April 26, 1955 S. ZUERKER 2,707,246

COMBINATION FOCUSING-ION TRAP STRUCTURES FOR CATHODE-RAY TUBES

Filed Sept. 4, 1952

Fig. 1.

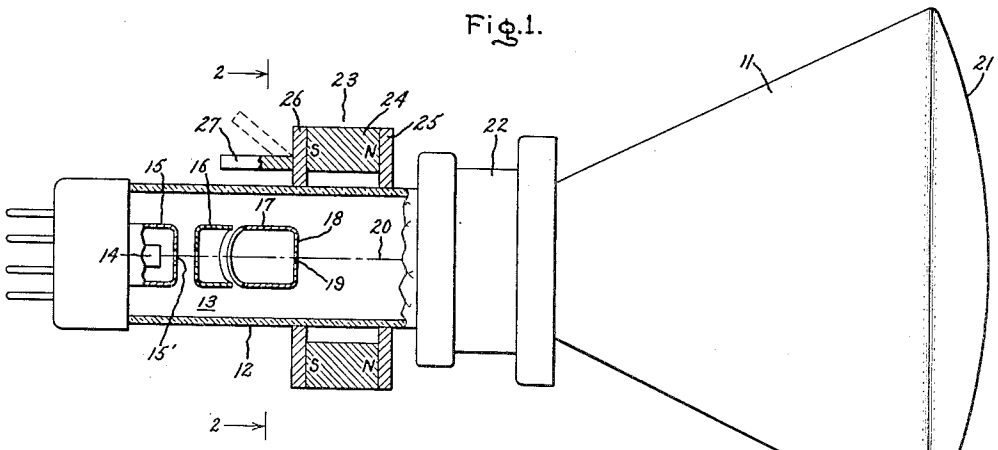


Fig. 3.

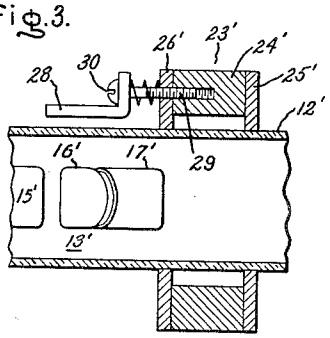


Fig. 2.

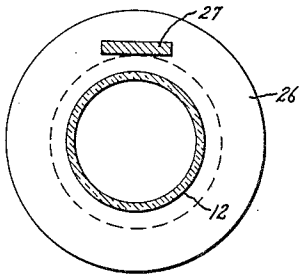


Fig. 4.

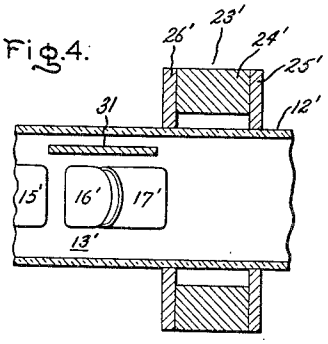
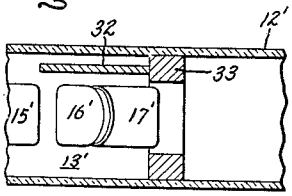


Fig. 5.



Inventor:
Siegfried Zuerker,
by Merton D. Morse
His Attorney.

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COMBINATION FOCUSING-ION TRAP STRUCTURES FOR CATHODE-RAY TUBES

Siegfried Zuerker, Pennellville, N. Y., assignor to General Electric Company, a corporation of New York

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11 Claims. (Cl. 313—79)

My invention relates to improved means for controlling and focusing the cathode ray of a cathode-ray tube. More particularly, it relates to a unitary structure adapted to surround the neck of the tube, which cooperates with internal tube elements to perform both the functions of focusing the beam and trapping negative ions.

Since it is commercially impractical completely to exhaust cathode-ray tubes of the type employed in television receivers, oscilloscopes, and the like, traces of gas are normally present in the tubes now available. As a result, negatively charged particles, called ions, are produced within the tube in a well-known manner and enter the cathode ray along with the electrons. These ions are projected against the fluorescent screen of the cathode-ray tube, tending to cause the formation of a black spot on the screen, commonly known as an ion spot.

