March 7, 1939. G. A. MORTON 2,149,977

TELEVISION TRANSMITTING TUBE

Filed Jan. 30, 1935 3 Sheets-Sheet 1

Fig. 1.

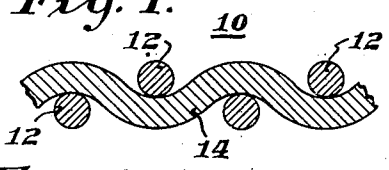


Fig. 2.

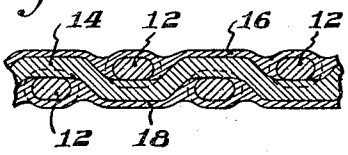


Fig. 3.

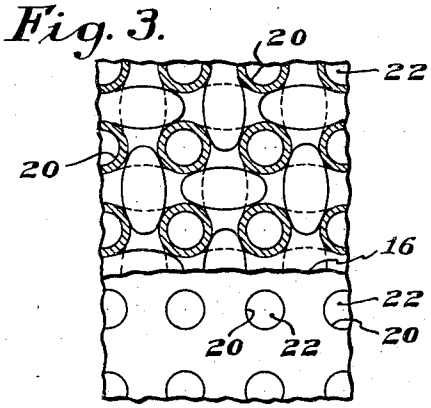


Fig. 4.

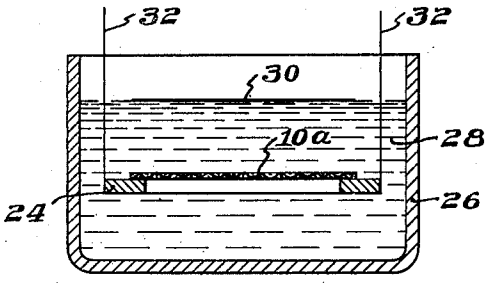


Fig. 7.

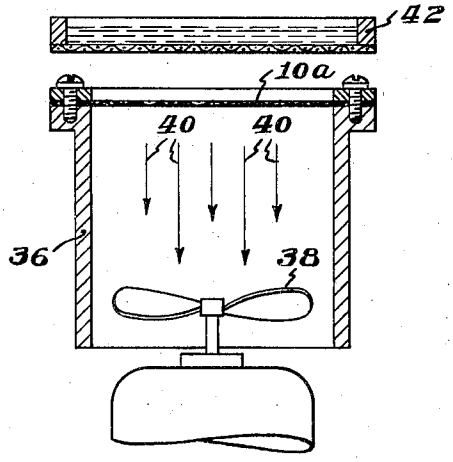


Fig. 5.

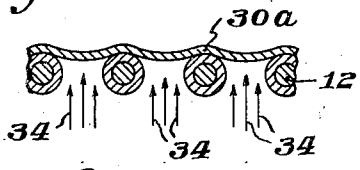


Fig. 6.

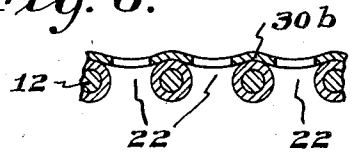


Fig. 8.

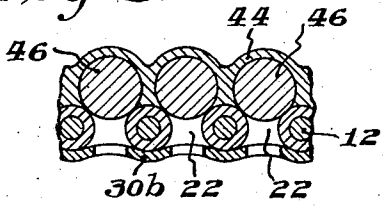
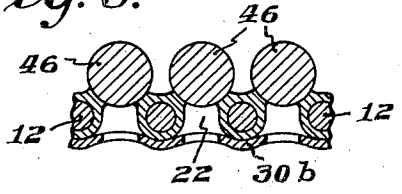


Fig. 9.



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March 7, 1939. G. A. MORTON 2,149,977

TELEVISION TRANSMITTING TUBE

Filed Jan. 30, 1935 3 Sheets-Sheet 2

Fig. 10.

