Oct. 22, 1940. D. J. MYNALL 2,219,193

CATHODE RAY APPARATUS

Filed April 21, 1938 2 Sheets-Sheet 1

Fig. 1.

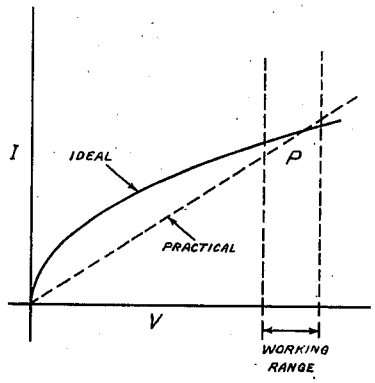


Fig. 2.

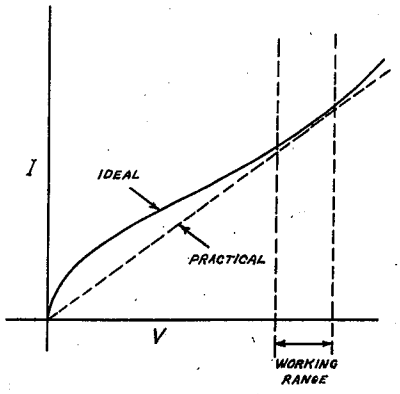


Fig. 3.

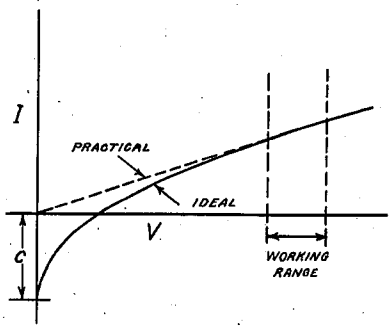
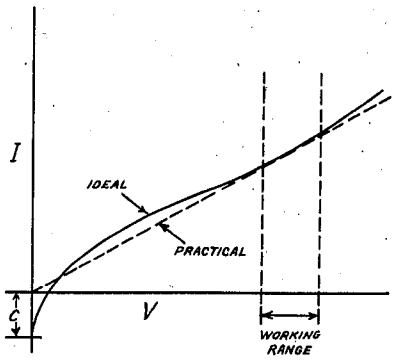


Fig. 4.



Inventor:
Dennis J. Mynall,
by Harry E. Dunham
His Attorney.

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Fig. 5.

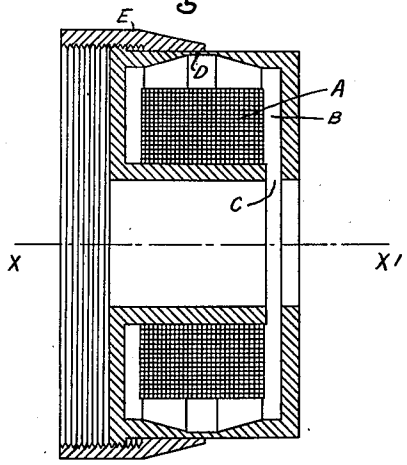


Fig. 6.

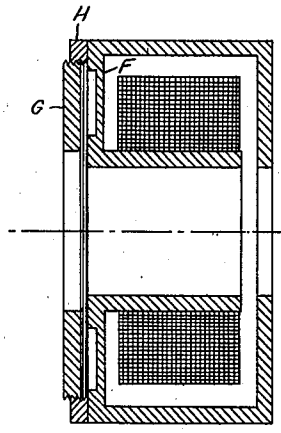


Fig. 7.

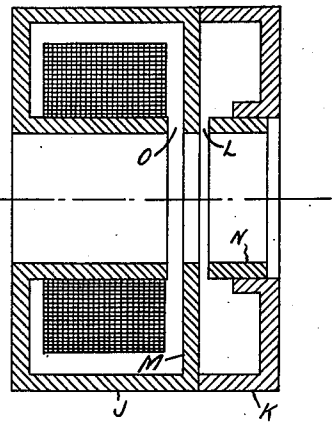
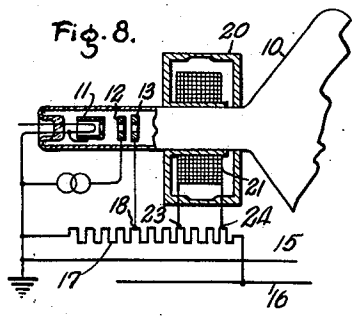


Fig. 8.



Inventor:
Dennis J. Mynall,
by Harry E. Dunham
His Attorney.

