United States Patent [19]

McCarthy et al.

[11] 3,890,541

[45] June 17, 1975

[54] CATHODE RAY TUBE APPARATUS

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[21] Appl. No.: **129,824**

[30] **Foreign Application Priority Data**

Apr. 2, 1970 United Kingdom 15746/70

[52] **U.S. Cl.** **315/366**

[51] **Int. Cl.** **H01j 29/70**

[58] **Field of Search** 315/23, 366

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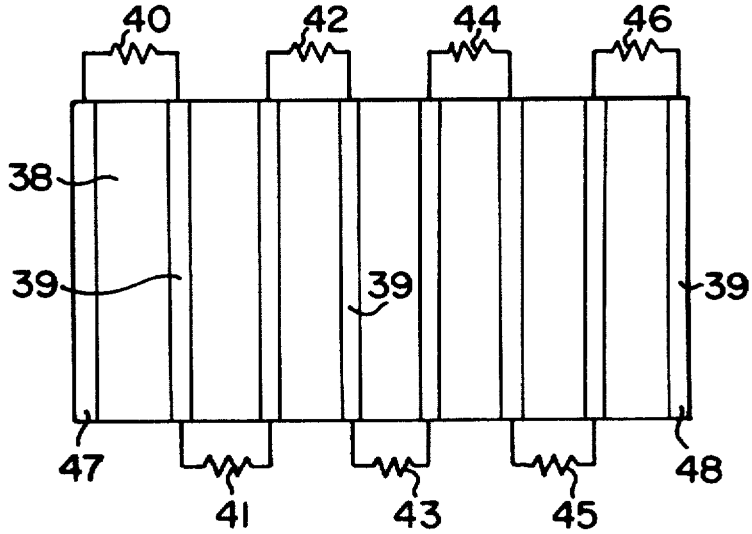
Attorney, Agent, or Firm—Louis Etlinger; Joseph E. Funk

[57] **ABSTRACT**

A cathode ray tube apparatus includes an electroluminescent viewing screen, an electron beam source, a plate-like electron-beam-directing electrode spaced from the screen surface, and means to connect a static potential between the screen surface and the plate-like electrode to produce a field in the space between them for directing an electron beam obtained from the source on to the screen, such that when the electron beam is subjected to orthogonal scanning before it is launched into the space at varying angles to the normal beam axis it is so directed within the space by the field that it is scanned orthogonally over the screen surface.

8 Claims, 16 Drawing Figures



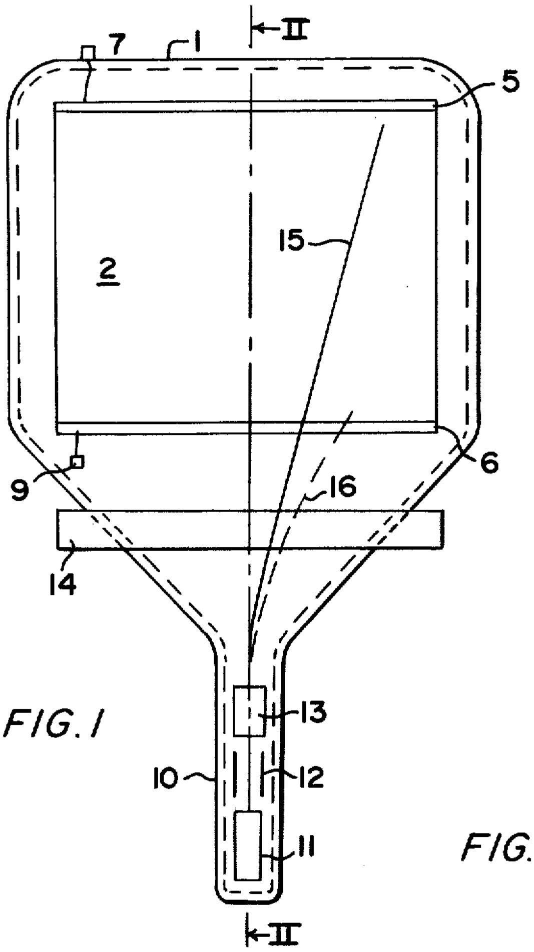


FIG. 1

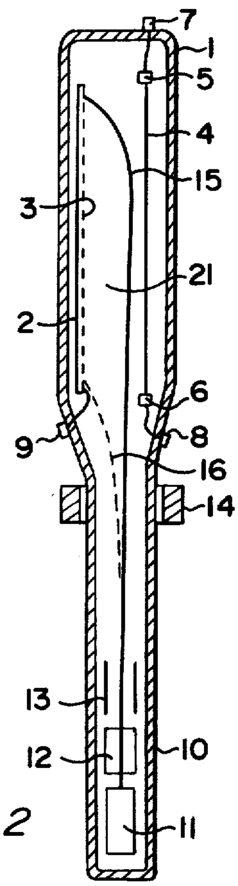
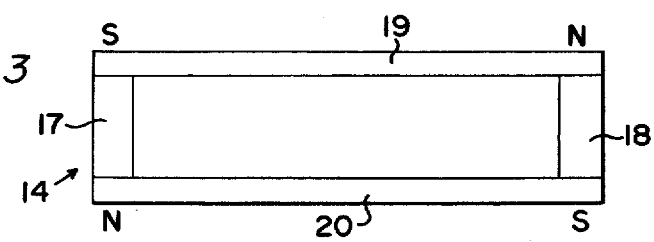


FIG. 2

FIG. 3



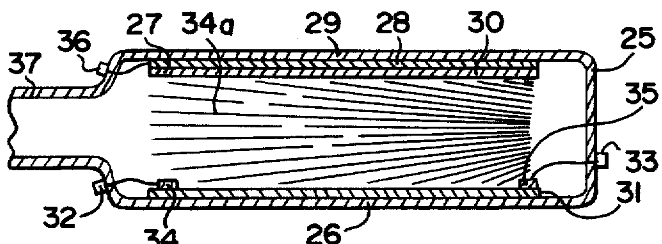


FIG. 4

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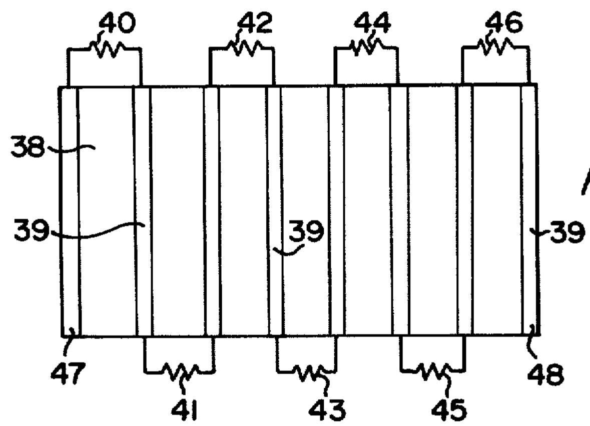

