Jan. 31, 1950 J. KELAR 2,496,127

ELECTRON GUN FOR CATHODE-RAY TUBES

Filed Feb. 5, 1947 2 Sheets-Sheet 1

Fig. 1

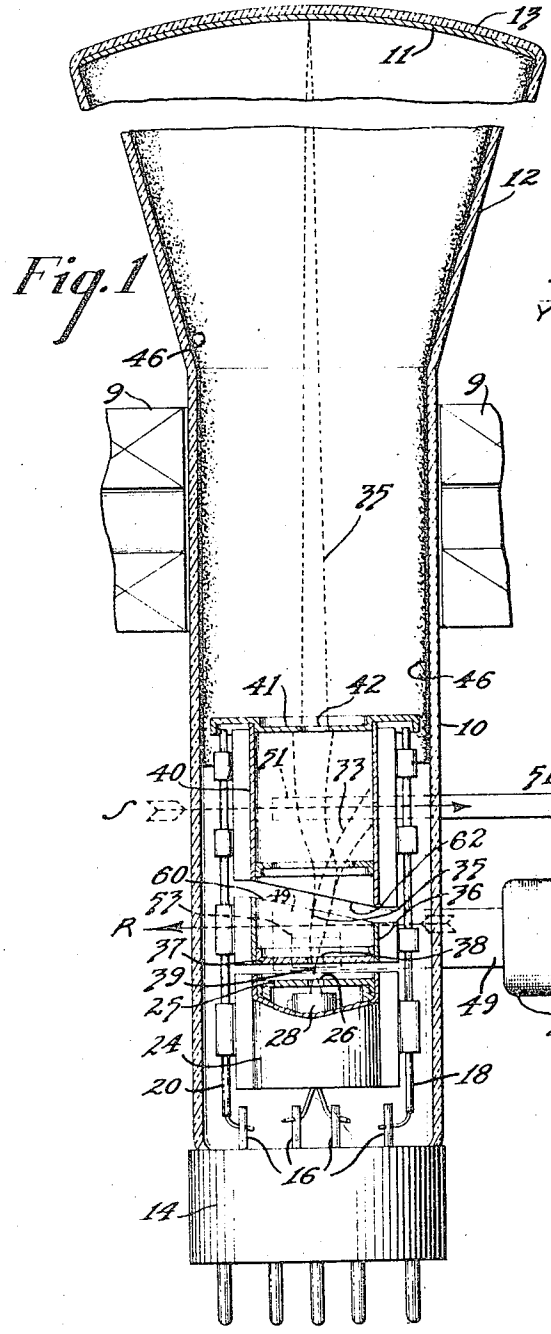


Fig. 3

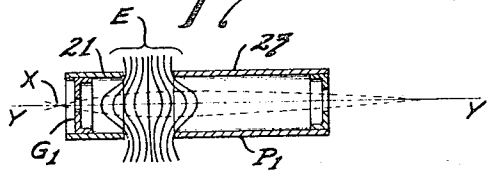


Fig. 4

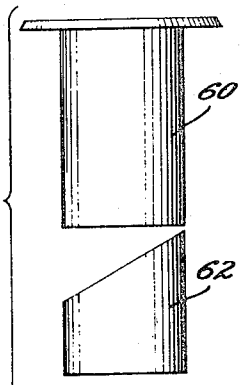
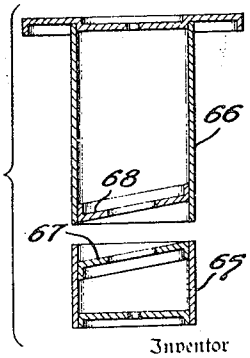


Fig. 5



Inventor

Joseph Kelar

By

William A. Zalusak

Attorney

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ELECTRON GUN FOR CATHODE-RAY TUBES

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Fig. 2

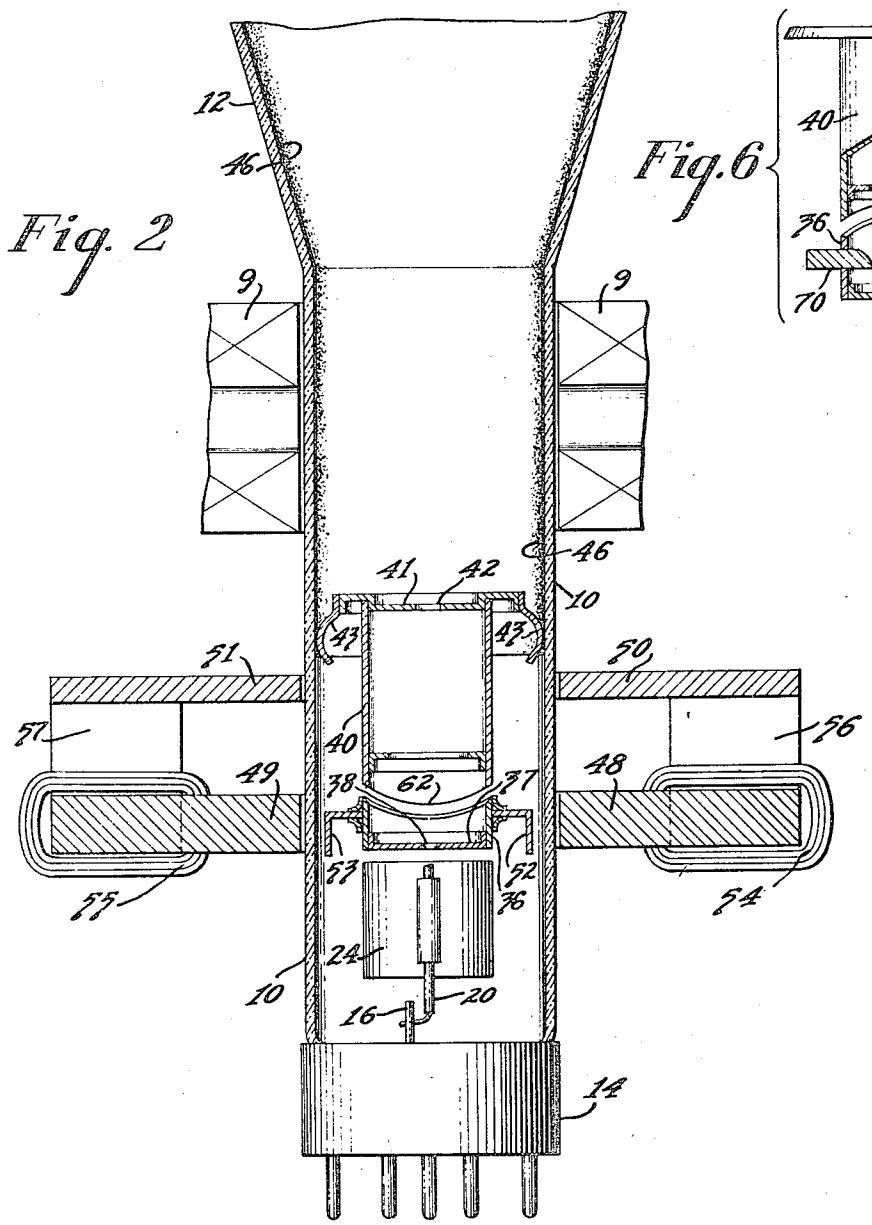
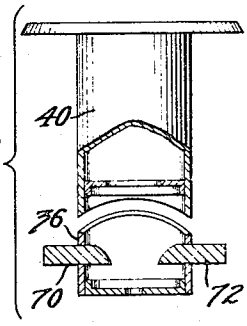


Fig. 6



Inventor
Joseph Kelar

By
William A. Zalesak
Attorney

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ELECTRON GUN FOR CATHODE-RAY TUBES

Joseph Kelar, Lancaster, Pa., assignor to Radio Corporation of America, a corporation of Delaware

Application February 5, 1947, Serial No. 726,589

38 Claims. (Cl. 250—162)

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My invention relates to electronic discharge devices in which, as in television receiving tubes, and similar devices, an electron beam or cathode ray from a thermionic cathode is directed to a fluorescent screen and is deflected to traverse the surface of the screen by conventional magnetic or electrostatic deflection.

