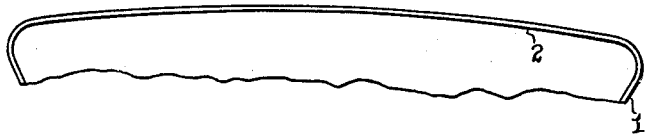
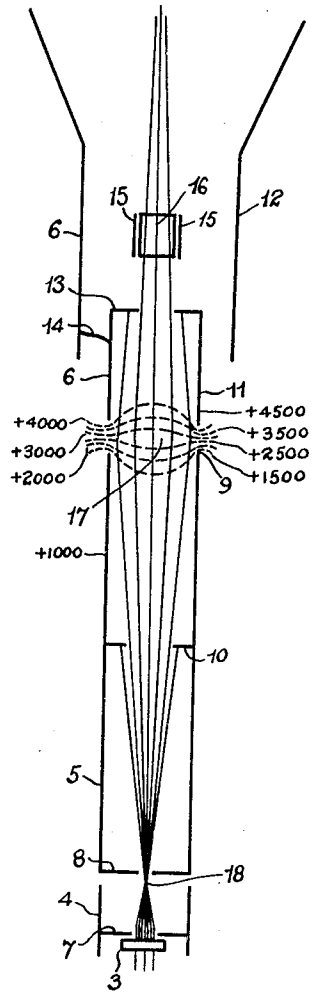
Oct. 24, 1939. J. D. McGEE ET AL 2,176,974

CATHODE RAY TUBE

Filed March 15, 1935





Inventors:
James Dwyer McGee
and
George E. Condliffe,
by: M. J. Oppenheimer
Atty.

Patented Oct. 24, 1939 2,176,974

UNITED STATES PATENT OFFICE

2,176,974

CATHODE RAY TUBE

James Dwyer McGee, London, and George Edward Condliffe, Gerrards Cross, England, assignors to Electric & Musical Industries Limited, Middlesex, England, a company of Great Britain

Application March 15, 1935, Serial No. 11,196
In Great Britain March 19, 1934

3 Claims. (Cl. 250—155)

The present invention relates to cathode ray tubes which comprises a cathode, an electrode system for directing a beam of electrons from the cathode upon a screen associated with the tube and means for deflecting the beam over the screen.

In order that the beam may form a small spot upon the screen it is usual to provide an electron lens which serves, in a manner analogous to an optical lens, to focus the beam upon the screen. Such an electron lens may be constituted by two suitably shaped and disposed electrodes having a suitable potential difference maintained between them, the electric field so produced having a focusing effect on the beam.

Where electrostatic deflecting plates are provided between such an electron lens and the screen, it has been found that the potential differences applied to the deflecting plates for deflecting the beam are liable to affect the field of the electron lens and thereby disturb the focusing.

It is an object of the present invention to provide a cathode ray tube arrangement in which this disadvantage is reduced.

According to the present invention there is provided a cathode ray tube comprising a cathode, an electrode system for directing a beam of electrons from said cathode to form a small spot upon a screen associated with the tube and deflecting plates adapted, when fed with suitable potential differences, to deflect the ray over the screen, said electrode system comprising a first and a second tubular electrode arranged to be traversed in succession by the beam, and said second tubular electrode being disposed nearer said screen than said first tubular electrode and being provided with an apertured diaphragm, the arrangement being characterised in that means are provided for maintaining said tubular electrodes at different positive potentials relatively to the cathode, these potentials being such that the two tubular electrodes co-operate in forming an electron lens which focuses the beam upon the screen and such that the ray is accelerated to its maximum velocity by said second tubular electrode, said diaphragm being located between said electron lens and said deflecting plates and substantially outside the field of said electron lens.

It has also been found desirable to reduce aberrations, corresponding to optical aberrations, by limiting the electron beam falling upon the screen to the portion thereof which has passed through the central portion of the electron lens. It is preferable that the obturation necessary for this purpose should be carried out at the higher potential electrode of the two electrodes forming the electron lens. At the same time it is important to arrange that the diaphragm which effects the obturation should not interfere with the focusing action of the electron lens.