FIG. 5

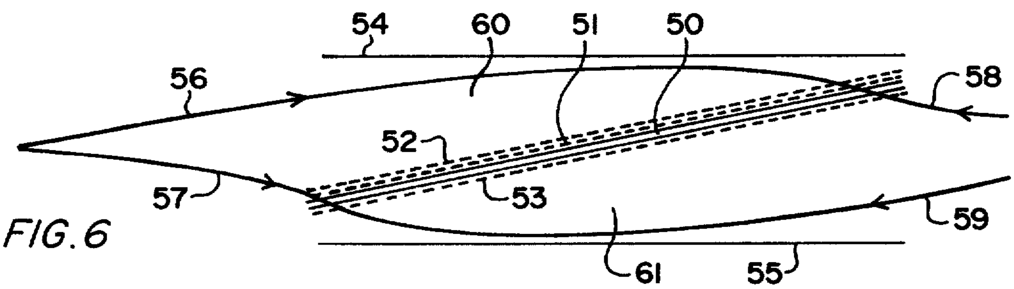

FIG. 6

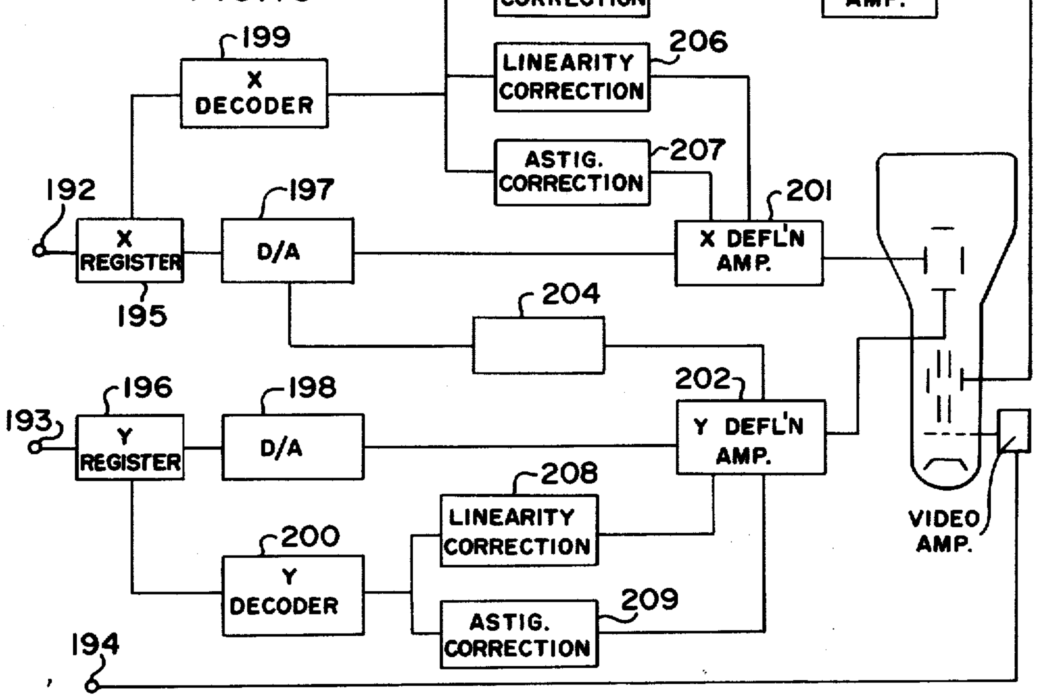

FIG. 16

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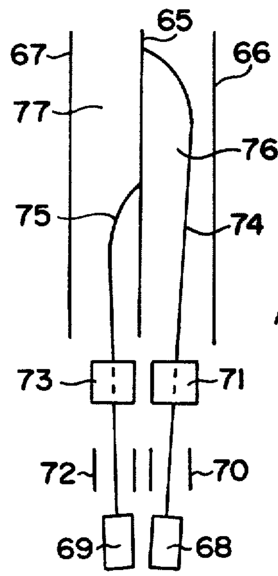

FIG. 7

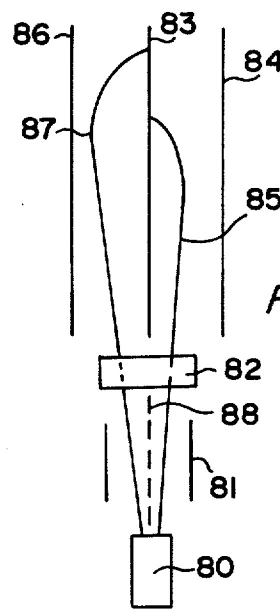

FIG. 8

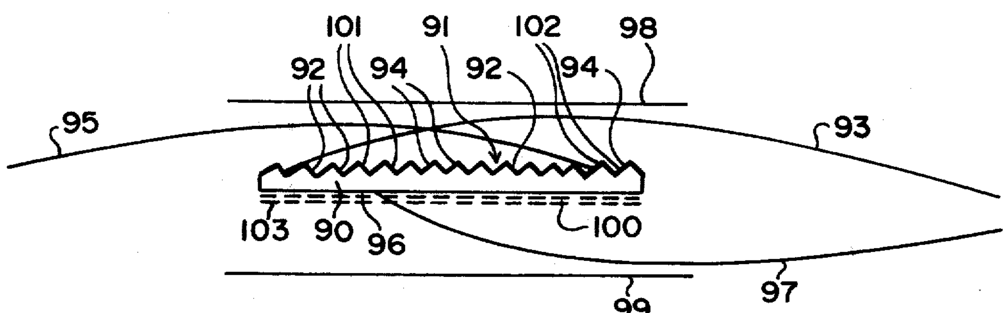

FIG. 9

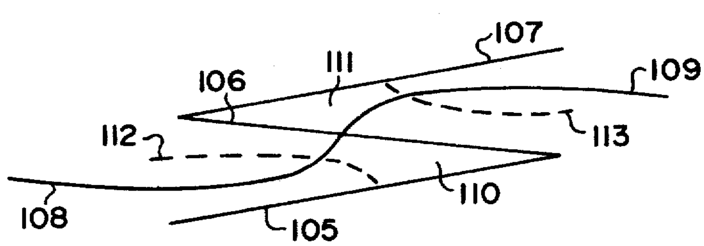

FIG. 10

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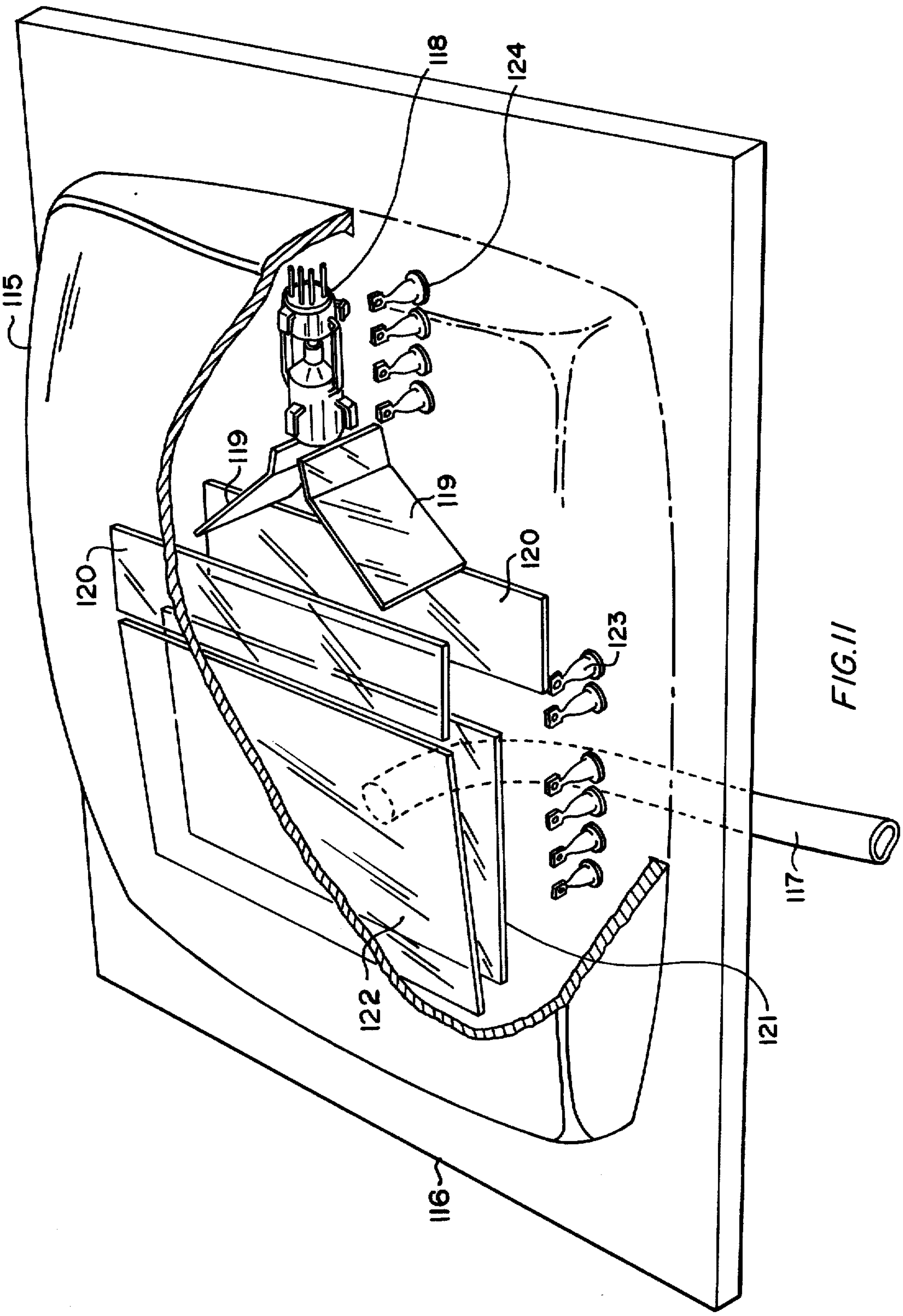

