United States Patent

Glenn

[15] 3,694,687

[45] Sept. 26, 1972

[54] **ELECTRON GUN WITH ANODE SEGMENTS FOR BEAM POSITION DETECTION**

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[73] Assignee: **Columbia Broadcasting System, Inc.**

[22] Filed: **Aug. 12, 1970**

[21] Appl. No.: **63,226**

[52] **U.S. Cl.** **313/78,** 313/83, 315/24

[51] **Int. Cl.**.......**H01j 29/74,** H01j 29/02, H01j 29/82

[58] **Field of Search**...313/78

[56] **References Cited**

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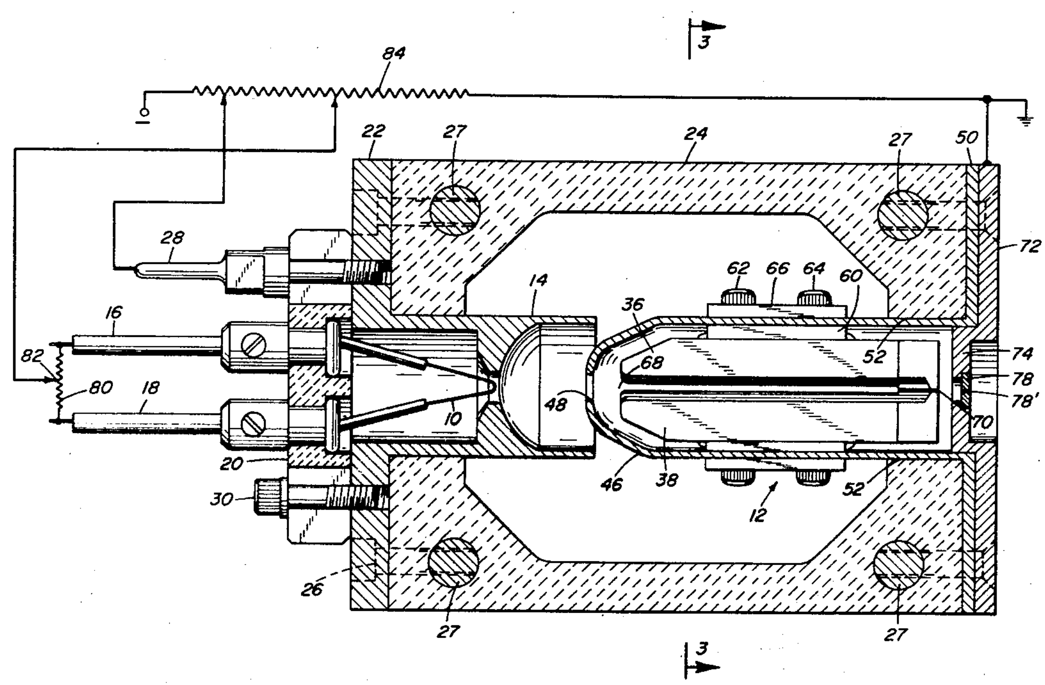
[57] **ABSTRACT**

In an electron gun, an anode structure in which the electron beam aperture is defined by four mutually insulated anode segments which may be energized to provide beam centering. In a preferred embodiment, the anode segments are shaped to intercept the beam if it is off-center, and are returned to ground potential through respective resistors thereby being operative automatically to center the beam.

