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[33]		Japan
[31]		43/75175

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**[54] NONUNIFORM CROSSED FIELD ELECTRON GUN
FOR PRODUCING A STABLE ELECTRON BEAM
ORBIT**
7 Claims, 6 Drawing Figs.

[52] **U.S. Cl.**..... 315/326,
313/84, 313/156, 315/39.3

[51] **Int. Cl.**..... H01j 11/04,
H01j 13/48

[50] **Field of Search**..... 313/84,
156; 315/39.3, 326

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ABSTRACT: A nonuniform crossed field electron gun has a long thin anode parallel to the axis of the tube and a cathode spaced from the anode by a constant interval and opposite the anode. An electrode of dihedral configuration has a vertex with an elongated aperture formed therein in the center area of the vertex. The cathode is positioned in the aperture and the electrode opens toward the anode. An electric field $E(y)$ is produced in the area between the anode and the electrode to provide movement of electrons in axial direction of the tube. A magnetic field $B(y)$ is produced which has a strength which varies as a function of the distance y from the cathode to the anode in a direction transverse to that of the electric field and the axis of the tube. When the electric field and the magnetic field are in a position $y=L$.

$$2L[B(L)] = P \int_0^L B(y) dy$$

$$E(L) = \frac{-2 \cdot \frac{e}{m} \cdot [B^2(L)]L}{P}$$

wherein L is the position of the stable orbit of electrons between the cathode and anode, d is the charge of electrons, m is the mass of electrons and P is a constant.