FIG. 11

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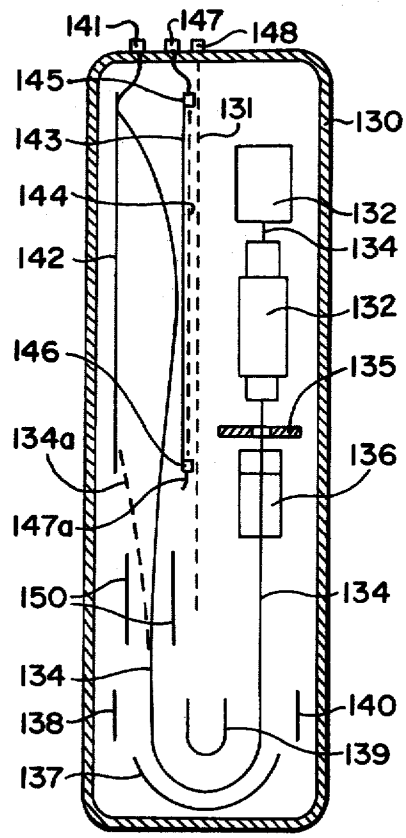

FIG. 12

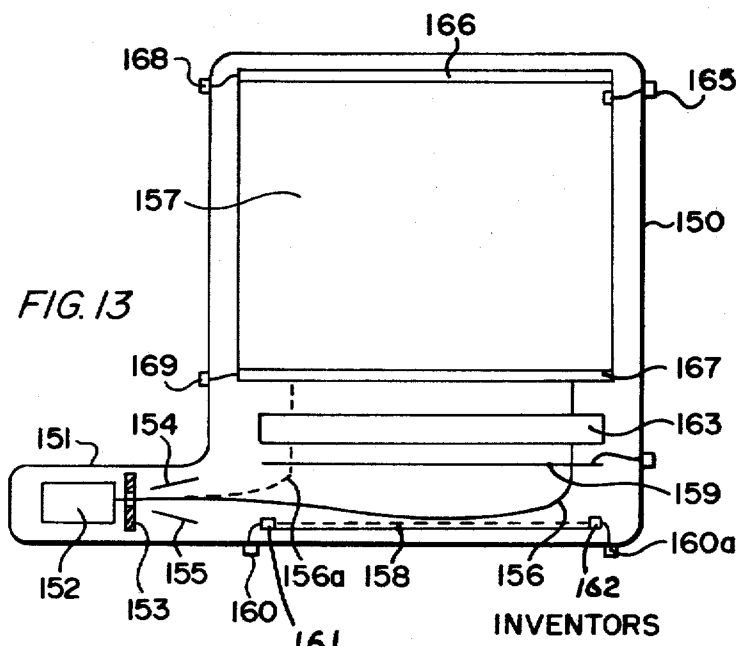

FIG. 13

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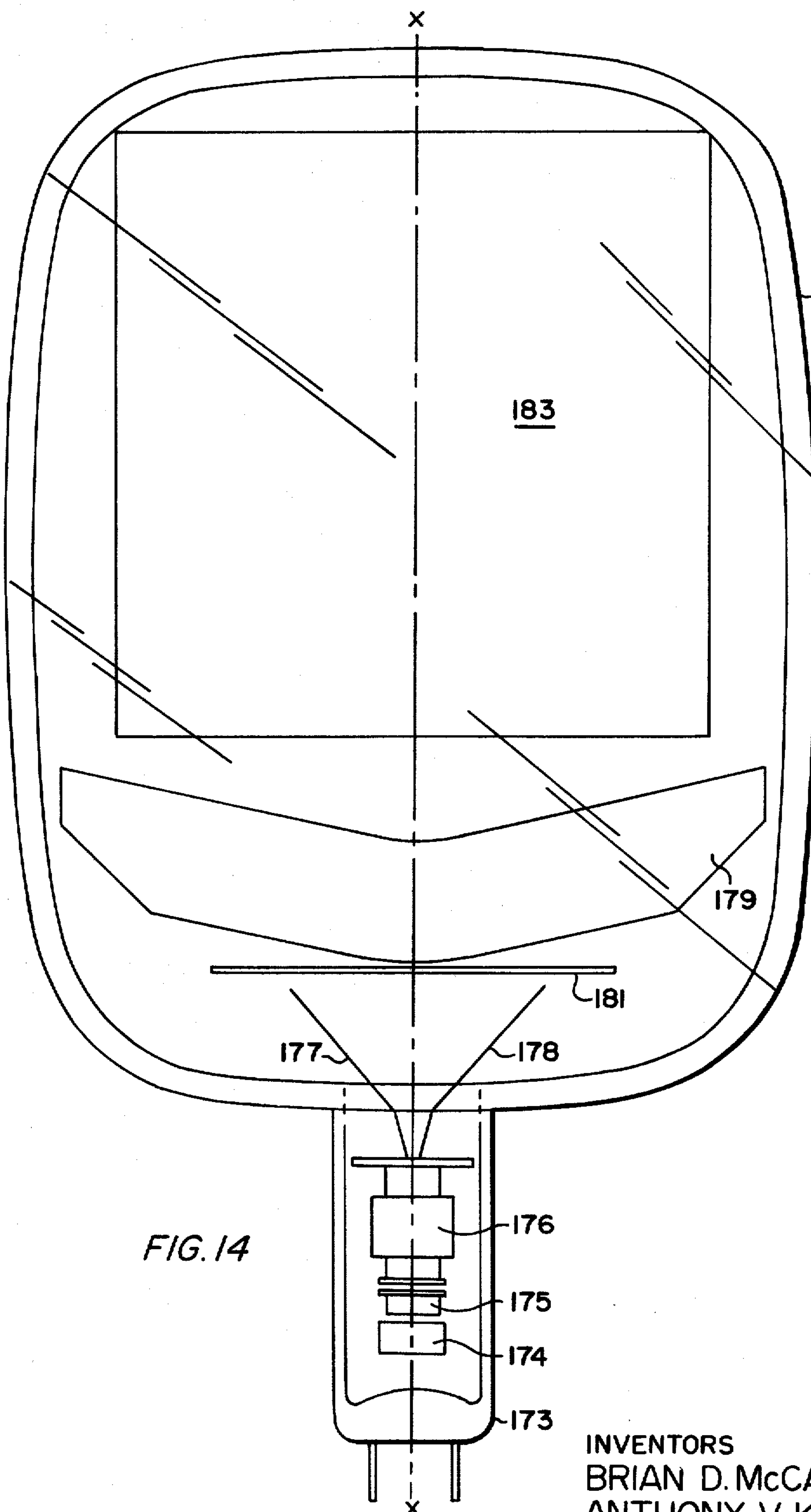

FIG. 14

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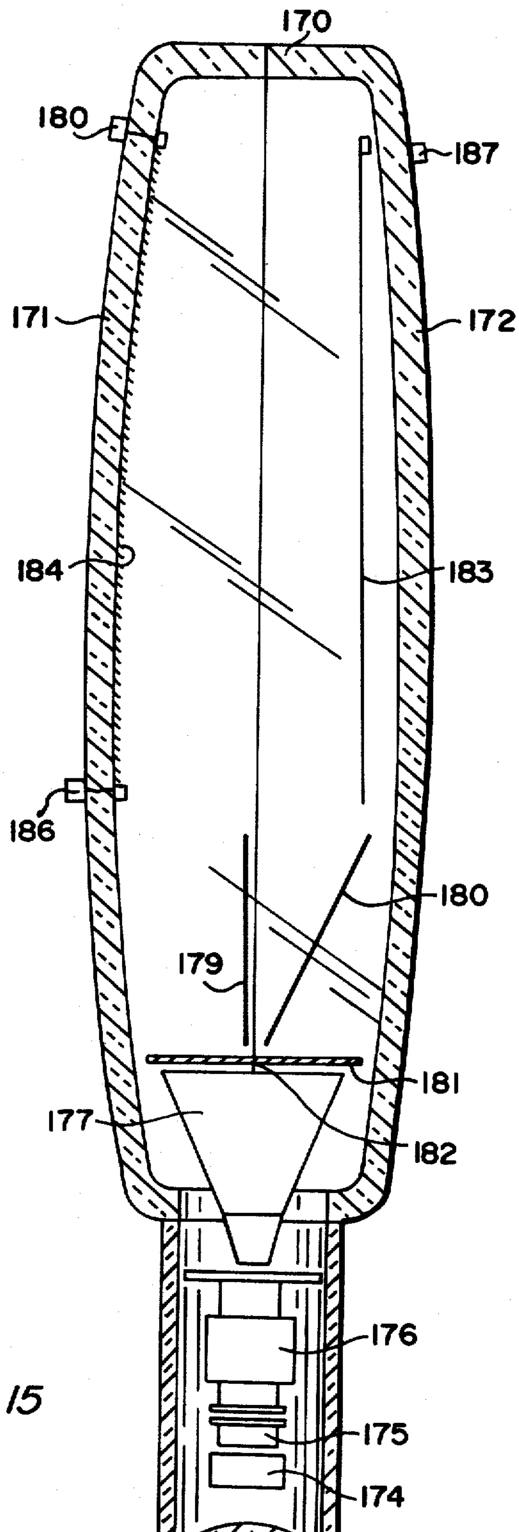

