Aug. 13, 1940. R. M. BOWIE 2,211,613

CATHODE RAY TUBE

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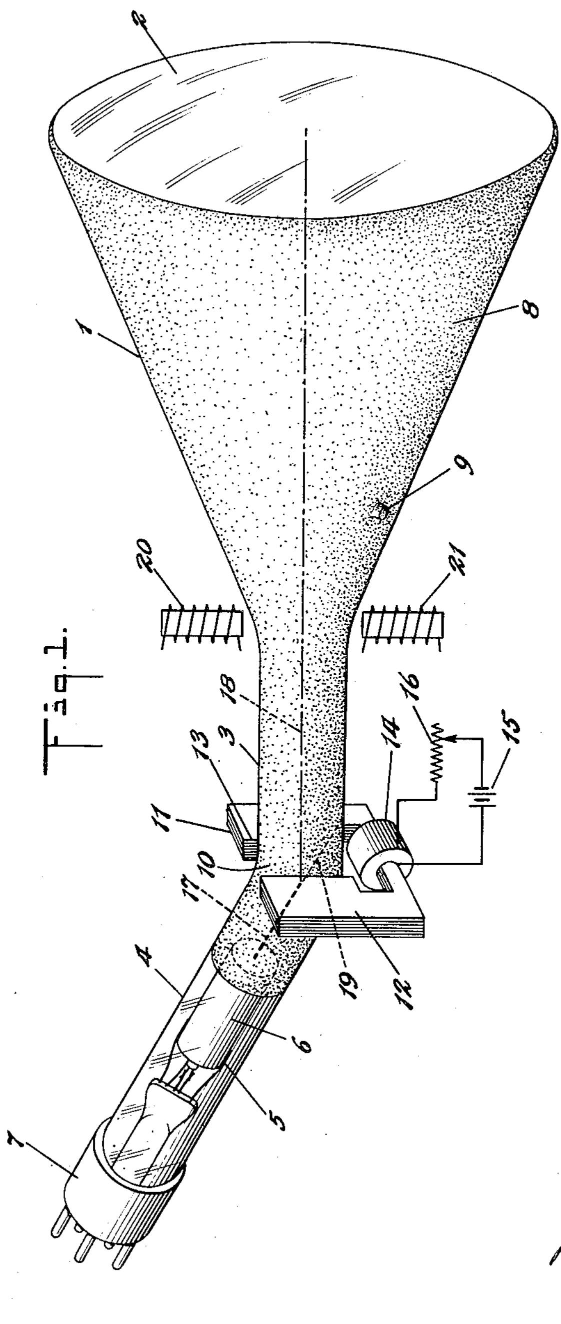

Fig. 1.

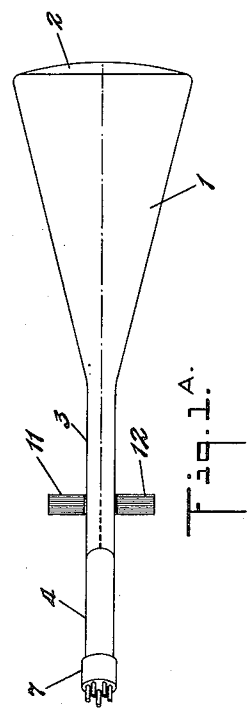

Fig. 1A.

