June 14, 1949. A. ROSE 2,473,220

METHOD OF MANUFACTURING TARGET ELECTRODES

Filed Aug. 16, 1941

Fig. 1.

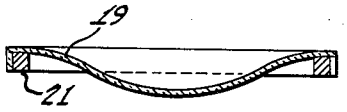


Fig. 2.

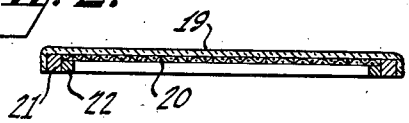


Fig. 3.

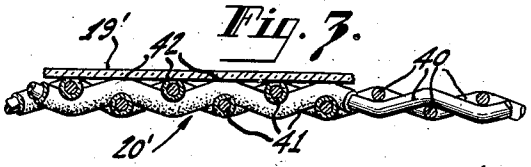


Fig. 4.

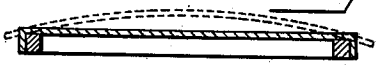


Fig. 5.

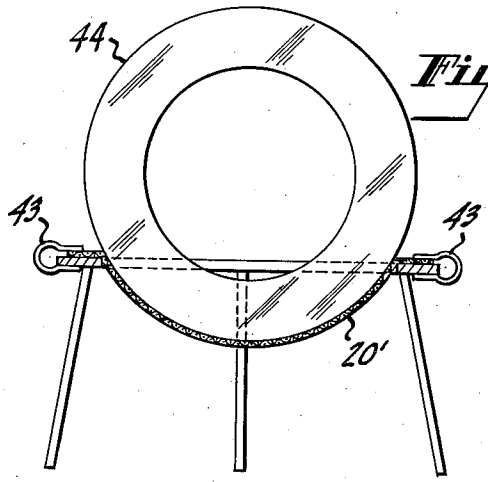
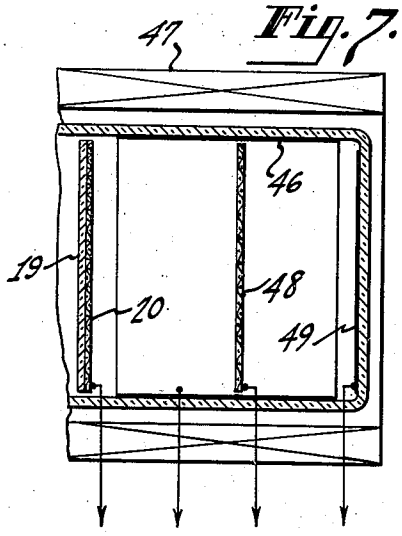


Fig. 7.



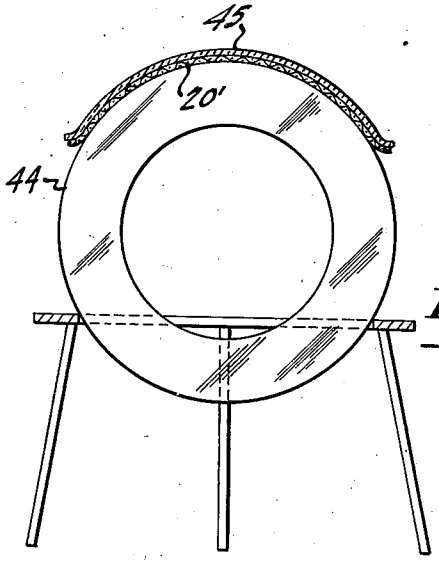


Fig. 6.

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METHOD OF MANUFACTURING TARGET ELECTRODES

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Application August 16, 1941, Serial No. 407,131

11 Claims. (Cl. 49—81)

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My present invention relates to television transmitting tubes and electrode structure and more particularly to methods of manufacturing electrode structures suitable for use in tubes of the low velocity electron beam scanning and electron image types. This application is a continuation in part of my copending original application Serial No. 357,543, filed September 20, 1940, for which application Serial No. 631,441 was filed November 28, 1945, as a continuation, after which application Serial No. 357,543 was abandoned.

