

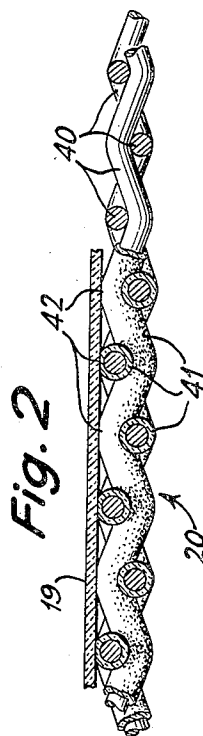
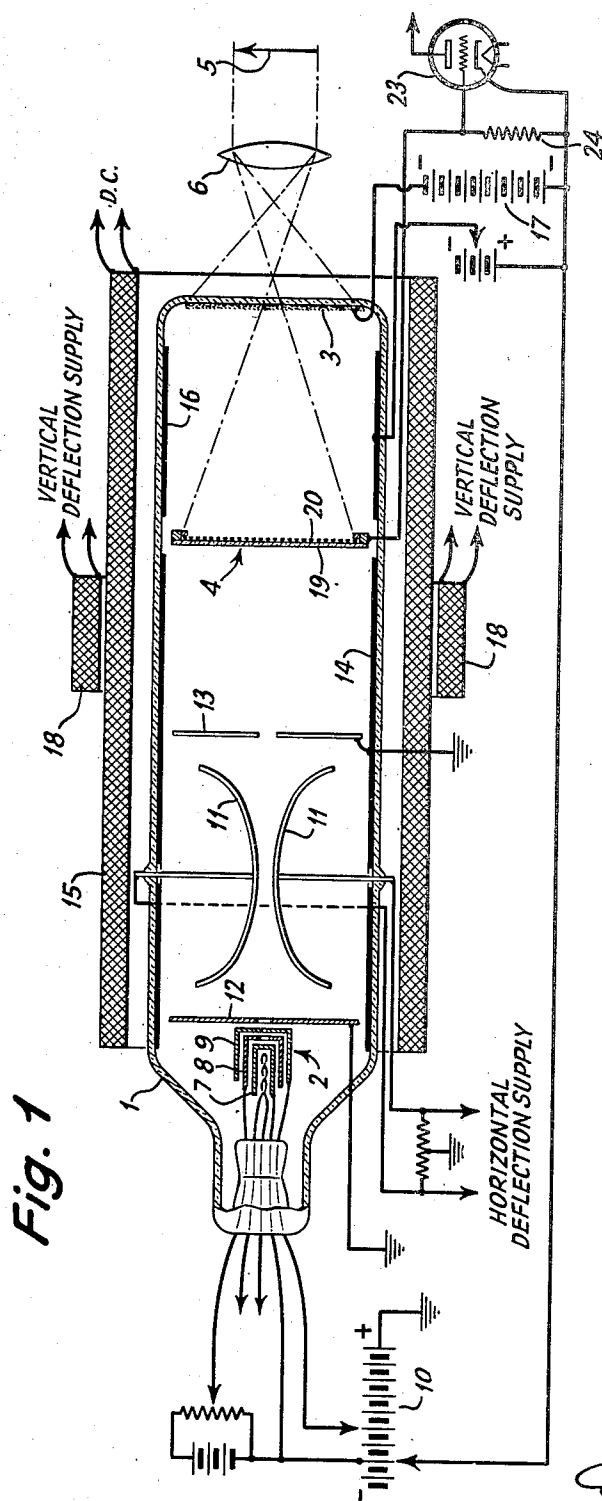
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2,403,239

TARGET ELECTRODE FOR ELECTRON DISCHARGE TUBES

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TARGET ELECTRODE FOR ELECTRON
DISCHARGE TUBESAlbert Rose, East Orange, N. J., assignor to Radio
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9 Claims. (Cl. 250—164)

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My invention relates to electron discharge tubes and more particularly to novel electrode structure for use in tubes of the low velocity electron beam scanning and electron image types.

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 optical image, due to electrical or mechanical nonuniformities over the target surface.

