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METHOD OF REDUCING SECONDARY EMISSION
FROM BOMBARDED SURFACES
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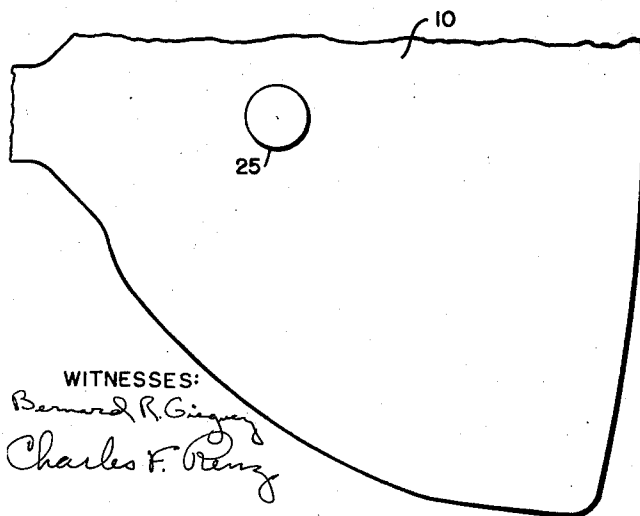
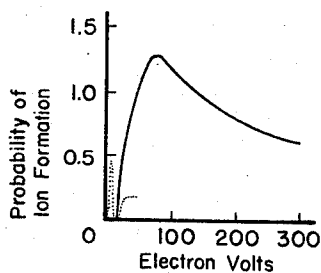
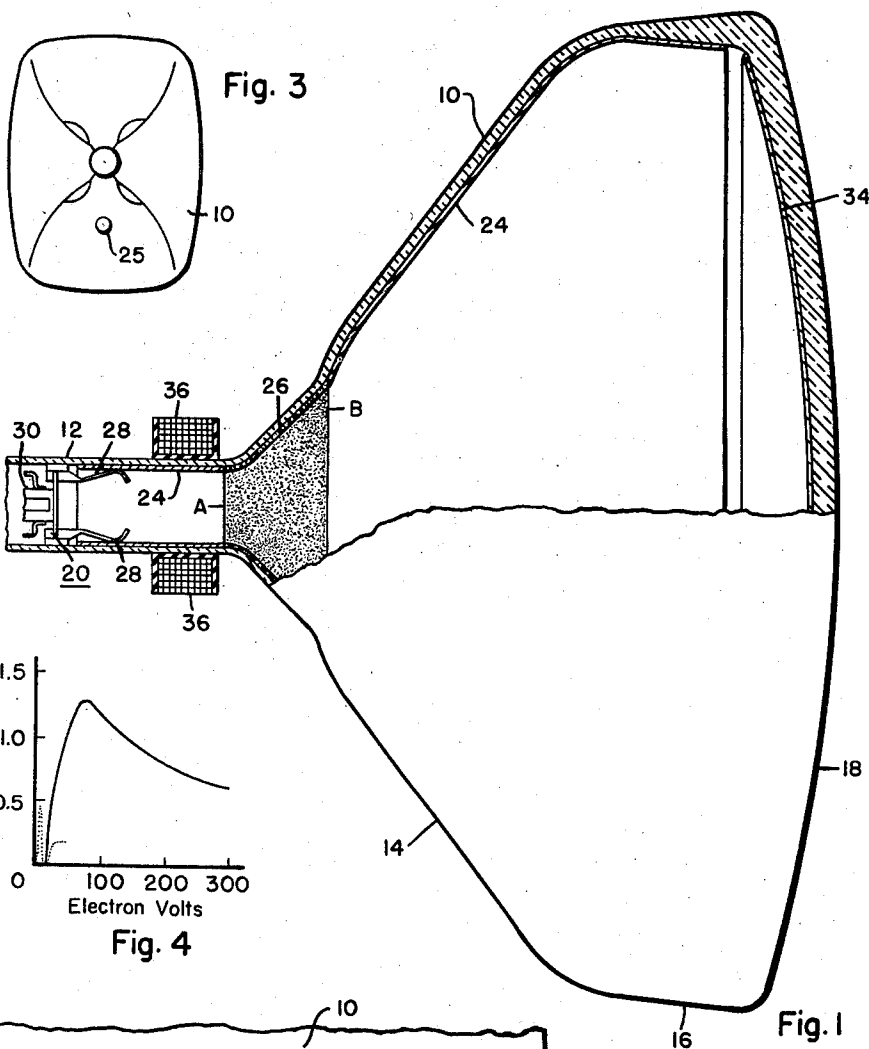


