Jan. 4, 1938. I. G. MALOFF 2,104,566

ELECTRON TUBE

Filed March 21, 1934

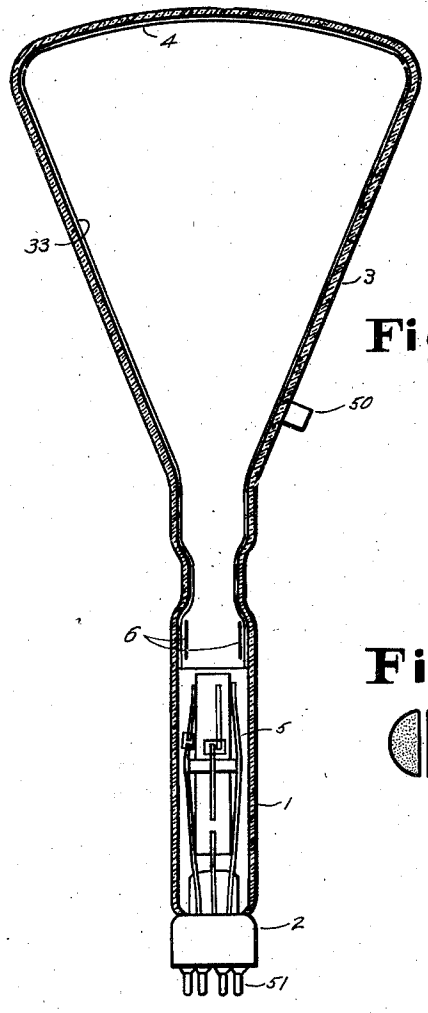


Fig. 1

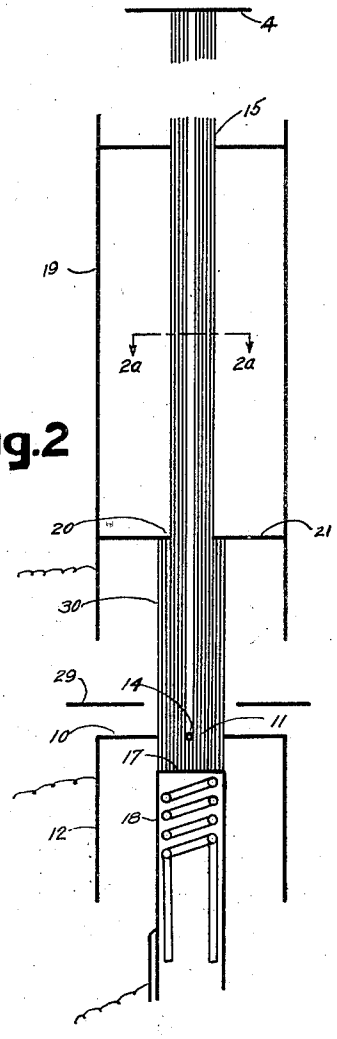


Fig. 2



Fig. 2a

Fig. 3a Fig. 3c

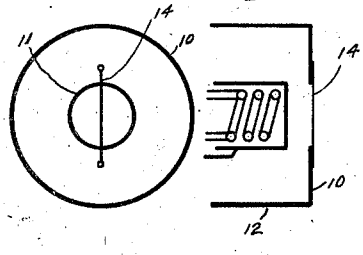
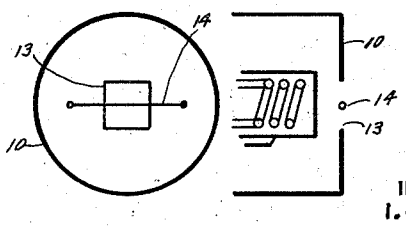


Fig. 3b Fig. 3d



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Patented Jan. 4, 1938 2,104,566

UNITED STATES PATENT OFFICE

2,104,566

ELECTRON TUBE

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Application March 21, 1934, Serial No. 716,684

10 Claims. (Cl. 250—27.5)

This invention relates to electronic devices, and principally to electronic devices of the cathode ray type which are frequently referred to as Braun tubes. Such types of electronic devices are of great importance in connection with television systems both at the receiver and transmitter and find considerable use also as oscillographs and oscilloscopes. Other and varied uses of this general type of electronic device are, of course, obvious and need no explanation.

