Sept. 23, 1958 W. J. KNOCHEL ET AL 2,853,639

CATHODE RAY TUBE

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Fig. 1.

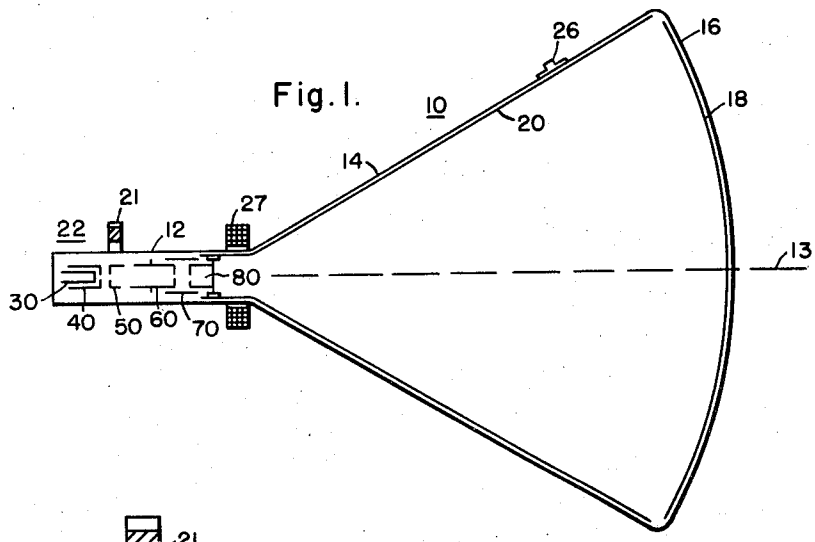


Fig. 2.

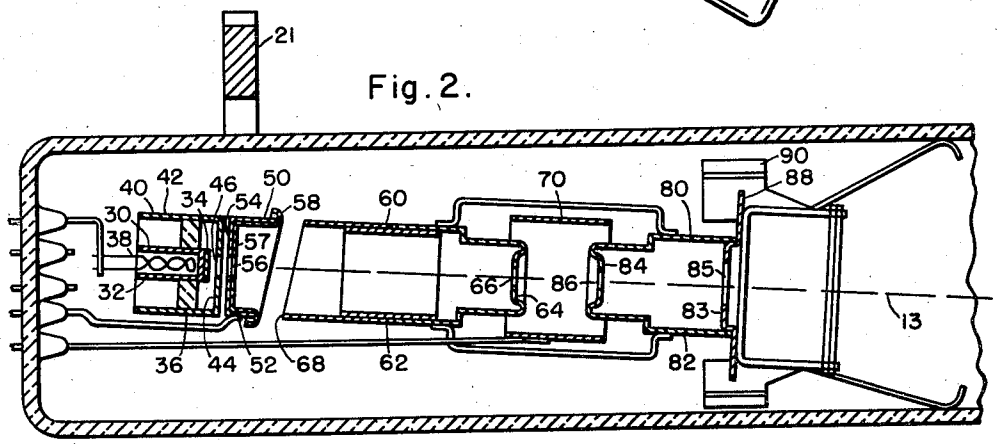
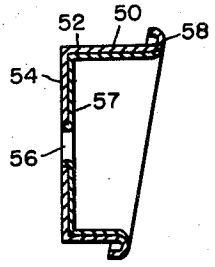


Fig. 3.



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CATHODE RAY TUBE

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6 Claims. (Cl. 313—82)

This invention relates to apparatus for producing an electron beam and more particularly to methods and structure for eliminating ions from the electron beam.

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 and structures have been utilized in order to reduce the ion blemish.

Negative ions are believed to be formed near the electron gun cathode and the first accelerating aperture and are controlled by various type ion traps within the electron gun structure. The problem of negative ions and suppression thereof 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 are believed formed within the cathode ray tube in the bulb space between the electron gun and the face plate and are much more difficult to control. The exact origin of these positive ions has been uncertain in the past, and the only successful remedy is to place a coating of a material of sufficient thickness upon the screen to prevent the ions from reaching the phosphor. This positive ion deterioration, and more specifically the X burn found in non-aluminized cathode ray tubes is more thoroughly discussed in copending application entitled Method of Producing Secondary Emission from Bombarded Surface, Serial No. 548,990, filed November 25, 1955, by E. J. Sternglass and W. J. Knochel and assigned to the same assignee.