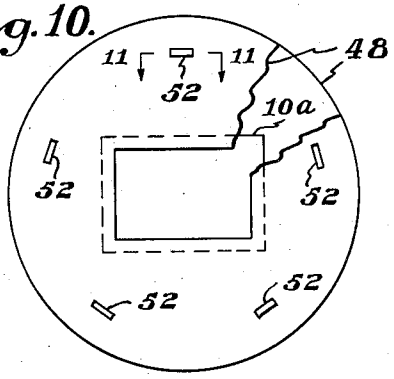


Fig. 11.

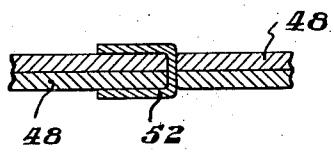


Fig. 12.

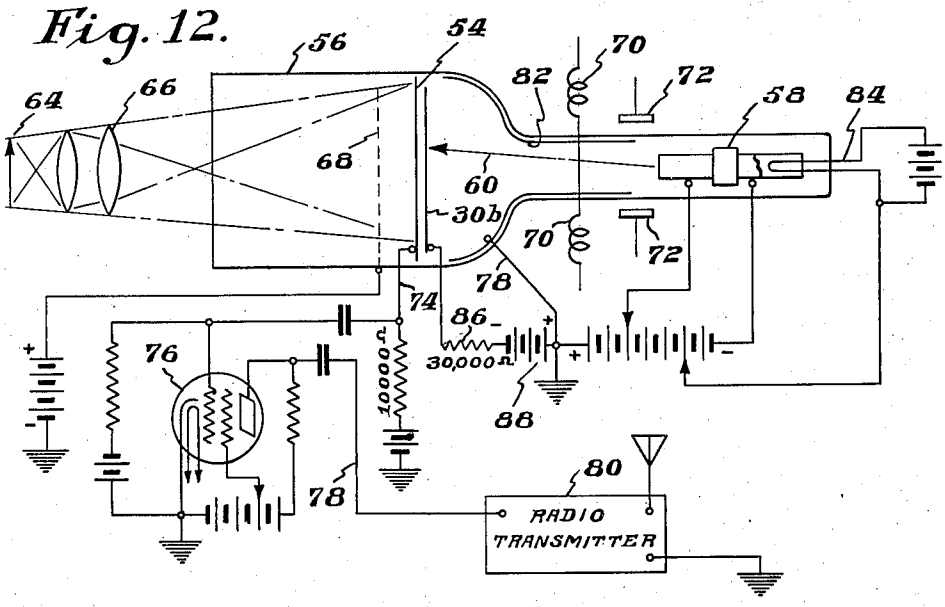
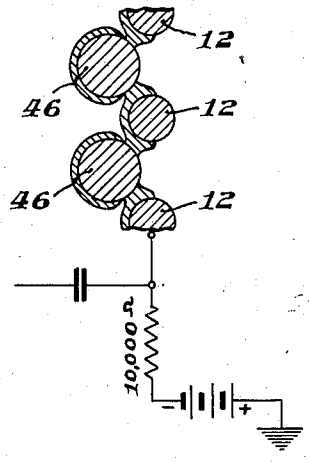


Fig. 14.



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TELEVISION TRANSMITTING TUBE

Filed Jan. 30, 1935 3 Sheets-Sheet 3

Fig. 13.