2 Claims, 8 Drawing Figures



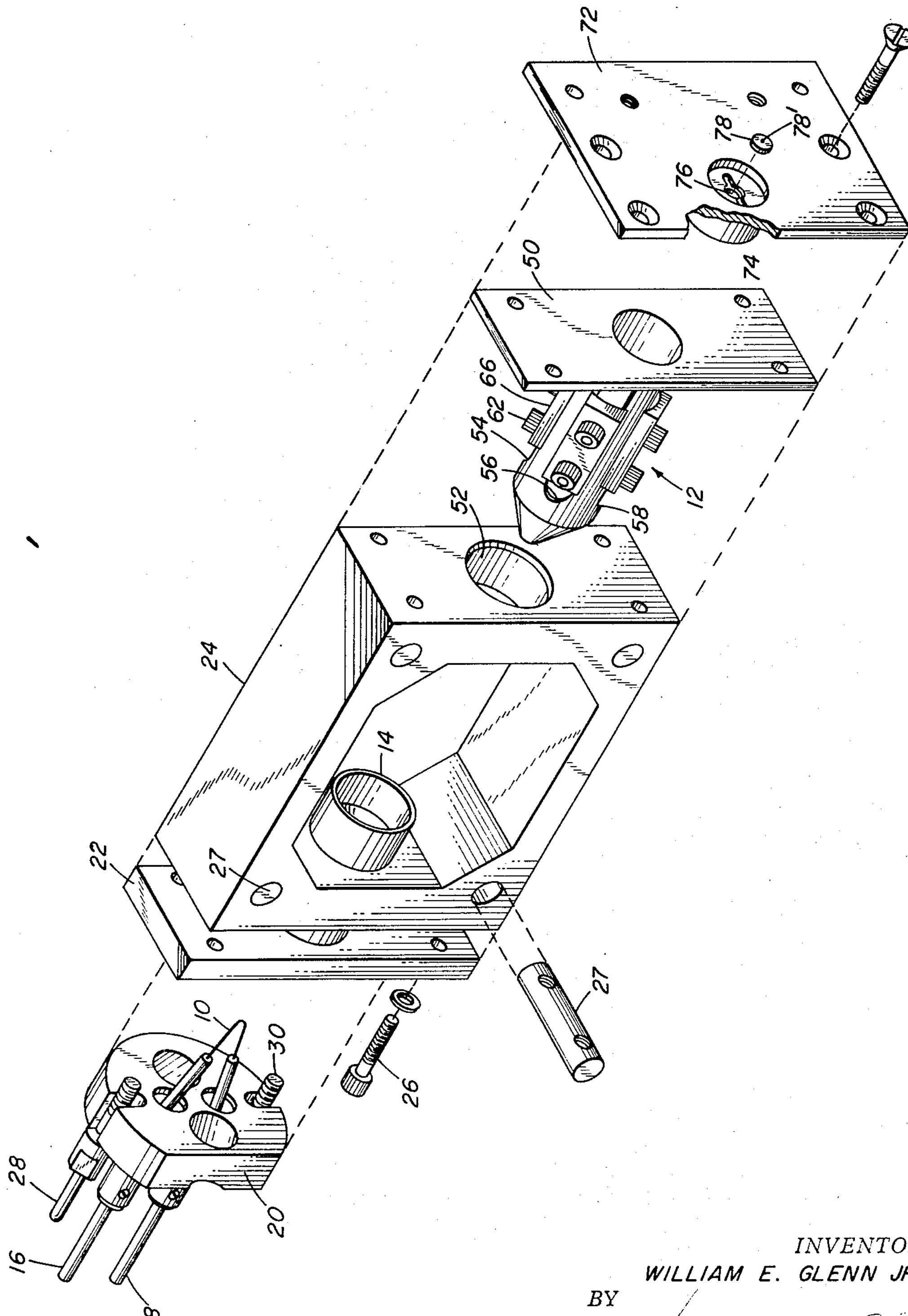


FIG. 1

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