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[54] **CATHODE RAY TUBE WITH MAGNETIC BEAM ALIGNMENT MEANS**

[75] Inventor: **Gordon R. Spencer**, Westwood, Mass.

[73] Assignee: **Raytheon Company**, Lexington, Mass.

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[51] **Int. Cl.** **H01j 29/46**

[58] **Field of Search** .... 313/84, 75, 82 T, 86, 481, 313/443, 448

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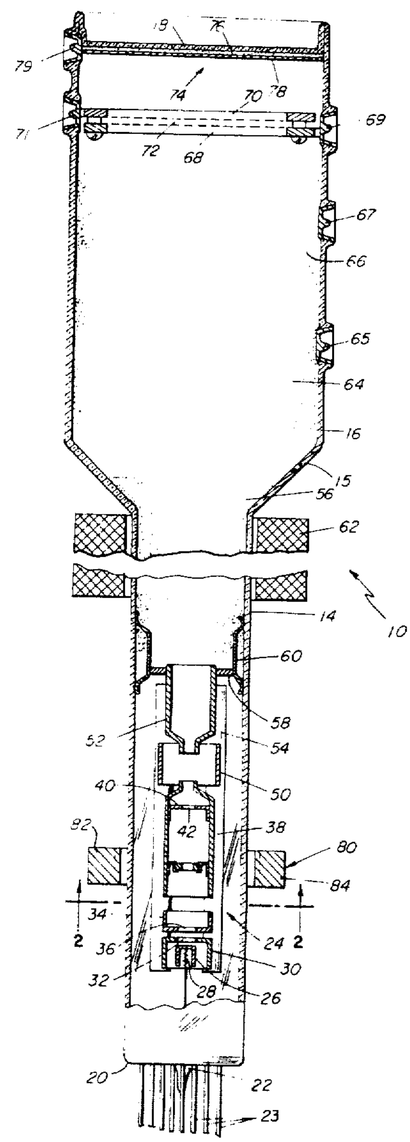
Primary Examiner—Gerard R. Strecker

Attorney, Agent, or Firm—John T. Meaney; Joseph D. Pannone; Harold A. Murphy

[57] **ABSTRACT**

A cathode ray tube having an evacuated envelope wherein an electron gun is operatively disposed for directing an electron beam toward an axially spaced target surface, the gun comprising an electron emitting cathode, an axially aligned series of beam forming elements, and magnetic means for correcting beam alignment within the gun after the envelope is sealed.