This invention is directed to the elimination of negative ions generated within the electron gun structures and not removed by the conventional negative ion traps. The ion burn on the screen that we are specifically trying to prevent results in an ion burn spot positioned to one side of the center of the phosphor screen and results in a spot deterioration of the screen. The effect of this ion bombardment on the phosphor or fluorescent screen of a cathode ray tube is to produce a thin film of deactivated material on the surface thereof. It is this deactivated area of fluorescent material which is referred to as an ion burn or blemish. This deactivated area absorbs a high proportion of the electron beam, resulting in only a small light output from the area.

The mass of the ion is greater than the electron while the charge is essentially the same. The negative ion will be focused and deflected essentially along the same path as the electron in an electrostatic field, while a magnetic field sufficient to apply a force to the electrons will have little effect on the negative ions. It is, therefore, seen that the negative ions generated within an electron gun structure would bombard the entire screen with electrostatically deflected type cathode ray tubes and essentially only one spot with electromagnetically deflected type cathode ray tubes. Since most television receivers

are the electromagnetic deflected type, cathode ray tubes, this explanation will be limited only to the generation of the small spot ion burn.

There are several designs and modifications of electron gun structures utilized in the tube industry for elimination of negative ions. These type designs may essentially be broken down into three classes, one in which the electron source or cathode of the electron gun is located off the axis of the tube neck and in which the initial direction of the electron and ion beams is tilted with respect to the neck axis. The electron beam is then bent and aligned with the tube neck by a transverse magnetic field. The ion beam continues in its original direction and is trapped by a disc in the anode whose aperture does not lie on the path of the ion beam. In the second, the electron source or cathode is again located off the main axis of the tube neck, and the electron and ion beams are first bent off the gun axis by a transverse electrostatic field and then the electron beam is bent and aligned along the axis of the tube by a transverse magnetic field. The electron gun itself may be straight, or bent so that its upper section is aligned with the tube neck. In the third type structure, the electron source or cathode is positioned on the axis of the tube neck and the electron and ion beams are bent off the axis by a transverse electrostatic field and the electron beam then bent and realigned with the axis by a transverse magnetic field or fields. These fields may be practically superposed as in the previously mentioned copending application Serial No. 518,871, so that the electron beam path does not deviate significantly from the axis of the tube neck. In both of these latter structures, the unwanted ions are trapped by a diaphragn in the anode whose aperture does not lie on the path of the ion beam. This invention is applicable to all three types of structure.

The second and third types of structure described above utilize what is known as a slashed or tilted electrostatic field within the gun structure to supply a transverse field component to deflect both the electrons and the ions generated at or near the cathode off the axis of the electron gun structure in order to effect the ion traping within the gun. It has been found that the electron gun structures described above do not remove all of the negative ions and that an objectionable deactivated area positioned to one side of the center of the phosphor screen appears during the operating life of the tube.

It is, accordingly, an object of our invention to provide an improved electron gun structure capable of providing a substantially ion free electron beam.

It is another object to provide an improved electron gun in which the parts are positioned coaxial with respect to the gun axis and tilted within the tube neck and requiring only one ion trap magnet.

It is another object to reduce electron emission from surfaces bombarded by positive ions within an electron gun.

These and other objects are effected in 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 side elevational view showing the relationship of the cathode ray gun embodying the principles of our invention to the other structural elements of a cathode ray tube;

Fig. 2 is a side elevational view, partly in section, of a cathode ray gun positioned within the neck of a cathode ray tube embodying the principles of our invention; and

Fig. 3 is an enlarged sectional view of an electrode element in the cathode ray gun embodying the principles of our invention.

Referring in detail to Fig. 1, there is shown a cathode ray tube embodying our invention. The tube is comprised of an envelope **10** having a tubular neck portion **12**, a flared bulb portion **14** and a face plate **16**. The face plate **16** of the envelope **10** has a suitable fluorescent coating **18** on the inside surface thereof and the flared bulb portion **14** has a conductive coating **20** of a material such as aqueous suspension of graphite. The neck portion **12** is a straight tubular member, and the axis **13** is normal to the face plate **16** and substantially at the center thereof.

The electron gun **22** is comprised of an indirectly heated cathode **30**, a control grid or electrode **40**, a screen grid or electrode **50**, a first anode **60**, a focusing electrode **70** and a second anode **80**. The graphite coating **20** on the interior of the flared bulb portion **14** serves as the third anode of the cathode ray tube and a suitable voltage is applied at a terminal **26**. The structure shown and described herein is of the type known as an electrostatic focus cathode ray tube gun. The gun parts may be of a material such as stainless steel type **305**. The invention is also applicable to electromagnetic focus type gun structures. Positioned on the exterior of the neck portion **12** of the envelope **10** is an ion trap magnet **21** and an electromagnetic deflection system illustrated by the coil **27**.

