

July 3, 1956

J. F. BARRY
POINT CONTACT TRANSLATORS

2,753,495

Filed April 8, 1952

3 Sheets-Sheet 1

FIG. 1

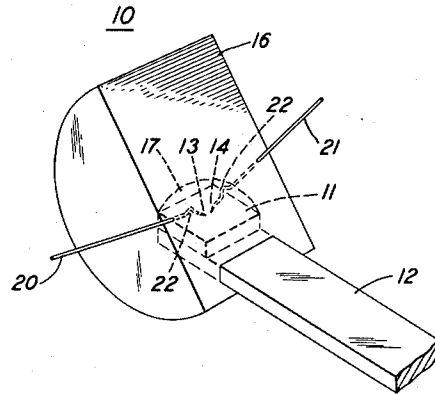
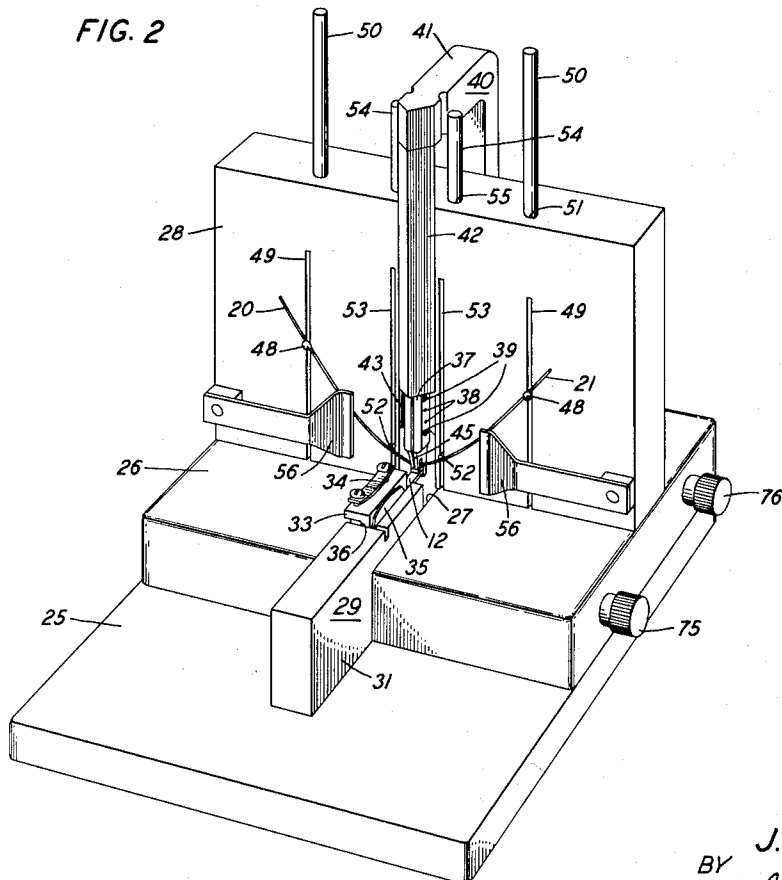