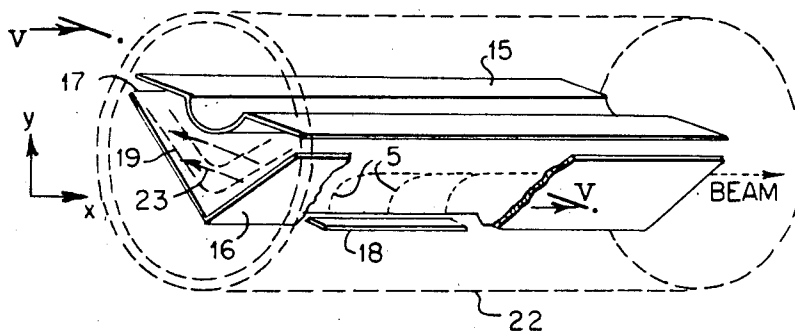


FIG. 1

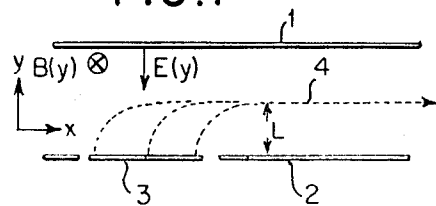


FIG. 2

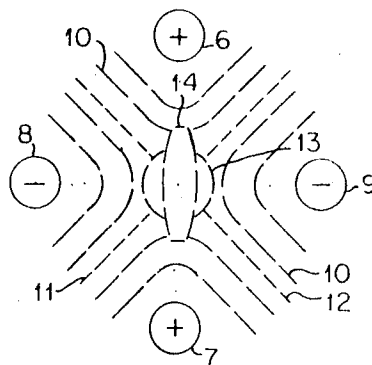


FIG. 3

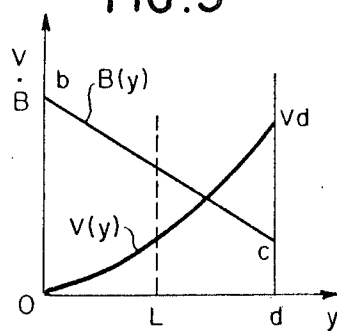


FIG. 4

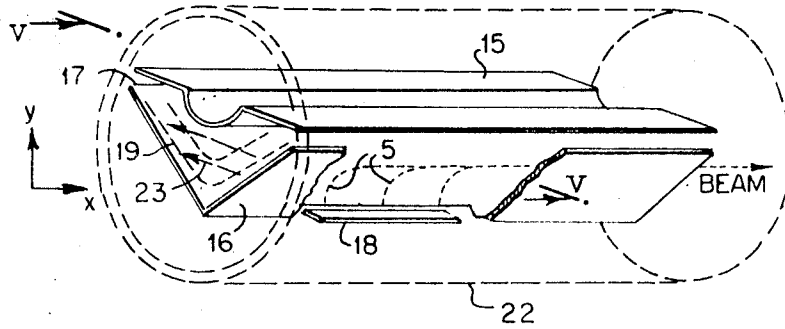


FIG. 5

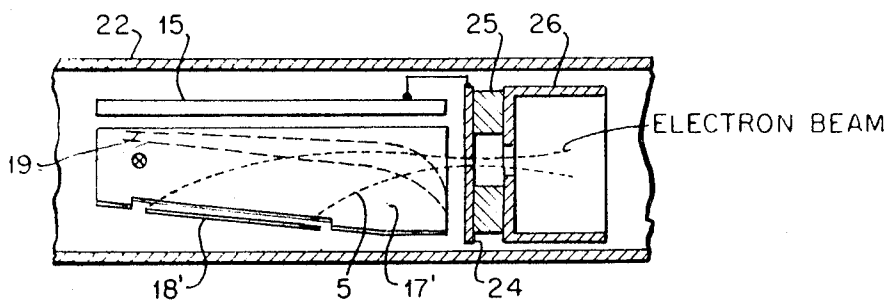
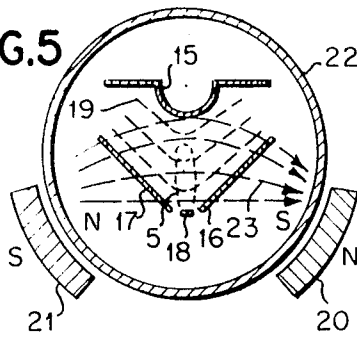


FIG. 6

NONUNIFORM CROSSED FIELD ELECTRON GUN FOR PRODUCING A STABLE ELECTRON BEAM ORBIT

DESCRIPTION OF THE INVENTION

Our invention relates to an electron gun. More particularly, the invention relates to a nonuniform crossed field electron gun.

The electron gun of our invention is particularly adapted for use in electron tubes such as cathode-ray tubes and travelling-wave tubes.

In an electron tube utilizing an electron beam such as, for example, a cathode-ray tube, a travelling-wave tube or a velocity modulation tube, the obtaining of a large beam current presents a considerable problem. An increase of the beam current in a cathode-ray tube permits the reduction of high voltage for acceleration and contributes to increased brightness. Increased beam current in a travelling-wave tube or a velocity modulation tube contributes to the output power.

Electron guns utilized to produce electron beams in conventional electron tubes, as aforescribed, generally comprise a cathode having an electron radiating surface directed at right angles to the axis of the tube and a plurality of electrostatic electron lenses positioned coaxially with the cathode. In an electron gun of this type, however, the area of the cathode is limited by the radius of the tube. Furthermore, even if a cathode of large area is utilized, it becomes very difficult to focus the emitted electrons, and it is therefore impossible to provide a beam of a current large enough for present purposes.

In another electron gun developed for use in microwave tubes of a specific type an electron beam is produced in the direction of the axis of the tube from a plate-shaped cathode having an electron radiating surface extending in the direction of the axis of the tube due to the utilization of a crossed field. An electron gun of this type is described in an article by G. S. Kino, entitled "A Design Method For Crossed Field Guns," IRE Transactions, Volume 7, July, 1960, pages 179 to 185. The electron gun described in the Kino article is commonly referred to as the Kino gun. The Kino gun may provide a slightly larger beam current than the electron gun of the first-mentioned type. On the other hand, however, the Kino gun has a considerably complicated mechanism and design. It is therefore extremely difficult to produce a stable electron beam with the Kino gun. Furthermore, it is practically impossible to focus the electron beam thinly in the Kino gun.

We have invented an electron gun which is described in pending U.S. Pat. application, Ser. No. 703,513, filed Jan. 22, 1968, now U.S. Pat. No. 3,492,531. This electron gun is a special crossed field electron gun and is based on the concept that when an electric field and a magnetic field which cross each other act on a space in which there is a movement of electrons, and the distribution of the magnetic field is made nonuniform so that the distribution is the same as the 2 for 1 betatron, a stable orbit of electrons is produced in such space. This electron gun is different in principle from the Kino gun and the first-mentioned type of electron gun, since it utilizes a magnetic field of nonuniform distribution. Our previously invented electron gun has the advantage that there is no limit in theory to the area of the cathode and the radiated electrons may be produced in a stable orbit. This electron gun is described in further detail with reference to FIG. 1.