Referring in detail to Fig. 2 which shows a preferred embodiment of our invention, the control grid **40** is comprised of a tubular member or skirt **42** coaxial with the electron gun axis **13** with a diaphragm or stop **44** positioned therein in which a small aperture **46** is centrally located on the gun axis. In the specific embodiment shown, the diaphragm **44** is located at the end of the cylindrical or tubular member **42** nearest the screen **18**. The plane of the diaphragm **44** is perpendicular to the axis of the electron gun **13**. Positioned within the control grid structure **40** is the cathode **30** comprised of a tubular member **32** of smaller diameter than the control grid skirt **42** with its longitudinal axis aligned on the gun axis. The end of the tubular member **32** nearest the diaphragm **44** of the control grid **40** is closed and a coating **34** of electron emissive material is placed on the exterior surface. The tubular member **32** is supported within the grid skirt **42** by means of a ceramic collar **36**. A heater filament **38** is provided within the tubular member **32** for controlling the temperature of the electron emissive coating **34**.

The screen grid or electrode **50** is comprised of a tubular skirt or cylindrical member **52** spaced along the gun axis and adjacent to the diaphragm end of the control grid **40**. The screen grid skirt **52** has a diaphragm member **54** positioned therein, and in the specific illustration closes the end of the cylinder adjacent to the control grid **40** which is perpendicular to the gun axis **13**. In a similar manner to the control grid diaphragm **44**, an aperture **56** is placed at the center of the diaphragm **54** with its center also on the gun axis. The unclosed end or rim **58** of the screen grid skirt **52** may be rolled outward as shown in Figs. 2 and 3 to eliminate possibilities of distortion of electrostatic fields due to sharp edges and burrs on the materials. The plane of the unclosed end or rim **58** of the cylinder **52** is slanted at an angle of 10° to 13° with respect to a plane perpendicular to the gun axis **13**. The screen grid **50**, as generally described above, is more completely described in a copending application, Serial No. 374,240, filed August 14, 1953, now Patent No. 2,773,212 entitled "Electron Gun," by J. A. Hall, and assigned to the same assignee.

In our invention, a coating **57** of inert conductive material is deposited on the surface of the diaphragm **54** facing the screen **18**. The coating **57** surrounds the aperture **56** in the diaphragm **54** and may cover the entire surface or only a portion thereof. It may also be desirable to extend the coating **57** into the aperture **56** so as to cover the edges thereof.

The first anode **60** is comprised of a cylindrical or skirt member **62** spaced along the axis and adjacent to the

slanted open end of the screen grid **50**. The first anode **60** is opened at the end adjacent the screen grid **50** and the rim **68** is also slanted so that the plane of the rim **68** is parallel to the rim **58** of the screen grid **50** and inclined to a plane perpendicular to the axis by about 10° to 13°. The other end of the first anode skirt **62** is closed by a diaphragm **64** perpendicular to the gun axis **13** and also having a centrally located aperture **66** therein.

The second anode **80** is comprised of a cylindrical or skirt portion **82** positioned along gun axis **13** at a distance greater than the other members of the electron gun from the first anode **60**. The end of the skirt **82** adjacent the first anode is closed by a diaphragm **84** perpendicular to the gun axis **13** and having a centrally located aperture **86** located therein. The opposite end of the second anode skirt **82** also has a diaphragm **83** therein which is perpendicular to the gun axis **13** with a large aperture **85** positioned therein. Integral with the diaphragm **83** is a flange **88** extending outwardly from the surface of the second anode to which flexible spring members **90** are attached which position the flange **88** on the electron gun **22** approximately centrally within the neck **12** and also make electrical contact with the graphite coating **20** on the flared portion of the envelope **10**. The aperture **85** is centrally located within the diaphragm **83** and is therefore approximately located on the tube axis. The first and second anodes **60** and **80** are connected together electrically and are supplied with voltage from the graphite coating **20** by means of the flexible conducting spring members **90**.

A sleeve or focusing electrode **70** surrounds the space between the first and second anodes **60** and **80** and is also coaxial with the gun axis. The tubular sleeve **70** is of a larger diameter than the first and second anode cylinders **62** and **68**. The control grid **40**, the screen grid **50**, the first anode **60**, focusing electrode **70** and the second anode **80** may be supported by providing radially projecting anchor pins on the cylindrical surface thereof. The anchor pins are embedded within longitudinal glass support rods which may extend along substantially the entire length of the gun structure. This desirable feature and improved assembly accuracy can be incorporated in this preferred embodiment because all gun electrodes are centered on a single gun axis.

