April 28, 1959 A. T. RACZYNSKI 2,884,551

CATHODE RAY TUBE

Filed June 29, 1955 2 Sheets-Sheet 1

Fig. 1.

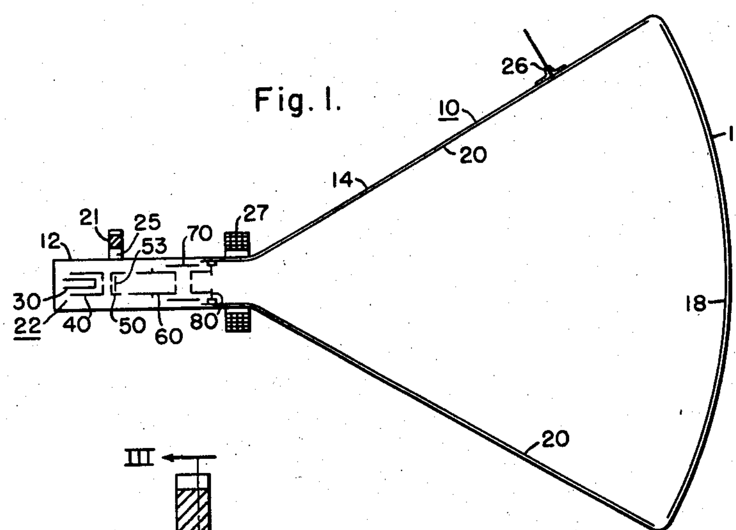


Fig. 2.

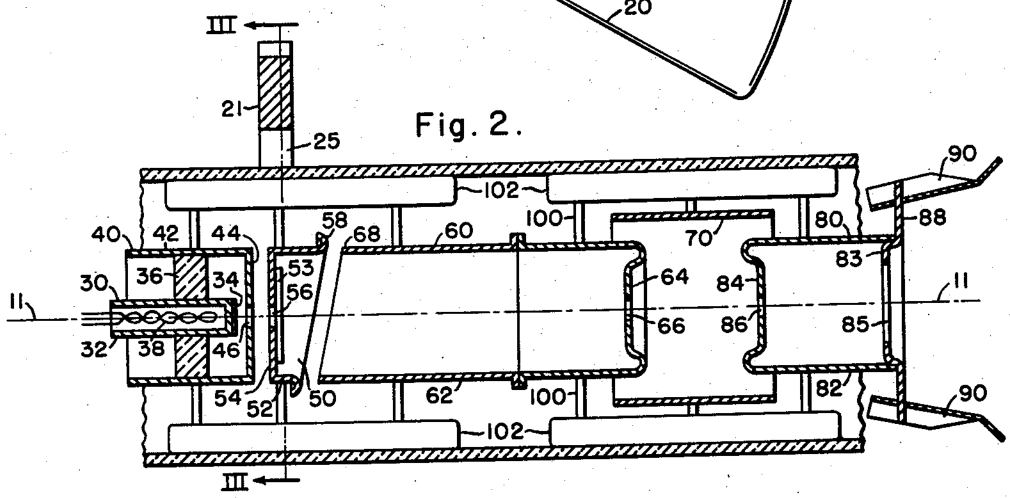


Fig. 3.

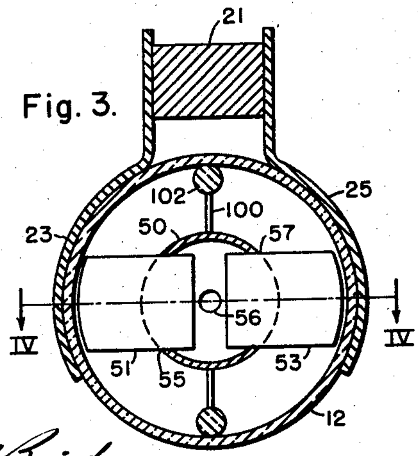
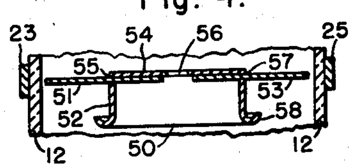


Fig. 4.