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UNITED STATES PATENT OFFICE

2,219,193

CATHODE RAY APPARATUS

Dennis James Mynall, Rugby, England, assignor to General Electric Company, a corporation of New York

Application April 21, 1938, Serial No. 203,311
In Great Britain May 1, 1937

3 Claims. (Cl. 250—27)

This invention relates to the operation of cathode ray tubes with magnetic focusing and is particularly though not exclusively concerned with the use of such arrangements in television reception.

Where a cathode ray tube is focused by means of a magnetic lens, and the electrical supplies to the tube anode-cathode circuit and the magnetic lens are taken from a common source of alternating or direct current, it is found that a variation of focus is consequent upon a variation of mains voltage, resulting in the necessity for manual control to counteract the changes. This is an undesirable feature in a television receiver and it is the object of this invention to provide a simple means of automatic compensation over a range sufficient to cover the variations of voltage encountered in practice.

In order that this result may obtain it is necessary (i. e. the ideal condition) that the flux produced by the magnetic means shall vary as the square root of the voltage of the energizing source (it being assumed that the electrostatic field between the cathode and the accelerating anode varies directly as such voltage). With the ordinary magnetic system operating in an unsaturated state this result will not be obtained, since both magnetizing current and flux increase approximately linearly with the exciting voltage. However, it is found that if means are provided for causing the magnetic system to operate on the knee of the saturation curve, the desired condition will be fulfilled. That is to say, the magnetic flux will increase as a function which is less than a linear function of the exciting voltage and which approximates a square root relation thereto.

The features of the invention which I desire to protect herein are pointed out with particularity in the appended claims. The invention itself, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the drawings in which Figs. 1 through 4 are curves which are referred to in the explanation of the invention, and Figs. 5 through 8 illustrate various embodiments of the invention.

Fig. 1 shows the difference between the ideal relationship of magnetizing current and anode-cathode voltage and the relationship which is attained with the energizing arrangements heretofore employed. The point of intersection—P—represents a condition of focus and is taken as the best setting for the average working of V. It is evident from Fig. 1 that a variation of V will result in a corresponding change in I which is more than that ideally required. This is why manual readjustment is necessary.

The preferred embodiment of the present invention consists in a cathode ray tube having electromagnetic means for focusing the ray, in which the focusing means is so arranged that the curve showing the relation which must hold between I (the current flowing through the focusing means) for varying values of V (the anode-cathode voltage of the tube) in order to maintain the ray in focus, and the curve showing the relation between I and V which holds under working conditions are so closely aligned over a predetermined range of the value of V that the ray is substantially maintained in focus over the said range.

According to a feature of the present invention, the alignment of the two curves is effected over a finite range of operating voltage by designing the magnetic circuit of the lens so that it operates in the condition of saturation. The ideal relationship between I and V may be written

$$I=aV^{\frac{1}{2}}$$

but in this case a is constant only for the lower values of I, and increases with I in the condition of saturation. Thus the effect of saturation is to give an S-shaped ideal curve to which the practical curve (of the form $I=bV$) may be aligned sufficiently closely to provide a range of values of V over which the focus does not appreciably change. This is shown in Fig. 2. The magnetic saturation may, for example, be introduced by a suitable restriction in the iron circuit of the lens, and the relation

$$I=aV^{\frac{1}{2}}$$

controlled, if required, by shunting the restriction magnetically. The control of the relation $I=bV$ maybe obtained in the normal manner by resistance in shunt and/or series with the resistance of the lens winding.

With a given form of lens construction the compensation is obtained only at the expense of increased energy dissipation in the lens. This may be undesirable, and accordingly a further feature of the invention consists in the introduction of an auxiliary magnetic field which is independent of the voltage V, working in conjunction with the normal field. The addition of the constant field causes the $I-V$ relationship required for constant focus to take the form $I=aV-c$, where c is constant, a is as before, and I now represents the current producing the variable part of the field. Fig. 3 illustrates the superposed constant field case where there is no saturation, and Fig. 4 gives the corresponding case where saturation occurs. It will be seen that either curve can be matched over a working range of V. The constant field, on which the value of c depends, is preferably obtained by incorporating a permanent magnet in the same system as that which provides the variable field, initial control being exercised, if required, by means of a magnetic shunt or shunts.

The constant field may also be obtained by the use of a permanent magnet physically separate from the remainder of the system, by means of an auxiliary winding supplied from a constant current or constant voltage device, or by means of a separate lens with windings supplied from a constant current or constant voltage device.

Magnetic circuits suitable for carrying out the invention are illustrated by way of example, in the accompanying drawings, the figures of which have been numbered 5 to 7 consecutively with those of the drawings hereinbefore referred to.

