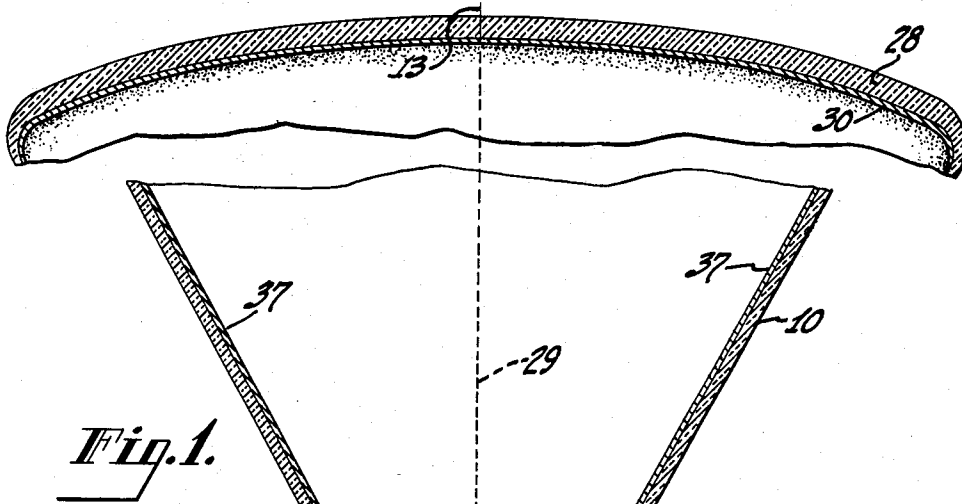
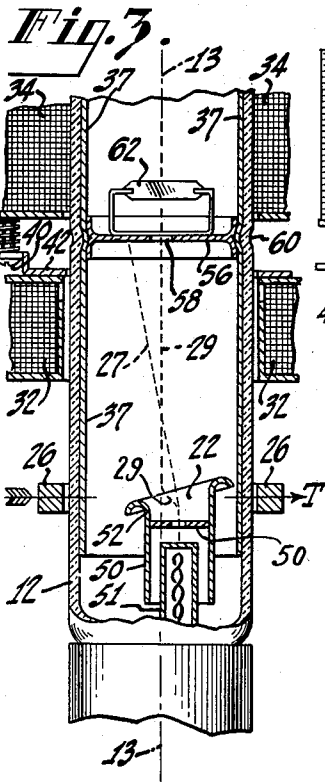
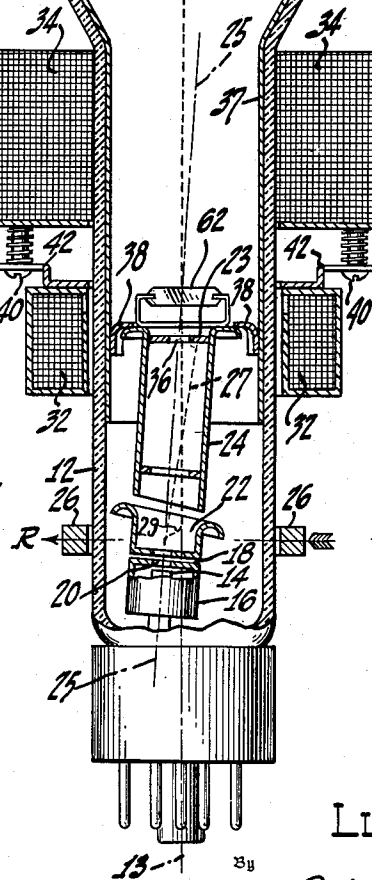
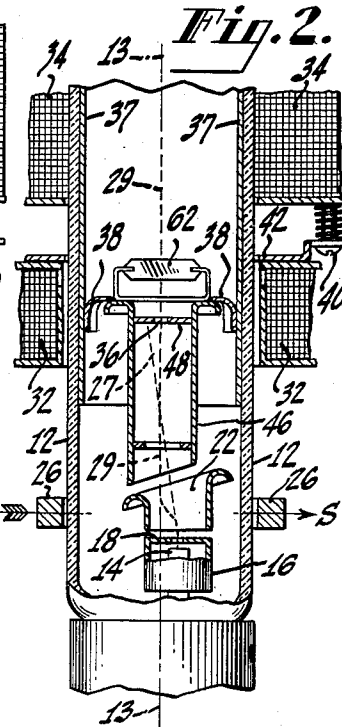


