PATENT SPECIFICATION

Application Date: Nov. 19, 1934. No. 33294/34. **447,493**

Complete Specification Left: Aug. 2, 1935.

Complete Specification Accepted: May 19, 1936.

PROVISIONAL SPECIFICATION

Improvements in and relating to Modulating Means for Cathode Ray Tubes

We, FREDERICK HERMES NICOLL, a British Subject, of 24, Basildene Road, Hounslow West, Middlesex, and ELECTRIC & MUSICAL INDUSTRIES LIMITED, a British Company, of Blyth Road, Hayes, Middlesex, do hereby declare the nature of this invention to be as follows:—

The present invention relates to modulating means for cathode ray tubes.

A form of cathode ray tube has been proposed in which the electrons from a cathode within a highly evacuated envelope are first accelerated towards an accelerator electrode, then decelerated towards a modulator electrode and again accelerated by two or more anodes, the anodes also serving, as an electron lens, to focus the electron beam upon a fluorescent screen. The potentials applied to the electrodes may be such that the electrons are brought substantially to rest in a virtual cathode in the neighbourhood of the modulator electrode. The brightness of the spot formed by the cathode ray upon the screen is varied by applying a varying negative potential to the modulator relatively to the cathode. The cathode structure may comprise an indirectly heated cathode located behind an apertured diaphragm arranged in the end of a metal tube and constituting with the tube what is known as a cathode shield. The tube projects backwards around the cathode. The other electrodes are commonly in the form of metal tubes having apertured diaphragms and it is usual to make the thickness of the material of the diaphragms not more than one tenth of the diameter of the apertures therein.

It is an object of the present invention to provide a cathode ray tube of the kind above described in which the sensitivity of control of the ray intensity over the useful working range is higher than with known tubes. This sensitivity is measured by the negative voltage which has to be applied to the modulator to extinguish the ray, the sensitivity being of course greatest when this voltage is least.

According to the present invention a cathode ray tube is provided with a modulator electrode in the form of an apertured diaphragm, the thickness of the material surrounding the aperture substantially exceeding one tenth of the diameter of the aperture.

Further according to the present invention, a cathode ray tube is provided with a modulator electrode comprising a plurality of apertured diaphragms located one behind the other in the electron path. The diaphragms may be of thin material and may be electrically connected together.

In carrying the invention into effect I may proceed as follows:—

A cathode ray tube is constructed in the manner already described, the accelerator, modulator and first anode being in the form of metal tubes all of the same size as the cathode shield. The accelerator tube is short and has an apertured diaphragm at the end remote from the cathode. The modulator tube is longer than the accelerator and has an apertured diaphragm intermediate the ends of the tube and on the cathode side of the centre of the tube. The first anode is of much greater length than the modulator and has an apertured diaphragm in the end nearer the cathode and a second apertured diaphragm about two thirds of the way along from this end. The second anode is in the form of a tube of considerably larger diameter than the other electrodes, the adjacent edges of the two anodes being located substantially in a plane. All the tubes are arranged co-axially.

When a cathode ray tube is constructed as above described with the diaphragm of the modulator of thickness not exceeding one tenth of the diameter of the aperture therein, a satisfactory focus of the ray can be obtained upon a screen within the envelope when suitable potentials are applied to the various electrodes. Thus the cathode screen may be maintained at cathode potential, which will be regarded as zero, the accelerator at a small positive potential, the modulator at a varying negative potential, the first anode at a fairly high positive potential and

the second anode at a still higher positive potential. The sensitivity of such a tube is however not as high as may often be desirable, and hitherto it has not been found possible to increase the sensitivity without impairing the focus of the spot upon the screen. According to the present invention, the effective thickness of the material around the aperture in the modulator is increased substantially and in this way the sensitivity can be increased without noticeably affecting the sensitivity or the shape of the modulation characteristic.

