July 6, 1965 G. A. GRANITSAS 3,193,364

METHOD OF MAKING ELECTRONIC DEVICES

Filed May 20, 1960



Fig. 1

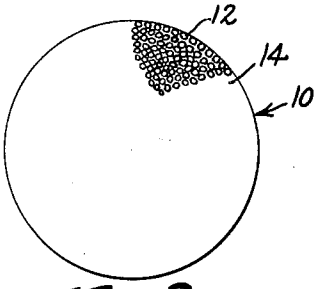


Fig. 2

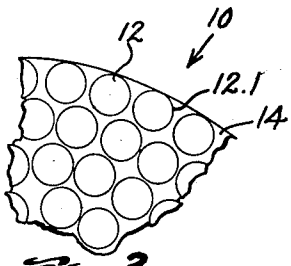


Fig. 3

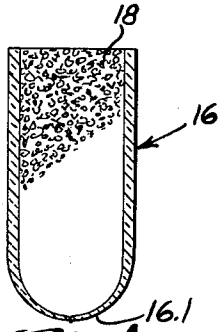


Fig. 4

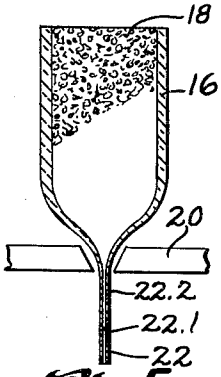


Fig. 5

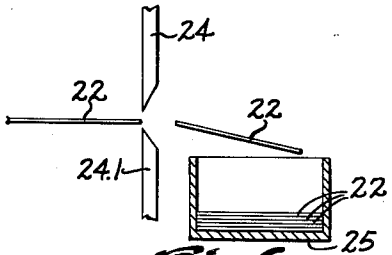


Fig. 6

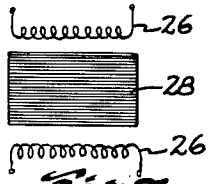


Fig. 7

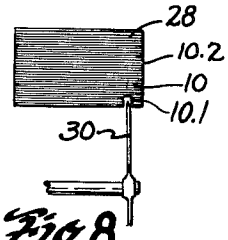


Fig. 8

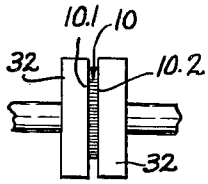


Fig. 9

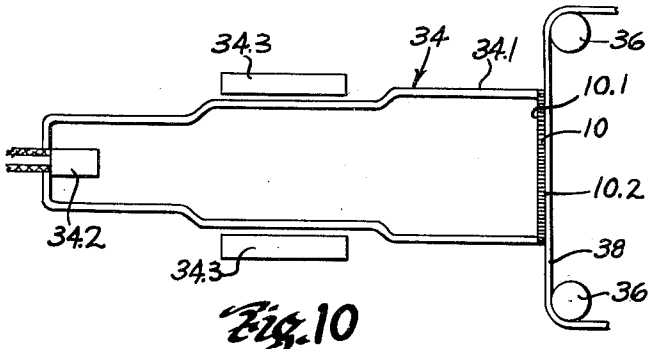


Fig. 10

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METHOD OF MAKING ELECTRONIC DEVICES

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3 Claims. (Cl. 65—4)

The field of this invention is that of electronic devices and the invention relates more particularly to a novel and improved electron image read-out or storage device and to a novel and advantageous method of manufacturing such a device.

An electronic read-out or storage device of the type with which this invention is concerned comprises a thin sheet or disc incorporating a multiplicity of electrical conductors which extend between the sheet faces in spaced, side-by-side relation within a matrix of insulating material, the conductor ends being exposed to receive and to transmit or retain an electron image or pattern projected upon one of the faces of the device by various means and being adapted to be scanned or otherwise sensed for reading out the charge pattern projected thereon. In devices of this sort, resolution of the electron image is enhanced by the uniformity of size between conductors, by the uniformity of conductor spacing within the matrix, and by the multiplicity of conductors within each surface area scanned or sensed by read-out means. Such devices are particularly useful in xerographic printing wherein the device is incorporated as the face plate of a cathode-ray tube, the electron gun of the tube being adapted to project an electron image upon one face of the device so that the device conductors transmit the electron image to the other face of the device to produce an electrostatic charge image upon paper tape or other suitable means disposed upon said other face. These devices can also be utilized in conjunction with suitable conductors leading away from such a cathode-ray tube face plate for exciting magnetic means to record an image projected by the tube upon magnetic tape.