12 Claims, 3 Drawing Figures



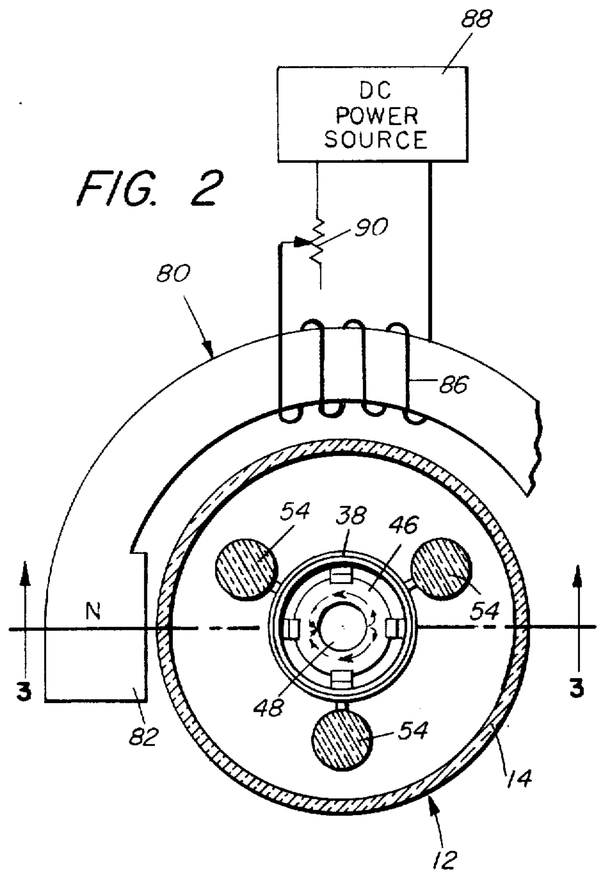


FIG. 2

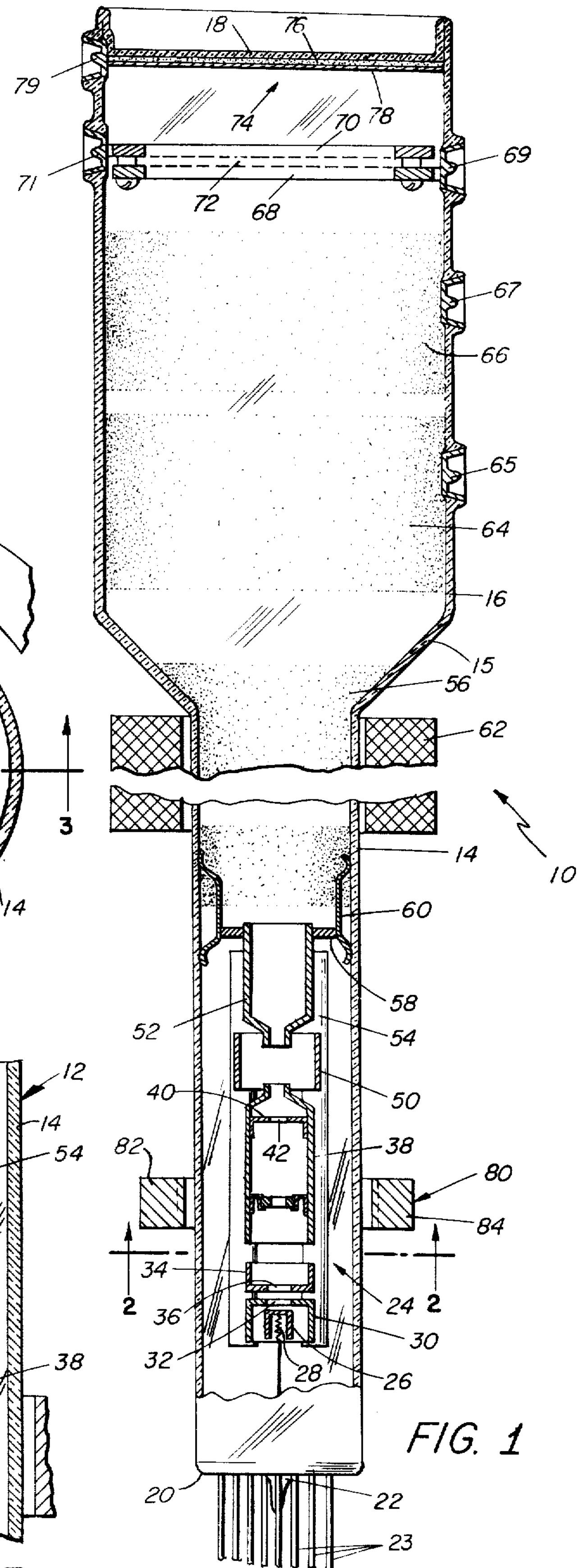


FIG. 1

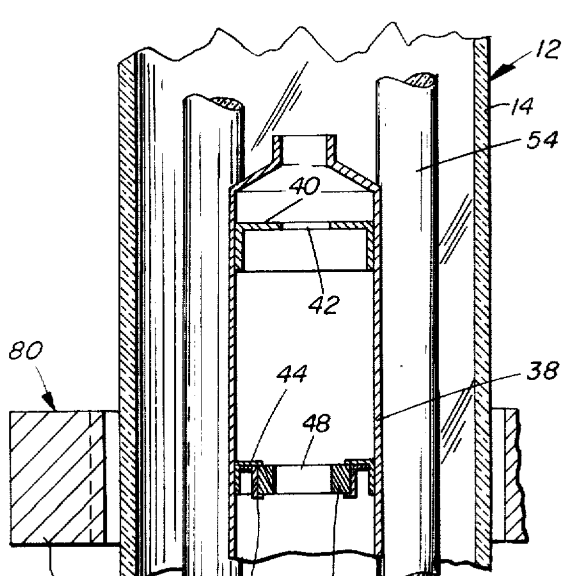


FIG. 3

CATHODE RAY TUBE WITH MAGNETIC BEAM ALIGNMENT MEANS

BACKGROUND OF THE INVENTION

This invention is related generally to cathode ray type electron tubes and is concerned more particularly with an electron gun having magnetic means for correcting beam alignment within the gun.