For example in one case with a modulator of known construction in the form of a diaphragm of thin material having an aperture 1.9 mm. in diameter the negative voltage required to extinguish the ray is 20 volts whereas when there is connected to this diaphragm a second diaphragm of thin material having an aperture of 2.5 mm. in diameter, arranged at a distance of 1.0 mm. from the first modulator diaphragm on the side thereof nearer the cathode, the voltage required to extinguish the ray is reduced to 12. The thickness of the material in which the aperture is formed is in this way effectively increased to 1 mm. although the actual material of the diaphragms may be thin.

With the particular arrangement of diaphragms described, the shape of the modulator characteristic is not appreciably changed from that with the single diaphragm although its steepness is increased. The focusing is also substantially unaffected. By modifying the sizes of the apertures and their separation, however, certain changes in the shape of the characteristic can be effected.

The apertures in the diaphragms may if desired be made of equal diameter or the larger diameter aperture in the arrangement first described may be arranged, for some purposes, further from the cathode than the aperture of smaller diameter.

A similar effect to that above described can be obtained with a single diaphragm of thin material having a lip around the aperture. The lipped portion may be of cylindrical shape, giving an effect nearly equivalent to that of two apertures of equal diameter, or it may be of conical or other flared shape giving the effect of apertures of different diameter. The behaviour of lipped apertures resembles closely that of apertures in equivalently spaced diaphragms provided that the distance between such diaphragms (and therefore the axial length of the lipped portion in the diaphragm with a lipped aperture) is not unduly great. The distance between the diaphragms is usually less than the diameter of either of the apertures. The lips may project either towards or away from the cathode and they may flare in either direction.

A further arrangement, which is nearly equivalent to that using multiple diaphragms, involves the use of relatively thick material for the diaphragm. Thus a single diaphragm 1.0 mm. thick having an aperture tapering from 1.9 mm. at one face to 2.5 mm. at the other face is approximately equivalent in its behaviour to the two thin diaphragms described in the first specific example. The aperture may also be made of other shapes.

Three or more diaphragms may be used and the apertures therein may be equal to or different from one another according to circumstances. In one example three diaphragms are used and the aperture in the centre diaphragm is made smaller than that in the two outer diaphragms. The equivalent aperture can also be made in a single diaphragm of thicker material the aperture having three portions of cylindrical shape (of different diameters corresponding to the apertures in the three separate diaphragms) united by flaring portions. Alternatively the boundaries of the aperture in the thicker material may be of curved shape, for example the cross-section of the boundaries in planes containing the axis may be part-circular.

When the modulator diaphragm has the form just described or the approximately equivalent form which can be made with three diaphragms having the apertures in the outer diaphragms larger than that in the centre diaphragm, the size of the aperture at the centre is preferably selected as small as possible consistent with the current in the tube at zero modulator voltage not being decreased by the return of electrons from the modulator and the diameters of the aperture at the faces of the diaphragm are arranged to give maximum sensitivity and current through the tube.

Dated this 19th day of November, 1934.

REDDIE & GROSE,
Agents for the Applicants,
6, Bream's Buildings, London, E.C.4.