It is an object of this invention to provide a novel and improved electron image read-out, a storage device of the character described which is adapted to accomplish maximal electron image resolution; to provide such a device having a multiplicity of electrical conductors of uniform size uniformly spaced within an insulating matrix; to provide such a device which can be manufactured in extremely thin form without having holes or passages extending between faces of the device; and to provide such a device in which the electrical conductors are adequately bonded within the insulating matrix. It is a further object of this invention to provide a novel and advantageous method of making such an improved electron image read-out or storage device; and to provide such a method which is simple, convenient and inexpensive.

Another object of this invention is to provide improved metallic fibers having insulating coatings which are useful in making the above-described electron image read-out or storage device; and to provide a simple, convenient, accurate and inexpensive method of making such fibers.

Briefly described, the electron image read-out or storage device provided by this invention comprises a multiplicity of homogeneous, electrically-conductive members, such as metallic fibers having an initial coating of an insulating material such as glass, which are disposed in uniformly spaced side-by-side relation within a matrix of insulating material, for example, by having the insulating coatings of the metallic fibers fused together, to form a thin, parallel-faced disc or sheet in which the conductive members extend between opposite faces of the sheet to expose ends of the conductors for providing scanning surfaces on the device. According to this invention, the coefficient of thermal expansion of the electrically-conductive members and of the insulating matrix correspond in the normal temperature range, that is, in the range of temperatures to which the device will be subjected during use, but the conductive members are expanded into air-tight connection to the matrix.

In the method of this invention, there is provided a tube of insulating material such as a soda lime glass material, preferably having one closed end, and an electrically conductive metallic alloy, preferably including germanium and most advantageously comprising a gold and germanium alloy having between 4% and 12% germanium content. The tube and alloy are each adapted to be drawn when heated to the same predetermined temperature, and are adapted to have substantially the same coefficients of thermal expansion in the normal temperature range, but the alloy is adapted to have a coefficient of thermal expansion which is less than that of the tube material, preferably having a negative coefficient of thermal expansion, in at least a portion of the temperature range between said predetermined drawing temperature and said normal temperature range. The alloy is disposed within the tube, for example in particle form, and the tube and alloy are heated to said predetermined temperature, wherein the particles will join into a homogeneous mass, and is drawn with the tube for forming glass-coated metallic fibers. The fibers are then arranged in side-by-side relation for forming a bundle and the bundle is treated so that the fiber coatings are fused together, the bundle ends then being abraded or otherwise trimmed for determining bundle length and for providing scanning surfaces thereon.

Other objects and advantages of this invention will appear in the following, more detailed description of the device and method provided by this invention, the description referring to the drawings wherein:

FIG. 1 is a plan view of the electron image read-out or storage device;

FIG. 2 is a side elevation view of the device of FIG. 1;

FIG. 3 is a partial plan view of the device to greatly enlarged scale;

FIG. 4 is a diagrammatic view illustrating the initial steps in the method of making the electron image device according to this invention;

FIG. 5 is a diagrammatic view showing subsequent steps in said method;

FIG. 6 is a diagrammatic view illustrating further subsequent steps in said method;

FIG. 7 is a diagrammatic view showing further subsequent steps in said method;

FIG. 8 is a diagrammatic view showing an intermediate step in said method which can be included in the method if desired;

FIG. 9 is a diagrammatic view indicating the final step of said method; and

FIG. 10 is a diagrammatic view illustrating use of the device provided by this invention.

Referring to the drawings, **10** in FIGS. 1 and 2 indicates the electronic read-out or storage device provided by this invention which comprises a multiplicity of homogeneous, electrically-conductive members **12** disposed in uniformly spaced, side-by-side relation within a matrix **14** of insulating material for forming a relatively thin, wafer-like disc or sheet having opposed faces **10.1** and **10.2**, the electrically-conductive members extending between the parallel disc faces and having their ends exposed. The preferably parallel faces of the disc are smoothly finished or polished so that the plane of each face subtends each conductive member to provide the members with substantially equal surface areas and with clearly-defined edges **12.1** in that plane as shown in FIG.

3. Preferably, the materials of which the electrically-conductive members and insulating matrix are comprised have substantially the same coefficients of thermal expansion in the normal temperature range, that is, within the range of temperatures to which the device will normally be subjected during use, and the electrically-conductive members are expanded into air-tight connection to the matrix material for a purpose to be described below.