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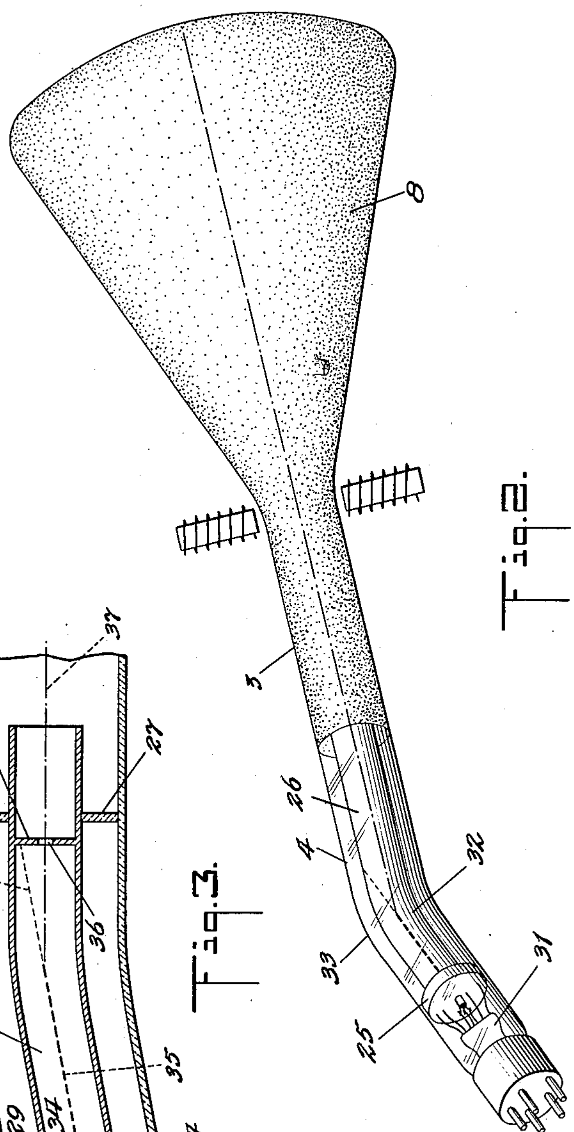


Fig. 2.

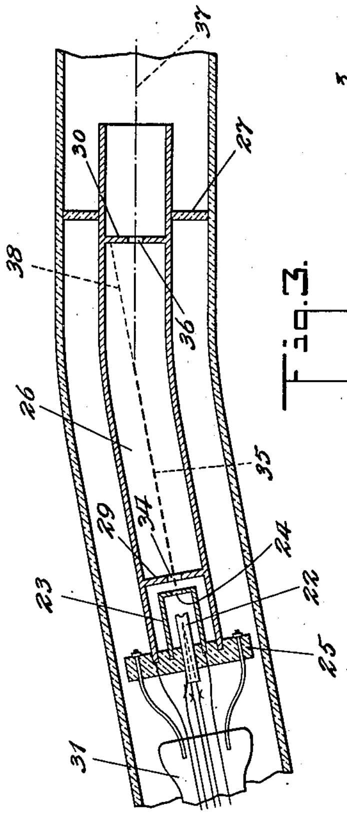


Fig. 3.

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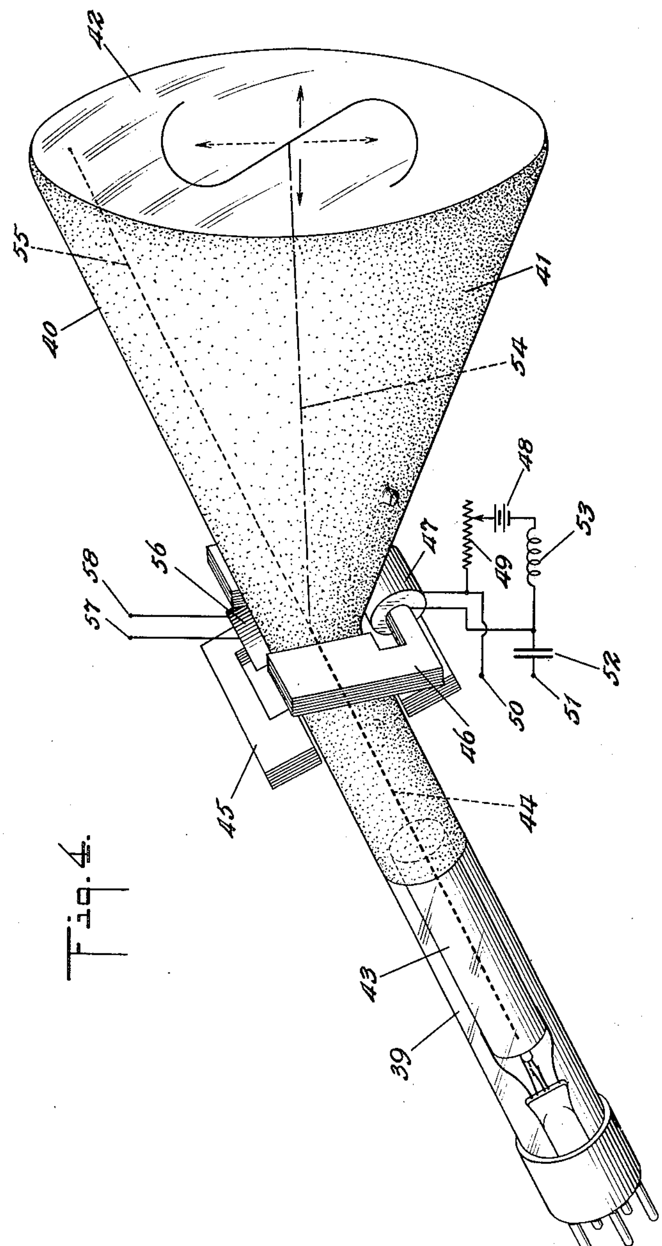