It is conventional to prevent the formation of ion spots by discriminatory deflection of the ions and electrons in order to filter the ions out of the beam by means of an ion trap. Although both ions and electrons in a cathode ray are substantially equally deflected by an electric field, the slower ions are deflected to an appreciably smaller extent than electrons when the beam is subjected to a magnetic field. This is so because the velocity of the ion is much lower than that of the electron. Thus, ions can be separated from electrons in a cathode ray by causing the beam to leave the cathode at an angle to the axis of the tube or by causing an axial beam to be deflected electrically at an angle to the axis and then subjecting the deflected beam to a magnetic field in order to re-direct the electrons along the axis of the tube. Ions present in the deflected beam will be substantially unaffected by the magnetic field and can be trapped out by suitable means, such as an impermeable disc having an anode aperture suitably located to accommodate the beam of re-directed electrons. A separate ion trap magnet is generally provided solely for this purpose.

In cathode-ray tubes of the type described above, it is also generally necessary to provide means for centering and adjusting the electron beam in order to orient properly the image traced by the electron beam on the picture screen. It is common practice to accomplish this function by means of an external magnetic focusing device. This may be of the electromagnetic type, employing a solenoid coil positioned externally around the neck of the cathode-ray tube, or of the permanent magnet type, having a toroidal structure arranged to produce a generally cylindrical magnetic field along the beam axis, or it may be a combination of both of these types.

The present invention relates to an improved structure adapted to surround the neck of a cathode-ray tube which comprises means cooperating with internal tube elements for both focusing the beam and trapping unwanted ions. In preferred embodiments of the invention, the structure includes a beam-focusing magnet and also an additional cooperating member of low-reluctance material extending along the neck of the tube and arranged to distort a portion of the magnetic focusing field in such a manner as selectively to deflect the electrons of the beam through the anode aperture of an ion trap within the tube. Thus, the same magnet structure cooperates with tube elements for both ion trapping and focusing purposes.

It is therefore a main object of my invention to provide an improved combination focusing-ion trap magnet assembly.

It is another object of my invention to provide an improved focusing-ion trap assembly which is simple and inexpensive to produce.

A further object of my invention is to provide a combination focusing-ion trap structure that may be constructed of relatively simple component parts and that is simple to fabricate by mass-production methods of manufacture.

For additional objects and advantages, and for a better understanding of the invention, attention is now directed to the following description and accompanying drawings. The features of the invention which are believed to be novel are particularly pointed out in the appended claims.

Referring to the drawings, Fig. 1 is a cross-sectional view of a cathode-ray tube incorporating a combination focusing magnet-ion trap magnet embodying my invention;

Fig. 2 is an end view of the focusing-ion trap structure embodying my invention, looking to the right from line 2—2 in Fig. 1;

Fig. 3 is a longitudinal cross section through a focusing-ion trap structure incorporating another embodiment of my invention;

Fig. 4 is a longitudinal cross section through a focusing-ion trap structure incorporating still another embodiment of my invention; and

Fig. 5 is a longitudinal cross section through a focusing-ion trap structure incorporating a still further embodiment of my invention.

Referring now to Fig. 1, there is shown a conventional cathode-ray tube assembly including a combination focusing-ion trap magnet embodying one form of my invention. The cathode-ray tube is provided with a glass envelope comprising a bowl portion **11** and an elongated cylindrical neck **12**. Within the neck **12**, near the end farthest from the bowl **11**, there is provided an electron gun indicated generally at **13**, the construction and operation of which is well-known in the art. Gun **13** includes a generally cylindrical cathode **14** supported concentrically within a cup-shaped control-grid member **15** having an aperture **15'** in alignment with the emitting surface of the cathode **14**. An accelerating-grid cylinder **16** and an anode cylinder **17** are supported in axial alignment with grid member **15** in spaced and insulated relation thereto. The end of anode cylinder **17** remote from the cathode **14** is provided with a disc-like member **18** having an aperture **19** to accommodate the electron ray or beam **20** projected from the gun **13**. Suitable supporting members, such as glass stalks (not shown), maintain the various parts of the gun **13** in their proper spaced relations according to well-known practice in the art. The opposing ends of accelerating-grid cylinder **16** and anode cylinder **17** are positioned in spaced and insulated relation to one another and shaped to define a gap therebetween extending at an acute angle with respect to the longitudinal axis of the cathode-ray tube. Since anode cylinder **17** is operated at a high positive potential with respect to grid cylinder **16** the cathode ray will be deflected inwardly, perpendicular to the plane of the paper as seen in Fig. 1, due to the electric field existing across the gap between members **16** and **17**. The gun **13** projects a beam of electrons **20** along the axis of the neck **12** and against the fluorescent screen **21**, causing it to emit light in a well-known manner.