Suitable voltages are applied to the filament **38**, control grid **40**, screen grid **50** and focusing electrode **70** by means of leads extending through a button stem provided in the end of the tube neck **12**. A table is given below of typical dimensions of a specific embodiment shown in Figs. 1 and 2 with representative voltages applied to each of the electrodes. The relative dimensions of these electrodes are expressed as ratios to the inside diameter of the control grid cylinder **42**.

Cylinder	Diameter	Length	Voltage
32	(Outside) ¼	0.68	0
42	(Inside) 1	0.87	−30.
52	(Inside) 1	0.55 (maximum length)	+275 to 500 v.
62	(Inside) 1	2.64 (maximum length)	+10 to 20 kv.
82	1	1.0	+10 to 20 kv.
70	1.3	1.4	−100 to +450.

Aperture:	Inside diameter
46	.062
56	.072
76	.200
86	.240

Gap between electrodes along axis **11**:

40–50	.038
50–60	.2

In the operation of the electron gun structure **22**, the electrons as well as negative ions are emitted from the electron emissive surface **34** of the cathode **30**. The electrostatic field of the control grid **40** and the screen

grid 50 accelerates the electrons and ions and forms a lens of short focal length bringing the electrons and ions to what is known as a cross-over point between or near the diaphragms 44 and 54. The control grid 40 controls essentially the number of electrons passing through the aperture 46 in the diaphragm 44 and thereby controls the intensity of the electron beam. The electron and ion beam thus formed passes through the aperture 56 in the diaphragm 54 of the screen grid 50. The electrostatic field or lens set up between the screen grid 50 and the first anode 60 acts on the beam at the time that the beam enters the aperture 56 in the diaphragm 54 of the screen grid 50 and acts to accelerate and deflect the electron and ion beam entering the slashed field. Since the adjacent ends of the screen grid 50 and the first anode 60 lie in parallel planes, tilted with respect to a plane perpendicular to the gun axis 13, the effect is to produce a transverse electrostatic field component which bends the paths of the electrons and ions within the beam just after cross-over. Since the electrons and ions are moving slowly at this point, the electron and ion beams are bent sharply downward. The magnetic field due to the ion trap magnet 21 is also concentrated at this point just after cross-over, and directed to produce a force directed upward on the electron and ion beam opposing the electrostatic field force. This field may be adjusted to compensate for the electrostatic field so that the electron beam will be bent and aligned with the axis of the tube neck 12. The magnetic field due to the ion trap magnet 21 will have little effect on the ions within the beam and as a result the ion beam will follow substantially the deflected path impressed thereon by the transverse component of the electrostatic field set up between the screen grid 50 and the anode 60 and will strike the inner surface of the diaphragm 64 of the first anode 60 while the electron beam will pass through the aperture 66 of the first anode 60.

It was found without the utilization of the inert conductive material coating 57 on the diaphragm 54 of the screen grid 50 that a secondary ion blemish appears during the life of the tube. An attempt to increase the transverse component of the ion trap slashed electrostatic field did not improve or remove this ion blemish. A suggested explanation of this effect is as follows: It is believed that positive ions formed within the tube bombard the surface of the diaphragm 54 of the screen grid 50 facing the screen 18. It is believed that the primary source of these positive ions is within the first anode and since this first anode operates at a potential over 10,000 volts while the screen grid operates at about 350 volts, that these positive ions are focused and accelerated into impingement on the surface of the diaphragm 54 surrounding the aperture 56. This is further borne out by the fact that inspection of the surface of the diaphragm 54 of a gun after being in operation shows a darkened area near the aperture 56 and primarily on one side of the aperture 56. It it also noted that the ion blemish on the fluorescent screen has the same shape as the darkened area on the diaphragm 54 of the screen grid 50. Although we do not wish to be limited to this explanation, it is believed that the primary negative ions which originate at or near cathodes are deflected into the inner surface of the first anode 60 and strike the inner surface of diaphragm 64 thereby generating secondary electrons which, in turn, form positive ions. It is a known phenomenon that slow secondary electrons form positive ions with very great efficiency where the energies range up to the order of 50 electron volts. The threshold for ionization lies typically near 10 volts and the maximum ionization cross-sections occur around 50 to 75 volts. The positive ions generated within the first anode 60 are accelerated by the high potential difference between the screen grid 50 and the first anode 60 into impingement with the surface of the diaphragm 54. This bombardment of the surface of the diaphragm 54 by the high energy positive ions results in the release of either electrons or negative ions from the surface. These electrons which are emitted by the screen grid 54 may, in turn, form negative ions by attachment to gas molecules while they are still moving slowly immediately after leaving the surface of the screen grid. These secondary negative ions originating off the axis of the screen grid 54 are not trapped in the first anode but pass through the gun to cause the observed off center ion burn.

