

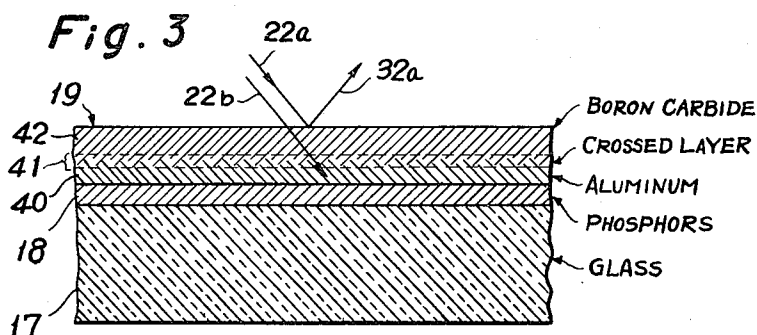
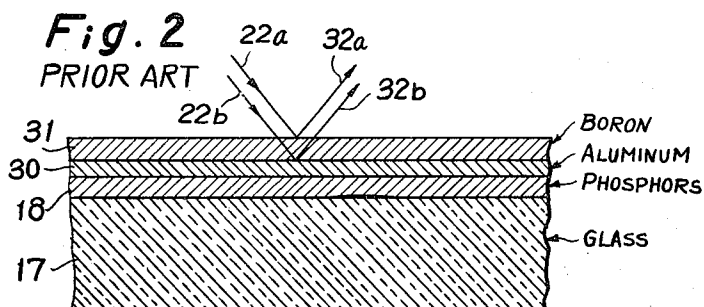
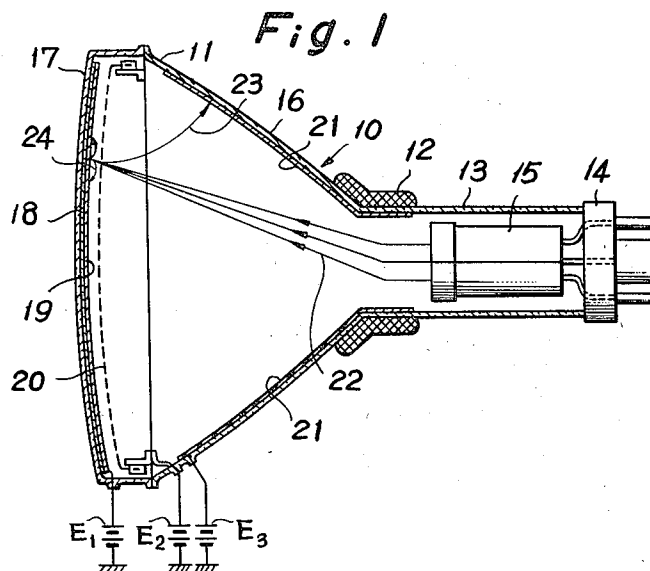
Sept. 19, 1972