The electron gun previously invented by us has the disadvantage that it is difficult to focus the electron beam in the lateral direction. The cross section of the electron beam thus becomes band-shaped or oval, since said electron beam may be focused in the direction of the axis of the tube. Although electron beams of such cross-sectional configuration may be effectively utilized with certain types of objects, they are unsuitable for electron tubes requiring thin beams such as, for example, cathode-ray tubes.

The principal object of the invention is to provide a new and improved nonuniform crossed field electron gun.

An object of the invention is to provide a nonuniform crossed field electron gun which focuses the electron beam in the lateral direction as well as in the direction of the axis of the tube.

5 An object of the invention is to provide a nonuniform crossed field electron gun which produces electron beams of large current.

10 An object of the invention is to provide a nonuniform crossed field electron gun which produces a thinly focused electron beam.

15 An object of the invention is to provide a nonuniform crossed field electron gun which functions with efficiency, effectiveness and reliability.

In accordance with the invention, a nonuniform crossed field electron gun for a tube having an axis comprises a long thin anode parallel to the axis of the tube. A cathode is spaced from the anode by a constant interval and opposite the anode. An electrode of dihedral configuration has a vertex with an elongated aperture formed therein in the center area of the vertex. The cathode is positioned in the aperture formed in the vertex of the electrode. The electrode opens toward the anode. Voltage means connected to the anode and the electrode provides different potentials to the anode and the electrode to produce an electric field $E(y)$ in the area between the anode and the electrode thereby providing movement of electrons in axial direction of the tube. Magnetic means in operative proximity with the tube produces a magnetic field $B(y)$ having a strength which varies as a function of the distance y from the cathode to the anode in a direction transverse to that of the electric field and the axis of the tube. When the electric field $E(y)$ and the magnetic field $B(y)$ are in a position $y=L$

$$2L[B(L)] = P \int_0^L B(y) dy$$

$$E(L) = \frac{-2 \cdot \frac{e}{m} [B^2(L)] L}{P}$$

wherein L is the position of the stable orbit of electrons between the cathode and anode, e is the charge of electrons, m is the mass of electrons and P is a constant.

The electrode comprises nonmagnetic material and the magnetic means comprises a pair of spaced magnets in operative proximity with the tube in symmetrical positions relative to a plane through the axis of the tube and the longitudinal center of the cathode and in asymmetrical positions relative to any other plane through the axis of the tube. The magnet is positioned in a manner whereby like poles of the magnet are opposite each other.

50 The electrode comprises a pair of thin plates joined to each other in dihedral configuration at an angle of substantially 90°.

55 The cathode is a direct heated-type cathode extending substantially parallel to the axis of the tube and substantially elongated and thin along its length. The cathode comprises a nickel ribbon. The cathode and the vertex of the electrode are substantially parallel to the axis of the tube. The cathode and the vertex of the electrode are oblique to the axis of the tube.

60 The anode is an elongated thin plate extending parallel to the axis of the tube and having a substantially cylindrical trough formed therein along its length and opening in the same direction as the electrode. The centerline of the trough is the centerline of the anode and is in a vertical plane through the vertex of the electrode.

65 In order that the invention may be readily carried into effect it will now be described with reference to the accompanying drawings, wherein:

70 FIG. 1 is a schematic diagram of the electron gun disclosed in our pending U.S. Pat. application, Ser. No. 703,513, now Pat. No. 3,492,531;

FIG. 2 is a schematic diagram illustrating electron focusing based on the principle of quadruple electrodes;

75 FIG. 3 is a graphical presentation illustrating the potential distribution and the magnetic field distribution in the nonuniform crossed field electron gun of the invention;

FIG. 4 is a perspective schematic diagram of an embodiment of the nonuniform crossed field electron gun of the invention;

FIG. 5 is a sectional view taken along the lines v-v of FIG. 4; and

FIG. 6 is a schematic diagram, partly in axial section, of a modification of the embodiment of FIGS. 4 and 5.