May 1, 1956

L. E. SWEDLUND
ION TRAP ELECTRON GUN

2,744,208

Filed Dec. 2, 1949



Inventor
LLOYD E. SWEDLUND
William A. Jalesak
Attorney

1

2,744,208

ION TRAP ELECTRON GUN

Lloyd E. Swedlund, Lancaster, Pa., assignor to Radio Corporation of America, a corporation of Delaware

Application December 2, 1949, Serial No. 130,775

7 Claims. (Cl. 313—78)

This invention relates to a cathode ray viewing tube and more particularly to the electron gun structure for such a tube.

This invention relates to the electron gun structure of a cathode ray tube, which is used to produce a beam of electrons, which, in turn, is focussed upon a fluorescent screen within the tube and deflected over the fluorescent screen to produce an illuminated raster. It has been found, in tubes of this type, that there is produced in the center of the phosphor screen, a darkening of the phosphor material. This darkened spot is formed by deterioration of the screen material due to excessive bombardment of the spot by negative ions generated within the tube and forming a component of the electron beam striking the fluorescent screen.

In the U. S. Patent 2,496,127 of Joseph Kelar, a specific type of gun structure is described for eliminating the negative ion component from the electron beam. The electron gun structure shown in the above cited patent is that consisting of a source of electrons and a plurality of tubular electrodes spaced from the electron source and from each other axially along the tubular neck of a cathode ray tube. The tubular electrodes are mounted within the tube neck coaxial with each other and with the envelope neck. These spaced electrodes are adapted to be maintained at different potentials relative to each other to form converging electrostatic fields for forming the electron emission from the electron source into a beam of electrons, whose path has a direction coincident with the axis of the tube.

To separate the negative ion component from such an electron beam, the above cited application proposes to cut the adjacent ends of two proximate tubular electrodes at an angle to the common electrode axis, so that there is formed, in the region between these two electrodes, an unsymmetrical electrostatic field or electron lens having an axis inclined to the common axis of the electrode structure. As the electron beam passes through this unsymmetrical field, it is deflected together with its ion component away from the common axis and in a direction to strike the side of the tubular electrode structure. The electrons, however, of the deflected beam are returned to the common axis of the tube by a first magnetic field, and then aligned with the axis of the tube by a second magnetic field. These two magnetic fields may be produced either by electromagnetic or permanent magnetic means. The reason for the need of two magnetic fields is, that the first magnetic field cannot, without great complexity of design, be formed equal and opposite to the unsymmetrical electrostatic field at every point. Because of this reason, the deflection produced by the first magnetic field produces an effect as if the electron beam left the first magnetic field from a point about 0.1 inch from the axis. A second magnetic field having a field in the opposite direction is then necessary to realign the electrons of the beam along the tube axis. Due to the large masses of the negative ions relative to the mass of an electron, the two magnetic fields, used to realign the

2

electron beam, have little or no effect on the negative ion component of the beam, so that the ions of the beam continue in their deflected direction to strike the edge of the tubular electrode structure. At the present time, television viewing tubes commonly use a magnetic focusing coil and magnetic deflecting coils, all coaxially mounted on the tube neck. If good focus of the beam is to be obtained, it is necessary that the electron beam pass through the focus coil perpendicular to and well centered with its air gap. Only a small deviation from this alignment will produce noticeable distortion. Also, if the electron beam does not enter the deflection coil fields on its axis, one side of the focused pattern will show more distortion than the other side, or the beam may strike the tube neck, when deflected to the edge of the screen. In tubes using a wide deflecting angle such as that approximating 70°, these above factors are more important than in tubes using a smaller deflection angle, since poor focusing will be more noticeable at the edge of the screen and there will be greater distortion produced if the electron beam is not accurately centered, relative to the focusing coil and the deflection fields.