KENJIRO TAKAYANAGI ET AL
ELECTRON SCATTERING PREVENTION FILM AND METHOD
OF MANUFACTURING THE SAME

3,692,576

Filed Jan. 9, 1970

2 Sheets-Sheet 1



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ATTORNEYS

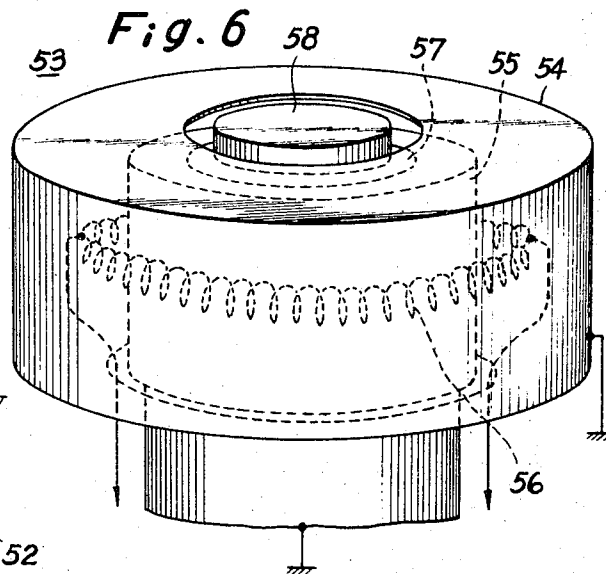
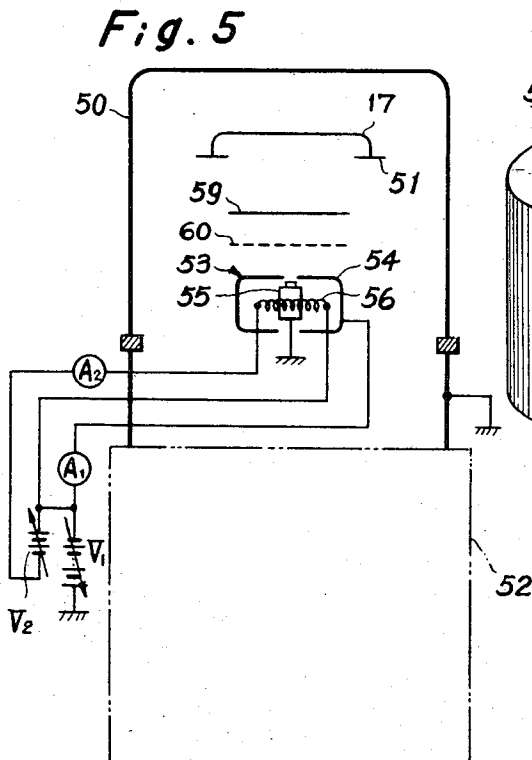
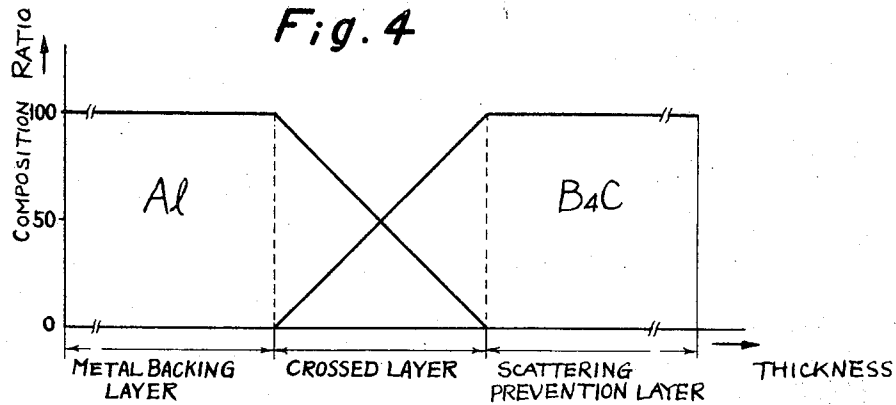
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ELECTRON SCATTERING PREVENTION FILM AND METHOD OF MANUFACTURING THE SAME

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7 Claims

ABSTRACT OF THE DISCLOSURE

A film for the prevention of scattering of electrons comprising an electrode layer, a crossed layer formed thereon consisting of an electrode constituent material and a material for the prevention of scattering of electrons smaller in atomic number than that of the electrode constituent material, and a scattering preventing layer and on which is formed a layer for the prevention of scattering of electrons of the second material on said crossed layer. A method of manufacturing the above electron scattering prevention film is also disclosed.

This invention relates to an electron scattering and reflection prevention film and a method manufacturing of the same, and more particularly to such a film for use in color television display tubes to minimize the reflection and scattering of a beam of electrons.

Generally in the post-acceleration color television tubes electron beams emitted from three electron guns are accelerated in a high voltage electric field and strike at a phosphor surface electron beams of high kinetic energy excite the phosphors and produce a luminous output. At the same time a large number of secondary electrons, reflecting electrons and scattering electrons are generated by the impact of electron beams of high kinetic energy.

The scattering electrons have no high kinetic energy as do the reflecting electrons, which therefore can be removed by utilizing the energy differences between the injected electrons and the secondary electrons. However the scattering electrons are accelerated by said post-acceleration electric field and strike at the phosphors again with high kinetic energy of the same intensity as the injected electrons with the result that undesirable halos are generated surrounding the luminous points which are produced by normal injecting electrons. As a consequence, the contrast of the reproduced images is reduced and adverse color contamination is effected.