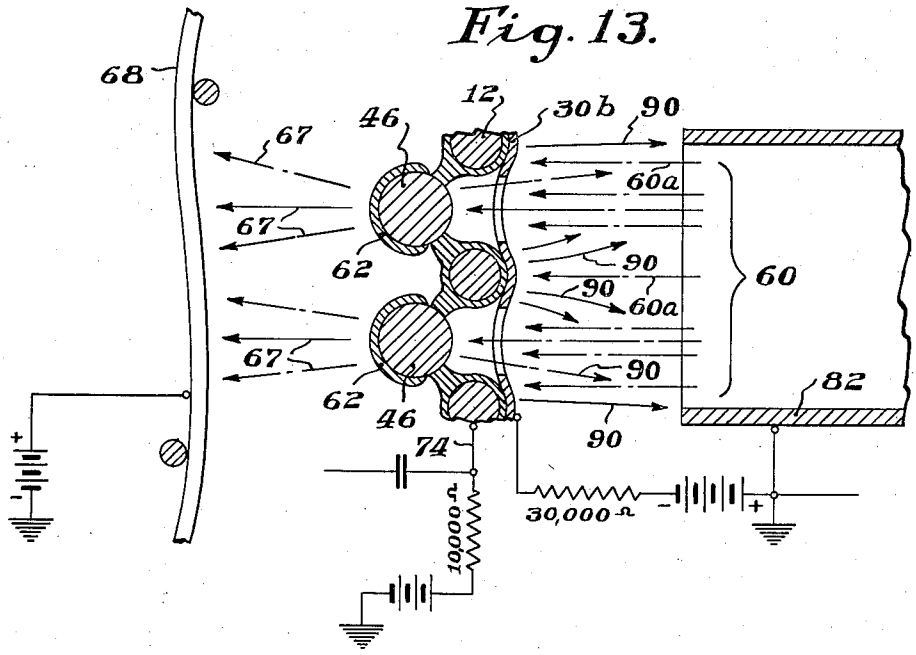


Fig. 15.

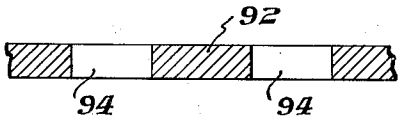
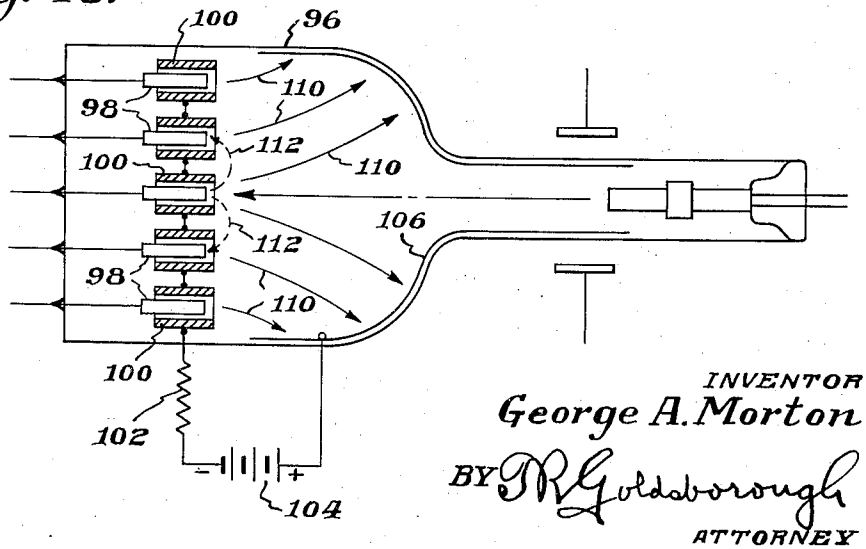


Fig. 16.



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Patented Mar. 7, 1939

2,149,977

UNITED STATES PATENT OFFICE

2,149,977

TELEVISION TRANSMITTING TUBE

George A. Morton, Haddon Heights, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application January 30, 1935, Serial No. 4,023

11 Claims. (Cl. 250—167)

My invention relates to television transmitting tubes of the type wherein an optical image of an object is translated into an electrical image and the electrical image is scanned by a cathode ray to provide a train of electrical impulses.

More especially, my invention relates to transmitting tubes wherein the translation of the optical image into an electric image is accomplished through the medium of a photo-sensitive screen of the so-called mosaic type. Broadly speaking, such a screen is constituted by a plurality of minute photo-cells insulatingly supported by and capacitively related to a common metallic electrode. In the operation of the tube, the optical image, focused upon the screen, causes the individual cells to acquire positive charges proportional to their illumination. These charges are successively neutralized by the cathode ray to give rise to the train of impulses.

The cathode ray may be caused to either scan the same side of the screen on which the optical image is focused or the opposite side, depending upon the nature of the supporting electrode. In any event, the scanning ray of electrons causes the emission of secondary electrons. These secondary electrons, unless they are immediately removed, are drawn over or find their way to elements adjacent the elements being scanned. This undesirable action causes a redistribution of the secondary electrons which interferes with the efficiency of operation of the tube.