WITNESSES

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April 28, 1959 A. T. RACZYNSKI 2,884,551

CATHODE RAY TUBE

Filed June 29, 1955 2 Sheets-Sheet 2

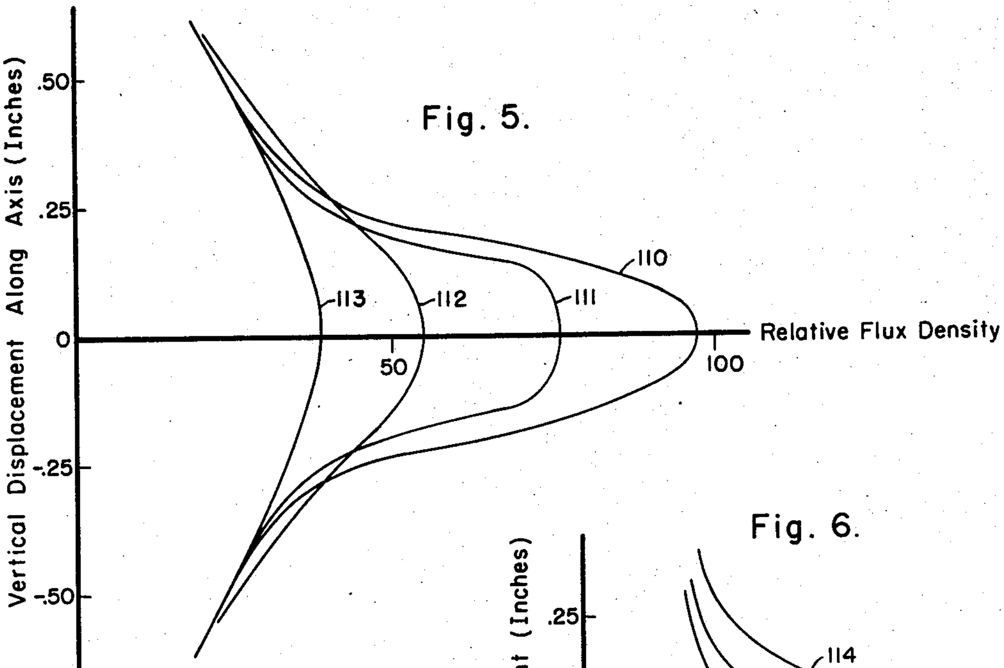

Fig. 5.

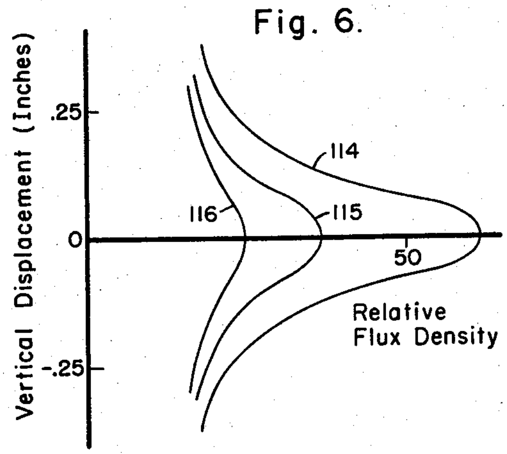

Fig. 6.