COMPLETE SPECIFICATION

Improvements in and relating to Modulating Means for Cathode Ray Tubes

We, FREDERICK HERMES NICOLL, a British Subject, of 24, Basildene Road, Hounslow West, Middlesex, and ELECTRIC & MUSICAL INDUSTRIES LIMITED, a British Company, of Blyth Road, Hayes, Middlesex, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention is an improvement in or modification of the invention forming the subject of Patent Applications Nos. 27199/33 and 20960/34 (Serial No. 431,327) (cognate), the complete specification of which describes and claims an electric circuit comprising a cathode ray tube of the hard type having arranged within its envelope, in the order mentioned, a cathode, a first accelerator, a decelerator having an apertured diaphragm and which also acts as a modulator, and a second accelerator, the accelerators and decelerator being so disposed that the ray can pass through them to a screen associated with the tube, and the tube having means whereby the ray can be deflected over the screen, and electrostatic or electromagnetic means for focusing the ray in a small spot upon the screen, characterised by means for applying to the accelerators potentials positive with respect to the cathode potential, and to the decelerator a potential equal, or nearly equal, to the cathode potential, the shape and disposition of the electrodes and the potentials applied thereto being such that, in operation, increases of potential of the decelerator, in the negative sense with respect to the cathode potential produce increases of current flowing to the first accelerator. The said specification also describes and claims a cathode ray tube of the hard type having an indirectly heated cathode and an anode, and having, between the cathode and anode, at least four auxiliary electrodes including two accelerators and a decelerator which also is a modulator, one of said accelerators being arranged upon either side of said decelerator, the arrangement being such that when the accelerators are maintained at suitable positive potentials relative to the cathode and when the decelerator is at a potential in the neighbourhood of cathode potential, increases of potential of the decelerator in a negative sense with respect to the cathode potential produce increases of current flowing to the accelerator located upon the cathode side of the decelerator.

In the operation of the cathode ray tubes hereinabove referred to the electrons from the cathode are accelerated towards the first accelerator electrode, then decelerated towards the modulator electrode and again accelerated by the second accelerator, which may be one of two anodes serving, as an electron lens, to focus the electron beam upon a fluorescent screen. The potentials applied to the electrodes are such that the electrons are slowed up to a velocity not differing greatly from zero in a deceleration region in the neighbourhood of the modulator electrode. The brightness of the spot formed by the cathode ray upon the screen is varied by applying a varying negative potential to the modulator relatively to the cathode. The cathode structure may comprise an indirectly heated cathode located behind an apertured diaphragm arranged in the end of a metal tube and constituting with the tube what is known as a cathode shield. The tube projects backwards around the cathode. The other electrodes are preferably in the form of metal tubes, all except the second anode, having apertured diaphragms, and it is usual to make the thickness of the material of these diaphragms not more than one tenth of the diameter of the apertures therein.

It is an object of the present invention to provide a cathode ray tube of the kind above described in which the sensitivity of control of the ray intensity over the useful working range is higher than with known tubes. This sensitivity is measured by the negative voltage which has to be applied to the modulator to extinguish the ray, the sensitivity being of course greatest when this voltage is least, providing that the current at zero modulator voltage is unaltered.

According to the present invention the modulator electrode of the cathode ray tube is provided with or is in the form of an apertured diaphragm, the thickness of the material surrounding the aperture substantially exceeding one-tenth of the diameter of the aperture.

Further according to the present invention, the modulator electrode of the cathode ray tube comprises a plurality of

apertured diaphragms located one behind another along the electron path. These diaphragms are, of course, all disposed between the first and second accelerators and they may be of thin material.

There is less penetration of the anode field through the thick, or multiple, modulator diaphragm than through a thin diaphragm; hence the negative voltage which has to be applied to the modulator to extinguish the ray is less than with a thin modulator diaphragm. However, with many kinds of cathode ray tubes the inclusion of a thick modulator diaphragm would effect little or no increase in sensitivity because it would cause the intensity of the ray at zero modulator volts to fall also. Where, however, a positive electrode is provided between the cathode and a modulator maintained at or near cathode potential, and the modulator is constructed in accordance with the present invention, the intensity of the ray at zero modulator potential is not greatly influenced by the effective length of the aperture in the diaphragm, and the sensitivity of the tube is therefore increased.

The invention will be further described with reference to the accompanying diagrammatic drawings, in which

Fig. 1 shows part of the electrode arrangement of one of the cathode ray tubes described in the patent specification above referred to, and

Figs. 2 to 8 are sections of alternative forms of modulating and decelerating electrode arranged in accordance with the present invention.