In Fig. 5 an electromagnetic electron-optical lens is shown in which a winding A in the annular tunnel B sends flux through the magnetic body of the lens (which may, for example, be of mild steel) and across the annular air gap C. The leakage flux from the air gap is used to focus a beam of electrons travelling in the general direction XX_1. As so far described, the lens construction is well-known, but the drawings show a restriction D in the magnetic circuit which can be shunted by the adjustable element, E, made of similar material to the body of the lens. This element shunts the restriction, so making it effectively of greater area, so that magnetic saturation sets in at a higher total flux in the magnetic circuit. This allows the saturation effect to be adjusted to function correctly over a fairly wide range of working conditions. If normal working conditions are not subject to extensive change, it is practicable to dispense with the adjustable element.

Fig. 6 shows a similar lens in which the restriction is situated at F. Adjustment may be effected by turning the magnetic shunt G, (made of similar material to the main body of the lens) in the threaded nonmagnetic ring H which is fixed to the main body. The effect of G is to shunt flux from the saturable part F, so modifying the saturation curve of the magnetic circuit considered as a whole.

In extreme cases, where great fineness of control is required, it is possible to use the methods of Fig. 5 and Fig. 6 in combination on the same lens. The usefulness of this is that the two methods modify the normal saturation curve in rather different manners, so that, when used together, the variety of characteristics which can be commanded is greater than for either alone.

Fig. 7 shows a normal lens having a magnetic circuit J, to which has been affixed a ring shaped permanent magnet K which sends flux across the annular air gap L, via a part M of the magnetic circuit of the lens, and an axially adjustable annular pole piece, N. The pole piece N may be of material similar to the magnetic circuit. The magnetic fluxes from the windings of J and from K are in such a sense that M carries their difference, which is never large. The adjustable element N allows the focusing field due to the magnet K to be set to the required amount, in relation to the focusing field from the other air gap O.

As before, it may be possible to dispense with the adjustments, if the working conditions are always to be within known limits.

In Fig. 8 of the drawings I have illustrated the application of my invention in schematic form. Thus, there is shown a cathode ray tube 10 of conventional type having a heated cathode 11, a control grid 12, and an accelerating anode 13. The remaining electrodes of the device, including the deflecting electrodes, are not shown since they are not relevant to my present invention.

Potential is supplied to the various electrodes from a source which is illustrated as comprising a pair of feeder lines 15, 16. These are connected across a potentiometer 17 from which voltages of various values may be obtained. In this connection it will be noted that the anode 13 is connected to the potentiometer at a point 18 which is highly positive with respect to the cathode 11.

Around the shaft of the cathode ray tube there is provided a magnetic flux system comprising a magnetic core 20 of the character illustrated more completely in Fig. 5 and an energizing coil 21. The terminals of the coil 21 are connected to the potentiometer 17 at taps 23 and 24. In this way assurance is obtained that potential variations of the common source 15, 16 tending to affect the velocity of the electron stream will produce simultaneous changes in the excitation of the coil 21 so as to obtain constant focusing as described above.

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

1. In combination, a cathode ray tube having means for developing an electron beam, means for producing an electrostatic field effective to accelerate the beam to a desired velocity, means for producing a magnetic field which coacts with the said electrostatic field to cause the beam to focus in a predetermined plane, a common voltage source for energizing both field-producing means, and means for causing the said magnetic field to vary approximately as the square root of the voltage of the said source, whereby the focus of the beam remains substantially constant irrespective of changes in such voltage.

2. In combination, a cathode ray tube having means for developing an electron beam, means for producing an electrostatic field effective to accelerate the beam to a desired velocity, means including a magnetic structure for producing a magnetic field which coacts with the said electrostatic field to cause the beam to focus in a predetermined plane, a common voltage source for energizing both field-producing means, and means forming a part of the flux path of the magnetic structure for causing the same to be sufficiently saturated so that the field which is produced by such means varies approximately as the square root of the voltage of said source, whereby the beam focus remains substantially constant irrespective of changes in such voltage.

3. A cathode ray apparatus having means for developing an electron beam, means for producing an electrostatic field effective to accelerate the beam to a desired velocity, means for producing a magnetic field which coacts with the said electrostatic field to cause the beam to focus in a predetermined plane, and a common voltage source for energizing both field-producing means, wherein the magnetic field-producing means includes a first magnetic structure producing a field of constant intensity and a second magnetic structure producing a field of intensity which varies with the voltage of the said source, the two fields acting differentially and the relation between them being such that the resultant field varies approximately as the square root of the voltage source in the normal operating range of the apparatus.

DENNIS JAMES MYNALL.