FIG. 2



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FIG. 3

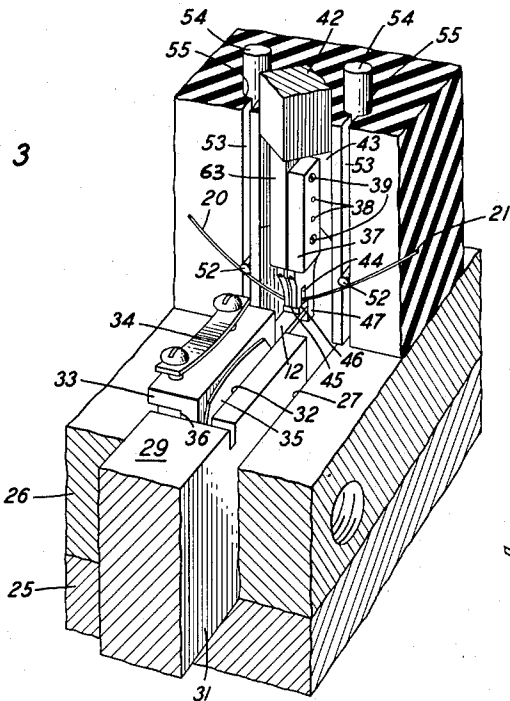


FIG. 6A

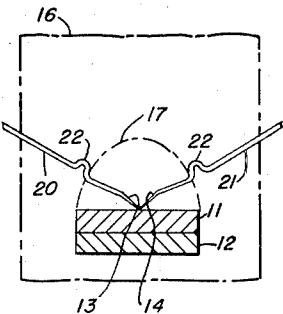


FIG. 6B

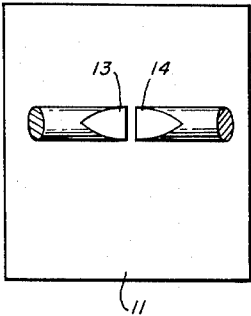
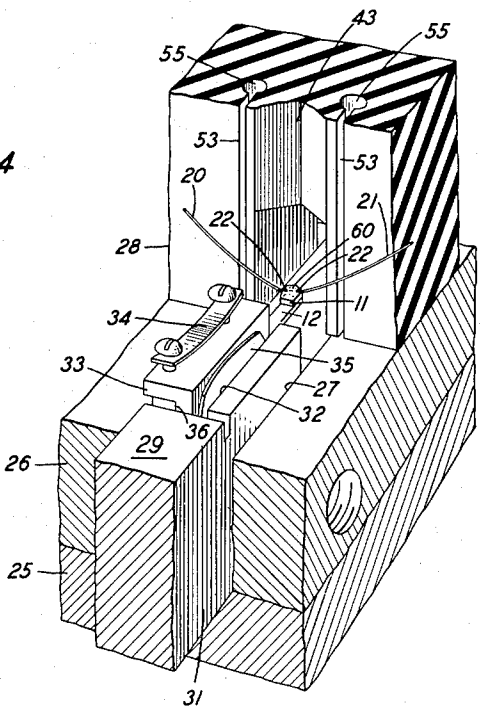


FIG. 4



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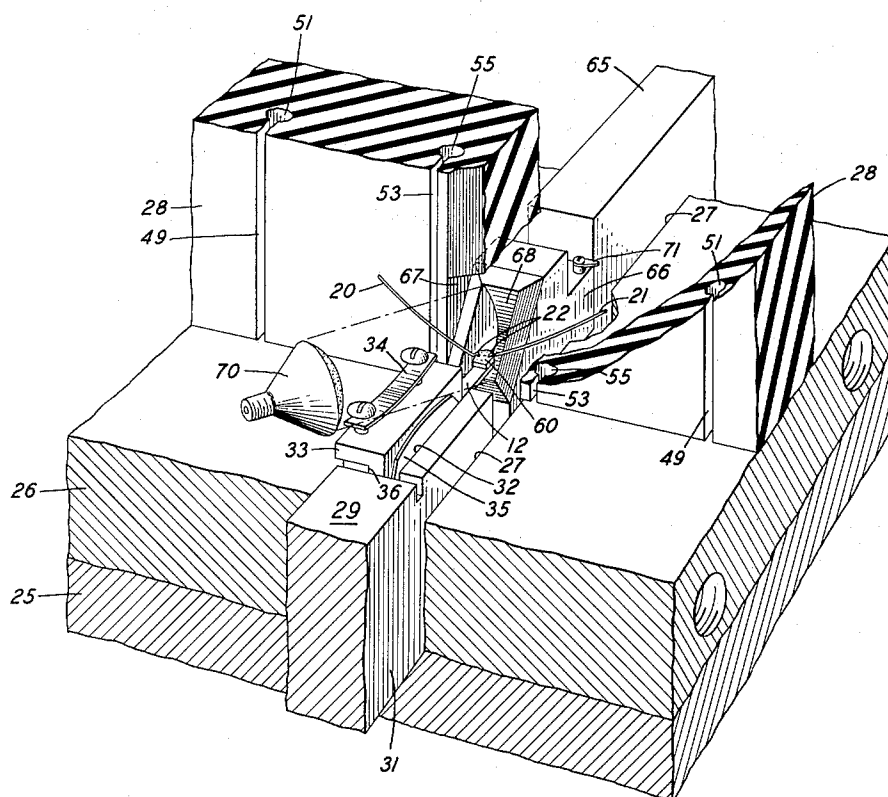
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FIG. 5



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POINT CONTACT TRANSLATORS

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Application April 8, 1952, Serial No. 281,233

15 Claims. (Cl. 317—235)

This invention relates to point contact semiconductive translators and to methods and apparatus employed in their manufacture.