In FIG. 1, a plate-shaped anode 1 is spaced from an electrode 2 and is positioned in opposition with said electrode. A cathode 3 is provided in nearly the same plane as the electrode 2. The space between the anode 1 and the electrode 2 is such that the electrode structure may be regarded as equivalent to part of an annular space for movement of electrons in a betatron, which annular space has an infinitely enlarged radius. The 2 for 1 rule of a betatron may be ordinarily expressed as

$$\int_0^L B(y) y dy = B(L) L^2 \quad (1)$$

Therefore, if the coordinate system of the space provided between the electrodes is determined as shown in FIG. 1, and a nonuniformly distributed magnetic field $B(y)$ is applied to the coordinate system in a plane perpendicular to the sheet of illustration, so that the strength of the magnetic field satisfies Equation (1) as the function of the distance y from the cathode 3 to the anode 1, a straight stable orbit 4 for the electrons is produced at the position $y=L$, as in the case of a betatron. By selecting the strength of the electric field E , which is provided in a direction crossing the magnetic field, to a value which will provide the critical voltage to electrons moving to the position $y=L$, electrons 5 radiated from all parts of the cathode 3 are all once collected in the stable orbit 4 in accordance with the cycloidal effect and are provided in the axial direction of the tube as a single electron beam.

A detailed explanation of the operation of the electron gun of FIG. 1 is provided in the disclosure of pending patent application, Ser. No. 703,513. As hereinbefore stated, it is difficult to focus the electron beam produced by the electron gun of FIG. 1 in the lateral direction. When the electrons radiated from the cathode 3 enter into the straight stable orbit 4, said electrons may be focused in the direction perpendicular to the surface of said cathode. Such direction is the x direction shown in FIG. 1. As hereinbefore mentioned, focusing cannot be provided in the lateral direction of the cathode, so that the cross-sectional configuration of the electron beam becomes band-shaped or oval.

The electron gun of our invention utilizes the concept of a stable orbit of electrons based on the 2 for 1 rule of the betatron. The electron gun of the invention is superior to the electron guns of other types, since it produces electron beams of large current. The problem of focusing the electron beam provided in the stable orbit in a lateral direction is solved in our invention by utilizing the principle of quadruple electrodes to provide electron focusing action. In accordance with our invention, a ribbon-shaped cathode is spaced from a long thin anode extending in the axial direction of the tube by a constant distance and is opposed to said anode. Instead of plate-shaped electrodes, an electrode is provided which is of dihedral configuration, or open V type configuration, opening toward the anode and accommodating the cathode along part of its vertex. An electric field of nonuniform distribution and a magnetic field of nonuniform distribution are provided in crossing relation with each other and are applied to the space of movement of electrons between the anode and the dihedral electrode. The electrons from the cathode pass through a single stable orbit determined by the crossed electric and magnetic fields and are derived in the direction of the axis of the tube as a thinly focused electron beam. The electron gun of our invention is thus very effectively utilizable in cathode-ray tubes.

In the electron gun of FIG. 1, in order to provide a straight or linear stable orbit, it is necessary to provide to the space of movement of electrons a magnetic field of nonuniform distribution which satisfies the 2 for 1 rule of the betatron expressed by Equation (1). It is also necessary to provide an electric field which will produce a voltage of a magnitude or value substantially equal to the critical voltage and to apply

such voltage to the position of the stable orbit determined by the distribution of the magnetic field. The distribution of the electric field for providing the stable orbit may be either uniform or nonuniform. This is evident from the following explanation.

In FIG. 1, the electrode structure comprises the anode 1 to which a positive potential is applied, the electrode 2 positioned opposite said anode and the cathode 3 positioned in essentially the same plane as said electrode. Assume that there is a two-dimensional space of movement of electrons which comprises the y direction perpendicular to the cathode 3 and the x direction parallel to said cathode, a magnetic field $B(y)$ perpendicular to the plane of the sheet of illustration and nonuniformly distributed in the y direction, and an electric field $E(y)$ applied to the space of movement of electrons and perpendicularly crossing the magnetic field and nonuniformly distributed in the y direction. The motion of the electrons radiated from the cathode 3 are ordinarily expressed as

$$\frac{d^2x}{dt^2} = -\frac{e}{m} \frac{dy}{dt} B(y) \quad (2)$$

$$\frac{d^2y}{dt^2} = \frac{e}{m} E(y) - \frac{e}{m} \frac{dx}{dt} B(y) \quad (3)$$

wherein e is the charge of the electrons, m is the mass of the electrons and t is the time.

On the other hand, the potential distribution $V(y)$ and the magnetic field distribution $B(y)$ in the space of movement of electrons may generally be expressed as

$$V(y) = [E_0] y^p \quad (4)$$

$$E(y) = \frac{\delta V}{\delta y} = -P[E_0] y^{p-1} \quad (5)$$

$$B(y) = -\left[\frac{b-c}{d} y\right] + b \quad (6)$$

wherein E_0 and P are constants which determine the electric field, b and c are constants which determine the magnetic field distribution, and d is the distance between the cathode 3 and the anode 1.