Fig. 4.

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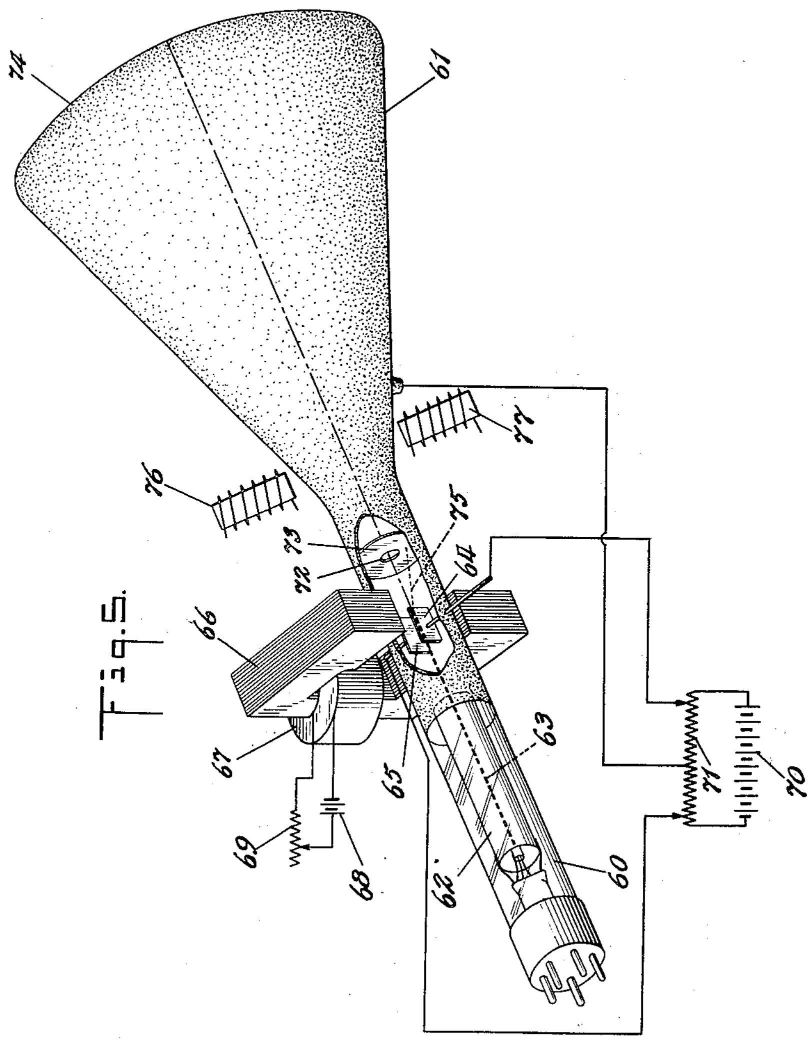


Fig. 5

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# UNITED STATES PATENT OFFICE

2,211,613

## CATHODE RAY TUBE

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10 Claims. (Cl. 250—157)

This invention relates to electron tubes and more particularly to tubes of the cathode ray type, such for example as are used in oscillograph systems, telautograph systems, television systems and the like.

