

April 25, 1950

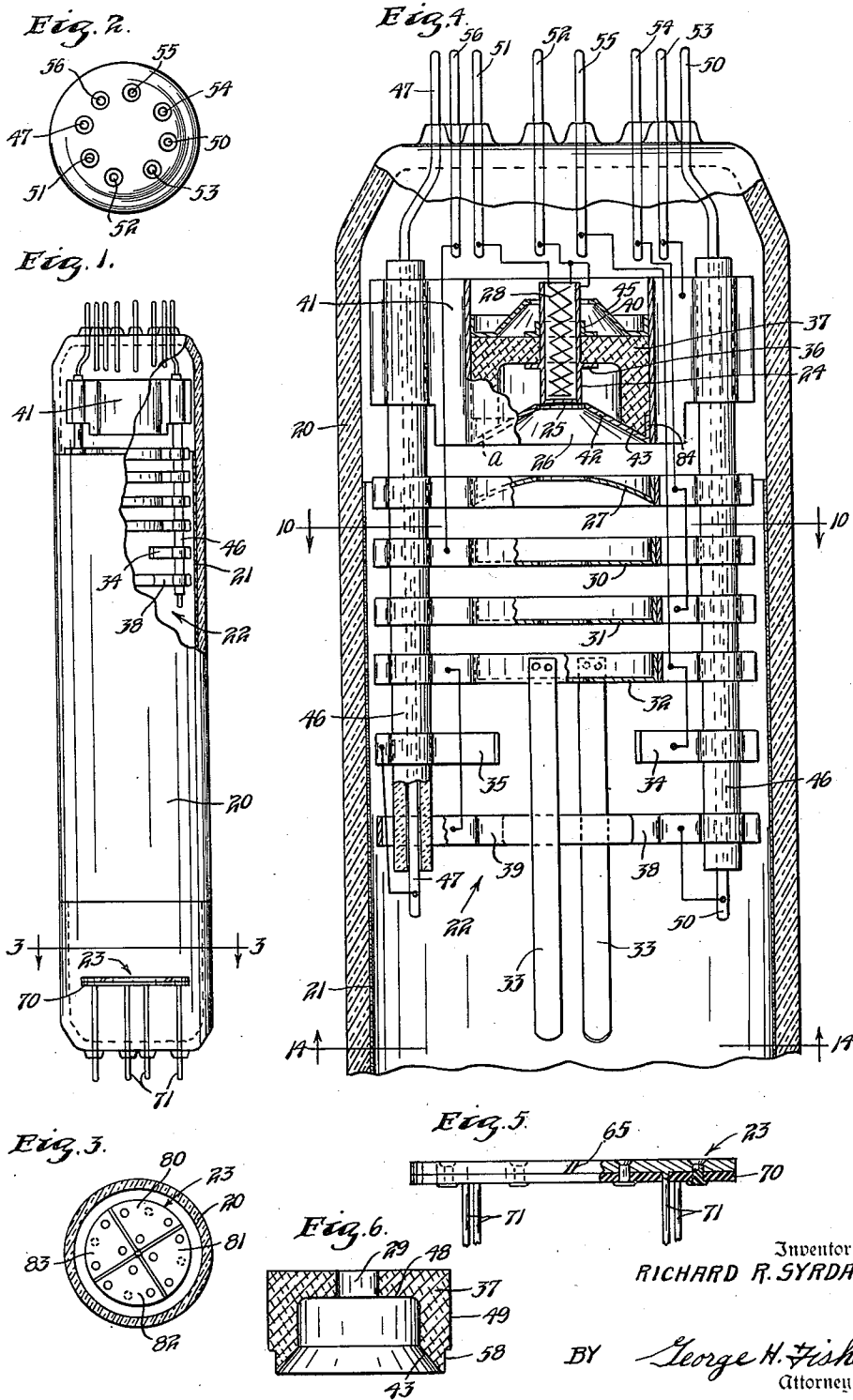
R. R. SYRDAL

2,505,261

BEAM TYPE OF ELECTRON DISCHARGE TUBES

Filed Aug. 29, 1947

3 Sheets-Sheet 1



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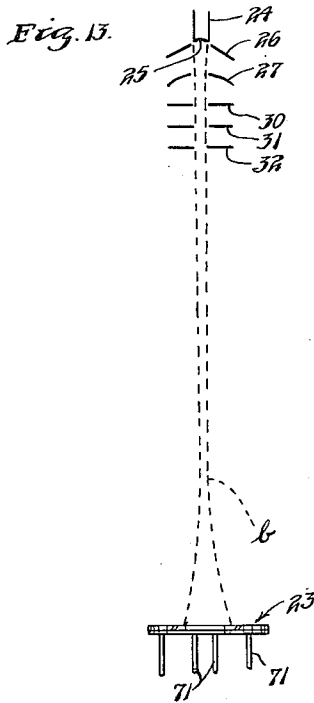
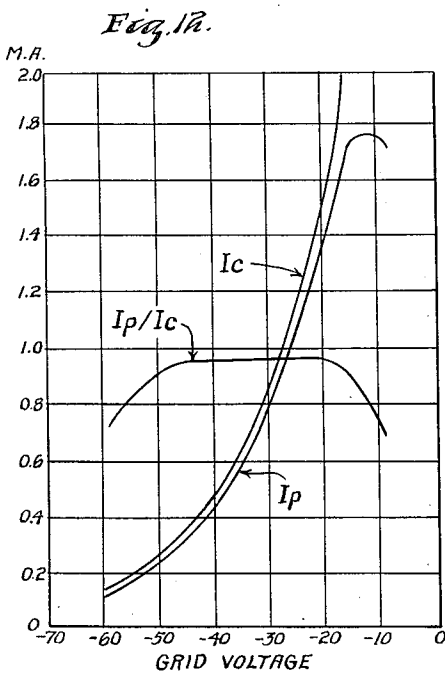
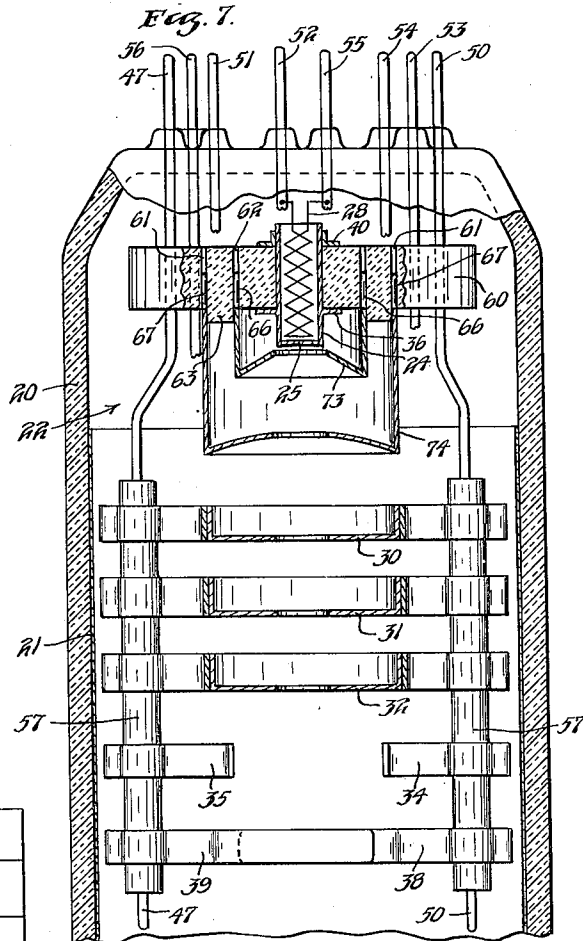
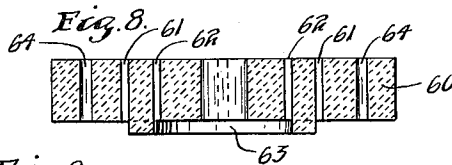
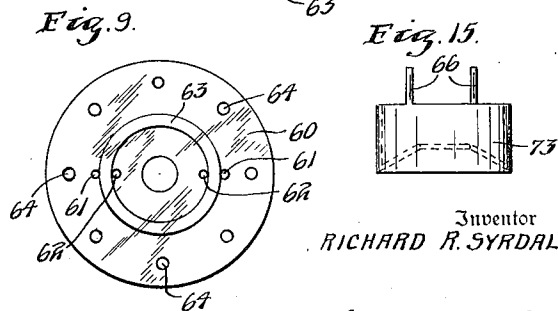
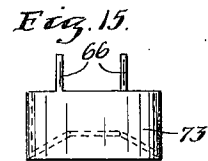
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BEAM TYPE OF ELECTRON DISCHARGE TUBES

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3 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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BEAM TYPE OF ELECTRON DISCHARGE
TUBES

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9 Claims. (Cl. 250—162)

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The present invention relates to a beam type of electron discharge device and more particularly to cathode ray tubes. It has been proposed to provide such devices with a plurality of target plates and means for selectively deflecting the beam to cause engagement with one or more of said plates. It is an object of this invention to provide an improved device of this type.