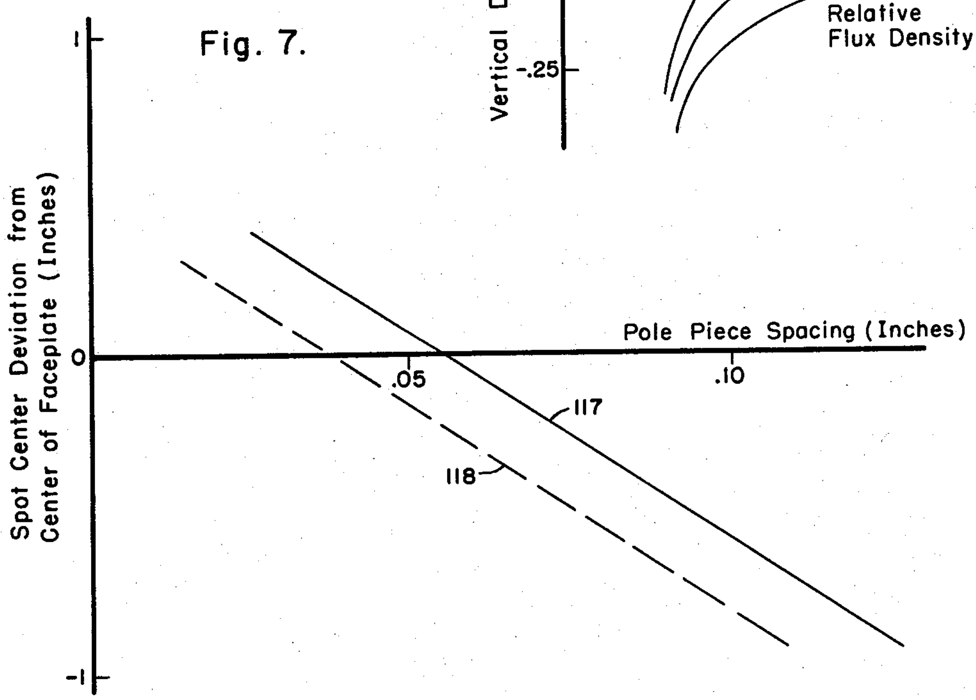

Fig. 7.

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CATHODE RAY TUBE

Andrew T. Raczynski, Horseheads, N.Y., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application June 29, 1955, Serial No. 518,871

3 Claims. (Cl. 313—76)

This invention relates to apparatus for producing an electron beam and, more particularly, to the structure eliminating ions from the electron beam.

In all types of cathode ray tubes it is found that the beam of electrons generated by the electron gun is also accompanied by negative ions of various types. It is believed that a majority of the ions are derived from the oxide coating of the electron emissive cathode structure. The effect of the ion bombardment on the fluorescent screen of a cathode ray tube is to produce a thin film of deactivated material on the surface thereof. The deactivated area of fluorescent material which is referred to as ion burn or blemish absorbs a high proportion of the electron beam resulting in a small light output from that deactivated area. It is the removal of the undesirable ions from the electron beam to which this invention is directed.

The mass of the ion is greater than the electron while the charge is essentially the same. The negative ion will be focused and deflected essentially along the same path as the electron in an electrostatic field while a magnetic field sufficient to focus the electrons to the extent necessary in a cathode ray tube will have little effect on the negative ions. It is, therefore, seen that the ions would bombard the entire screen with electrostatically deflected type cathode ray tubes and essentially only one spot with electromagnetically deflected type cathode ray tubes. It has been found that an ordinary cathode ray tube with magnetic deflection may develop an ion blemish in as little as one hour of operation. The use of electrostatic deflection results in reduced ion bombardment over the entire face of the cathode ray tube and the life of the tube is much longer. However, over a short period of operation the electrostatic deflection type tube will have reduced light output over the entire screen.

There are several methods of reducing the objectionable ion bombardment by choice of suitable gettering material, fluorescent screen material and materials used in the electron gun structure. Another reduction method that is also used is metallic backing material on the fluorescent screen. Although these methods have been utilized, the tube industry has found that the only practical method is to trap the ions out of the electron beam before leaving the electron gun.

There are several designs and modifications utilized in the tube industry but all essentially rely on systems in which the electron source or cathode of the electron gun is located off the main axis of the tube and the beam is deflected by a single magnetic field referred to as the ion trap magnet onto and along the longitudinal axis of the tube neck. These type structures which may be referred to as bent gun structure require that the individual parts of the electron gun are set at angles with respect to other parts resulting in weak mechanical structures. It is also obvious that such structures are more difficult to assemble than where the electron gun parts are assembled in a straight line. Some structures which are referred to in the art as straight guns are also utilized,

but it is necessary that the gun be tilted within the tube neck and also that the diaphragm nearest the fluorescent screen be tilted with respect to the anode cylinder or that the aperture in the diaphragm be located off center. With both the tilted guns and the bent guns the neck of the tube must be of a larger diameter than if the entire gun was coaxial with the tube neck. A coaxial electron gun structure is described in U.S. Patent 2,496,127, but the structure requires two ion traps which overbalances the advantages of the coaxial structure. The gun described in the above mentioned U.S. patent utilizes a slashed electrostatic field to deflect both the electrons and the ions generated by the cathode of the electron gun off the tube axis and then a first magnetic field is utilized to return the electron beam back to the axis. Since the electron beam returned to the axis by the first magnetic field approaches at an angle to the axis, it is necessary that a second magnetic field be utilized to align the electron beam along the main axis of the tube. The ions are substantially not effected by the magnetic fields and are trapped within the gun.