In Fig. 1, a cathode 1 is housed in a cathode shield electrode 2 adapted to be maintained at or near cathode potential. A first accelerator 3, a modulator and decelerator 4, and a second accelerator or first anode 5 are in the form of metal tubes all of the same diameter as the cathode shield 2. The first accelerator tube 3 is short and has an apertured diaphragm 7 at the end remote from the cathode. The modulator tube 4 is longer than the accelerator and has an apertured diaphragm 8 intermediate the ends of the tube and on the cathode side of the middle of the tube. The first anode 5 is much longer than the modulator 4 and has an apertured diaphragm 9 in the end nearer the cathode and a second apertured diaphragm 10 about two thirds of the way along from this end. The second anode is in the form of a tube 6 of considerably larger diameter than the other electrodes, the adjacent edges of the two anodes being located substantially in a plane. All the tubes are arranged co-axially.

When a cathode ray tube is constructed as shown in Fig. 1 with the diaphragm of the modulator of thickness not exceeding one-tenth of the diameter of the aperture therein, a satisfactory focus of the ray can be obtained upon a screen within the envelope when suitable potentials are applied to the various electrodes. Thus the cathode shield 2 may be maintained at cathode potential, which will be regarded as zero, the first accelerator 3 at a small positive potential, the modulator 4 at a varying negative potential, the first anode 5 at a fairly high positive potential and the second anode 6 at a still higher positive potential. The sensitivity of such a tube is however not as high as may often be desirable, and hitherto it has not been found possible to increase the sensitivity without impairing the focus of the spot upon the screen. According to the present invention, the effective thickness of the material around the aperture in the modulator is increased substantially and in this way the sensitivity can be increased without noticeably affecting the shape of the modulation characteristic.

For example in one case where the modulator 4 shown in Fig. 1 comprises a diaphragm 8 of thin material having an aperture 1.9 mm. in diameter, the negative voltage required to extinguish the ray is 20 volts, whereas when, as shown in Fig. 2, there is connected to this diaphragm a second diaphragm 8^1 of thin material having an aperture 2.5 mm. in diameter, arranged at a distance of 1.0 mm. from the diaphragm 8 on the side thereof nearer the cathode, the voltage required to extinguish the ray is reduced to 12. The thickness of the material in which the aperture is formed is in this way effectively increased to 1 mm. although the actual material of the diaphragms may be thin.

With the particular arrangement of diaphragms described, the shape of the modulator characteristic is not appreciably changed from that with the single diaphragm although its steepness is increased. The focusing is also substantially unaffected. By modifying the sizes of the apertures and their separation, however, certain changes in the shape of the characteristic can be effected.

The apertures in the diaphragms may if desired be made of equal diameter, or the larger diameter aperture in the arrangement first described may be arranged, for some purposes, further from the cathode than the aperture of smaller diameter.

A similar effect to that above described can be obtained with a single diaphragm of thin material by increasing the thickness of the material of the diaphragm immediately surrounding the aperture.

Thus the diaphragm may be provided with a flange or lip around the aperture. The lipped portion may be of cylindrical shape, as shown at 8*a* in Fig. 3, giving an effect nearly equivalent to that of two apertures of equal diameter, or it may be conical, as shown at 8*b* in Fig. 4, or of other flared shape, giving the effect of apertures of different diameter. The behaviour of lipped apertures resembles closely that of apertures in equivalently spaced diaphragms provided that the distance between such diaphragms (and therefore the axial length of the lipped portion in the diaphragm with a lipped aperture) is not unduly great. The distance between the diaphragms is usually less than the diameter of either of the apertures. The lips may project either towards or away from the cathode and they may flare in either direction.

A further arrangement, which is nearly equivalent to that using multiple diaphragms, involves the use of relatively thick material for the diaphragm (Fig. 5). Thus a single diaphragm 1.0 mm. thick having an aperture tapering from 1.9 mm. at one face to 2.5 mm. at the other face, as shown in Fig. 6, is approximately equivalent in its behaviour to the two thin diaphragms shown in Fig. 2. The aperture may also be made of other shapes.

