

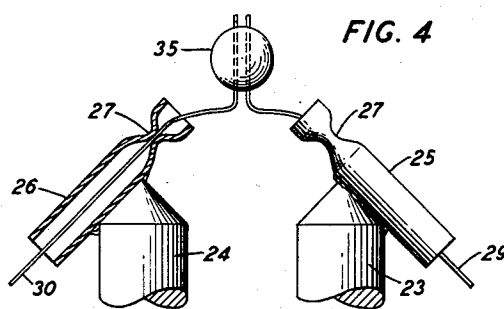
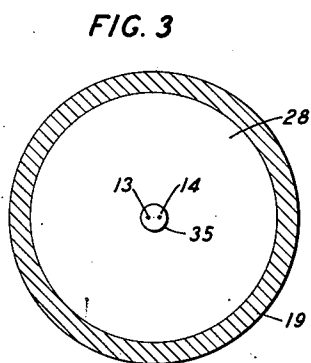
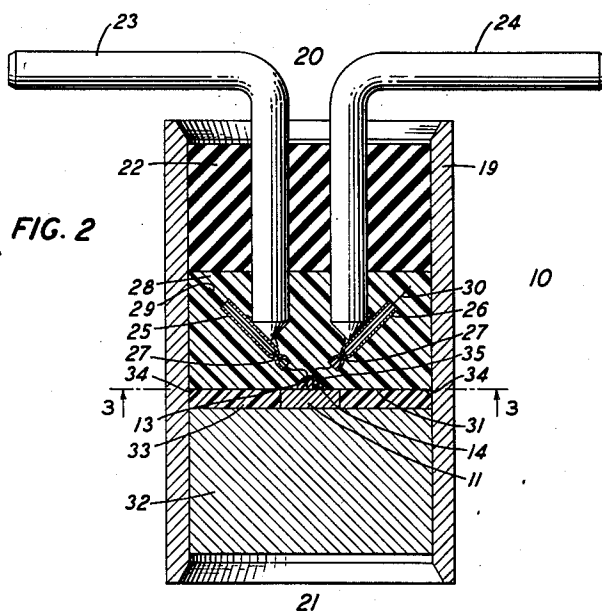
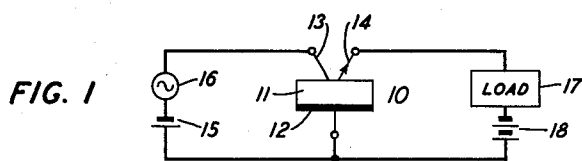
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SEMICONDUCTOR TRANSLATING DEVICE

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SEMICONDUCTOR TRANSLATING DEVICE

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This invention relates to translating devices and more particularly to translating devices including a body of semiconductive material on a surface of which a pair of closely spaced contacts bear, and to their methods of manufacture.

A translating device of the type to which this invention pertains, for such purposes as amplification, wave generation and the like, comprising a block of semiconductive material mounted on a conductive backing member and a pair of limited area contacts which make asymmetric connections with the surface of the semiconductor body sufficiently close together for mutual influence is disclosed in the application of John Bardeen and Walter H. Brattain, filed June 17, 1948, and assigned Serial No. 33,466 now Patent 2,524,035, issued October 3, 1950. One for of the device employs a pair of closely spaced fine wires which make rectifying contact with the surface of a block of semiconductive material, such as silicon or germanium.

The mechanical parameters of the elements of such translating devices are such that considerable difficulty is encountered in reproducing them, and in their handling and assembly. For example, one type of device employs a square germanium wafer 50 mils on a side and about half as thick, and a pair of contacts of 5-mil Phosphor bronze wire having pointed ends which contact the wafer surface with an optimum separation of 2 mils. This separation is not only difficult to obtain in manufacturing the devices, manual adjustment being necessary, but also tends to be unstable when the unit is subjected to vibrations and temperature changes.

One object of this invention is to improve translating devices of the type discussed above. More specific objects of this invention are to provide a translating device structure and method of making such a structure in which contact area, spacing and surface conditions may be controlled to an extent greater than heretofore possible.

In accordance with one feature of this invention, in a semiconductor translating device of the general construction described hereinabove, a prescribed contact area and spacing of the contacts are realized expeditiously and the spacing is maintained accurately at the desired magnitude even though the device be subjected to mechanical shocks or substantial temperature variations.

More specifically, in accordance with one feature of this invention, the two contacts are fabricated in a unitary assembly wherein the

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contacts are fixed in prescribed space relation and the contact ends thereof are fixed with respect to a reference surface of the assembly, the semiconductor body is fabricated as a second assembly having a reference surface, and the two reference surfaces are related so that when one is placed against the other, the contacts bear against the semiconductive body with a pressure requisite for efficient operation of the device.

In one illustrative embodiment of this invention, the contacts in the form of wires are embedded in an insulating body, for example of a plastic, and end portions of the wires and one face of the insulating body are lapped or polished thereby to provide two end contact areas coplanar with the body face. The wire size is made such that, after the lapping or polishing, the contact areas are of prescribed magnitudes. The semiconductive body also is embedded in an insulating body and the two are lapped or polished to provide a surface in which a face of the semiconductor is coplanar with one of the insulator. The two assemblies are then mounted with the lapped or polished faces against each other. The contacts thus are positioned in the proper space relation against the semiconductive body and, as has been noted, the contact areas are of prescribed magnitudes. Hence, optimum relation of the body and contacts is realized with facility and maintained.