Fig. 2

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METHOD OF REDUCING SECONDARY EMISSION FROM BOMBARDED SURFACES

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2 Claims. (Cl. 313—107)

This invention relates to the reduction of secondary emission from surfaces bombarded by charged particles within a vacuum or gas enclosure and, more particularly, to surfaces in cathode ray tubes of the character utilized for television purposes.

One of the important factors in determining the life of a non-aluminized cathode ray tube is the deterioration of the fluorescent screen by ion bombardment. Both positive and negative ions have been shown to be involved in this deterioration of the fluorescent screen and various methods of reducing their effect have been developed.

Negative ions are believed to be formed near the electron gun cathode and the first accelerating apertures and are controlled by the use of ion traps. The problem of negative ions and methods of reducing their effect is more thoroughly discussed in a copending application entitled, Cathode Ray Tube, Serial No. 518,871, filed June 29, 1955, by A. T. Raczynski and assigned to the same assignee.

The positive ions formed within a cathode ray tube are generally believed to be formed in the bulb space between the electron gun and the face plate and are much more difficult to control. The exact point of origin of these positive ions has been uncertain in the past and the only successful remedy is to place a coating of a material such as aluminum on the screen to prevent the ions from reaching the phosphor, or to coat the screen with a material of high secondary emission yield in which case the accelerating potential for the positive ions can be reduced. Both of these procedures are costly and time consuming and in some cases only partially effective in that they do not reduce the positive ion formation, but only prevent damage to the fluorescent screen.

The positive ion deterioration or ion blemish is characterized in non-aluminized cathode ray tubes by what is referred to as X-burn. The X-burn consists of a deteriorated area on the screen of the tube having the shape of an X on the diagonals of a rectangular picture tube and is particularly severe in tubes using rectangularly shaped envelopes. In these tubes the deflected electron beam is known to graze the envelope wall where the neck joins the bulb or flared portion of the envelope. This is particularly so in the wide deflection type tubes now popular because of their short length. It is believed that this fact plays an important role in the ion burn phenomenon and it is, accordingly, an object of this invention to reduce the generation of positive ions due to the electron beam grazing this area within a cathode ray tube.

It is another object to provide a method to reduce the secondary emission from a surface bombarded by high energy particles at an angle divergent from the normal.

It is another object to provide a coating of suitable material to reduce the generation of secondary electrons due to bombardment by high energy particles at an angle divergent from the normal.

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It is another object to provide suitable coatings within a cathode ray tube to reduce positive or negative ion formation due to bombardment of surfaces within the cathode ray tube by the electron beam at an angle divergent from the normal.

These and other objects are effected by our invention as will be apparent from the following description taken in accordance with the accompanying drawing throughout which like reference characters indicate like parts, and in which:

Figure 1 is a partial view with parts broken away of a cathode ray tube embodying my invention;

Fig. 2 is a partial elevation view taken at a right angle to Fig. 1 of a cathode ray tube;

Fig. 3 is a schematic rear view of the exterior of a cathode ray tube; and

Fig. 4 is a curve showing the probability of positive and negative ion formation with respect to electron energy.

Referring in detail to Fig. 1, an envelope 10 of a cathode ray tube is illustrated comprised of an elongated neck or shaft portion 12, a flared or tapered bulb portion 14, a substantially rectangular bulb portion 16 integral with the larger end of the flared portion 14. The open end of the rectangular bulb portion 16 is provided with a transparent window 18. An electron gun 20 is positioned within the neck or shaft portion 12. A portion of the gun 20 is shown in the drawing and is provided with suitable voltages through the sealed end of the neck portion (not shown).