With the foregoing in mind, it is one of the objects of my invention to provide an improved screen structure for television transmitting tubes which, when embodied in the same, operates in such manner that the various conditions for most efficient operation can be realized, which may be disposed between the electron gun and the lens system in a plane perpendicular to the aligned axes of the gun and the lens system, and which is effective as a shield to prevent interference between the effects of photoelectric emission from the lens side of the screen and secondary emission from the opposite side of the screen.

Another object of my invention is the provision of an improved screen construction for television transmitting tubes which not only has the advantages referred to, but which can be made in a practical way to obtain the required number, size and distribution of the individual, minute elements comprising the mosaic surface, in order not only to obtain the necessary detail for faithful reproduction, but also to obtain a value of capacity between the individual elements and the supporting base structure which is substantially greater than the capacity between adjacent elements. This insures storing up of the electrostatic charges linearly.

Another object of my invention is to provide an improved photoelectric device of the character referred to wherein there are means associated with the screen for preventing redistribution of secondary electrons over the scanned mosaic surface.

Another object of my invention resides in the provision of an improved photosensitive screen for television transmitting tubes which can be made without difficulty, comparatively speaking, in which the individual elements are substantially more efficient photoelectrically than in the various constructions proposed heretofore, and which has the advantages of the hypothetical ideal screen.

Another object of my invention resides in the improved method of making a screen of the character referred to.

Other objects and advantages will hereinafter appear.

In accordance with my invention, I employ a supporting conducting base member, in the form of a wire screen or a perforated sheet, the wire screen being of the proper mesh, or the perforated sheet having the proper number and distribution of apertures to give the required number of individual elements per square inch over the mosaic surface. The supporting base member is enameled or otherwise treated to give the same an insulating coating. A metallic layer is then applied to one side of the base member to form a grid. The base member is then placed in a horizontal position with the grid side down. Air is drawn downwardly through the apertures while minute silver spheres are sprinkled over the upper surface. In this way, a silver sphere is drawn over each of the apertures to close the same. The excess spheres are brushed away while maintaining the air suction, and a binder is applied to hold the remaining spheres in place over the respective apertures. The assembly is then baked at a temperature sufficient to drive off the binder and soften the enamel so that individual silver spheres are partly embedded therein and thereby fixed securely to the base member. The screen is then placed in the tube, in a plane perpendicular to the axis of the electron gun with the grid surface facing the latter, and with the edges of the screen in close proximity to the wall structure of the tube so that the same is effective as a shield to prevent undesirable interference between the respective effects due to

secondary emission from the surface of the screen facing the electron gun and the photoelectric emission from the opposite surface of the screen. The surfaces of the minute silver spheres, on this opposite surface of the screen, are then photosensitized.

My invention resides in the improved screen structure of the character hereinafter described and claimed, and the method of making the same.

For the purpose of illustrating my invention, an embodiment thereof is shown in the drawings, wherein

Figure 1 is an enlarged fragmentary sectional view of wire mesh used in constructing my improved screen;

Fig. 2 is a view similar to Fig. 1, illustrative of the construction after the enameling step;

Fig. 3 is a plan view, partly broken away, of Fig. 2;

Fig. 4 is a simplified, diagrammatic view, illustrative of the method of carrying out the next step in the manufacture of the screen;

Figs. 5 and 6 are views similar to Fig. 2, showing the construction after completion of the step in Fig. 4;

Fig. 7 is a simplified, diagrammatic view, illustrative of the method of carrying out the next step in the manufacture of my improved screen;

Figs. 8 and 9 are views similar to Fig. 2, showing the construction following the method step in Fig. 7;

Fig. 10 is an elevational view, partly broken away, showing the method of mounting the screen;

Fig. 11 is an enlarged sectional view, the section being taken on the line 11—11 in Fig. 10;

Fig. 12 is a simplified diagrammatic view, showing the manner in which my improved screen construction is embodied in a television transmitting tube, and illustrative of the manner of operation;

Fig. 13 is an enlarged, fragmentary, sectional view, taken from Fig. 12, illustrative of the principle of operation;

Fig. 14 is a view similar to Fig. 13, showing a modification;

Fig. 15 is a view similar to Fig. 1, showing a modification; and

Fig. 16 is a simplified, schematic view, showing the manner in which my invention might be embodied in an electron device other than a television transmitting tube.