In television pickup tubes utilizing high velocity electron beam scanning with optical or electron image projection on a surface other than the surface scanned by the high velocity beam it has been proposed to utilize double-sided mosaic-type targets, as disclosed in British Patent 442,666. Such target electrodes are exceedingly difficult to construct, the task of forming a structure having over 100,000 electrically discrete highly insulated metal plugs extending through the target and insulated from a signal screen embedded in the target being a tedious and difficult manufacturing problem. In addition, such electrodes, even though prepared with exceptional care, produce a spurious signal not representative of the electron or opitcal image, due to electrical or mechanical nonuniformities over the target surface.

In my above mentioned copending application I disclosed a tube incorporating and a method of manufacturing electrodes equivalent to double-sided electrodes, which tube I claimed in said application, and I will here set forth and claim my previously described method of manufacture as well as an improved modification of the method. The article produced by the improved method will be described below in general terms. A fuller and more detailed description of my new electrode structure is set forth in my application filed concurrently herewith and patented July 2, 1946, No. 2,403,239.

It is an object of my invention to provide electrode structure for a television transmitting tube having higher sensitivity and lower distortion than tubes constructed heretofore as well as a method whereby such structure may be manufactured with ease and at low cost. It is a further object of my invention to provide methods of manufacturing television transmitting tube electrodes suitable for use with low velocity electron beam scanning which are capable of exceptionally high sensitivity with substantial elimination of all spurious signal, and it is a still further object to provide such a tube and target

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structure therefor which is easy to manufacture.

In accordance with my invention I provide an imperforate homogeneous target of electrically semi-conducting or semi-insulating material which is very thin in comparison with the electron beam diameter or picture element size, and a signal screen electrode very closely adjacent or adjoining thereto. Further, in accordance with my invention I provide a method of manufacturing a target of vitreous material wherein the material is stretched taut over a support member which in one modification may be the signal screen electrode. These and other objects, features, and advantages of my invention will be apparent when taken in connection with the following description and accompanying drawing in which:

Figs. 1 and 2 are views of portions of the electrode structure;

Fig. 3 is a greatly enlarged sectional view of a portion of a target structure and associated signal screen made in accordance with an improved modification of my method of manufacture.

Fig. 4 is a section illustrating a modified method of applying the target film.

Figs. 5 and 6 show details relative to the mounting of the glass film on the screen.

Fig. 7 illustrates a modification.

The target of my invention comprises a very thin imperforate target sheet 19 of homogeneous electrically semiconducting material, the properties of which have been set forth in my said original application, and reference is made to it for a disclosure thereof as well as for the manner of utilizing the target. Closely associated with the target sheet 19 of semiconducting material and preferably adjacent or adjoining one surface of the sheet I provide a signal screen 20 coextensive with and very closely spaced with respect to the surface of the semiconducting sheet. The enlarged fragmentary section of Fig. 3 shows a target sheet 19' and a type of adjoining signal screen 20' more particularly described and claimed in my currently filed application when made in accordance with my improved method.

The target sheet 19 or 19' as indicated above is of semiconducting material and I have found that the specific resistance of the material used should lie within the range of 10^9 to 10^{12} ohm-centimeters. Preferably an exceptionally thin homogeneous sheet of vitreous material such as glass having the desired specific resistance and being smooth and of uniform thickness may be used. I have found that a thin sheet of glass having a specific resistance of approximately 5×10^{10} ohm-

centimeters is suitable and the glass described below which I have used may be formed in very thin films.