The cathode ray tube of the prior art usually used for television and oscilloscope purposes employs a translucent screen which has the property of fluorescing when subjected to the bombardment of an electronic beam. In cases where it is desired to produce variations in intensities of the resulting fluorescent effects, which variations might be in accordance with variations in photoelectric currents resulting at a point of transmission in accordance with the scanning of a subject of which the electro-optical image is desired, the cathode ray beam or pencil of electrons may be modulated by means of an electrostatic control electrode or grid which is disposed in the path of the electrons moving from the cathode, as the electron source, toward the fluorescent viewing plane. To produce this intensity variation the control electrode or grid is biased under the influence of the applied signal effects and thereby varies the degree of fluorescence in accordance with the control exercised upon the developed cathode ray.

According to still other arrangements of the prior art, proposals are made for controlling the intensities of the observable effects upon the fluorescent end wall of the cathode ray tube by deflecting under control of the applied signals the cathode ray pencil with respect to an aperture or opening in a screen plate or with respect to a limiting or beam defining edge of a screen plate which is opaque to the passage of the electrons. This type of prior art arrangement functions so as to control variably the number of electrons which pass through the opening or past the beam defining edge of the shield.

Still other arrangements of the prior art have provided for intensity control of the fluorescent effects by a variation in the velocity of impact of the electron stream upon the fluorescent screen. Other arrangements operate to control the observable intensity of the fluorescent spot by varying the velocity of traversal of the cathode ray stream projected at constant instantaneous impact velocity upon the fluorescent viewing plane so that the variations produced in the periods of actual impact of the cathode ray beam at any differential area upon the screen produce the effects of varying lights and shadows from the resulting light spot, the intensity of fluorescence being a function of both velocity of impact and time of impact.

All such arrangements of the prior art while, in general, satisfactory, particular reference being made to the grid control effect so universally used, nevertheless are somewhat unsatisfactory for extremely accurate control for one reason or another. One of the more important objections of these systems of the prior art, which this invention attempts to obviate, is that the intensity controls of the types above outlined frequently cause the effects of streaking or the like in the viewed electrooptical effects produced from screen fluorescence.

While the grid control has, up to the present time, been practically universally adapted, it nevertheless has an inherent disadvantage in that upon impressing various voltages or biasing potentials to produce the control action a change or variance in the cross-sectional area of the electron beam takes place. This effect, as will become more apparent from what follows, results in "streakiness" of the fluorescent image and is what this invention attempts to overcome.

Cathode ray tube, as designed for television work, reference being made herein to the subject of television merely in order to illustrate one suitable use for a type of cathode ray tube and control therefor, as herein disclosed, are usually characterized by a long tubular neck, one end of which carries the base of the tube, and a conical portion terminating in a section whose normal projection is perpendicular to the axis of the tube. This section is usually concave on the inside, although for small tubes especially it may be flat or even convex, and provided with screen structure of a fluorescent character upon which the cathode ray stream or pencil developed in the neck portion of the tube impinges. This pencil or beam of rapidly moving electrons, termed the cathode ray, has its origin in a heated cathode or, where desired, even a cold cathode located at the base end of the tube. From the point of origin of the cathode ray beam or pencil to the point where it strikes the fluorescent screen the beam is controlled by either electrostatic or electromagnetic fields or both so arranged as to accelerate, focus and deflect the cathode ray pencil in the direction or directions desired.

One suitable means for deflecting the cathode ray beam is by the use of electrostatic deflecting

plates conveniently located in the neck of the tube, or, where desired, externally of the tube. An electrostatic field produced between these plates upon the application of voltages of suitable frequency thereto produces an acceleration of the beam in line with the field between the plates. For television work two sets of deflecting plates may be used and, if so, the surfaces of each set are at right angles to each other. Such an arrangement permits deflection of the cathode ray pencil in two planes perpendicular to each other but both normal to the axis of the tube. Where desired, of course, it is possible to substitute electromagnetic deflection for the electrostatic deflection hereinabove suggested and it has been found in many instances that most satisfactory results are obtained by combining electromagnetic and electrostatic deflection systems, in which case the electrostatic deflecting plates are formed of non-magnetic material and supported beneath the magnetic deflecting coils. In this last suggested embodiment substantially no interacting fields exist to produce distortion.