In a highly evacuated cathode ray tube in which an electron beam from a conventional electron gun is focused on a fluorescent screen and deflected over the screen both vertically and horizontally by magnetic deflection there may appear at the center of the screen after the tube has been in operation for some time a discoloration or dark spot usually referred to as ion spot. This dark spot is due to bombardment of the screen by negatively charged heavy particles or negative ions, which appear to originate at or near the cathode and are of much greater mass than the electrons, although each negative ion usually has the same negative charge as an electron.

Since both the electrons and the negative ions have the same negative charge both are deflected to the same extent by an electrostatic field, and therefore in a cathode ray tube with full electrostatic deflection the negative ions trace the same pattern on the screen as the electrons and the darkening effect of the negative ions is spread so uniformly over the entire scanned area that the darkening of the screen does not become objectionable during the life of the tube.

In a conventional cathode ray tube with magnetic deflection, a substantially constant electrostatic field accelerates the discharge or stream from the cathode towards the screen, the heavy negative ions travelling much more slowly toward the screen and through the magnetic deflecting field than the lighter electrons. The force exerted on a charged particle travelling in a magnetic field is a function of its velocity as well as its mass. The discharge or stream leaving the cathode is non-homogeneous and is a composite beam consisting of a mixture of light electrons and heavy negative ions all having the same negative charge. As this composite stream passes through the magnetic deflecting fields, which have components perpendicular to the direction of motion of the stream, the light electrons will be deflected much more than the heavy negative ions, which continue on their course through the magnetic fields practically undeflected.

In a cathode ray tube with electrostatic focusing both the electrons and the negative ions are equally constrained by the focusing field and the composite stream from the cathode is formed into

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a beam focused into a small spot at the center of the screen. The negative ions in the beam produce on the screen a spot which is small and quite dark. With magnetic focusing the focusing field constrains the electrons in the composite stream into a beam focused on the screen, but has practically no effect on the negative ions which constitute an unfocused ion beam and produce an ion spot which is as large as the unfocused electron beam and which in a conventional tube may be an inch or more in diameter.

In order to prevent the negative ions from reaching the screen combinations of electrostatic and magnetic fields have been used to separate or trap out the negative ions from the composite stream so that only the electrons reach the screen. The operation of these ion traps depends on the difference in deflection of ions and electrons by electrostatic and magnetic fields. An electrostatic field deflects both the electrons and the negative ions to the same extent, while for practical purposes the magnetic field deflects only the electrons.

The combinations of electrostatic and magnetic fields heretofore proposed as ion traps require mechanical constructions of the electron gun and associated parts of the tube that are difficult to make and assemble, and are not practical and feasible for production of cathode ray tubes on a large scale. In some cases the bulb of the tube has a neck which is bent or is at an angle to the bulb. Such a bulb is difficult to make and to handle. In other cases the electron gun structure is bent or is formed of parts set at an angle to each other, a construction which is not rugged and in which proper alignment of the tube parts is difficult. In some cases the gun is tilted or unsymmetrical with reference to the axis of the tube. Such structure complicates the problems of gun assembly and limits the tube to magnetic focusing.

It has also been proposed that the composite beam emerging from the gun be directed through an electrostatic field between a pair of parallel beam bending plates mounted near the end of the gun to bend the composite beam away from the longitudinal axis of the gun, and that there be provided across the electrostatic field between the plates a magnetic field of such strength and directions as to keep the electrons in the composite beam in a path along the axis of the tube. This design is not practical for the reason that satisfactory insulation and mounting of the electrostatic beam bending plates in this position close to the end of the anode of the gun is very difficult, because of the high voltage required on the anode

and the small space available for these beam bending plates in the conventional type of tube.

In the proposed constructions the electrostatic and magnetic fields are applied to the composite beam after it has left the gun, has passed through the focusing field, and is a concentrated beam at maximum velocity. The separation of the negative ions and electrons in the concentrated high velocity beam is difficult, since with a given strength of the two fields the greater the velocity of the beam the less the divergence between the paths of the electrons and of the ions.

The principal object of my invention is to provide a cathode ray tube having an ion trap of simple rugged construction well adapted to production on a large scale and by the equipment and methods commonly used in the production of conventional cathode ray tubes.

Another object of my invention is to combine the electrostatic and magnetic fields in a novel way to improve the separation of the negative ions from the electrons and the trapping of the negative ions.

A further object is to provide a construction in which the entire electron gun is on the axis of the tube which makes easier the checking and control in production.

A further object is to provide an electron gun in which all the anode cylinders and aperture discs are symmetrical about the axis of the gun which permits simple alignment and assembly of the gun parts.

Another object is to provide an electron gun which is as easy to make and has no more parts than the conventional gun, and in which possibility of error in assembling and aligning the cylindrical electrodes of the gun in relation to each other is no greater than in the conventional gun.

A cathode ray tube that is practical for production on a large scale should have a straight electron gun mounted on the axis of the tube, and should be adapted to electrostatic as well as magnetic focusing.

In accordance with another object of my invention the combined electrostatic and magnetic fields for separating the negative ions and the electrons are as close to the cathode as feasible so that the separation occurs at a point in the path of the composite stream where the velocity of the beam is low and the divergence of the electrons and of the negative ions is greater for a given strength of the fields than at a point further along the path of the beam where the velocity of the beam is high. The negative ions are removed from the composite stream or discharge from the cathode and discarded before the electrons in the stream enter the focusing field on their way to the scanning field. In this way a better and more complete separation of the electrons from the negative ions is obtained and the focusing and scanning fields have to deal only with an electron beam, which is an advantage from the operating standpoint.

Reference is made to an earlier filed copending application Serial No. 643,095, filed January 24, 1946.

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:

Fig. 1 is a longitudinal sectional view of a cathode ray tube according to my invention;

Fig. 2 is a longitudinal sectional view of a cathode ray tube essentially the same as that of Fig. 1 and in which the tube is turned 90° from the position of the tube of Fig. 1;

Fig. 3 represents graphically a conventional electron lens;

Fig. 4 represents graphically an electrode structure forming a modification of my invention;

Fig. 5 is a sectional view of the second grid-first anode electron lens, according to my invention; and

Fig. 6 is a partial sectional view of the second grid-first anode electron lens, according to another modification of my invention.

Figs. 1 and 2 disclose a preferred type of cathode ray tube employing my invention. The envelope has a tubular neck portion 10 and a bulb portion 12 fused thereto. The bulb portion 12 is closed by face plate 13 which is coated on its inside with a fluorescent film 11. Mounted within the neck portion 10 of the tube envelope is an electron gun structure for forming, accelerating and focusing an electron beam 35 on the fluorescent screen 11. A neck yoke diagrammatically shown at 9 surrounds the neck of the tube portion 10. Yoke 9 comprises a magnetic focusing coil as well as a pair of horizontal, or line, deflection coils and a pair of vertical, or frame, deflection coils for causing the electron beam to scan the surface of film 11.