I have found that with the ordinary structure of cathode ray tube, that is, one having an elongated neck which is located substantially coaxially of the end carrying the fluorescent screen, there is a decided tendency for the cathode beam to produce a localized blackening or darkening of the screen. This tendency is particularly marked in cathode ray tubes employing a fluorescent material containing sulfides and the like, and more especially so in the case of cathode ray tubes employing magnetic action for the co-ordinate deflections of the beam.

Accordingly it is one of the principal objects of the present invention to provide a cathode ray tube of novel construction wherein the tendency towards undesirable darkening of the screen is substantially avoided. I have found that this localized blackening or darkening of the fluorescent screen is caused by the presence of negatively charged heavy particles or ions which are emitted from, or are developed at, the cathode. When such heavy particles strike the fluorescent material of the screen, some action or reaction takes place which causes the fluorescent material to decrease its luminous efficiency. Because of the relatively heavy mass of these negatively charged particles as compared with the beam electrons they are subjected to very little deflecting action by the usual magnetic deflecting means, with the result that the darkening of the screen becomes localized at or near the center thereof where it is most conspicuous. While the exact physical nature of the blackened or darkened area is not well-known, it may consist of a very thin coating of the metal particles, although the darkened spot is not usually visible under ordinary reflected light.

It is well-known that the trajectory of a charged particle in a constant electric field is independent of charge-to-mass ratio of the particle, and this is so even if the electric field changes at a rate which is slow compared to the time of flight of the particle. Consequently it is practically impossible to separate heavy particles such as ions, from electrons, merely by using electric fields. If it is assumed that the beam is non-homogeneous, that is it is composed of both heavy and light particles all of which have their origin in or at the same cathode, and that such a beam is acted upon by a magnetic field having a component perpendicular to the direction of motion of the particles, then the beam can be separated into several beams, depending upon the charge-to-mass ratios of the various particles composing the beam. If such a magnetic field is applied in a region which is substantially free from electric fields, the bending of the trajectory of the various particles in the beam can be expressed mathematically as follows:

$$r=\frac{1}{H}\sqrt{2E\frac{m}{q}}$$

where,

$r$=radius of curvature of trajectory

H=component of magnetic field strength perpendicular to beam

E=potential through which the particles have fallen since leaving the cathode

$\frac{m}{q}$=mass-to-charge ratio

I have found that it is possible to construct a cathode ray tube wherein the objectionable heavy particles are deflected or shunted before they reach the fluorescent screen by taking advantage of the different actions exerted on the particles by magnetic and electric fields.

Accordingly it is a feature of the present invention to provide a cathode ray tube with an elongated neck which is offset at an angle with respect to the axis of the screen, so that the heavy particles strike a part of the tube envelope remote from the screen or at least remote from the useful part of the screen.

Another feature relates to a bent neck cathode ray tube having means to subject the electrons in the beam to a constant magnetic field, in addition to the usual deflecting means. As a result of this arrangement the objectionable heavy particles are shunted away from the electron beam before they strike the fluorescent screen, while the electrons in the beam are guided around the bend of the tube so that they may be subjected to the usual deflecting action.

Another feature relates to a cathode ray tube having specially arranged separate magnetic and electric fields to shunt away the objectionable heavy particles from the fluorescent screen, while allowing the electron beam to impinge upon the screen after the usual deflecting action thereon.

Another feature relates to a conventional cathode ray tube having a straight neck which is provided with separate electric and magnetic deflecting means, said means being so biassed electrically that the objectionable heavy particles in the beam are diverted away from the fluorescent screen.