According to a further feature of the present invention, therefore, there is provided a cathode ray tube comprising a cathode, an electrode system for directing a beam of electrons from said cathode to form a small spot upon a screen associated with the tube, said electrode system comprising a first and a second tubular electrode arranged to be traversed in succession by the beam, and said second tubular electrode being disposed nearer said screen than said first tubular electrode and being provided with an apertured diaphragm, the arrangement being characterised in that means are provided for maintaining said tubular electrodes at different positive potentials relatively to the cathode, these potentials being such that the two tubular electrodes co-operate in forming an electron lens which focuses the beam upon the screen and such that the ray is accelerated to its maximum velocity by said second tubular electrodes, said diaphragm being located on the same side of said electron lens as said screen and substantially outside the field of said electron lens and the aperture therein being of such size that said diaphragm is adapted to intercept a substantial portion of said beam so as to limit the beam current to that which has passed through the central portion of said electron lens.

In this aspect the invention is applicable where the deflection is accomplished electrostatically or electromagnetically.

Other features of the invention will be apparent from the following description and the appended claims.

The invention will be described with reference to the accompanying drawing, which shows an electrode assembly for a cathode ray tube arrangement according to the present invention, suitable for use in a television receiver.

It will of course be understood that this electrode assembly is mounted within a suitable highly evacuated glass envelope of which only a fragment is shown at 1.

The envelope is usually in the form of a cylindrical portion flaring out into a frusto-conical portion. On the base of the frusto-conical portion is disposed a fluorescent screen 2. Within the cylindrical portion are a cathode 3, which may be of the indirectly heated type, a modulat-

ing electrode 4, a first anode 5 and a second anode 6, all of these electrodes being disposed coaxially within the tube.

The cathode 3 may conveniently be in the form of a shallow body of pill-box shape having the cathode heater disposed within it. The modulating electrode 4, which is of cylindrical shape, surrounds the cathode 3 and has a diaphragm 7, with a small central aperture in it, disposed close to the cathode. The first anode 5 is in the form of a cylinder of the same diameter as, but considerably longer than, the modulating electrode 4. One end of the first anode is situated close to the modulating electrode and this end is closed with a first diaphragm 8 having a central aperture about the same size as the aperture in the diaphragm of the modulating electrode 4. The other end 9 of the first anode 5 is open. Between the ends of the first anode 5 there are disposed one or more intermediate diaphragms of which one is shown at 10. The apertures in the diaphragms 8 and 10, and any others that may be provided, increase in size with increasing distance from the modulator 4. These apertures do not obturate the beam of electrons passing through the first anode 5 to any great extent.

The second anode 6 is made up of two tubular members 11 and 12 electrically connected together. The first member 11 consists of a short cylinder of diameter equal to that of the first anode 5. One end of this cylinder is adjacent the end 9 of the first anode and is open whilst the other end is closed with a diaphragm 13 having a central aperture which is of such size that it obturates a considerable fraction of the beam of electrons passing through the second anode 6. The second member 12 of the second anode is in the form of a cylinder, of larger diameter than the first member 11, having a frusto-conical skirt 14. Preferably this second or outer member 12 is mounted as a sliding fit in the glass envelope and the skirt, which lies in the surface of a frustum of a cone, may be in the form of either a continuous sheet or a plurality of fingers. Alternatively the member 12 may be in the form of a metallic coating on the inside of the wall of the envelope. The cylindrical part of the outer member 12 extends into the cylindrical portion of the envelope sufficiently far to overlap slightly the first or inner member 11. Thus the larger member 12 extends towards the screen 2 further than the smaller member 11 and if the larger member 12 is not arranged to overlap the smaller member 11 as shown, it is preferably arranged to extend towards the cathode 3 at least as far as the end 13 of the smaller member 11. The members 11 and 12 are shown connected by a wire 14; if desired, however, they may be connected by a conductive annular ring extending across the space between the members or they may be connected by a circuit external to the tube.

In operation the cathode 3 is earthed, the modulating electrode 4 is maintained at an average potential of say 20 volts negative with respect to the cathode and the first and second anodes 5 and 6 may be maintained at positive potentials of 1000 volts and 5000 volts respectively with respect to the cathode 3.