A defect in cathode ray tubes of the magnetic deflection type similar to that shown in Fig. 1 is the formation of an ion spot on the fluorescent screen. This ion spot is a darkening of a portion of the screen due to the bombardment of the fluorescent material by negative ions. These negative ions are formed within the tube at or near the cathode and become a component of the negative electron beam focused on the fluorescent screen by the electron gun. Although a few of the negative ions in the cathode ray tube may be produced by the ionization of residual traces of gas left within the tube after exhaust, recent evidence points to the cathode as the source of most of the negative ion component of the electron beam. Research has shown that the greatest number of the ions are hydrogen, oxygen, the halogens and various hydrocarbons. The fact, that these elements and radicals appear in the oxide coating of the cathode and that the ion spot has been found to resemble the electron image of the cathode on the fluorescent screen, would substantiate the belief that the cathode is the source of the destructive negative ion component of the electron beam.

In a transverse electrostatic field, moving ions and electrons are deflected from their paths the same amount, while a transverse magnetic field deflects the ions only a negligible amount compared to its deflection of electrons. The deflection of moving charged particles in a transverse magnetic field is inversely proportional to the square root of their masses. In a cathode ray tube using magnetic deflection, the ion component of the electron beam is not deflected from the center of the screen and causes the localized darkening or ion spot, mentioned above.

The gun structure of Fig. 1 comprises a plurality of cylindrical electrodes spaced from each other longitudinally along the axis of the neck 10 of the tube envelope to provide a preliminary focus upon screen 11 of the electron beam formed by the gun. Ceramic rods 18 and 20 mounted respectively on stem lead pins 16, support a signal grid electrode cylinder 24. Cylinder 24 is co-

axially aligned with the tube neck 10. A plate or disc 25 closes the upper end of the grid cylinder and has an opening or aperture 26 at its center. Mounted within the grid cylinder 24 is a thermionic cathode cylinder 28 having a closed end spaced from the grid aperture 26. This closed end of the cathode adjacent to the grid opening 26 is coated with a mixture of alkaline earth oxides to provide a source of electron emission. A heater filament (not shown) within the cathode cylinder maintains the cathode at the temperature most favorable for electron emission.

An auxiliary tubular electrode 36 is axially spaced along the tubular neck 10 from the grid cylinder 24. The electrode 36 is also mounted on the supporting ceramic side rods 18 and 20. The tubular portion 36 is closed at its lower end by a shield or screen grid disc 37 having an aperture 38 at its center. Axially spaced along the tube neck 10 from electrode 36 is tubular first anode electrode 40. Electrode 40 is also, preferably, of a cylindrical configuration and is mounted coaxial to electrode 24 and 36 on the ceramic side rods 18 and 20. The upper end of electrode 40 is closed by a disc 41 having an opening or aperture 42 at its center. A conductive second anode coating 46 is applied to the inner surface of the tube envelope and is extended over the inner surface of the bulb 12 to a point adjacent the phosphor screen 11. Conductive coating 46 may overlap the upper end of the tubular electrode 40, as is shown in Figs. 1 and 2. This conductive coating 46 is, preferably, of a graphite mixture. As a second anode electrode, coating 46 accelerates and focuses the electron beam produced toward the tube face 13.

It is well known that a sufficiently narrow electron beam will be focused by any known uniform electrostatic or magnetic field provided these fields have an axial symmetry with the beam. Such a field constitutes an electron lens. Because of the large number of geometrical structures that will satisfy this requirement, electrode lenses and electron guns assume a variety of forms.

Fig. 3 illustrates an electron lens formed by two tubular electrodes 21 and 23 of different potential spaced along a common axis Y. The transverse lines E between electrodes 21 and 23 illustrate roughly the position of equipotential surfaces of the electrostatic field forming an electron lens. These surfaces are symmetrical about the axis Y of the two cylindrical electrodes. If a beam of electrons, diverging from a point X on the axis Y and to the left of an apertured grid plate G_1 of electrode 21, is directed along axis Y through the aperture of grid G_1, it will pass through the non-uniform field between electrodes 21 and 23. The shape of this field and its symmetry about axis Y effects a converging of the electron beam back toward the axis, as is graphically shown by the dotted lines.

In Fig. 1, the tubular electrodes 24, 36, 40 and 46 are, preferably, maintained at different positive potentials. This arrangement produces a series of electron lenses between adjacent electrodes. This lens system tends to form the electron emission from the cathode 28 into a beam, and tends to accelerate and form a partial focussing of the beam onto screen 11. In the type of tube shown in Fig. 1, the focussing coil of the yoke 9 provides the principal focussing of the beam as a fine spot on screen 11.

The control or signal electrode 25 is operated at a small negative potential and modulates the

electron emission from the cathode. Screen grid 37 is an accelerating electrode. The bipotential lens between electrodes 36 and 24 bends the electron beam toward the gun axis and causes the electrons to cross over at a point such as 39 beyond aperture 26. Grids 25 and 37 form an electron lens of very short focal length providing a short crossover point 39. The beam 35 is composed mostly of electrons but has also an undesired negative ion component as described above. To eliminate this negative ion component the adjacent ends of the tubular electrodes 36 and 40 are modified. Normally, in a conventional gun structure the adjacent ends of the electrodes 36 and 40 are formed perpendicular to the gun axis in a manner shown in Fig. 3. However, in Fig. 1 the adjacent ends of the tubular electrodes 36 and 40 are formed parallel to each other but at an angle to the gun axis. Preferably, accelerating electrode 36 is maintained at about 250 volts positive potential while the first anode electrode 40 is operated at several thousand volts. An electrostatic lens field is established between the electrodes 36 and 40, yet, due to the fact that the adjacent ends of these electrodes are cut at an angle to the gun axis, the electron lens formed is not coaxial with the gun. The low potential area of the forward or overlapping portion 60 of grid electrode 36 pushes the lens field up at one edge while portion 62 of electrode 40 pushes the edge of the lens field down in the opposite direction, so that effectively the lens is tilted about an axis perpendicular to the gun axis and to the plane of the paper of Fig. 1. Furthermore, the tilted lens is unsymmetrical relative to the gun axis.

The effect of the tilted electrostatic lens between electrodes 36 and 40 on the electron beam 35 is such that the beam is bent sharply toward the wall of the gun structure. The effective field of the tilted lens extends into the tubular electrode 36 so that the bending of the beam 35 starts close to the crossover 39, at first abruptly and then more gradually as the beam passes through the tilted lens formed between electrodes 36 and 40.