The relation between the potential distribution and the magnetic field distribution, expressed by Equations (4) and (6), is illustrated in FIG. 3. In FIG. 3, the abscissa represents the distance y from the cathode 3 toward the anode 1 and the ordinate represents the potential V and the magnetic field strength B . The potential distribution curve is indicated as $V(y)$ and the magnetic field distribution curve is indicated as $B(y)$. In FIG. 3, 0 is the position of the cathode 3, d is the position of the anode 1, b is the strength of the magnetic field at the position of the cathode, 0 is the strength of the magnetic field at the position of the anode and V_d is the anode potential.

In order that a stable orbit may exist in the space of movement of electrons, the condition for zero acceleration at the position where the speed of electrons radiated from the cathode 3 toward the anode 1 in the y direction becomes zero must be satisfied. That is, the condition $d^2y/dt^2=0$ must be satisfied at the position $y=L$, when $dy/dt=0$. If this condition for the existence of a stable orbit is substituted in Equations (5) and (6) for Equations (2) and (3), the following equations are derived, which indicate the relation between the magnetic field and the electric field.

$$2L[B(L)] = P \int_0^L B(y) dy \quad (7)$$

$$E(L) = \frac{-2 \cdot \frac{e}{m} [B^2(L)] L}{P} \quad (8)$$

Equation (7) is substantially equivalent to Equation (1) which represents the 2 for 1 rule of the betatron, and a stable orbit is provided at the position $y=L$ when the magnetic field distribution $B(y)$ satisfies the relation provided by said equation. When an electric field satisfying Equation (8) is applied at the position $y=L$, electrons 5 from the cathode 3 all enter

into the stable orbit. It is thus a fact that a stable orbit may be provided even if the electric field distribution is nonuniform.

In accordance with the invention, an electric field of nonuniform distribution is utilized as the electric field in order to provide a stable orbit, and a special electrode structure, based on the principle of quadruple electrodes, is utilized in order to focus electrons in the lateral direction under the control of the electric field. The quadruple electrode construction is shown in FIG. 2. In FIG. 2, two positive potential poles 6 and 7 are provided in coplanar position and two negative potential poles 8 and 9 are provided in coplanar position, the plane of one pair of poles intersecting the plane of the other pair of poles at right angles. The positive potential poles 6 and 7 are positioned opposite each other and the negative potential poles 8 and 9 are positioned opposite each other.

In the electrode arrangement shown in FIG. 2, the potential distribution is indicated by the lines 10. The potential indication by lines 11 and 12 pass from intermediate positions between positive potential poles and negative potential poles through the axis between all the poles and become zero at such axis. Thus, if an electron beam 13 is provided along the axis in a direction perpendicular to the plane of illustration, said electron beam is focused so that it has a cross-sectional configuration, illustrated by the crosshatched lines 14, of an oblong elongated in one direction and compressed in the perpendicular direction.

In accordance with the invention, one quarter of the electrode structure of FIG. 2 including a positive potential pole, is added to the structure of our previous electron gun structure described in pending Pat. application, Ser. No. 703,513. FIGS. 4 and 5 illustrate a preferred embodiment of the electron gun of our invention. In FIGS. 4 and 5, an anode 15 is the equivalent of a positive potential pole of the quadruple electrode structure of FIG. 2. An electrode 16,17 is positioned in correspondence with the zero potential lines 11 and 12 of the quadruple electrode structure of FIG. 2 and is provided as a dihedral configuration having a vertex with an elongated aperture formed therein in the center area of the vertex. The electrode 16,17 opens toward the anode 15. A cathode 18 is positioned in the aperture formed in the vertex of the electrode 16,17.

The angle of the dihedral electrode 16,17 is substantially 90°. It is not, however, necessary to strictly regulate this angle. In the illustrated embodiment, the space of movement of electrons is enclosed by the anode 15 and the electrode 16,17. Therefore, in order to provide a nonuniform magnetic field in the space of movement of electrons, it is necessary that the electrode 16,17 comprise nonmagnetic material such as, for example, copper or stainless steel. The cathode 18 is of direct heated-type and comprises a long thin nickel ribbon and an electron radiating material coated on the surface of said ribbon. The cathode 18 extends in a direction parallel to the axis of a tube 22, shown in broken lines, which supports the electron gun structure. The anode 15 is an elongated thin plate extending parallel to the axis of the tube 22 and having a substantially semicylindrical trough formed therein along its length and opening in the same direction as the electrode 16,17. The centerline of the trough is the centerline of the anode 15 and is in a vertical plane through the vertex of the electrode 16,17.