To control the intensity of the cathode ray thus deflected and positioned upon the tube screen, according to the prior art as above mentioned, the electrostatic or grid control usually consisted of an electrode member substantially surrounding the electron emitting area in such manner that the issuing electrons were drawn through an aperture of predetermined size, but of substantially less area than the emitting area. Modulation of the cathode ray beam to vary the intensity of the resulting fluorescent effects was accomplished by varying the negative bias upon the control electrode or grid member. With zero bias on the grid electrode the effective aperture has been found to be the same as the actual aperture. However, as the negative bias is increased the effective diameter of the aperture in the control grid member, in effect, decreases in size with the result that the size of the beam spot on the screen also decreases in diameter. In television scanning this will result in a variation in the light spot diameter with each change in modulation. This effect then becomes observable in the form of dark lines on the fluorescent screen because the line definition at all times throughout the scanning period remains constant.

It is, therefore, one of the primary objects of this invention to overcome this changing spot size defect and to produce a scanned area on the fluorescent viewing screen which is devoid of all streaked effects.

Still other objects of the invention are to provide more suitable means for controlling the density of a beam of electrons.

Another object of the invention is to provide means by which a beam of electrons may be modulated and controlled by suitable controlling electrodes without in any way affecting the operation or changing the actual diameter of the resulting area of fluorescence upon the viewing screen.

Other objects of the invention are to provide modulation or control arrangements for varying the intensity of a cathode ray pencil of electrons in which the control is more sensitive than that found in arrangements heretofore used in the prior art; to provide a control system which is extremely simple in its arrangement; to provide a control system which readily adapts itself to use in connection with cathode ray tubes of the present type so that it will be unnecessary to redesign the general structure of the tube; and to provide a control system that is extremely efficient in its operation.

Still other and further objects of the invention will become apparent and suggest themselves to those skilled in the art to which the invention relater from reading the following specification and claims in connection with the accompanying drawing, wherein:

Fig. 1 illustrates one type of cathode ray tube to which this invention is applicable;

Fig. 2 illustrates one form of electrode structure which may be enclosed within the tube shown by Fig. 1;

Fig. 2*a* represents a transverse section through the electron stream on the line A—A;

Fig. 3 shows various forms of modulating electrode which may be incorporated as a part of the electrode structure within the tube of Fig. 1;

Fig. 3*a* designates an electrode structure having a circular aperture across which the control element is provided;

Fig. 3*b* indicates an electrode structure with a square aperture controlled similarly to the arrangement of Fig. 3*a*; and

Figs. 3*c* and 3*d* respectively indicate longitudinal sections of the electrode structures shown by Figs. 3*a* and 3*b*.

The general type of cathode ray tube used for television purposes is similar to that shown by Fig. 1. This tube, as has been above stated, is characterized by a long tubular neck portion **1** upon one end of which is supported the base **2**. The other end of the tube is a conical portion **3**. On the inner end of the conical tube portion **3** a fluorescent screen **4** is supported. The cathode rays are generated within an electron gun structure designated as **5** and the rays or electron stream thus developed and projected toward the fluorescent screen member **4** may be suitably deflected in one direction by applying suitable controlling voltages to the electrostatic deflecting plates **6** and then the beam may be deflected in a direction at right angles to the first plane of deflection by means of a pair of electromagnetic deflecting coils **7** supported adjacent the plates **6**. Of course, magnetic deflection in two directions or electrostatic deflection in two directions may be provided where desired. Whenever a combination of electro-magnetic and electrostatic deflection is used the electrostatic deflecting members are preferably formed from non-magnetic material so as not to be subjected to the influence of the magnetic deflecting fields.

According to the conventional type of cathode ray tube design a control grid member, such as the structure **10** shown by Figs. 3*a* and 3*c*, is usually arranged to surround substantially the cathode emitting surface and the developed electrons are projected toward the fluorescent screen structure **4** through the aperture **11** which may be of the size of the emitting area, or preferably larger than the emitting area in order that all emitted electrons may pass through. Such structure as is used in the cathode ray tubes now usually known varies the modulation of the beam or electron stream by varying the negative bias applied to the grid or control electrode **10**. For conditions of zero bias on this control element **10** the effective aperture through which the cathode ray stream **15** is adapted to pass is the same as the actual aperture **11** so that the cathode ray pencil emerging from the grid structure will have an actual electronic diameter equal to the diameter of the aperture **11**. However, as the negative bias is increased to vary the intensity of

the resulting electronic light spot on the fluorescent screen structure the effective diameter of the aperture 11 decreases due, for example, to repulsion of the emerging electrons from the edges of the diaphragm member, so that the spot size also decreases. This effect produces, as has been above defined in the statement of invention, dark lines on the fluorescent screen because the line definition remains always constant.