It is found that cleaning the surface of the diaphragm 54 of screen grid 50 and then placing the inert conductive material coating 57 such as gold, platinum, silver, etc., on it has resulted in the elimination of the secondary ion blemish spot near the center of the face plate 18 of the tube. After the normal cleaning and hydrogen baking operation, the part was degreased, dipped in muriatic acid to remove surface oxides, nickel strike applied (very thin plate) and then plated with coating 57. It is believed that the coating 57 on the diaphragm 54 provides an inert non-oxidizable surface under conditions found in the tube and during its manufacture. The non-oxidizable surface is a poor secondary electron emitter and, therefore, the production of negative ions near the screen grid 50 is substantially reduced so as to prevent the ion blemish on the face plate 18. It is believed that the oxide coating formed on the screen grid 50 without the gold coating may be a primary cause of secondary emission. The material normally utilized in the electron gun structure is a stainless steel on which oxide coatings are formed fairly readily. It is, therefore, seen that by providing this inert coating 57 on the diaphragm surface an economical way of eliminating secondary ion blemishes is obtained. If the inert material utilized on the diaphragm 54 is also of a high atomic number material, the coating may cover the edge of the aperture 56 in order to further reduce secondary emission due to the bombardment of electrons at grazing angles on the edge of the aperture 56. Other specific materials which may be utilized in the coating of the diaphragm in order to further reduce the cost are platinum-silver, etc. This effect may also be obtained or enhanced by applying a similar inert conductive coating to the inside of anode 60, especially on diaphragm 64 to prevent secondary electron emission from this part.

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. In particular, it may be embodied in electron guns which are coaxial with the tube neck, to those which are bent to align the upper part of the gun with the tube neck and to those in which a bent anode is essential to the primary on trapping action.

We claim as our invention:

1. A cathode ray tube comprising an evacuated envelope, said envelope having a straight neck portion, the axis of which is substantially normal to the face plate of said cathode ray tube, an electron gun positioned within said neck portion, said gun comprising a plurality of electrodes consisting of at least a cathode, control grid, screen grid and anode, said control grid, screen grid and anode having coaxial tubular portions, said screen grid having an apertured conducting disc mounted transversely therein, said disc having a conductive coating of a low secondary emissive material on the surface thereof facing said screen.

2. An electron gun structure comprising a cathode, a control grid, a screen grid and a high potential accelerating anode in the order named, said screen grid consisting of at least an apertured diaphragm positioned transverse to the path of the electron beam, said diaphragm having a relatively non-oxidizable conductive coating on the surface thereof facing said high voltage accelerating electrode.

3. A cathode ray tube comprising an envelope and having therein a target member, a cathode, means for forming an electron beam of the electrons generated by said

cathode and directing said electron beam along a path to said target, said means including a beam limiting apertured diaphragm of a first conductive material positioned transverse to said electron beam and a second conductive material coating inert to oxidation deposited on a portion of the surface of said diaphragm.

4. A cathode ray tube comprising an envelope and having therein a target member, a cathode, means for forming an electron beam of the electrons generated by said cathode and directing said electron beam along a path to said target, said means including an apertured diaphragm member of a conductive material positioned transverse to said electron beam and a coating of a relatively non-oxidizable material deposited on a portion of the surface of said diaphragm.

5. A cathode ray tube comprising an envelope and having therein a target member, a cathode, means for forming an electron beam of the electrons generated by said cathode and directing said electron beam along a path to said target, said means including a diaphragm member

having an aperture located therein and a coating of conductive material relatively inert to oxidation covering at least the inside surface of said aperture.

6. A cathode ray tube comprising an envelope having therein a target member, a cathode, means for forming a beam of electrons generated by said cathode and directing said electron beam along a path to said target, said means including a diaphragm member having aperture located therein and a coat of electrical conductive material relatively inert to oxidation and of a high atomic number material covering at least the inside surface of said aperture.

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