In making my improved screen, I employ a metallic base member in the form of a wire screen 10 of from 100 to 400 mesh, for example, and which is comprised of the woof wires 12 and the warp wires 14. A 150-mesh screen will have 22,500 openings or apertures per square inch, while a 200-mesh screen will have 40,000 openings to the square inch. While a finer mesh screen may be used, if required, it has been found that for present requirements screens of from 150 to 200-mesh give satisfactory detail.

For the purpose of making the screen as nearly as possible the equivalent of a flat, perforated, metal sheet provided with the same number of apertures per square inch, it is first passed through rollers and thereby flattened out, as represented in Fig. 2. Both surfaces of the screen will then be flat for all practical purposes.

The next step in the construction consists in applying an enamel or other insulating coating over the entire surface of the screen, but without closing the openings or apertures. In this connection, satisfactory results have been obtained by using vitreous enamel having a specific resistance of at least 10^{10} ohms per cm^3. The enamel frit is first ground very fine and then applied to the surfaces of the metal base member by spraying, dusting, settling from liquid suspension, or by any other method effective to coat the surfaces uniformly without clogging the apertures. The screen is then heated to fuse the enamel, the temperature and duration of the heating period depending upon the characteristics of the enamel used. In this way, a continuous and uniform insulating coating of enamel, the thickness of which is of the order of .0005'', is formed over all the surfaces.

On one side of the member 10 there will be an insulating layer 16, and on the other side there will be an insulating layer 18, with insulating bushings 20 lining the openings 22 and extending through the base member and merging with the layers 16 and 18.

In Fig. 3, part of the insulating layer 16 has been removed to illustrate more clearly the insulating bushings 20.

In carrying out the next step in the manufacture of my improved screen, the enameled screen is placed upon a frame 24 and in a horizontal plane within a tank 26, below the surface of water 28 in the tank. A film 30 of platinum chloride dissolved in lavender oil, or any other suitable metallizing compound, is then floated on the surface of the water, over the screen. This film is relatively thin, the dimension being of the order of .0001 inch. The frame 24 is then raised by the supporting elements 32 to lift the screen 10*a* vertically upwardly and out of the tank. During this movement, the film 30 is picked up by the screen to form a thin and uniform layer 30*a* of material over the upper surface, as illustrated in Fig. 5. A blast of air is then directed at the other side of the screen, as represented by the arrows 34, to blow out any apertures which might have been closed previously by the layer 30*a*. The film is then reduced to a metallic conducting layer by heating or by some other suitable method. The construction then appears as illustrated in Fig. 6, with a metallic grid 30*b* on one side thereof. By reason of the method of construction just described, each aperture on one side of the screen is surrounded completely by the metallic material of the grid, but is not closed thereby.

In carrying out the next step in the construction, the enameled screen 10*a* is placed in a horizontal plane, as shown in Fig. 7, over the open end of a pipe 36 and with the grid side down. A fan 38 at the other end of the pipe, operates to draw air downwardly through the minute apertures in the screen, as represented by the arrows 40. At the same time, minute silver spheres, each having a projected area somewhat greater than the area of the individual apertures, are sprinkled upon the upper surface of the screen, whereupon one of the spheres or beads is drawn over each of the apertures to close the same. The excess silver beads are then brushed away or otherwise removed from the upper surface of the screen, during which operation the suction provided by the fan 38 is effective to hold the desired beads over the respective apertures.

It is proposed to make the silver beads by spraying metal with a Schoop metal sprayer into the air, and collecting the solidified spherical droplets or beads. The beads are then sifted to obtain those of the proper dimensions, and are

placed in a sieve 42 of a mesh slightly less than the mesh of the screen 10a. The screen 42 is then tapped to cause the silver beads to drop through and upon the upper surface of the screen 10a.

With one of the silver beads over each of the apertures in the screen 10a, and with the fan 38 still operating, the upper surface of the screen is coated with a layer 44 of a suitable binding material such as cellulose nitrate. In this way the silver beads 46 are sealed in place over the respective apertures 22.