As the field of the tilted lens is electrostatic, both the electron and negative ion components of the beam are bent by the lens action to the same degree. To separate the electrons from the deflected beam, a magnetic field is impressed upon the region of the tilted lens field. The lines of force of the magnetic field are transverse to the gun axis and parallel to the axis about which the electron lens is tilted. In Fig. 1, the magnetic field would be directed perpendicular to the plane of the paper. The direction of the magnetic field is such that its effect on the electron component of the beam is opposite to that of the unsymmetrical electrostatic field of the tilted lens. The dotted arrow R in Fig. 1 indicates the direction in which the electron component of beam 35 is bent by the magnetic field. Since the deflection of moving charge particles in a transverse magnetic field depends upon the mass of the particles, the strength of the magnetic field imposed upon the electron beam 35 is selected so as to divert the electrons back toward the axis of the gun. Due to the much larger masses of the ion particles, this magnetic field has little or no effect upon the ion component of beam 35. Accordingly, the ions of the beam 35 continue on in the same direction that they were deflected by the electrostatic field of the tilted lens and tend to separate from the electrons as a beam 33 which

strikes the edge of the tubular electrode 40 as graphically shown in Fig. 1.

The magnetic field which is used to separate the electrons from the ion component 33 of beam 35, is produced by a magnet having poles 48 and 49 aligned on opposite sides of the envelope neck 10 as shown in Fig. 2. The poles 48 and 49 are arranged to produce a uniform magnetic field through the region of the tilted electrostatic lens. The direction of the field is parallel to the axis about which the lens field was tilted. The effect of the superimposed magnetic and electrostatic fields upon the electron beam is that the bend produced by the electrostatic field takes place in a much shorter distance axially along the gun than does the bend of the electrons in the opposite direction produced by the magnetic field. This is undoubtedly due to the unavoidably large spacing between the poles 48 and 49 of the magnet which produces a magnetic field of greater extent than that of the electrostatic field of the tilted lens between electrodes 40 and 36.

It is not practically possible to completely neutralize the effect of the electrostatic field on the electron beam by the superimposed magnetic field of poles 48 and 50. Consequently, the electrons are bent first in one direction away from the gun axis by the electrostatic field and are then more gradually brought back to the gun axis by the magnetic field. The bending of the electron beam by the magnetic field is from a point off of the gun axis, so that the electron beam returns to the axis of the gun at an angle. This results in that the portion of the electron beam passing through the masking or limiting aperture 42 tends to strike the fluorescent screen 11 at an offcenter point. I found that the defect could be improved by increasing the length of the gun structure which would bring the electron spot closer to the center of the screen 11. Although such a cathode ray tube having an electron beam focused at an offcenter spot may be used with good results, it was felt that further improvement could be made. In order to align the electron beam with the axis of the gun, I have provided a second magnet having poles 50 to 51 mounted in alignment with each other on opposite sides of the tube neck 10. The second magnet 50 and 51 is arranged so that the magnetic field established between the poles 50 and 51 is transverse to the axis of the gun and also parallel to the magnetic field established between poles 48 and 49. However, the direction of the magnetic field between poles 50 and 51 is opposite to that produced by the first magnet 48, 49. The field of the second magnet 50, 51 bends the electron beam in the direction of the dotted arrow S of Fig. 1, so as to direct the electron beam back into alignment with the gun axis. This expediency of the second magnetic field also provides a convenient means for accurately centering the electron beam on the center of the fluorescent screen 11.

The operation of the ion trap gun structure of Figs. 1 and 2 is that the mixed beam of electrons and negative ions is brought to the first focus or crossover 39 by the immersion lens between the cathode surface and the control grid 25. In passing through aperture 38 the beam is divergent. The tilted lens between the accelerating anode electrode 36 and the first anode 40 reduces the divergence of the beam so that when the electron beam is realigned with the gun axis by the magnetic field of magnet 50—51, there will be only a slight spreading of the beam from the gun axis. The beam in passing through the limiting aperture 42 of the first anode is reduced to the core or the somewhat parallel portion of the beam. The bi-potential lens between the first anode 40 and the second anode 46 then accelerates and focuses this portion of the beam on the screen 11.

In the ion trap gun of Figs. 1 and 2, the tilted lens is part of the beam focusing lens system of the gun. The electrostatic bending of the mixed beam takes place very close to the first cross-over 39 and in a region where the beam particles are moving relatively slowly. This does not necessitate the use of strong magnetic and electrostatic fields to separate the electrons from the ions. Furthermore, the tilted lens field is more uniform and creates less distortion and aberration than the electrostatic field between two plates of different potentials which have formerly been used to separate the electrons from the negative ions.

It is difficult to produce a sharply defined magnetic field by magnet poles 48 and 49 so as to conform closely with the electrostatic field. However, to intensify the strength of the magnetic field produced by magnets 48—49, it has been found practical to use L-shaped pole pieces 52 and 53 mounted on opposite surfaces of the tubular electrode 36. The pole pieces 52 and 53 are in alignment with the magnet poles 48 and 49. Although the pole pieces 52 and 53 do intensify the strength of the magnetic field within the desired region of the electrostatic field between electrodes 36 and 40, the bending produced by the magnetic field of the electron stream is still effective over a greater distance axially along the electron gun.

Magnets 48—49 and 50—51 may be of any appropriate type for establishing their respective magnetic fields. However, the preferred structure is shown in Figs. 1 and 2, in which two electromagnetic coils 54 and 55 are positioned around the legs respectively of the magnets 48 and 49. These coils 54 and 55, preferably, have the same number of turns of wire and are otherwise substantially identical. Hence, by connecting the coils 54 and 55 in series with each other and with a source of direct current (not shown), a relatively constant electromagnetic field is produced in the space between pole pieces 48 and 49.

For establishing a magnetic field of poles, 50—51 in a direction opposite to the field between poles 48 and 49, the magnet poles 50 and 51 are maintained with a polarity opposite respectively to the polarity of poles 48 and 49. A preferred expediency for establishing the polarity of poles 50 and 51 is to respectively provide therefor extensions 56 and 57. Extension 57 of magnet pole 51 as shown in Fig. 1 is fixedly mounted on a core segment 58 which extends through coil 55 to the side opposite from magnet pole 49. This arrangement provides the magnet pole 51 with a polarity opposite to that of magnet pole 49. In a similar manner extension 56 of magnet pole 50 is fixed to a core segment (not shown) on the opposite side of coil 54 from magnet pole 48.

The two cylinders 36 and 40 (Figs. 1 and 2) may be produced from two rectangularly shaped flat blanks, each of which is slit transversely between its ends at the desired angle. The blanks then are rolled into semi-cylindrical shapes with the lateral edges extending outwards from the cylindrical surface. These lateral edges then are welded together to form a cylinder, which is then

clipped apart to form the two electrodes 36 and 40. It is also possible to form electrodes 40 and 36 as a single cylinder and then separating them by cutting the cylinder into two parts at the desired angle to its axis.

The tilt of the electron lens is so chosen, that at the lowest operating voltage of electrode 40, the ion component of the beam is bent enough to be blanked off by the limiting aperture disk 41. At this voltage of electrode 40 the ion component of the beam will not pass through aperture 42 and will always be effectively trapped within electrode 40 over the operating voltage range of the electrode.

The adjacent ends of the tubular electrodes 36 and 40 are, preferably, cut at an angle of 13½° from a plane perpendicular to the axis of the electrodes. This angle has proved to give the best results. Changes in this angle will change the amount of the bending of the electron beam. A smaller angle would cause less bending than desirable while a steeper angle would require a stronger magnetic field to divert the electrons back toward the axis of the gun. Also, a steeper angle would probably produce distortions in the electrostatic lens, particularly so, if the electrode parts are not carefully made. Furthermore, I have found that the end of one electrode, such as 60 of Fig. 4, may be left straight or perpendicular to the axis of the gun while the adjacent end of the other electrode 62 of Fig. 4 may be cut at an angle. Such a procedure, however, creates other structural difficulties and tends to produce a misalignment of parts. If the end of only one cylinder is cut at an angle it will be necessary to cut it at a steeper angle than if the adjacent ends of both tubular electrodes were at an angle.