In the electron gun structure described above and shown in the above cited Kelar patent, correct alignment of the electron beam with the tube axis, and hence the focusing field and deflecting fields, requires two independently variable magnetic fields. However, the adjustments become so complex that they are impractical for a commercial tube. A practical compromise however, was reached in the operation of the above described tube by using two electromagnets in series and producing fields having a set relationship. An alternative method was to use a pair of permanent magnets adjustably mounted on the tube neck so that the field strength in the ion trap region can be varied by moving the magnets along the neck. Such an adjustment generally does not result in the optimum position for the second field. Also, the use of a double magnet requires extra neck length. This is undesirable since the over-all length of the cathode ray tube should be as short as possible to reduce the set size. Reducing neck length does not increase deflecting power as is required in widening the deflecting angle. Thus, it is desirable to do away with two magnets and use only a single magnet to realign the electron beam. This has also been found desirable from the standpoint of economy and in reducing the complexity of accurate adjustments to realign the electron beam with the tube axis.

The use of a single magnet with the gun structure described in Patent 2,496,127, Kelar, although producing fair results, does not provide correct alignment of the electron beam with the tube axis. Such misalignment however, has been somewhat compensated by tilting of the focus coil so that the plane of the focusing field is not perpendicular with the axis of the tube. This has an undesirable result in that the beam then enters the deflecting yoke off center and thus produces distortion of the picture.

It is therefore an object of my invention to provide an improved and novel electron gun structure for separating the ion components of the electron beam from the electrons of the beam.

It is another object of my invention to provide an electron gun structure having a negative ion trap therein of relatively simple design.

It is a further object of my invention to provide an electron gun structure for a cathode ray tube which has an ion trap structure therein and a relatively simple structural arrangement for aligning the electron beam with the tube axis.

It is a further object of my invention to provide an electron gun structure having a negative ion trap therein of

3

simple structure for aligning the electron beam accurately with the tube axis.

It is another object of my invention to provide an electron gun structure for a cathode ray tube having an ion trap structure therein and means for accurately aligning the electron beam with the axis of the focusing coil and deflecting yoke used with the tube.

It is another object of my invention to provide an electron gun structure for a magnetically focused and deflected cathode ray tube, having an ion trap structure therein, and means for providing an accurate alignment of the electron beam with the axis of the focusing field and the deflecting fields to provide an improved focusing of the electron beam for a wide angle deflection tube.

My invention is to electron gun structures mounted offset to the major axis of the cathode ray tube, which normally is the same as the axis of the deflection coil and that of the electron beam focusing field. An electrostatic refracting means such as an unsymmetrical electron lens is used to direct the negative ions and electrons toward the axis of the deflection and focusing fields. A single magnetic field is then used to bend the electron component of the beam in a direction opposite to the action of the electrostatic refracting means to align the electron stream with the axis of the deflecting and focusing fields. An apertured diaphragm is mounted within the neck of the tube adjacent the end of the deflecting coil yoke facing the electron source. The aperture of the diaphragm is on the axis of the tube which is also the common axis of the focusing coil and deflecting yoke. When the magnetic field, used for aligning the electron component of the beam, is adjusted so that a maximum electron beam will pass through the limiting diaphragm aperture, the electron beam is not moved off the axis at the entrance to the focus and deflecting fields as is likely to happen in previous ion trap tubes.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing, in which:

Figure 1 discloses a cathode ray tube having an electron gun structure according to my invention;

Figures 2 and 3 are to modifications of the electron gun structure of Figure 1.

The tube comprises an envelope structure having a conical portion 10 (Figure 1) and connected at its smaller end and on a common axis 13 with a tubular neck portion 12. Unsymmetrically mounted within the neck portion of the tube and offset from axis 13 are electron gun structures comprising a source of electrons, or cathode electrode 14, partially enclosed by a control tubular grid 16. One end of the control grid 16 is closed by a plate portion 18 having an aperture 20 closely spaced from the cathode electrode 14. The cathode electrode may comprise a tube closed at one end; the closed end being closely spaced, as shown in Figure 1, from the control grid aperture 20. This closed end of the cathode electrode may be coated as is well known in the art, by a mixture of strontium and barium carbonates which, during tube operation, provide a source of electron emission.