In my copending application, Serial No. 357,543, filed September 20, 1940, I described and claimed a tube and electrode structure having high sensitivity and substantially uniform signal generating properties. I will here describe an improved electrode structure which is particularly adapted for use in such television transmitting tubes therein described, the method of manufacture of such electrodes being more fully described and claimed in my application, Serial No. 407,131, filed concurrently herewith.

It is an object of my invention to provide a television transmitting tube having higher sensitivity and lower distortion than tubes constructed heretofore. It is a further object of my invention to provide improved electrode structure for a television transmitting tube utilizing low velocity electron beam scanning which is capable of developing exceptionally high sensitivity with substantial elimination of all spurious signal, and it is a still further object to provide a television signal developing target structure 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 which is contiguous thereto, adjoins exceptionally small areas of and is insulated from the thin homogeneous target. These and other objects, features and advantages of my invention will be apparent when taken in connection with

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the following description and accompanying drawing in which:

Figure 1 is a longitudinal cross-sectional view of a television transmitting tube utilizing an electrode made in accordance with my invention, and

Figure 2 is a greatly enlarged sectional view of a portion of the target structure and associated signal screen shown in Figure 1. The tube shown in Figure 1, as well as the operation thereof, is fully disclosed in my above first-mentioned application and will be described below only in rough outline.

Referring specifically to my tube structure shown in the drawing, the tube comprises an evacuated envelope 1 enclosing at one end an electron gun structure 2 and at the opposite end a semi-transparent photocathode 3 of the conventional type with a target electrode 4 intermediate the electron gun and photocathode positioned to be scanned on one side by an electron beam from the electron gun and to have an electrostatic image formed on the opposite side. This electrostatic image may be formed on the rear surface of the target 4 by projecting light, such as represented by the object arrow 5, through the lens 6 upon the photocathode 3 to liberate electrons therefrom, or the light may be projected directly upon the rear surface of the target in accordance with my prior teaching.

The electron gun assembly is preferably of the low velocity electron beam generating type, as described in my joint patent with Harley A. Iams, No. 2,213,175, and comprises a cathode 7, a control electrode 8 connected to the usual biasing battery and an anode 9 provided with a beam limiting aperture through which electrons may be directed toward the target 4, the anode 9 being maintained at a positive potential with respect to the cathode by a battery or potential source 10.

Intermediate the electron gun 2 and the target 4 I provide a pair of deflection plates 11, a pair of shield plates 12—13, one on either side of the deflection plates 11 having slots for the passage of the electron beam, and a conductive wall coating 14. The plates 11 are connected to a source of deflection potential and to the shield plates 12—13 and coating 14, through a center-tapped resistance of 1 to 10 megohms. A magnetic coil 15 of slightly larger diameter than the envelope 1 extends over and beyond the space between the electron gun 2 and target 4 to develop a magnetic focusing field and may extend beyond the photocathode 3 to focus electrons from the photocathode upon the rear surface of the target 4. The electrons from the photocathode 3 are

accelerated by an electrostatic field such as generated by the wall coating 16 operated at a positive potential with respect to the cathode 3 by a battery or other potential source 17.

Deflection of the electron beam in a direction normal to that produced by the plates 11 is accomplished by a pair of deflection coils 18, as well known in the art. The deflection coils 18 may, of course, be replaced by a second pair of deflection plates and, in fact, any other type of electron gun and associated deflection structure capable of resolving an electron beam having a velocity approaching zero adjacent the target may be used in the place of those described.

In accordance with my invention the target comprises a very thin imperforate target sheet 19 of homogeneous electrically semi-conducting material, the properties of which will be discussed in considerable detail later, supported as shown in Figure 1 in a plane normal to the longitudinal axis of the envelope 1 and consequently normal to the projected electron beam. Contiguous with the target sheet 19 of semi-conducting material and preferably adjoining exceptionally small areas of the rear surface of the sheet I provide a signal screen 20 coextensive with and very closely spaced over the nonsupported areas with respect to the rear surface of the semi-conducting sheet. The enlarged fragmentary section of Figure 2 shows the general form of the target sheet 19 and closely associated signal screen 20 as constructed in accordance with my invention.