An electron tube of the cathode ray type usually includes an evacuated envelope wherein an electron gun is suitably disposed for directing an electron beam onto a spaced target surface. The gun generally comprises a beam forming series of grid, anode, and focusing elements axially aligned with an electron emitting cathode. A tube of the described type usually is provided with an electron deflection means which causes the beam emanating from the gun to scan the target surface in the form of a raster pattern. By suitably modulating the scanning electron beam, signal data may be written electronically on the target surface in a well-known manner.

For high resolution scanning modes, aberrations may be minimized by diametrically restricting the beam generated within the gun. Consequently, one or more of the beam forming elements in the gun may be provided with respective beam limiting apertures which permit passage of only a desired central axial portion of the generated beam. Generally, the beam, thus limited, subsequently passes through one or more focusing elements which sharply focus the limited beam onto the target surface. Consequently, it is important that the beam generated within the gun be axially aligned with the beam limiting aperture and the focusing element in the gun.

However, after the gun is sealed in the tube envelope, it may be found that the beam generated within the gun is not axially aligned with the beam limiting apertures or the focusing elements in the gun. As a result, aberrations may not be minimized sufficiently to achieve the desired high resolution. Furthermore, misalignment may be such that the focusing elements do not bring the limited beam to a sharp focus at the target surface. Consequently, the tube may be rejectable as not meeting high resolution requirements. Rejections of this nature lower production yields, and increase the cost of manufacturing tubes of the described type.

Therefore, it is advantageous and desirable to provide a cathode ray type of electron tube with post assembly means for adjusting the alignment of the beam generated within the electron gun.

SUMMARY OF THE INVENTION

Accordingly, this invention provides an electron tube of the cathode ray type having an evacuated envelope wherein an electron gun is operatively disposed for directing an electron beam toward a spaced target surface. The electron gun comprises beam generating means including a coaxial series of beam forming elements aligned with an electron emitting cathode, and electron deflection means disposed within one of the beam forming elements. The shielding element may be a beam limiting anode comprising a hollow conductive cylinder having therein an axially disposed opening which diametrically restricts the generated electron beam. The electron deflection means includes an annular member of magnetically permeable material which is axially disposed in a substantially electrostatic field-

free space at a predetermined distance from the beam restricting opening and in the direction of the cathode. After the tube envelope is sealed, the annular member may be magnetized, by external magnetic means to have a transverse magnetic field suitably oriented and of the proper intensity for deflecting an electron beam emanating from the direction of the cathode into axial alignment with the beam restricting opening in the anode cylinder.

The preferred embodiment, shown herein, comprises a direct viewing storage tube including an evacuated envelope wherein a mesh-like storage electrode is disposed between an output viewing screen electrode and an axially spaced electron gun. The storage electrode is provided with a dielectric target surface which is scanned in raster fashion by an electron beam emanating from the gun during operation of the tube. By applying suitable voltages to the storage electrode and regulating the electron beam, the storage tube may be operated in a well-known sequence of priming, writing, reading and erasing modes.

BRIEF DESCRIPTION OF THE DRAWING

For a better understanding of this invention, the following, more detailed, description makes reference to the accompanying drawing wherein:

FIG. **1** is an axial view, partly in section, of a preferred embodiment of this invention;

FIG. **2** is a fragmentary cross sectional view taken along the line **2**—**2** in FIG. **1** and looking in the direction of the arrow; and

FIG. **3** is a fragmentary axial sectional view taken along the line **3**—**3** in FIG. **2** and looking in the direction of the arrows.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to the drawing wherein like characters of reference designate like parts, there is shown in FIG. **1** a storage tube **10** of the direct viewing type comprising a tubular envelope **12** which preferably is made of dielectric material such as glass, for example. The envelope **12** includes a neck portion **14** having an open end integrally joined, by an outwardly flared portion **15**, to an open end of a larger diameter portion **16**. The other end of larger diameter portion **16** is closed by a peripherally sealed end plate **18**, and the opposing end of neck portion **14** is closed by a peripherally sealed end disk **20**. The disk **20** is suitably provided with an exhaust tubulation **22** which may be made of glass, for example, and which is sealed-off after processing of the tube is completed. Extending axially through the disk **20**, in a vacuum-tight manner is a plurality of insulatingly spaced terminal pins **23**. The pins **23** provide means for applying suitable voltages to respectively connected elements of electron gun **24** which is axially disposed within neck portion **14**.