A further feature relates to the novel organization, arrangement and relative location of parts which go to make up an improved cathode ray tube.

Other features and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawings,

Fig. 1 illustrates in partial perspective a cathode ray tube embodying features of the invention.

Fig. 1*a* is a plan view of Fig. 1.

Fig. 2 illustrates a modified embodiment of the invention.

Fig. 3 is an enlarged detail view, of part of the electrode structure of Fig. 2.

Fig. 4 illustrates another embodiment of the invention.

Fig. 5 illustrates a still further embodiment of the invention.

Referring more particularly to Fig. 1, the cathode ray tube comprises a highly evacuated enclosing envelope consisting of a funnel shaped section **1** the large end of which is closed off by the substantially flat screen portion **2**. The small end of the section **1** is formed with an elongated neck comprising two portions **3** and **4**. The portion **3** is preferably disposed co-axially of the funnel shaped section **1**, while the portion **4** is offset at an angle with respect to the portion **4** for purposes about to be described. The neck portion **4** has sealed therein any well-known form of electron gun such as is generally used in cathode ray tubes. This gun is represented diagrammatically in Fig. 1 by the numeral **5** and may be supported on the stem in any well-known manner. Any suitable form of contact base **7** may be fastened to the neck for the purpose of making electrical contact with the various electrodes of the electron gun. Preferably, although not necessarily, the envelope is of glass and is coated on its interior surface as indicated by the stippled area with a conductive material such as "Aquadag," except of course the screen portion **2**, which is provided with any well-known fluorescent material preferably, although not necessarily, zinc sulfide or a mixture of sulfides. In the usual form of electron gun there is provided an electron emitting cathode, a control grid, a first anode and a second anode coacting to produce a focussed beam. Merely for the sake of simplicity in the drawing these various electrodes are omitted from Fig. 1 with the exception of the first anode **6**. The "Aquadag" coating **8** may serve as the usual second anode and for this purpose a contact terminal **9** is provided therefor so that the appropriate potential may be impressed thereon. As pointed out hereinabove, the beam consists for the most part of electrons emitted by the cathode and also a certain percent of relatively heavy negatively charged particles originating at or near the cathode, and is represented in the drawing by the heavy dotted line. Because of the difference of potential between the electron gun cathode and the second anode **8**, this composite beam is composed of particles having velocities given by the following equation:

$$v=\sqrt{2E\frac{q}{m}}$$

where,

$v$=velocity of a particle in the beam

E=potential difference between cathode and anode

$\frac{q}{m}$=charge-to-mass ratio of a particle

The region of space adjacent the bend **10** is, in accordance with the invention, pervaded with a magnetic field of constant intensity. For this purpose, there is provided an electromagnet **11** having poles **12**, **13** and an energizing winding **14**. Winding **14** may be energized from any suitable source of steady magnetizing current represented diagrammatically by the battery **15**. For the purpose of adjusting the intensity of magnetization a series variable resistor **16** is preferably provided. It is important that the poles of the magnet be so disposed, and the polarity of magnetization be such that the electrons in the beam are bent back along the axis of the straight portion **3** of the neck. Assuming for example that the tube is positioned so that the bent portion **4** and the straight portion **3** are disposed in a vertical plane, then the magnet is so positioned that the magnetic lines of force between poles **11** and **12** are substantially horizontal, and the polarity of battery **15** is so arranged that the pole **11** is a north pole and pole **12** is a south pole. I have found that with the proper magnetization as above-described, when the particles in beam **17** enter the region adjacent the poles of the magnet, the electrons are deflected along the path represented by the dot-dash line **18**, and strike the screen **2** at the center thereof. On the other hand, the negatively charged particles or ions, are deflected through a much smaller angle and follow the path represented by the light dotted line **19** and strike the portion **3** of the tube neck. The beam which strikes the screen **2** therefore consists substantially entirely of electrons and this beam can be subjected to any of the well-known types of control. For example as shown schematically in Fig. 1 a pair of deflecting magnets **20** and **21** may be provided to deflect the electron beam with a vertical component of movement under control of suitable signals. Likewise a similar set of magnets (not shown) may be provided and energized by suitable signals to impart to the electron beam a horizontal component of movement.