FIG. 15

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CATHODE RAY TUBE APPARATUS

FIELD OF THE INVENTION

This invention relates to cathode ray tube apparatus which can be used to provide visible displays, either in black and white or in colour, and to cathode ray tube apparatus which acts as a camera pick-up tube. A feature of cathode ray tube apparatus according to the present invention is that it has a smaller back to front dimension for a given area of display or image production than have those commonly in commercial use and it thus enables a display or image to be provided in a space with a limited depth. The apparatus is particularly suitable for use in providing displays on aircraft control panels, though its use in not limited to this application.

BACKGROUND OF THE INVENTION

Cathode ray tube apparatus which have a smaller back to front dimension than those commonly used have previously been proposed and have been referred to as "flat"cathode ray tube apparatus. However, none of the previously proposed apparatus has, so far, been brought into general commercial use.

Examples of such previously proposed flat cathode ray tube apparatus are described in U.S. Pat. Specifications Nos. 2,795,729 and 2,795,731. These previously proposed arrangements required an array of parallel electrodes behind the viewing screen to control the scanning of the electron beam in one direction and were either complicated to manufacture or needed comparatively high voltages to be switched and applied to respective electrodes in the array during a scanning operation.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a novel and improved cathode ray tube apparatus.

An additional object of this invention is to provide a cathode ray tube apparatus which is comparatively simple to manufacture and operate.

It is a further object of this invention to provide a flat cathode ray tube apparatus which employs, to a large extent, known electron beam deflection systems and electronoptical focussing and accelerating systems.

Briefly, in the cathode ray tube apparatus of the invention a space for a beam directing field is provided between a surface of a viewing screen and a beam directing electrode and a beam directing field, which is produced in the space, is such that an electron beam which is deflected into a given trajectory before it enters the space is directed to a discrete spot on the screen corresponding to the particular trajectory.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and objects of the invention will become more apparent upon reference to the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a diagrammatic front view of a cathode ray tube,

FIG. **2** is a section on the line II—II of FIG. **1**,

FIG. **3** is a side view of a magnetic lens assembly shown in FIGS. **1** and **2**,

FIG. **4** is a diagrammatic section through an envelope similar to that of FIG. **2** showing diagrammatically a beam directing field,

FIG. **5** is a plan view of a beam directing electrode,

FIG. **6** is a diagrammatic section of a part of a two-colour cathode ray tube,

FIGS. **7, 8,** and **9** are diagrammatic sections of alternative cathode ray tube arrangements which may be used for colour,

FIG. **10** is a diagrammatic section of a further screen and beam directing arrangement,

FIG. **11** is a cut-away perspective view of a demountable experimental type cathode ray tube,

FIG. **12** is a diagrammatic section through a modified cathode ray tube,

FIG. **13** is a diagrammatic front view of a further cathode ray tube arrangement,

FIG. **14** is a diagrammatic front view of a particular embodiment of a cathode ray tube,

FIG. **15** is a section on the line X-X of FIG. **14** and

FIG. **16** is a schematic diagram of an electrical circuit for use with a cathode ray tube of the type shown in FIGS. **14** and **15**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIGS. **1** and **2** there is shown a cathode ray tube having an envelope **1** through which there is visible a planar transparent support screen **2**. On the inner face of the support screen there is an electroluminescent screen **3** which comprises a transparent conducting layer and a coating of material which luminesces when bombarded by electrons. Directly behind and spaced from the screen **2** there is a beam-directing electrode **4** which is in the form of a single sheet, though it may be made from a plurality of electrically interconnected sheets. The support screen **2** upon which the luminescent material is provided may alternatively be the transparent face of the envelope **1**. In a further modification, the beam directing electrode is made of a transparent material and the screen may be viewed from either or both sides of the envelope. The beam directing electrode **4** is of greater height in the normal direction of the beam than the screen **2** and along the edges of the electrode **4** extending beyond the area of the screen **2** there are, as shown in FIG. **1**, strips of electrically conducting material **5** and **6**. Terminals **7** and **8** on the envelope **1** are electrically connected to the strips **5** and **6**. A uniform resistive layer is applied to the electrode **4** between the strips **5** and **6**. The conducting layer of the electroluminescent screen **3** is electrically connected to a terminal **9** on the envelope **1**.

The envelope **1** has a neck **10** which houses an electron gun **11** and orthogonally operating electrostatic deflecting electrode systems **12** and **13**. An electromagnetic collimator lens structure **14** is positioned around the flared part of the envelope. Other correcting lens systems may be provided as required. An electron beam, indicated in two positions by solid and dotted lines **15** and **16** respectively, is shown impinging upon the screen at points distant from and near to the beam source **11**.

As may be seen from FIG. **3** the collimator lens **14** includes a pair of magnets **17** and **18** joined by a pair of pole pieces **19** and **20** arranged to provide a ring magnet assembly.

In operation, biassing potentials, with respect to the E.H.T. potential applied to the electroluminescent screen **3** via the terminal **9**, are applied between the terminals **7** and **8** and connected across the electrode **4** between the strips **5** and **6.** The biassing potential on the strip **5** is of a higher value than that on the strip **6** and an electric field is produced in the space **21** (FIG. **2**) between the beam directing electrode **4** and the screen **3** having an intensity which is greatest in the part of the region of the space **21** furthest from the electron gun **11.** The uniform layer of resistive material between the strips **5** and **6** causes the beam directing biassing potential to be so distributed over the electrode **4** that the field in the space **21**, though static, is non-uniform and varies in intensity substantially linearly throughout the space **21** in the direction from the strip **6** to the strip **5**, reaching a maximum value in the region of the space **21** extending between the edge of the screen **3** remote from the source **7** and the strip **5.**

Deflection potentials are applied to the deflecting electrode systems **12** and **13** in a known manner to cause the electron beam emitted by the gun **11** to be deflected in two orthogonal directions and to set up a raster or other selected pattern before it enters the space **21.** When the electron beam is given a lateral component of movement from the undeflected path before it enters the beam directing field space **21** between the screen **3** and the electrode **4**, its direction of entry into the space changes and the distribution of the beam directing field in that space is such that the beam is caused to be directed, as it passes through the space **21**, towards a given position on the screen **3** according to the angle through which it is moved laterally from its undeflected path before it enters the space **21**, or in other words according to its direction of entry into the space **21.** The electron beam may initially be directed towards the electrode **4** as it enters the space **21** in order eventually to impinge upon certain positions on the screen **3.** The actual position in which the beam impinges upon the screen **3** is determined by the angle through which it is deflected before it enters the beam directing field, the velocity of the beam and the distributed intensity of the field in the part of the space **21** through which it passes.

The deflection fields set up by the systems **12** and **13** determine the angle at which the beam enters the region **21** and by suitably shaping these fields, the shape of the area of the screen **3** scanned by the beam may be controlled. The collimator lens structure **10** is designed to correct for the form of distortion commonly known as "keystone" distortion in which the width of a display nearer to the source **11** would otherwise be less than the width of the display further from the source **7.** However, as has been indicated above, keystone distortion may alternatively be corrected by suitably shaping the deflection fields for example by interchanging the electrode systems **12** and **13** and shaping the electrodes of the system **12** to provide the required correcting field.

A scanning roster may be set up by the electrode systems **12** and **13** in such a way that the scanning lines developed on the screen **3** are either in planes substantially at right angles to the axis of the electron beam emerging from the gun **11** or parallel to this axis.

Instead of setting up a raster pattern the beam may be deflected by the systems **12** and **13** to write alphanumeric information directly on to the screen. This latter form of display is particularly suitable for use in displaying quantative information, for example when monitoring information on an aircraft control panel. It is necessary in modern aircraft to monitor a large number of different sources of information and, since these sources can be scanned electrically comparatively easily, information exceeding given limits from any of the sources may be slected and written on the separate parts of the display simultaneously, in order to highlight the fact that a limit has been exceeded.