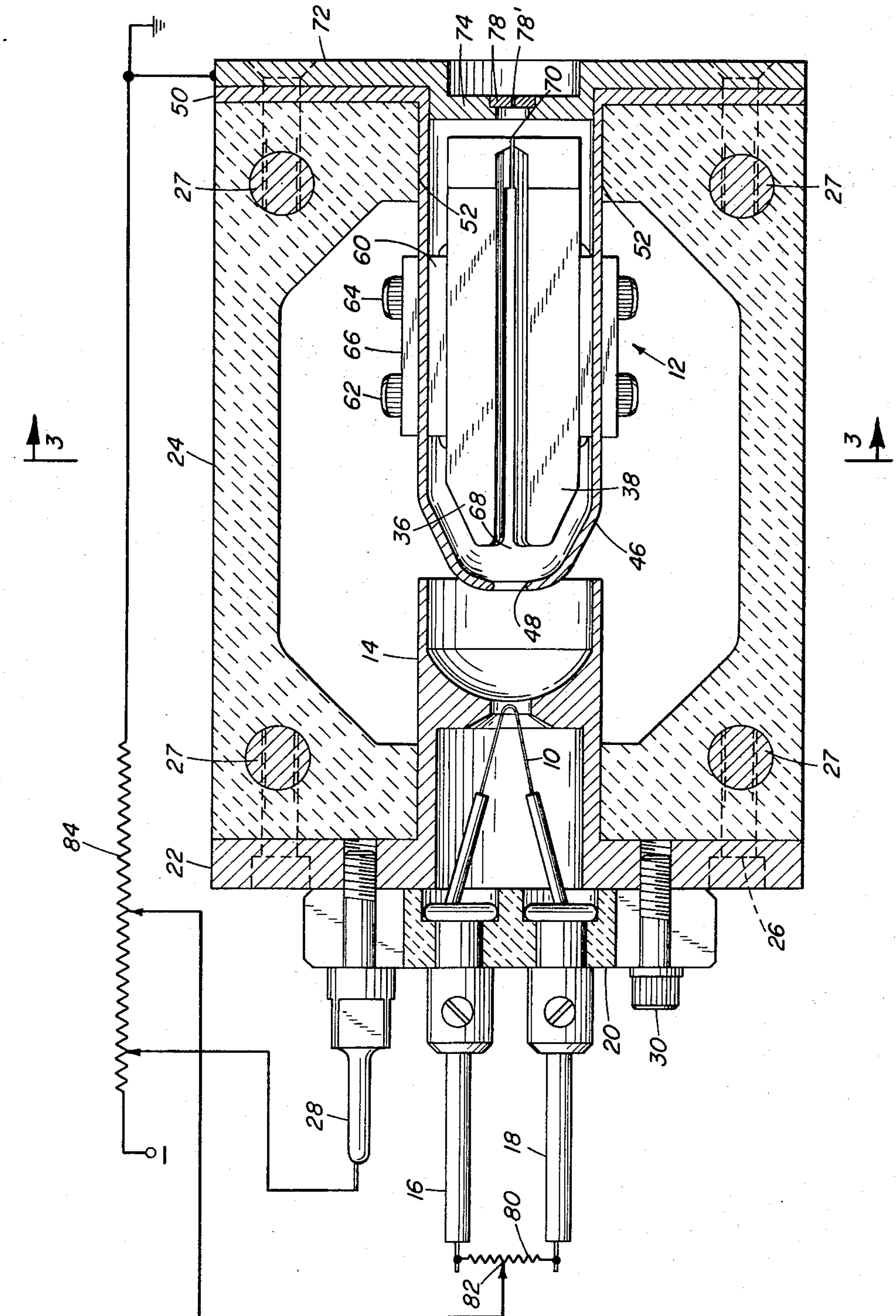

FIG. 2

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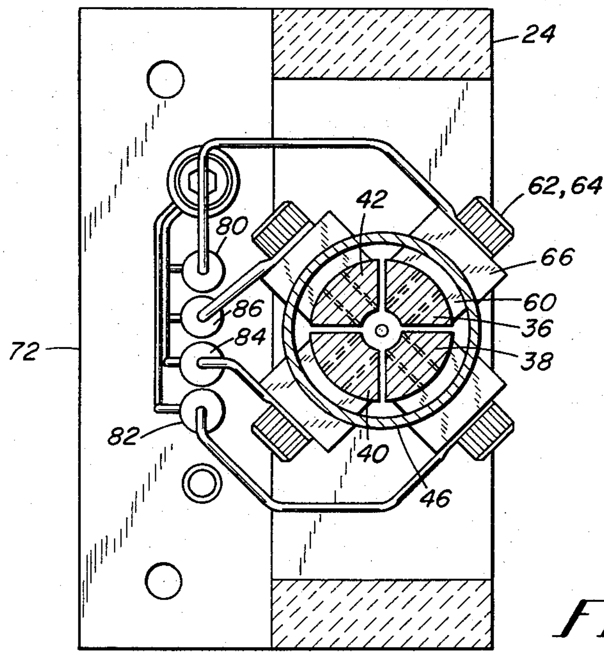