The structure of the ion trap disclosed in Figs. 1 and 2 has proved to be a very practical design relative to tube construction. The ion trap of Figs. 1 and 2 is formed from a straight gun structure mounted coaxially with the tube neck 10. This design simplifies the construction of an ion-trap type of gun structure. For example, it eliminates the problems and difficulties involved in constructing an ion trap gun producing an electron beam eccentric to the gun axis. Furthermore, the ion trap gun of Figs. 1 and 2 is made from conventional electron gun structure. The modifications required are simple and can be effected with little or no changes in conventional tube assembly. The magnetic pole pieces 52 and 53 are the only additional structure used within the tube. These pole pieces, however, can be easily assembled to the tubular electrode 36 and do not complicate the construction of the electron gun. The simple structure and design of the tilted lens ion trap gun disclosed in Figs. 1 and 2 eliminate the complications of either a bent tube neck or a bent gun electrode structure commonly associated with previous ion trap guns.

The tilted lens ion trap gun structure of Figs. 1 and 2 may be used in cathode ray tubes having electrostatic as well as in tubes having magnetic focusing without a change in the ion trap design. For example, in Fig. 1, second anode 46 is operated between 6,000 to 10,000 volts. The electron beam is focused electrostatically by adjusting the potential of first anode electrode 40. The gun of Fig. 2 distinguishes from that of Fig. 1, in that the electrodes 40 and 46 are joined together by spring clips 43 mounted on the edge of the limiting grid disc 41 and forming an electrical contact with the conductive surface 46. The two anodes 40 and 46 thus electrically connected together to form a second anode electrode are usually operated at around 6,000 to 10,000 voltage range. However, this range is not limiting. Focus of the electron beam in the gun of Fig. 2 may be produced magnetically by a coil (not shown) placed outside on the glass neck 10 of the tube. The focusing coil may also be used to correct misalignment of the gun structure. The magnetically focused gun of Fig. 2 has an advantage over the electrostatically focused gun of Fig. 1 in which the electrode 40 of Fig. 1 is used for electrostatic focusing. Changes in the potential of the electrode 40 in Fig. 1 will change the tilted electrostatic field between electrodes 36 and 40. This will result in changes in the electrostatic deflection of the electron beam. Such changes in electrostatic deflection of the electron beam must be compensated for by corresponding changes in the magnetic fields of magnets 48, 49, 50 and 51.

However, a tube with an electrostatic focus is desirable since it obviates the use of focusing coils improperly aligned therewith. The focusing coils, which are relatively expensive, may be replaced with a simple electrode in the tube. For example, the gun structure shown in Fig. 2, which is a magnetic focused tube, may be modified by adding an additional focusing electrode beyond electrode 40. This focusing electrode may either take the form of a tube mounted coaxial with the gun and with its lower end overlapping the upper end of electrode 40, or the additional focusing electrode may take the form of an apertured disc mounted coaxial of the tube stem beyond cylinder electrode 40. Electrodes 40 and 46 may still be maintained at the same common potential. In any of these several types of cathode ray tubes mentioned, and having various combinations of electrostatic and magnetic focusing means, it is possible to use, without alteration, the same gun sub-assembly comprising the ion trap section of electrodes 36 and 40.

Fig. 5 discloses a modification of the tilted lens forming electrodes. In this case, the conventional tubular electrodes are used, such as electrode 66 corresponding with electrode 40 of Figs. 1 and 2, and electrode 65 corresponding to the accelerating grid electrode 36 of Figs. 1 and 2. However, the adjacent ends of electrodes 65 and 66 are maintained perpendicular to the gun axis. The tilted lens is formed between electrodes 65 and 66 by the use of apertured discs 67 and 68 positioned in the adjacent ends respectively of electrodes 65 and 66. These apertured discs 67 and 68 are mounted parallel to each other but at an angle to the axis of the gun and to the ends of the tubular electrodes. This modification of Fig. 5 also produces an electrostatic field between the electrodes 65 and 66 which is unsymmetrical to the gun axis. The effect of the unsymmetrical electrostatic field upon an electron beam passing along the gun axis is such as to bend the electron beam away from the gun axis.

If the non-uniform electrostatic field produced by the tilted lens between electrodes 40 and 36 of Figs. 1 and 2 is to be completely neutralized relative to its effect upon the electrons, the magnetic field imposed on the electrostatic field must produce an effect upon the electrons equal and opposite to that produced by the electrostatic field at every point within the field region. However, to approach this ideal condition, the modification of Fig. 6 includes means for producing a more intensified magnetic field for diverting the elec-

trons of the mixed beam back to the gun axis. This magnetic field may be produced by pole pieces 70 and 72 corresponding respectively to the pole pieces 52 and 53 of Figs. 1 and 2. Pole pieces 70 and 72 may be mounted so that they extend through opposite sides of the tubular electrode 36. Furthermore, the opposing ends of the pole pieces 72 and 70 may be shaped so as to produce a magnetic field approaching the same shape as that of the tilted electrostatic field between electrodes 36 and 40. This expediency of mounting the pole pieces so that they extend into the tubular electrode 36 produces a more concentrated magnetic field which results in a less gradual bend of the electrons back to the gun axis.

I have found that the type of electrode formed by cutting the electrode cylinders at an angle and with no apertured discs in the tilted lens structure as shown in the preferred form of Fig. 1 and 2 had a number of advantages. This preferred form of the ion trap of Figs. 1 and 2 permits the building of the entire gun on the axis of the tube which is easier to check and control during production than an electron gun that must be mounted eccentrically of the tube axis or at some angle to the axis of the tube. Furthermore, the advantage of having all cylinders and apertured discs symmetrical about the axis of the gun permits simple tools for alignment during gun assembly compared to, for example, a gun in which the cylinders are bent.

In the ion trap gun of Figs. 1 and 2, a tilted lens of large diameter is formed and the subsequent use of the center portion of it introduces less aberration. The lens structure of Figs. 1 and 2 is also easier to make using fewer parts and eliminates the possibility of incorrect assembly of the cylinders in relation to each other. Because of the large diameter of the tubular electrodes without any barriers which the beam might strike, I have found that it is possible to orient the neutralizing magnetic fields in such a way that if the original beam was not accurately centered in the gun it could be brought back to the gun axis and produce a better focus on the fluorescent screen. Also, the electron beam can be adjusted to go through the center of the limiting aperture 42 after the tube is installed in the equipment even though the gun parts are not in perfect alignment.

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.

What I claim as new is:

1. A cathode ray tube comprising an envelope having a tubular portion, an electron gun structure within said tubular envelope portion for producing and focusing along the axis of said tubular portion a beam of electrons wherein negatively charged ions may be present, said electron gun structure including as a part thereof means for deflecting said beam from the axis of said tubular portion, and means returning only the electrons of said deflected beam to the axis of said tubular portion.

2. A cathode ray tube comprising an envelope, an electron gun enclosed within said envelope, a fluorescent screen spaced from and positioned within said envelope transversely of the axis of said electron gun, said electron gun including structure producing a mixed beam of electrons and negative ions along the axis of said gun and structure for focusing said mixed beam on said fluorescent screen, said focusing structure including as a part thereof means deflecting said mixed beam from said gun axis, and means returning only the electrons of said deflected beam to said gun axis.