Referring to FIG. **4** there is shown a section through a part of a glass envelope **25** having a viewing face **26** and an electroluminescent layer **27** deposited upon a conducting layer **28** formed directly on the inside of the other face **29** of the envelope and forming a viewing screen **30.** On the inside of the face **26** there is a transparent uniform resistive coating **31** formed by depositing a thin layer of oxidized chromium. The screen **30** is viewed through the coating **31.** Alternatively, the conducting layer **28** can be of a transparent material and an image on the screen **30** can be viewed through the face **29.**

Terminals **32** and **33** on the envelope **25** are electrically connected to the opposite edges of the coating **31** via respective conducting strips **34** and **35.** The coating **31** forms a beam directing electrode. The conducting layer **28** is electrically connected to a terminal **36.** An electron gun (not shown) is housed, together with other beam controlling elements, in the neck **37** of the envelope.

In operation, an E.H.T. voltage is connected to the terminal **36** and biassing voltages, which are lower than that of the E.H.T., but which are positive with respect to that of the electron-beam source and have a potential difference between them are connected to respective terminals **32** and **33.** The voltage connected to the terminal **32** is greater than that connected to the terminal **33** so that the gradient of the field intensity across the space between the screen **30** and the beam directing electrode **31** is smaller nearer to the gun and increases with distance from the gun. Such an arrangement produces a field which increases linearly in intensity with distance from the gun along the length of the envelope, as indicated by the lines **34***g*. The relative voltages might, for example, be an E.H.T. of 20 KV connected to the terminal **36,** and biasing potentials of 15 and 10 kV obtained from the same source applied to the terminals **32** and **33** respectively. Alternatively, a field of linearly increasing intensity with distance from the gun can be provided by depositing the electroluminescent layer **27** on the uniform resistive coating **31** to form the viewing screen. The conductive layer **28** can than be employed as the beam directing electrode. In the operation of this embodiment a voltage difference is applied across the resistive coating **31** via the two terminals **32** and **33** to provide the E.H.T. and a biassing potential of lower value is applied to the conductive layer **28** forming the beam directing electrode via the terminal **36.** In this embodiment the E.H.T. potentials on the terminals **32** and **33** are chosen with respect to the biassing potential on the beam directing electrode formed by the layer **28** in such a way that a smaller gradient of field intensity **34** is provided across the space between the screen and the beam directing electrode as the electron gun is approached along the space.

Although in this embodiment the screen and beam directing electrode are deposited directly on the inner faces of the envelope, either or both of them may be formed on supports which are then introduced into the envelope before its manufacture is complete.

Referring to FIG. **5** there is shown diagrammatically a plan view of a beam directing electrode which is designed to provide a non-linear beam deflecting field and which can be used in place of electrode **4** of FIG. **1.** The electrode of FIG. **5** has an insulating support sheet **38** across which there are provided conductive strips **39** arranged on parallel axes in planes which are at right angles to the surface of the sheet **38** and at right angles to the normal undeflected direction of the beam.

The strips **31** which have a low value of electrical resistance are connected together in a zig-zag manner to form a series circuit by means of resistor elements **40** to **46.** A voltage is connected between the ends **47** and **48** of the circuit. The elements **40** and **46** are graded so that the voltage drop is not linearly distributed over the length of the circuit, but provides a required distribution of the beam directing field, for example, an exponential distribution over the length of the screen in the undeflected direction of the beam. It is possible for the strips **39** to be proportioned, in such a way that they contribute to a required distribution of the field due to their resistance or lack of resistance. The strips **39** may be graded along their length with respect to resistance, for example by varying their widths, in order to provide a modification of the beam directing field pattern. The resistor elements **40** to **46** may be a resistive frit applied to the sheet **38,** which may be of glass. Variations in the shape of the field may also be obtained by suitably shaping the strips **39** or by varying the pattern in which they are applied.

Referring to FIG. **6** there is illustrated diagramatically an arrangement of electrodes which enables two separate displays to be obtained, one on each side of a screen **50.** The screen **50** provides a translucent support for a translucent conducting layer **51** and it has a luminescent phosphor layer **52** and **53** on respective opposite sides thereof. The arrangement includes two transparent beam directing electrodes **54** and **55** provided by transparent glass sheets coated on their inner surfaces with a transparent conducting layer and arranged one on each side of the screen **50.** Two electron beams from sources not shown on opposite sides of the electrode assembly are indicated respectively by lines **56, 57** and **58, 59** at the extremes of their deflection. The screen **50** is tilted with respect to the electrodes **54** and **55** and beam directing fields are produced in the regions **60** and **61** between the electrode **54** and the screen **50** and the electrode **55** and the screen **50** which are of lower intensity nearer to their respective beam sources, due to the relative positions of the screen and the electrodes, when beam directing biassing potentials are applied to the electrodes **54** and **55** with respect to the screen. Employing this arrangement it is possible to provide two separate and independent displays by making the screen **50** opaque with a luminescent phosphor coating on each side so that displays of written information may be read off both sides of the screen independently. Such displays are of value in providing information to two parts of an area, for example in an airport lounge. A two colour display may be provided by making the screen **50** of FIG. **6** translucent and having on each side a phosphor coating which luminesces in a colour different from that of the other when it is bombarded by its respective electron beam.

Referring to FIG. **7** there is shown a diagrammatic illustration of a further arrangement for providing tow separate displays, one on each side of a screen **65,** in which beam directing electrodes **66** and **67** are arranged parallel to one another and electron guns **68** and **69** having their respective deflection systems **70, 71** and **72, 73** are positioned at the same end of the structure to direct electron beams **74** and **75** into beam directing field regions **76** and **77** between the screen **65** and the electrodes **66** and **67** respectively. In a similar manner to that previously described with reference to FIGS. **1** and **2** the distribution of the static beam directing fields over the regions **76** and **77** varies in intensity linearly over the area of the screen in the directions of travel of the undeflected beams in order to act upon the beams **74** and **75** according to their angles of entry into the beam directing fields and to provide impingement of the beams on the screen in a required position. This arrangement may also be used to give either two separate displays or correlated displays in two different colours in a similar manner to that of FIG. **6.**

Referring to FIG. **8** there is outlined an arrangement for providing either two separate black and white displays to be viewed independently from opposite sides or two correlated displays each in a different colour to be viewed together, which employs a single electron beam gun source **80.** The gun source **80** provides a beam which passes via deflecting systems **81** and **82** either between a screen **83** and a beam directing electrode **84** on a path **85** or the screen **83** and a beam directing electrode **86** on a path **87.** The beam may thus be switched between the path **85** and the path **87** to provide a two colour display with a modulation signal synchronised with the beam switching applied to the beam. Alternatively a beam splitting electrode may be positioned between the deflecting electrodes of the system **81** as indicated by the dotted line **88** in order to enable writing or scanning to take place on the opposite sides of the screen at the same time. In the arrangement shown the horizontal component of movement of the beams is provided in common by the deflection system **82.** This embodiment is used preferably for colour displays viewed from one side only, however if information is to be written independently on the opposite sides of the screen and the two displays are to be viewed from the opposite sides of the screen, it must be remembered that on one side of the screen the beam moves from right to left while on the other side the beam moves from left to right and that the modulation signals applied to the beams must be co-ordinated with the movement of the beams in order that mirror writing by one of the beams is avoided.

In FIG. **9** there is shown a screen and beam directing electrode arrangement that may be used to provide a three colour display. In this arrangement a translucent screen **90** is provided with a serrated surface **91,** the opposite surface **96** being planar. A phosphor **101** which luminesces in a first colour when bombarded by electrons is applied to the faces **92** of the serrated surface **91** and an electron beam **93** obtained from a first source (not shown) is directed to impinge upon the faces **92.** A phosphor **102** which luminesces is a second colour when bombarded by electrons is applied to the faces **94** of the serrated surface **91** and an electron beam **95** obtained from a second source (not shown) is directed to impinge upon the faces **94**. On the surface **96** on the other side of the screen **90** there is a conducting layer **100** upon which there is provided a third phosphor layer **103** which luminesces in a third colour. An electron beam **97** from a third source (not shown) is directed towards the third phosphor layer, The conducting layer **100** is arranged between two beam directing electrodes **98** and **99**, at least one of which is transparent, in a manner similar to that of the previously described embodiments, and enables two beam directing fields to be provided. A uniform beam directing field is produced between the electrode **98** and the layer **100** and the faces **92** and **94** are so angled that the respective beams **93** and **95** may be caused to impinge upon them over the area of the surface **91** according to the direction in which the beams are launched into the beam directing field. A beam directing field, which increases in intensity in the direction of projection of the beam **97**, is produced between the beam directing electrode **99** and the layer **100** to cause the beam **97** to be directed upon the third phosphor layer on the surface **96**, in accordance with the direction in which the beam **97** is launched into the field. Co-ordinated scanning of the screen **90** by the electron beams **93, 95** and **97** may be used to produce a three colour display on the screen **90** which may be viewed through the transparent beam directing electrode.

