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ELECTRICALLY CONDUCTIVE DEVICE

Filed May 17, 1939

FIG. 1



FIG. 2



FIG. 3

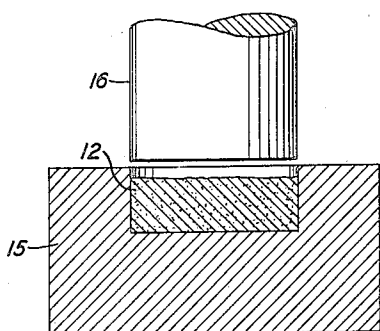


FIG. 4

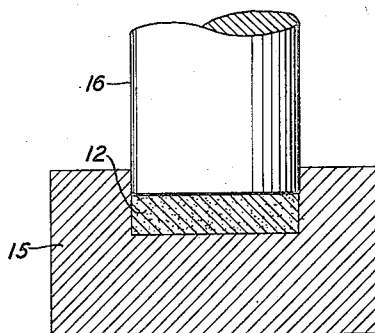


FIG. 5

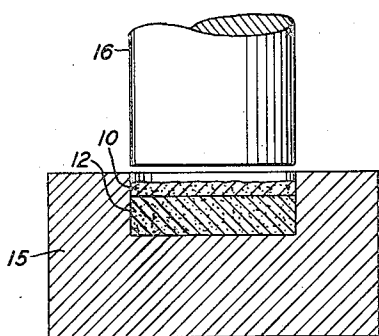
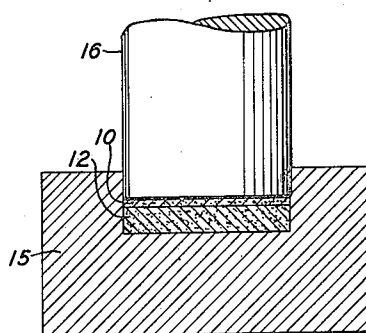


FIG. 6



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ELECTRICALLY CONDUCTIVE DEVICE

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15 Claims. (Cl. 175—366)

This invention relates to electrically conductive devices, particularly composite bodies comprising metallic and non-metallic portions, and to methods of manufacturing such devices.

In the manufacture of electrical devices, such for example, as rectifiers, non-linear resistances and circuit elements having a resistance which varies appreciably with temperature, it is often advantageous to combine in an integral unitary element several materials or portions conductive, semiconductive or nonconductive in character. For many purposes, the materials used may be classed in two general groups, one of metallic or electrically conductive materials and the other of non-metallic materials including both semiconductors and non-conductors of electricity.

One object of this invention is to simplify and to facilitate the manufacture of electrically conductive bodies comprising metallic and non-metallic portions.

Another object of this invention is to obtain a unitary self-sustaining composite electrically conductive unit.

In accordance with one feature of this invention, a composite electrically conductive body is fabricated by applying high pressures to a plurality of superposed layers of finely divided materials of different character to bond the layers together into a dense, self-supporting unit.

Another feature of this invention resides in a composite electrically conductive unit comprising a plurality of layers of metallic and non-metallic materials bonded together in a unitary body by interengagement of the boundary particles of adjacent layers.

The invention and the foregoing and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Figs. 1 and 2 show conductive units made in accordance with the invention; and

Figs. 3 to 6, inclusive, illustrate certain stages of a preferred method of making conductive units.

Referring now to the drawing, in Fig. 1, the conductive unit illustrated comprises a relatively thin layer of uranium oxide 10 firmly bonded to a thicker layer 12 of copper.

In Fig. 2 is shown a unit comprising a layer of copper 12 with a layer 13 of cuprous oxide firmly bonded thereto and a layer 14 of tin firmly adhering to the surface of the copper oxide.

Conductive units such as those illustrated in Figs. 1 and 2 may be made in the following manner: A measured quantity of fine metallic material such as copper powder 12, of 225 to 325 mesh, is placed and levelled in a die 15, as shown

in Fig. 3. The metallic powder is partially compressed by a plunger 16 as in Fig. 4. A suitable pressure is about fifteen tons per square inch. As shown in Fig. 5, the plunger 16 is then removed and a quantity of non-metallic material, for example, uranium oxide powder of about 325 mesh, preferably finer, is spread over the partially compressed metal and levelled. The pressure is again applied by the plunger 16, compressing the non-metallic powder and further compressing the metal powder. The pressure for this second compression may be of the order of one hundred tons per square inch or higher. This high pressure not only compacts the two layers but firmly bonds them together by interengagement of the adjacent particles of the two layers. The resulting unit is dense and relatively rugged. The foregoing figures as to grain size are merely illustrative and are not intended as limiting, since finer or coarser materials may be successfully bonded.

The first press on the metal powder is in the nature of a levelling operation insuring uniformity of thickness throughout the layer and a substantially plane surface for reception of the non-metallic powder. Such a step is desirable when the foregoing characteristics are important in the finished unit.

Suitable units for some purposes may be prepared by omitting the initial pressing of the powder first placed in the die. In this case, successive layers are placed in the die and the high pressure applied compacting and bonding in the same operation. For instance, a unit like that shown in Fig. 2 could be fabricated by charging the die 16 with successive layers of copper, cuprous oxide and tin powders and applying a pressure of about one hundred tons per square inch thereto.