Another object of the invention is to provide such an improved electron discharge device in which substantially all of a high efficiency electron beam strikes at least one of a plurality of coplanar target plates.

Another object of the invention is to provide an improved electron discharge device with a plurality of target plates that are coplanar and yet overlapping so that substantially all of a high efficiency electron beam impinges at least one of the target plates.

Another object of the invention is to provide such an improved electron discharge device utilizing an insulating member having broad surfaces for rigidly engaging a plurality of electrodes and firmly supporting them in proper spaced relation.

Yet another object is to provide such an electron discharge device in which an insulating member for supporting certain of the electrodes is supported by a novel arrangement facilitating ready assembly of the device and accurate positioning of the electrodes.

Still another object is to provide such an electron discharge device sufficiently lightweight and compact that the entire electrode structure may be supported entirely by a small number of insulating posts.

Another object is to provide such an electron discharge device in which potentials to various centering electrodes used are placed on the electrodes by leads passing through specially provided apertures in the insulating posts used to support the electrodes.

In accomplishing the above objects, I provide the target plates with beveled edges so that the target plates may be coplanar even though overlapping. I also provide the electrode supporting insulating member with a ridge having surfaces engaging a portion of the electrodes being supported. The insulating member is mounted between an electrode and a washer, both telescoped within and secured to a metal sleeve. I also employ a number of novel features, the details of which will be apparent from the following description.

For a further understanding of the invention

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reference may be made to the following drawings of which:

Figure 1 is a view in elevation of a cathode ray tube partly cut away embodying the invention;

Figure 2 is an upper end view of the tube shown in Figure 1;

Figure 3 is a cross-sectional view taken along line 3—3 of Figure 1 in the direction of the arrows and showing the target plates;

Figure 4 is a partial fragmentary section of Figure 1 on an increased scale and showing one form of the invention;

Figure 5 is an elevation view of the target plates shown partly in section;

Figure 6 is a vertical sectional view in elevation of one form of electrode supporting insulating member used in the form of the invention shown in Figure 4;

Figure 7 is a fragmentary section of the tube and shows a second modification of the invention;

Figure 8 is a longitudinal sectional view of the electrode supporting insulating member used in the second modification of the invention as seen in Figure 7;

Figure 9 is a bottom view of the electrode supporting insulating member shown in the second modification of the invention as seen in Figure 7;

Figure 10 is a cross-sectional view along line 10—10 of Figure 4 in the direction of the arrows and showing the shape of the anode electrodes used;

Figure 11 is a diagrammatic drawing of the cathode ray tube showing the voltages placed on the various electrodes;

Figure 12 is a graph showing the comparison between the cathode current and target current for changing grid voltage and the plate current to cathode current ratio;

Figure 13 is a diagram showing the shape of the electron beam;

Figure 14 is a cross-sectional view along line 14—14 in the direction of the arrows in Figure 4 showing the shapes of the centering electrodes and the contacts to the aquadag from the last anode electrode; and

Figure 15 is a side view of the control electrode used in Figure 7.

The electron discharge device is vertical and comprises broadly an envelope containing an electron gun comprising means for emitting, directing, and focusing an electron beam along an axis at the upper end, the leads to which pass through the envelope at the end adjacent to the gun, and a plurality of mutually insulated target plates at the lower end which are situated in the

path of a beam emitted by the gun, the leads to said target plates passing through the envelope at the end adjacent to the plates.

Referring now to the drawings, the cathode ray tube in Figure 1 comprises an envelope 20 having a coating of aquadag 21 over a major portion of the inside of the envelope. Inside the envelope and spaced at opposite ends are the electron gun 22 containing a plurality of electrodes and insulating support means therefor, and the target plate assembly 23 containing a plurality of target plates and insulating support means therefor, with the above mentioned aquadag extending from that portion of the envelope near the middle of the electron gun down toward the target plates.

