

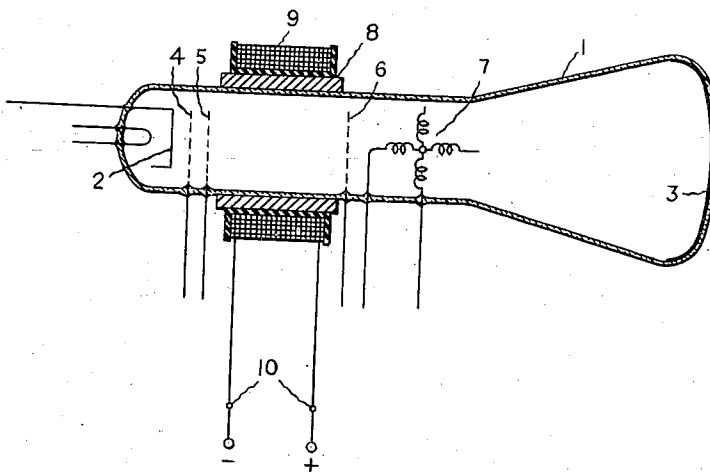
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R. B. GETHMANN

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FOCUSING ARRANGEMENT FOR CATHODE-RAY TUBES

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Inventor:
Richard B. Gethmann,
by *Merton D. Mome*
His Attorney.

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FOCUSING ARRANGEMENT FOR CATHODE-RAY TUBES

Richard B. Gethmann, Bridgeport, Conn., assignor to General Electric Company, a corporation of New York

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This invention relates to cathode-ray tubes and the like and more particularly to improved magnetic arrangements for focussing the electron beams in such tubes.

It is an object of this invention to provide a magnetic focussing arrangement for cathode-ray tubes and the like whereby the electron beam in such tubes is maintained substantially in focus, regardless of variations in the tube energizing potentials due to line potential changes.

Yet another object of this invention is to provide a magnetic focussing arrangement for cathode-ray tubes and the like which requires fewer ampere turns, and wherein the loss in focus during the warm-up period is substantially reduced as compared to the conventional systems.

The features of this invention which are believed to be new are set forth with particularity in the appended claims. The invention itself, however, together with further objects and advantages thereof, may best be understood by reference to the accompanying drawing wherein the single figure shows a cathode-ray tube utilizing a focussing arrangement in accordance with the present invention.

It is contemplated in the present invention to provide a hollow cylindrical permanent magnetic member surrounding the electron beam of a cathode-ray tube, this member being magnetized in the direction of the longitudinal axis of the tube. It is further contemplated to wind a coil about the circumference of the cylindrical permanent magnet member and to pass a unidirectional current therethrough, hence setting up an electromagnetic focussing field in the same direction as the focussing field due to the permanent magnetic member.

When an electromagnetic focussing arrangement alone is utilized, it may be shown that:

$$(1) \quad I = K\sqrt{E}$$

where:

I is the current through the focussing coil required to focus the electron beam,

E is the beam accelerating potential,

K is a coefficient depending upon the design of the focussing coil.

Hence, assuming that the beam accelerating potential and the potential across the electromagnetic focussing coil vary linearly with change in line potential, for every change in line potential the beam will no longer be in focus, and some type of control must be provided to change the value of I to bring the beam back into focus.

On the other hand, a cylindrical permanent

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magnet provides a magnetic field which focusses the electron beam only for a particular beam accelerating potential. Hence, when such type of focussing arrangement is used, it is necessary either to maintain a particular constant beam accelerating potential, or to provide some means, such as a variable magnetic shunt, to change the magnetic field of the permanent magnet to refocus the beam for changes in line potential.

In accordance with the present invention, a combination of the two above-mentioned types of systems is utilized, and in the present system, Equation 1 now becomes:

$$(2) \quad I = K\sqrt{E - E_0}$$

where E_0 is the beam accelerating potential at which the permanent magnet alone focusses the beam.

Now, the equation of the straight line, tangent to the curve representing Equation 2 at a point E_1 , and passing through the origin, is:

$$(3) \quad I = \left[\frac{dI}{dE} \right]_{E=E_1} \cdot E$$

$$= \frac{K}{2\sqrt{E_1 - E_0}} \cdot E$$

but,

$$I_1 = K\sqrt{E_1 - E_0}$$

Therefore, substituting in Equation 3:

$$K\sqrt{E_1 - E_0} = \frac{K}{2\sqrt{E_1 - E_0}} \cdot E_1$$

which gives

$$(4) \quad E_0 = \frac{E_1}{2}$$

When the resistance of the focus coil is made such that the current-potential relationship is:

$$(5) \quad I = \frac{K}{2\sqrt{E_1 - E_0}} \cdot E$$

and when the permanent magnet field is adjusted so that:

$$E_0 = \frac{E_1}{2}$$

The current to focus the beam at a beam accelerating potential E is:

$$(5) \quad \left[I = \frac{K}{2\sqrt{E_1 - \frac{E_1}{2}}} \cdot E \right]$$

$$= \frac{K}{\sqrt{2E_1}} \cdot E$$

Therefore assuming that the beam accelerat-

ing potential and the potential across the focussing coil vary linearly with change in line potential, any increase or decrease in E in Equation 5 is accompanied by a corresponding increase or decrease in the focussing current I of this equation, sufficient to keep the system substantially in focus at all times.