The assembly is then baked at a temperature sufficient to remove the layer 44 of binding material and to soften the enamel to permit the silver beads 46 to sink into and become partly embedded therein, as illustrated in Fig. 9. Upon subsequent cooling, therefore, the silver beads 46 are securely fixed to the screen base member and sealed in position over the apertures by the insulating layer of enamel.

The screen 10a is next placed between two discs 48 of mica, as shown in Fig. 10. The mica discs are provided with rectangular openings 50 somewhat smaller than the size of the screen.

The mica discs may be held together by nickel clips 52 which are passed through registering slits in these discs and bent over against the same, as shown in Fig. 11.

The completed screen, designated generally in Fig. 12 by the reference numeral 54, is then sealed in a highly evacuated tube 56 and in a plane perpendicular to the axis of an electron gun 58 at one end of the tube. The side of the screen 54 which is provided with the grid 30b faces the gun 58. The gun 58 is of conventional design, and operates to develop and direct a ray 60 of electrons at the screen. The surfaces of the silver beads 46, on the other side of the screen, are then photosensitized in a well known manner, whereby the proper amount of photosensitive material 62 is deposited over these surfaces of the beads.

In operation, an image of the object 64 is projected onto the photosensitized surface of the screen by a suitable lens system 66 whose axis is perpendicular to the screen and in alignment with the gun 58. There will then be photoelectric emission, as represented by the arrows 67 in Fig. 13, from any particular element 46, 62, in an amount corresponding to the light intensity on such element at the instant, and this element will accordingly store up an electric charge in an amount corresponding to the light intensity. In this way, during any framing period, individual electrostatic charges are stored over the surface of the screen, the value of the charge at any particular elemental area corresponding to the light intensity at the instant on such area. The electrons emitted from the lefthand surface of the screen 54 due to photoelectric action are withdrawn or removed by an electrode 68 which is maintained at a potential positive with respect to the potential of the screen 54. The electrode 68 may be in the form of a few fine wires stretched across a suitable frame, so as not to interfere with the projection of the light image onto the screen 54.

The picture signals are developed as the ray 60 is caused to scan the righthand surface of the screen 54, for which purpose the ray may be deflected horizontally by coils 70 and simultaneously deflected vertically by plates 72. The ray 60 is focused on the screen 54, and as the electrons of the ray strike the exposed surfaces of the metallic beads 46, the electrostatic charges previously stored are neutralized, whereby electrical impulses, corresponding in amplitude to the respective charges, appear in a connection 74 which is connected to the metallic base member 10, and are applied as shown to the grid circuit of an amplifier tube 76. The amplified picture signals are then applied by a connection 78 to a suitable radio transmitter 80 and are utilized to modulate a carrier wave.

During the scanning action, the secondary electrons which are emitted from the righthand surface of the screen 54 are collected by an anode 82 which is maintained at a relatively high positive potential with respect to the cathode 84 of the electron gun, as represented in Fig. 12. The electrode 82 may be in the form of a silver coating on the inner surface of the tube 56, and serves not only to collect the electrons of secondary emission, as explained, but to focus the ray on the screen 54 and impart a relatively high velocity to the electrons so that they strike the righthand surfaces of the elements 46 at a relatively high rate of speed. The grid 30b is connected through a resistance 86 to a battery 88 whereby the grid is maintained at a polarity substantially negative with respect to the collector electrode 82.

As indicated in Fig. 12, the dimension of the complete screen 54, as shown in Fig. 10, is only slightly less than the inside diameter of the large end of the tube 56. The edges of the mica discs 48, are in close proximity to the wall structure of the tube. The screen, therefore, is effective as a shield to prevent any appreciable interfering action between the electrons due to secondary emission from the righthand surface of the screen and the electrons due to photoelectric emission from the lefthand surface of the screen. In this connection, it is important that the screen 54 is impervious to the flow of electrons in the ray 54 so that there is no interference of these electrons with respect to electrons of photoelectric emission on the opposite or lefthand side of the screen.