A suitable supporting arrangement, not shown in the FIGS. supports the tube housing 22. A suitable voltage source, not shown in the FIGS. is connected from outside the tube 22 to the electrodes 16,17 in the electron gun structure, as well as to the anode 15 and the cathode 18. It is especially desirable to support one end of the cathode 18 with spring bias, so that thermal expansion may be compensated for.

If it is assumed that a positive potential is applied to the anode 15 and a zero, or slightly negative potential is applied to the electrode 16,17 in the structure of FIGS. 4 and 5, an electric field of nonuniform distribution similar to that in the region of one-quarter of the quadruple electrode structure shown in FIG. 2 is provided in the space of movement of elec-

trons enclosed by said anode and said electrode, in accordance with Equation (4). This potential distribution is shown in FIGS. 5 and 6 by the equipotential broken lines 19. The electrons 5 radiated from the cathode 18 are directed toward the anode 15 and are focused in the lateral direction within the nonuniform electric field, in accordance with the principle of quadruple electrodes.

If a magnetic field of nonuniform distribution, satisfying Equation (7), is provided, however, in a direction crossing the electric field, the electrons 5 are collected in a stable orbit and are thinly focused in the lateral direction as well. The nonuniform magnetic field may be provided, for example, by a pair of magnets 20 and 21, as shown in FIG. 5. The magnets 20 and 21 are spaced from each other and are in operative proximity with the tube 22 in symmetrical positions relative to a plane through the axis of said tube and the longitudinal center of the cathode 18. The magnets 20 and 21 are in asymmetrical positions relative to any other plane through the axis of the tube 22.

Each of the magnets 20 and 21 has a curved pole face which corresponds with the wall of the tube 22. The magnets 20 and 21 are asymmetrical relative to the axis of the tube 22 in a manner whereby like poles of said magnets are opposite each other. Magnetic lines of force 23 in FIGS. 4 and 5 illustrate the condition of the magnetic field provided by the magnets 20 and 21 in the space of movement of electrons. In FIGS. 4 and 5, the magnetic field is provided in a distribution which is strong on the side of the cathode 18 and is gradually weakened as it approaches the anode 15. Needless to say, however, the magnetic field may also be provided in a distribution which increases as the anode 15 is approached, as far as Equations (7) and (8) are satisfied.

Equation (8) may be rewritten as Equation (9), in order to express the anode voltage V_d .

$$V_d = \frac{2 \cdot \frac{e}{m} [L^2 - P] d^2 P}{P^2} [B(L)] \quad (9)$$

The relation between L and the constants may be expressed by substituting Equation (6) for Equation (7).

$$L = \frac{2d[b]}{b-c} \left[\frac{P-2}{P-4} \right] \quad (10)$$

Since the position L of the stable orbit is within the range $0 < L < Ad$, the range of P is determined as follows:

When $b > c$, which indicates a decreasing magnetic field,

$$2 > P > 4c/b + c \geq 0 \quad (11)$$

When $b < c$, which indicates an increasing magnetic field,

$$2 < P < 4c/b + c < 4 \quad (12)$$

Therefore, if L equals $d/2$, so that the position of the stable orbit is just at the intermediate position between the cathode 18 and the anode 15, the following equation is derived from Equation (10).

$$P = \frac{4 + \frac{4c}{b}}{3 + \frac{c}{b}} \quad (13)$$

If d and L are selected as $d = 5$ times 10^{13} m and $L = 2.5$ times 10^{13} m, and if b and c are selected as $b = 100$ times 10^{14} wb/m² and $c = 0$ wb/m², so that the magnetic field strength at the position of the stable orbit L becomes 50 times 10^{14} wb/m², Equation (13) may be expressed as $P = 4/3$ and $c/b = 0$. Therefore, if a voltage of 78 volts, derived from Equation (9), is applied to the anode 15, and a magnetic field $B(y) = -200$ times 10^{12} y + 10^{-2} wb/m, derived from Equation (6), is applied between the anode and the cathode, Equations (7) and (8) are satisfied at the intermediate position between the anode and the cathode; that is, the position $L = 2.5$ times 10^{13} m. A stable orbit is thus formed at this position.