A conventional deflecting coil assembly **22** is mounted on the neck **12** adjacent the bowl **11** to provide vertical and horizontal electron beam deflection in order to provide means for scanning the screen **21** to produce the television picture, in a manner well-understood in the art. Its details form no part of the present invention. A suitable assembly is that shown, for example, in Patent 2,565,331 Chas. E. Torsch, issued August 21, 1951, and assigned to the same assignee as the present invention. Although a magnetic deflecting assembly has been shown, it is apparent to those skilled in the art that electrostatic deflecting means or combination electrostatic-magnetic deflecting means may be employed instead.

An electron-beam focusing lens 23 is mounted on the neck 12 at a position between the gun 13 and the deflecting coils 22. As is well-known, its function is to produce a magnetic field of proper magnetic intensity to cause the beam of electrons 20 to come to a sharp focus in the form of a spot on the screen 21 and to center the spot thus formed.

As shown more clearly in Fig. 2, focusing lens 23 preferably is of the permanent magnet type in order to provide sufficient leakage flux for ion-trapping purposes. Lens 23 comprises a generally cylindrical permanent magnet 24 having a pair of generally annular pole pieces 25 and 26 axially aligned therewith and abutting against its north and south poles respectively.

Lens 23 is provided with a deflecting strip 27 in the form of a low-reluctance bar of magnetic material such as soft steel disposed along the axis of the cathode-ray tube and having one end abutting against pole piece 26.

Strip 27, being in effect an extension of a segment of pole piece 26, provides a low-reluctance path for leakage flux from the focusing magnet 24. The concentration of magnetic flux associated with strip 27 provides a localized field that effectively deflects the electron beam passing under its influence. By adjusting the circumferential position of strip 27, the direction of the magnetic field associated therewith may be made to oppose the electric field set up across the gap between grid cylinder 16 and anode cylinder 17 in order to re-deflect the electrons of the cathode ray 20. By adjustment of strip 27, for example by bending to its the position represented by the dashed lines in Figs. 1 and 2, it is possible to adjust the strength of the magnetic field in order to direct the re-deflected electrons of beam 20 through anode aperture 19. Electrons passing through aperture 19 will constitute a substantially ion-free electron beam that may be focused and deflected in the usual manner. Ions initially present in the beam 20 will be practically unaffected by the magnetic field of strip 27 and, hence, will not be directed through aperture 20, but instead will be filtered out of beam 20 by impermeable disc 18.

In the ideal case, the relative strengths of the electric and magnetic fields are adjusted so as to oppose one another in such a manner that, as far as the electrons are concerned, there is point-by-point neutralization of the two fields. Thus, the electrons suffer no deflection at all in passing through the two fields. In practice, however, it is difficult to achieve this result and the electrons are usually deflected by the electric field to some extent and then redeflected by the magnetic field, as described above.

Although the field of lens 23 may be distorted to some extent by the presence of strip 27, the focus is not materially affected thereby.

Electrons deflected away from the axis by the radial flux component on the field in the vicinity of strip 27 tend to be rotated about the axis by the tangential flux component of the focusing field according to the familiar right-hand rule, as are all paraxial electrons in the field. However, since the rotation thus imparted is a constant factor, it will not noticeably affect the image traced on the secreen 21. Furthermore, the slight asymmetry of beam 20 due to the presence of strip 27 will be minimized by the focusing action of lens 23.

While I have thus far described my invention with reference to the embodiment thereof shown in Figs. 1 and 2, other embodiments are illustrate in the ensuing figures in which the elements bearing the numerals designated prime correspond to similar elements of the embodiment shown in Figs. 1 and 2 bearing the same numerals.