An arrangement in which pairs of luminescent screens can be arranged to provide a tapered beam directing field between them will now be described with reference to FIG. **10**, in which there are shown diagrammatically three luminescent screens **105, 106** and **107** on transparent supports and incorporating respective transparent electrically conducting electrodes. The screen **106** has a luminescent coating on each side. Electron beams are indicated at **108** and **109** projected into the spaces **110** and **111** between the electrodes of screens **105** and **106** and **106** and **107** respectively. In one mode of operation the electrode associated with the screen **106** is connected to a first potential, for example 1 kV and operated as a viewing screen and the electrodes **105** and **107** are connected to a second potential, for example 0.8kV, and operated as beam directing electrodes. Scanning is provided by horizontal and vertical deflection systems arranged outside the spaces **110** and **111** in the way previously described. An arrangement operated in the way described may be used to provide a two colour display by providing phosphors on the opposite sides of the screen **106** which luminesce in different colours and with the beams **108** and **109** impinging on the opposite sides of the screen **106**, as shown. In a further mode of operation the potentials applied to the screen **106** and the beam directing electrodes **105** and **107** are modulated in such a way that, for example, for one line scan the screen **106** acts as a beam directing electrode directing the beams **108** and **109**, as indicated by the dotted lines **112** and **113**, towards luminescent coatings of still further colours on the screens **105** and **107**, while for the next line scan the beams **108** and **109** are directed in the way originally described towards the opposite faces of the screen **106**. In such a mode of operation, with each of the luminescent layers luminescing in a different colour, it is possible to provide multi-colour displays. If required a stack of such screens may be arranged and three dimensional displays may thus be provided. Such displays are of considerable value in showing the relative positions of moving objects, for example aircraft stacked above an airport. Of course, if desired, the phosphors may luminesce to provide black and white displays. To enable the invention to be more clearly understood a demountable experimental cathode ray tube assembly which has been successfully operated will now be described with reference to FIG. **11** which shows in a diagrammatic perspective view a standard **19** inch cathode ray tube face dish at **115**, cut-away to disclose an electrode assembly and mounted and sealed upon a base plate **116** into which a vacuum pump tube **117** extends.

The electrode assembly for this device includes a standard cathode ray tube electron gun **118**, a pair of horizontal deflection plates **119**, a pair of vertical deflection plates **120**, a luminescent screen **121** and a beam directing electrode **122**. Provision is made in this experimental device for the connections (not shown) to the electrode assembly to be made via sealed terminals, as indicated at **123** and **124**. The beam directing electrode **122** has a Nesa conducting coating and is operated as a single element monoplate, the intensity of the beam directing field being increased in the direction of emission of the electron beam from the gun **118** by inclining the electrode **122** towards the luminescent screen **121**, so that they are closest at their edges remote from the gun. In this embodiment any corrections required to overcome aberrations or distortions of the electron beam are made electrically by applying correction potentials to the beam deflection and focussing electrodes in a way to be outlined below. The operation of the device, which has given acceptable pictures on the screen **121** of area approximately 3 inches by 4 inches, will be understood from the description of previous embodiments. If correction of the keystone effect is to be provided by the shaping of the deflecting electrodes it will be necessary to transpose the plates **119** and **120** so that the horizontal deflection plates **119**, which will be suitably shaped, are arranged between the screen **121** and the beam directing electrode **122** and the vertical deflection plates **120**. The vertical deflection plates **120** may, in such a case be considerably shortened.

In FIG. **12** a flat compact rectangular glass envelope **130**, shown in section across its narrower dimension, contains a cathode ray tube assembly and has no projection to house the electron gun assembly as in the previously described embodiments. In this embodiment the housing is divided by a screen electrode **131**, which shields the part of the envelope housing an electron gun assembly **132** from the part housing a display screen **133**. An electron beam **134** passes from the gun assembly **132** via an accelerating electrode **135** and between a pair of diverging deflection plates, of which one is shown at **136**, and which provide horizontal deflection of the beam, to an electron mirror or reversing lens having electrodes **137** to **140**. Electron mirrors or reversing lenses are known for folding or reversing an electron beam obtained from a gun through 180° for impingement on a display screen arranged in a plane which is parallel to the axis of the gun. The electrodes **137** and **139** of the reversing lens system are curved in a known manner over their length in order to provide a field such that the beam **134** will leave the reversing lens system in a direction which is substantially parallel, though opposite to, the direction in which it left the gun assembly **132**, whatever the deflection given to it by the horizontal deflection electrodes. The side electrodes **138** and **140** can also be shaped over their length as required to direct the beam as it leaves the reversing lens.

The display section of the cathode ray tube includes an electroluminescent screen **142** which comprises a transparent conducting layer and a coating of material which luminesces when bombarded by electrons supported on a transparent support screen. The conducting layer of the screen is connected to a terminal **141.** Directly behind and spaced from the screen **142** there is a beam-directing electrode **143** which is parallel and co-extensive with the screen **142.** The electrode **143** has a uniform coating of conducting material **144** connected between two strips of electrically conducting material **145** and **146.** A terminal **147** on the envelope **130** is connected to the strip **145** and the strip **146** is connected via a lead **147**a to a further terminal on the envelope not shown. The screen **131** is connected to a terminal **148** on the envelope.

Between the exit of the reversing lens and the space between the beam-directing electrode **143** and the screen **142,** there is a pair of deflecting electrodes **150** which extends for substantially the width of the screen **142** and provides vertical deflection of the beam **134** over the screen **142** from the solid line position to the dotted line position **134**a. The operation of this emodiment is similar to that for the previously described embodiment, with the exception that the reversing lens system is interposed between the horizontal and vertical deflection electrodes. The beam **134** is first accelerated by a positive potential on the electrode **135** between the horizontal deflection electrodes towards the relatively negative repeller electrode **137** of the reversing lens from which the collimated beam passes between the vertical deflection electrodes **150** into the beam-directing field between the screen **142** which is at final anode potential and the electrode **143.** The beamdirecting field, as in previous embodiments, is arranged to increase in intensity in the direction of the beam away from the gun due to the direction of the connection of potential between the strips **145** and **146,** and the linear distribution of the coating material **144.**

In FIG. **13** a cathode ray tube assembly having the gun assembly located in an extension to one side of the main part of the envelope is shown. This arrangement uses a second beam-directing arrangement to direct the beam. The assembly of FIG. **13** includes an envelope **150** having a tubular side projection **151** housing an electron gun **152,** and accelerating electrode **153,** and a pair of deflection plates **154, 155** providing horizontal deflection of a beam **156** over a luminescent screen **157,** as indicated by the solid line **156** and the dotted line **156***a* . A beam directing field, which increases in intensity in the direction of the projection of the beam from the gun, is developed between electrodes **158** and **159.** The electrode **159** has a longitudinal slot through which the beam **156** passes and potentials of the appropriate values to provide the field necessary to direct the beam in the way shown are connected between the electrodes **158** and **159.** Potentials, applied between terminals **160** and **160**a are distributed over the electrode by a uniform coating connected between strips **161** and **162** on the electrode **158.**

After passing through the slot in the electrode **159,** the beam **156** passes between a pair of deflector plates **163** to give vertical deflection of the beam before it enters a beam-directing field of the type previously described between the electroluminescent screen **157** and a beam-directing electrode behind and spaced from the screen **157.** The screen **157** is electrically connected to a terminal **165** and the beam-directing electrode behind the screen has a uniform conducting coating between conducting strips **166** and **167** which are connected electrically to terminals **168** and **169** in order to provide a beam directing field in the space behind the screen **157** which increases in intensity in the vertical direction of scanning of the beam in the way previously described. In operation the beam **156** is scanned along the slot in the electrode **159** of the second beam directing arrangement under the influence of the horizontal beam deflection electrodes **154** and **155,** thereby causing it to pass between the vertical deflection electrodes **163** at a position that determines its horizontal coordinate on the screen **157.** Its vertical co-ordinate depends upon the amount by which it is deflected by the vertical deflection electrodes **163** in combination with the effect of the beam directing field in the space behind the screen **157.**

In FIGS. **14** and **15** there is shown diagrammatically the essential features of a further practical experimental embodiment providing a monochrome display. The electrode assembly in this embodiment is housed in an envelope **170** consisting of two commercially available dished glass parts **171** and **172** and a tubular extension part **173** which extends into a semi-circular cut-out in each of the dished parts. The three parts are frit sealed in a well known manner after assembly of the electrodes.

