

July 14, 1964

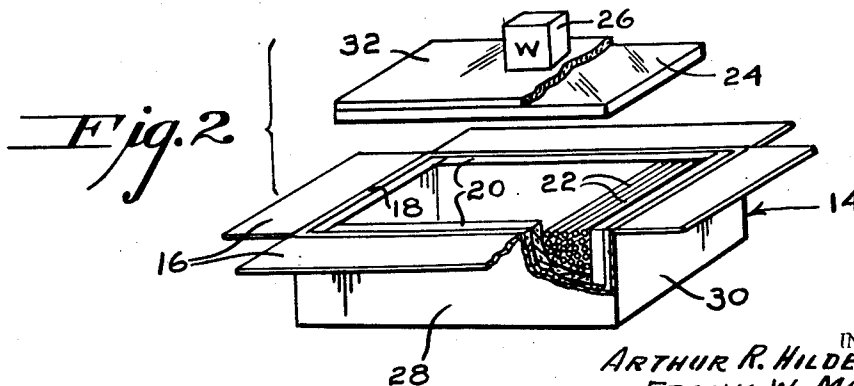
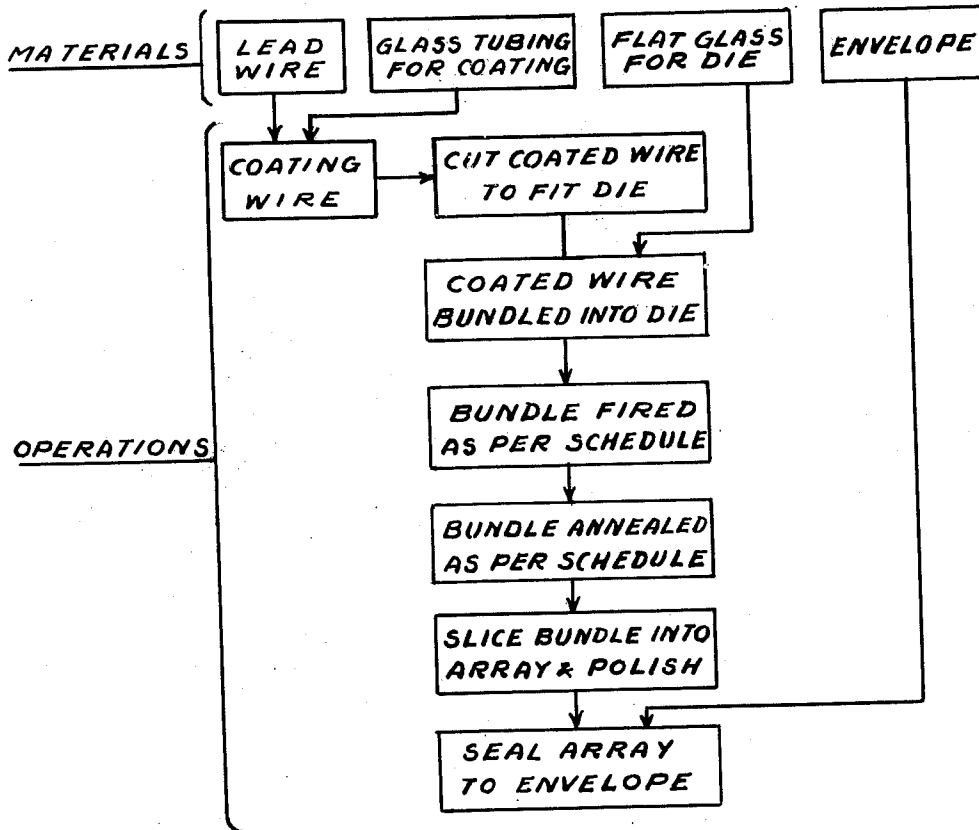
A. R. HILDEBRAND, JR., ETAL

3,140,528

MULTIPLE LEAD FACEPLATE

Filed Sept. 27, 1960

Fig. 1



INVENTORS
ARTHUR R. HILDEBRAND JR.
FRANK W. MARTIN
AND KENNETH G. POLLOCK

BY *Clarence R. Petty*
ATTORNEY

1

3,140,528

MULTIPLE LEAD FACEPLATE

Arthur R. Hildebrand, Jr., Frank W. Martin, and Kenneth G. Pollock, Corning, N.Y., assignors to Corning Glass Works, Corning, N.Y., a corporation of New York
Filed Sept. 27, 1960, Ser. No. 58,743
5 Claims. (Cl. 29—25.14)

This invention relates to an electrostatic printing tube and more particularly to a method of manufacturing the multiple lead array comprising the faceplate of the tube.