One general object of this invention is to improve semiconductor translators.

Another object is to facilitate the manufacture of semiconductor translators of the point contact type.

A further object is to simplify the methods of and apparatus for manufacturing semiconductive translating devices having critically spaced point contacts.

One feature of this invention resides in a beaded point contact, semiconductive translator construction wherein a transversely loaded cantilever wire contact is positioned on the semiconductive wafer to form a highly stable structure. This construction lends itself to methods of fabrication which eliminate to a large extent the requirement for the positioning of the contact with micromanipulators and in the case of a translator having more than one point contact, particularly where critical spacing of the contacts is involved, it also eliminates the need for inspection and adjustment under a microscope.

Another feature resides in the method of mounting critically spaced contacts wherein the contacts are positioned on the surface of a semiconductive wafer abutting the opposite faces of a shim, transversely loaded to the desired contact pressure and wire distortion, clamped in position, and beaded.

A further feature resides in the apparatus for assembling the elements of a translating device wherein the various elements are fixed in prescribed relation by reference surfaces against which they abut and by guides which in combination with the reference surfaces eliminate the need for precise adjusting and inspecting techniques.

The above and other objects and features of this invention will be more fully appreciated from the following detailed description when read in conjunction with the accompanying drawing in which:

Fig. 1 is a perspective view, partially in phantom, of a typical translating device constructed in accordance with this invention;

Fig. 2 is a perspective view of the apparatus employed in the manufacture of the device shown in Fig. 1;

Figs. 3, 4, and 5 are enlarged perspective views of a broken-away portion of the apparatus of Fig. 2 showing a translating device in various stages of fabrication; and Figs. 6A and 6B are respectively an enlarged front elevation and an enlarged plan view showing the details of the relationship between the contacts and semiconductor of the translating device shown in Fig. 1.

Referring now to the drawing, a triode semiconductive translating device 10 having elements which function electrically as those disclosed in Patent 2,524,035 granted October 3, 1950 to J. Bardeen and W. H. Brattain, and which has been termed a transistor is shown. This transistor comprises a semiconductive wafer 11, for example of silicon or germanium, mounted on a metallic ribbon

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12 which may be of copper with an ohmic connection therebetween, termed the base connection. A pair of point contacts 13 and 14 engage one surface of the semiconductive wafer in such relationship that electrical interaction can occur between them. One contact 13, the emitter, may be connected to the ribbon 12 through an input circuit while contact 14, the collector, is connected to the base connection 12 through an output circuit. The size of a typical transistor and the difficulties in its manufacture resulting therefrom can be appreciated from a consideration of the dimensions of the illustrated unit which comprises a germanium wafer 20 mils thick and 50 mils on a side soldered to a copper base ribbon 20 by 50 mils in cross section and contacted within a 15 mil radius of the geometric center by a beryllium copper emitter wire 5 mils in diameter and a Phosphor bronze collector wire 5 mils in diameter. These contact wires are chisel pointed to form line contacts which are parallel, aligned and spaced 2 mils apart as can best be seen in Figs. 6A and 6B. Uniform contact pressure must be established and contact must be maintained throughout the operational life of the device.

This structure is encased in a bead 16 of a styrene-polyester casting resin which contains a cavity 17 containing a soft protective material such as polyethylene-polyisobutylene surrounding the point contacts and the semiconductor surface. This housing construction is disclosed in the application of J. V. Domaleski, E. L. Gartland, and J. J. Kleimack, Serial No. 198,294, filed November 30, 1950, now Patent No. 2,668,110.