As illustrated in Fig. 13, as the electrons of the ray, represented by the arrows 60a, bombard the righthand surfaces of the elements 46, they cause the emission of secondary electrons from the latter, represented by the arrows 90. These secondary electrons, due to the difference in potential between the collector electrode 82 and the grid 30b, and the fact that the latter is substantially more negative than the electrode 82, are drawn to and collected by this electrode, from which they pass to ground by way of the connection 78. Without this action and condition of operation, some of the secondary electrons from the individual elements 46 would be drawn to the elements immediately adjacent thereto to cause a redistribution of the electrons over the entire effective surface of the screen. This undesirable action would interfere with the efficiency and fidelity of operation.

In the construction in Fig. 14, the wire mesh is enameled only on one side thereof, so that the opposite or righthand side is exposed to the electrons of the scanning ray. The screen, therefore, can function in the same manner and for the same purpose as the grid 30b in Figs. 12 and 13. The change in connections is as shown. Otherwise, the connections and operating action are the same as in Figs. 12 and 13.

In lieu of the wire mesh in Fig. 1, it is proposed to use a metal plate or thin metal sheet 92

provided with perforations 94 equivalent in size, number and arrangement to the perforations in the wire mesh, as shown in Fig. 15. The construction and method of manufacture when using a perforated sheet, otherwise, is the same as explained above. In such case, however, it is not necessary to roll the sheet as in the case of the wire mesh.

In Fig. 16, the tube 96 shown is provided with a number of metallic elements 98, each of which is disposed within a metallic cylindrical shield 100. The shields 100 are electrically connected to each other, as shown, and are connected through a resistance 102 to a battery 104 which places them at a potential substantially more negative than the potential of a collector electrode 106 corresponding to and serving the same purpose as the collector electrode 82 in Fig. 12.

The tube 96 may be an electron commutator or any other form of electron device in which the undesirable action of redistribution of secondary electrons between the elements might occur.

In operation, as the electron ray 108 strikes one of the elements 96, the secondary electrons, as represented by the arrows 110, are drawn toward and collected by the electrode 106. Otherwise, some of the secondary electrons emitted from the element being scanned at the instant would be drawn toward the adjacent elements, as represented by the broken arrows 112.

From the foregoing it will be seen that I have provided an improved screen construction particularly adaptable for use in television transmitting tubes, and which is so constructed that the optical image of the object may be projected upon one side of the screen and the scanning ray directed at the other side, whereby interference is prevented between the respective operating effects of the secondary electrons and the photoelectrons.

Furthermore, it will be seen that in my improved screen construction means are provided for preventing redistribution of secondary electrons over the effective operating surface of the screen.

Although my invention has been shown and described more in connection with a construction for a television transmitting tube, it will be understood that the same has a much broader aspect, and may be embodied in and practiced in connection with electron devices for other uses, such as is illustrated in Fig. 16.

It will be understood that various modifications, within the conception of those skilled in the art, are possible without departing from the spirit of my invention or the scope of the claims.

I claim as my invention:

1. An electrode element comprising screen structure substantially impervious to the flow of electrons through the same, said structure comprising a conducting base member provided through the same with relatively minute and spaced holes at least of the order of ten thousand to the square inch, a layer of insulating material over at least one surface of said member and about the edges of said holes, and metallic elements disposed respectively over said holes, the projected area of said elements being greater than the area of the individual holes and said elements being partly embedded in and fixed to said member by said material whereby the holes at said surface are closed and sealed off by said elements and the insulating material whereby said elements are insulated from said member and from each other by said material, said elements over their outside surfaces being photosensitive, the holes at the other surface of said member being open whereby the inside metallic surfaces of said elements are exposed on this side of said member.

2. An electrode element comprising screen structure substantially impervious to the flow of electrons through the same, said structure comprising a metallic base member provided through the same with relatively minute and spaced holes at least of the order of ten thousand to the square inch, a layer of insulating material over at least one surface of said member and about the edges of said holes, and spherical metallic elements disposed one over each of said holes, the projected area of said elements being greater than the area of the individual holes and said elements being partly embedded in and fixed to said member by said material whereby the holes at said surface are closed and sealed off by said elements and the insulating material and whereby said elements are insulated from said member and from each other by said material, said elements over their outside surfaces being photosensitive, the holes at the other surface of said member being open whereby the inside metallic surfaces of said elements are exposed on this side of said member.

