine wire electrodes are about .005" in diameter with a spacing at their points of about .002". It is obvious that the dimensions and spacings of these components are entirely too small to lend themselves to production methods involving any but the most highly skilled labor. The fabrication of point contact transistors using such microscopic components, therefore, is slow and arduous and is accompanied by a high percentage of rejects which result in an unduly high cost for the individual units. In addition to the difficulties encountered in the manufacture of this type of point contact transistor, the resulting units are fragile and delicate mechanically and are incapable of withstanding rough usage.

It is, accordingly, an object of the present invention to provide a new and improved point contact transistor unit which is devised so that its various components may be manufactured mechanically, and which may be assembled without the need for an undue amount of manual dexterity.

A further object of the invention is to provide an improved transistor unit which may be constructed simply and expeditiously and which is relatively rugged and efficient in operation.

Another object of the invention is to provide an improved and simplified manufacturing method for fabricating point contact transistor units.

A feature of the invention is the provision of an improved circuit element in the form of a transistor unit which utilizes pre-formed metallic strips for the various electrodes, and which strips are mounted rigidly and securely on an insulating base with a semi-conductive block soldered to the end of one strip and with the ends of the other strips in resilient point contact relation with the block.

Another feature of the invention is the provision of such an improved point contact transistor unit in which a plurality of preformed metallic strips are securely supported on an insulating base, with a semi-conductive block supported at the end of one of the strips and with the other strips having pointed ends in resilient contact with a face of the block; and in which the critical dimension between such pointed ends is established mechanically and then set by an insulating spacer to obviate the need for difficult manual spacing.

Yet another feature of the invention is the provision

of such an improved transistor unit which incorporates an insulating base member having three rectangular apertures formed at one end thereof, and having three metallic strips conveniently swedged into the apertures and extending along the base with a selected configuration with the end of one strip supporting a semi-conductive block in resilient point contact relation with the ends of the other two strips.

Still a further feature of the invention is the provision of an improved manufacturing process in which a central resilient metallic strip is anchored to the surface of an insulating base with a semi-conductive block affixed to one end, and two other metallic strips are formed out of a strip of flat metallic stock and anchored to the base while still attached to the stock, with the latter strips exending along the base on either side of the central strip with their ends preformed to be separated a selected distance and in resilient point contact with the block.

The above and other features of the invention which are believed to be new are set forth with particularity in the appended claims. The invention itself, however, together with further objects and advantages thereof, may best be understood by reference to the following description when taken in conjunction with the accompanying drawings in which:

Figures 1, 2 and 3 are three different embodiments of the improved point contact transistor unit of the invention.

Figure 4 is a partial view of one of the components of the emobdiment of Figure 3 showing the point contact relation of such component with a semi-conductive block.

Figure 5 is a view of one of the components of the embodiment of Figure 3.

Figures 6 and 7 are sectional views showing how the component of Figure 5 may be swedged to the base panel of the unit.

Figure 8 shows a typical casing for housing the transistor units of Figures 1–3; and

Figure 9 shows various steps in the manufacture of the transistor unit of Figure 3.

The circuit element of the present invention constitutes a transistor unit which comprises a flat insulating base member having a pair of ends. A pair of electrically conductive strips is mounted in spaced mutually insulated relation on the surface of the base and the strips extend along this surface from one end of the base toward the other end thereof, the strips having a pair of points formed at the respective extremities thereof. These points are spaced from one another by a selected amount by an insulating spacer. A third electrically conductive strip is mounted on the surface of the base and spaced and insulated from the pair of strips mentioned above. The third strip extends along the base and has an extremity facing the points of the other two strips. Finally, a semi-conductive member has one surface affixed to the extremity of the third strip and has another surface in resilient contact with the points of the extremities of the other two strips.

The embodiment of the invention shown in Figure 1 has a flat insulating base 10 which may be composed, for example, of molded plastic material such as phenolic. Base 10 may, for example, be .062" thick, .625" long and .312" wide.

A pair of resilient metallic strips 11 and 12 are anchored by appropriate rivets 13 and 14 on one surface of base 10 and extend along that surface in spaced parallel relation. These strips may, for example, be composed of Phosphor bronze or of beryllium copper of No. 4 hardness, or of any other suitable electrically conductive resilient material. Strips 11 and 12 have respective end portions 15 and 16 extending beyond one end

of base 10 to constitute terminals for the transistor, and these strips have further end portions 17 and 18 turned inwardly in the plane of the surface of base 10 to define a pair of contiguous edges 19 and 20 facing each other along an axis intermediate the axes of strips 11 and 12 and parallel thereto.