Instead of allowing the objectionable particles to strike the glass part **3**, the electrodes may be arranged to intercept these objectionable particles. Thus there is shown in Figs. 2 and 3, an arrangement for accomplishing this object. In this embodiment the cathode ray tube envelope is substantially the same as the envelope of Fig. 1 and comprises a staight neck portion **3** and a bent or offset neck portion **4**. As shown in detail in Fig. 3 the electron gun comprises an electron emitting cathode **22** of known construction preferably, although not necessarily, in the form of a tubular metal sleeve carrying electron emissive material on its end adjacent grid aperture **24**. Surrounding the cathode is a tubular metal grid electrode **23** having in its forward end an opening **24** for the emerging beam. The cathode and grid electrodes are preferably, although not necessarily, supported on a single circular ceramic block **25** having a central opening through which is fitted the cathode sleeve **22**, and also having a concentric circular groove in which the tubular grid **23** is seated. The ceramic block **25** is provided with another concentric circular groove in which is seated the end of a tubular metal member **26** forming the first anode for the electron gun. The forward end of this tubular member **26** may be supported in any suitable manner, such for example by the annular mica disc **27**. Preferably the tubular member **26** is provided on its interior with a series of perforated metal diaphragms **29**, **30** to assist in focussing the beam. The electron gun as described may be supported in any suitable manner from the stem **31** of the envelope.

As will be seen from Figs. 2 and 3, the tubular anode **26** is formed with a bend **32** conforming to the bend **33** in the neck of the envelope, and the greater part of the inner surface of the envelope is provided with a conductive coating 8 of "Aquadag" or other suitable conductive material forming the second anode. The electrons which leave the cathode 22 pass through the aperture 24 in the end of grid 23 and thence accelerated through the perforation 34 by the first anode potential. The composite beam 35 constituted of electrons and negative ions then enters the region adjacent the bend 32 where are situated magnetic poles similar to the poles 11, 12 shown in Fig. 1. With the particular position of the tube as shown in Fig. 3, these poles are positioned so as to produce a magnetic field perpendicular to the paper. The intensity of magnetization of these poles is adjusted as described so that the electrons in the beam are deflected to pass through the perforation 36 and thence along the path designated by the dotted line 37 axially of the neck 3. The negative ions however are scarcely deflected by the magnet poles and continue along the path 38, striking the wall of tube 26. Thus the beam that emerges from the electron gun, emerges axially thereof and is a homogeneous electron beam substantially free from negative ions or other objectionable heavy negatively charged particles.