In one system of electrostatic printing, a cathode ray type tube envelope is employed utilizing an array on the faceplate thereof comprising a plurality of leads extending from the inside of the tube to the outside thereof. These leads consist of electrically conductive wires, insulated from each other and all of the uniform length.

The evacuated tube, with a multiple lead array as its faceplate and an appropriate electron gun in its neck comprises the printing instrument. To print or write, specially treated paper which will hold an electrostatic charge, is passed transversely along the array. By selectively applying the modulated cathode ray beam to the wires on the inner surface of the cathode ray tube, a charge, in a given configuration, is deposited on the paper as it passes the particular wire on which the beam falls. Subsequently, means are provided to develop and fix the electrostatic charge deposited on the paper.

In the manufacture of a typical faceplate array, which may be either of the type having a single row of leads or a randomly disposed multi-lead device, certain considerations must be considered. First and foremost of these is the fact that the encapsulating dielectric material surrounding the wires must accurately match the expansion coefficient of the wire.

Another phenomenon which must be carefully considered is the fact that the encapsulating dielectric material, which matches the coefficient expansion of the wires, must also have a low dielectric constant "K." It has been found that if an encapsulating material having a high dielectric constant is used, an undesired static charge is produced on the leads adjacent those carrying a charge due to the beam. This due primarily to the fact that a high dielectric constant capacitor is formed between the two adjacent wires which capacitor is very easily charged by the flow of current in one wire to produce an undesirable charge in the adjacent wires. Also, if the K is too high, a static charge is built up over the entire array, which charge may be attributed to the fast moving paper across the lead ends.

Still another fact that must be considered is the fact that the array will eventually be sealed to a tube envelope. It is imperative that the seal be durable and it is, therefore, important that the coefficient of expansion of the encapsulating portion of the array also very closely match the coefficient of expansion of the envelope.

It has been found that by encapsulating the leads with an encapsulating material having a low dielectric constant and a coefficient of expansion which matches both the coefficient of expansion of the leads and the envelope to which the array is sealed, an electrostatic writing tube may be formed that is noted by its absence of undesired static charges and by its ease of manufacture.

It is, therefore, an important object of the present invention to provide a method of forming a multi-lead array for the faceplate of an electrostatic printing tube wherein the array is noted by its absence of undesired static charges during operation.

Another important object of the present invention is to provide a method of forming a multi-lead array for the faceplate of an electrostatic printing tube wherein the leads, the encapsulating material therefor and the envelope all have matching coefficients of expansion.

2

Still another important object of the present invention is to provide a method of forming a multi-lead array for the faceplate of an electrostatic printing tube that is noted by its ease of manufacture and its adaptability to mass production.

The features of our invention which we believe to be novel are set forth with particularity in the appended claims. Our invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings in which,

FIG. 1 represents a flow chart of the novel process; and FIG. 2 represents the bundling step of the flow chart.

While the foregoing process will have included herein an example including a wire having a specific composition and size, combined with an encapsulating material comprising glass of a specific composition, it should be understood that other glass and wire combinations may be used provided, however, the expansion characteristics of the glass-wire seal as well as the glass-bulb seal are compatible and the glass for the glass-wire seal has an appropriate dielectric constant. It should also be understood that while the encapsulating material is described as glass, other materials may be used provided the above condition of dielectric constant-coefficient of expansion is met.

Referring now to FIG. 1, which depicts a flow chart of our novel process, it will be seen that the process may briefly be described as follows:

The chosen wire is first prepared by providing a suitable glass coating thereon and subsequently cutting the coated wire into suitable lengths to fit a die. The coated wires are then stacked in a die and the die is fired to form a bundle of wires. The bundle is then annealed and a slicing operation is performed on the bundle to form an array which is then sealed to an appropriate envelope to form the faceplate of a writing tube.

Description of Individual Operations

Wire coating.—The desired lead wire, having the required diameter is cleaned and straightened and a glass coating having a thickness of about 1.5–2.5 mil is applied thereon.

One desirable method of wire coating consists in heating a length of tubing to about 140–150° C. above the softening point and drawing the wire through the tubing at such a rate that a 1.5–2.5 mil coating of glass is deposited on the wire. The coated wire is then stored until ready for further use.