For a further, more detailed understanding of the electron gun, reference is made to Figure 4. In the electron gun herein shown there are an electron emitting member or cathode 24, an ordinary coiled wire heater element 28, a control electrode or grid 26, four anode electrodes 27, 30, 31, 32, two spring members 33, and two pairs of centering electrodes 34, 35 and 38, 39. These electrodes are symmetrical about an axis. The cathode 24 is tubular in shape and has a spherically concave electron emissive surface 25. The heater element 28 is fitted into the tubular portion of the cathode. The grid 26 has a conical surface 42 which is concave away from the cathode. The first anode electrode 27 has a spherical surface concave away from the cathode. The remaining three anode electrodes 30, 31 and 32 have flat surfaces. The two spring members 33 make contact between anode electrode 32 and the aquadag 21. The entire assembly can be said to be the means for emitting, directing, and focusing an electron beam along an axis.

The insulating member 37 supporting the cathode and grid can perhaps be more clearly seen in Figure 6. It has a central aperture 29 and an annular ridge 49 having cylindrical surfaces coaxial with the longitudinal axis of said centrally located aperture dropping from a lower surface 48. Toward the lower end of the ridge the diameter of the outer surface is abruptly decreased to form a reduced portion 58 of constant diameter. The reason for this will be discussed shortly. The bottom surface of ridge 49 is beveled to form a concave conical surface 43 extending outwardly away from the center.

The electron emissive electrode or cathode 24, containing a collar 36 which is formed as part of the cathode, is inserted upwardly, with the emissive surface facing down, through the central aperture 29 in the insulating member 37 until the collar 36 rests firmly against the lower surface 48 of the insulating member. A washer 40 is clamped firmly, as by spot welding, around the cathode on the opposite side of the insulating member from the collar 36 to hold the cathode firmly with respect to the insulating member.

A cylindrical flange 34, formed integral with the control electrode 26 and making an acute angle with the surface of the electrode, is firmly fastened, as by spot welding, to a cylindrical metal sleeve 41 at the lower end of the sleeve. As shown in Figure 4 the control grid is fastened to the inner surface of the metal sleeve. The grid 26 has a conical surface 42 in order to help obtain the focusing characteristics desired for the proposed use of this cathode ray tube. The reduced portion 58 of the insulating member 37 is to provide the necessary space for the grid flange 34 fastened to the metal sleeve when the insulat-

ing member 37 is telescoped down into the metal sleeve 41 to such a depth that the conical surface 42 of the grid is positioned on the ridge against the beveled surface 43 of the insulating member as shown at *a*. The beveled surface of the insulating member has the same conical shape as has the grid 26 to provide a broad, smooth surface for accurate positioning of the grid in close proximity to the cathode which is held firmly by the insulating member 37. A flanged washer 45 is telescoped within the metal sleeve 41 against the upper surface of the insulating member and is fastened, as by spot welding, to the inner surface of the metal sleeve to hold the washer firmly against the upper surface of the insulating member and prevent any possible longitudinal movement of the insulating member and the cathode with respect to the grid.

A bottom plan view of metal sleeve 41 has the same appearance as metal sleeve 59 seen in Figure 10 and now to be described.

Figure 10 shows a metal sleeve 59 holding the flat anode electrode 30 firmly with respect to a plurality, shown in the drawing as two, hollow insulating posts 46, preferably made of a ceramic material. Here it can be seen that the sleeve is circular in shape and has two wings. These wings have circular portions which surround the insulating posts 46. The wings are crimped to fasten the metal sleeves firmly to the insulating posts. The ceramic posts 46 align the various electrodes in proper spaced relationship with respect to each other along the axis of the electron beam due to the metal sleeves being clamped firmly to the posts which may be considered a supporting means. The electrode 30 is fastened to its metal sleeve 59, as by spot welding, just as are the other electrodes to their respective sleeves.

Centering electrodes 34, 35 and 38, 39 are fastened to the insulating posts 46 toward the bottom end of the posts. Two heavy leads 47 and 50 coming from the upper end of the envelope are inserted through apertures provided in the insulating posts 46 to hold the insulating posts, and thus the electron gun in proper alignment within the tube. Due to the small size of the tube and its components the electron gun can be supported entirely by means of these two insulating posts mounted on the two leads. In addition, lead 47 is connected with centering electrode 35 and lead 50 is connected with centering electrode 38 for reasons soon to be described.