FIG. 3

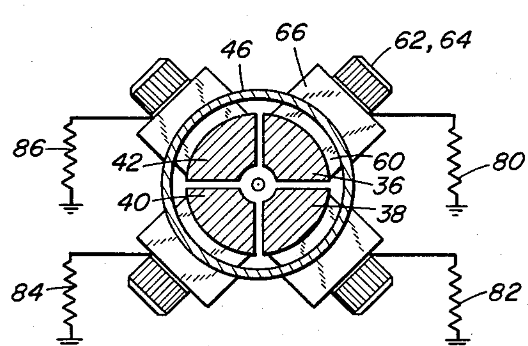

FIG. 5

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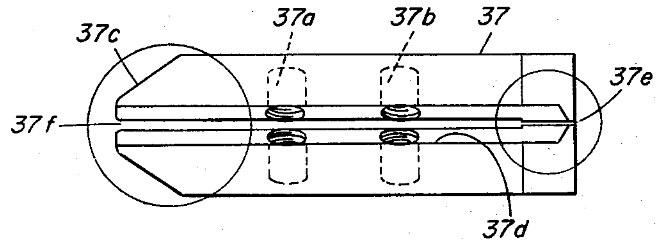

FIG. 4

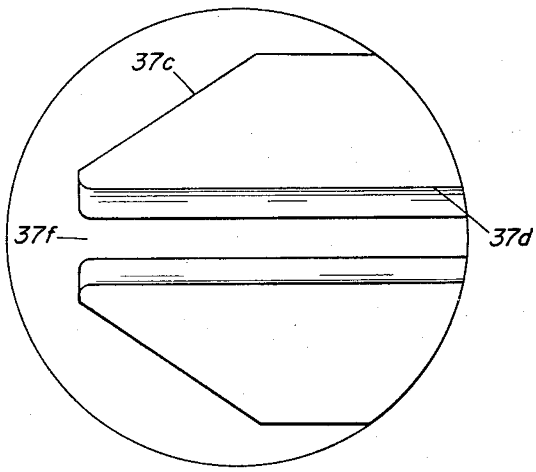

FIG. 4A

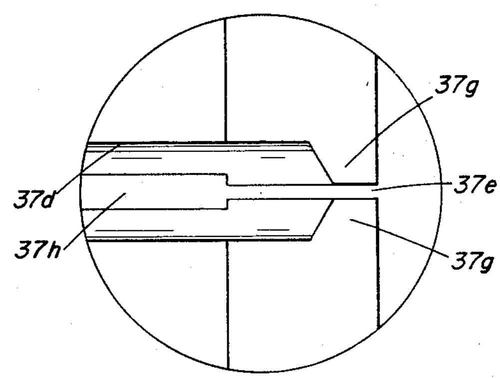

FIG. 4B

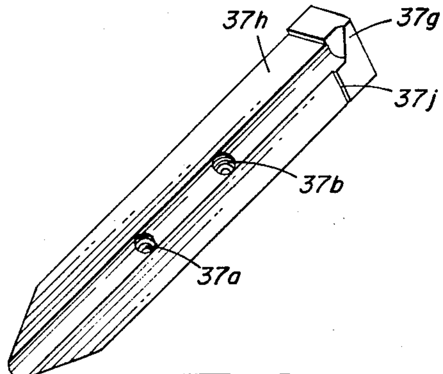

FIG. 4C

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ELECTRON GUN WITH ANODE SEGMENTS FOR BEAM POSITION DETECTION

BACKGROUND OF THE INVENTION

The present invention relates to electron guns and particularly to an improved electron gun structure for producing a fine, intense, focussed beam of electrons.

There are many applications requiring a fine, relatively high density beam of electrons, such as apparatus for impressing a pattern on an electron-sensitive medium, such as film, which corresponds to the information to be impressed upon the medium for later reproduction by scanning with a flying spot scanner, for example. Electron guns for producing such beams usually include a small beam-limiting aperture, and very accurate alignment of the grid and cathode electrodes with the anode aperture is required to maximize the electrons transmitted through the beam-limiting aperture. Desirably, the gun structure includes means for centering the electron beam on the limiting aperture, and is capable of providing a high intensity beam of small cross-section without requiring an excessive degree of accuracy in manufacture and assembly, or require mechanical alignment after assembly.

An electron gun having most of these desirable properties is disclosed in applicant's U.S. Pat. No. 3,358,174 wherein the control grid comprises four mutually insulated segments which are energized to steer the electron beam through the limiting aperture. The opposed grid sections are energized by direct current voltages of adjustable magnitude, which are respectively above and below the grid voltage, which controls the intensity of the electron beam, so that adjustment of the centering voltages does not disturb the intensity control.