It is, accordingly, an object of my invention to provide an improved electron gun structure capable of providing a substantially ion free electron beam.

It is another object to provide an electron gun in which the parts are positioned coaxial within the tube neck and requiring only one ion trap magnet.

It is another object to provide an economical gun structure with the ion trap for utilization within small diameter neck cathode ray tubes.

It is another object to provide a structure in which the electron beam remains substantially on the longitudinal axis of the electron gun structure while the ions are reflected off the axis.

These and other objects are effected by my invention as will be apparent from the following description taken in accordance with the accompanying drawings throughout which like reference characters indicate like parts and in which:

Fig. 1 is a side elevational view showing the relationship of the cathode ray gun embodying the principles of my invention to the other structural elements of a cathode ray tube;

Fig. 2 is a side elevational view partly in section of a cathode ray gun embodying the principles of my invention;

Fig. 3 is a transverse view of the screen grid according to my invention;

Fig. 4 is a cross-sectional view of the screen grid; and

Figs. 5, 6 and 7 are graphs for purpose of explanation.

Referring in detail to Fig. 1, there is shown a cathode ray tube employing my invention. The tube is comprised of an envelope **10** having a tubular neck portion **12**, a flared bulb portion **14** and a face plate **16**. The face plate **16** of the envelope **10** has a suitable fluorescent coating **18** on the inside surface thereof, and the flared bulb portion **14** has a conductive coating **20** of a material such as graphite. An electron gun **22** is mounted on the inside of the neck portion **14** of the envelope **10**.

The electron gun **22** is comprised of an indirectly heated cathode **30**, a control grid or electrode **40**, a screen grid or electrode **50**, a first anode **60**, a focusing electrode **70**, and a second anode **80**, in the order named. The coating **20** on the interior of the flared bulb portion serves as the third anode of the cathode ray tube, and a suitable voltage is supplied at terminal **26**. The structure described and shown herein is of the type known as an electrostatic focus type cathode ray gun. Positioned on the exterior of the neck portion **12** of the envelope **10** is an ion trap magnet **21** with pole plates **23** and **25** and an electrostatic or electromagnetic deflection system represented by the coil or yoke **27**.

Referring in detail to Fig. 2, the control grid **40** is comprised of a tubular member or skirt **42** coaxial with the tube neck axis **11** with a diaphragm or stop **44** positioned therein in which a small aperture **46** is centrally located on the axis **11** of the tube neck. In the specific embodiment shown, the diaphragm **44** is located at the end of the cylindrical or tubular member **42** nearest the screen **18**. The plane of the diaphragm **44** is perpendicular to the axis **11** of the tube neck. Positioned within the control grid structure **40** is the cathode **30** comprised of a tubular member **32** of smaller diameter than the control grid skirt **42** with its logitudinal axis lying on the axis **11**. The end of the tubular member **32** nearest the diaphragm **44** of the control grid **40** is closed and a coating **34** of electron emissive material is placed on the exterior surface. The tubular member **32** is supported in the grid skirt **42** by means of a ceramic collar **36**. A heater filament **38** is provided within the tubular member **32** for controlling the temperature of the electron emissive coating **34**.