Strips 11 and 12 have respective looped portions 21 and 22 extending upwardly from the plane of the surface of base 10. The contiguous edges 19 and 20 define a pair of pointed corners 23 and 24 facing the other end of base 10 and resiliently biased toward that end by the looped portions 21 and 22.

A third resilient metallic strip 25 is anchored to the surface of base 10 by a rivet 26 and extends from the other end of the base along an axis parallel to and intermediate the axes of strips 11 and 12. Strip 25 has an end portion 27 extending beyond the other end of base 10 to constitute a terminal for the unit, and the strip has a further end portion which is looped down into an aperture in base 10 and upwardly to present a face 28 to the pointed corners 23 and 24 of strips 11 and 12.

A resilient semi-conductive block 29 composed, for example, of germanium has one surface affixed to the face 28 of strip 25 and has an opposite surface in resilient point contact with the pointed corners 23 and 24 of strips 11 and 12. The pointed corners are accurately spaced by a desired amount by an insulating spacer 30 placed between the contiguous edges 19 and 20 of strips 11 and 12.

In the embodiment of the invention illustrated in Figure 1, strips 11, 12 and 25 may be conveniently punched from flat resilient metallic stock and preformed into the illustrated configuration. The various strips may be anchored to the base 10 in a simplified and non-critical manner, manufacturing tolerances being absorbed by the resilient nature of ends 17 and 18 due to loops 21 and 22, and by the resiliency of face 28 of strip 25. Accurate spacing between the pointed corners 23 and 24 is achieved by a simple expedient to be described and by interposed insulating spacer 30 between the contiguous edges 19 and 20.

Insulating spacer 30 may be an accurately gauged piece of mica having a thickness, for example, of .002". Strips 11 and 12 may be of the order of .062" wide and .005" thick. The length of strips 11 and 12 may be .187" and the length of strip 25 may be of the order of .125", all measured from the nearest point of anchor.

With the construction illustrated in Figure 1, the end of face 28 of metallic strip 25 constitutes a base electrode for the rectangular semi-conductive block 29 soldered thereto, and electrical connection is made to the base through metallic strip 25 from terminal 27. The pointed corners 23 and 24 of metallic strips 11 and 12 form the emitter and collector electrodes for the block 29, and respective electrical connection is made to these latter electrodes through strips 11 and 12 from their terminal portions 15 and 16.

The embodiment of Figure 2 is similar in some respects to that of Figure 1, and similar elements have the same number formed. In the latter embodiment, metallic strips 11', 12' are anchored at one end of a surface of base 10' by rivets 13' and 14' and extend along that surface with turned-in ends 17' and 18' forming contiguous edges 19' and 20' as in the previous embodiment. As also in the previous embodiment, strips 11' and 12' have respective end portions 15' and 16' extending beyond one end of base 10' to constitute terminals, and the contiguous edges 19' and 20' define pointed corners 23' and 24' facing the other end of base 10'. The contiguous edges 19' and 20' are separated, as before, by an insulating spacer 30' to provide a desired separation for the pointed corners 23 and 24.

In the embodiment of Figure 2, however, metallic strip 25' is anchored at the same end of base 10' as strips 11' and 12' by means of a suitable rivet 26'. Strip 25' has an end portion 27' extending beyond the end of base 10 intermediate portions 15' and 16' to function as a terminal, and strip 25' has an intermediate portion which extends through a longitudinal slot in the panel intermediate strips 11' and 12' in spaced parallel relation therewith. The end of strip 25' extends beyond the pointed corners 23' and 24' of strips 11' and 12' and has a turned-up extremity 28' facing these corners.

A semi-conductive block 29' has one surface soldered or otherwise affixed to the turned-up extremity 28' of strip 25' and has an opposite surface in resilient point contact with corners 23' and 24' of strips 11' and 12'. The turned-up end 28' of metallic strip 25' forms the base electrode for the semi-conductive block 29' and, as before, electrical connection is made to that electrode through terminals 27' and strip 25'. The pointed corners 23' and 24' constitute the emitter and collector electrodes and electrical connection is made to these electrodes through strips 11' and 12' and corresponding terminals 15' and 16'.

In the embodiment of Figure 3, components similar to those of Figure 1 have the same numbers but with double primes. In the latter embodiment, the insulating base 10" has an aligned series of three rectangular apertures 35, 36 and 37 adjacent and parallel to one end thereof. Metallic strip 25" is supported in intermediate aperture 36 by swedging a pair of ears 40 formed on that strip in a manner to be described. As before, strip 25" has a terminal portion 27" extending beyond the end of base 10" and, in this instance, has an intermediate portion which extends along the upper surface of the base and intermediate the sides of the base toward the other end thereof.

