Feb. 28, 1939. H. A. SNOW 2,148,588

CATHODE RAY TUBE

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Fig. 1.

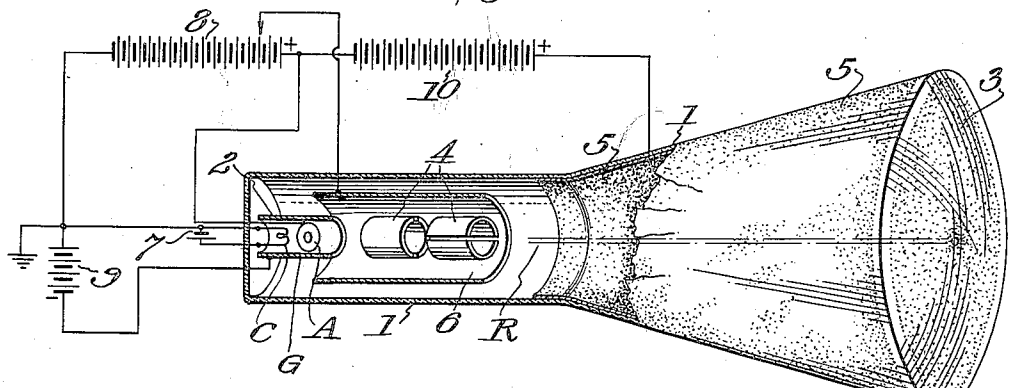

Fig. 2.

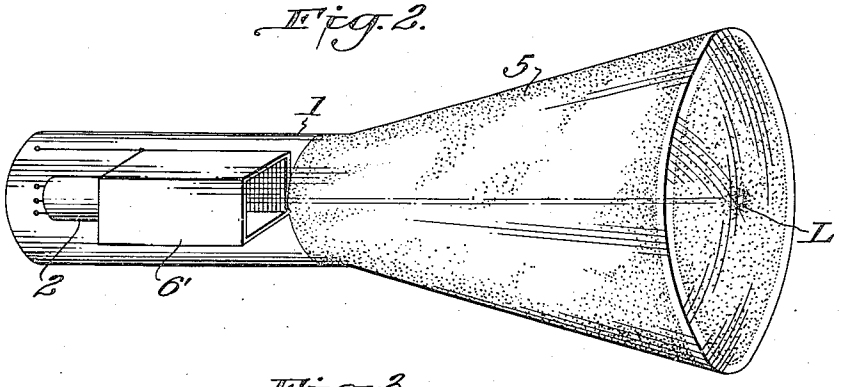

Fig. 3.

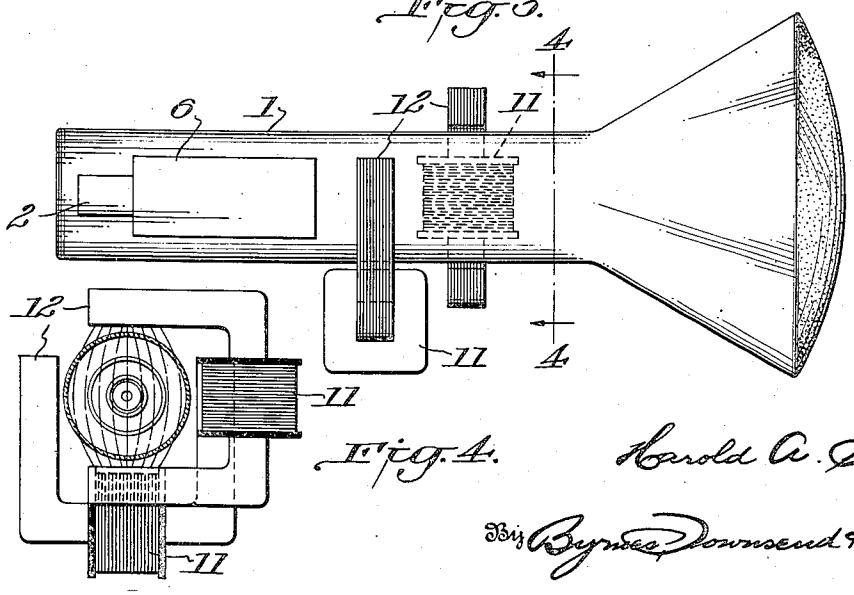

Fig. 4.