In accordance with one feature of the present invention, the translator structure differs from that disclosed in the above-mentioned application in the arrangement of the contact wires. These wires are mounted in stable equilibrium as transversely loaded cantilevers rather than the conventional column form wherein an intermediate bend, usually a C-shape, provides resiliency. Among the advantages of the present construction are a reduction of the tendency for the point to shift its location on the semiconductive surface and the creation of a tendency for the point to return to its original position when it does shift. Thus, in the present construction the emitter and collector wires 20 and 21 are formed with flat chisel points 13 and 14 which provide line contacts and ends which are bent slightly towards the wafer surface from the axes of their straight portions, in the cavity 17. An anchor bend 22 is formed in the contact wires with its plane normal to the line of the chisel contact edge. These anchor bends are embedded in the cast casing or bead of the unit to secure the wires in position, and, as will be explained below they facilitate the proper orientation of the contact wires during the assembly operation.

A transistor can be constructed as shown in Fig. 1 by securing a semiconductive wafer to a conductive member by a base connection which should be low resistance and ohmic. Contacts can then be applied to the wafer-conductor subassembly by placing their pointed ends on the wafer, supporting them at or near their ends spaced from the wafer and loading them transversely so that a contact pressure is established between the wafer and the points. The relationship of the elements can then be fixed.

One advantageous method of establishing the proper spacing between the critically spaced contacts is to support the contact bodies, wires in the present case, although sheet members may also be used, with a restricted portion thereof engaging the semiconductive surface and abutting the opposite sides of a spacer which is held against the surface. The contact bodies are supported as simple beams; they are supported at an angle to the plane of the semiconductive surface they contact, at points at or near their ends. More particularly they are sup-

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ported at their contact ends by the semiconductive body and held at an angle to the supporting surface of that body ranging from about 45 degrees to about 70 degrees by a support spaced a substantial distance from the contact ends. The contact ends are abutted against the opposite faces of the spacer so that their separation is fixed by the spacer. Further, when straight chisel edges are formed on the contact bodies and the bodies are maintained in a common plane and abut the spacer, the line contacts formed by the chisel edges are parallel and aligned with each other. A transverse load is then applied to the contacts intermediate the supports to establish a desired contact force and distortion. When the semiconductive surface is horizontal and the contacts are at an angle to the horizontal the loading is applied as a free weight thereby eliminating the usual axial micrometer loading. The loaded contacts are then fixed in position as by clamping. A housing may then be applied to the structure. Where a beaded housing is utilized, spring sections of the contacts are maintained free by forming a cavity in the bead in the region of the contacts and solidifying a bead over a portion of the contact bodies while they remain distorted; thus spring compression holds the contacts on the surface through changes which might otherwise produce their shifting. One way of forming a beaded housing comprises removing the spacer from between the clamped contacts, encompassing the regions of contact between the contact bodies and the semiconductor with a mass of viscous fluid, coating the mass with a tough membrane of lacquer, and then applying a mass of hardenable material over the assembly to embed a portion of all the elements and enclose the fluid mass.

A transistor as shown in Fig. 1 can be fabricated in the apparatus of Fig. 2. This apparatus functions as a multiple purpose jig to insure the establishment and maintenance until a bead casing is cast around the assembly, of the element relationships set forth above without the aid of a microscope, micrometer adjustments or the hand adjustments heretofore employed. The apparatus comprises a base 25, a guide 26 on the base having a central slot 27 transverse the base, and a unitary support and reference member 28 having its major surfaces normal to the major surface of the base 25 and the guide 26.

A holder 29 for the ribbon-wafer subassembly of a transistor is mounted in the guide slot 27 and is prearranged to fix the position of the wafer so that a plane defined by the longitudinal axis of the subassembly and a normal to the wafer surface coincides with a plane defined by normals to the surfaces of tool base 25 and reference member 28 and permits adjustment of the wafer position in the dimensions normal to member 28. Adjusting means (not shown) are provided in holder 29 whereby the position of the wafer may be shifted transverse the above planes in setting up the apparatus for use. This holder 29 as may best be seen in Fig. 4, comprises a block 31, having a groove 32 on its upper surface so positioned that one wall 36 provides a reference surface against which the side of ribbon 12 may be held to insure its proper orientation in the holder. A clamping member 33 cooperates with the bottom and reference wall 36 of the groove 32 to maintain the ribbon in position. Springs 34 and 35 bias member 33 to its clamping position and permit the release or insertion of ribbons.