The target sheet 19 as indicated above is of semi-conducting 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 constructing this portion of my structure the glass may be blown to form a very thin cylindrical glass film which is laid upon an insulated wire mesh screen having crimp promontories which extend above the plane of the screen and to which the glass film is sealed by heating the glass film supported by the insulated screen until the glass film is in a semi-molten state, whereupon by surface tension the sheet of glass contracts to form a substantially plane surface.

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. Following the assembly of the semi-insulating sheet 19 and signal screen 20, these parts are supported in the tube as shown in Figure 1 and an electrical connection made from the signal screen to a translating device such as the thermionic tube 23 and to the positive terminal of the potential source 17 through an output impedance 24 and thence to the battery 19 at a point substantially equal to or slightly positive with respect to the potential applied to the cathode 7. The wall coating 16 is shown connected through an auxiliary potential source to maintain this coating slightly negative with respect to the signal screen 20, although these electrodes may be operated at the same potential.

While one method of forming such an electrode assembly is fully disclosed in my concurrently

filed application referred to above, I will describe below a preferred method whereby an electrode structure having improved operating characteristics may be constructed. In constructing my electrode 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, whereas larger areas between the very small support areas are uniformly spaced with respect to the signal screen 20. To provide small areas of contact I utilize a woven wire mesh screen, which is not rolled or flattened to an appreciable degree, so that the wires of the woof and the wires of the warp are substantially nonplanar. I have found that it is desirable to utilize woven wire mesh having alternate points of the crossed mesh wires extending above the normal plane of the signal screen. Thus the crimp promontories of the crossed wires extend both above and below the main body of the screen. It is also desirable 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 holes by surface tension of the glass working along the enamel. This is especially true if the temperature of the firing exceeds a predetermined maximum. In addition, the electrical properties of such a structure are unsatisfactory, especially when 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 existence of the crimp permits the glass to touch only at the crimp promontories, leaving the exposed surface of the glass sheet planar and spaced, on the average, far enough from the signal screen to provide the desired target capacitance as described in my first above-mentioned application.

Briefly, the woven wire screen 20 is etched to provide a relatively high light transmission such as 65% and coated on at least the side which is to face the glass sheet 20 with a thin film of enamel having high electrical insulation properties. Such an enamel should have a specific resistance higher than that of the glass sheet 20, and may be 5×10^{12} ohm-centimeters or higher. This resistance is considerably above that of the thin glass sheet 19 which may range from 10^9 to 10^{12} ohm-centimeters. The enamel likewise preferably has a softening point which is lower in temperature than the glass sheet 19. The enamel may be applied by spraying to a thickness of .0001" to .0002" followed by firing to vitrify the enamel, whereupon the thin glass sheet 19 is supported on the screen 20 and fired for a period of time and at such a temperature that surface tension developed in the softened glass draws it taut over the surface of the enameled screen. Since the enamel has a lower tempera-

ture 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 crimp promontories. The promontories tend to prevent the glass from drawing into the interstices of the mesh and the firing is controlled over such a short period of time or at such a low temperature as 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 glass for the sheet 19 and the enamel for the wire mesh may have the following composition, these percentages by weight resulting in materials which have the above desired properties.

Component	Glass sheet		Mesh enamel	
	Percent		Percent	
Na ₂ O	37		30	
Li ₂ O	1		8	
B ₂ O ₃	16		16	
Al ₂ O ₃	2		2	
SiO ₂	44		44	

Referring to Figure 2 which shows a structure made in accordance with this method, the wires 40 are covered with the thin film of enamel 41 in such a manner that the crimp 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 crimp promontories 42 and that the enamel 41 has become sealed to the glass sheet. 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 when utilized as shown in Figure 1. In the absence of a longitudinal magnetic field, such as developed by the coil 15, the electrode coating 16 may serve to collect secondary electrons developed by impinging primary electrons from the photocathode 3. If, however, the longitudinal magnetic field is utilized, I have found it desirable to provide a relatively coarse wire mesh screen between the photocathode 3 and the target 4 to collect the secondary electrons. However, to avoid the use of such an auxiliary electrode the signal screen 20, as indicated in Figure 2, may be enameled on only one side, that is, the side adjoining the thin glass sheet 19.