According to this invention, a convenient and inexpensive method of manufacturing an electronic device of the character above described includes as steps the provision of a tube 16 of insulating material such as glass or a suitable plastic which is adapted to be drawn when heated to a predetermined temperature. The tube is preferably, but not necessarily, closed at one end, as at 16.1, and is disposed to receive an electrically-conductive metallic alloy 18 therein. The metallic alloy is preferably provided in particle form and is closely packed within the tube by vibrating the tube or by other suitable means, but within the scope of this invention, the alloy can comprise a rod inserted within the tube 16 or can be introduced within the tube in any convenient manner. The alloy is adapted to be drawn when heated to said predetermined tube-drawing temperature, and, when the alloy is provided in particle form, must also be adapted to fuse at said predetermined temperature. Preferably also the materials comprising the insulating tube and the metallic alloy have substantially the same coefficients of thermal expansion in the normal temperature range, but most advantageously, the alloy has a coefficient of thermal expansion within at least a portion of the temperature range between said drawing temperature and said normal temperature range which is less than that of the selected insulating material.

An alloy ideally suited for these purposes comprises an eutectoid alloy of germanium and gold, preferably having between 4% and 12% germanium content, which is adapted to fuse and to be drawn at a temperature between 475° and 600° centigrade. Such an alloy has a melting point closely corresponding to the eutectic melting point of gold and germanium alloys, has good drawing qualities, and has a relatively high tensile strength. Further, such an alloy has a negative coefficient of thermal expansion as it cools from said drawing temperature, but has a positive coefficient of thermal expansion in the normal useable temperature range. An insulating tube material suitable for use with such an alloy can comprise a soda lime glass which can be readily adapted to be drawn at a temperature corresponding to the drawing temperature of the alloy and which can be adapted to have a positive coefficient of thermal expansion corresponding to that of the alloy in the normal temperature range. Further, it should be noted that a germanium alloy in fluid or semi-fluid form will tend to wet glass so that the above-described metallic alloy and insulating material can be associated in the manner set forth below for forming an air-tight connection therebetween.

When the alloy is disposed within the tube of insulating material, the tube and alloy are heated by conventional means, for example, by the heater means 20 diagrammatically indicated in FIG. 5. The alloy particles within the tube are fused and thereafter the tube is drawn, preferably from the closed end thereof, to form a glass-coated metallic fiber 22. The fiber is then permitted to cool so that the drawn fiber core 22.1 composed of the germanium alloy 18 expands slightly as a result of its negative coefficient of thermal expansion in cooling from drawing temperature, and so that the fiber cladding 22.2 composed of the soda lime glass 16 contracts slightly as a result of its positive coefficient of thermal expansion, thereby to attach the core and cladding in air-tight connection.

After formation, the coated fibers 22 are cut into substantially equal lengths by conventional means, such as the fiber cutting tool 24 and block 24.1 diagrammatically illustrated in FIG. 6, and the fibers are arranged in side-by-side relation within a container 25 for forming a bundle as shown in FIG. 6. Preferably, the fiber lengths are aligned within the bundle by a suitable technique such as that disclosed in an application filed February 14, 1958, in the name of Wilfred P. Bazinet, Jr., Serial No. 715,406, now Patent No. 2,992,956 issued July 18, 1961 and thereafter the bundle is treated, preferably by heating the bundle by use of the heater coils 26 diagrammatically illustrated in FIG. 7 if the fiber cladding is of a glass material. This is to bond or fuse the fiber claddings together to form the integrated bundle unit 28.

The gold and germanium alloys above described have relatively low fusing and drawing temperatures in addition to the desirable characteristics of thermal expansion noted above and therefore can be simultaneously drawn with a common glass such as crown or other soda lime glasses to form glass-coated metallic fibers of high strength. Such fibers can be readily heated for fusing the fiber coatings together without weakening the fibers or reducing the quality of the bond between the metallic fibers and their coatings. However, it should be understood that these and other alloys of germanium and gold can include approximately 5% of copper, nickel, silver or platinum and can have substantially the same characteristics as the alloys above described. In addition, alloys of germanium and silver including between 5% and 90% germanium may be used as they also are adapted to wet glass and to have negative coefficients of thermal expansion as they cool from drawing temperature, but these alloys have significantly higher drawing temperatures ranging from 650° centigrade to about 900° centigrade. Accordingly, these alloys can be simultaneously drawn only with glasses of higher melting temperature such as the silicate glasses, under the tradenames Pyrex and Vicor which have melting temperatures of approximately 600° centigrade and 1000° centigrade respectively. Further, certain low melting alloys such as the alloy of indium and tin under the tradename Cerroseal can be used and drawn simultaneously with various glasses to form glass coated metallic fibers, these alloys having melting temperatures between 240° Fahrenheit and 260° Fahrenheit and having negative coefficient of thermal expansion as they cool from melting temperature. However, such alloys tend to melt and to flow from within their coatings as the fibers are heated by fusing the fiber coatings together. Accordingly, the ends of fibers formed of such alloys must be sealed by any suitable means having a higher melting temperature than the coating glass during formation of a fiber bundle, the fiber sealing means being thereafter removed during trimming of the bundle ends to provide scanning surfaces thereon.