Although the patented electron gun structures has excellent mechanical stability, it nonetheless has several disadvantages. For example, since the video drive signals applied to the control grid for modulating the intensity of the electron beam must be applied to all four segments, four DC restorers or clamping circuits are required to maintain the grid electrode as a whole at the appropriate potential relative to the cathode and anode. Moreover, since in the normal operation of the gun the elements of the segmented control grid are at a relatively high voltage, typically 10,000 volts negative with respect to ground, a large number of high-voltage feedthrough insulators into the evacuated enclosure containing the gun electrodes are required. Additionally, the relatively long conductors required to apply the video signal to the four mutually insulated grid segments introduces objectionable capacity which interferes with proper driving of the grid.

SUMMARY OF THE INVENTION

The primary object of the present invention is to overcome the above-outlined shortcomings of previously available electron guns.

Another object is to provide a simple electron gun structure which provides a focussed beam which automatically centers itself in the limiting aperture of the anode.

Briefly, these and other objects are attained in an electron gun having a cathode, a single, unitary control grid, and an anode electrode including a plurality (typically four) mutually insulated segments defining an

opening for the passage of electrons. In the preferred embodiment, the anode segments are shaped to intercept the electron beam if it is off-center, the segments being connected to ground potential through respective resistors. If the beam is intercepted, the segment intercepting the beam is charged negatively and deflects the beam toward the center of the limiting aperture. Alternatively, the beam may be steered through the aperture by applying suitable potentials to opposed anode segments. Since the anode is normally at ground potential and has no video applied to it, the problem of applying proper potentials to the anode segments is greatly simplified. A single connection being all that is required to energize the grid, the video drive system and the high-voltage feedthrough insulator problems are also significantly simplified.

DESCRIPTION OF THE DRAWINGS

Other objects, features, and advantages of the invention, and a better understanding of its construction and operation, will be had from the following description, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a greatly enlarged exploded view in perspective showing the details of construction of the electron gun of the invention;

FIG. 2 is an elevation view in section of the electron gun assembly;

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 2;

FIG. 4, 4A and 4B are sectional views, greatly enlarged, showing the details of construction of the segmented anode electrode;

FIG. 4C is a perspective view, greatly enlarged, of one of the anode segments; and

FIG. 5 is a sectional view, similar to FIG. 3, schematically illustrating the electrical connections from the anode segments to ground.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, the improved electron gun shown in elevation cross-section in FIG. 2 and in exploded perspective in FIG. 1 includes a filamentary cathode 10, a segmented anode structure 12, and an interposed grid electrode 14. The cathode 10 is formed of a refractory metal, preferably tungsten, and is bonded to a pair of rigid lead-in conductors 16 and 18, which are sealed through a ceramic header 20. The lead-in conductors may be formed of tungsten or other refractory material.

The grid electrode 14 is of generally cylindrical shape and is supported on an integral generally rectangular flange 22. The cylindrical portion projects through an opening in one end surface of a generally rectangular ceramic supporting frame 24, and is secured to the frame by four screws, one of which is seen at 26 in FIG. 1, which pass through flange 22 and are anchored in frame 24, preferably in metal pins 27 inbedded in the frame and having threaded openings for receiving the screws 26. The lead-in conductor for the grid passes through a slot in the periphery of ceramic header 20 and is threaded into flange 22. The threaded grid lead-in conductor 28 and a second screw 30 extending through another slot in the header together secure the header **20** to flange **22**. At its flanged end the grid is formed with a cylindrical cavity, in which the cathode **10** is contained, the end wall of which contains an aperture **32** into which the end of the filamentary cathode extends. The surface of the wall facing the anode is hemispherical in shape and merges into a cylindrical section extending toward the anode. In a particular embodiment of the invention the grid **14** is formed of stainless steel, has an overall length of 0.595 in., has an inside diameter of 0.318 in. at the end confronting the anode, and an aperture **32** 0.073 in. in diameter.