Connected, as by riveting, to the fourth anode 32 are two bowed spring members 33, shown slightly offset in Figure 4, which make contact with the aquadag coating to put the potential of the fourth anode 32 on the aquadag. This connection is more clearly seen in Figure 14.

As has been stated above, lead 47 is connected with centering electrode 35 and lead 50 is connected with centering electrode 38. The remaining leads in the upper end of the tube make connection with the remaining electrodes in the following manner. Pins 51 and 52 are connected to the heater 28 with pin 52 further being connected to the cathode 24. Pin 53 is connected to the metal sleeve 41 to make electrical connection with the control electrode 26. Pin 54 is connected to the first and third anode electrodes 27 and 31 through the metal sleeves holding the electrodes. Pin 55 is connected to the fourth anode electrode 32 through its metal sleeve and from there to centering electrodes 34 and 39 and to the aquadag 21 by means of the

spring members 33. Pin 56 is connected to the second anode electrode 30 through the metal sleeve holding it.

The construction of the target plates 23 at the opposite end of the tube from the electron gun can be more clearly seen in Figures 3 and 5. The target plates 80, 81, 82, and 83 are shown to be mutually insulated and to have two converging, rectilinear beveled edges 65 which permit overlapping while at the same time enabling them to remain coplanar. The beveled edges of each plate form an angle equal to the angle formed by the beveled edges of each of the other plates. The edges are all beveled in the same direction and, as seen in Figure 3 looking down from above, the beveled edges extend radially from the center of the plate assembly through which the axis of the electron beam extends with each plate overlapping the plate counterclockwise to it. These target plates are fastened, as by riveting, as shown in Figure 5, to an insulating member 70 to hold them in their coplanar overlapping relationship. Insulating member 70 has apertures to permit leads 71 passing through the adjacent end of the tube to make electrical connection with the plates 80, 81, 82 and 83.

Figure 13 shows the formation of the beam due to the voltages placed on the various electrodes. Due to the shapes of the cathode and grid and the potential placed on the grid the beam leaves the cathode at a fairly high rate of convergence which continues until the aperture of the first anode electrode is reached. The lens system caused by the shapes of the anodes and the potentials impressed thereon decrease this rate of convergence. At point *b* the repelling effect of the electrons in the beam toward each other have finally equalized the convergence effect placed upon them by the lens system. Beyond point *b* the repelling effect becomes greater and the beam diverges until it hits the target plate assembly. It is desired that the cross-section of the beam striking the target plate be of such size that, when properly deflected, it can impinge on only one plate, but that a slight movement to either side will cause a portion of the beam to impinge one of the adjacent plates. This eliminates one possibility of having a "dead spot" which would occur if the beam could move a bit toward one side of a plate and yet still remain entirely on that target plate. A second possibility of having a "dead spot" is also eliminated by the overlapping target plates in that there are no gaps between the plates to receive a portion of the beam when it moves off one of the plates. Because there are no "dead spots" the sensitivity of the tube is greatly increased. The beam shown in Figure 13 is striking all of the target plates equally.

A set of voltages which have been found to work satisfactorily on the electrodes in this tube to give the desired shape of the electron beam as shown in Figure 13 can be seen in diagrammatic form in Figure 11. In this figure, the cathode 24 is shown to be at zero potential with the voltages on the remaining electrodes taken with respect to the cathode voltage. The heater 28 is shown at zero potential with an A. C. voltage of 6.3 volts applied to the heater winding. The control electrode 26 is shown at -10 volts with an A. C. modulating voltage of 6.3 volts applied. The first anode electrode 27 and the third anode electrode 31 are at +310 volts potential. The second anode electrode 30 is at +75 volts potential. The fourth anode electrode 32, the centering electrodes 34 and 39

and the aquadag 21 are at +240 volts potential. The other centering electrodes 35 and 38 are connected to variable taps to obtain a proper setting of potential to center the electron stream when there is no deflecting force. When these voltages for the centering electrodes 35 and 38 have been obtained the connections to the potentiometer are soldered fast to hold the settings at these positions. The target plates 80, 81, 82 and 83 are at a potential of +310 volts.