According to the present invention these above mentioned difficulties have been substantially overcome by changing the control electrode structure to some extent from the form now used in tubes known in the art. In the new form of the control electrode herein disclosed the control electrode structure includes the disk or plate member 10 formed with the shielding structure 12 attached thereto so that it resembles closely the usual grid structure 10 above discussed but is distinguishable therefrom both in formation and operation as will herein be pointed out. As shown by all of Figs. 3*a* through 3*d* inclusive, the aperture of the control electrode 10 may be round, as shown by the apertures 11 of Figs. 3*a* and 3*c*, or square, as shown by the aperture 13 of Figs. 3*b* and 3*d*, or may be of any other suitable formation, such as triangular, rhomboidal, rectangular or of a most irregular shaping where it is desired to produce peculiarly shaped light spots on the screen 4. In addition, the aperture should be formed slightly larger than the aperture in the regularly used control elements, wherein the light spot diameter depended upon the aperture diameter, and as above mentioned equal or exceed the area of emission of the electrons. Across the aperture 11 or 13 in such manner as to divide the area of the aperture into two substantially equal parts there is attached to either side thereof, by welding or by other suitable means, a wire 14 which is stretched and forms electrical contact with the disk surface 10.

The effect of this design, as can be seen more particularly from Fig. 2 of the drawing and also from Fig. 2*a* thereof, is to control the center of the electron pencil or beam 15, which is developed by drawing the electrons issuing from the electron emitting surface 17 of the heated cathode member 18 by means of the application of suitable positive voltages upon an anode electrode 19 for example, rather than to change the beam diameter as is the case when modulation is produced by the usual type of control electrode. The apertures 11 and 13, depending upon the shaping of the disk member as in Figs. 3*a* and 3*c*, are so large that little or no current will be cut-off from the outside of the electron beam and the wire 14 stretched across the aperture will cut a diametric swath from the beam 15. As the bias on the control electrode comprising the disk member 10 and the shielding portion 12 is increased negatively the apparent size of the wire 14 as regards the control of the electron beam will increase. This effective or apparent increase in the size of the wire 14 causes a reduction in the number of electrons forming the central portion of the electron beam or pencil 15 which passes through the aperture 20 of the disk member 21 forming a part of the anode structure 19. This effect, in turn, results in an electron stream which takes the general form of the aperture 20 of the electrode 19 except that the fluorescent spot produced upon the fluorescent screen structure 4 is divided by the wire member 14 into two parts as can be readily appreciated from an observation of Fig. 2*a* which represents a cross-section through the electron stream on the line A—A intermediate the aperture 20 and the screen structure 4. From what has been above stated, it will be appreciated that the wire 14 effectively casts its shadow upon the screen structure 4 but this shadow is not in any way detrimental to any detail of the area scanned provided that the electron beam is swept back and forth across the fluorescent screen structure in such manner that the resulting shadow or dark line produced is perpendicular to the direction of beam motion, for example, if the plates 6 produce rapid beam motion across the screen 4 then the area of the beam in which the electrons are controlled will be perpendicular to the path of the deflected beam.

The foregoing description is intended to illustrate but a single broad form of the invention and to set forth broadly a new principle of controlling an electron stream. Therefore, it is believed to be obvious that I may without departing from the spirit and scope of this invention provide other and various ways and means for controlling the intensity of the fluorescent spot resulting upon the fluorescent screen of a cathode ray tube or other type of electronic device as long as the effect of variation in the size or diameter of the resulting fluorescent spot is avoided. I, therefore, believe myself, in accordance with the modifications of this general scheme herein suggested, to be entitled to make and use any and all of these modifications which fall fairly within the spirit and scope of the invention as set forth by the appended claims.

Having thus described the invention, what I claim and desire to secure by Lettters Patent is the following:

1. An electron tube comprising a source of cathode rays, a fluorescent screen upon which the cathode rays impinge to produce luminous effects, an apertured shield electrode interposed between the source of electrons and the screen to control the bounding area of the electron beam in its path from the source to the screen, a control element connected with the shield electrode and dividing the aperture in the shield electrode into two substantially equal portions, said control element being adapted to receive varying voltage to vary the electron density within the central section of the electron beam to control thereby the intensity of the luminous effect produced.