The electrode assembly includes a conventional electron gun assembly having a cathode **174,** a modulating or control electrode **175** and a focussing electrode assembly **176.** A pair of horizontal deflection plates **177** and **178** is positioned at the mouth of the tubular part **173** and between these plates **177, 178** and a pair of vertical deflection plates **179, 180** there is an inter plate screen **181** having a longitudinal slot **182.** A rectangular luminescent screen **183** of the type described with reference to FIG. **1** is positioned near to one of the inner surfaces of the envelope **170** and on the other surface of the envelope there is a transparent electrically conducting Nesa coating indicated at **184** covering a rectangular area corresponding to that of the screen **183.** Terminals **195** and **186** are electrically connected to conducting strips along the edges of the coating **184** remote from and near to the gun assembly respectively so that the coating **184** can be connected to provide a beam-directing electrode. A terminal **187** is electrically connected to the screen **183.** In the embodiment shown the screen **183** is approximately 4¼inches square and the total length of the tube including the portion **173** is 10 inches. In operation the potential difference applied between the cathode **174** and the final anode terminal **187** connected to the screen **183** is 4 kV. The terminal **186** is connected to the same potential as the screen **183** and the terminal **185** is connected to a potential which is 3 kV below that of the screen **183,** thereby to provide a beam-directing field in the space between the coating **184** and the screen **183** which has a greater intensity gradient remote from the electron gun assembly. An electron beam from the gun assembly is delfected by the plates **177, 178** to scan the slot **182** in the inter plate screen **81** and passes into the deflecting field of the plates **179, 180** where it is scanned orthogonally before it enters the field in the beam-directing space. The beam directing field directs the beam on to the screen **183** according to its angle and velocity of entry into the space between the screen and the coating **184** so that it scans the screen in a raster pattern. The deflecting fields are such that the raster pattern on the screen has the required **3**:**4** aspect ratio. The electrode **175** is modulated in the normal manner to provide a picture on the screen.

In FIG. **16** there is shown a circuit arrangement which enables a cathode ray tube beam to be controlled at a plurality of discrete positions as it is scanned over an electroluminescent screen and a parameter of the beam to be corrected for any abberation or distortion that might otherwise occur. The position of the beam is controlled by means of a co-ordinate signal output in binary form from a computer which establishes the co-ordinates of each of the plurality of positions of the beam on the electroluminescent screen. In the circuit in FIG. **16** the x and y co-ordinate outputs from the computer are applied in binary form via terminals **192** and **193,** and in synchronism with a video signal applied to a terminal **194,** to x and y registers **195** and **196** respectively. Each of these registers can be set to one of **256** different code combinations and a parallel output from each of the registers is applied to respective digital to analogue converters **197** and **198.** Further outputs from these registers **195** and **196** are applied to respective x and y decoders **199** and **200.** The digital to analogue converters **197** and **198** are capable of converting each of the **256** code combinations applied to them into discrete voltage levels and, with the code combinations fed to the registers in a natural binary sequence, the outputs from the converters **197** and **198** are scanning waveforms having a generally saw-tooth configuration with trace-defining portions formed of **256** discrete steps. The outputs from these converters **197** and **198** are applied via respective deflection amplifiers **201** and **202** to the x and y deflection electrodes of a cathode ray tube **203.** It is thus possible to identify **256** discrete deflection positions of the cathode ray tube beam in both the x and the y directions, and thus to identify 65,536 positions to which the beam can be deflected on the screen of the cathode ray tube. The x and y deflection signals cause the beam to scan from a co-ordinate position of X=O and Y=O in the lower left hand corner of the screen, as seen by the viewer, from the left to the right and from the bottom to the top of the screen. In order to correct for trapezium distortion which results in the x scan near to the top of the screen remote from the gun being longer than the scan near to the bottom of the screen, a coupling circuit **204** is connected between the y deflection amplifier **202** and the digital to analogue converter **197.** This coupling **204** is so porportioned that a part of the signal from the y deflection amplifier **202** is applied to the converter **197** and modulates the x deflection analogue signal output of the converter **197** according to the y deflection of the beam in order to correct the trapezium distortion. If a d.c. coupled circuit is employed it is also necessary to connect an "off-set" potential between the y deflection amplifier **202** and the x deflection amplifier **201** in order to correct what would otherwise be a parallelogram type scan into a rectangular scan.

It has been found that it is not necessary to perform the other corrections of the beam parameters at each of the co-ordinate positions and only a part of the binary signal from the x and y registers **195** and **196** is applied to the decoders **199** and **200** so that, for example for every **256** changes of code in the registers **195** and **196** there are only **32** changes of code applied to the decoders **199** and **200.** Furthermore, it has been found that it is only necessary to apply correction to the focussing of the beam in accordance with its scanning in the x direction and that movement of the beam in the y direction produces substantially no change in the focussing of the beam on the screen of the tube. However, correction for linearity and astigmatism are applied according to the scanning of the beam in both the x and the y directions. The signals for the correction of these parameters are applied to the respective x and y deflection amplifiers under the control of the outputs from the x and y decoders **199** and **200.** In the circuit of FIG. **16** these corrections are made by applying, for each of the inputs to the x decoder **199,** an output from the x decoder to an automatic focus correction circuit **205,** a linearity correction circuit **206** and an astigmatism correction circuit **207** and for each of the inputs to the y decoder **200** an output from the y decoder to a linearity correction circuit **208** and an astigmatism correction circuit **209.** These correction circuits are porportioned to provide a discrete output for each of the possible **32** inputs to the decoders in accordance with the distortions of the beam which iti is known would otherwise occur. Thus outputs from the focus correction unit circuit **205** are applied via an amplifier **210** to the focus control electrode of the cathode ray tube **205** and the outputs from the linearity and astigmatism correction circuit **206, 207** and **208, 209** are applied to their respective x and y deflection amplifiers **201** and **202.**

It will be understood that with this form of control of the electron beam any co-ordinate position on the screen may be selected and addressed and the computer output may be programmed to direct the beam in other ways than to produce a raster scan, for example to produce alpha-numeric writing. Furthermore the corrections applied may be varied in accordance with the mechanical structure of the cathode ray tube. The circuit described has been developed to provide control for an experimental model of cathode ray tube and the need for certain of the corrections may be avoided by, for example, a different design of the electrode structure.

It is possible to operate cathode ray tubes in accodance with the present invention with a beam directing field of uniform intensity throughout the beam directing field space as may be seen from FIG. **9,** however without some modification such as that shown to the screen in FIG. **9,** the beam tends to become defocussed outside a limited area, although for some applications such an arrangement may be acceptable.

The bending of the beam in the beam directing field produces a self-focussing effect of the beam and little correction is, in fact, required. The effect of "deflection focussing" is well known in the operation of electrostatically deflected cathode ray tubes and it has previously been described in the literature, for example in the first mentioned of the Patent Specifications referred to above.

In its application to the production of a colour television image the tubes of the present invention have the advantage over tubes employing limited distributions of colour phosphors in the form of dots or stripes, that it is possible to obtain continuous straight lines in colour and thus stereoscopic effects which the known tubes are unable to reproduce.

The reversing lens arrangement of FIG. 12 may be provided by a combination of electromagnetic and electrostatic deflection systems.