3. A cathode ray tube comprising an envelope, an electron gun enclosed within said envelope, a fluorescent screen spaced from and positioned within said envelope transverse to the axis of said electron gun, said electron gun including structure producing a mixed beam of electrons and negative ions along the axis of said gun and structure for focusing said mixed beam on said fluorescent screen, said focusing structure including as a part thereof electrostatic refracting means for deflecting said mixed beam from said gun axis, and magnetic means returning only the electrons of said deflected beam to said gun axis.

4. A cathode ray tube comprising an envelope, an electron gun enclosed within said envelope, a fluorescent screen spaced from and positioned within said envelope transversely of the axis of said electron gun, said electron gun including structure producing a mixed beam of electrons and negative ions along the axis of said gun and structure for focusing said mixed beam on said fluorescent screen, said focusing structure including means for forming an electrostatic electron lens with its axis of symmetry inclined to the axis of said gun for deflecting said mixed beam from said gun axis, and magnetic means for returning only the electrons from said deflected beam to said gun axis.

5. A cathode ray tube comprising an envelope, an electron gun enclosed within said envelope, a fluorescent screen spaced from and positioned within said envelope transversely of the axis of said electron gun, said electron gun including a structure producing a mixed beam of electrons and negative ions along the axis of said gun and structure for focusing said mixed beam on said fluorescent screen, said focusing structure including as a part thereof means forming an unsymmetrical electrostatic field relative to the axis of said gun for deflecting said mixed beam from said gun axis, and magnetic means for returning only the electrons of said deflected beam to said gun axis.

6. A cathode ray tube comprising an envelope having a tubular portion, a fluorescent screen positioned within said envelope transverse to the axis of said tubular envelope portion, an electron gun coaxially mounted within said tubular portion for producing a mixed beam of electrons and negative ions and for focusing a portion of said beam at the point of interception of said gun axis with said screen, said electron gun including a pair of electrode structures spaced axially along said tubular portion, said electrode structures each having an aperture for the passage of said mixed beam therethrough, said electrode structures adapted to be maintained at different electrostatic potentials and constructed to form therebetween an unsymmetrical electrostatic field relative to the axis of said gun for deflecting said mixed beam from said gun axis, and magnetic means returning only the electrons of said deflected beam to said gun axis.

7. A cathode ray tube comprising an envelope having a tubular portion, a fluorescent screen positioned within said envelope transverse to the axis of said tubular envelope portion, an electron

gun coaxially mounted within said tubular portion for producing a mixed beam of electrons and negative ions and for focusing a portion of said beam at the point of interception of said gun axis with said screen, said electron gun including a pair of tubular anode electrodes positioned coaxial to and spaced axially along said tubular envelope portion for the passage of said mixed beam therethrough, said tubular anode electrodes adapted to be maintained at different electrostatic potentials, the adjacent ends of said tubular electrodes constructed to form an electron lens therebetween with the axis of symmetry of said lens inclined to the common axis of said tubular electrodes for deflecting said mixed beam from said common axis, and magnetic means for returning only the electrons of said deflected beam to said gun axis.

8. A cathode ray tube including a fluorescent screen, an electron gun comprising a thermionic cathode, an apertured electrode adjacent said cathode for focusing the electrons emitted from said cathode at a crossover point close to said cathode, a tubular auxiliary anode adjacent said electrode, a tubular first anode aligned with and spaced from said auxiliary anode, said apertured electrode and said tubular anodes being coaxial with a straight line from said cathode to the center of said screen, the planes of the proximate ends of said anodes being parallel and transverse to and inclined to said line to form a tilted electrostatic lens between said proximate ends, and means for producing in the region of said tilted lens a magnetic field of a strength and direction to constrain the electrons in said stream to follow a path to said line.

9. A cathode ray tube comprising an envelope having a tubular portion, an electron gun coaxially mounted within said tubular envelope portion and producing during tube operation a mixed beam of electrons and negative ions, a fluorescent screen positioned within said envelope transverse to the axis of said gun, said electron gun including a cathode positioned at one end of said tubular envelope portion, a grid electrode adjacent said cathode for focusing said mixed beam at a crossover point on said gun axis close to said cathode and a first and a second tubular anode electrode coaxially spaced successively along said tubular envelope portion from said grid electrode, said anode electrodes adapted to be maintained at different levels of electrostatic potential and arranged to provide a plurality of bi-potential electrostatic lenses between said crossover point and said fluorescent screen for accelerating and focusing said beam at the point of intersection of said gun axis and said screen, an auxiliary tubular anode electrode positioned between said grid electrode and said first anode electrode to form with said first anode electrode an electrostatic lens for deflecting said mixed beam from said gun axis, and means for returning only the electrons of said deflected beam to said gun axis.

10. A cathode ray tube comprising an envelope having a tubular portion, an electron gun coaxially mounted within said tubular envelope portion, and producing during tube operation a mixed beam of electrons and negative ions, a fluorescent screen positioned within said envelope transverse to the axis of said gun, said electron gun including a cathode positioned at one end of said tubular envelope portion, a grid electrode adjacent said cathode for focusing said mixed beam at a crossover point on said gun

axis close to said cathode and a first and a second tubular anode electrode coaxially spaced successively along said tubular portion from said grid electrode, said anode electrodes adapted to be maintained at different levels of electrostatic potential and arranged to provide a plurality of bi-potential electrostatic lenses between said crossover point and said fluorescent screen for accelerating and focusing said beam at the point of intersection of said gun axis and said screen, an auxiliary tubular anode electrode coaxially spaced between said grid electrode and said first anode electrode, the adjacent ends of said auxiliary anode and said first anode constructed and arranged to form an electron lens therebetween with the axis of symmetry of said lens inclined to the common axis of said electron gun for deflecting said mixed beam from said gun axis, means for producing a magnetic field in the region of said electron lens to divert the electron portion of said deflected beam back to the axis of said gun and means producing a second magnetic field within said tubular first anode to align said electron beam portion within the gun axis.

11. A cathode ray tube comprising an envelope having a tubular portion, an electron gun coaxially mounted within said tubular envelope portion and producing during tube operation a mixed beam of electrons and negative ions, a fluorescent screen positioned within said envelope transverse to the axis of said gun, said electron gun including a cathode positioned at one end of said tubular envelope portion, a grid electrode adjacent said cathode for focusing said mixed beam at a crossover point on said gun axis close to said cathode and a first and a second tubular anode electrode coaxially spaced successively along said tubular envelope portion from said grid electrode, said anode electrodes adapted to be maintained at different levels of electrostatic potential and arranged to provide a bi-potential electrostatic lens between said crossover point and said fluorescent screen for accelerating and focusing said beam at the point of intersection of said gun axis and said screen, an auxiliary tubular anode electrode coaxially spaced between said grid electrode and said first anode electrode, the adjacent ends of said auxiliary anode and said first anode constructed and arranged to form an electron lens therebetween with the axis of symmetry of said lens inclined to the axis of said electron gun for deflecting said mixed beam from said gun axis, means positioned outside of said tubular envelope portion to produce a magnetic field in the region of said electron lens to divert the electron portion of said deflected beam back to the axis of said gun, a plurality of metal pole pieces mounted on the outer surface of said auxiliary anode for concentrating the strength of said magnetic field to a small axial portion of said gun, and means producing a second magnetic field within said tubular first anode to align said electron beam portion with the gun axis.