In accordance with the teaching of my invention the semiconducting material such as glass may be blown to form a very thin glass film which is laid upon a metal supporting ring **21**, whereupon it will appear as shown in Fig. 1 bulging downwardly at the center. The ring **21** is then placed in a furnace very carefully and carefully heated until the glass film is in a semi-molten state, whereupon by surface tension the bulging sheet of glass contracts to form a substantially plane surface. During the heating the thin glass film folds down against the edges of the ring **21** as shown in Fig. 2 as the film preferably overlaps the ring. The film may be inverted and placed on top of the frame with the bulge upwards when placed in the furnace as shown in dotted lines in Figure 4. The wire mesh signal screen **20** is then assembled in very close proximity to the sheet **19** such as by a slip ring construction shown in Fig. 2 wherein the metal ring **22** supports the signal screen **20**. I have made such assemblies wherein the thickness of the sheet of glass is less than 0.0002", which is less than one-fourth the thickness of mica usually used for high resistance types of mosaic electrodes.

While an electrode made in accordance with the method described above is satisfactory when the electrode area is relatively small, I have found that a glass sheet mounted near a fine mesh screen cannot readily be spaced close enough or uniformly enough to provide good insulation and signal strength over relatively large target areas. Thus, it is especially difficult to maintain uniform spacing between the signal screen **20** and the sheet **19** as shown in Figure 2 when the target is to be of relatively large area.

In accordance with a modification of the above described embodiment of my invention I utilize the principles of shrinking a thin sheet of glass by surface tension over a supporting member or foundation and so perform the process that very small areas of the glass sheet are in contact with the supporting member which in this modification may be very small elemental areas of the signal screen **20'**. To provide uniform spacing when utilizing a signal screen of the type shown in Fig. 2, it is desirable to roll the screen so that the wires of the woof and the wires of the warp are substantially coplanar. In the improved modification, however, and especially where target electrodes for use in tubes of the type shown in my said original application of relatively large areas are to be utilized, I have found that it is desirable to utilize woven wire mesh which is not rolled or at least is not rolled to any great degree so that alternate points of the wire of the crossed mesh wires extend above the normal plane of the signal screen. Thus the crimp promontories of the crossed wires extend above the main body of the screen. It is also desirable in this modification of my invention to provide a thin coating of vitreous enamel or other vitreous material on the side of the signal screen adjoining the thin glass sheet **19** for the purpose of bonding the screen to the sheet over the raised promontory areas, and to insulate the screen from the thin glass sheet. While a thin glass sheet may be fused to an enameled rolled fine mesh screen, the thin glass tends to be drawn into the apertures and become thickened in the apertures if the temperature of the firing exceeds a predetermined maximum. In addition the electrical

properties of such a structure are unsatisfactory especially where the wire screen is greater than 150 mesh per inch. While such an assembly is satisfactory when utilizing a relatively coarse mesh screen, such as less than 150 mesh per inch, the structure is far from satisfactory when utilizing a fine mesh screen, such as from 150 to 250 mesh per inch. I have found that, when utilizing my method of shrinking the glass by surface tension, the thin sheet of glass is substantially tangent to the surface of the woven wire mesh at the crimp promontories. Thus, it is important that the screen following weaving should not be rolled to the extent of flattening the normal crimp that appears in the wires, in fact, the existance of the crimp permits the glass to touch only at the crimp promontories and still be spaced on the average far enough from the signal screen to provide the desired target capacitance as described in my said original application.

Following the weaving of the wire mesh screen to form the signal screen **20'** as shown in Fig. 3, the mesh is preferably immersed in a high current electrolytic etching solution to obtain a high polish on the mesh and to increase the interstitial areas between the crossed wires. For example, a 230 mesh per inch screen may be etched to about 65% light transmission, the etching solution being chosen with respect to the particular metal of which the signal screen is made. I have used stainless steel wire mesh inasmuch as its coefficient of expansion is sufficiently close to that of the glass, although an even closer match between the coefficients of expansion may be desirable to eliminate all crinkling of the glass upon cooling.