Instead of providing a bend in the neck portion intermediate its ends as in Figs. 1 and 2, the neck portion may be straight and may be joined to the funnel shaped part of the envelope at an angle to the axis of the latter. Thus as shown in Fig. 4 the neck 39 is straight throughout substantially its entire length except for the region where it joins the funnel shaped part 40 of the envelope. In other words, the neck is joined to the part 40 so that the axis of the neck is at a predetermined angle with respect to the axis of the part 40. As in the previous embodiments the inside surface of the envelope is provided with a conductive coating 41 and the substantially flat end 42 is provided on its inner surface with a suitable fluorescent coating. An electron gun 43 of any well-known construction is mounted in the neck 39 and emits a substantially parallel beam 44 of electrons and negative ions which travel along the axis of the neck 3. Mounted outside the tube and preferably adjacent the region where the neck joins the part 40 of the envelope, are two electro-magnets 45, 46 so disposed that their respective fields are in mutually perpendicular directions. The magnet 45 is used to deflect the beam from right to left as indicated by the full line arrows on the screen, while the magnet 46 is used to deflect the beam vertically as represented by the dotted arrows. In addition to serving as the vertical deflecting means, the magnet 46 also serves to segregate the electrons from the negative ions or other negatively charged objectionable particles. For this purpose the winding 47 is connected to a source of steady biassing potential such for example as the battery 48 in series with a variable resistor 49. Winding 47 is also arranged to be connected to the terminals 50, 51 leading to a suitable source of deflecting signal current, and preferably the signal current is segregated from the biassing circuit by means of the condenser 52 and choke coil 53. Thus the magnet 46 is energized by a steady direct current for biassing and having superimposed thereon the variable deflecting signal current. In accordance with the invention the steady biassing current is adjusted to such a magnitude that the electron beam is normally deflected along the dot-dash line 54 and strikes the center of the screen 42, when no deflecting signal is applied to terminals 50, 51. The excitation of winding 47 therefore effects the vertical deflection of the electron beam, and the maximum magnitude of the vertical deflecting signal is preferably chosen so that the electron beam never strikes the marginal portion of the screen 42. As pointed out hereinabove, the magnet 46 exerts very little deflecting action on the negative ions or negatively charged heavy particles in the beam with the result that these ions and particles follow substantially their original path as indicated by the dotted line 55 thus striking the screen only at its marginal area. It will be understood of course that the magnet 45 for effecting the horizontal movement of the electron beam is provided with a winding 56 connected to terminals 57, 58 leading to a suitable source of signal deflecting current. If desired the horizontal deflection of the electron beam may be effected by electrostatic deflecting electrodes as is well understood in the art, instead of the magnet 45.

Referring to Fig. 5, there is shown a method of segregating the negative ions or particles from the electron beam, in a cathode ray tube of the straight neck type. In this embodiment the cathode ray tube is formed with a straight neck 60 which is formed co-axially with the funnel shaped portion 61. The electron gun 62 emits a beam 63 of negative ions and electrons the beam passing between the electrically charged deflecting plates 64, 65 and also between the poles of electro-magnet 66, the said poles being disposed so as to produce a magnetic field therebetween which is perpendicular to the field between plates 64, 65. The winding 67 of magnet 66 is connected to a source of steady current represented by battery 68 in series with an adjustable resistor 69. Likewise the plates 64, 65 are connected across a source of steady potential represented by battery 70 and potentiometer 71. Preferably, although not necessarily, the conductive coating on the interior of the envelope is connected to the mid-point of the potentiometer 71. I have found that by suitably adjusting the intensity of the magnetic field between the poles of magnet 6, with respect to the electric field between plates 64, 65 it is possible to have the electrons in the beam continue in a substantially straight line along the axis of the tube and thence through the perforation 72 in the metal diaphragm 73 to the center of the screen 74, while the heavy particles or ions in the beam are deflected along the path 75. Instead of adjusting the relative magnetic and electric field strengths so as to cause the heavy particles to strike the diaphragm as shown, it is possible to adjust these field strengths so that the heavy particles strike the neck of the tube in which event the diaphragm 73 may be omitted. The beam that reaches the screen therefore consists substantially entirely of electrons and it can be deflected in a vertical direction, a horizontal direction, or both, by suitable deflecting means either in the form of electromagnets or in the form of electrostatic deflecting plates similar to plates 64, 65 it being understood that these deflecting members or electrodes are preferably positioned at the region of the tube indicated schematically by the magnets 76, 77.

While certain specific embodiments and materials have been disclosed it will be understood that the invention is not limited thereto and that various changes and modifications may be made without departing from the spirit and scope of the invention. Furthermore it is understood that the invention is not limited by the theories set forth as to the cause of the darkening of the cathode ray tube screen. Furthermore while the invention is disclosed in connection with an all glass cathode ray tube envelope, it will be understood that the invention is capable of application to cathode ray tubes wherein the funnel shaped part is of metal rather than of metal coated with a conductive material.