So, to remove the phenomena effectively it has been proposed to sinter a single thin layer of a material of small atomic number such as boron or carbon deposited on the metal backing of aluminum evaporated on the phosphor layer so that the amount of scattering electrons from the phosphor surface is reduced, as seen in U.S. Pat. No. 2,878,411. But the aforementioned conventional single thin layer was not capable of obtaining a desired effect enough to prevent the scattering of electrons and absorb satisfactorily the secondary electrons emitted from the shadow mask. Another drawback was that the single

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layer was readily peeled off during normal heating at a temperature of about 430° C. in the course of manufacture of the color television tubes and accordingly the manufacture was very difficult. Furthermore it was desired that the layer be thicker to fully absorb the secondary electrons which however caused the single layer more readily to peel off during manufacturing. In view of these drawbacks the above proposed construction was not entirely practicable.

The present invention is intended to provide a film for the prevention of scattering of electrons and devoid of such drawbacks as described while being easily practicable.

A primary object of the present invention is to provide a film for the prevention of scattering of electrons by the bombardment of the electron beams.

A second object of the invention is to provide a scattering prevention film for electrons, which can maintain itself in a very stable condition without peeling off owing to temperature variations and similar factors.

Another object of the invention is to provide an electron scattering prevention film which can offer a color television tube which is good in contrast and has no color contamination, and be particularly adapted for the post-acceleration color television tubes.

Still another object of the invention is to provide a method of manufacturing an electron scattering prevention film by having a crossed layer formed between a metal backing layer and a electron scattering prevention layer.

Further objects and features of the invention will be understood clearly from the description made with reference to the accompanying drawings, in which;

FIG. 1 is a vertical cross sectional view of a post-acceleration color television tube having an electron scattering-prevention film according to the present invention;

FIG. 2 is an enlarged partial cross section of a screen of a tube having a conventional film for the prevention of electron scattering;

FIG. 3 is an enlarged partial cross section of a screen of a tube having an electron scattering-prevention film, in accordance with the present invention;

FIG. 4 is a diagram showing a ratio of composition of an evaporated film varying with the film thickness;

FIG. 5 is a vertical cross sectional diagram of an embodiment of a device for manufacturing a film for the prevention of electron scattering in accordance with the present invention; and

FIG. 6 is a perspective view of heating means for the evaporating material.

Referring to FIG. 1, a post-acceleration type color television tube 10 generally consists of a glass bulb 11 and is externally provided with a deflection yoke 12. Within neck 13 of the funnel are sealed three electron guns provided on a connecting base 14. The bulb 11 generally comprises the funnel neck 13, a funnel 16 and a face plate 17. On the inner surface of the face plate 17 are disposed a phosphor layer 18 consisting of three color dot phosphors, i.e., of red, green and blue and a film 19 for the prevention of the electron scattering later described and formed integrally with a metal backing in accordance with the present invention. A shadow mask 20 has apertures larger in diameter than each diameter of dots of phosphors of the phosphor layer 18 provided in re-

sponse to respective dot trios spaced apart from respective layer 18 and film 19 and in parallel therewith.

According to one aspect of the present invention, a first electric power source E_1 is connected to a metal backing layer and a transparent conducting electrode such as nesa glass. A second power source E_2 of 8.8 kv. is connected to a shadow mask 20 and third power source E_3 of 9.6 kv. is connected to an anode 21 provided on the inner walls of the funnel 16. The power voltages E_1 to E_3 of the above power sources may preferably have the mutual relationships of $E_1 > E_2$, $E_2 < E_3$ and $E_1 > E_3$, so that there may be formed an intense post-acceleration electric field between the shadow mask 20 and the phosphor layer 18 with respect to the electron beams 22 emitted from the electron guns 15. Between the shadow mask 20 and the anode 21 is formed a weak negative acceleration electric field, which permits a major portion of the secondary electron 23 emitted from the shadow mask 20 when the electron beam 22 strikes at the shadow mask 20 being absorbed at the anode 21.

Some of the secondary electrons generated in the surroundings of the apertures of the shadow mask 20 are drawn to the post-acceleration electric field between the shadow mask 20 and the phosphor layer 18, and enter the acceleration electric field through the apertures, hence are accelerated and strike at the phosphor layer 18 partly causing deterioration of contrast. As the initial speeds of the secondary electrons correspond to about ten or more volts when they are emitted from the shadow mask 20, the kinetic energy thereof is almost equivalent to the energy of the post-acceleration voltage when the secondary electrons strike at the phosphor layer 18 and said kinetic energy is smaller than that of the electron beams 22 striking at the phosphor layer 18 through the shadow mask 20. By preferred selection of thicknesses of the metal backing layer evaporated on the phosphor layer 18 and the scattering prevention film it is possible to allow the primary electron beams 22 only to reach the phosphor screen 18 for illumination.