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Fig. 5.

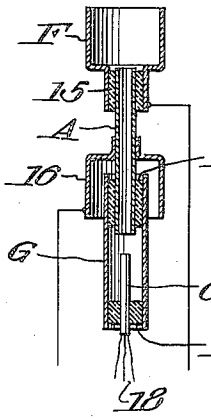


Fig. 6.

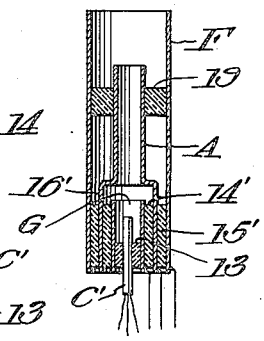


Fig. 8.

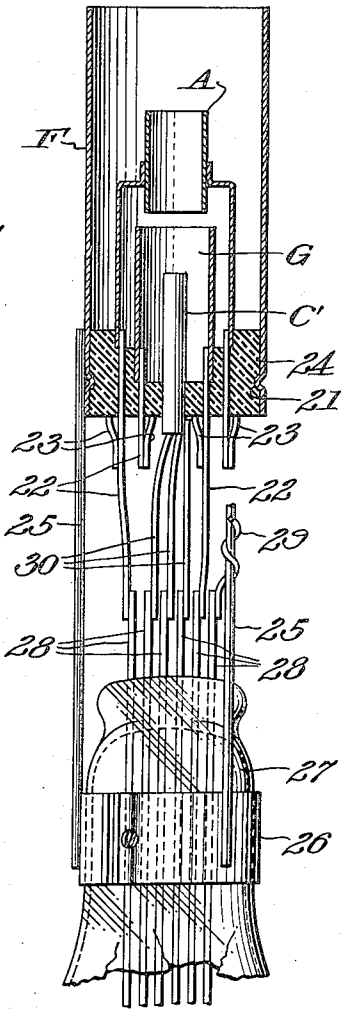
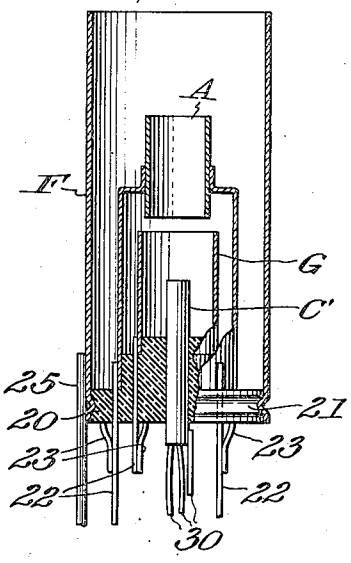


Fig. 7.



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UNITED STATES PATENT OFFICE

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CATHODE RAY TUBE

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33 Claims. (Cl. 250—160)

This invention relates to cathode ray tubes and particularly to cathode ray tubes that are well adapted for use in electronic television systems.

The known types of cathode ray tubes such as employed for oscillographic analysis of alternating currents have not proved satisfactory when used for the reception of television signals. The simpler tube structures include no provision for a control of the intensity of the light spot and those which provide this control are open to the objection that the focusing varies with the modulation voltage impressed upon the control electrode.

Objects of the invention are to provide cathode ray tubes of improved mechanical design and electrical characteristics. An object is to provide a cathode ray tube which includes an additional electrode for facilitating the focusing of the beam. A further object is to provide an improved mechanical construction for electron guns of cathode ray tubes, which improved construction is applicable to the known types of electron guns as well as to novel types contemplated by this invention. Further objects are to provide other improved design and constructional features, which objects will be apparent from the following specification.

In the accompanying drawings which illustrate embodiments of the invention,

Fig. 1 is a perspective view of one form of tube constructed in accordance with the invention, some of the parts being broken away and others shown diagrammatically,

Fig. 2 is a perspective view of a tube in which the focusing electrode is of non-circular cross-section,

Figs. 3 and 4 are, respectively, an elevation, and a transverse section on line 4—4 of Fig. 3, of another embodiment.

Figs. 5 to 7 are longitudinal sectional views of different types of novel electrode gun constructions, and

Fig. 8 is a fragmentary view, with parts in section, of another form of electron gun and a support for mounting the same.