The anode structure as a whole, is of generally cylindrical, relatively elongated configuration and is made up of four segments **36, 38, 40** and **42**, each forming, as best seen in FIGS. **3** and **5**, essentially a quarter of the cylindrical structure. The segments are conveniently formed by drilling and slotting a cylindrical, rod-like member of refractory metal, such as titanium. As shown in the greatly enlarged illustration of FIGS. **4**, **4A** and **4B**, the anode segments are formed from a rod **37**, typically ¼ inch in diameter and 0.802 inch long. Prior to dividing the rod into quarters, two sets of transverse holes, at 90° to each other, one set being visible at **37*a*** and **37*b*** in FIG. **4**, are drilled and tapped through the rod. One end of the rod is tapered at **37*c*** from the full diameter to a diameter of 0.067 inch over a distance of 0.120 inch. A central longitudinal bore **37*a*** having a diameter of 0.067 inch is then drilled in the rod, starting at the tapered end, which, as shown in FIG. **4B**, stops short of the other end, in a particular embodiment by 0.016 in., with the bore completed by a 0.005 in. diameter opening **37*e***. The rod is then divided into four segments mutually separated by slots **37*f*** equally spaced at 90° from each other, and at 45° relative to the drilled and tapped holes. For the major part of its length each slot has a width of **.015** in. As shown in FIG. **4B**, each **.015** in. wide slot terminate short of the bottom of the cylindrical bore, and is continued by a slot having a width of 0.005 inch. In this way, a protrusion **37*g*** is formed on each of the four segments which together form the exit aperture of the anode structure to narrowly confine the beam, and to also intercept electrons if the beam is off center.

One of the separate anode segments is shown in FIG. **4C**, looking toward the inner surface thereof. The protrusion **37*g*** at the exit end is clearly visible, as are the tapped holes **37*a*** and **37*b*** extending through the segment and bisecting the 90° angle defined by the intersecting surfaces **37*h*** and **37*j***.

Reverting now to FIGS. **1** and **2**, the four anode segments are supported in mutually spaced and insulated relationship on an anode shield **46** consisting of a hollow cylindrical metal tube, one end of which is tapered and partially enters the grid electrode **14**, and the other end of which is secured to a rectangular flange **50**. The taper at the grid end is generally parallel to the taper of the anode segments, and an aperture **48** for the passage of electrons from the cathode to the anode is formed in the end of shield **46**. The other end extends through a circular opening **52** in ceramic supporting frame **24** and is secured in position by screws passing through openings in the flange **50** and extending into block **24** where they are anchored in threaded openings in pins **54** and **56**, which extend transversely of block **24**. The tube **46** and flange **50** are preferably formed of titatium, the tubular portion being formed with four longitudinal slots, three of which are visible in FIG. **1** at **54, 56** and **58**. The slots are displaced 90° relative to each other about the circumference of the tubular section and are utilized to mount the four anode segments in spaced and insulated relationship to each other.

Since all four segments are similarly mounted, to avoid repetition only the mounting of anode segment **36** will be described. As seen in FIGS. **2, 3** and **5**, the segment **36** is spaced and insulated from the inner wall of the anode shield **46** by a ceramic spacer **60** which straddles the slot **54** and is held in place by a pair of screws **62** and **64** which extend through the slot and the ceramic spacer into the tapped holes in anode segment **36**. The screws are insulated from the anode shield, and the assembly completed, by a second insulating spacer **66** positioned outside the anode shield **46** and straddling the slot **54**. The spacer blocks **60** and **66** are preferably formed of boron nitride because of its properties of being a good electrical insulator as well as a good thermal conductor so as to quickly dissipate the heat generated in the anode segments by electron bombardment. Alternatively, the spacer blocks may be formed of anodized aluminum.

The four anode segments are all assembled in the manner described immediately above, with the tube shield **46** in the assembled position shown in FIG. **2**. The exploded view of FIG. **1** taken by itself is slightly misleading in showing the segments assembled to the tube shield, and separate from the block, because obviously the assembled anode structure will not pass through opening **52** in ceramic block **24**. Assembled as described, the four anode quadrants define a central aperture **68** into which electrons from the cathode are directed. The beam passage **68** is of essentially uniform cross-section throughout most of its length, narrowing down, however, to a reduced area exit aperture **70** having a diameter of approximately 0.005 inch defined by the protrusions on the anode quadrants illustrated in FIG. **4B**. The anode structure is completed by an aperture cup **72** formed of titatium, for example, having a cylindrical central portion **74** dimensioned to be received in the anode shield **46** and to be spaced approximately 0.030 inch from the anode segments. The anode cup is secured to the insulating block **24**, along with the anode shield, by four screws anchored in pins **54** and **56** disposed transversely of block **24**. The anode cup has a central aperture **76** at the outer end of which is positioned an accurately dimensioned disc-like insert **78**, preferably formed of platinum, having an accurately dimensioned electron beam limiting aperture **78'** located centrally thereof. The insert **78** may be secured to the aperture cup in any suitable way, as by spot welding or by a retaining member (not shown) which is welded or otherwise secured to anode cup **72**. In a particular embodiment of the electron gun, the aperture **76'** is **10** microns in diameter.