Thickness of the film coated on the phosphor layer 18 which may be enough to prevent the hazard of deterioration of contrast by the secondary electrons above described is about 5,000 Å. in the conversion value of aluminum, where for instance the voltage of the phosphor layer is 20 kv. and that of the shadow mask is 9 kv., and about 8,000 Å. where the voltage of the phosphor layer is 25 kv. and that of the shadow mask is 11 kv.

The electron beams of high kinetic energy passing through the shadow mask 20 and striking at the phosphors emit a large number of secondary electrons and scattering electrons during striking at the screen. Due to small initial speeds these secondary electrons will not excite nor illuminate the phosphors. The scattering electrons however are the electrons tending to disperse in diverse directions with nearly the same energy as of the injecting electron beams. Hence, among the scattering electrons, electrons 24 emitted at angles larger than a critical angle (the angle is defined by the voltages of the phosphor layer and the shadow mask and the distance between the phosphor layer and the shadow mask) will follow an arcuate path in the post-acceleration electric field again to strike the phosphor layer losing almost no energy. As they do this, they cause halos surrounding the luminous points, produced by the normal electron beams. In consequence, the contrast of image will deteriorate and the color contamination takes place. As the scattering electrons 24 have nearly the same energy as the primary electron beams, the lack of contrast and the color contamination can not be eliminated even by coating only a thicker layer or film on the phosphor layer. This has been a major draw-back with the prior art type of post-acceleration color television tubes.

As seen in FIG. 2, there has been proposed in prior art evaporation forming an aluminum metal backing layer 30 on the phosphor layer deposited on the inner surface of

the glass face plate 17 and further on the layer 30 sintering a layer 31 for preventing the scattering of electrons. The layer 31 constitutes of a material smaller in atomic number such as boron or carbon. This sort of composition however had the effect that although the reflection and scattering of electrons the electrons penetrating through the prevention layer 31 were found to disperse about the boundary between the prevention layer 31 and the metal backing layer 30 besides the electrons 32a reflected and scattered on the surface of the layer 31 and metal backing 30, thereby producing scattered electrons 32b so that a number of the back-scattered electrons in total was not reduced to a large extent. Furthermore, as the metal backing layer 30 and the prevention layer 31 which each have a different heat expansion coefficient were in contact with each other with a clear boundary therebetween, the prevention layer 31 and the metal backing layer 30 invariably peeled off from each other or from the phosphor layer 18 by difference of internal stresses in the respective layers particularly due to temperature variations of heating and cooling or shocks.

The film for preventing the reflection and scattering of electrons according to the present invention removes fully the above described drawbacks.

An enlarged view in FIG. 3 shows a partial cross section of the screen of the tube provided with a film for preventing the scattering of electrons according to the present invention. By means of evaporation later described aluminum is applied on phosphor layer 18 to form a metal backing layer 40 thereon, which is continuously provided with a compound or crossed layer 41 of a mixture of aluminum and a material for preventing the electrons scattering comprising an element having a smaller atomic number; and, further formed thereon is a prevention layer 42 solely consisting of the described prevention material so as to constitute the electrons scattering prevention film integrally with the metal backing layer 40.

The described prevention material is generally assumed to comprise an element having an atomic number of at least less than one half of the atomic number "13" of aluminum in order to obtain the contrast ratio of 20 on the condition that the ratio of emission of reflected electrons is proportional to the atomic number. Such a material is required to have properties sufficient to meet all the requirements in the manufacturing of television tubes. With these factors in consideration the inventors have conducted experiments with materials such as boron, carbon, LiF, LiCO_3 , and B_4C and adopted boron carbide (B_4C) as the most preferred material.

As shown in FIG. 4, the crossed layer 41 has the composition ratio of aluminum progressively varying from 100% to 0% and that of the prevention material varying from 0% to 100% from the side of the metal backing layer 40 to the side of the prevention layer 42, the mixture ratios of both materials having successively varying density gradients.