While I have described the use of an intermediate thin coating of enamel upon the wire mesh of insufficient thickness to destroy the crimp promontories, the thin glass sheet may be sealed directly to these crimp promontories without the use of such an intermediate enamel film. For example, the above steps, with the exception of those relating to the application and firing of the enamel, may be performed, whereupon the thin glass upon firing and shrinking by surface tension becomes attached directly to the crimp promontories. 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 assembly comprising the sheet 19 and contiguous signal screen 20 is supported in the tube 1 and connected as described above, and in operation high velocity electrons representative of an electron image of the picture to be transmitted are focused on the rear surface of the thin target sheet 19 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 19 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 5 may be focused directly on the rear surface of the target sheet 19, as also shown in Figure 1. The opposite or front surface of the target sheet 19 is then scanned with an electron beam preferably of low velocity to develop a train of signals representative of the gradation in light and shade areas of the optical image.

The mode of operation may be considered in more detail taking into account the following assumptions: First, that the electron beam scans an area A of beam cross-sectional area on the front side of the sheet 19; second, that a corresponding area B on the opposite side of the sheet 19 and opposite area A receives a portion of the electrostatic image, and third, that the intensity of the electrostatic image over the area B is zero. The scanning beam such as the beam of low velocity electrons charges the area A in a negative direction to cathode potential so that no further electrons from the beam can be collected over the area A and no signal is transmitted to the signal screen 20. Now let picture electrons such as from the cathode 3 be projected on the surface of the sheet 19 opposite A and over the area B at such a velocity as to charge it positively by secondary emission. The charge on B may be stored continuously by making the signal screen 20 sufficiently positive with respect to the photocathode 3 to collect the secondary emission on the signal screen 20, provided the side opposite the sheet 19 is not insulated. Since the area B is positive, the space around B and including an area of the signal screen 20 will also be positive by electrostatic influence. Points very near B will have almost the same potential as B and, in particular, the area A directly opposite B and on the scanned side of the target sheet 19 will have almost the same potential as area B. A portion of the electrons of the scanning beam in passing over the area A will therefore be able to land and deposit enough charge to reduce the residual charge on the area A to the potential of the cathode 7. During the subsequent frame time and prior to the next scanning of the area A by the electron beam, the positive charge at B and the negative charge at A unite by conduction through the sheet of semi-conducting material to return both areas A and B to their original uncharged states. Assuming the proper selection of specific resistance for the material of sheet 19, very little transverse redistribution of the charges from area to area of the target will result. If, however, the specific resistance of the material is too high, such as 10^{13} ohm-centimeters or more, the neutralization of the charges on opposite sides of the sheet 19 is not completed by conduction during a single frame time, and the electrostatic picture side or rear surface of the sheet 19 will tend to charge up to the signal screen potential. However, if the semi-conducting material is chosen with the proper specific resistance, a positive charge on area B will be neutralized by the negative charge on area A during a single frame period.

Further, I have found that four conditions should be satisfied if the semi-conductor is to operate efficiently to transmit a well-defined television picture with adequate signal strength and without spurious effects. In the first place, the period of discharge between the two sides of the target sheet should be equivalent to the frame time. Secondly, the capacitance between the two surfaces of the semi-insulator should be as great as and preferably several times greater than the capacitance between the picture side of the target and the signal screen.