The contact wires 20 and 21 of the transistor are supported against member 28 to define a plane parallel to that member. A wire positioning element 40 including a contact spacer and a pair of contact body guides is also supported on member 28. This wire positioner comprises a yoke 41 having a spring biased clamp (not shown) which engages the rear surface of member 28 to maintain and permit adjustment of the vertical position of the yoke. The yoke arm 42 engages the front surface of member 28 and is adapted to be slid vertically

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in slot 43. The structure which establishes the proper wafer-contact orientation, as may best be seen in Fig. 3, is carried on the lower end of arm 42. It comprises a two-piece body having a first portion 63 integral with arm 42 and a second portion 37 secured to the first by dowels 38 and screws 39 to permit the mounting of contact spacers or shims 45 of varying thicknesses therebetween. A slot 44 is formed in portions 63 and 37 to form a pair of contact body guides which are in a common plane, are parallel to the plane of member 28 and are oriented so that their rearmost limits are essentially common with that plane. Shim 45 extends to or below surface 46 which is parallel to the wafer surface and it divides slot 44 into separate contact guides. The thickness of this shim establishes the spacing of contacts 13 and 14 on the semiconductive surface. Since the point at which shim 45 engages the semiconductive surface determines the location of contacts 13 and 14 it is desirable in most constructions that this engagement occur at or near the center of that surface. Portions 47 of elements 63 and 37 extend downward from surface 46 behind slot 44 and are critically spaced from the slot to provide a wafer reference surface or stop.

In assembling a transistor, a ribbon-wafer subassembly is mounted in holder 29 which is then slid into slot 27. Arm 42 is adjusted in slot 43 so that surface 46 is approximately at the height of the upper surface of wafer 11. The holder 29 and arm 42 are so oriented that the plane defined by the axial center of the ribbon-wafer subassembly and a normal to the major surface of the wafer falls within shim 45. The holder 29 is slid toward member 28 until wafer 11 is engaged by stop or reference surface 47 and is clamped by means of set screw 75. This fixes the horizontal position of the ribbon-wafer subassembly relative to the wire positioner 40. Arm 42 is then adjusted so that the shim 45 engages the surface of the wafer. Chisel pointed contact wires 20 and 21 having their anchor bends 22 extending upward are then slid into opposite sides of the guides formed by slot 44 so that their points abut the intersections of the surfaces of the shim 45 and the upper surface of wafer 11. The contact wires are supported on their ends spaced from wafer 11 by headed pins 48 extending from slots 49 in member 28. These pins are secured to rods 50 in bores 51 in member 28 so that their heights can be adjusted to provide the desired contact angle between the wafer and the points 13 and 14. Having supported the wires as simple beams they are then transversely loaded to establish the proper contact pressure. This loading is applied by means of weighted pins 52 extending from slots 53 in member 28 and supported on rods 54 which are free in bores 55 in member 28. The loaded contact wires are then secured in position against the surface of member 28 by means of clamps 56.

Thus, the orientation of the contact points on the wafer surface is established by abutting the various elements against reference surfaces. Further, the line contacts of the chisel points are made to engage the wafer surface since they are formed normal to the plane of the anchor bends 22 and those bends are maintained normal to the wafer surface by the walls of slot 44. In constructing a transistor of the dimensions set forth above the end of arm 42 has slot 44 6.5 mils wide, shim 45 is 2 mils wide, and the slot and shim are oriented so that shim 45 bisects the wafer and slot 44 also bisects it when it is abutting reference surface 47.