The screen grid or electrode **50** is comprised of a tubular skirt or cylindrical member **52** spaced along the axis **11** and adjacent to the diaphragm end of the control grid **40**. The screen skirt **52** has a diaphragm **54** positioned therein, and in the specific example closes the end of the cylinder **52** adjacent to the control grid **40** and is perpendicular to the main axis **11**. In a similar manner to the control grid diaphragm **44**, an aperture **56** is placed at the center of the diaphragm **54**. The unclosed end or rim **58** of the screen skirt **52** may be rolled outward as shown in Fig. 2 to eliminate possibilities of distortion of electrostatic fields due to sharp edges and burs on the material. The plane of the unclosed end or rim **58** of the cylinder **52** is slanted at an angle of 10° to 13° with respect to a plane perpendicular to the axis **11**.

The screen grid **50**, as generally described above, is more completely described in a copending application, Serial No. 374,240, filed August 14, 1953, now Patent No. 2,773,212, entitled Electron Gun, by James A. Hall, and assigned to the same assignee. In my invention, it is necessary to incorporate two pole piece members **51** and **53** adjacent to the apertured diaphragm **54** of the screen grid **50**. The pole pieces **51** and **53** are made of high permeability material such as soft iron. The pole pieces **51** and **53** may be inserted through openings **55** and **57** provided in the skirt or cylindrical wall **52** adjacent to the closed end or it may be desirable to attach the pole pieces **51** and **53** on the opposite side of the diaphragm **54**. In the specific example shown, the pole pieces **51** and **53** are inserted within the interior of the screen grid **50** from opposite sides of the aperture **56** and positioned at equal distances from the aperture **56**. The spacing of the pole pieces from each other is of the order of .055 inch and extend out adjacent to the neck portion **12** of the envelope **10** to offer minimum air gap to external magnet **21**. The pole pieces **51** and **53** enter from opposite sides of the screen grid **50** at a point where the length of the cylinder **52** is equal to the mean length.

The first anode **60** is comprised of a cylindrical or skirt member **62** spaced along the axis **11** and adjacent to the slanted open end of the screen grid **50**. The first anode **60** is open at the end adjacent the screen grid **50** and the rim **68** is also slanted so that the plane of the rim **68** is parallel to the plane of the rim **58** of the screen grid **50** and inclined to a plane perpendicular to the axis **11** by about 10° to 13°. The other end of the first anode skirt **62** is closed by a diaphragm **64** perpendicular to the axis **11** also having a centrally located aperture **66** therein. The second anode **80** is comprised of a cylindrical or skirt portion **82** positioned along the axis **11** at a distance greater than the other members of the gun from the first anode **60**. The end of the skirt **82** adjacent the first anode **60** is closed by a diaphragm **84** perpendicular to the axis **11** and having a centrally located aperture **86** therein. The opposite end of the second anode skirt **82** also has a diaphragm **83** therein perpendicular to the axis **11** with a large central aperture **85** therein. Integral with the diaphragm **83** is a flange **88** extending outwardly from the second anode **80** to which flexible spring members **90** are attached which position the electron gun **22** within the neck **12** and also make electrical contact with the Aquadag coating **20** on the flared portion **14** of the envelope **10**. The first and second anodes **60** and **80** are connected together electrically and are supplied with voltage from the Aquadag coating **20** by means of the flexible spring members **90**.

A sleeve or focusing electrode **70** surrounds the space between the first and second anodes **60** and **80**, and is coaxial with the axis **11** and of larger diameter than the first and second anode cylinders **62** and **82**. The control grid **40**, the screen grid **50**, the first anode **60**, focusing electrode **70** and second anode **80** may be supported by providing radially jetting anchor pins **100** on the cylindrical surfaces thereof. The anchor pins **100** are embedded within longitudinal glass support rods **102** extending along substantially the entire length of the gun structure. Suitable voltages are supplied to the elements of the electron gun **22** by means of leads (not shown) extending through the button stem provided in the end of the tube neck **12**. A table is given below of typical dimensions of a specific embodiment shown in Fig. 1 with representative voltages of each member. The relative dimensions of these electrodes are expressed as ratios to the diameter of the control grid cylinder **42**.

Cylinder	Diameter	Length	Voltage
32	(Outside) ¼	0.72	0.
42	(Inside) 1	0.87	−30.
52	(Inside) 1	0.71 (maximum length)	+275 to 500 v.
62	(Inside) 1	2.57 (maximum length)	+10 to 18 kv.
82	1	1.02	10 to 18 kv.
70	1.3	1	−100 to +450.