12. A cathode ray tube comprising an envelope having a tubular portion, an electron gun coaxially mounted within said tubular portion and producing during tube operation a mixed beam of electrons and negative ions, a fluorescent screen positioned within said envelope transverse to the axis of said gun, said electron gun including a cathode positioned at one end of said tubular portion, a grid electrode adjacent said cathode for focusing said mixed beam at a

crossover point on said gun axis close to said cathode and a first and a second tubular anode electrode coaxially spaced successively along said tubular portion from said grid electrode, said anode electrodes adapted to be maintained at different levels of electrostatic potential and arranged to provide a bi-potential electrostatic lens between said crossover point and said fluorescent screen for accelerating and focusing said beam at the point of intersection of said gun axis and said screen, an auxiliary tubular anode coaxially spaced between said grid electrode and said first anode electrode, the adjacent ends of said auxiliary anode and said first anode each determining a plane inclined at the same angle to the axis of said gun, said auxiliary anode adapted to be maintained at a different potential than said first anode electrode whereby said adjacent ends form therebetween an electrostatic electron lens having an axis of symmetry inclined to the axis of said gun for deflecting said mixed beam from said gun axis, means positioned outside of said tubular envelope portion to produce a magnetic field in the region of said electron lens to divert the electron portion of said deflected beam back to the axis of said gun, a plurality of metal pole pieces mounted on the outer surface of said auxiliary anode for concentrating the strength of said magnetic field to a small axial portion of said gun, and means producing a second magnetic field within said tubular first anode to align said electron beam portion with the gun axis.

13. A cathode ray tube comprising an envelope having a tubular portion, an electron gun coaxially mounted within said tubular portion and producing during tube operation a mixed beam of electrons and negative ions, a fluorescent screen positioned within said envelope transverse to the axis of said gun, said electron gun including a cathode positioned at one end of said tubular portion, a grid electrode adjacent said cathode for focusing said mixed beam at a crossover point on said gun axis close to said cathode and a first and a second tubular anode electrode coaxially spaced successively along said tubular portion from said grid electrode, said anode electrodes adapted to be maintained at different levels of electrostatic potential and arranged to provide a bi-potential electrostatic lens between said crossover point and said fluorescent screen for accelerating and focusing said beam at the point of intersection of said gun axis and said screen, an auxiliary tubular anode coaxially spaced between said grid electrode and said first anode electrode, the adjacent ends of said auxiliary anode and said first anode electrode each determining a plane inclined at the same angle at the axis of said gun, said auxiliary anode adapted to be maintained at a different potential than said first anode electrode, whereby said adjacent ends form therebetween an electrostatic electron lens having an axis of symmetry inclined to the axis of said gun for deflecting said mixed beam from said gun axis toward said axis of symmetry, means positioned outside of said tubular envelope portion to produce a first magnetic field in the region of said electron lens and perpendicular to said deflected beam to divert the electron portion of said electron beam back to the axis of said gun, a pair of side metal pole pieces mounted on said sides of said auxiliary tubular electrode and aligned with the direction of said magnetic field for concentrating the strength of said field to a small axial portion of said gun, and means producing a second magnetic field within said tubular first anode parallel to and in the opposite direction to said first magnetic field for aligning said electron beam portion within the gun axis.

14. A cathode ray tube having means for directing a beam of electrons and ions along a beam path and including an electron gun and focusing structure comprising a pair of tubular electrodes spaced along a common axis and through which the beam path lies, adjacent ends of said tubular electrodes being parallel and at an angle to said axis for providing an electrostatic deflecting field for said beam, and magnetic means adjacent said path for returning only said electrons to said beam path.

15. A cathode ray tube having means for directing a beam of electrons and ions along a beam path and including an electron gun and focusing structure comprising a pair of tubular electrodes spaced along a common axis and through which the beam path lies, adjacent ends of said tubular electrodes being parallel and at an angle to said axis for providing an electrostatic deflecting field for said beam, and means adjacent the tubular electrodes providing a magnetic field in the vicinity of the adjacent ends of said tubular electrodes for returning only said electrons to said beam path.

16. A cathode ray tube having means for directing a beam of electrons and ions along a beam path and including an electron gun and focusing structure comprising a pair of tubular electrodes spaced along a common axis and through which the beam path lies, one of the adjacent ends of said tubular electrodes being at an angle to said axis for providing an electrostatic deflecting field for said beam and magnetic means adjacent said path for returning only said electrons to said beam path.

17. A cathode ray tube comprising an evacuated envelope, an electron gun enclosed within said envelope for producing and focusing along a normal path a beam of electrons wherein negatively charged ions may be present, said electron gun including a pair of apertured grid plates spaced within said envelope along a common axis and through which the beam path extends, said grid plates positioned parallel to each other and inclined at an angle to said common axis, said grid plates adapted to be maintained at different electrostatic potentials whereby an electron lens is formed therebetween with an axis of symmetry inclined to said common axis to deflect said beam of electrons from said normal path, and means for returning only the electrons of said deflected beam to said normal path.

18. A cathode ray tube comprising an evacuated envelope, a gun structure enclosed within said envelope for producing and focusing along a normal path a beam of negatively charged particles wherein electrons are present, a fluorescent screen spaced from said gun structure and mounted within said envelope transversely of said normal path, said gun structure including a pair of tubular electrodes spaced along a common axis and through which the beam path lies, an apertured grid plate closing each of the adjacent ends of said tubular electrodes, said grid plates positioned parallel to each other and inclined at an angle to said common axis, said tubular electrodes adapted to be maintained at different electrostatic potentials whereby an electrostatic lens is formed between said grid plates with an axis of symmetry

inclined to said common axis to deflect said negatively charged beam from said normal path, and means for returning the electrons of said deflected beam to said normal path.

19. A cathode ray tube comprising an envelope, an electron gun enclosed within said envelope for producing and focusing along a normal path a beam of electrons wherein negative ions may be present, said electron gun including electrostatic refracting means for deflecting said electron beam from said normal path, and means producing a magnetic field for returning only the electrons of said deflected beam to said normal path, said means including pole pieces mounted within said envelope for concentrating the strength of said magnetic field within the region of said electrostatic refracting means.

20. A cathode ray tube comprising an envelope, an electron gun enclosed within said envelope for producing and focusing along a normal path a beam of electrons wherein negatively charged ions may be present, said electron gun including a pair of tubular electrodes spaced along a common axis and through which said beam path extends, the adjacent ends of said tubular electrodes each having a portion inclined at an angle to said common axis, said tubular electrodes adapted to be maintained at different electrostatic potentials whereby an electron lens is formed between said inclined portions with an axis of symmetry inclined to said common axis to deflect said electron beam from said normal path, means producing a magnetic field for returning only the electrons of said beam to said normal path, said means including pole pieces mounted on one of said tubular electrodes for concentrating the strength of said magnetic field within the region of said deflected electron beam.