A conductive coating 24 of an aqueous suspension of graphite is provided on the inner surface of the rectangular bulb portion 16, the flared portion 14 and a portion of neck 12. In the prior type conventional tubes this graphite inside conductive coating extended from the large end of the envelope 10 into the neck portion 12 to a point just adjacent the electron gun 20. In our invention this graphite coating 24 extends from the large end of the envelope 10 to a point on the flared portion 14 of the envelope 10 designated by the line B. The flared portion from the line B is coated with a high atomic number material coating 26 such as silver to the line A just within the neck portion 12 of the envelope 10. The graphite coating 24 is also applied from the line A to the point just adjacent the electron gun 20. The silver coating 26 is in contact with the graphite coating 24 so as to provide a continuous conductive coating in a similar manner to conventional type cathode ray tubes from the large end of the envelope 10 to the neck portion 12. An electrode terminal 25 is provided through the flared portion 14 of the envelope 10 for application of a high accelerating potential to the combination graphite and silver coatings 24 and 26. Contact springs 28 are provided on the end of the electron gun 20 to establish electrical connection with the graphite coating 24 to provide voltage to the final anode 30 of the electron gun.

The transparent window 18 is provided with a coating 34 of fluorescent material on the inner surface which is excited to luminescence by impingement of electrons from the electron gun 20. Suitable electromagnetic deflection coils 36 are provided on the neck portion 12 near the flared portion 14 to cause the electron beam to scan a raster on the fluorescent screen 34 of the tube 10. An electromagnetic ion trap magnet (not shown) may also be provided on the neck 12 of the tube 10 to suppress negative ions in a manner described in the previously mentioned copending application.

In order to fully explain the operation of our invention in this embodiment, it is necessary to discuss some of the phenomena existing within a cathode ray tube. It has been determined that in a non-aluminized cathode

ray tube the fluorescent screen 34 generally operates at a negative voltage of a few hundred volts with respect to the graphite conductive coating 24. The fluorescent material is normally a good insulating material and the voltage of the fluorescent screen 34 depends on secondary electron emission and therefore on the nature of the material and the energy of the bombarding electrons. This negative potential at which the fluorescent screen operates is the result of the net effect of the primary impingement, the secondary electron emission yield of the screen and the space-charge produced by the secondary emission from the fluorescent screen. The electric field thus formed between the graphite coating and the fluorescent screen acts to accelerate any positive ions that may be formed in the bulb space and they will be drawn to the less positive fluorescent screen causing deterioration of the fluorescent material by bombardment.

It should also be noted in the structure shown that the electric field will have a slight tendency to concentrate positive ions originating near the bulb wall into lines along the picture diagonals.

Positive ions are formed with very great efficiency by secondary electrons whose energies range up to the order of 50 electron volts since the threshold for ionization lies typically near 10 volts and the maximum ionization cross sections occur at around 50 to 75 volts as indicated by the solid line graph shown in Fig. 4 and drop off rapidly toward high electron energies. For example, the threshold energy for oxygen is 12.5 electron volts and for hydrogen is 15.7 electron volts. The graph shown in Fig. 4 is representative of a typical gas showing the ionization cross section plotted against the electron energy. The threshold energy of the gas is indicated by the point at which the curve crosses the X axis. The dotted line graph is representative of the negative ion formation.

It is believed that the largest number of such secondary electrons arise at points where the electron beam from the gun 20 strikes the inner wall of the neck portion 12 or the immediately adjacent area of the flared portion 14 of the envelope designated by the area between lines A and B. This is especially true in the case of a rectangular 90° deflection envelope. In this type of bulb design the electron beam strikes the neck when it is deflected to the extreme corners of the rectangular raster. Thus there will be grazing of the inside neck coating at 4 points corresponding to the place where the beam is traveling to the corners of the raster. The secondary electrons generated due to the impingement of the electron beam on the area between line A and line B causes the formation of positive ions in the vicinity which will be drawn to the fluorescent screen by the electric field between the coating 24 and the fluorescent screen 34. Due to the shape of the source of secondaries and the electric field within the envelope, as previously explained, the ions bombarding the fluorescent screen will be concentrated to deteriorate the fluorescent material in the familiar X-shaped ion burn.