The four target plates are connected to two transformers 72 and 73. Target plates 81 and 83 are connected to opposite ends of the primary of transformer 72 while target plates 80 and 82 are connected to opposite ends of the primary of transformer 73. The secondaries of the transformers 72 and 73 are connected to any applicable signal receiving device. When there is no deflecting force the electron beam strikes squarely in the center of the target plate assembly, each target plate receiving an equal portion of the beam. When a force, such as the earth's magnetic field, deflects the beam, for example to the right, target plate 81 will receive an increased number of electrons while the number of electrons impinging plate 83 will decrease and thus cause a difference of potential at the opposite ends of the primary of transformer 72 to cause a current flow. Because the beam is modulated by the control grid the voltage across the primary and the current flow through the primary of the transformer is A. C. and thus induces a voltage in the transformer secondary. The four plates correspond to the four directions; north, south, east and west. Transformer 72 may be considered as the transformer sending out a signal for an east or west deflection of the beam while transformer 73 may be considered as the transformer sending out a signal for north or south deflection. Because of the overlapping target plates the only portion of the beam which is lost, that is, which does not strike any of the target plates, is that portion of the beam which strikes the very center of the target plate assembly where the four target plates come together. Because of the very small size of this hole and its position with respect to the target plates the portion of the beam lost is insignificant. Also, because the plates are coplanar, it permits easy, rapid assembly and still insures that each plate covers 90° of the total circle.

A modification of the invention is shown in Figure 7. The shapes of the various electrodes, with certain small exceptions are the same as those shown in Figure 4. The changes come in the lengths of the flanges of the control electrode and first anode electrode and the pins on the flanges of the two above mentioned electrodes. The second, third and fourth anode electrodes and centering electrodes are all mounted on two ceramic posts just as is done in Figure 4. The spring members making electrical connection between the aquadag and the fourth anode electrode are the same as shown in Figure 4. The connections from the pins passing through the end of the envelope are all the same as those in Figure 4. The insulating member shown in Figure 7 supporting the cathode and grid also supports the first anode electrode. This insulating member 69 supports the cathode 24 in the same manner as does insulating member 37 in Figure 4. The cathode is bound to the insulating member by a collar formed on the cathode and a washer. This member 60 is provided with an annular ridge on its bottom surface to provide a plurality of surfaces to engage the control elec-

trode and the anode electrode and to aid in positioning and supporting them in proper spaced relation toward each other and with respect to the cathode. The control electrode 73 is positioned on the inside surface of ridge 63 on the insulating member 60 and has two pins 66 which fit into holes 62 in the insulating member and through which electrical connection can be made. This control electrode with its two pins can perhaps be better seen in Figure 15. The first anode electrode 74 is positioned on the outer surface of ridge 63 and has two pins 67 which fit into holes 61 through which electrical connections can be made. The same pins make connection to the control electrode and first anode electrode in this modification of the invention as in the other even though the manner of making the connection is slightly different. With the exception of a cylindrical surface rather than a conical surface and its larger size the first anode electrode resembles closely the appearance of the control electrode shown in Figure 15.

The insulating member 60 in this case is supported by all of the pins passing through the end of the envelope, the holes 64 being provided for the insertion of the pins into the insulating member. A longitudinal sectional view and a bottom view of the insulating member 60, showing its shape and the positioning of the holes 61, 62, and 64, can be seen in Figures 8 and 9.

Figure 12 shows the high cathode current I_c and target current I_p , ranging in the order of 0.5 to 1.5 milliamperes, which can be obtained with this tube using either modification. Figure 12 also shows the high efficiency, target current to cathode current ratio, of this tube. This efficiency over the level portion of the curve averages better than 95%, dropping off at a grid voltage of less than -45° and greater than -20° . The high target current is due to the wide apertures used in the electrodes and to the superior lens system used. The efficiency drops off at the low end because of the large negative grid voltage which tends to drive the electrons back to the cathode. The dropping off of the efficiency at the high end is due to the small negative voltage on the grid which is unable to prevent the beam from spreading and as a result a portion, which increases with a positive increase in grid voltage, strikes the first anode electrode.