Coaxial with the control electrode 16 and spaced therefrom along a common axis 25 is another tubular electrode 22, which is adapted during tube operation, to be maintained at a positive potential relative to that of the cathode electrode, to pull the electron emission from the coated surface of cathode 14 through the control grid aperture 20 and thus form it into an electron beam 29. Closely spaced from the accelerating electrode 22 is a second accelerating electrode 24 mounted coaxial with both the control grid electrode 16 and accelerating electrode 22 and also spaced along the tubular envelope por-

4

tion farthest from cathode 14. Accelerating electrode 24 is closed at its end by an apertured disc 23. The apertured disc 23 allows the electron beam to pass when the beam is centered in the neck by magnetic means to be disclosed. Disc 23 traps the negative ion stream, which at this point is not on the axis 25, as described below.

As shown in Figure 1, electrode 24 extends along the gun axis 25. Apertured disc or diaphragm 23, is positioned adjacent to the point of intersection of axis 25 with tube axis 13. Diaphragm 23 is apertured at 36 to provide a small limiting aperture for the electron beam. Diaphragm 23 is positioned substantially in the center of the focusing field of coil 32, as shown. This position is not critical and good effects can be obtained in extending the diaphragm as high as to the edge of the deflecting field.

The second accelerating electrode 24 is adapted to be maintained during tube operation, at a higher positive potential, relative to that of a cathode, than the first accelerating electrode 22. In one tube of the type shown in Figure 1, the first accelerating electrode 22, during tube operation, is maintained at about 300 volts positive relative to cathode potential and the second accelerating electrode is maintained about 12,000 volts relative to cathode potential. As is well known, there is thus provided, between the electrodes 22 and 24, a converging electrostatic field which tends to provide a preliminary focusing or convergence of the electron beam.

During the operation of a cathode ray tube of the type described, it has been found that negative gas ions, such as, for example, negative ions of oxygen, are formed in the cathode region and tend to pass through the electron gun structure along the same path as the electron beam. Since the negative ions are only slightly affected by the magnetic focusing and deflecting fields, they concentrate near the center of the screen. This negative ion component of the beam has proved to be detrimental to the phosphor screen of the cathode ray tube and has produced, over a period of time in the bombarded region, a reduced luminescence of the phosphor material in a small area near the center of the screen. This produces an objectionable blemish on the television picture. To eliminate these negative ions from the beam, an ion trap structure has been designed and put into use, similar to that described in the U. S. Patent 2,496,127 of Kelar.

Figure 1 shows the several electrodes 14, 16, 22 and 24 spaced from each other along a common axis 25, which is inclined to axis 13 of the tubular envelope portion. To eliminate the ion component of the electron beam, the adjacent ends of electrodes 22 and 24 respectively, are designed to form an electron lens field having an axis inclined to the axis 25 of the electrode structure of the electron gun. As shown, the adjacent or proximate ends of electrodes 22 and 24, are open, and the planes of these ends are inclined at an angle to the axis 25 of the electrode structure. The electrostatic electron lens field thus formed between electrodes 22 and 24 deflects the electron and negative ion stream off the gun axis 25 to a path whose direction is toward axis 13. The inclination of the planes of the proximate ends of these electrodes 22 and 24 is similar to that described in the above cited U. S. Patent 2,496,127, which discloses that the inclination is around $13\frac{1}{2}^\circ$ from the electrode axis, in a tube of the type described. However, this angle of inclination is not critical, as present guns are being made with approximately a 10° tilt. This inclination must be such, however, that the unsymmetrical electrostatic field, produced between the inclined ends of the tubular electrodes 22 and 24, will bend the ion stream off gun axis 25 to an extent that it cannot pass through the apertured disc 23 and also bend the electron beam toward the tube axis 13.