Semi-conductive block 29" is supported on the remote end of strip 25" with its lower face soldered to the end of the strip. Strips 11" and 12" are, likewise, swedged into respective apertures 35 and 37 on either side of strip 25" and extend to the other end of the base on either side of strip 25". Strips 11" and 12" have end portions 17" and 18" turned inwardly to produce contiguous edges 19" and 20" which, as before, are separated by an insulating spacer 30". The corners 23"—24" of the contiguous edges are bent downwardly into resilient point contact relation with the upper face of semi-conductor block 29". These corners hold the strips 11" and 12" up from the surface of base 10" so that the corners bear resiliently on the upper surface of block 29". It is preferable that the rear edge X only of corner 23" (Figure 5), and only the rear edge of corner 24", actually contact the crystal surface to maintain an extremely small contact area between the crystal and the electrodes.

Strip 12" is shown in Figure 5 and like strips 11" and 25" has a pair of curved-up ears 40 which are swedged into the bore of rectangular aperture 36. The swedging of these ears is shown in the cross-sectional views of Figures 6 and 7. In Figure 6, the ears are pressed into the square aperture and then straightened outwardly into the molded material of the base, which material flows on each side of the ears so that the metallic strip is securely supported within the aperture.

As previously noted, corners 23" and 24" of strips 11" and 12" are bent over to form a resilient point contact with the upper face of crystal 29" and this configuration is clearly shown in Figure 4. In this manner, strips 11" and 12" are resiliently supported in the respective apertures 35 and 37 so that the desired resilient point contact of corners 23" and 24" with the upper face of crystal 29" may be obtained.

The structures of Figures 1, 2 and 3 may be coated with a moisture-protecting coating such as a non-hygroscopic oil, and they are then sealed in a suitable capsule such as that shown in Figure 8. The capsule of Figure 8 includes two sections 41 and 42, section 41 having a slotted protuberance 43 and section 42 having reduced

corner sections 44 and 45. The corners of the base of the structures of Figures 2 and 3, for example, are held and restricted from any lateral motion by the reduced corners 44 and 45 of section 42, and the terminal lugs of these structures extend through the slotted protuberance 43. A similar casing may be used for the structure of Figure 1 with an additional protuberance provided in section 42 for terminal 27. The casing may be composed of a suitable opaque molded insulating material and is formed into an integral unit with the transistor structure enclosed therein. It is usual to pot the structure within the casing in a suitable cement or wax.

A suitable manufacturing process for the transistor, such as the structure of Figure 3 is illustrated in Figure 9. In accordance with the process, a molded insulating base 10'' is provided having an aligned series of rectangular apertures 35, 36 and 37 adjacent and parallel to one end. A semi-conductive block or crystal 29'' is soldered to one end of metallic strip 25'', and the strip is swedged in the manner described previously into central aperture 36 of base 10''. Strip 25 may be punched and formed in any known manner from suitable flat metallic stock, and quantities of strip and crystal assemblies with crystal 29'' soldered to the end of each metallic strip can be conveniently provided by mass production techniques. The metallic strips 11'' and 12'' are sheared and formed out of a solid strip of flat resilient metal stock 50 by means, for example, of a progressive die, and the strips are left attached to the raw stock until they have been swedged into apertures 35 and 37 with their bent-over corners in resilient point contact engagement with the top surface of crystal 29''. After strips 11'' and 12'' have been swedged into apertures 35 and 37, they are cut from the stock along the line 51. This method facilitates handling and maintenance of the relative location of strips 11'' and 12'' to each other and especially of pointed corners 23'' and 24'' since the flat stock can be gauged very accurately so that there is no need to attempt to space these corners manually. As a final step in the process, the mica spacer 30'' is interposed between the contiguous edges 19'' and 20'' of strips 11'' and 12'' to provide a final spacing for pointed corners 23'' and 24'' to the desired exact microscopic distance.