A casing is applied to the clamped structure of Fig. 3 after removing the wire positioning element 40 as shown in Fig. 4. The device of Fig. 1 is provided with a cavity so that a portion of the contact wires are free. When these wires are cast while loaded that portion within the cavity has sufficient resilience so that contact is stable through any relative movement between the casing and the wafer such as that resulting from different rates of thermal expansion for these elements. The cavity 14 is

formed by applying a globule 60 to the upper surface of the wafer 11 of some material which remains fluid throughout the operating temperature of the device. A heated loop of wire can be employed as an applicator when the globule is of polyethylene-polyisobutylene, the material being picked up from a supply by dipping the loop therein. This globule should be sufficiently stable at the molding temperature of the casing that it does not shift its position or change its shape. A reinforcement in the form of a membrane of lacquer can be applied over the globule 60 by means of a fine brush to insure its stability. It is to be noted that the globule does not extend to the anchor bends 22 of the contact wires since these bends should be embedded in the walls of the cast casing.

A mold holder 65 is mounted in the extension of slot 27 to the rear of member 28 as shown in Fig. 5. This holder carries a mold 66 which may be secured thereto with pins (not shown) and is thermally insulated from it. The mold is provided with a heater housed in a suitable cavity (not shown) to facilitate the curing of the housing material therein. This mold heater may be of the resistance type having terminals 71. The holder is advanced in slot 27 so that mold 66 extends through aperture 67 in member 28 and mold cavity 68 encompasses wafer 11, globule 60, and the portions of ribbon 12 and wires 20 and 21 immediately adjacent the wafer. The mold is locked in position by set screw 76. The open face of the mold is then made horizontal by elevating the front edge of base 25 and the resin for the casing is poured into it. This resin, which may be Selectron supplied by the Pittsburgh Plate Glass Company, loaded with finely divided silica, milled glass fiber and pigment, is mixed with a catalyst. Its rate of curing may be accelerated with chemical accelerators and/or heat supplied by an infra-red lamp 70 and/or conductively and radiantly from integral means in the cavity block 66.

When the casting resin has cured to an extent that it is capable of maintaining the orientation of the transistor elements, wires 20 and 21 are released from clamps 56, ribbon 12 is released from holder 29, and mold holder 65 is slid through aperture 67 and removed from the assembly apparatus. The mold 66 can be released and the casting removed from its holder. If desired the mold may be placed in a curing oven to complete the curing of casing 16 after which the casing is removed from the mold.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of this invention. Numerous other arrangements and applications of this invention, particularly to devices having other than two critically spaced contacts, may be devised by those skilled in the art without departing from its spirit and scope.

What is claimed is:

1. In the fabrication of a transistor, or the like, comprising a semiconductive body and a pair of catwhiskers that make pressure contact with a plane surface of the body at respective closely spaced contact points, the method of precisely mounting and precisely loading the catwhiskers which comprises temporarily fixing a spacer on the surface normal thereto, said spacer having a thickness at its point of engagement therewith which is a function of the contact separation, positioning the catwhiskers on opposite sides of said spacer, each in contact with both its respective contact point and the spacer and each inclined oppositely in a common plane normal to said surface of the body, yieldably holding each catwhisker, as so positioned, at a place along its length that is separated from the contact point, applying a measured force to each catwhisker between its contact point and the said place at which it is yieldably held, the force being directed in said normal plane and more inclined with respect to said plane surface than the catwhisker, whereby each catwhisker tends to bend and to press against its contact point with a predetermined force, removing the

spacer and permanently securing the body and the catwhisker in the established relationship.

2. The method of fabricating a semiconductive translator having a pair of critically spaced restricted area contacts which comprises securing a semiconductive body to a conductive element with an ohmic connection, supporting the semiconductive body against a reference surface, fixing the position of the semiconductive body in the dimensions parallel to the plane of said reference surface, mounting a spacer on a surface of the semiconductive body, supporting a pair of contact wires in a plane which is fixed relative to said reference surface as simple beams with their contact ends abutting the body surface and spacer surface, the contact ends being on opposite sides of said spacer, applying a transverse load to the contact wires toward a plane containing the body, clamping the body, element and contact wires in their established relationship, removing the spacer element, applying a mass of viscous fluid to encompass that region including the portion of the body surface and a portion of the contact ends, and applying a mass of hardenable material over the assembly to enclose the body, fluid mass and portions of the contact wires and conductive element.