In the drawings, the reference numeral 1 identifies the flask or evacuated envelope of conventional or any desired shape, which has a suitable electron gun 2 for directing a beam or ray of electrons R axially of the tube and towards the fluorescent screen 3. One of the pairs of deflecting electrodes 4 are arranged in advance of the electron gun, and these electrodes may be of the conventional flat plate type or they may be of semi-cylindrical form. A screen anode 5, preferably a metallic film formed as described hereinafter, is provided at the flaring portion and the adjacent section of the cylindrical portion of the tube 1.

Except for the semi-cylindrical form of the deflecting electrodes, the several elements which have been described may be of conventional design. In accordance with the invention, an additional electrode 6 is provided in the cylindrical portion of tube 1, the electrode 6 being cylindrical and of greater transverse dimensions than the electron gun 2 and deflecting plates 4. The axial length of the electrode 6 is preferably such that it surrounds the deflecting electrodes and at least a substantial portion of the electron gun.

For convenience of description, the element 6 will be designated as a "focusing electrode" but the electrode has other important functions in addition to that of facilitating the focusing of the cathode ray upon the fluorescent screen.

The several advantages resulting from the addition of the focusing electrode 6 to a cathode ray tube will be best understood by first stating the relative direct current potentials normally established on the several tube elements. As indicated diagrammatically, the electrode gun 2 includes a cathode C that is heated to emitting temperature by an appropriate current source 7, an anode A which is maintained at a positive potential with respect to cathode C by a current source 8 and, for television and other uses, a control electrode G which is given a more negative potential than that of the cathode by a current source 9. The shield anode 5 is maintained at a relatively high positive potential by a current source 10 which may be independent of, or in series with, the anode current source 8. In the prior tubes of this general type, the presence of deflecting electrodes in the space between the electron gun and the shield electrode distorted the electrostatic field established in that region by the high positive potential on the shield or accelerating electrode, thus rendering it difficult to maintain a proper focus of the electron beam.

As indicated in Fig. 1, a positive potential is impressed on the focusing electrode 6 by an adjustable connection to the current source 8.

The outstanding effect of the addition of the positive potential electrode 6 is the control exercised upon the electron stream R. By adjustment of the focusing electrode potential, the beam may be focused to an approximate spot or point of light on the screen 3. While this focusing of the beam is not entirely independent of the potentials applied to the other tube elements,

the potential on electrode 6 has a substantial control on the focusing of the beam and therefore permits greater latitude in the physical design and the choice of the potentials which may be applied to the other electrodes. For example, the focus is not disturbed by the application of a fluctuating potential to the control electrode G of the electron gun. It is therefore possible to vary the intensity of the spot of light on screen 3 without affecting the shape of the light spot, i. e., without disturbing the focus of the beam. In this respect, the novel tube presents marked advantages over known tubes in which the shape of the light spot is altered by changes in the voltages impressed upon the control electrode of the electron gun and/or upon the deflecting plates.

The geometry of the tube elements and the potentials applied to the other elements are preferably such that the positive potential on the focusing electrode 6 is less than the potential upon the anode A of the gun 2, as is indicated in Fig. 1. When a proper focus is obtained with these relative potentials on anode A and electrode 6, the stray or "background" light normally existing as a diffused glow on the screen is materially reduced.

The focusing electrode 6 also has a "shielding" action on the electrostatic field within the tube, or more accurately, a stabilizing control on the shape of the field established by the high positive potential applied to the screen anode 5. As noted above, the introduction of the customary flat deflecting electrodes into this field results in a distortion of the field, thus affecting the focus of the beam whether or not alternating potentials are applied to the deflecting electrodes. Electrostatic deflection of the beam has therefore presented serious problems in tubes of the type including a screen anode and, for many purposes, it has been customary to employ electromagnetic deflection. The focusing electrode 6 eliminates, or at least reduces, the distortion effect of electrostatic deflecting electrodes and makes it possible to maintain a good focus in a tube of the general type shown in Fig. 1. This stabilizing action may be improved, if desired, by employing deflecting electrodes 4 of the illustrated semi-cylindrical form.