The order of charging the materials into the die need not be that of the foregoing examples. For instance, the unit of Fig. 1 can be made by first placing the uranium oxide layer and then the copper or that of Fig. 2 by employing the order; tin, cuprous oxide and copper.

Various combinations of materials other than those illustrated may be employed for constructing circuit elements by this process. For example, a layer of conductive metal powder may be pressed on either side of a layer of insulating material, such as some of the relatively non-conductive oxides, to form a condenser type of device. Conductors and semiconductors may be supplied with integral insulating backings or covers and insulators surfaced with conducting material and so on.

Devices made in accordance with this invention may be connected in electrical circuits by making contact to opposite faces thereof. For example, the device shown in Fig. 1 may be em-

ployed as a thermally sensitive resistor by making circuit connections respectively to the uranium oxide and copper portions. The rectifier device illustrated in Fig. 2 would be connected in circuit contacting the tin and the copper layers.

Although specific embodiments of the invention have been shown and described, it will be understood that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. The method of making a composite electric circuit element that comprises superposing a plurality of layers of finely divided metallic and non-metallic materials, and applying pressure thereto to bond the layers together into a dense, self-supporting body.
2. The method of making a conductive unit that comprises charging a die with two or more layers of finely divided materials, at least one layer being of metallic material and at least one layer of non-metallic material, and applying a high pressure to bond said materials together and compact them into a dense body.
3. The method of making an electrically conductive unit that comprises applying moderate pressure to a first powdered material to compress it, removing the pressure, depositing a second powdered material upon the compressed material, and applying high pressure to compress the second material, further compress the first material and bond the two materials into a dense self-sustaining body, one of said materials being metallic and the other non-metallic.
4. The method of making an electrically conductive unit that comprises compressing a measured quantity of finely divided metal under moderately high pressure, applying a measured layer of finely divided non-metallic material thereto, and compressing at a much higher pressure, whereby the non-metallic material is firmly bonded to the metal and the resulting structure is sufficiently dense to be self-supporting.
5. The method of making an electrically conductive unit that comprises compressing a measured quantity of finely divided electrically conductive material under moderately high pressure, applying a measured layer of finely divided semi-conductive material thereto, and compressing at a much higher pressure, whereby the semi-conductive material is firmly bonded to the conductive material and the resulting structure is sufficiently dense to be self-sustaining.
6. The method of making an electrically conductive unit that comprises compressing a measured quantity of finely divided copper under moderately high pressure, applying a layer of finely divided uranium oxide thereto, and compressing at a much higher pressure, whereby the uranium oxide is firmly bonded to the copper and the resulting structure is sufficiently dense to be self-sustaining.
7. The method of making an electrically conductive unit that comprises compressing a measured amount of 225 to 325 mesh copper powder in a die at about fifteen tons per square inch, applying a layer of uranium oxide powder, finer than 325 mesh, to the surface of the compressed copper powder, and applying a pressure of approximately one hundred tons per square inch to the combination to firmly bond the uranium oxide to the copper.
8. An electrically conductive unit comprising a plurality of superposed layers of materials, at least two adjacent layers being of different materials, each layer comprising a densely compressed mass of finely divided particles of material, and the boundary particles of adjacent layers being interlocked to firmly bond the layers together in a self-supporting body.
9. An electrically conductive unit comprising a plurality of superposed layers of materials, at least two adjacent layers being respectively of a metallic and a non-metallic material, each layer comprising a densely compressed mass of finely divided particles of material, and the boundary particles of adjacent layers being interlocked to firmly bond the layers together in a self-supporting body.
10. A self-supporting body including an electrically conductive portion and comprising a plurality of superposed layers of different materials having different electrical conductivities, a layer of said plurality having an electrical conductivity, which is high relative to that of the other layers, each layer comprising a densely compressed mass of fine particles of material, and the boundary particles of adjacent layers being interlocked to firmly bond the layers together.
11. A conductive unit comprising a layer consisting of very fine particles of metallic material having thereon a layer consisting of very fine particles of non-metallic material, said particles of each layer being compressed into very dense masses, and the particles of each material at their adjacent surfaces interengaging to firmly bond the two layers together in a self-supporting body.
12. A conductive unit comprising a layer including very fine particles of electrically conductive material having thereon a layer of very fine particles of semiconductive material, said particles of each layer being compressed into very dense masses, and the particles of each material at their adjacent surfaces interengaging to firmly bond the two layers together in a self-supporting body.
13. An electrically conductive unit comprising a layer of semiconductive material between two layers of conductive material, each layer comprising a densely compressed mass of fine particles of material, and the boundary particles of adjacent layers interengaging to firmly bond the layers together.
14. An electrically conductive unit comprising a layer of copper, a layer of cuprous oxide, and a layer of tin, each layer comprising a dense compressed mass of fine particles of its particular material, and the particles of adjacent layers mutually interengaging to firmly bond the layers together.
15. An electrically conductive unit comprising a layer of copper, and a layer of uranium oxide, each layer comprising a densely compressed mass of finely divided particles of the particular material, and the boundary particles of copper and uranium oxide mutually interengaging to firmly bond the layers together.

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