Aperture:	Inside diameter
46	.062
56	.072
76	.200
86	.240

Gap-between electrodes along axis 11

40—50	0.045
50—60	.2
60—80	.75

In the operation of the electron gun structure **22**, the electrons as well as the negative ions are emitted from the electron emissive surface **34** of the cathode **30** and the electrostatic field between the control grid **40** and the screen grid **50** accelerates and forms a lens of short focal length bringing the electrons and ions to what is known as a cross-over point between the two diaphragms **44** and **54**. The control grid **40** controls essentially the number of electrons passing through the aperture **46** in the diaphragm **44**, and thereby controls the intensity of the electron beam. The electron and ion beam thus formed passes through the aperture **56** in the diaphragm **54** of the screen grid **50**. The electrostatic field or lens set up between the screen grid and the first anode in effect acts on the beam at the time of entering the aperture **56** in the diaphragm **54** of the screen grid **50** and acts to focus and deflect the electron and ion beam entering the field. Since the adjacent ends of the screen grid **50** and the first anode **60** lie in parallel planes tilted to a plane perpendicular to the axis **11**, the effect is that a bending electrostatic field is impressed on the electrons and ions within the beam just after cross-over. Since the electrons and ions are moving slowly at this point, due to the low acceleration voltages, then the electron and ion beam is bent sharply downward at this point. The magnetic field between the pole pieces **51** and **53** is also concentrated at the point just past cross-over so that a magnetic field is set up with the force directed upward on the electron and ion beam or opposing the electrostatic field force. Since as previously stated, the deflection of particles in the magnetic field depends on the mass of the particle involved, the field can be adjusted to compensate for the electrostatic field as to the electrons, while little effect will be had by the magnetic field on the ions which are of much greater mass. The ion beam will thus follow substantially the deflection path impressed thereon by the electrostatic field set up between the screen grid **50** and the first anode **60**, and will strike the wall **62** of the first anode **60** while the electron beam will remain substantially on the axis **11** and pass through the aperture **66** of the first anode **60**. The importance of the structure disclosed herein is the need for the concentration of the magnetic field to a narrow region by the pole pieces **51** and **53** to substantially overcome the electrostatic field set up between the screen grid **50** and the first anode **60** as to the electron beam. It is also important to realize that the positioning of the pole pieces **51** and **53** with respect to the aperture **56** and the size of the pole pieces **51** and **53** are of great importance.

In Fig. 5 there is shown a plot of the magnetic flux density versus distance along axis **11** (Fig. 2) with different arrangement of pole pieces. The graph shows that the maximum concentrated intensity is obtained by utilizing pole pieces filling as much of the gap between the electron beam and the magnet pole plates as possible represented by curve **110**. When smaller pole pieces were used it was found that location of such pole pieces closed to the beam (curve **111**) was more desirable than location close to the magnet (curve **112**). The curve **113** represents the field distribution where no pole pieces were used. In Fig. 7, using a given length and width of pole piece as represented by curve **110** of Fig. 5, various thicknesses of pole pieces were used. It was found that the greatest concentration of flux density was obtained with the pole pieces physically thin. The curves **114**, **115** and **116** of Fig. 6 were obtained with pole pieces having a thickness of .018 inch, .026 inch and .036 inch, respectively.

It is known that the angle of exit of the electron beam from the gun determines the undeflected spot location on the tube screen. An electron beam leaving the gun on axis **11** will have a deviation of zero from the center of the face plate. Therefore, emergence of the beam along the gun axis is evidence that the electrostatic and magnetic deflections in the ion trap structure neutralize each other, and the electron beam remains essentially on the axis **11** (Fig. 2) throughout its travel through the electron gun structure and the remainder of the distance to the screen. The results of tests shown in Fig. 7 indicate how the optimum spacing for a given pole piece thickness may be readily found. The curve shown in Fig. 7 is a plot of pole piece spacing versus distance of the undeflected electron spot from the geometric center of the tube face. The line **117** is plotted for pole pieces of a thickness of .018 inch and line **118** for thickness of .026 inch. However, it was found that pole pieces which come too close to the electron beam cause some aberration of the electron beam. For example, with the aperture in the diaphragm of the screen grid having a diameter of .036 inch, a spacing of .036 inch between pole pieces of a thickness of .026 inch caused substantial aberration of the beam. It was found that with a .036 aperture and pole pieces of .018 inch thickness, the curves of Fig. 7 predict a spacing of .055 inch and models constructed along these lines were found to have satisfactory spot shape and centering.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit and scope thereof.