The capacitance between the areas A and B should be several times the capacitance between B and the signal screen 20. These relationships of capacity are to insure that a reasonably large fraction of the picture charge is converted to useful picture signal. This fraction of picture charge so used is actually

$$\frac{C_{AB}}{C_{AB} + C_{B20}}$$

where C_{AB} =capacitance between areas A and B and C_{B20} =capacitance between area B and the signal screen 20. Due to the exceptionally small spacing desired between the signal screen 20 and the semi-insulating sheet 19, the capacitance between B and any surrounding conductors other than the signal screen 20 is negligibly small. The third condition is that the thickness of the semi-insulator should be less than one-half the diameter of a picture element, and the signal screen 20 spaced less than a picture element from the nearest adjacent surface of the target sheet 19 in order to confine the electrostatic influence of a picture element on the picture side to only the corresponding element on the scanned side. The fourth condition requires that the time constant for the lateral diffusion of a picture charge should be equal to or greater than the period of frame scanning. This condition may be expressed and satisfied by the following relationship:

$$\frac{\rho EC}{\pi Dt} \geq 1$$

Where

ρ =volume resistivity of target (ohm-cm.).
 E =elemental picture area (square centimeters).
 C =capacitance between picture side of target and signal screen (farads/cm.²).
 D =thickness of the target sheet (cms.).
 t =frame time (seconds).

A reasonable set of values for these parameters satisfying all of the four conditions above is:

$\rho = 5 \times 10^{10}$ ohms-cms.
 $E = 10^{-4}$ square cms.
 $C = 10^{-10}$ farads/cm.²
 $D = 10^{-3}$ cms.
 $t = 1/30$ sec.

While in the example given above I have described a tube making use of electron image projection to form the electrostatic picture image on the rear surface of the semi-insulating target, I have also mentioned that this electrostatic image may be formed by light projected directly on the rear surface, provided the surface is sensitized with caesium. However, the described electron image projection method is preferred because of the larger obtainable signal.

My electrode may be distinguished from the conventional double-sided type of mosaic electrode, 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 structure 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 semi-conducting target sheet 19, which must be homogeneous, and any other electrode in the tube such as the signal screen 20. 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 scans 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 "Orthon" 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 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 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 structure disclosed without departing from the scope of the invention as set forth in the appended claims.

I claim:

1. A target electrode for an electron discharge device comprising a thin imperforate sheet of insulating material sealed to a foundation including a woven wire mesh screen, the said sheet being sealed only to the crimp promontories of said foundation.
2. A target electrode for an electron discharge device comprising a thin imperforate sheet of insulating material sealed to a woven wire mesh screen, the said sheet contacting the wire mesh screen only over the crimp promontories thereof.
3. A target electrode for an electron discharge device including a woven wire mesh screen, a thin coating of insulation on said woven wire mesh and a contiguous thin sheet of insulating material sealed only to the crimp promontories of said insulated wire mesh screen.

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4. A target electrode adapted to be scanned by an electron beam comprising an insulated woven wire mesh screen, a contiguous sheet of material having a specific resistance of from 10^9 to 10^{12} ohm-centimeters, said sheet of material being sealed only to the crimp promontories of said insulated wire mesh screen.

5. A target electrode adapted to be scanned by an electron beam comprising a woven wire mesh screen having crimp promontories extending from the surface thereof, a thin coating of insulation on said wire mesh screen, an imperforate sheet of insulating material contiguous with the insulated crimp promontories of said screen, said sheet having a specific resistance lower than the specific resistance of said coating of insulation.

6. A target electrode comprising a woven wire mesh screen having crimp promontories extending above the surface thereof, a coating of insulation covering one side only of said wire mesh screen and a thin imperforate sheet of glass contiguous with the coating of insulation only over the crimp promontories of said wire mesh screen.

7. A target electrode comprising a woven wire

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mesh screen having crimp promontories extending above the surface thereof, a coating of insulating material having a specific resistance of at least 5×10^{12} ohm-centimeters over at least one side of said screen and a thin sheet of insulating material having a specific resistance of 10^9 to 10^{12} ohm-centimeters contiguous only with the insulated crimp promontories of said screen.

8. A target electrode comprising a woven wire mesh screen having crimp promontories extending above the surface of said screen, a coating of insulation on said screen of insufficient thickness to prevent a light transmission of 50% of incident light through the interstices of said screen, and a thin planar sheet of insulation contiguous with and tangent to the insulated crimp promontories of said screen.

9. A target electrode comprising a perforated metal screen having small sections extending above the surface thereof, a coating of insulation over said small sections, and a thin sheet of insulating material contiguous with and sealed only to the small sections of the insulated screen.

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