Furthermore, the semi-cylindrical deflecting electrodes 4 may supplement, or for some purposes, may replace the focusing electrode 6 since a steady positive potential impressed upon the deflecting electrodes has the same general effect upon the beam as does the positive potential on the focusing electrode.

The control which the electrode 6 exercises upon the beam R is clearly demonstrated by altering the transverse cross-section of the focusing electrode. The shape of the beam is controlled by the shape of the focusing electrode and, as shown in Fig. 2, an electrode 6' of square cross-section will produce a square spot L when the beam is focused on the screen 3. For television purposes, this control of the beam shape is particularly important as it is obvious that a square or rectangular spot of light will afford better definition than the customary circular light spot.

While the focusing electrode presents special advantages when included in tubes employing screen anodes and electrostatic deflection, it will be apparent that it is equally applicable to tubes of other types. As shown in Figs. 3 and 4, cathode ray tube 1 may include, in addition to the electron gun 2 and the focusing electrode 6, one or more electromagnetic elements which, preferably, comprise iron-cored electromagnets having laminated cores 12 of U-shape. Opposite ends of the cores 12 are arranged closely adjacent opposite sides of the tube 1 and, due to the high magnetic flux resulting from the use of the cores, the deflecting system is more sensitive than the known air-core deflecting systems.

So far as concerns the electrical properties of tubes employing the novel focusing electrodes, the characteristics are substantially independent of the physical structure and the supporting structure of elements of any given design. For convenience of assembly, however, the electron gun and focusing electrode are arranged as a structural unit which may be rapidly and accurately assembled, and readily supported in the tube.

As shown in Figs. 5 and 6, the several elements of the electron gun and the focusing electrode are preferably of cylindrical form supported or retained in proper coaxial relation by a plurality of tubular insulating bushings. In the form shown in Fig. 5, the inner tubular element C' is of the type including both the cathode and a heating element for raising the cathode to emitting temperature, and a tubular control electrode G is mounted on the element C' by means of a short tubular insulator 13.

The electrode G extends well beyond the cathode element C' and its projecting end is connected to, and centers, a tubular anode A by an insulator tube 14. The outer end of the anode A carries an insulator tube 15 to which is secured the reduced inner end section of the focusing element F. The inturned flange of a cylinder 16 is secured to the intermediate section of the tubular anode A, and provides convenient points of connection to a lead and/or supporting wires 17 which pass through or are embedded in the glass seal of the tube. The leads to and supporting wires for the other elements, indicated by numeral 18, are connected to the tube elements in any known or convenient manner.

It is particularly to be noted that the anode A may be a tube of relatively large diameter, as illustrated, since the shape and focus of the beam are controlled by the focusing electrode F. In some prior constructions, the anode has taken the form of one or more disks having minute openings therethrough and it has been difficult to aline such an anode with the cathode, and to maintain the desired axial alinement of these elements. In accordance with this invention, the several elements are retained in alinement by the tubular sleeves and it is not necessary to provide or to effect a careful alinement of anodes having minute apertures therethrough. The focusing of the beam is effected electrically and not by the mechanical expedient of fine apertures.

As shown in Fig. 6, the elements C' and G, as well as the insulating tube 13, may be substantially as shown in Fig. 5, but the anode A is provided with an enlarged extension 16' that surrounds the control element G and is supported therefrom by a relatively long tubular insulator 14'. Similarly, the focusing electrode F extends rearwardly to surround the enlarged section 16' of the anode A, and is connected thereto and maintained in proper alinement by a tubular insulating sleeve 15'. If desired, a second insulating tube 19 may be arranged between the outer or fluorescent screen ends of the anode A and focusing electrode F.

Grooves, indentations or roughened spots, not shown, may of course be provided on the tubular elements for locking the same in desired position on or with reference to the tubular insulating members.

A simpler construction for an electron gun is illustrated in Fig. 7. A single block 20, of quartz, porcelain, glass or the like has an outer peripheral wall conforming in size and shape to the inner wall of the focusing electrode. Cylindrical steps rise above the lower portion of the block 20 to provide shoulders over which the anode A and control element G telescope, and the block has a central bore in which the cathode and heater assembly C' is received with a sliding fit. The outer electrode F is secured to the block by pressing a portion of the electrode into a groove 21. The anode and control electrodes are fixed upon the block by wires 22 which are welded to the electrodes and pass through the block, the lower ends of the wires having anchoring wires 23 welded thereto. The upper ends of the anchor wires bear against the block 20 and thus lock the electrodes against longitudinal movement.