The above-noted and other features of this invention will be understood more clearly and fully from the following detailed description when read in conjunction with the accompanying drawings in which:

Fig. 1 represents one circuit employing a translating device constructed in accordance with this invention;

Fig. 2 is a sectioned elevational view of a translating unit illustrative of this invention;

Fig. 3 is a plan view of the contact assembly taken along line 3-3 of Fig. 2; and

Fig. 4 is a partial elevational view of the contact assembly of Fig. 2 at an intermediate stage of its manufacture.

Referring now to the drawing, Fig. 1 represents a circuit in which is employed a three-electrode translating unit 10 including a body of semiconductive material 11 having a base electrode 12, an emitter electrode 13 contacting the upper face of the body 11 and a collector electrode 14 which also makes contact to the upper face of the body 11 and is very close to the emitter 13. The emitter 13 is connected to

the base electrode 12 through a signal input 16, which may be a coupling transformer, and a battery 15, which biases it slightly positive relative to the base. The load 17 for the unit is connected in series with a battery 18, providing a negative bias on the collector relative to the base electrode 12, between the collector 14 and the base 12.

The unit 10 constructed in accordance with this invention, as disclosed in Fig. 2, is composed of three major portions: a cylindrical shell 19, a stem or contact assembly 20, and a semiconductor or base assembly 21.

The stem assembly 20 comprises an insulating plug 22 with conductive rods 23 and 24 of a material such as nickel molded therein. The ends of the rods 23 and 24 are conically shaped and tubes 25 and 26 of conductive material, such as nickel, are mounted on the sides of the cones, as by soldering or welding. Secured in the tubes 25 and 26 at their reduced portions are fine wires 29 and 30 forming at their respective ends the emitter 13 and collector 14, the spacing of which is critical in providing the proper translating action for a unit of this type. An encasing cylinder 28 of suitable insulating material is molded around the structure supporting the wires 29 and 30 to provide a rugged contact assembly having accurately spaced contacts which remain fixed during assembly and handling.

The semiconductor assembly 21 comprises a wafer of semiconductive material 11, for example germanium, mounted on a plug 32 of metal, such as brass, to which it is secured with a low resistance ohmic contact by copper plating the back surface of the wafer and soldering it to the plug. A cylinder of insulating material 33 is molded around the wafer to give mechanical stability to the structure.

In forming the stem or contact assembly, a special technique is employed in order to obtain the proper contact spacing and areas. Wire, for example of Phosphor bronze, having a cross-sectional area equal to the desired area of the contacts is wound, advantageously under tension, around a pair of spaced parallel posts having diameters or thicknesses equal to the contact separation desired, for example 2 mils, so that the two lengths of wire forming the sides of the loop are coplanar in a plane normal to the posts. Successful units have been made with one mil diameter wire. A small drop of thermosetting material which can be machined and polished and has a resistance to abrasion comparable to that of the wires, for example, a polyester-alkyd is placed at about 1/2-inch intervals along these parallel wires so that beads 35 are formed encasing both wires. The plastic is then set. This may be done in the case of the above-mentioned material by heating in air. The wires on one side of each bead are then cut and the free ends attached to the rods 23 and 24 of the stem assembly so that the portions within the bead 35 are parallel to the axis of the plug 22, by passing each of them through one of the tubes 25 and 26 and crimping them in the proper position inside the tubes as shown at 27 in Figs. 2 and 4. The assembly at this stage in its construction appears as disclosed in Fig. 4. Next a plastic cylinder, which may be of the same material as the bead 35, and having a diameter equal to that of the plug 22 is molded around this assembly and over the bead 35.

The plastic cylinder is then milled down on a

plane 31 normal to the axis of the plug 22 until that plane cuts into the bead 35 a sufficient distance to insure that the wires are properly spaced, parallel, and perpendicular to the milled surface. This plane surface 31 and the coplanar ends of the contact wires are then carefully polished to complete the stem assembly, the similarity in the resistance to abrasion of the wire and the plastic producing a substantially continuous plane having an appearance as shown in Fig. 3.

The semiconductor assembly is produced by plating and tinning one surface of a wafer 11 of some semiconductive material such as germanium and sweating that surface to the end of the plug 32. A plastic cylinder 33 which may be of a polyester-alkyd having resistance to abrasion comparable to that of the germanium is molded around the wafer and is milled and polished down on a plane perpendicular to the axis of the plug 32 until a plane containing a highly polished semiconductor surface surrounded by a smooth plastic is produced.

The germanium surface may then be subjected to an etching process to improve its translating properties. One such process comprises immersing the exposed surface of the wafer in a solution, which may be composed of the following materials in the proportions indicated:

5 cc. of H_2O_2
20 cc. of distilled water
5 cc. of HF (48% hydrofluoric acid)

The wafer and surrounding plastic, which is not attacked by this etchant, is then washed in cool water and dried with an air blast.