In prior art structures a continuous graphite coating was utilized having an atomic number of 6. It has been found that low atomic number materials give rise to a much larger number of low and medium energy secondary electrons than a material of high atomic number when the electron beam strikes the surface at grazing incident angles. We have, therefore, found that by coating the area of the cathode ray tube envelope 16 (which is bombarded by the electron beam at a grazing angle of incidence) with a high atomic number material such as silver or gold that the generation of these secondary electrons is materially reduced. It should be noted that the electron beam strikes this area at a grazing angle approaching 90° relative to the normal.

The reason why materials of low atomic number less than about 25 give rise to a larger number of low energy secondary electrons than higher atomic number materials

lies in their difference in scattering powers. An electron beam entering a low atomic number material tends to maintain its original direction without sideways scattering to a far greater extent than in a high atomic number material. In the high atomic number materials, the electrons are scattered and diffused long before they reach the end of their range. As a result, an electron beam impinging at grazing incidence upon a low atomic material will spend a large fraction of its energy in ionization close to the surface, allowing many low energy electrons to escape. In the case of the high atomic number material, not only are many incident electrons scattered out again before they have an opportunity to form low energy secondary electrons, but also the remaining incident primary electrons are scattered deep into the surface where few low energy secondaries can escape.

The consequence of this difference in scattering of a low atomic number material and a high atomic number material is that changing the angle of incidence has a very large effect on the low energy (0-50 volt) secondary emission yield from low atomic number materials and only a small effect on high atomic number materials. Thus, it has been found for normal incidence that graphite shows a low energy secondary electron yield of about the same magnitude as silver at primary energies from 5 to 10 kilovolts. However, at grazing incidence, 60° or greater, graphite will have a greater number of low energy secondary electrons than silver by an estimated factor of the order of 40, with the relative effect growing strongly with the accelerating potential. As explained above, the back scattered electrons of high energy above 50 electron volts do not contribute strongly to the ionization of gases.

The table below gives the measured values of the low energy secondary electron yield and back scattered fraction of fast electrons at 7-8 kilovolts for targets of graphite, silver and gold at normal incidence. Here Δ is the yield of low energy secondaries, η is the back scattered fraction and $\delta = \Delta + \eta$.

Graphite	-----	$\delta = .50$; $\eta = .07$; $\Delta = .43$
Silver	-----	$\delta = .73$; $\eta = .35$; $\Delta = .38$
Gold	-----	$\delta = .81$; $\eta = .43$; $\Delta = .38$

Therefore, use of any metallic coating of high atomic number on the tube walls will materially reduce the yield of 0-50 volt secondaries due to electron bombardment at grazing incidence. The atomic number of such an element or the average atomic number of a compound used as coating material should be in excess of about 25. For example, silver has an atomic number of 47 and gold 79. Another suitable material is molybdenum powder having an atomic number of 42. The material may be placed in a suspension of suitable organic binder such as nitrocellulose or methacrylate and painted on the impingement surface of the tube. The organic binder can be removed by heating in the usual bake-out and exhaust processes.

It is also desirable that this surface be rough in order to even further reduce the low energy secondary electron yield. A sintering process of imbedding high atomic numbered particles in the surface might be used or other well-known techniques as sand blasting or evaporation of a metal in an inert atmosphere to produce a "black" surface. Another advantage that the silver, gold or molybdenum coating has over graphite is the additional effect that electrons falling on the coating are scattered more completely and tend far less to emerge again in their original direction. This will have a tendency to cause any positive ions that are formed to be less concentrated along the diagonals of the fluorescent screen and hence be less objectionable.

It should be pointed out that because of the bulb shapes now used for cathode ray tubes where the deflection angle is not as great as 90°, as illustrated in the drawing, the coating 26 will not have to extend into the flared

portion of the envelope. It will probably be sufficient to coat only a small area near the end of the neck. It is also possible to utilize an insert rather than the coating shown.