The thickness of each layer as described above may be provided such that scattering electrons will be reduced in number and the secondary electrons from the shadow mask will not illuminate the phosphor screen while the primary electron beams may sufficiently penetrate through the layers and illuminate the phosphors. Distribution of thicknesses respectively of the metal backing layer 40, the crossed layer 41 and the scattering prevention layer 42 may be preferably presented as 3:1:6 to 2:2:6 in a preferred ratio in the conversion value of aluminum.

In the scattering prevention film shown in FIG. 3, as the crossed layer exists between the metal backing layer and the scattering prevention layer, the primary electron beam 22b which has penetrated into the scattering prevention layer 42 reaches the phosphor layer 18 without being dispersed and illuminates the phosphors. In effect the prevention of scattering of electrons was markedly large and also the contrast was promoted by about twenty percent

over the conventional construction. Presence of the crossed layer will not cause peeling of the scattering prevention layer from the metal backing layer as seen to happen in conventional cases by temperature variation.

The table below shows the contrast ratios obtained by measurement of the effect of electron scattering prevention on the face plate having the thicknesses of the layers being respectively varied, where the total value of thicknesses of the metal backing layer 40, the crossed layer 41, and the layer of boron carbide (B_4C) is made constant at 5000 A. in the conversion value of aluminum. Also, respective thicknesses of the layers have been calculated on the basis of the conversion value of aluminum.

	Conventional film	Film of this invention	
		(I)	(II)
Metal backing layer of aluminum (A).....	2,000	1,500	1,000
Crossed layer of aluminum and boron carbide (A).....		500	1,000
Scattering prevention layer of boron carbide (A).....	3,000	3,000	3,000
Contrast ratio.....	10.8	13.4	13.4

Description is now made with respect to the method and apparatus for manufacturing the electrons scattering prevention film as shown in FIG. 4 as well as in FIGS. 5 and 6.

The face plate 17 having a phosphor layer on its inner surface is carried by a substratum holder 51 in a belljar 50, which is tightly closed with vacuum by an oil diffusion pump 52 before evaporating. Heating means 53 shown on an enlarged scale in FIG. 6 consists of a crucible 55 surrounded by an electrode 54 and a cathode filament 56 encircling said crucible.

In the crucible 55 is provided boron carbide in powder form, 57 (B_4C , melting point $2450^\circ C.$), and on which is deposited solid aluminum 58 (Al, melting point $660^\circ C.$). By means of the diffusion pump 52 air is exhausted from the belljar 50 to cause a vacuum of 10^{-5} to 10^{-6} mm. Hg. A voltage V_2 is provided at 7 v. and an electric current A_2 at 80 A. The heater 56 is heated to emit thermions, which are deflected by an electric field produced by the electrode 54 with a voltage V_1 of 5 kv., a current A_1 of 50 ma., and the thermions are concentrically bombarded at the materials 57 and 58 in the crucible.

Then a shutter 59 is closed and the materials 57 and 58 are heated preliminarily for two to three minutes. By this heating the gas in the materials 57 and 58 will be released. Aluminum 58 will melt and a portion thereof will permeate through the boron carbide so as to form a compound of both materials.

After the preliminary heating the shutter 59 is opened and the voltage in the electrode 54 is raised slowly from 5 kv. to 8 kv. during approximately five minutes. At the instant the aluminum 58 which is lower in melting point first evaporates to the phosphor layer of the face plate 17 and thereby the metal backing layer 40 is formed in the thickness of 1500 A.

With the voltage of 8 kv. being retained for a further five minutes the compounded and crossed portion of said two materials will evaporate. A crossed layer 41 will then be formed continuously retaining aluminum and boron carbide in a compounded and crossed condition of a gradient of density composition ratio in a thickness of 500 A. and having no boundary with the metal backing layer 40. The high voltage current A_1 flowing at a voltage of 8 kv. is about 100 ma.

Continuing the heating evaporates the boron carbide 57 which has remained after evaporating of the aluminum 58 and thus the vacuum evaporation is completed. On the crossed layer 41 is formed a scattering prevention layer 42 of boron carbide successively in a thickness of 3000 A. without having a boundary surface.

The leaked thermions from the heating means 53 and the electrons reflected after bombarding at the material

to be evaporated in a large number will bombard at the face plate of the substratum, which is heated or charged up and causes an electric discharge and peeling off of the layers. Sometimes it may occur that the air contained in the evaporating material in the crucible 55 will expand by heating or the powders will disperse by spurting. The powders may reach the substratum and contaminate the evaporating surface to cause peeling. Therefore it is so arranged that a meshed collector electrode 60 is provided so as to avoid the occurrences of these phenomena. The meshed collector electrode 60 is disposed between the crucible 55 and the face plate 17. The collector electrode 60 may be at a ground potential but it may have an appropriate bias potential. The electrode 60 will have an electrostatic shield effect absorbing the electron flow and the molecules of charged evaporating materials and will not cause the peeling effect as described hereinbefore.