It is usual practice to grind the surface of the semiconductive block contacting the pointed corners of the resilient strips so that it is absolutely flat and then to etch that surface. The grinding may be made with a suitable abrasive such as 600 mesh alumina AL_{23} followed by further grinding with fine emery paper. The surface of the block or slab is then etched with a suitable etching solution which is applied with a swab or by immersing the surface in the solution. The block is then soldered to the central metallic strip. After such soldering, it is sometimes necessary to re-etch the block, and during the subsequent re-etching process, it is possible for the material in the metallic strip to get into the etaching solution and become deposited on surfaces of the crystal block. For example, when Phosphor bronze is used for the metallic strip, the copper in the bronze is liable to deposit a copper coating on the block. For that reason, it is sometimes preferable to substitute nickel instead of bronze for the central metallic strip, for any nickel taken into the etching solution will not harm the crystal block; whereas a copper deposit will. It is usually found preferable to plate this surface of the crystal block in order to reduce the resistance of the contact between it and the metallic strip to a low value. Although Phosphor bronze and nickel have been used for the metallic strips, other metals may be employed without appreciably affecting the performance of the unit.

The points of the outer metallic strips contacting the surface of the crystal block may be sharpened, either mechanically or by means of an etching process, to an area having a diameter of the order of .0001''.

The invention provides, therefore, a new and improved transistor unit that may be constructed simply and without the need for minute spacing and assembling of microscopic fine wire or cat-whisker electrodes. The unit of the invention lends itself to mechanical formation of the various metallic strips by punching, shearing, die-cutting and the like, and the various strips may be assembled on the base and in contact with the crystal without the need for accurate manual spacing.

While particular embodiments of the invention have been shown and described, modifications may be made and it is intended in the appended claims to cover all such modifications as fall within the true spirit and scope of the invention.

I claim:

1. A circuit element including in combination, a flat insulating base member having a pair of ends, a pair of electrically conductive strips mounted in spaced mutually insulated relation on said base and extending along said base from one end thereof toward the other, said strips having a pair of points formed at the respective extremities thereof remote from said one end of said base and said points being spaced one from the other by a selected amount, a third electrically conductive strip mounted on said base spaced and insulated from said pair of strips and extending along said base with an extremity facing said points at the extremities of said pair of strips, and a semi-conductive member having one surface affixed to said extremity of said third strip and having another surface in contact with said points at the extremities of said pair of strips.

2. A transistor unit including in combination, a flat rectangular insulating base member having a pair of ends, a pair of metallic resilient strips anchored to one surface of said base member adjacent one end thereof and extending along said surface from said one end of said base toward the other end thereof in spaced parallel relation, said strips having a pair of points formed at the repective extremities thereof remote from said one end of said base, an insulating spacer interposed between said extremities of said strips to space said points a selected amount one from the other, a third metallic strip anchored to said surface of said base spaced and insulated from said pair of strips and extending along said base on an axis intermediate and parallel to said pair of strips, said third strip having an extremity facing said points at the extremities of said pair of strips, and a semi-conductive crystal having one surface affixed to said extremity of said third strip and having another surface in resilient contact with said points at the extremities of said pair of strips.

3. A transistor unit including in combination, a flat insulating base member having a pair of ends, a pair of metallic resilient strips anchored to one surface of said base and extending beyond one end of said base to form respective terminals for the element, said strips further extending along said surface toward the other end of said base in spaced parallel relation, said strips having a pair of points formed at the respective extremities thereof remote from said one end of said base, an insulating spacer interposed between said extremities of said strips to space said points a selected amount one from the other, a third metallic resilient strip anchored to said surface of said base adjacent one end thereof and extending beyond said last mentioned end to constitute a terminal for the element, said third strip further extending along said base on an axis parallel to and intermediate said pair of strips with an extremity facing said points at the extremities of said pair of strips, and a semiconductive crystal having one surface affixed to said extremity of said third strip and having another surface in resilient contact with said points.

4. A transistor unit including in combination, a flat insulating base member having a pair of ends, a pair of metallic resilient strips anchored to one surface of said

base and extending along said surface from one end of said base toward the other end thereof in spaced parallel relation, said strips each having a looped section extending upwardly from said surface and having a pair of points formed at the respective extremities thereof remote from said one end of said base, said points facing said other end of said base and resiliently biased toward said other end by said looped sections of said strips, an insulating spacer interposed between said extremities of said strips to space said points a selected amount one from the other, a third resilient metallic strip anchored to said surface of said base and extending from said other end of said base toward said one end thereof, said third strip extending along said surface on an axis parallel to and intermediate said pair of strips with the extremity of said third strip remote from said other end of said base having a looped configuration to present a face of said third strip to said points at the extremities of said pair of strips, and a semi-conductive crystal having one surface affixed to said face of said third strip and having an opposite surface in resilient contact with said points.