What I claim is:

1. A cathode ray tube having an evacuated envelope containing an electron gun for producing a scanning beam, a fluorescent screen, and means between said gun and screen to exert a deflecting action on the electrons in said beam for the purpose of exerting a selective deflecting action on the electrons as compared with undesirable negative ions in the beam to reduce the tendency of said screen to blacken permanently by reason of the impingement of negative ions thereon.

2. A cathode ray tube having an evacuated envelope containing a fluorescent screen and an electron gun for producing a scanning beam and for focussing said beam in a spot on said screen, means to deflect said beam in a desired scanning path over said screen, and separate deflecting means to exert a selective deflecting action on the electrons and the negative ions in said beam for the purpose of reducing the tendency of said screen to blacken by reason of the impingement of said negative ions thereon.

3. A cathode ray tube having an evacuated envelope containing a fluorescent screen having a scanning field, an electron gun for producing a scanning beam of electrons having substantially parallel paths said beam also including undesirable relatively heavy negative particles or ions, and means to divert said particles or ions away from the scanning field of said screen while allowing the electrons to trace a desired scanning path over said field.

4. A cathode ray tube comprising an enclosing envelope having an enlarged portion joined to a bent neck portion, a fluorescent screen carried by said enlarged portion, an electron gun mounted within the neck portion for developing a scanning beam of electrons, and means to prevent localized blackening of said screen by undesirable negative ions in said beam.

5. A cathode ray tube comprising an enclosing envelope with an enlarged portion carrying a fluorescent screen, a neck portion joined to said enlarged portion, an electron gun positioned within the neck and normally emitting a beam toward the wall of the neck, a bent tubular anode member within the neck into which the beam passes, and means to direct said beam through said tubular anode so that the undesirable negative ions in the beam which tend to cause localized blackening of the screen are prevented from reaching the screen while allowing the scanning constitutents to reach said screen.

6. A cathode ray tube comprising an enclosing envelope having an enlarged portion carrying a fluorescent screen, a neck joined to said enlarged portion, an electron gun within said neck, a tubular anode to receive the beam from the gun and to assist in focussing the scanning constituents thereof on said screen, said anode being bent so as to segregate the scanning constituents from the undesirable negative ions which tend to cause localized blackening of the screen.

7. A cathode ray tube comprising an enclosing envelope having an enlarged portion carrying a fluorescent screen, a neck joined to said enlarged portion, a press sealed into said neck, a ceramic member supported from said press, an electron gun supported from said ceramic member, a tubular anode having one end supported from said ceramic member, and supported at the other end from the wall of the neck, said anode being bent for the purpose of segregating the scanning constituents of the beam from the negative ion constituents which tend to cause localized blackening of the screen.

8. A cathode ray tube comprising an enclosing envelope having a funnel-shaped portion carrying a fluorescent screen, a neck portion joined to said funnel-shaped portion so that the axis of the neck portion is at an angle to the axis of the funnel-shaped portion, and a pair of magnets for producing crossed magnetic fields in the region where the neck portion joins the funnel-shaped portion for the purpose of preventing undesirable negative ions from blackening the screen.

9. A cathode-ray tube including an elongated neck portion and a funnel-shaped body portion closed off by a fluorescent screen window; an electron gun mounted within said neck portion and including an electron-emitting cathode, a first or low potential anode and a second or high potential anode; and magnetic means located between said first anode and said screen and effective after the electrons have been acted upon by said second anode for exerting a selective deflecting action on the electron and negative ions whereby said negative ions are prevented from producing a localized blackening of said screen.

10. A cathode-ray tube comprising an enclosing envelope having an enlarged portion carrying a fluorescent screen with a scanning field, a neck joined to said enlarged portion so that the neck axis is in line with the marginal periphery of the screen, means to confine the undesirable negative ion constituents of the beam which tend to cause localized blackening of the screen to a part of the screen outside said scanning field while allowing the electrons in the scanning beam to scan said field, the last-mentioned means including a pair of magnets for producing cross magnetic fields substantially at right angles to the beam axis.

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