3. The method of fabricating a semiconductive translator having a pair of critically spaced restricted area contacts which comprises securing a semiconductive body to a conductive element with an ohmic connection, supporting the semiconductive body against a reference surface, fixing the position of the semiconductive body in the dimensions parallel to the plane of said reference surface, mounting a spacer on a surface of the semiconductive body, supporting a pair of contact wires in a plane which is fixed relative to said reference surface as simple beams with their contact ends abutting the body surface and spacer surface, the contact ends being on opposite sides of said spacer, applying a transverse load to the contact wires toward a plane containing the body, clamping the body, element and contact wires in their established relationship, removing the spacer element, applying a mass of viscous fluid to encompass that region including a portion of the body surface and a portion of the contact ends, mounting an open faced mold around the assembly, and pouring a quantity of hardenable material into said mold and over the assembly to enclose the body, fluid mass and portions of the contact wires and conductive element.

4. In the fabrication of a semiconductive translator, comprising a semiconductive body and a catwhisker that makes pressure contact with a plane surface of the body at a predetermined contact point, the method of precisely mounting and precisely loading the catwhisker which comprises, temporarily fixing a positioning spacer on the surface normal thereto, positioning the catwhisker in contact with both its respective contact point and the spacer, and inclined to said surface of the body, yieldably holding said catwhisker, as so positioned, at a place along its length that is separated from the contact point, applying a measured force to said catwhisker between its contact point and the said place at which it is yieldably held, the force being directed in a plane normal to said plane surface and more inclined with respect thereto than the catwhisker whereby said catwhisker tends to bend and to press against its contact point with a predetermined force, and then permanently securing the body and the catwhisker in the established relationship.

5. In the fabrication of a transistor, or the like, comprising a semiconductive body and a pair of catwhiskers that make pressure contact with a horizontal plane surface of the body at respective closely spaced contact points, the method of precisely mounting and precisely loading the catwhiskers which comprises, temporarily fixing a spacer on the surface normal thereto, said spacer having a thickness at its point of engagement therewith which is a function of the contact separation, positioning

the catwhiskers on opposite sides of said spacer, each in contact with both its respective contact point and the spacer and each inclined oppositely in a common plane normal to said surface of the body, yieldably holding each catwhisker, as so positioned, at a place along its length that is separated from the contact point, applying a measured force as a free weight to each catwhisker between its contact point and the said place at which it is yieldably held, the force being directed in said normal plane and more inclined with respect to said plane surface than the catwhisker, whereby each catwhisker tends to bend and to press against its contact point with a predetermined force, removing the spacer and permanently securing a body and the catwhisker in the established relationship.

6. Apparatus for fabricating semiconductive translators having a bent wire contact body whose axis lies in a plane, comprising a holder for a semiconductive body, a contact positioning element aligned with the body, said element containing a plane slot whose central plane intersects the body, said slot being at least as wide as the thickness of the contact wire and forming a contact guide, and means to load the contact wire while it is in said slot to establish a contact pressure between the contact and the body.

7. Apparatus for fabricating transistors comprising a semiconductive body support arranged to fix the position of a semiconductive body in two dimensions and permit the movement of the body in the third dimension, a contact positioning element, a stop on said element adapted to engage the semiconductive body on said support and thereby fix its position in the third dimension, contact body guides associated with said positioning element restricting the movement of the contact bodies transverse of the surface of the semiconductive body to be contacted, contact body supports spaced from the semiconductive body and cooperating therewith to maintain the contact bodies as simple beams, and means to apply a transverse load to the contact bodies intermediate said supports and the semiconductive body to establish contact pressure on the semiconductive body.

8. Apparatus for fabricating transistors comprising a semiconductive body support arranged to fix the position of a semiconductive body in two dimensions and permit the movement of the body in the third dimension, a contact positioning element, a stop on said element adapted to engage the semiconductive body on said support and thereby fix its position in the third dimension, contact body guides in a common plane associated with said positioning element restricting the movement of the contact bodies transverse of the surface of the semiconductive body to be contacted, a spacer having a thickness equal to the desired contact separation intermediate the guides and contacting the semiconductive surface, contact body supports spaced from the semiconductive body and cooperating therewith to maintain the contact bodies as simple beams, and means to apply a transverse load to the contact bodies intermediate said supports and the semiconductive body to establish a contact pressure on the semiconductive body.