To separate the electrons of the beam 29 from the negative ions present in the beam, a magnetic field is applied adjacent to electrode 22. In Figure 1, the direc-

tion of the magnetic field will be perpendicular to the paper and having an effect on the electrons of the beam in the direction of the arrow "R" as shown, which is opposite to the deflection produced by the unsymmetrical electrostatic fields. This magnetic field is of a strength to deflect the electrons of the beam to the center of limiting apertured disc 23. The much heavier negative ions present in the beam will not be appreciably affected by this magnetic field and will hence continue on in the diverted direction to strike the side of disc 23, as shown at 27. The magnetic field, producing the effect shown by the arrow "R," may be of any desired type, such as that produced by an electromagnet connected to a direct current source, or, as is shown in Figure 1, by a permanent magnet 26, in the form of a ring, which encircles the tubular envelope portion 12 adjacent electrode 22. The poles of the permanent magnet ring 26 are positioned so as to provide a magnetic field perpendicular to the paper of Figure 1 and to produce the magnetic effect in the direction of the arrow "R," as shown.

Thus, the purpose of misaligning the gun parts relative to the tube axis 13 is to provide a simplified structure for separating the ion and electron components of the electron beam. Furthermore, the use of a single, magnetic field leaves the beam off the gun axis 25, as shown, but does align the beam with the center of the beam limiting disc 23. The gun is tilted away from tube axis 13 about the center of disc 23 an amount to align the final beam direction substantially with tube axis 13.

The conical envelope portion 10 is closed by a transparent face plate 28, as shown in Figure 1. On the inner surface of the face plate 28 is a thin film 30 of a phosphor material which will produce a visible luminescence when struck by an electron beam. Principal focusing means are provided to bring the electrons of the beam to a fine focused point on the phosphor screen 30. Such focusing means may be, for example, as shown in Figure 1, a focusing coil 32 mounted around the tubular envelope portion 12 of the envelope. The focusing coil 32 is carefully made and mounted so that the axis of coil 32 will coincide with axis 13 of the tubular envelope portion. To provide scansion of the electron beam over the phosphor screen 30, two pairs of magnetic coils are used, which provide a pair of magnetic fields perpendicular to each other and to the axis 13 of the envelope portion. These two pairs of deflecting coils are normally formed, as a single assembly unit, in the deflecting yoke represented by 34 of Figure 1. The neck yoke has an open center as is shown and is mounted coaxial with the focusing coil 32. In the example shown, the neck yoke 34 is constructed to have a relatively close fit about the neck portion 12 of tube envelope and is constructed so that the center planes of the perpendicular pair of deflecting fields will intersect substantially on the axis 13 of the tube envelope. Each pair of deflecting coils are respectively connected to circuits providing appropriate saw-tooth currents to provide, respectively, line and frame scanning of the electron beam as is well known.

The angle of tilt of the electron gun relative to tube axis 13 may vary from tube to tube. However, since aperture 36 can be centered relatively accurately on the tube axis, then, when the beam provides maximum current to the screen, as judged by its brightness, the electron beam will be substantially aligned with the axis 13 of the neck. Diaphragm 23, can be made to relatively close tolerances and may be positioned within the tubular neck 12 sufficiently accurately by flexible spring spacer members 38. The ion magnet field is adjusted to provide maximum screen light and thus maximum current through aperture 36.

To prevent the collection of charges on the glass surface of the envelope cone portion 10, a conductive coating 37 is provided on the inner surface of cone 10 and extends into the neck portion 12 to a point below diaphragm 23. Coating 37 may be non-light-reflective, such as a colloidal

dispersion of carbon in a binder material, as is well known.

The aperture 36 may limit the cross-sectional area of the electron beam as it leaves the gun structure. Since aperture 36 is located at the center of the neck portion 12, and the deflecting yoke 34 is centered on the neck 12, adjustment of the ion magnet field to provide maximum screen light, will provide good centering of the beam in the yoke 34. Positioning the limiting aperture 36 adjacent the opening of deflecting yoke 34, the electron beam passing down the axis 13 of the tube will pass into the deflecting yoke 13 substantially at the center of the perpendicular deflecting fields. If any misalignment of gun parts occurs, or if the electron beam is not centered relative to the axis 13 of the tube, the limiting aperture 36 positioned, as shown, near the opening of the neck yoke 34 will provide a much more axially aligned electron beam, than if the defining diaphragm 23 were closer to the electron source.