The etched screen is supported from its two opposite sides for example on a tripod and held by suitable clamps **43** as shown in Fig. 5, so as to form a cylindrical shape under the weight of a cylindrical form such as heavy glass tubing **44** and the screen is then fired in air in an oven, while supporting the glass tubing, at a relatively low temperature for a sufficient length of time to form a light coating of oxide and to fix the shape of the screen.

Following the firing operation the screen is enameled at least on the convex side which, as later described, is the side next to the glass diaphragm with a low temperature high resistance enamel. This enameling operation may be performed by a spraying method wherein the enamel is suspended in a finely divided state in a suitable suspending agent which is sprayed over either one or both sides of the screen. The thickness of the enamel should be insufficient to reduce the light transmission of the screen below 50% and likewise should be of insufficient thickness to destroy the crimp contour of the woven wires. I have found thickness of approximately .0001 to .0002 inch sufficient to provide a good bond between the metal and glass sheet without destroying the crimp contour. One particular enamel which I have found satisfactory is that of the following composition by weight.

	Percent
Na_2O	30
Li_2O	8
B_2O_3	16
Al_2O_3	2
SiO_2	44

Following the application of the enamel to the wire mesh, the wire mesh is fired at a sufficient

temperature to vitrify the enamel particles and to form a smooth coating over the wires of the screen while still retaining the crimped character of the wire mesh. In this manner the crimp promontories coated with the vitrified enamel extend above the surface of the screen. A section of thin glass which approximates the cylindrical contour of the formed screen is taken preferably from a bubble blown from glass chosen to have a softening point somewhat above that of the enamel. This glass is then sealed to the insulated crimp promontories of the screen. For use with wire mesh screens coated with the above enamel a glass of the following composition is particularly satisfactory wherein the percentages are by weight:

	Percent
Na_2O	37
Li_2O	1
B_2O_3	16
Al_2O_3	2
SiO_2	44

The thin glass section 45 from the cylindrical blown bubble is laid over the enameled surface of the wire mesh screen supported on the cylindrical glass tubing Fig. 6 and fired in an oven at or slightly above the softening point of the thin glass, whereupon the surface tension of the thin glass draws it taut over the surface of the enameled screen. Since the enamel has a lower temperature softening point than that of the thin glass, it tends to adhere to the thin glass sheet at the points of contact. such as at the crimped promontories. The promontories tend to prevent the glass from drawing into the intersticies of the mesh and the firing is controlled over such a short period of time or at such a low temperature to prevent such action. Firing for too long a period of time or at too high a temperature permits the thin glass to sink into the holes of the screen. The temperature and time control prevents this unsuitable result. Following the sealing of the thin glass sheet to the glass promontories, the assembly is lifted from the section of tubing and flattened by firing it on a plane surface at a relatively low temperature insufficient to replastize the thin glass sheet. Due to the extreme thinness of the film and screen and the heating, the assembly sinks down flat upon the plane surface, whereupon after cooling the assembly remains flat and is ready for use.

Referring to Fig. 3 which shows a structure made in accordance with this latter method the wires 40 are covered with the thin film of enamel 41 in such a manner that the crimped promontories 42 are not destroyed. It will be observed from the figure that the thin glass sheet 19' is in contact with the enamel screen only at the crimped promontories 42 and that the enamel 41 has become sealed to the glass sheet. In this manner uniform spacing between the sheet 19' and the wires of the mesh is maintained even over a relatively large area. While I have described an assembly wherein the wire mesh screen may be coated over its entire exposed area with a thin film of enamel, the use of such an insulated screen requires the use of an auxiliary electrode to collect secondary electron emission. In the absence of a longitudinal magnetic field, such as developed by the coil 47 (Fig. 7), the accelerating electrode coating 46 may serve to collect secondary electrons developed by impinging primary electrons from the photocathode 49. If, however, the longitudinal magnetic field produced by coil 47 is utilized, I have found it desirable to provide a relatively coarse wire mesh screen 48 between the photocathode 49 and the target assembly to collect the secondary electrons. However to avoid the use of such an auxiliary electrode the signal screen 20' of Fig. 3 may be enameled on only one side; that is, the side adjoining the thin glass sheet. The secondary electrons may then be collected by the screen at the unenameled side.