It will be seen from the above description that I have provided a high efficiency tube, the high efficiency of which is due to the beveled, overlapping target plates which cause all but a very small portion of the beam leaving the electron gun to impinge at least one of the plates and to the ingenious gun structure which focuses and directs virtually the entire beam of electrons leaving the cathode along an axis toward the target plate assembly. It will also be seen that due to the small size of the tube the only support means necessary for the gun are the insulating posts and the conducting leads passing therethrough, said leads serving the double purpose of positioning the posts and putting a potential on various of the centering electrodes.

Although specific examples of the invention have been shown and described, it will be understood, of course, that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

I claim:

1. An electron discharge device comprising means including a plurality of electrodes and in-

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insulating support means therefore for directing an electron beam along an axis; said insulating means comprising an insulating member having a centrally located aperture for the insertion therein of a first of said electrodes and further having a conical surface extending outwardly from said aperture, a second of said electrodes being conical in shape and positioned on said conical surface of the insulating member to position said second electrode in proper relation to said first electrode; and target means located in the path of said electron beam for impingement thereby.

2. An electron discharge device comprising a plurality of electrodes directing an electron beam along an axis; an insulating member having a centrally located aperture for the insertion therein of a first of said electrodes and a conical surface extending outwardly from said aperture; a sleeve having fastened thereto a second of said electrodes and telescoped about said insulating member such that said second electrode rests against said conical surface; a washer telescoped within said sleeve and fastened thereto preventing longitudinal movement of the insulating member within the sleeve; a plurality of insulating posts to which said sleeve and the remaining electrodes are secured to position the electrodes in proper spaced relationship along said axis; and target means located in the path of said electron beam for impingement thereby.

3. A cathode ray tube comprising an envelope; an electron gun in said envelope having a plurality of electrodes, including an electron emissive electrode, for emitting, directing, and focusing a converging electron beam along an axis, an insulating member having a centrally located aperture for the insertion therein of the electron emissive electrode and further provided with an annular ridge having two of its surfaces coaxial with the longitudinal axis of said centrally located aperture and a third surface beveled to form a conical surface concave away from the aperture, a second of said electrodes being conical in shape and positioned on said insulating member with said conical portion of the electrode resting on the beveled surface of said ridge so that the ridge positions the second electrode in close proximity to the first electrode, and means including a plurality of insulating posts and a metal sleeve enclosing said insulating member positioning the insulating member and said electrodes with respect to the remaining electrodes of said gun along said axis; and target means, also in said envelope, located in the path of said electron beam for impingement thereby.

4. A cathode ray tube comprising an envelope; an electron gun in said envelope having a plurality of electrodes, including an electron emissive electrode, for emitting, directing, and focusing a converging electron beam along an axis, an insulating member having a centrally located aperture for the insertion therein of the electron emissive electrode and further provided with an annular ridge having two of its surfaces coaxial with the longitudinal axis of said centrally located aperture and a third surface beveled to form a conical surface concave away from the aperture, a metal sleeve to which is fastened a second of said electrodes conical in shape, a flanged washer, and insulating posts, said insulating member being telescoped within said metal sleeve with said beveled surface against the conical portion of the second electrode and said washer being telescoped within said sleeve and

fastened thereto to prevent longitudinal movement of the insulating member said insulating posts supporting said sleeve and the remaining of said electrodes in proper spaced relation along said axis; and target means, also in said envelope, located in the path of said electron beam for impingement thereby.

5. A cathode ray tube comprising an envelope having an aquadag coating over a large portion of its inner surface; an electron gun in said envelope having a plurality of electrodes, including an electron emissive electrode and a plurality of centering electrodes, for emitting, directing, and focusing a converging electron beam along an axis, an insulating member having a centrally located aperture for the insertion therein of the electron emissive electrode and further provided with an annular ridge having two of its surfaces coaxial with the longitudinal axis of said centrally located aperture and a third surface beveled to form a conical surface concave away from the aperture, a second of said electrodes being conical in shape, and positioned on said insulating member with the conical portion of said second electrode resting on the beveled surface of said ridge so that the ridge positions the second electrode in close proximity to the first electrode, and means including a plurality of insulating posts and a metal sleeve enclosing said insulating member positioning the insulating member and said electrodes with respect to the remaining electrodes of said gun along said axis, one of the remaining of said electrodes making contact with said aquadag to put the potential of said electrode on said aquadag, said insulating posts being hollow to permit passage of heavy wire leads therethrough to support said insulating posts and connected to various of said centering electrodes to put a potential thereon; a plurality of coplanar, mutually insulated target plates each having two converging, rectilinear beveled edges, said beveled edges of each plate forming an angle equal to the angle formed by the beveled edges on each of the other plates; and means mounting said plates in the path of said beam with said beveled edges in overlapping relationship so that substantially every portion of said beam impinges at least one of said target plates.