Three or more diaphragms may be used and the apertures therein may be equal to or different from one another according to circumstances. In the example shown in Fig. 7, three diaphragms are used and the aperture in the middle diaphragm 8 is made smaller than those in the two outer diaphragms 8*c* and 8*d*. The equivalent aperture can also be made in a single diaphragm of thicker material, the aperture having three portions of cylindrical shape (of different diameters corresponding to the apertures in the three separate diaphragms) united by flaring portions. Alternatively the boundaries of the aperture in the thicker material may be curved as shown in Fig. 8, for example the cross section of the boundaries in planes containing the axis may be part-circular.

When the modulator diaphragm has the form shown in Fig. 8 or the approximately equivalent form which can be made with three diaphragms having the apertures in the outer diaphragms larger than that in the middle diaphragm, the size of the aperture at the middle is preferably selected as small as possible consistent with no decrease in the current in the tube at zero modulator voltage due to the return of electrons from the modulator, and the diameters of the aperture at the faces of the diaphragm are arranged to give maximum sensitivity and current through the tube.

Having now particularly described and ascertained the nature of our said invention, and in what manner the same is to be performed, we declare that what we claim is:—

1. The improvement in or modification of the electric circuit claimed in patent specification No. 27199/33—20960/34 (Serial No. 431,327), which consists in the fact that the modulating and decelerating electrode of the cathode ray tube comprises an apertured diaphragm in which the thickness of the material surrounding the aperture substantially exceeds one-tenth of the diameter of the aperture.

2. Apparatus as claimed in Claim 1, wherein the diaphragm is provided with a flange surrounding the aperture.

3. Apparatus as claimed in Claim 1 or 2, wherein the cross section of the aperture is varied longitudinally of the axis of the tube.

4. The improvement in or modification of the electric circuit claimed in patent specification No. 27199/33—20960/34, (Serial No. 431,327), which consists in the fact that the modulating and decelerating electrode of the cathode ray tube comprises a plurality of apertured diaphragms located one behind another along the electron path.

5. Apparatus as claimed in Claim 4, wherein the apertures in at least two of said diaphragms are of different diameters.

6. Apparatus as claimed in Claim 5, wherein said electrode is provided with at least three diaphragms, the apertures in the outer two of said three diaphragms, being of larger diameter than the aperture in the inner of said three diaphragms.

7. The improvements in or modification of the cathode ray tube claimed in patent specification No. 27199/33—20960/34 (Serial No. 431,327), which consists in the fact that the tube has the features set forth in any one of the preceding claims.

8. The improved cathode ray tubes having modulator electrodes substantially as herein described or as shown in Figs. 2 to 8 of the accompanying drawings.

Dated this 1st day of August, 1935.

REDDIE & GROSE,
Agents for the Applicants,
6, Bream's Buildings, London, E.C.4.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1936.

TH

[This Drawing is a reproduction of the Original on a reduced scale.]

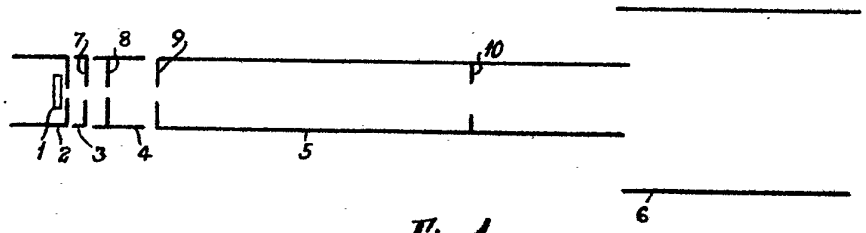

Fig. 1.

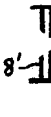

Fig. 2.

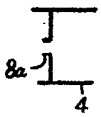

Fig. 3.

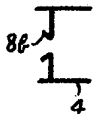

Fig. 4.

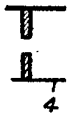

Fig. 5.

Fig. 6.

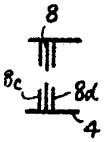

Fig. 7.

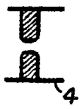

Fig. 8.

Malby & Sons, Photo-Lith.