A preferred type of mounting block 24, shown in Fig. 8, may be formed by counterboring a cylindrical block to provide internal shoulders for positioning the cylindrical electrodes. This construction brings only a relatively small part of the lower end of the cathode assembly into contact with the insulating block. The general construction is otherwise the same as that of the Fig. 7 form of electron gun.

As shown in Fig. 8, the larger sizes of electron guns are preferably supported by large wires or rods 25 which are welded to the outer electrode F and which are secured to a split ring 26 that is clamped upon the lower portion of the glass press 27. At least one of the securing wires 22 of the inner electrodes is welded to a lead-in wire 28, and the connection to the outer electrode is made by welding a wire 29 to a lead-in wire and to one of the supporting rods 25. The connecting wires 30 extend to the cathode assembly C' and serve to prevent any movement of the cathode system in the block.

It will be apparent that proper physical alinement of the several tubular elements will be effected by the tubular insulating members, thus insuring electrical alinement of these elements. While the assembly preferably includes a focusing electrode F, it will be apparent that this general arrangement for alining the tube elements may be employed in structures which do not include a focusing electrode F and/or a control electrode G.

Reverting to the screen anode 5, a convenient method of forming this electrode is to mount, within the envelope 1 and adjacent the desired location of the screen anode, a container of suitable shape in which a vaporizable metal, such as magnesium, is located.

During the exhaust of the tube, the screen end of the tube is heated to a relatively high temperature and the container is then heated to vaporize the metal therein. The metal vapor deposits on the cooler portions of the tube to form the screen anode 5 and, by an appropriate lead brought through the wall of tube 1, a high positive potential may be impressed on the metal film. When the volatilizable metal comprises or consists of magnesium, it is not necessary to provide a getter for cleaning up the residual gases in the tube.

A convenient method of forming the screen 3 is to mix a flourescent material, such as willemite, with a high melting point binder such as soft glass, and another binder such as wax, having a low vaporizing point. The mixture is uniformly distributed on the end of the tube by melting the wax binder and, when uniform distribution is effected, the temperature of the end wall is raised to vaporize the wax binder and soften or fuse the harder binder. The screen thus produced is firmly adherent to the glass wall of the tube and has excellent fluorescent properties.

While preferred embodiments of the invention include the described screen electrode and fluorescent screen constructions, and the focusing electrode element, it will be apparent that the invention is not restricted to the joint use of these several features. Many variations in the described constructions will be apparent to those familiar with the design and construction of cathode ray tubes and are included within the scope of the following claims.

I claim:

1. A cathode ray tube comprising, in combination with an evacuated envelope, an electron gun in said envelope, and an electron-sensitive element spaced from said gun and in the path of a beam of electrons emitted therefrom, of a focusing electrode surrounding a portion of said gun and projecting beyond the same in the direction of said electron-sensitive element.

2. A cathode ray tube comprising, in combination with an evacuated envelope, an electron gun in said envelope, an electron-sensitive element spaced from said gun and in the path of a beam of electrons emitted therefrom, and a screen anode between said gun and element, of a focusing electrode means surrounding a portion of the beam path adjacent the electron gun.

3. A cathode ray tube as set forth in claim 2, in combination with electrostatic deflection means located within the focusing electrode means.

4. A cathode ray tube as set forth in claim 2, in combination with electromagnetic deflection means positioned outside of the evacuated envelope for establishing a magnetic flux in a zone between the focusing electrode means and said screen anode.

5. A cathode ray tube as set forth in claim 2, in combination with iron-core electromagnetic deflection means positioned outside of the evacuated envelope for establishing a magnetic flux in a zone between the focusing electrode means and said screen anode.

6. In a cathode ray tube, the combination with an electron gun comprising a cathode, an anode and a control electrode; a fluorescent screen on which the beam emitted from said gun may be focused; of means rendering the focus of the beam substantially independent of variations in the potential impressed on said control electrode, said last named means comprising electrode means substantially surrounding a portion of the path of the beam which is spaced from said anode.