The electron gun **24** includes beam generating means comprising an electron emitting cathode **26** which may be indirectly heated, as by heating filament **28**, for example. The cathode **26** is axially disposed in the open end of an insulatingly spaced grid cup **30**, the closed end of which is provided with a centrally disposed aperture **32**. Axially spaced from the closed end of grid cup **30** is a juxtaposed closed end of a second grid cup **34** having therein a centrally disposed aperture **36** which is axially aligned with the aperture **32** in grid cup **30**.

The opposing open end of second grid 34 is spaced from one end of an electron accelerating anode 38 comprising a hollow conductive cylinder which is axially aligned with the second grid cup 34. The first and second grid cups 30 and 34, respectively, regulate the flow of electrons from the cathode 26 and cooperate with the anode 38 in forming the emitted electrons into a beam directed toward the other end of electron gun 24.

As shown more clearly in FIG. 3, in a substantially electrostatic field-free space adjacent the entrance end of anode cylinder 38, there is transversely disposed within the anode cylinder a continuous annular member 46. The member 46 is made of magnetically permeable material, such as barium orthoferrite, for example, having therein a central aperture 48 which is axially aligned with the apertures 32 and 36 in grid cups 30 and 34, respectively. The annular member 46 is suitably supported adjacent its periphery by conventional means, as by inwardly extending radial flange 44 having attached thereto a plurality of spaced tabs 45, for example. Axially spaced a predetermined distance within anode cylinder 38 is a transversely disposed portion 40 having therein a centrally disposed aperture 42. The aperture 42 permits passage of only a central axial portion of the electron beam, thereby minimizing aberrations.

The opposing end portion of anode cylinder 38 is preferably tapered inwardly to form a reduced diameter end which may be insulatingly disposed in one end of a coaxial focusing element 50. The focusing element 50 comprises a hollow conductive cylinder which is axially aligned with the beam restricting aperture 42 and is maintained at a suitable potential for focusing the limited beam of electrons passing through the aperture 42. The other end of focusing element 50 may insulatingly encircle an end portion of a hollow conductive cylinder 52 which constitutes a second anode of gun 24. Adjacent the encircled end portion, second anode cylinder 52 preferably is tapered outwardly to form a larger diameter portion which extends axially toward the open end of neck portion 14.

The described beam forming elements of gun 24 are supported in spaced coaxial relationship with one another by suitable attachment to a plurality of axially extending side rods 54, three being shown by way of illustration in the drawing. The side rods 54 preferably are made of dielectric material, such as glass, for example, and are symmetrically disposed about the gun 24. Adjacent the open end of neck portion 14, there may be coaxially disposed in spaced relationship with second anode 52 a hollow conductive cylinder 56 which function as a third anode. The third anode cylinder 56 conveniently may comprise a continuous band of conductive material, such as graphite, for example, which is adherringly deposited by conventional means on the inner surface of envelope 12. The second anode 52 is electrically coupled to the adjacent end portion of third anode cylinder 56 by suitable means. For example, the larger diameter portion of second anode cylinder 52 may be provided with an outwardly extending radial flange 58 which supports a plurality of resilient tabs 60 in electrical contacting relationship with the adjacent end portion of third anode cylinder 56. The opposing end portion of third anode cylinder 56 may extend well up onto the outwardly flared portion 15 of envelope 12.

The gun 24 is aligned with the axial centerline of tube 10 and projects a beam of electrons into the larger diameter portion 16 of envelope 12. The electron beam may be deflected in a predetermined manner by suitable means, such as external deflection yoke 62, for example, which is disposed adjacent the flared portion 15 of envelope 12 and encircles the third anode cylinder 56 within the neck portion 14. In the larger diameter portion 16 of envelope 12, the electron beam passes through an axially aligned pair of insulatingly spaced, hollow conductive cylinders which constitute first and second collimating electrodes 64 and 66, respectively. Each of the electrodes 64 and 66 respectively, may comprise a continuous band of conductive material, such as graphite, for example, which is adherringly deposited, by conventional means, on the inner surface of envelope 12. The collimating electrodes 64 and 66 are electrically connected to respective terminal buttons 65 and 67 which extend, in a vacuumtight manner, through the wall of envelope 12. The terminal buttons 65 and 67 provide means for maintaining the collimating electrodes 64 and 66, respectively, at suitable potentials for aligning the electron beam with the axial centerline of tube 10.