The integrated bundle unit 28 is then cut transversely of the fiber axes, for example, by means of the diamond-tooth saw 30 diagrammatically shown in FIG. 8 or other conventional means, for providing thin wafer-like discs or sheets 10 having parallel faces 10.1 and 10.2. The disc surfaces are then abraded or polished in any conventional manner, for example with grinding wheels as indicated at 32 in FIG. 9, for providing surfaces to be scanned or sensed by various means. Although in the method herein described, the fibers forming the integrated bundle 28 are of substantial length so that the bundle can be cut transversely of the fiber axes for forming several discs 10, it should be understood that, if the fibers are cut into relatively short lengths prior to formation of the integrated bundle, the bundle ends could be abraded both for polishing the ends to provide scanning surfaces thereon and for reducing bundle length to form a single disc 10.

As will be readily understood, in the disc 10 formed

by the above-described method, each electrically-conductive member 12 comprises the core 22.1 of a fiber 22 and the matrix 14 is formed of fused fiber claddings 22.2. Since such fibers can be conveniently and inexpensively drawn to very small, relatively uniform diameter with a relatively thin cladding, and in fact can be assembled in bundled relation and redrawn as a bundle to form even smaller, more uniformly sized fibers on the order of 25 microns diameter, it can be seen that the electron image read-out or storage device provided by this invention can be adapted to have a great multiplicity of electrical conductors uniformly spaced in each area of the device to be scanned or sensed by various means and that the proportion of conductive surface to matrix surface forming the disc surface 10.1 and 10.2 will be very high. However, each fiber core or electrically-conductive member is expanded into air-tight connection to its cladding or matrix so that, even though the disc 10 may be extremely thin, there is no tendency for the conductors to loosen and fall from within the disc matrix.

As shown in FIG. 10, the electronic device 10 provided by this invention can be incorporated within a cathode-ray tube 34 of otherwise conventional design to form the face plate of the tube, for example by being fused to the tube envelope 34.1, the tube including an electron gun 34.2 and conventional electron beam deflecting means 34.3 for forming an electron image upon the face 10.1 of the device in accordance with a signal received by the tube in a conventional manner. Suitable rolls 36 can be mounted adjacent the tube face plate for supporting a recording means such as the paper tape 38 which is adapted to receive an electrostatic charge. As will be readily understood, the electron image formed by the electron gun 34.2 upon the device face 10.1 will be transmittant through the device conductors 12 for producing a corresponding negative electrostatic charge image upon the tape 38, the electrostatic charge image being formed with very high resolution as a result of the multiplicity of the device conductors 12 utilized in transmitting the charge image. Thereafter the paper tape or other means can be advanced through positively charged powdered ink (not shown) in conventional manner to collect ink upon the electrostatic charge image or can be otherwise treated for permanently imprinting the charge image upon the tape.

Although a particular embodiment of this device and method has been described for the purpose of illustration, it should be understood that this invention includes all modifications or equivalents thereof which fall within the scope of the appended claims.

Having described my invention, I claim:

1. The method of making an electronic device of the character described which comprises the steps of providing a tube of glass material which is adapted to be drawn when heated to a drawing temperature and which has a given coefficient of thermal expansion, providing a substantially eutectic alloy of germanium and gold which is adapted to be drawn when heated to said drawing temperature and which has a negative coefficient of thermal expansion compared to the glass in the drawing temperature range and a coefficient of thermal expansion corresponding to that of said glass material in the normal useable temperature range, disposing the alloy within the glass tube, heating the tube and alloy to said drawing temperature, and drawing the tube and alloy simultaneously in the same direction for forming a glass-coated metallic fiber.

2. The method of making an image-transmitting electronic device including the steps set forth in claim 1 and including the additional steps of permitting the fibers to cool for expanding the drawn alloy into air-tight connection with its drawn glass coating, cutting the fiber into lengths, assembling the fiber lengths in side-by-side relation for forming a bundle, heating the bundle for fusing the coatings of the fiber lengths together, and cutting the bundle adjacent its ends for establishing the bundle length.

3. The method of making an electronic device as set forth in claim 1 wherein said alloy embodies between four and twelve percent germanium.

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