5. A transistor unit including in combination, a flat insulating base member having a pair of ends, a pair of metallic resilient strips anchored to one surface of said base adjacent one end thereof and having respective intermediate portions extending along said base toward the other end of said base in spaced parallel relation, said strips having end portions remote from said one end of said base turned inwardly so that the extremities of said end portions face one another on an axis parallel to and intermediate the axes of the intermediate portions of said strips with pointed corners of said respective extremities facing said other end of said base, an insulating spacer interposed between said extremities of said strips to space said corners a selected amount, a third resilient metallic strip anchored to said surface of said base and extending from said one end of said base toward said other end intermediate said pair of strips and in spaced parallel relation thereto, said third strip extending beyond said corners of said pair of strips and having a bent-over end portion extending perpendicularly to said surface of said base and facing said corners, and a semi-conductive crystal having one surface affixed to said bent-over portion of said third strip and having an opposite surface in resilient contact with said pointed corners.

6. A transistor unit including in combination, a flat insulating base member having a pair of ends, a pair of metallic resilient strips anchored to one surface of said base adjacent one end thereof and having respective intermediate portions extending along said base toward the other end of said base in spaced parallel relation, said strips having end portions remote from said one end of said base turned inwardly so that the extremities of said end portions face one another on an axis parallel to and intermediate the axes of the intermediate portions of said strips with pointed corners of said respective extremities turned downwardly to face said surface of said base, an insulating spacer interposed between said extremities of said strips to space said corners a selected amount, a third resilient metallic strip anchored to said surface of said base and extending along said surface intermediate said pair of strips and in spaced parallel relation therewith, said third strip extending under and beyond said corners of said pair of strips and having an end portion facing said corners, and a semi-conductive crystal having one surface affixed to said end portion of said third strip and having an opposite surface in resilient contact with said pointed corners.

7. A transistor unit including in combination, a flat insulating base member having a pair of ends with an aligned series of three rectangular apertures adjacent and parallel to one of said ends, a pair of metallic resilient strips anchored in the outer two of said apertures and having respective intermediate portions extending along said base toward the other end of said base in spaced parallel relation, said strips having end portions remote from said one end of said base turned inwardly so that the extremities of said end portions face one another on an axis parallel to and intermediate the axes of the intermediate portions of said strips with pointed corners of said respective extremities turned downwardly to face said surface of said base, an insulating spacer interposed between said extremities of said strips to space said corners a selected amount, and a third resilient metallic strip anchored in the intermediate one of said apertures in said base and extending along said surface intermediate said pair of strips and in spaced parallel relation therewith, said third strip extending under and beyond said corners of said pair of strips and having an end portion facing said corners, and a semi-conductive crystal having one surface affixed to said end portion of said third strip and having an opposite surface in resilient contact with said pointed corners.

8. A circuit element including in combination, a base member, a pair of resilient metallic strips, means for supporting said strips in spaced and mutually insulated relation on said base with said strips extending in substantially the same direction from said supporting means and having free extremities remote from said supporting means, and a semi-conductive member supported on said base, with said free extremities of said strips establishing respective resilient contact with said semi-conductive member.

9. A circuit element including in combination, a base member, a pair of resilient metallic strips, means for supporting said strips in spaced and mutually insulated uni-planar relation on said base with said strips extending from said supporting means parallel to a surface of said base, said strips having free ends remote from said supporting means and said free ends having pointed bent-over extremities facing said surface of said base, and a semi-conductive member supported on said base, with said pointed bent-over extremities of said strips establishing respective resilient contact with a surface of said semi-conductive member.

10. A circuit element including in combination, a base member, a pair of resilient metallic strips mounted in spaced contiguous mutually insulated relation on said base member with said strips extending along said base member and having free extremities adjacent one another, and a semi-conductive member supported on said base member, with said free extremities of said strips establishing respective resilient contact with said semi-conductive member.

11. In a transistor, an elongated resilient plate-like base electrode, an insulating plate to which the electrode is secured, a semiconductor member secured to one end of the base electrode, an elongated resilient plate-like emitter electrode having a sharp end and secured to the insulating plate in contact therewith and extending therealong, and an elongated resilient plate-like collector electrode having a sharp end and mounted on the insulating plate in contact therewith and extending therealong.

12. A transistor comprising an insulating plate, a base electrode mounted on the plate, a semiconductor crystal mounted on the base electrode, and leaf spring emitter and collector electrodes having contacting ends and mounted on the plate in positions in which the contacting ends bear against portions of the crystal adjacent to one another, said emitter and collector electrodes being secured to the plate in positions extending therealong.

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