Axially spaced from the second collimating electrode 66 is a transversely disposed, decelerator electrode 68 which generally comprises a fine mesh screen stretched across the opening of a conductive support ring. The decelerator electrode 68 is disposed in coaxial alignment with the axial centerline of tube 10, and is insulatingly secured by conventional means to a parallel storage electrode 70. The storage electrode 70 generally also comprises a fine mesh screen stretched across the opening of a conductive support ring. The storage electrode surface adjacent the decelerator electrode 68 constitutes a target surface 72 which preferably is coated with a dielectric material, such as magnesium fluoride for example. The decelerator electrode 68 and the storage electrode 70 are electrically connected to respective terminal buttons 69 and 71 which extend through the wall of envelope 12 in a vacuum-tight manner.

The storage electrode 70 is axially spaced from a generally parallel collector electrode 74 which may comprise an output viewing screen 76 having an inner surface coated with a film 78 of conductive material, such as aluminum, for example. The conductive film 78 is electrically connected to a terminal button 79 which extends through the wall of envelope 12 in a vacuum-tight manner, and provides means for maintaining the collector electrode 72 at a suitable electrical potential during operation of the tube. The output viewing screen 76 generally comprises a layer of fluorescent material such as zinc sulfide, for example, which may be deposited by conventional means directly on the inner surface of end plate 18 and which fluoresces locally when struck by accelerated electrons. The end plate 18 may comprise a transparent dielectric material, such as glass, for example, which is suitable for direct viewing of the output screen 74.

In operation, the deflection yoke 62 produces a varying magnetic field which causes the electron beam emanating from gun 24 to scan the dielectrically coated target surface 72 in raster fashion. The decelerator electrode 68 generally is maintained at a lower positive potential than the third anode 56 for the purpose of establishing therebetween a retardation field which decelerates the beamed electrons as they approach the target surface **72**. As a result, the first and second collimating electrodes **64** and **66**, respectively, are enabled to direct the electrons electrostatically into a perpendicular approach to the target surface **72**, while the electron beam is scanning the target surface in a raster pattern. In this manner, the storage tube **10** may be operated in a well-known sequence of priming, writing, reading and erasing modes.

Briefly, in the priming mode, the scanning electron beam deposits electrons on the dielectrically coated target surface **72** to charge it uniformly to the potential of the cathode **26** in gun **24**. For the subsequent writing mode, the potential of target surface **72** generally is increased to a considerably higher positive value, such that the scanning electron beam produces localized emission of secondary electrons from respective discrete increments of the target surface. Also, in the writing mode, the scanning electron beam is modulated by a data signal which usually is applied to the control grid **30** of gun **24**. Thus, signal data is stored on the target surface **72** in a varying pattern of positively charged increments which correspond to the modulations introduced in the scanning beam by the data signal. Subsequently, for the reading mode, the potential of target surface **72** generally is decreased to a value slightly below cathode potential whereby the least charged increments the target surface may repel electrons. Accordingly, in the reading mode, varying amounts of electrons from the scanning beam are allowed to pass through respective apertures in the mesh-like storage electrode **70** depending upon the adjacent charge increments of the target surface **72**.

The collector electrode **74** is maintained at a higher positive potential than the storage electrode **70** for the purpose of establishing an electron accelerating field therebetween. As a result, the electrons passing through the apertures in storage electrode **70**, during the reading mode, are provided with sufficient kinetic energy to pass through the conductive film **78** and impinge on aligned incremental areas of the output screen **76**. Consequently, the fluorescent material of output screen **76** produces a visible pattern of the stored signal data which may be viewed directly through the end plate **18**. Thus, the signal data stored on target surface **72** is read-out in a non-destructive manner by the scanning electron beam. The stored data may be erased by increasing the potential of the target surface **72** to a relatively high positive value with respect to the cathode **26**, as in the writing mode, for example. However, in the erasing mode, the scanning electron beam produces a saturation emission of secondary electrons from successive discrete increments of the target surface **72** thereby charging it uniformly to a higher positive potential with respect to cathode **26**.