6. A cathode ray tube comprising an envelope; an electron gun in said envelope having a plurality of electrodes, including an electron emissive electrode, for emitting, directing, and focusing a converging electron beam along an axis, and an insulating member having a centrally located aperture for the insertion therein of the electron emissive electrode, said insulating member being further provided with an annular ridge having two of its surfaces coaxial with the longitudinal axis of said centrally located aperture and having an electrode engaging each of said surfaces positioning them relative to each other and to said electron emitting electrode, said electrodes being positioned with respect to the rest of the electron gun by said insulating member supported on leads through the end of the envelope, a plurality of said leads extending the length of the gun and supporting the remaining electrodes of said gun along said axis; and target means, also in said envelope, located in the path of said electron beam for impingement thereby.

7. A cathode ray tube comprising an envelope having an aquadag coating over a large portion of its inner surface; an electron gun in said envelope having a plurality of electrodes, includ-

ing an electron emissive electrode and a plurality of centering electrodes, for emitting, directing, and focusing a converging electron beam along an axis, and an insulating member having a centrally located aperture for the insertion therein of the electron emissive electrode and further provided with an annular ridge having two of its surfaces coaxial with the longitudinal axis of said centrally located aperture and having an electrode engaging each of said surfaces positioning them relative to each other and to said electron emitting electrode, said electrodes being positioned with respect to the rest of the electron gun by said insulating member supported on leads through the end of the envelope, a plurality of said leads extending the length of the gun and supporting the remaining electrodes of said gun along said axis, one of the remaining of said electrodes making contact with said aquadag to put the potential of said electrode on said aquadag, said leads extending the length of the gun being positioned within hollow insulating posts and connected to various of said centering electrodes to put a potential thereon; a plurality of coplanar, mutually insulated target plates each having two converging, rectilinear beveled edges, said beveled edges of each plate forming an angle equal to the angle formed by the beveled edges on each of the other plates; and means mounting said plates in the path of said beam with said beveled edges in overlapping relationship so that substantially every portion of said beam impinges at least one of said target plates.

8. A cathode ray tube comprising an envelope; an electron gun in said envelope having a plurality of electrodes, including an electron emissive electrode, for emitting, directing, and focusing a converging electron beam along an axis, and an insulating member having a centrally located aperture for the insertion therein of the electron emissive electrode, said insulating member being further provided with an annular ridge having at least one of its surfaces coaxial with the longitudinal axis of said centrally located aperture and having an electrode engaging said surface positioning it relative to said electron emitting electrode, said electrodes being positioned with respect to the rest of the electron gun by said insulating member supported on leads through the end of the envelope, a plurality of said leads extending the length of the gun and supporting the remaining electrodes of said gun along said axis; and target means, also in said envelope, located in the path of said electron beam for impingement thereby.

9. A cathode ray tube comprising an envelope having an aquadag coating over a large portion of its inner surface; an electron gun in said envelope having a plurality of electrodes, including an electron emissive electrode and a plurality of centering electrodes, for emitting, directing, and focusing a converging electron beam along an axis, and an insulating member having a centrally located aperture for the insertion therein of the electron emissive electrode and further provided with an annular ridge having at least one of its surfaces coaxial with the longitudinal axis of said centrally located aperture and having an electrode engaging said surface positioning it relative to said electron emitting electrode, said electrodes being positioned with respect to the rest of the electron gun by said insulating member supported on leads through the end of the envelope, a plurality of said leads

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extending the length of the gun and supporting the remaining electrodes of said gun along said axis, one of the remaining of said electrodes making contact with said aquadag to put the potential of said electrode on said aquadag, said leads extending the length of the gun being positioned within hollow insulating posts and connected to various of said centering electrodes to put a potential thereon; a plurality of coplanar, mutually insulated target plates each having two converging, rectilinear beveled edges, said beveled edges of each plate forming an angle equal to the angle formed by the beveled edges on each of the other plates; and means mounting said plates in the path of said beam with said beveled edges in overlapping relationship so that substantially every portion of said beam impinges at least one of said target plates.

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