It can be seen, therefore, that assuming E_1 to be the normal operating beam accelerating potential, the permanent magnetic field is made such that it focusses the electron beam at an accelerating potential of

$$\frac{E_1}{2}$$

The resistance of the electromagnetic coil is made such that, when E_1 is impressed thereacross, a current

$$I_1 = \frac{K}{\sqrt{2E_1}} \cdot E_1$$

flows therethrough and, as previously shown, this current is of the required value to focus the electron beam. As has also been shown, when E_1 changes to $(E_1 \pm \Delta E_1)$ due to line potential changes I_1 changes to:

$$(I_1 \pm \Delta I_1) = \frac{K}{\sqrt{2E_1}} (E_1 \pm \Delta E_1)$$

and, hence, the beam is substantially still in focus.

Referring now to the figure, there is shown a cathode-ray tube 1 such as the type used in television receivers and the like. An electron beam is generated at the cathode 2 and directed towards a screen 3. The intensity of the electron beam may be controlled by control electrode 4, and electrodes 5 and 6 may act as accelerating electrodes therefor. The usual beam deflection means for scanning purposes are shown at 7.

In accordance with this invention, intermediate the accelerator electrodes 5 and 6, for example, a cylindrical shaped member 8 is mounted about the ray tube 1 surrounding the electron beam, the member 8 being composed of permanent magnet material, and having a coil 9 wound around the periphery thereof. The terminals of coil 9 are connected to a source of unidirectional potential 10, the value of which is assumed to vary linearly with the beam accelerating potential due to changes in the alternating current line potential.

The member 8 is magnetized so that a magnetic field is set up in the direction of the longitudinal axis of the tube as previously described. This magnetic field may have a predetermined intensity, in accordance with the previously developed mathematical analysis. Unidirectional potential is impressed across the coil 9, and the resistance of this coil may similarly be given a predetermined value, as previously described. It is apparent that coil 9 may be wound externally or internally to cylindrical magnet 8, or the two may have separate positions along the axis of tube 1.

The present invention therefore provides a simple and inexpensive magnetic focussing device for cathode-ray tubes and the like. Due to the presence of the permanent magnetic field, the ampere turns of the focussing coil may be less than in conventional electromagnetic focussing systems, and in addition the usual drift during the warm-up period in such conventional systems is greatly reduced in the present system due to the above-mentioned permanent magnet field. The improved arrangement for focussing an electron

beam in cathode-ray tubes, and the like, also has the desirable feature that the focussing characteristics of the arrangement are substantially immune to changes in line potential.

This invention finds ready application in television receiver systems and provides in such systems a focussing arrangement that may be preset and wherein manual readjustment is not required for each variation in line potential. In a television receiver employing this improved focussing arrangement, it has been found that satisfactory operation is obtained for changes in line potential up to 20 per cent.

While a certain specific embodiment has been shown and described, it will of course be understood that various modifications may be made without departing from the invention. The appended claims are therefore intended to cover any such modifications as fall 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 tube having a neck portion, a source of electrons, means for forming said electrons into an electron beam, beam accelerating means, and beam focussing means, said beam accelerating means being connected to a source of unidirectional potential, and said beam focussing means comprising, in combination, a hollow cylindrical permanent magnet of uniform cross section having an inner diameter substantially equal to the outer diameter of said neck portion and adapted to be supported directly on said neck portion, an electromagnet comprising a coil wound around the outer surface of said permanent magnet, said magnets together providing the total focussing magnetomotive force for said beam, said electromagnet being connected to said previously mentioned source, and the individual magnetomotive forces of said magnets being so correlated that said beam is in focus for a certain unidirectional potential value of said source, and remains substantially in focus for variations in said unidirectional potential value.

2. In a cathode-ray tube having a neck portion, a cathode, an accelerating electrode, and a cathode-ray beam focussing arrangement, said accelerating electrode being connected to a source of unidirectional potential, said focussing arrangement comprising, in combination, a hollow cylindrical permanent magnet of uniform cross section having an inner diameter substantially equal to the outer diameter of said neck portion and adapted to be supported directly on said neck portion, an electromagnet comprising a coil wound around the outer surface of said permanent magnet, said magnets together providing the total focussing magnetomotive force for said beam, said electromagnet being connected to said previously mentioned source, the internal resistance of said electromagnet having a predetermined value and the individual magnetomotive forces of said magnets being so correlated that said beam is in focus for a certain potential value of said source and remains substantially in focus for variations in said potential value.

3. In a cathode-ray tube and the like, a cathode, an accelerating electrode, and a cathode-ray beam focussing arrangement, said accelerating electrode being connected to a source of unidirectional potential and having a unidirectional potential E_1 impressed thereon, said focussing arrangement comprising, in combination, a permanent magnet and an electromagnet, said magnets together providing the total focussing magneto-

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motive force for said beam, said electromagnet being connected to said previously mentioned source, and the internal resistance of said electromagnet being such that a current

$$I_1 = \frac{K}{\sqrt{2E_1}} \cdot E_1$$

flows therethrough, where K is a constant dependent upon the design of the electromagnet, and said permanent magnet having such a magnetomotive force that it focusses said beam at an accelerating potential of

$$\frac{E_1}{2}$$

on said accelerating electrode, the arrangement

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being such that said beam is in focus at a potential source value of E_1 , and remains substantially in focus for variations in said potential value.

RICHARD B. GETTMANN.

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