I claim as my invention:

1. A cathode ray tube comprising an envelope having a tubular neck portion, an electron gun structure coaxially positioned within said neck portion, a target screen spaced from said electron gun and positioned substantially perpendicular to the axis of said neck portion, said electron gun comprised of at least a cathode, a control grid, a screen grid and an anode, said control grid comprised of a diaphragm having an aperture centrally located therein and positioned adjacent said cathode for focussing a mixed electron and ion beam generated by said cathode to a crossover point on said axis, said screen grid positioned intermediate said control grid and said anode, said screen grid and said anode having a tubular portion and having their adjacent ends lying in planes parallel to each other and tilted with respect to said axis for impressing a tilted electrostatic field on said mixed beam adjacent said crossover point, said screen grid having a transverse diaphragm therein, said diaphragm having an aperture centrally located therein and positioned on said axis, a magnetic field impressed on said beam by means of a magnet and pole plates positioned on the exterior of said neck, and field concentrating means positioned within said neck and extending from a point near said pole plates to a point near the aperture in said screen grid to provide a narrow field region near said crossover point to counteract the electrostatic deflection force on said electrons.

2. A cathode ray tube comprising an envelope having a tubular neck portion, an electron gun structure coaxially positioned within said neck portion, a target screen spaced from said electron gun and positioned substantially perpendicular to the axis of said neck portion, said electron gun comprised of at least a cathode, a control grid, a screen grid and an anode, said control grid comprised of a diaphragm having an aperture centrally located therein and positioned adjacent said cathode for focussing a mixed electron and ion beam generated by said cathode to a crossover point on said axis, said screen grid positioned intermediate said control grid and said anode, said screen grid and said anode having a tubular portion and having their adjacent ends lying in planes parallel to each other and tilted with respect to said axis for impressing a tilted electrostatic field on said mixed beam adjacent said crossover point, said screen grid having a transverse diaphragm therein, said diaphragm having an aperture centrally located therein and positioned on said axis, a magnetic field impressed on said beam by means of a magnet and pole plates positioned on the exterior of said neck, and concentrating means positioned within the region between said pole plates and said aperture in said screen grid for concentrating said electromagnetic field to a narrow region near said crossover point to counteract the electrostatic deflection force on said electrons, said concentrating means comprised of a plurality of metal pole pieces positioned transverse to said axis and adjacent said diaphragm in said control grid and substantially filling the region between a point near the aperture in said diaphragm in said screen grid to a point near said neck portion.

3. A cathode ray tube comprising an envelope having a tubular neck portion, an electron gun structure coaxially positioned within said neck portion, a target screen spaced from said electron gun and positioned substantially perpendicular to the axis of said neck portion, said electron gun comprised of at least a cathode, a control grid, a screen grid and an anode, said control grid comprised of a diaphragm having an aperture centrally located therein and positioned adjacent said cathode for focussing a mixed electron and ion beam generated by said cathode to a crossover point on said axis, said screen grid positioned intermediate said control grid and said

anode, said screen grid and said anode having a tubular portion and having their adjacent ends lying in planes parallel to each other and tilted with respect to said axis for impressing a tilted electrostatic field on said mixed beam adjacent said crossover point, said screen grid having a transverse diaphragm therein, said diaphragm having an aperture centrally located therein and positioned on said axis, a magnetic field impressed on said beam by means of a magnet and pole plates positioned on the exterior of said neck, and concentrating means comprised of two diametrically opposed pole pieces transverse to said axis and positioned adjacent said crossover point and substantially filling a region between the aperture in said diaphragm in said screen grid and said pole plates.

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