The above described gun structure and that shown in Figure 1, has several distinct advantages over prior structure. First, only a single magnetic field is necessary to realign the electron gun with the tube axis. Furthermore, by positioning the masking diaphragm 23 adjacent to the deflecting fields, a much more accurate alignment of the electron beam with the center of the deflecting fields is provided. Furthermore, the arrangement permits the elimination of misalignment of the electron beam with the axis of the focusing field which improves the focusing of the electron beam on the fluorescent screen, as described above.

In Figure 1, the focusing coil 32 is illustrated as being adjustably mounted relative to the deflecting yoke 34. For example, a pair of set screws 40 are used to fasten the focusing coil 32, through rigid ear portions 42, to the casing of the deflecting yoke 34. By adjusting the length of either set screw 40, the plane of the focus coil 32 may be tilted relative to the tube axis 13, to center the deflected pattern on the tube screen, whenever necessary. This arrangement also provides means for correcting any small unsymmetrical deflection or tilt of the neck 12 with respect to the face plate 28. If the axis of the envelope neck portion 12 and the conical envelope portion 10 are slightly misaligned, the electron beam on the neck axis can be directed onto the cone axis by such a tilting of the focus coil 32. Correction of such misalignment of tube neck and cone may also be made by adjusting the ion trap magnet 26 until the electron beam is brought off center of the tube axis to a small degree and then tilting the plane of the focusing coil 32 relative to the axis 13 of the tube so as to direct the off-center beam through the masking aperture 36 along the axis of the face plate 28. Such adjustments would provide a certain amount of distortion due to the tilt or off-center position of the focusing field. However, electrical centering within the yoke can be used to avoid such distortions, due to tilting the focusing coil 32. It has been found however, that very little centering is needed. The focus coil may also be used for centering by decentering it on the neck. The effect is similar to tilting the focus coil and in some cases is preferable to tilting. It is thus seen by the use of a single ion trap magnet, certain adjustments can be made which are difficult with the prior structure utilizing a pair of ion trap magnets.

Figures 2 and 3 disclose modifications of the structure described in Figure 1. Each of these modifications utilize an electron source offset from the common axis of the deflection coil and the focusing coil, as well as an electrostatic refracting field for directing the electron beam toward this common axis, and a magnetic field for aligning the electron beam with the common axis. In these figures, the same numerals are used for identical structures shown in Figure 1.

In Figure 2 for example, there is disclosed a cath-

ode 14, a control electrode 16 and an accelerating electrode 22 similar to the corresponding structure of Figure 1. However, electrodes 14, 16 and 22 are coaxially mounted on an axis which is offset from axis 13 of the tube neck 12 and which is also parallel to axis 13. An accelerating electrode 46, of Figure 2, is a tubular structure closed by a diaphragm 48, as shown and mounted within the tube neck 12 coaxial with the tube axis 13. The proximate ends of cylinders 22 and 46 are spaced from each other along axis 13 and also lie in planes which are inclined to axis 13 as well as to the common axis of electrodes 14, 16 and 22. As described above, and in the U. S. Patent 2,496,127, to Kelar, cited above, this provides an unsymmetrical electrostatic field or electron lens which bends the electron beam 29 formed by electrodes 16, 14 and 22 toward the axis 13. As in Figure 1, a magnetic field, provided by a permanent magnetic ring 26, has a direction perpendicular to the plane of the paper of Figure 2 and such to have an effect on the electrons of the beam in the direction of the arrow "S." The ring 26 is shown and constructed so that the field established by the ring 26 will direct the electrons of the diverted beam through the limiting aperture 36 of diaphragm 48, in a manner similar to that described for the arrangement of Figure 1.

The tube of Figure 2 is also provided with a focusing coil 32 and a deflecting yoke 34 comprising the deflecting coils described above. The arrangement of Figure 2 thus provides an ion-free electron beam which is substantially aligned with the axis 13 of the tube neck 12, which is also the common axis of the focusing coil 32 and deflecting yoke 34. The apertured limiting diaphragm 48 is also provided within the focusing field of coil 32 and near the opening of yoke 34 to accurately align the electron beam with the axis of the deflecting yoke as described above. Also, focusing coil 32 is adjustable relative to the axis 13 of the tube by the set-screw arrangement 40 described in Figure 1. The limiting diaphragm 48 is positioned accurately on the axis 13 of the tube neck 12 by spring spacers 38, which also form contact with the conductive coating 37 as described for the tube of Figure 1.