While I have described the use of an intermediate thin coating of enamel upon the wire mesh of insufficient thickness to destroy the crimped promontories, the thin glass sheet may be sealed directly to these crimped promontories without the use of such an intermediate enamel film. For example, the above steps may be performed with the exception of those relating to the application and firing of the enamel, thereupon the thin glass upon firing and shrinking by surface tension becomes attached directly to the crimped promontories which are of exceedingly small area in comparison to the elemental picture area. Such electrode structure, however, is more difficult to utilize, inasmuch as the glass of the sheet 19' is of relatively low electrical resistance and it is therefore necessary to provide substantially uniform electron beam velocity over the entire scanned areas.

The target, whether of the form shown in Fig. 2 or that shown in Fig. 3, is supported in the tube as described in connection with my said original application and in operation high velocity photo electrons representative of an electron image of the picture to be transmitted are focused on the rear surface of the thin target sheet to form a positive electrostatic image on this rear surface by secondary electron emission. Other methods of forming a positive electrostatic image on the target sheet may be utilized, such as by scanning the rear surface of the sheet with a modulated high velocity electron beam or by providing a discontinuous coating of caesium or other light sensitive material on the rear surface of the sheet which, by emission of photo-electrons, forms an electrostatic image consisting of positive charges representative of the optical image to be transmitted. Thus in the latter case the light from the object may be focused directly on the rear surface of the target sheet 19.

An electrode structure made in accordance with my invention may be distinguished from the conventional double-sided type of mosaic such as the type described in my U. S. Patent 2,213,173 in that I provide no conductive plugs extending through and insulated from a wire mesh screen embedded in high resistance insulation such as vitreous enamel. In this type of construction it is necessary to provide exceptionally high resistance between the plugs and the embedded screen for the express purpose of preventing electrical leakage between the plugs and the screen. In my improved television transmitting tube I avoid the difficulties attendant upon the prior art structure by wholly eliminating the embedded screen. I have found it disadvantageous to provide any good metal contact between the semiconducting target sheet 19, which must be homogeneous, and any other electrode in the tube such as the signal screen 20. As indicated above, this desirable feature is obtained either by supporting the signal screen 20 out of contact with the glass sheet 19 or by providing a thin coating of high resistance enamel between the screen and glass sheet. The signal screen

20' must therefore be and is substantially insulated from the sheet 19' so that electrical contacts between the signal screen and the sheet 19' are a minimum. My invention is further distinguished over the prior art which utilizes a mica foundation for a mosaic electrode or any other insulation having high electrical resistance such as mica which is of the order of 10^{20} ohm-centimeters. My invention should therefore not be confused with tubes using these types of electrodes. In fact, I have attempted to operate tubes of this type wherein the target consisted of a mica foundation scanned on one side by a low velocity electron beam, the electrostatic image being formed on the opposite side and have found that such tubes will not operate with a low velocity electron beam because after a few scansions of the beam, elemental areas of the target become charged up to the secondary electron collector potential thereby preventing any further operation. With my new and improved tube, however, I have obtained from 3 to 10 times the sensitivity usually obtained in tubes of the "Orthicon" type as described in U. S. Patents 2,213,174-6 which, in turn, are from 10 to 50 times more sensitive than the conventional "Iconoscope" which utilizes a high velocity electron beam. Consequently, the television transmitting tubes utilizing electrodes made in accordance with my invention when utilized in conjunction with low velocity electron beam scanning have produced sensitivities of the order of 30 to 500 times the sensitivity of the well-known Iconoscope type of tube.