It will be recognized that the electron gun assembly as shown is not vacuum tight and is intended to be used with an envelope structure which may be either the neck portion of a conventional cathode ray tube, or it may be mounted within the vacuum housing of an electron beam recorder of the type shown, for example, in Glenn U.S. Pat. No. 3,116,962.

An important feature of the present construction is that automatic beam steering is provided. As shown in FIG. **5**, the individual anode segments **36**, **38**, **40** and **42** are returned to ground potential through respective resistors **80**, **82**, **84** and **86** which, in a typical embodiment, each have a value of approximately 5 megohms. The resistors are conveniently connected to their respective anode segments via the mounting screws **62** and **64**, and as shown in FIG. **3**, may be compactly packaged adjacent the ceramic housing **24** by connection of one terminal of each to one of the mounting screws of its respective anode segment, and connecting the other terminals together and to a point of ground potential.

In a particular embodiment of the invention, the gun operates at a beam voltage of about 14 KV., with a beam limiting aperture of 10 microns, with a beam current of about 100 nanoamps (0.1 microamp) through the aperture and about 500 microamps collected on the anode segments. If the beam is off-center, one of the segments will intercept more electrons than the other three, primarily on the protrusions **37***g*, and become charged more negatively than the others and thereby deflect the beam toward the center of the aperture. It has been found that with **5** megohm resistors connecting the anode segments to ground potential, steering of the beam occurs at only 20 percent of the normal beam current intercepted by a segment. In that embodiment the following gun dimensions were employed: the filamentary cathode **10** was of tungsten wire about **.005** in. in diameter and the width of the hair pin at its maximum dimension was 0.090 in.; the aperture **32** in the grid was about 0.073 in. and the end of the filament **10** terminated at the end of the aperture; the hemispherical portion of the grid has a diameter of about 0.344 in. and the conical portion of anode shield **46** extended into the cylindrical portion of the grid by about 0.019 inch. The filament was heated by direct current of about 3.5 amperes resulting from a voltage of the order of 2 volts impressed across a mid-tapped resistor **80** which provides a cathode terminal **82** for connection with the 14KV. terminal of the anode-cathode supply illustrated generally by a tapped resistor **84**. The anode is operated at ground potential, and the control grid was about 300 volts negative with respect to the cathode. The intensity of the beam is modulated by a signal applied to the external electrode **28** for the control grid by suitable drive circuitry (not shown).

With the structure described and illustrated it is possible to accurately center the electron beam in the beam limiting aperture without energization of the anode segments. Since the anode is normally at ground potential, the video drive and the high voltage feedthrough problems are greatly simplified.

While a particular embodiment of the invention has been illustrated and described, it will now be apparent to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and it is the intention, therefore, in the appended claims to cover all such changes and modifications as fall within the true spirit of the invention.

I claim:

1. An electron gun for producing a focused beam of electrons comprising,

a filamentary cathode;

an anode structure having a beam-defining aperture and including a hollow, cylindrical, conductive shield having a plurality of elongated conductive segments supported internally thereof substantially parallel to each other, said segments being insulated from said shield and spaced and insulated from each other and defining an opening for the passage of electrons toward said beam-defining aperture, each of said segments, at the end thereof confronting said beam-defining aperture, being formed with a protrusion extending into said opening for the passage of electrons and shaped to intercept electrons if said beam is off-center, and

a grid electrode interposed between said cathode and said anode structure and having an opening therethrough for the passage of electrons from said cathode toward said anode structure, said grid electrode having a substantially hemispherical shape facing said anode, said shield being tapered in the direction of said grid electrode, and the end of said cathode extending into said grid opening.

2. An electron gun according to claim **1** wherein said anode structure has four segments.

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