The unit is assembled by pressing the stem assembly 20 into one end of the cylindrical shell 19 and the semiconductor assembly 21 into the other end so that it contacts and moves the stem assembly a slight amount, thereby indicating that the two plane surfaces containing the contacts 13 and 14 and the semiconductor 11 are contacting each other with the proper pressure. It is to be noted that a chamfer 34 is provided on the plastic end 33 of the plug 32. This chamfer 34 permits a slight accumulation of foreign matter which might be picked up from the inner walls of the shell 19 while sliding in the assemblies 20 and 21 without keeping the contact areas separated, thereby insuring continuity between the contact wires and the wafer. Friction and the elastic forces of the elements are sufficient to maintain contact.

Units constructed in accordance with this invention are easily controlled and reproduced as to their mechanical characteristics. The particular difficulty encountered heretofore in the control of contact area, spacing, and position both in manufacture and in subsequent operation of translating units of this type are overcome. With this structure the fine wire contacts, which heretofore have been left exposed until final assembly and therefore subject to damage, are embedded in a plastic cylinder thereby stabilizing their mechanical qualities and permitting easier handling. Contact area can be controlled by choice of cross-section area of wire, contact spacing and position are fixed within the bead 35, and contact pressure is limited by the large areas which engage each other.

While the above disclosure has been limited to a single embodiment it is to be understood that many modifications of this structure and method are within the scope of this invention. For example, a spring-loaded assembly might be

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employed for higher contact pressures or where the device is subject to expansion and contraction due to large changes in temperature; multiple contacts can be made employing the same techniques; and glass, ceramic, or other materials may be substituted for the plastic to obtain desired characteristics.

What is claimed is:

1. A signal translating device comprising a body of semiconductive material having a free plane face, a block of insulating material having a plane face, a pair of critically spaced wire contacts embedded in said insulating block and having end faces exposed and coplanar with said insulating plane face, and means holding said semiconductive body and said insulating block together with said plane faces bearing against each other and said end faces of said contacts bearing against the face of said body.

2. A signal translating device comprising a first block of plastic material having a semiconductive body embedded therein, said body having an exposed face coplanar with one face of said block, a second block of plastic material having a plane face, a pair of wire contacts embedded in said second block and having portions exposed and coplanar with said plane face, and means holding said first and second blocks together with said one and plane faces bearing against each other and said contact portions bearing against said exposed face of said body.

3. A signal translating device comprising a semiconductive body having a plane face, a pair of Phosphor bronze contacts having coplanar portions, a block of plastic material embedding said contacts and having a plane face coplanar with said coplanar contact portions, said plastic having substantially the same resistance to abrasion as said Phosphor bronze contacts, and means holding said body and said block together with said plane faces bearing against each other and said coplanar contact portions bearing against said face of said body.

4. A signal translating device comprising a first block of plastic material having a germanium body embedded therein, said plastic of said block having substantially the same resistance to abrasion as said germanium, said body having an exposed face coplanar with one face of said block, a second block of plastic material having a plane face, a pair of Phosphor bronze wire contacts embedded in said second block and having end faces exposed and coplanar with said plane face, and means holding said first and second blocks together with said one and plane faces bearing against each other and said end faces of said contacts bearing against said exposed face of said body.

5. The method of manufacturing a signal translating device which comprises mounting a pair of contacts in critically spaced relationship, molding an insulating material around a portion of said contacts, mounting the free portions of

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said contacts on supporting members, polishing the contacts and embedding insulation to a plane surface, and mounting said plane surface against the plane surface of a semiconductor body so that the contacts bear against said body.

6. The method of manufacturing a signal translating device which comprises mounting a pair of contact wires in critically spaced relationship, molding a plastic bead around parallel lengths of said wires, severing the wires on one side of the bead, securing the free ends of said wires to conductive members, polishing a plane surface on the bead and embedding wires normal to the wires, and mounting said plane surface so that the wires bear against the plane face of a semiconductive wafer.

7. The method of manufacturing a signal translating device which comprises tensioning a pair of Phosphor bronze contact wires in critically spaced relationship, molding a bead of plastic having a hardness substantially that of Phosphor bronze around parallel lengths of said wires, severing the wires on one side of the bead, securing the free ends of said wires to conductive members, embedding said bead, said conductive members and said free ends in a plastic body, polishing a plane surface on said plastic body until the ends of said embedded wires within said bead are coplanar therewith, molding a second plastic body around a semiconductive wafer, polishing a plane surface on said second body until said wafer surface is exposed and mounting said plane surfaces in contact so that said contact wires bear against said exposed face of the wafer.

8. A signal translating device comprising a first unit assembly including a support having a reference surface and a semiconductive body fixedly mounted on said support and having a face portion in predetermined relation with said surface, a second unit assembly including a second support and a pair of contacts fixedly mounted thereby, said second support having a reference surface and said contacts having end faces in predetermined relation thereto, and means mounting said first and second assemblies with said reference surfaces in abutting relation, said predetermined relations being such that when said reference surfaces abut, said end faces bear against said face portion.

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