7. In a cathode ray tube, the combination with an evacuated envelope a fluorescent screen, and means within said envelope for establishing an electron beam and directing the same towards said screen, of two sets of substantially semi-cylindrical deflecting electrodes between said means and said screen and a focusing electrode substantially surrounding said deflecting electrodes.

8. The invention as set forth in claim 7, in combination with a screen electrode for estab-

lishing an electric field in the zone between said means and said screen, and means for reducing that distortion of the electric field tending to defocus the beam which results from the presence of said deflecting electrodes.

9. In a cathode ray tube, the combination with a fluorescent screen, and means for directing an electron beam upon said screen, of electrode means of tubular form and non-circular cross-section and long relative to its cross-section and arranged to surround a portion of the path of said beam to shape the cross-section of the said beam to substantially the non-circular geometrical shape of the said tubular means.

10. In a vacuum tube, an electrode assembly comprising a plurality of tubular electrodes in telescoped and coaxial alinement, and tubular insulating sleeves between and secured to the opposed cylindrical surfaces of adjacent pairs of said tubular electrodes, thereby to maintain said electrodes in the desired coaxial relationship.

11. In an electrode assembly for mounting within the evacuated container of a cathode vacuum, the combination with a plurality of electrodes having tubular portions telescoped upon each other, of insulating tubes of less length than and between the telescoped portions of adjacent tubular elements, said insulating tubes being secured to the tubular elements to aline the same in co-axial relationship.

12. An electrode assembly as set forth in claim 11, wherein one of said electrodes is an anode, in combination with a tubular focusing electrode having a portion telescoped over at least a part of said anode and a portion projecting beyond said anode, and tubular insulating means between said focusing electrode and anode for retaining the same in coaxial alinement.

13. An electrode assembly as claimed in claim 11, in combination with means secured to one of said electrodes for supporting the assembly from the press of a vacuum tube.

14. An electrode assembly for a vacuum tube comprising a plurality of telescoped and axially alined cylindrical electrodes, insulating means having coaxial cylindrical spacing surfaces against which only the end portions of said telescoped electrodes seat, and supporting means for said assembly secured to one of said electrodes.

15. An electrode assembly as claimed in claim 14, wherein said insulating means comprises a plurality of annular rings of insulating material.

16. An electrode assembly as claimed in claim 14, wherein said insulating means comprises a single cylindrical member counterbored to provide a plurality of internal cylindrical surfaces.

17. An electrode assembly as claimed in claim 14, wherein said insulating means comprises a single cylindrical member having cylindrical stepped portions extending from one end thereof.

18. In the manufacture of cathode ray tubes, the process of forming a fluorescent screen upon the inner wall of the cathode ray tube which comprises mixing a fluorescent material with soft glass and a volatile binder, depositing the mixture upon a part of the wall of the tube, and heating said tube and mixture to volatilize the binder and to soften the soft glass, thereby to secure the soft glass and fluorescent material upon the tube wall.

19. In a cathode ray tube, the combination with a fluorescent screen and an electron gun having a tubular anode, of means for focusing the electron beam upon the screen to produce a light spot having a diameter of an order substantially less than that of the opening through said tubular anode.

20. An electron gun for a cathode ray tube comprising an insulating base having stepped cylindrical portions of different diameters, cylindrical electrodes having only their respective end portions telescoped on the respective cylindrical portions of said base, and means preventing relative movement of said electrodes and base.

21. An electron gun assembly adapted to be secured as a unit to the press of a cathode ray tube, said assembly comprising a cylindrical cathode, an anode including a tubular portion spaced axially from said cathode, a control electrode including a tubular portion surrounding the end of said cathode and extending towards the tubular portion of the anode, said anode and control electrode each including tubular portions telescoped upon and coaxial with a portion of said cathode, and annular insulating members between the opposed tubular surfaces of the said telescoped portions, said insulating members being secured to and maintaining said tubular portions in axial alinement.

22. An electron gun assembly as claimed in claim 21, in combination with a tubular focusing electrode surrounding and extending at one end axially beyond the corresponding end of said anode, and a plurality of insulating members of annular form between and securing said focusing electrode in co-axial alinement with said anode.