9. Apparatus for fabricating transistors comprising a semiconductive body support arranged to fix the position of a semiconductive body in two dimensions and permit the movement of the body in the third dimension, a contact positioning element, a stop on said element adapted to engage the semiconductive body on said support and thereby fix its position in the third dimension, contact body guides associated with said positioning element restricting the movement of the contact bodies transverse of the surface of the semiconductive body to be contacted, contact body supports spaced from the semiconductive body and cooperating therewith to maintain the contact bodies as simple beams, and means to apply a transverse load to the contact bodies intermediate said supports and the semiconductive body to establish a contact pressure on the semiconductive body, clamps ar-

ranged to secure the loaded contact bodies in position and a mold adapted to encompass the semiconductive body and a portion of the contact bodies to enable a housing to be cast around them.

10. Apparatus for fabricating transistors comprising a first and a second reference surface, said surfaces being normal to each other, means for supporting a semiconductive wafer with its major surface parallel to said first reference surface, means for supporting a pair of wire contacts in a plane parallel to said second reference surface, and a contact positioning element supported by the body having said second reference surface, said element having a stop adapted to abut with an edge of a semiconductive wafer to fix its position in one dimension, said element having a portion projecting from said stop, said portion having a pair of slots arranged to receive the ends of contact wires and maintain them in registry with a wafer abutting the stop.

11. Apparatus for fabricating transistors having critically spaced restricted area contacts comprising a first and a second reference surface, said surfaces being normal to each other, a guide on said first surface, a support for a semiconductive body positioned in said guide and arranged for movement normal to said second surface, a contact positioner supported by the element having said second reference surface and adapted to be moved normal to said first surface and into engagement with a semiconductive body in said support, said contact positioner having a stop arranged to engage an edge of a semiconductive body in said support, a slot normal to said first reference surface and having its center plane parallel to said second reference surface and so spaced from said stop that it bisects a semiconductive body in said support and against said stop, said slot having a width at least as great as the thickness of the contact bodies of the transistor, a contact spacer having its center plane normal to said first and second reference surfaces and bisecting a semiconductive body in said support, said spacer having a thickness equal to the desired separation between contacts, contact supports on said second reference surface spaced from said contact positioner whereby the contact bodies are supported as simple beams when mounted in said slot and on the semiconductive body, and weights adapted to be secured to said contact bodies intermediate said support and said semiconductive body whereby the transverse load thereon establishes a desired contact pressure.

12. A structure for establishing a critical orientation between a pair of transistor contacts comprising a main body portion, a stop normal to and projecting from a surface of said body portion, said body having a slot extending to said surface, said slot being of substantially the same width as the thickness of the contact bodies, said body having a contact spacer intercepting said slot at said surface, said spacer having a thickness equal to the desired spacing of said contacts.

13. A structure for establishing a critical orientation between a pair of transistor contacts comprising a stop, contact body guides critically spaced from said stop and arranged to maintain the contact bodies in a common plane, and a spacer shim transverse said plane and arranged to engage the surface of a semiconductive wafer abutting said stop.

14. A structure for establishing the orientation between a semiconductive wafer of fixed dimensions and a pair of critically spaced point contacts comprising a main body portion, a stop on said body portion providing a reference surface against which an edge of the wafer is abutted, said body portion having a slot of sufficient width to receive the thickness of the contact bodies and being so spaced from said stop that its center plane bisects the contact surface of the wafer abutting said stop and is normal thereto, said body having a spacer normal to said slot and the contact surface of said wafer,

said spacer having a thickness equal to the point contact spacing.

15. A semiconductive translator structure comprising a semiconductive body, a conductive member, an ohmic connection between said body and said member, a pair of wires, a chisel edge on the end of each of said wires, said chisel edges engaging said body with a parallel critically spaced relationship, a buffer mass of fluid material on the portion of said body engaged by said wires and the ends of said wires adjacent said chisel edges, a resinous bead surrounding said body and buffer mass,

each of said wires having an anchoring irregularity embedded in said bead, the portion of said wires within said buffer mass being maintained on said body as transversely loaded cantilevers.

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