2. A cathode ray tube having means for controlling the intensity of luminous effects produced by the bombardment of a fluorescent screen of a cathode ray tube by an electron pencil generated therein which comprises a shielding electrode interposed between the source of electrons and the screen, said electrode having an aperture therein of a cross-sectional shaping corresponding to the shaping of the area of fluorescence desired through which the electrons pass toward the screen, a wire member stretched across the aperture in the shield member so as to divide the aperture into substantially equal portions, and means for applying to the shield and wire members varying voltages to cause a repulsion of the electrons in the area adjacent the wire member so as to vary thereby the electron density within the central portion of the electron pencil and thereby vary the overall intensity of the fluorescent effect resulting while maintaining constant the bounding limits over which fluorescence takes place.

3. An electron tube for varying the intensity

of fluorescent effects produced on the fluorescent end wall of a cathode ray tube which comprises an electron source, means for causing the electrons generated at the source to pass toward the fluorescent end wall of the tube as a pencil of electrons, means for causing the electron pencil developed within the tube to traverse the fluorescent end wall along a series of paths substantially at right angles to each other, a shield electrode interposed between the source of electrons and the fluorescent end wall, said shield having an aperture therein through which the electrons pass, and a conductor stretched across said aperture and in electrical contact with the shield, said conductor being arranged across the aperture in a plane transverse to the path of rapid motion of the electron pencil across the fluorescent screen and adapted to divide the aperture into two substantially equal portions so that upon the application of signal voltages to the said conductor the electron density of the electron beam within a central portion thereof varies proportionally to the voltage upon the conductor.

4. A cathode ray tube comprising a surface for emitting a stream of electrons, a target positioned in the stream and adapted to luminesce under impact of the electrons, means to focus the emitted electron stream on the target, means to establish a predetermined maximum boundary area of the electron stream impinging upon the target, and means acting only within maximum boundary of the emitted electron stream to vary the area of electron impact within the maximum boundary area.

5. A cathode ray tube comprising a surface for emitting a stream of electrons, a target positioned in the stream and adapted to luminesce under impact of the electrons, means to focus the emitted electron stream on the target, means to establish a predetermined maximum boundary area of the electron stream impinging upon the target, and means acting within the electron stream emitted for bi-secting the electron stream under the control of signals.

6. A cathode ray tube comprising a surface for emitting a stream of electrons, a target positioned in the stream and adapted to luminesce under the impact of the electrons, means to focus the emitted electron stream on the target, means to establish a predetermined maximum boundary area of the electron stream impinging upon the target, and means acting within the electron stream for dividing the electron stream into a plurality of similar segments.

7. A cathode ray tube comprising a surface for emitting a stream of electrons, a target positioned in the path of the electron stream and adapted to luminesce under the impact of the electrons, means to direct the emitted electron stream on the target, means to establish a predetermined maximum boundary area of the electron stream directed upon the target, and means acting within the electron stream for dividing the electron stream into a plurality of similar segments each of a size variable in accordance with the potential of the electron stream dividing means relative to the electron emitting surface.

8. A cathode ray tube comprising a surface for emitting a stream of electrons, a target positioned in the stream and adapted to luminesce under impact of the electrons, means to focus the emitted electron stream on the target, means to establish a predetermined maximum boundary area of the electron stream impinging upon the target, means acting only within maximum boundary of the emitted electron stream to vary the area of electron impact within the maximum boundary area, and means for moving the impact area across the target.

9. A cathode ray tube comprising a surface for emitting a stream of electrons, a target positioned in the stream and adapted to luminesce under impact of the electrons, means to direct the emitted electron stream on the target, means to confine the electrons within a predetermined maximum boundary area of the electrons upon the target, a control electrode acting within the boundary limits of the produced electron stream emitted from the surface for bi-secting the electron stream under the control of signals.

10. A cathode ray tube comprising a surface for emitting a stream of electrons, a target positioned in the path of the electron stream and adapted to luminesce under the impact of the electrons, means to focus the emitted electron stream on the target, means to establish a predetermined maximum boundary area of the electrons upon the target, and control electrode means bi-secting the area of the emitted electron stream and acting only within the electron stream for dividing the electron stream into a plurality of similar segments each of a size variable in accordance with the potential acting upon the control electrode means relative to the electron emitting surface.

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