From the foregoing, it may be seen that a sharply focused electron beam is required in order to obtain high resolution in the writing and reading modes. Consequently, aberrations are minimized by providing anode **38** in gun **24** with a beam limiting aperture **42** which diametrically restricts the beam generated in the gun to a desired central axial portion. The beam, thus limited, passes through the subsequent focusing element **50** which is maintained at a suitable potential for sharply focusing the limited beam onto the target surface **72**. Therefore it is important that the generated beam be axially aligned with beam limiting aperture **42** which, in turn, is axially aligned with the focusing element **50**.

After the envelope **12** is sealed, the alignment of the generated beam with the aperture **42** may be ascertained by operating the tube **10** without the aid of deflection yoke **62** and with element **50** maintained at the same potential as the adjacent anode. As a result, the electron beam will produce on the output screen **76** a visible spot, the intensity of which may be increased to show the electron-optical shadow of the beam limiting aperture **42**. If the beam is found to be off-center with respect to the aperture **42**, the tube **10** is deenergized; and the neck portion **14** is disposed transversely between spaced opposing pole pieces **82** and **84**, respectively, of a magnet **80** as shown in FIG. **2**. The magnet **80** preferably comprises an electromagnet provided with a horseshoe-shaped core having a closed end encircled by a helically wound coil **86**. One end of the coil **86** is connected electrically through a current control device, such as variable resistive element **90**, for example, to one terminal of a direct current source **88**; and the other end of coil **86** is connected electrically to the other terminal source **88**. The control device **90** provides means for adjusting the current flow from source **88** to coil **86** and thereby regulating the strength of the resulting magnetic field established between the pole pieces **82** and **84**, respectively.

The continuous annular member **46** in neck portion **14** is positioned between the respective pole pieces **82** and **84** such that a magnetic field established between the pole pieces is directed across the aperture **48** in member **46**. A selected pair of opposing arcuate portions of the member **46** may be aligned with the pole pieces **82** and **84** respectively, either by rotating the tube **10** about its axial centerline or rotating the magnet **80** about the neck portion **14**. The control device **90** is adjusted to provide, between the pole piece **82** and **84**, a magnetic field of sufficient strength to permanently magnetize the member **40** to the intensity desired. As a result, the selected pair of opposing arcuate portions of member **46** form north and south magnetic poles, respectively, and the associated magnetic field is directed across the aperture **48**. Consequently when the tube **10** is again energized without the aid of deflection yoke **62**, it will be observed that the resulting visible spot on output screen **76** is relocated with respect to the electron-optical shadow of the beam limiting aperture **42**. With the member **46** magnetized to provide a transverse magnetic field of the proper intensity and orientation, the axial direction of the generated beam is adjusted such that the beam is aligned with the limiting aperture **42** and consequently, with the subsequent focusing element **50**.

Thus, the magnetized annular member **46** functions as a magnetic deflection means which is supported within anode cylinder **38**, where it is effectively shielded from disturbance by normally encountered magnetic fields, such as the field produced by deflection yoke **62**, for example. It has been found that a suitable annular member **46** may be magnetized to provide it with a magnetic field having a flux density across aperture **48** of approximately 30 gauss, which has proved to be adequate for correcting a typical badly misaligned beam. The member **46** was magnetized, as described, by a large electromagnet having between its pole pieces a flux density of approximately 2,000 gauss, for example, which is about forty times the flux density produced by the deflection yoke **62**. Passing the neck portion 14 repeatedly through a fully energized deflection yoke 62, failed to degauss the magnetized member 46, as indicated by lack of any observable change in the position of the visible spot on output screen 76. Also, passing the neck portion 14 axially through a fully energized degaussing coil did not produce any resultant movement of the visible spot on the output screen 76, thus indicating that the effect on shielded annular member 46 is negligible. These observations support the conclusion that a magnetized member 46 having the described annular configuration is extremely stable when exposed to normally encountered magnetic fields.

Accordingly, there has been disclosed herein a low cost means for correcting beam alignment within the electron gun of a cathode ray type tube. The correcting means comprises a magnetically permeable member disposed in a substantially electrostatic field-free space within a beam forming element of the gun, and at a predetermined axial distance from an associated beam restricting aperture in the gun. The magnetically permeable member may be magnetized, by external magnetic means, to have a magnetic field of the proper intensity and orientation to direct a misaligned generated beam into axial alignment with the beam restricting aperture.