Similarly, if $b=16.66$ times 10^{14} wb/m^2 and if $c=83.33$ times 10^{14} wb/m^2 , c/b becomes 5. If such an increasing magnetic field, which increases from the cathode 18 as the reference toward the anode 15, is applied, P may be expressed as $P=3$ from Equation (13). The anode voltage is then 48.85 volts and the magnetic field is $B(y)=133.4$ times 10^{12} $y+0.1666$ times 10^{12} wb/m^2 . A stable orbit may thus be provided at the position $L=2.5$ times 10^{13} m .

FIG. 6 illustrates a modification of the embodiment of FIGS. 4 and 5. In the modification of FIG. 6, the cathode 18' and the vertex of the electrode 16', 17' extend obliquely with or inclined to the axis of the tube 22. In the embodiment of FIGS. 4 and 5, the cathode 18 and the vertex of the electrode 16, 17 extend parallel to the axis of the tube 22. It has been confirmed by experiment that by positioning the cathode obliquely to the axis of the tube 22, the force of the electric field, as against the electrons, may be provided with a component in the axial or x direction. This results in a reduction of the suppression effect on electrons by the space charge. It is desirable to select the angle of inclination of the cathode 18' relative to the axis of the tube 22 as from 5° to 6° .

FIG. 6 illustrates a first grid 24 for acceleration of electrons, a magnet 25 for prefocusing of electrons and a second grid 26. The first grid 24 for the acceleration of the electrons has the same potential applied to it as that applied to the anode 15. The first grid 24, the magnet 25 and the second grid 26 function as the principal electron lens.

While the invention has been described by means of specific examples and in specific embodiments, we do not wish to be limited thereto, for obvious modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

We claim:

1. A nonuniform crossed field electron gun for a tube having an axis, said electron gun comprising
 - a long thin anode parallel to the axis of the tube;
 - a cathode spaced from said anode by a constant interval and opposite said anode;
 - an electrode of dihedral configuration having a vertex with an elongated aperture formed therein in the center area of said vertex, said cathode being positioned in the aperture formed in the vertex of said electrode, said electrode opening toward said anode;
 - voltage means connected to said anode and said electrode for providing different potentials to said anode and said electrode to produce an electric field $E(y)$ in the area between said anode and said electrode thereby providing

movement of electrons in axial direction of said tube; magnetic means in operative proximity with said tube for producing a magnetic field $B(y)$ having a strength which varies as a function of the distance y from said cathode to said anode in a direction transverse to that of the electric field and the axis of the tube, wherein when said electric field $E(y)$ and said magnetic field $B(y)$ are in a position $y=L$,

$$2L[B(L)] = P \int_0^L B(y) dy$$

$$E(L) = \frac{-2 \cdot \frac{e}{m} \cdot [B^2(L)]L}{P}$$

wherein L is the position of the stable orbit of electrons between the cathode and anode, e is the charge of electrons, m is the mass of electrons and P is a constant.

2. A nonuniform crossed field electron gun as claimed in claim 1, wherein said electrode comprises nonmagnetic material and said magnetic means comprises a pair of spaced magnets in operative proximity with the tube in symmetrical positions relative to a plane through the axis of the tube and the longitudinal center of the cathode and in asymmetrical positions relative to any other plane through the axis of the tube, said magnets being positioned in a manner whereby like poles of said magnets are opposite each other.

3. A nonuniform crossed field electron gun as claimed in claim 1, wherein said electrode comprises a pair of thin plates joined to each other in dihedral configuration at an angle of substantially 90° .

4. A nonuniform crossed field electron gun as claimed in claim 1, wherein said cathode is a direct heated-type cathode extending substantially parallel to the axis of the tube and substantially elongated and thin along its length, said cathode comprising a nickel ribbon.

5. A nonuniform crossed field electron gun as claimed in claim 1, wherein said cathode and the vertex of said electrode are substantially parallel to the axis of said tube.

6. A nonuniform crossed field electron gun as claimed in claim 1, wherein said cathode and the vertex of said electrode are oblique to the axis of said tube.

7. A nonuniform crossed field electron gun as claimed in claim 3, wherein said anode is an elongated thin plate extending parallel to the axis of the tube and having a substantially semicylindrical trough formed therein along its length and opening in the same direction as said electrode, the centerline of the trough being the centerline of the anode and being in a vertical plane through the vertex of said electrode.