Bundling operation.—Referring now to FIG. 2, it will be seen that the bundling die consists of a metallic container 14 having four sides, a bottom and lips 16 for ease of handling. The inside of container 14 is lined with a refractory material 18 to prevent any material from adhering to the walls. Adjacent refractory material 18, the die is further lined with an inner coating 20 consisting of pieces of glass which may be the same material that has been previously utilized to coat the wire. The bundling operation is performed by stacking the coated wires 22 parallel to the major axis of the die, that is, perpendicular to side wall 28 and parallel to end wall 30. After the bundle is assembled, as shown in FIG. 2, a top piece of glass 24, which also may be the same material as the coating on the wires, is placed on the top of the bundle. A layer of refractory material 32 is then placed over this top covering and a small weight 26 designated as block W is placed thereon to maintain a constant pressure. The bundle is now ready for firing.

The major axis of the die is defined in this instance as being a plane parallel to the open top of enclosure 14, that is, parallel to glass covering piece 24 as positioned in FIG. 2.

Firing the bundle.—The firing cycle is accomplished in four stages; namely, outgassing, sealing, homogenizing and annealing. The outgassing step or cycle is performed under a vacuum of from 50–200 microns of mercury. The function of this operation is to drive moisture out of the bundle and to remove gases absorbed on what is probably a hydrated layer of glass on the coated wire. The die, in a vacuum furnace, has its temperature raised to about 150–200° C. below the softening point of the glass used for coating the wires. It is held at this temperature for about ½ hour to insure complete outgassing. After about ½ hour the bundle is free of absorbed gases. The temperature is then raised at a uniform rate to about 10–20° C. below the softening point of the glass at which time the vacuum is broken to prevent foaming of the glass. The remainder of the heat treatment may be conducted at atmospheric pressure. Both the outgassing step and the sealing step which follows are usually carried on in the same furnace.

Sealing.—The prior uniform rate of temperature rise is maintained until the temperature of the die reaches about 50–60° C. above the softening point of the glass and the die is held at this temperature for about five to fifteen minutes, or until the seal between adjacent wires is complete. While excellent results were obtained by raising the temperature at the rate of 10° C. per minute during the outgassing and sealing steps, it will be obvious that a faster or a slower rate may be used depending on the particular glass utilized and on the results anticipated. Since the temperature at which the coated wires become sealed to each other is within the devitrification range of the glass, it is imperative that the bundle be homogenized; that is, any crystalline phase that may have been formed must be dissolved.

Homogenization.—The weight is now removed from the bundle and the entire die is plunged into a furnace which is at a temperature representing about 50–100° C. above the liquidus of the glass and the die is held there for about five minutes. By so doing, any crystals that may have been formed during the preceding steps are thus removed.

Annealing.—The temperature of the die is now rapidly lowered to a point somewhat above the annealing point of the glass to exhibit the reformation of any other crystalline phases. The bundle is then removed from the die and placed in a furnace slightly above the annealing temperature of the glass and held there for about two hours to insure complete annealing after which, the bundle is allowed to cool to room temperature.

Slicing bundles into arrays.—The bundle slicing operation may be accomplished in any one of a number of ways, however, it is preferable that a diamond saw be used since this produces a cleaner cut as well as being capable of producing a thinner array. The bundle is sliced perpendicularly to the axis of the wires so that in the final product the wires extend from one side of the array to the other. After the bundles are sliced and the arrays have been formed, they are ground and, if necessary, polished to the desired thickness which may range from about .050–.075 inch. Flatness of both surfaces of the array is essential and care must be exercised to insure that both surfaces are completely parallel.

Sealing array to bulb.—This step is usually accomplished in an open top furnace wherein both the bulb and the array are uniformly heated to a temperature of about 100° C. above the annealing point of the envelope with the array in position on the envelope. It is wise at this point to provide some sort of heat sink on the array during the sealing operation to prevent its sagging. The seal is made by softening the edges of the array with a flame and sealing it to the envelope. If the expansion match between the array and the envelope is conducive to a good seal, then there will be little residual stress in the seal area after the sealed bulb has been annealed.

As an example of the types of glass and wire that may

be used there is submitted herewith a tabulation indicating the approximate composition, in weight percent, of wire coating glass and envelope glass which has been successfully used in conjunction with tungsten wire having a coefficient of expansion of about $47 \times 10^{-7}/^{\circ}\text{C}$. at the setting point of the coating glass and a diameter of about 0.001 inch $\pm 3\%$. Additionally, other essential characteristics are provided.