21. A cathode ray tube comprising an envelope, an electron gun enclosed within said envelope for producing and focusing along a normal path a beam of electrons wherein negatively charged ions may be present, said electron gun including a pair of tubular electrodes spaced along a common axis and through which said beam path extends, the adjacent ends of said tubular electrodes each having a portion inclined at an angle to said common axis, said tubular electrodes adapted to be maintained at different electrostatic potentials whereby an electron lens is formed between said inclined portions with an axis of symmetry inclined to said common axis to deflect said electron beam from said normal path, means producing a magnetic field for returning only the electrons of said beam to said normal path, said means including a pair of pole pieces mounted on opposite sides of the common axis of said tubular electrodes said pole pieces extending through the wall of one of said tubular electrodes for concentrating the strength of said magnetic field within the region of said deflected electron beam.

22. A cathode ray tube comprising an envelope, an electron gun structure within said enevelope for producing along a normal path a beam of electrons wherein negatively charged ions may be present, said electron gun structure including as a part thereof means for deflecting said beam from its normal path, and means returning only the electrons of said deflected beam to the normal path of said beam.

23. In a system including a cathode ray tube in which the ions are segregated from the developed cathode ray beam by causing said developed cathode ray beam to deviate from the axis of said cathode ray tube, apparatus for axially aligning the electrons in said deviated cathode ray beam, said apparatus comprising means for producing a first substantially constant magnetic field acting substantially transversely to the axis of said cathode ray tube, means for causing the electrons in said cathode ray beam to pass through said first magnetic field, means for producing a second substantially constant magnetic field acting substantially transversely to the axis of said cathode ray tube, and means for causing the electrons in said cathode ray beam to pass through said second magnetic field subsequent to their passage through said first magnetic field.

24. A system in accordance with claim 23, in which said first substantially constant magnetic field is of greater intensity than said second substantially constant magnetic field.

25. A system in accordance with claim 23, in which said first and second substantially constant magnetic fields are of opposite polarity.

26. A system in accordance with claim 23, in which said first substantially constant magnetic field is of greater intensity than, and of opposite polarity to, said second substantially constant magnetic field.

27. In a system including a cathode ray tube in which the ions are segregated from the developed cathode ray beam by causing said developed cathode ray beam to be deviated from the axis of said cathode ray tube, the combination of means for producing a pair of parallel relatively constant magnetic fields of opposite polarity, and means for causing said deviated cathode ray beam to pass sequentially through said pair of magnetic fields to thereby effect a substantial realignment of the electrons in said deviated beam with the axis of said cathode ray tube.

28. A system in accordance with claim 27, in which said means for producing a pair of substantially parallel relatively constant magnetic fields of opposite polarity includes an electromagnet assembly formed so as to have two pairs of pole pieces, the plane of one of said pairs being substantially parallel to the plane of the other of said pairs, with the pole pieces of said pairs being so disposed as to lie side-by-side in spaced-apart relationship.

29. The method of separating the ions from the electrons of a cathode ray beam directed along a normal path, said method comprising the steps of, deflecting said beam from its normal path, and sequentially subjecting said beam to the influence of a pair of magnetic fields of different intensities acting transversely to the normal path of said beam to axially realign the electrons of said beam along said path.

30. The method of separating the ions from the electrons of a cathode ray beam directed along a normal path, said method comprising the steps of, deflecting said beam from its normal path, and sequentially subjecting said beam to the influence of a pair of magnetic fields of opposite polarity acting substantially transversely to the normal path of said beam to axially realign the electrons of said beam along said path.

31. The method of separating the ions from the electrons of a cathode ray beam directed along a normal path within a cathode ray tube, said method comprising the steps of, passing the electron beam through an electrostatic lens field the axis of which forms an angle with the normal

path of the cathode ray beam to deflect said beam from its normal path, and sequentially subjecting said beam to the influence of a pair of magnetic fields acting substantially transverse to the normal path of said electron beam to realign the electrons of said beam along said path.

32. The method of separating the ions from the electrons of a cathode ray beam directed along a normal path, said method comprising the steps of, passing said cathode ray beam through an electrostatic field which acts to produce a deviation of said cathode ray beam from its normal path, passing said deviated beam through a first relatively constant magnetic field of a strength and direction to cause the electrons in said deviated beam to follow a path which intersects the normal path of said cathode ray beam, and sequentially subjecting the electrons following said path to a second magnetic field of a strength and direction to cause said electrons to travel substantially along said normal beam path.

33. The method of separating the ions from the electrons of a cathode ray beam directed along a normal path within a cathode ray tube, said method comprising the steps of, passing the electron beam through an electrostatic lens field the axis of which forms an angle with the normal path of the cathode ray beam to deflect said beam from its normal path, passing the cathode ray beam through a first magnetic field acting substantially transverse to the normal path of said beam and in a direction to return the electrons of said beam to the normal path of said cathode ray beam, and sequentially passing the electrons of the beam through a second magnetic field substantially transverse to the normal path of said beam and of opposite direction to that of said first magnetic field to realign the deflected electrons with the normal path of said beam.

34. A cathode ray tube adapted to be used with magnetic means for affecting the path of electrons only within the tube and comprising an envelope having a tubular portion, a fluorescent screen positioned within said envelope transverse to the axis of said tubular envelope portion, an electron gun mounted within said tubular portion for producing a mixed beam of electrons and negative ions and for focusing a portion of said beam at the point of interception of said beam with said screen, said electron gun including a pair of electrode structures spaced axially within said tubular portion, said electrode structures each having an aperture for the passage of said mixed beam therethrough, said electrode structures adapted to be maintained at different electrostatic potentials and constructed to form therebetween an unsymmetrical electrostatic field relative to the axis of said gun for deflecting said mixed beam from said gun axis.

35. A cathode ray tube adapted to be used with magnetic means for affecting the path of electrons only within the tube and including a fluorescent screen, an electron gun comprising a thermionic cathode, an apertured electrode adjacent said cathode for focusing the electrons emitted from said cathode at a cross-over point close to said

cathode, a tubular auxiliary anode adjacent said electrode, a tubular first anode aligned with and spaced from said auxiliary anode, said apertured electrode and said tubular anodes being coaxial with a straight line from said cathode to said screen, the planes of the proximate ends of said anodes being parallel and transverse to and inclined to said line to form a tilted electrostatic lens between said proximate ends.

36. A cathode ray tube having means for directing a beam of electrons and ions along a beam path and adapted to be used with a magnetic means adjacent said path for affecting movement of said electrons only, said first means including an electron gun and focusing structure comprising a pair of tubular electrodes spaced along a common axis and through which the beam path lies, adjacent ends of said tubular electrodes being parallel and at an angle to said axis for providing an electrostatic deflecting field for said beam of electrons and ions.

37. A cathode ray tube having means for directing a beam of electrons and ions along a beam path and adapted to use a magnetic means adjacent said path for affecting movement of the electrons only along said path and including an electron gun and focusing structure comprising a pair of tubular electrodes spaced along a common axis and through which the beam path lies, one of the adjacent ends of said tubular electrode being at an angle to said axis for providing an electrostatic deflecting field for said beam.

38. A cathode ray tube adapted to be used with magnetic means for affecting the path of electrons only within the tube and comprising an evacuated envelope, an electron gun enclosed within said envelope for producing and focusing along a normal path a beam of electrons wherein negatively charged ions may be present, said electron gun including a pair of apertured grid plates spaced within said envelope along a common axis and through which the beam path extends, said grid plates positioned parallel to each other and inclined at an angle to said common axis, said grid plates adapted to be maintained at different electrostatic potentials whereby an electron lens is formed therebetween with an axis of symmetry inclined to said common axis to deflect said beam of electrons from said normal path.

JOSEPH KELAR.

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