The above embodiment used two kinds of evaporating materials 57 and 58. Three or more evaporating materials may also be used for forming the evaporated film. A plurality of evaporating materials combined into alloy or reacting with each other during heating may also be used.

The requirements pertinent for realizing this invention may be seen from the result of the above experiments and are as follows. The total thickness of the scattering prevention layer 42 of B_4C the crossed layer 41 of B_4C and Al, and the metal backing layer 40 of Al must be 5,000 A. in the conversion value of aluminum to obtain the contrast ratio of 20. The thickness of the scattering prevention layer 42 of B_4C should be more than 2,500 A. in order to obtain the contrast ratio of 20. The larger the thickness the better is the effect of prevention of the scattering of electrons. The thickness of the crossed layer 41 is up to 500 A., the larger is the thickness of the layer 41 the larger is the effect of prevention of scattering. In case the thickness of the crossed layer 41 is more than 500 A. the contrast ratio may be raised about twenty percent more than in case the crossed layer does not exist.

In the above embodiment, the invention was merely applied in the post-acceleration color television tube. However this invention is not only restricted to this example, generally it may be applied in all electron beam devices which are required to have fewer scattering electrons to be generated by impact of electron beams, particularly cathode-ray beams.

What we claim is:

1. An electron scattering-prevention film for an electron beam device, said film comprising a metallic electrode layer which is penetrable by primary electron beams, a crossed layer, and a scattering-prevention layer, said scattering-prevention layer being of a compound of an element having an atomic number less than one half the atomic number of the metal of said electrode layer, said crossed layer having a continuously varying composition from said scattering-prevention layer to said electrode layer ranging from zero to 100% of said metal and from 100 to 0% of said compound, the total thickness of said layers being substantially at least 5000 A., and the thicknesses of said electrode layer, crossed layer, and scattering-prevention layer ranging from 3:1:6 to 2:2:6 in the conversion value of aluminum.

2. An electron scattering-prevention film as claimed in claim 1, wherein said metal is aluminum.

3. An electron scattering-prevention film as claimed in claim 1, wherein said compound is selected from the group consisting of boron, carbon, lithium fluoride, lithium carbonate, and boron carbide.

4. An electron scattering-prevention film as claimed in claim 3, wherein said compound is boron carbide.

5. An electron scattering-prevention film as claimed in claim 4, wherein said metal is aluminum.

6. A method of manufacturing an electron scattering-prevention film for an electron beam device by an evaporation-deposition process, said film comprising a metallic electrode layer which is penetrable by primary electron

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beams, a crossed layer, and a scattering-prevention layer, said scattering-prevention layer being of a compound of an element having an atomic number less than one half the atomic number of the metal of said electrode layer, said crossed layer having a continuously varying composition from said scattering-prevention layer to said electrode layer ranging from zero to 100% of said metal and from 100 to 0% of said compound, the total thickness of said layers being substantially at least 5000 Å., and the thicknesses of said electrode layer, crossed layer, and scattering-prevention layer ranging from 3:1:6 to 2:2:6 in the conversion value of aluminum, said method comprising arranging a substrate for evaporation-deposition of the required film; selectively heating a mixture of said metal and said compound, said compound being of a higher melting point than that of said metal; applying a first stage of heat to said mixture to evaporate said metal to deposit the same on said substrate; applying a second stage of heat to evaporate a mixture of said metal and said compound to deposit said crossed layer; and con-

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tinuing the application of heat to deposit said compound to form the scattering-prevention layer.

7. A method of manufacturing an electron scattering-prevention film as claimed in claim 6, wherein said heating and depositing steps are conducted in a single crucible of a single electron beam heating device so as to successively deposit said electrode layer, said crossed layer and said scattering-prevention layer, whereby owing to differences in the melting points of said metal and said compound, the composition of said crossed layer continuously varies.

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RALPH S. KENDALL, Primary Examiner

U.S. Cl. X.R.

117—219, 33.5 C, 211; 313—92 R