3. An electrode element comprising screen structure substantially impervious to the flow of electrons through the same, said structure comprising a metallic base member provided through the same with relatively minute and spaced holes at least of the order of ten thousand to the square inch, a layer of insulating material over at least one surface of said member and about the edges of said holes, and metallic elements disposed respectively over said holes, the projected area of said elements being greater than the area of the individual holes and said elements being partly embedded in and fixed to said member by said material whereby the holes at said surface are closed and sealed off by said elements and the insulating material and whereby said elements are insulated from said member and from each other by said material, each of said elements protruding outwardly and substantially beyond the surface of the insulating layer, the outer surfaces of the protruding portions of said elements being photosensitive.

4. An electrode element comprising screen structure comprising metallic elements insulated from each other, said structure including means in the form of a metallic grid the material of which is insulated from said elements and is exposed over a side of said structure in the form of electrically connected and individual shields disposed respectively about said elements, the outside surfaces of said elements on the other side of said structure being photosensitive.

5. An electrode element comprising screen structure comprising metallic elements spaced and insulated from each other, said structure including means in the form of a metallic grid the material of which is insulated from said elements and is exposed over a side of said structure, the openings in said grid being in registration respectively with the spaces between said elements, the outside surfaces of said elements on the other side of said structure being photosensitive.

6. An electrode element comprising screen structure comprising an apertured metallic base member provided over the surfaces thereof with a layer of insulating material, metallic elements fixed to said member and disposed respectively at the apertures therein to close the same, a grid

fixed to said member and disposed over the surface on one side thereof, the apertures in said grid being in registration respectively with the apertures in said member, the outside surfaces of said elements on the other side of said member being photosensitive.

7. An electrode element comprising screen structure substantially impervious to the flow of electrons through the same, said structure comprising a metallic base member provided through the same with relatively minute and spaced holes and with a layer of insulating material over its surfaces, a grid fixed to said member and disposed over the surface on one side thereof, the apertures in said grid being in registration respectively with the apertures in said member, and metallic elements carried by said member and disposed respectively at the apertures therein to close the same, said elements being insulated from each other and from said member by the insulating layer, the outside surfaces of said elements on the other side of said member being photosensitive.

8. An electron device comprising a tube provided with screen structure and with means for developing a ray of electrons and directing the ray at said screen, said screen being provided with a plurality of metallic elements each insulated from said screen and from the other elements, an electrode disposed between said means and said screen for collecting secondary electrons emitted by said elements from the ray side of said screen, and electrode means associated with said screen and disposed between the same and said collector electrode for shielding the individual elements from such secondary electrons.

9. An electron device comprising a tube provided with screen structure and with means for developing a ray of electrons and directing the ray at said screen, said screen being provided with a plurality of relatively minute metallic elements each insulated from said screen and from the other elements, an electrode disposed between said means and said screen for collecting secondary electrons emitted by said elements from the ray side of said screen, and a grid carried by and insulated from said screen and disposed over the surface thereof on the ray side of the same, the apertures in said grid being in registration respectively with the apertures in said screen, the surfaces of said elements on the other side of said screen being photosensitive.

10. An electron device comprising a tube provided with metallic elements spaced and insulated from each other, means for developing a ray of electrons and directing the same at said elements whereby secondary electrons are emitted from the latter, an electrode for collecting said secondary electrons, and electrode means shielding the individual elements from secondary electrons emitted from adjacent elements during bombardment of the latter by the electrons of said ray, said electrode means being insulated from said collector electrode whereby said electrode means can be maintained at a potential substantially more negative than said collector electrode.

11. An electron device comprising a tube provided with metallic elements spaced and insulated from each other, means for developing a ray of electrons and directing the same at said elements whereby secondary electrons are emitted from the latter, an electrode disposed between said means and said elements for collecting said secondary electrons, and a grid disposed immediately adjacent said elements and shielding the individual elements from secondary electrons emitted from adjacent elements during bombardment of the latter by the electrons of said ray, said grid being insulated from said electrode whereby said grid can be maintained at a potential substantially more negative than said electrode.

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