Furthermore, although the cathode ray tubes described employ electrostatic deflection, it is possible to use electromagnetic deflection systems or a combination of the two. Similarly an electrostatic collimating lens structure may be employed in place of the magnetic lens **14** described with reference to FIGS. **1, 2** and **3.** Furthermore, although the parts of the collimator lens **14** have been shown as rectangular members it is to be remembered that the illustrations are diagrammatic and that the parts of the lens may be of other suitable shapes, for example the pole pieces may be curved, in the view shown in FIG. **1,** so that for example their central part is further from the gun **11** than their ends. As proviously mentioned, it is also possible to shape one of the deflection fields when using either electrostatic or electromagnetic deflection fields in order to provide a correction to the electron beam direction which compensates for the keystone distortion that would otherwise result. A degree of electrostatic collimation is naturally provided by virtue of the beam directing field and this must be taken into account when designing the collimating lens structure or the shaping of the deflection field to provide correction of the beam deflection. The collimating electrode system may involve the use of electrostatic transition electrode systems of the parallel plate type, alternatively a field mesh through which the beam passes may be positioned between the deflecting electrodes and the beam directing and screen system and held at a suitable potential.

Since a display must normally be viewed from only one side of the screen it is possible in most embodiments for the envelope of the assembly to have a transparent face on only one side and for the remainder of the envelope to be opaque and even of a different material. For example a construction is possible in which the transparent face is of glass and the remainder of the envelope is of metal. In such an arrangement the metal envelope may act as the beam directing electrode, being for example earthed while the screen and electron gun are at relatively positive and negative potentials.

However, as has been explained above it is possible to provide an envelope with viewing faces on both sides of the screen; and where there is a display on a transparent screen in such an envelope the view through one face will be a mirror image of that through the other. In some applications such a feature may not be objectionable. However, where two different displays are provided on the opposite faces of an opaque screen, the use of two separate guns and scanning systems enables two quite separate displays to be provided from normal signals. With an opaque screen and a single gun directing a beam on to a beam splitting electrode the modulating signal applied to the one of the split beams, in the case of a raster display, or one of the beam deflecting signlas in the case of a co-ordinate display, must be suitably co-ordinated if a mirror image display through one of the faces of the envelope is to be avoided. If necesssary phosphors with a relatively slow decay time may be used to enable colour mixing to take place when providing multicolour displays. Arrangements providing displays in more than one colour are particularly advantageous in displays on aircraft control panels since it is possible to highlight a display of a parameter in a colour which attracts the eye should that parameter exceed a given limit.

A suitable beam directing field pattern between the screen and the beam directing electrode may be provided by forming the beam directing electrode so that it is not planar in order to give a variation in the field pattern over the area of the screen. Furthermore, the electrode and the screen need not be co-terminus in area, and the area covered by the electrode may be of a shape to produce required field effects. The beam directing electrode, although generally an electrically unitary structure may be made mechanically from a plurality of members connected electrically.

Although particular embodiments have been described modifications and combinations thereof may be made within the scope of the present invention.

In the embodiment of a beam directing electrode illustrated in FIG. **5** the conducting strips **39** are interconnected by resistors **40** to **46.** A required field pattern could be produced by shaping the conducting strips, employing graded resistive strips instead of conductive strips or by providing a graded series of resistance coatings of different value between the strips **39.** A further possibility, is that the intermediate strips **39** could be omitted and the graded series of coatings could contact one another, electrical connection to the assembly being made via the end strips **39.** A linear or non-linear beam directing field may thus be provided as required.

It is also possible, in order suitably to shape the field to feed one or more potentials of different value to those at the ends to the beam directing electrode at separate positions along its length so that, where required, the strength of the beam directing field may be given a special value, for example an increase at these positions. The possibility also exists of varying the static beam directing field either linearly or non-linearly as required by varying the spacing between the screen and the beam directing electrode.

The beam directing electrode need not be a continuous layer it may be provided by a succession of parallel wires at right angles to the normal direction of the beam forming a grid. Each wire of such a grid could be supported between a pair of insulating supports and be connected to adjacent wires via resistors in the zig-zag manner described with reference to FIG. **5,** be connected to provide a plurality of sections, each fed separately with a suitable electric potential, or be part of a continuous length of wire of suitably resistive material to provide a beam directing field of linearly increasing intensity.

In embodiments in which it is required to write on one side of the screen only in order to produce a display it is possible for the screen to be formed on the face of the envelope of the tube.

With regard to the electrically conductive transparent coating described it is, of course, possible to use other materials than oxidised chromium.

In the absence of the deflection of the beam **134** in the embodiment of FIG. **12**, by either the horizontal on the vertical deflection electrodes **136, 150**, the beam **134** enters the beam-deflecting field between the screen **142** and the electrode **143** in a direction which is parallel but opposite to that in which it was emitted from the gun.

In general the trajectory of the electron beam between the source and the screen is a continuous curve and there is no requirement for special means to maintain the beam parallel to the plane of the screen throughout any part of its trajectory.

From the foregoing description it may be seen that a flat cathode ray tube may be provided in which when an electron beam is launched from a gun into the space between a screen and a beam directing electrode at an angle relative to the normal direction of the beam determined by scanning means, the beam may be caused to impinge on a selected position on the screen according to the combined effect of a beam directing field distributed throughout the space and the angle at which the beam enters the space.

We claim:

1. Cathode ray tube apparatus including an electron beam source, an electroluminescent screen, a beam-directing electrode spaced from the screen and including an insulating support sheet, a series of parallel strips of conductive material on the support sheet and resistor elements interconnecting the ends of the strips to provide a series connection; the electron beam source being arranged to launch an electron beam into the space between the screen and the beam-directing electrode, means to connect beam-directing potentials between the screen and the beam-directing electrode to provide a beam-directing field in the space between them for directing the electron beam towards the screen and means to deflect the beam in two directions arranged to be operative upon the beam before it enters the space.

2. Cathode ray tube apparatus according to claim **1** wherein the resistor elements are graded to provide a non linear distribution of voltage drop of a potential applied between the ends of the series circuit throughout the series circuit.

3. Cathode ray tube apparatus according to claim **1** having a second electroluminescent screen parallel to and luminescent in a colour different from that of the first mentioned electroluminescent screen, a second electron beam source and a second beam-directing electrode spaced from the second screen, the second electron beam source being arranged to launch an electron beam into the space between the second screen and the second beam-directing electrode, and means to connect beam-directing potentials between the second screen and the second beam-directing electrode to provide a beam-directing field in the space between them for directing the beam from the second source towards the second screen and second means to deflect the beam from the second source in two directions arranged to be operative upon the second beam before it enters the space between the second screen and the second beam directing electrode.

4. Cathode ray tube apparatus according to claim **1** having a second electroluminescent screen which is parallel to the first mentioned screen, a second beam-directing electrode spaced from the second screen, and means to connect beam-directing potentials between the second screen and the second beam-directing electrode to provide a beam-directing field in the space between them for directing the electron beam towards the second screen, wherein the means to deflect the beam in two direction is arranged to deflect the beam in either the space between the first mentioned screen and beam-directing electrode or the space between second mentioned screen and beam-directing electrode.

5. Cathode ray tube apparatus according to claim **1** having a second electroluminescent screen parallel to and luminescent in a colour different from that of the first mentioned electroluminescent screen, a second electron beam source and a second beam-directing electrode spaced from the second screen, the second electron beam source being arranged to launch an electron beam into the space between the second screen and the second beam-directing electrode, and means to connect beam-directing potentials between the second screen and the second beam-directing electrode to provide a beam-directing field in the space between them for directing the beam from the second source towards the second screen and second means to deflect the beam from the second source in two directions arranged to be operative upon the second beam before it enters the space between the second screen and the second beam directing electrode.

6. cathode ray tube apparatus according to claim **5** including an electroluminescent screen support having a serrated surface with faces angled in two directions, wherein the second electroluminescent screen is formed upon the faces of the screen support which are angled in one direction, a third electroluminescent screen is formed upon the faces of the screen support which are angled in the other direction, a third electron beam source arranged to launch an electron beam into the field space between the support for the second and third electroluminescent screens and the second beam directing electrode to direct the electron beam therefrom towards the third electroluminescent screen, and third means to deflect the beam from the third source in two directions before it enters the space between the second beam directing electrode and the screen support for the second and third electroluminescent screens, the three luminescent screens each being luminescent in a different colour when bombarded by electrons.

7. A cathode ray tube according to claim **1** including an electron beam reversing lens arranged in the path of the beam of electrons between the electron gun and the said space, the arrangement of the electron gun, the reversing lens and the space being such that a beam of electrons which is undeflected by the said means for deflecting in passing from the gun through the reversing lens to the space enters the space in a direction which is parallel but opposite to that in which it was emitted from the gun.

8. A cathode ray tube according to claim **1** including a second beam-directing system arranged in the path of the beam between a first means for deflecting the beam in one of the orthogonal directions and a second means for deflecting the beam in the other orthogonal direction to change the direction of the beam.

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