In order that the ray may be deflected over the fluorescent screen 2, two pairs of electrostatic deflecting plates 15 and 16 are arranged within the envelope between the diaphragm 13 and the screen 2 so that the diaphragm 13 lies between the deflecting plates 15, 16 and the electron lens 17 formed between the adjacent ends of the electrodes 5 and 11.

When suitable potential differences are applied to the pairs of plates 15 and 16, the ray is deflected whilst it is passing through the hollow conductor constituted by the outer member 12 of the second anode, that is to say, it is deflected whilst it is in a field-free space.

The focusing of the ray upon the fluorescent screen is due to the electrostatic fields set up between the various electrodes. Two clearly distinguished "electron lens" fields exist; one in the region of the cathode 3, modulating electrode 4 and the end of the first anode 5 near to the modulating electrode and a second 17, already referred to. Equi-potential lines of the electron lens 17 are indicated by dotted lines marked with values of potential which may exist in the example considered.

Both of the electrostatic fields above referred to operate upon the beam of electrons passing through them in a manner analogous to the operation of an optical lens upon a beam of light and it is known that such electron lenses exhibit many of the aberrations, such as spherical aberration, for example, which are associated with optical lenses.

A cone of electrons emitted from the cathode 3 diverges outwardly through the aperture in the diaphragm 7 of the modulating electrode 4 and passing through the first electron lens, that is to say, the field in the region of the modulating electrode 4, is caused to converge to a point 18 lying in the neighbourhood of the aperture in the first diaphragm 8 of the first anode 5. Preferably this aperture is made sufficiently large to allow substantially the whole of the beam to pass through. After passing through the first focus the cone diverges outwardly in straight lines until it reaches the second electron lens 17 which operates to focus the ray upon the fluorescent screen 2.

The conditions which must be established in order to bring the ray to a focus with least possible aberration may best be appreciated from a consideration of the analogous optical case of a light beam brought to a focus by two separated lenses. In the first place the light beam should be symmetrical about the axes of both lenses and this requires that any deflection of the light beam, if such is desired, must be effected after the beam has emerged from the second lens. In the second place the light beam must be confined to the axial region of both lenses. After passing through the second lens, however, the beam may be deflected off the axis of the lens, for example by a plane mirror, without introducing any aberration.

In a similar manner the beam of electrons should be confined to the axial region about the axes of the electron lenses, should be symmetrical about these axes and any deflection of the ray should be effected after the ray has passed through the second electron lens.

In the arrangement above described, the beam emitted from the cathode 3 is confined to the axial region and is directed to the centre of the first electron lens by the aperture in the diaphragm 7. After passing through the first focus 18 the beam diverges outwardly so as practically to fill the second electron lens 17, the intermediate aperture 10, and any other apertures that may be provided, in the first anode being of such size that, without cutting down the beam to a great extent, they limit it to a cone (or conical frustum) whose base substantially fills the open end 9 of the first anode 5. On the other hand the aperture in the

diaphragm 13 of the second anode 6 is made sufficiently small for the diaphragm 13 to intercept a substantial portion of the beam so as to allow only the central or axial portion of the beam to pass through the second electron lens 17 and on to the fluorescent screen. Spherical aberration is thus largely avoided. The deflection of the ray after it has passed through the second lens 17 and in field free space has already been referred to.

The accelerating effect which the second anode 6 exerts upon the beam is completed by the itme the beam leaves the inner member 11 (the electrons having then reached their maximum velocity) and the beam passing through the hollow conductor formed by the outer member 12 of the second anode is composed of electrons of substantially homogeneous velocities directed to one small point on the screen. Furthermore the diaphragm 13 is located substantially outside the field of the electron lens 17 and has a relatively small aperture. The diaphragm 13 thus acts as an efficient electrostatic screen between the deflecting plates 15, 16 and the electron lens 17. Deflection of the ray by the plates 15, 16 therefore produces substantially no disturbance of the focus.

It will be noted that the outer member 12 of the second anode 6 plays no direct part in focusing the ray but is maintained at the same potential as the inner member 11 in order to screen the ray and assist in confining the second electrostatic focusing field 17 to a definite region. The outer member 12 also acts as an efficient collector of secondary electrons emitted from the fluorescent screen.

The screening effect of the diaphragm 13 can be made even more efficient by covering the aperture therein with a mesh of fine wires.