Figure 3 discloses a simplified gun structure in which the accelerating electrode has been eliminated and a prefocusing and beam acceleration takes place between a control grid electrode 50 and the wall coating 37, which in this modification is extended farther into the end of the tube to enclose the end of the control electrode 50. Control electrode 50, furthermore, has a skirt portion 52 extending beyond a control grid diaphragm 54. The end of skirt portion 52 is cut at an angle so that the plane of the end of the skirt portion is inclined to the axis 13 of the tube neck. This inclination provides a refracting, unsymmetrical electrostatic field or electron lens between portion 52 and wall coating 37. Both cathode 51 and control electrode 50 are coaxially mounted on an axis parallel to axis 13 of the envelope neck portion 12 but offset therefrom. The inclination of the plane of the end of the grid 52 is in the direction to direct the electron beam emerging from the control grid cylinder toward axis 13 of the tube.

As in Figures 1 and 2, a permanent magnet 26 is positioned around the neck 12 of the tube of Figure 3 and substantially in the region of the refracting electrostatic field. As before, ring 26 provides a magnetic field whose effect on the electrons of the beam is in the direction shown by the arrow "T" to direct the electrons of the beam through a limiting aperture 58 and substantially on the axis 13 of the tube. To limit the cross-sectional area of the beam and provide more accurate alignment of the beam with the center of the deflecting coil of yoke 34, a limiting diaphragm 56 is

mounted within the tube and adjacent the open center of deflecting yoke 34. Diaphragm 56 is positioned with limiting aperture 58 coaxial with the axis 13 of the tube. Diaphragm 56 may be mounted as is shown by spring fingers positioned on either side of a small constricted portion 60 on the envelope neck portion. Furthermore diaphragm 56 may be used as a supporter for a getter 62 as shown. Getters 62 are also disclosed in Figures 1 and 2, and supported on the anode structure.

While certain specific embodiments have been illustrated and described, it will be understood that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

I claim:

1. A cathode ray tube comprising an envelope having a tubular portion, an electron gun structure within said tubular envelope portion for producing a mixed beam of electrons and negative ions, said gun structure comprising an electron source and a plurality of tubular electrodes axially spaced from said electron source along the tubular portion of said envelope and mounted on a common axis inclined to and intersecting the axis of said tubular portion with said electron source farthest from the axis of said tubular envelope portion, the proximate ends of an adjacent pair of said electrodes being inclined to said common electrode axis to form an unsymmetrical electrostatic lens between said proximate ends for changing the direction of the path of said mixed beam to substantially intersect said axis of said tubular envelope portion.

2. A cathode ray tube comprising an envelope having a tubular portion, an electron gun structure within said tubular envelope portion for producing a mixed beam of electrons and negative ions along a path, said gun structure comprising an electron source and a plurality of tubular electrodes axially spaced from said electron source along the tubular portion of said envelope and mounted on a common axis inclined to and intersecting the axis of said tubular portion with said electron source farthest from the axis of said tubular envelope portion, the proximate ends of an adjacent pair of said electrodes being inclined to said common electrode axis and toward the axis of said tubular envelope portion, the electrode spaced farthest from said electron source including a plate member positioned transversely to the common axis of said electrodes and to the axis of said tubular envelope portion at a point adjacent to the intersection of said axes, said plate member having an aperture through which said axes pass.

3. A cathode ray tube comprising, an envelope having a tubular portion, an electron gun within said tubular envelope portion, said electron gun including an electron source and a plurality of tubular electrodes axially spaced from said electron source along the tubular portion of said envelope and mounted on a common axis inclined to and intersecting the axis of said tubular portion with said electron source farthest from the axis of said tubular envelope portion, the proximate ends of an adjacent pair of said electrodes being inclined to said common electrode axis and toward the axis of said tubular envelope portion, the electrode spaced farthest from said electron source including a plate member positioned at an angle to the common axis of said electrodes and substantially perpendicular to the axis of said tubular envelope portion at a point adjacent to the intersection of said axes, said plate member having an aperture through which said axes pass.