	Wire Coating Glass	Envelope Glass
SiO ₂	76	70
Na ₂ O.....	4	4
B ₂ O ₃	4	20
PbO.....	14	6
K ₂ O.....	2	
Al ₂ O ₃	2	
Misc.....	2	
Dielectric Constant.....	5.1	
Coeff. of Exp.....	$40 \times 10^{-7}/^{\circ}\text{C}$.	$36 \times 10^{-7}/^{\circ}\text{C}$.
Softening Temp.....°C	730	756
Annealing Temp.....°C	560	518
Liquidus.....°C	1,070	

The foregoing description has been set forth in terms of forming an array for the faceplate of a cathode ray tube wherein the array has many spaced wires in contiguous relationship wherein all of the wires are in planes parallel to the major axis of the enclosure of the die. It will now become obvious to those skilled in the art that a single row array may be formed by placing a single layer of coated wires on the bottom glass plate of the die and thereafter utilizing the techniques previously described.

Further, while the individual wires in either the single or the multi-row array may be arranged in a plane or planes parallel to the major axis of the enclosure, the wires in each instance may also be arranged to "fan" out in the manner of spokes radiating from a hub. This latter embodiment finds particular application where it is desired to produce a writing tube having either a domed or curved faceplate or having a flat faceplate with the electrical features of a dome faceplate. In either event, in this last mentioned embodiment, the individual wires will all be parallel to the axis of the beam emanating from the gun in the completed assembly.

While we have described what is presently considered a preferred embodiment of our invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the inventive concept contained therein and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What is claimed is:

1. A method for producing an electrostatic printing member having a matrix of conductors insulated from each other comprising the steps of providing a plurality of wires having a uniform coating of insulating material adhered thereto, arranging said wires in an enclosure wherein said coatings on adjacent wires are contiguous and said wires are parallel to the major axis of said enclosure, outgassing the arranged coated wires by heating under vacuum, fusing said insulating material to form a bundle, homogenizing the insulating material of the bundle so formed, annealing said insulating material, cooling said bundle, and thereafter slicing a relatively thin array from said bundle wherein said conductors extend from one side of said array to the other side thereof.

2. A method for producing an electrostatic printing member having a matrix of conductors insulated from each other comprising the steps of providing a plurality of glass coated wires, the coating glass having a relatively low dielectric constant and a coefficient of expansion compatible with the coefficient of expansion of said wires, arranging said wires in an enclosure in adjacent and contiguous parallel relationship in at least one row and

5

in at least one plane parallel to the major axis of said enclosure to form a bundle, outgassing said bundle by heating under vacuum and maintaining said condition for about ½ hour, raising said bundle temperature and releasing said vacuum at a point about 10–20° C. below the softening temperature of said glass, continuing to raise said bundle temperature to about 50–60° C. above the softening temperature of said glass and maintaining said bundle at above said softening temperature for about five to fifteen minutes to completely seal said glass, plunging the bundle into a furnace having a temperature of about 50–100° C. above the liquidus temperature of said glass and maintaining said bundle at above said liquidus temperature for about five minutes, cooling said bundle to the annealing temperature of said glass, maintaining said bundle at said annealing temperature for about two hours, allowing said bundle to cool to room temperature, slicing a relatively thin array from said bundle wherein said conductors extend from one side of said array to the other, and grinding both flat surfaces of said array.

3. A method for producing a matrix of conductors insulated from each other comprising the steps of providing a plurality of wires having a uniform coating of insulating material adhered thereto, arranging said wires in an adjacent and contiguous parallel relationship with each other, fusing said insulating material to form a bundle, homogenizing the insulating material of the bundle so formed, annealing said insulating material, and thereafter cooling said bundle.

4. A method for producing a matrix of conductors insulated from each other comprising the steps of pro-

6

viding a plurality of wires having a uniform coating of glass adhered thereto, arranging said wires in an adjacent and contiguous parallel relationship with each other to form a bundle, outgassing said bundle by heating under vacuum, raising said bundle temperature to about 50–60° C. above the softening temperature of said glass to fuse said glass, homogenizing said glass, annealing said glass, cooling said bundle and thereafter slicing a relatively thin array from said bundle.

5. A method for producing a matrix of conductors insulated from each other comprising the steps of providing a plurality of wires having a uniform coating of glass adhered thereto, arranging said wires in an enclosure in an adjacent and contiguous parallel relationship to form a bundle, outgassing said bundle by heating under vacuum, raising said bundle temperature to about 50–60° C. above the softening temperature of said glass to fuse and seal said glass plunging the bundle into a furnace having a temperature of about 50–100° C. above the liquidus temperature of said glass, annealing said glass, cooling said bundle, and slicing a relatively thin array from said bundle wherein said conductors extend from one side of said array to the other side thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

2,189,340	Donal	Feb. 6, 1940
2,197,753	Liebmann	Apr. 23, 1940
2,619,438	Varian et al.	Nov. 25, 1952
2,752,731	Altosaar	July 3, 1956