The invention has been described with respect to a cathode ray tube embodiment in which the charged particles are in the form of electrons and also with respect to the forming of positive ions. It should be noted that the same invention will also apply to negative-ion formation and, therefore, the coating will reduce the number of negative ions formed since it is known that slow secondary electrons attach themselves with great probability to neutral molecules. The dotted curve on Fig. 4 illustrates the probability of ion formation with respect to electron energy. The coating might be utilized within the gun structure where electrons or ions strike the edges at grazing incidence. A coating of high atomic number material deposited on an area surrounding an aperture should substantially reduce both positive and negative ion formation.

It may be desirable to apply a coating on the interior surface of the final anode of an electron gun in those structures where the negative ions are deflected into the surface in order to remove the negative ions from the electron beam. This is applicable to the previously mentioned copending application.

In this application, the negative ions approach to the inner surface of the anode at low incident angles to the surface. The bombardment of the surface by the negative ions gives rise to secondary emission which, in turn, forms negative and positive ions. The positive ions formed at this point in the gun will be accelerated back toward the cathode structure. The bombardment by the positive ions of intervening elements will, in turn, result in deterioration of surfaces and generation of additional secondary electrons which may constitute a stray beam. This method of reducing ion formation is particularly applicable to high voltage devices such as the Van de Graaff accelerator tubes and linear accelerators, where ion currents are known to present severe limitations in the voltages attainable.

While we have shown our invention in only one form, it will be obvious to those skilled in the art that it is not so limited but is susceptible of various other changes and modifications without departing from the spirit and scope thereof.

We claim as our invention:

1. A cathode ray tube comprising an envelope having a neck portion, a flared portion and a faceplate portion, said flared portion being rectangular in shape, an electron gun positioned within said neck portion for generating an electron beam, deflection means positioned on the neck portion for deflecting said electron beam to scan a raster on said faceplate, said envelope of such configuration that the electron beam must be deflected at least 90° to scan said raster, and wherein said electron beam grazes a portion of the envelope surface when the electron beam is deflected to extreme corners of said

raster causing emission of low energy secondary electrons from said grazed surface and thereby generating a large number of ions within said envelope which are accelerated to said faceplate resulting in ion burn, a first electrical conductive coating provided on the inner surface of the flared portion of said envelope and extending into said neck portion of said envelope to said electron gun, said first electrical conductive coating of a material of an atomic number less than 25, a second coating of electrical conductive material provided on the grazed surfaces of said envelope inner surface and in electrical contact with said first conductive coating, said second conductive coating having an atomic number greater than 25 and exhibiting the property of low emission of low energy secondary electrons and of lower emission than said first coating in response to low angle incident electron bombardment to thereby reduce generation of ions within said envelope.

2. A cathode ray tube comprising an envelope having a neck portion, a flared portion and a faceplate portions, said flared portion being rectangular in shape, an electron gun positioned within said neck portion for generating an electron beam, deflection means positioned on the neck portion for deflecting said electron beam to scan a raster on said faceplate, said envelope of such configuration that the electron beam must be deflected at least 90° to scan said raster, and wherein said electron beam grazes a portion of the envelope surface when the electron beam is deflected to extreme corners of said raster causing emission of low energy secondary electrons from said grazed surface and thereby generating a large number of ions within said envelope which are accelerated to said faceplate resulting in ion burn, a first electrical conductive coating provided on the inner surface of the flared portion of said envelope and extending into said neck portion of said envelope to said electron gun, said first electrical conductive coating of a material of an atomic number less than 25, a second coating of electrical conductive material provided on the grazed surfaces of said envelope inner surface and in electrical contact with said first conductive coating, said second conductive coating providing a rough surface of a material having an atomic number greater than 25, said second coating exhibiting the property of low emission of low energy secondary electrons and of lower emission than said first coating in response to low angle incident electron bombardment to thereby reduce said generation of ions within said envelope.

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