23. An electron gun assembly adapted to be secured as a unit to the press of a cathode ray tube, said assembly comprising a base of insulating material having a central opening and a plurality of stepped cylindrical surfaces coaxial with said opening, a tubular cathode seated in said central opening and projecting substantially beyond one face of said base, a tubular control electrode having one end thereof seated against the cylindrical surface of said base adjacent the central opening, a tubular anode including a tubular section axially spaced from said cathode and a tubular section surrounding the control electrode, the end of the second tubular section of said anode being seated against another of the said cylindrical surfaces of said base, and locking means secured respectively to said control electrode and anode, said locking means comprising wires extending through said base and means secured to the ends of said wires which project through the base to prevent movement thereof with respect to said base.

24. An electron gun assembly as claimed in claim 23, wherein certain of the wires of said locking means terminate adjacent said base and others of said wires are relatively long and are adapted to be electrically connected to lead-in wires of a press with which said electron gun assembly is associated.

25. An electron gun assembly as claimed in claim 23, in combination with a tubular focusing electrode surrounding and coaxial with the said anode, one end of said focusing electrode being secured to a cylindrical surface of said base, and means secured to said focusing electrode for attaching said assembly to a press.

26. An electron gun assembly as claimed in claim 23, wherein the first tubular portion of said anode has a uniform internal diameter of an order substantially in excess of the luminescent spot which is to be produced on the fluorescent screen of a cathode ray tube with which said electron gun is to be associated, in combination

with a tubular focusing electrode surrounding and coaxial with the said anode, one end of said focusing electrode being secured to a cylindrical surface of said base, and means secured to said focusing electrode for attaching said assembly to a press.

27. In a cathode ray tube, the combination with an electron gun comprising a cathode and an anode, a fluorescent screen and means determining the path taken by an electron beam passing from said anode to said screen, of means adapted to focus the electron beam on the screen, said focusing means including a shielding electrode means external to said anode and extending longitudinally thereof at least over the major portion of its length, said electrode being adapted to be maintained at a direct current potential which is positive and of lesser magnitude than the positive potential of the anode of the said electron gun relative to the cathode.

28. A cathode ray tube comprising an envelope having a press, a cathode, grid and anode having conductors embedded in said press and supported by said conductors and press, and insulating members interposed between and seated upon said cathode and grid, and said grid and anode and constituting means that holds them in spaced relation and against independent lateral displacement.

29. A cathode ray tube comprising an envelope having a press, a cathode, a control electrode and an anode, conductors embedded in said press and individually connected with each tube electrode, and an insulating member interposed between said cathode and control electrode and constituting means for positioning the said cathode and control electrode in predetermined spaced relation and against relative movement with respect to each other.

30. An electron gun structure comprising an electron source, a control electrode and an accelerating electrode, a non-conducting support member, conductors embedded in said support member and making electrical contact with said electron source, said control electrode and said accelerating electrode, and an insulating member interposed between said electron emitting electrode and said control electrode and supported from one of said electrodes for positioning said electron emitting electrode and said control electrode in predetermined fixed location relative to each other.

31. In combination with an envelope containing a group of concentric electrodes including an anode and cathode, a plurality of said electrodes surrounding said cathode and having marginal beads, a circumferentially stepped insulator having offset vertical surfaces to which said beads are frictionally applied to position said electrodes in spaced relation.

32. In a cathode ray tube the combination with an electron gun comprising a cathode and an anode, a fluorescent screen, a second anode adapted to be maintained at a potential positive relative to said first anode being positioned intermediate the screen and said first anode and deflecting electrode elements intermediate the two said anodes and means for determining the path taken by an electron beam passing from said anode to said screen, of electrode means additional to said gun and surrounding a portion of said gun and the deflecting electrode elements and extending longitudinally thereof for reducing the background light on said screen when an electron beam emitted from said gun is directed thereupon.

33. In a cathode ray tube for television and the like the combination with a luminescent target of an electron gun for directing toward said target an electron beam of approximately circular cross-section, said gun comprising a cathode and an anode, and means for altering the shape of the beam to rectangular cross-section, said last named means comprising electrode means adapted to focus the beam on said target when the direct current potential on said means is positive and of lesser magnitude than the positive potential of the anode of said electron gun.

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