It will be noted that the diaphragm 13 in the second anode 6 effects a greater obturation of the beam of electrons than any aperture in the first anode 5. The first anode current is therefore kept low, a condition which is of advantage when the first anode-cathode potential difference is derived from a potentiometer from which the second anode-cathode potential difference is also derived, because with such an arrangement the first anode current must be small compared to the current flowing through the potentiometer resistance, in order that the voltage upon the first anode may not vary appreciably with variations in the current thereto.

The intermediate diaphragm or diaphragms in the first anode 5 are also instrumental in arresting the progress to the second anode 6 of any secondary electrons which may be emitted from the walls of the first anode.

In some cases where it is not necessary to keep the first anode current low, any or all of the intermediate diaphragm apertures in the first anode may be reduced in size so that they serve to limit the ray to the axial region. The diaphragm aperture in the second anode may then be made of larger size so that it does not limit the ray so long as the diaphragm acts as an efficient screen between the deflecting plates and the electron lens 17.

The first anode 5 may be divided into two or more sections in which case the section furthest from the cathode may be regarded as constituting the first anode of the tube. The sections may be maintained at positive potentials with respect to the cathode which are greater the greater the distance of the section from the cathode. The sections need not be of the same diameter but may increase in diameter with increasing distance from the cathode or the central sections may be of larger diameter than those sections adjacent the cathode and second anode respectively. In any case diaphragms in these sections are preferably large enough to ensure that they do not obturate the beam to any great extent.

Additional electrodes may also be provided between the cathode 3 and the modulator 4. For example there may be provided, in known manner, an apertured cathode shield close to the cathode maintained at a low potential, for example cathode potential, and an accelerating electrode, arranged between the cathode shield and the modulator and maintained at a positive potential (relatively to the cathode) which is usually less than the potential of the first anode 5.

It is not essential that the diaphragm 13 should be arranged at the end of the inner member 11 of the second anode 6 so long as it is substantially outside the field of the electron lens 17 and is effective in providing the required screening.

We claim:

1. A cathode ray tube comprising a cathode, a screen, an electrode system for directing a beam of electrons from said cathode to form a small spot upon said screen, deflecting electrodes for deflecting said beam over said screen in response to potential differences applied to said electrodes, said electrode system including a first and a second hollow electrode positioned to be traversed in succession by said beam, said second hollow electrode disposed nearer said screen than said first hollow electrode and surrounding said deflecting electrodes, and deflecting electrodes being spaced from said second hollow electrode at a distance at least equal to the maximum dimension of said deflecting electrodes, adjacent portions of said hollow electrodes spaced from each other to form an electron lens for focusing the beam upon said screen when said hollow electrodes are maintained at different positive potentials relative to said cathode, and a beam defining diaphragm formed as a part of said second hollow electrode and arranged between said electron lens and said deflecting electrodes substantially outside the electrostatic field of said electron lens, whereby a substantial part of said beam is intercepted.

2. A cathode ray tube comprising a cathode, a screen, an electrode system for directing a beam of electrons from said cathode to form a small spot upon said screen, said electrode system including a first and a second anode positioned to be traversed in succession by said beam, said second anode disposed nearer said screen than said first anode and comprising two tubular members of different cross-sectional areas electrically connected together, said tubular member of larger cross-section disposed nearer said screen than said tubular member of smaller cross section, and an apertured diaphragm formed as a part of said tubular member and arranged near the end of said tubular member of smaller cross section close to said other member and deflecting electrodes positioned wholly within said tubular member of larger cross-section and spaced at a distance from said tubular member of smaller cross-section at least equal to the maximum dimension of said deflecting electrodes.

3. An electronic device comprising an envelope, a cathode, an internally apertured cylindrical shield electrode surrounding said cathode, an internally apertured cylindrical electrode apertured at one end, positioned adjacent to and

coaxial with said shield electrode with the apertured end nearest the shield electrode, a second anode apertured at one end, positioned in register with the first named anode with said apertured end remote from the first named anode, a third anode surrounding a portion of the second anode, a galvanic connection between the second and third anodes, and deflecting electrodes positioned wholly within the third anode and spaced from said second anode at a distance at least equal to the maximum dimension of said deflecting electrodes.

JAMES DWYER McGEE.
GEORGE EDWARD CONDLIFFE.