In Fig. 3, I have shown an embodiment providing means for facilitating adjustment of the ion-trapping flux. Deflecting strip 28, corresponding to strip 27 in Figs. 1 and 2, is also of low-reluctance magnetic material, and is provided at one end thereof with an L-shaped portion having a tapped hole therein to receive an adjusting screw 29. Screw 29 is preferably of non-magnetic material and is provided with a conventional slot 30 for adjustment purposes. Pole piece 26′ of magnet 24′ is also tapped to receive screw 29 in order to provide means for maintaining strip 28 and magnet 24′ in adjustable spaced relation with one another.

In Fig. 4, there is shown a low-reluctance strip of magnetic material 31, corresponding to strip 27 of Figs. 1 and 2, situated within the glass envelope of tube neck 12′. Strip 31 may be positioned along the axis of the cathode-ray tube in insulated spaced relation with respect to the gun 13′ by any convenient method common in the art, such as the conventional glass stalks (not shown). The focusing assembly 23′ may be adjusted along the neck 12′ in order to provide the correct field strength for ion-trapping purposes.

In the embodiment illustrated in Fig. 5, the focusing and ion-trapping apparatus is located entirely within the glass envelope of tube neck 12′. Strip 32 of this figure corresponds to strip 27 of Figs. 1 and 2 and like strip 27, is also of low-reluctance magnetic material. Strip 32 may be held in place in a manner similar to that used to support strip 31 of the embodiment shown in Fig. 4. Ring magnet 33 corresponds to the magnetic assembly 23 of Fig. 1 and is a conventional type of generally cylindrical internal focusing magnet.

Although I have described my invention with reference to a permanent magnet-type focusing magnet, it may in some cases be feasible to employ a combination permanent magnet-electromagnet-type focusing lens where sufficient flux leakage is provided to maintain an ion-trapping field.

It is noted also that although the various embodiments of my invention are described with reference to focusing assemblies having generally-cylindrical permanent magnets, it is substantially equivalent in each and very embodiment shown to employ a permanent-magnet assembly of the type having a plurality of spaced magnetic bars forming a generally-segmented cylinder, as is well-known in the art.

It is seen from the foregoing description and the associated drawing that I have provided improved combination focusing-ion trap devices that eliminate the need for a separate ion-trap magnet, thereby representing a saving of magnetic material while performing both focusing and ion-trapping functions in an entirely efficient and satisfactory manner.

While certain specific embodiments have been shown and described, it will, of course, be understood that various modifications may be made without departing from the principles of the invention. The appended claims are therefore intended to cover any such modifications within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a cathode-ray indicating system of the type including a cathode-ray device having means therein for producing a beam and projecting it against a sensitive screen, means for directing said beam at an angle to the longitudinal axis of said device and means comprising an ion-trapping member with a beam-receiving aperture therein for trapping ions out of said beam, the combination of a focusing magnet assembly arranged to produce a magnetic focusing field, means for distorting a portion of said field to re-direct electrons of said beam through said aperture, said distorting means comprising a magnetic member of low-reluctance material positioned on one side of said assembly adjacent said directing means and within said field.

2. In a cathode-ray indicating system of the type including a cathode-ray device having means therein for producing a beam and projecting it against a sensitive screen, electric means tending to direct said beam at an oblique angle to the longitudinal axis of said device and means comprising an ion-trapping member with a beam-receiving aperture therein for trapping ions out of said beam, the combination of a permanent magnet-type focusing assembly arranged to produce a magnetic focusing field, means for distorting a portion of said field in order to oppose said electric directing means and direct electrons of said beam through said aperture, said distorting means comprising a magnetic member of low-reluctance material positioned on one side of said assembly adjacent said electric directing means and within said field.

3. In a cathode-ray indicating system of the type including a cathode-ray device having means therein for producing a beam and projecting it against a sensitive screen, electric means for directing said beam at an oblique angle to the longitudinal axis of said device and means comprising an iron-trapping member with a beam-receiving aperture therein for trapping ions out of said beam, the combination of a permanent magnet-type focusing assembly arranged to produce a magnetic focusing field including leakage flux, means for distorting

a portion of said leakage flux in order to oppose said electric directing means and re-direct electrons of said beam through said aperture, said distorting means comprising a magnetic member of low-reluctance material positioned on one side of said assembly within said leakage flux and having one end thereof in abutting relation with said assembly.