From the foregoing, it will be apparent that all of the objectives of this invention have been achieved by the structure shown and described herein. It also will be apparent, however, that various changes may be made by those skilled in the art without departing from the spirit of the invention as expressed in the appended claims. It is to be understood, therefore, that all matter shown and described is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. An electron gun comprising:

electron beam generating means including an electron emitting cathode and an axially disposed series of electrodes, at least one of which comprises a hollow cylindrical electrode having a substantially electrostatic field-free space therein

beam limiting means including an electrode wall element disposed transversely with respect to the cylindrical electrode and having a beam restricting aperture therein; and

beam aligning magnetic means including a continuous annular magnetic member coaxially disposed in the substantially electrostatic field-free space within the cylindrical electrode for providing a transverse magnetic field between selected opposing portions of the annular magnetic member and deflecting the beam into alignment with the aperture.

2. An electron gun as set forth in claim 1 wherein the beam limiting means is supported on the cylindrical electrode in axially spaced operative relationship with the magnetic means.

3. An electron gun as set forth in claim 2 wherein the magnetic member is spaced a predetermined axial distance from the beam restricting aperture and in the direction of the cathode.

4. An electron gun comprising:

a hollow cylindrical electrode having a substantially electrostatic field-free space therein;

an electron emitting cathode operatively disposed adjacent one end of the cylindrical electrode for directing a beam of electrons therein;

an electrode wall element disposed transversely with respect to the cylindrical electrode and adjacent the other end thereof, the wall element having a beam restricting aperture therein; and

continuous annular magnetic means disposed in the substantially electrostatic field-free space within the cylindrical electrode for providing a transverse magnetic field selectively oriented to deflect the electron beam from the cathode into alignment with the aperture in the wall element.

5. An electron gun as set forth in claim 4 wherein the magnetic means includes a continuous annular magnetic member transversely disposed in the substantially electrostatic field-free space within the hollow cylindrical electrode and having an opening therein aligned with the beam restricting aperture in the wall element.

6. An electron gun as set forth in claim 5 wherein the continuous annular member is magnetizable traansversely across the opening therein to have a magnetic field directed between selected opposing portions of the continuous annular member.

7. An electron tube of the cathode-ray type comprising:

an evacuated envelope;

an electrode having a target surface transversely disposed within the envelope;

an electron gun operatively disposed within the envelope for directing a beam of electrons toward the target surface; the gun including:

electron beam generating means including an electron emitting cathode and an axially disposed series of electrodes, at least one of which comprises a hollow cylindrical electrode having a substantially electrostatic field-free space therein;

beam limiting means including an electrode wall element disposed transversely with respect to the cylindrical electrode and having a beam restricting aperture therein; and

beam aligning magnetic means including a continuous annular magnetic member coaxially disposed in the substantially electrostatic field-free space within the cylindrical electrode for providing a transverse magnetic field between selected opposing portions of the annular magnetic member and deflecting the beam into alignment with the aperture.

8. An electron tube as set forth in claim 7 wherein the beam limiting means is supported on the cylindrical electrode in axially spaced operative relationship with the magnetic means.

9. An electron tube as set forth in claim 8 wherein the magnetic member is spaced a predetermined axial distance from the beam restricting aperture and in the direction of the cathode.

10. An electron tube of the cathode-ray type comprising:

a sealed envelope;

an electrode having a target surface transversely disposed within the envelope;

an electron gun operatively disposed within the envelope for directing a beam of electrons toward the target surface; the gun including:

a hollow cylindrical electrode axially disposed with respect to the target surface and having a substantially electrostatic field-free space therein;

an electron emitting cathode operatively disposed adjacent one end of the cylindrical electrode for directing a beam of electrons therein;

an electrode wall element disposed transversely with respect to the cylindrical electrode and adjacent the other end thereof, the wall element having a beam restricting aperture therein; and

continuous annular magnetic means disposed in a substantially electrostatic field-free space within the cylindrical electrode for providing a transverse magnetic field selectively oriented to deflect the electron beam from the cathode into alignment with the aperture in the wall element disposed within the sealed envelope.

11. An electron tube as set forth in claim **10** wherein the magnetic means includes a continuous annular magnetic member transversely disposed in the substantially electrostatic field-free space within the hollow cylindrical electrode and having an opening therein operatively aligned with the beam restricting aperture in the wall element.

12. An electron tube as set forth in claim **11** wherein the continuous annular member is magnetizable by means external of the envelope to have a magnetic field directed transversely across the opening therein and between selected opposing portions of the continuous annular member.

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