While I have indicated the preferred embodiments of my invention and have indicated the specific application as directed to the production of electrodes for cathode ray television transmitting tubes, it will be apparent that my invention is by no means limited to the purpose of television transmission and that many variations may be made in the particular method and structure disclosed without departing from the scope of the invention as set forth in the appended claims.

I claim:

1. The method of manufacturing a target electrode for a television transmitting tube comprising forming a bubble of vitreous material, cutting a section of film therefrom, supporting said film on a horizontal frame, heating said film and frame while said frame is in a horizontal position to a temperature sufficient to render said film semiplastic, and maintaining said temperature until the surface tension of said vitreous material causes said film to contract and tighten on said frame.

2. The method of manufacturing a target electrode for a television transmitting tube which comprises placing a thin non-planar film of vitreous material over a horizontal support having areas to which said film may be sealed, and heating said film and support to a temperature at which it becomes attached to said horizontal support and at which the film material is plastic and the surface tension of the film material causes the film to flatten.

3. The method of manufacturing a target electrode for a television transmitting tube comprising heating a thin film of vitreous material in contact with a horizontal supporting member to cause said vitreous material to become attached to said member and continuing the heating until said film shrinks by surface tension to become taut over said member.

4. The method of manufacturing a target electrode for a television transmitting tube comprising heating a vitreous material to a temperature at which it becomes plastic, blowing a bubble of the vitreous material, cutting a section of film therefrom, heating the thin film of vitreous material in contact with a horizontal supporting member to the softening temperature of said material and continuing said heating until said film becomes attached to said member and shrinks by surface tension to become taut.

5. The method of manufacturing a target electrode adapted to be scanned by an electron beam comprising heating an apertured crimped wire mesh screen in horizontal contact with a thin vitreous material film until the film seals to and becomes taut over the said screen and discontinuing said heating before the film becomes sufficiently soft to sink into and become thickened in the apertures of said screen.

6. The method of forming a target electrode adapted to be scanned by an electron beam comprising supporting a non-planar thin glass film in contact with an insulated woven mesh foundation, said foundation having regularly spaced promontories over one side thereof and being horizontally disposed, heating the film and continuing said heating until said film becomes sealed at said promontories substantially tangent to the horizontal surface of said foundation.

7. The method of forming a target electrode adapted to be scanned by an electron beam comprising coating one side of a woven wire mesh screen with a thin film of electrically insulating material leaving the apertures of said screen unfilled, supporting a thin glass film on said insulated screen and heating said screen until the film adheres to small elemental areas over the surface of said insulated screen and becomes taut by surface tension.

8. The method of manufacturing a target electrode for television transmitting tubes comprising supporting a thin glass film on a horizontal support member, heating said film and said member until said film becomes semi-plastic and becomes sealed to said member and continuing said heating until the film shrinks by surface tension and becomes taut and substantially plane between separated points over the surface of said support member.

9. The method of attaching a thin glass film to a wire screen, comprising forming the screen into a cylindrical surface, placing it on top of a cylinder with the convex surface of the screen extending upwards, placing the thin glass film on top of the screen, heating the screen until the glass film conforms to the shape of the screen, fuses thereto and becomes taut by surface tension, cooling the film and screen and reheating on a flat support until the screen and attached film flatten out substantially to a plane.

10. The method of attaching a thin glass film to a wire screen, comprising forming the screen into a cylindrical surface, enameling the screen, supporting the screen with convex surface extending upwards, placing the thin glass film on top of the screen, heating the film and screen until the glass film conforms to the shape of the screen, fuses to the enameled cross-over points of the wires of the screen and becomes taut by surface tension, cooling the film and screen and reheating on a flat support until the screen and attached film flatten out substantially to a plane.

11. The method of manufacturing a target electrode for a television transmitting tube comprising placing a section of a glass bubble on a frame

and heating the glass section and frame to a temperature at which the glass is plastic, becomes attached to said frame and draws taut thereacross by surface tension and cooling the frame and attached film.

ALBERT ROSE.

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