4. In a cathode-ray device assembly of the type including a cathode-ray device having an envelope, means for producing a cathode ray, means for directing said ray at an angle to the longitudinal axis of said cathode-ray device, and means for trapping ions out of said ray including an ion-trapping member having a ray-receiving aperture therein, the combination of means for focusing said ray including a permanent magnet-type focusing device for developing a focusing field, a distorting member of low reluctance material positioned adjacent the envelope of said cathode-ray device within the leakage flux region of said field opposite said directing means, said member having one end thereof in abutting relation with the one end of said magnetic focusing device nearer said directing means thereby to provide selective means for directing electrons in said ray through said aperture.

5. In a cathode-ray device assembly of the type including a cathode-ray device having an envelope, means for producing a cathode ray, means for directing said ray at an angle to the longitudinal axis of said cathode-ray device, and means for trapping ions out of said ray including an ion-trapping member having a ray-receiving aperture therein, the combination of means for focusing said ray including a permanent magnet-type focusing device for developing a focusing field, a distorting member of low-reluctance magnetic material adapted to be positioned along said envelope within the leakage flux region of said field opposite said directing means, and adjustable means for mounting said distorting member on said focusing device so as to maintain one end thereof in adjustable spaced relation with one end of said focusing device opposite said directing means, thereby to direct the electrons in said ray through said aperture.

6. In a cathode-ray device assembly of the type including a cathode-ray device having an envelope and a neck, means for producing a cathode ray, means for directing said ray at an angle to the longitudinal axis of said cathode-ray device, and means for trapping ions out of said ray including an ion-trapping member having a ray-receiving aperture therein, the combination of means for focusing said ray including a permanent magnet-type focusing device arranged to develop a focusing field, and a distorting member of low-reluctance material positioned within said envelope and within the leakage flux region of said field opposite said ray-directing means to distort a portion of said field to provide selective means for directing electrons in said ray through said aperture.

7. In a cathode-ray device having an envelope including a neck portion, means for producing a cathode ray, means for directing said ray at an angle to the longitudinal axis of said cathode-ray device, and means for trapping ions out of said ray including an ion-trapping member having a ray-receiving aperture therein, the combination therewith of means for focusing said ray including a permanent magnet-type focusing device within said envelope arranged to develop a focusing field and a distorting member of low-reluctance material positioned along said neck within said envelope and within the leakage flux region of said field opposite said ray-directing means to distort a portion of said field to provide selective means for directing electrons in said beam through said aperture.

8. An ion-trapping device for a cathode-ray device or the like having means for directing a cathode ray at an angle to the longitudinal axis of said cathode ray-device, comprising means to produce a magnetic focusing field and means for distorting a portion of said field for ion-trapping purposes, said distorting means comprising a magnetic member of low-reluctance material supported by one side of said assembly adjacent said directing means and within said field.

9. An ion-trapping device for a cathode-ray device or the like of the type having means for directing a cathode ray at an angle to its longitudinal axis, means for trapping ions out of said ray, comprising means for producing a magnetic focusing field, and a magnetic member of low-reluctance material positioned on one side of said focusing means adjacent said directing means and within said field, thereby to distort a portion of said field for ion-trapping purposes.

10. In combination with a cathode-ray device having means for producing a cathode beam, means for directing said beam at an angle to the longitudinal axis of said device, and means for trapping ions out of said cathode beam including an ion-trapping member having a beam-receiving aperture therein, means for focusing said beam including a magnetic type focusing device for developing a focusing field having a component generally along the axis of said device, means for deflecting electrons in said beam through said aperture, said deflecting means comprising a distorting member of low-reluctance material positioned along the neck of said cathode-ray device within the field produced by said magnetic focusing device and opposite said directing means.

11. In a cathode-ray device having an envelope and a neck, means for producing a cathode beam, electric means for directing said beam at an oblique angle to the longitudinal axis of said cathode-ray device, means for trapping ions out of said beam including an ion-trapping member having a beam-receiving aperture therein, the combination of means for focusing said beam including a permanent magnet-type focusing device within said envelope for developing a focusing field having a component generally along the axis of said cathode-ray device, selective means for deflecting electrons in said beam substantially along said longitudinal axis and through said aperture, said deflecting means comprising means for distorting a portion of said field in order to oppose said electric-directing means, said distorting means including a distorting member of low-reluctance material positioned along said neck within said envelope within the leakage flux region of said field opposite said electric-directing means.

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