4. An electron gun for a cathode ray tube, said gun comprising a cathode electrode having a surface for the emission of electrons, a first tubular electrode spaced from said cathode electrode surface, a centrally apertured wall portion mounted transversely across said first tubular electrode, the electron emitting portion of said cathode surface being in a position displaced from the

axis normal to said apertured wall portion at its center thereof, and a second tubular electrode adjacent said first tubular electrode and between said first tubular electrode and said cathode surface, said first and second tubular electrodes being aligned on a common axis inclined to said normal axis, one of the adjacent ends of said tubular electrodes being formed at an angle to said common axis to form an unsymmetric electron lens field to direct electrons from said cathode surface toward said normal axis.

5. A cathode ray tube comprising an envelope having a tubular portion, an electron gun structure within said tubular electrode portion including a plurality of electrodes for producing a mixed beam of electrons and negative ions along a path having a specific direction, said electrodes including a cathode electrode a control grid electrode and a first accelerating electrode, said electrodes being of substantially tubular form and mounted in spaced relationship along a common axis extending along said beam path, said common axis being inclined to and intersecting the axis of said tubular envelope portion, a second tubular accelerating electrode coaxially mounted on said common axis and adjacent to and between said first accelerating electrode and said point of intersection of said axes, the proximate ends of said adjacent first and second accelerating electrodes being inclined to said common axis and toward the axis of said tubular envelope portion, said second accelerating electrode including an apertured plate member mounted adjacent to the end thereof remote from said first accelerating electrode, said plate member positioned transversely to said common axis of said electrodes and substantially normal to the axis of said tube envelope portion at a point adjacent to the point of intersection of said axes.

6. An electron discharge device comprising an envelope, an electron gun structure within said envelope and including beam forming electrode means for producing a mixed beam of electrons and negative ions along a path having a specific direction, means providing a pair of deflecting fields having directions perpendicular to each other and perpendicular to an axis inclined to said beam path, said electron gun comprising electrode means between said beam forming means and said deflecting means for producing a refracting field for directing said mixed

beam toward said axis and away from said beam path, said electron gun including an electrode having a diaphragm positioned transversely to said beam path and to said axis and between said beam refracting means and said beam deflecting means, said diaphragm having an aperture therethrough surrounding said beam path and said axis, whereby said discharge device is adapted to be used with means producing a magnetic field in the region of said refracting field for acting on said mixed beam to deflect only the electrons of said beam through the aperture of said diaphragm.

7. A cathode ray tube comprising an envelope having a tubular portion, an electron gun structure within said tubular portion for producing a mixed beam of electrons and negative ions directed along a path, said gun structure comprising a plurality of apertured electrodes coaxially mounted on a common axis coincident with said beam path and inclined to the axis of said tubular envelope portion, an adjacent pair of said apertured electrodes having adjacent end portions unsymmetrically disposed relative to said common axis to form therebetween an unsymmetrical electrostatic field relative to said common axis for directing said mixed beam toward the axis of said tubular envelope portion.

References Cited in the file of this patent UNITED STATES PATENTS

2,181,850	Nicoll	Nov. 28, 1939
2,211,614	Bowie	Aug. 13, 1940
2,274,586	Branson	Feb. 24, 1942
2,456,474	Wainwright	Dec. 14, 1948
2,460,609	Torsch	Feb. 1, 1949
2,472,766	Woodbridge	June 7, 1949
2,496,127	Kelav	Jan. 31, 1950
2,580,355	Lempert	Dec. 25, 1951
2,604,599	Breeden	July 22, 1952

OTHER REFERENCES

The Negative-Ion Blemish in a Cathode-Ray Tube and Its Elimination, by R. M. Bowie. Proceedings of the Institute of Radio Engineers, vol. 36, No. 12 (pages 1482-1486), December 1948.