

Oct. 13, 1942.

R. C. WINANS

2,299,047

ELECTRONIC DISCHARGE DEVICE

Filed June 25, 1940

2 Sheets-Sheet 1

FIG. 1

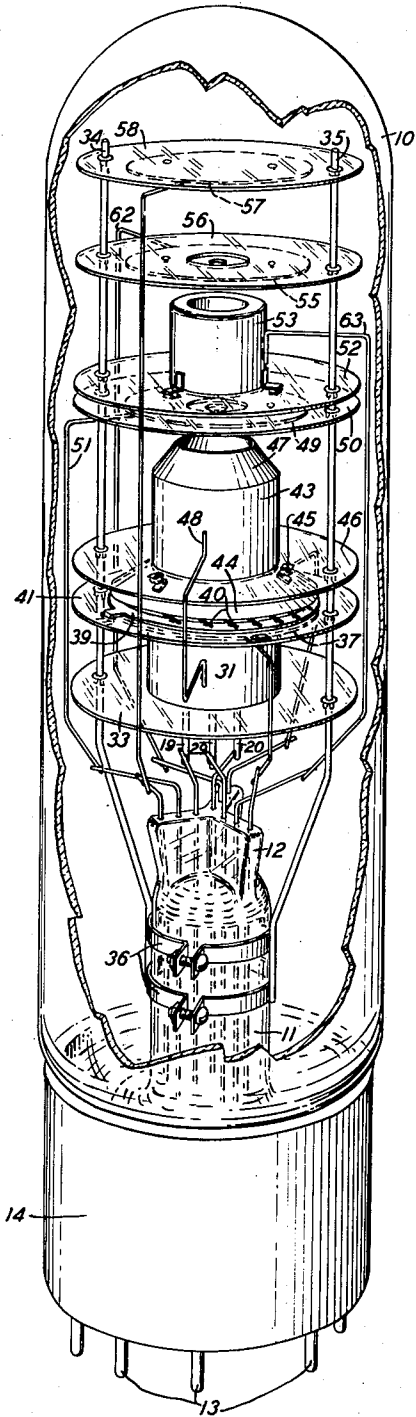


FIG. 2

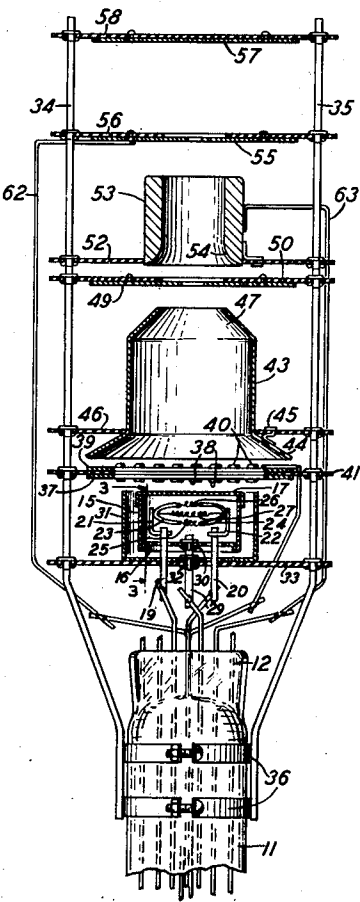
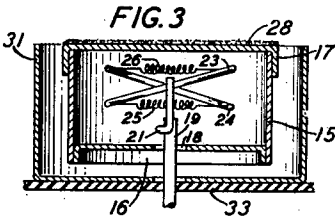


FIG. 3



INVENTOR
R. C. WINANS

BY

Walter C. Kiesel
ATTORNEY

Oct. 13, 1942.

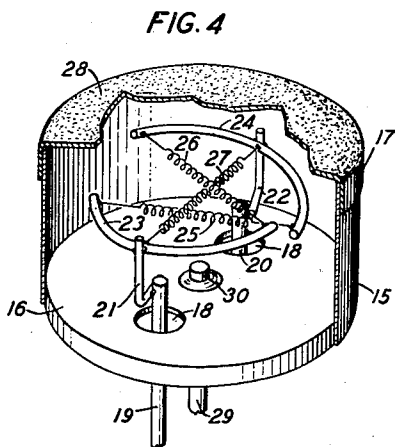
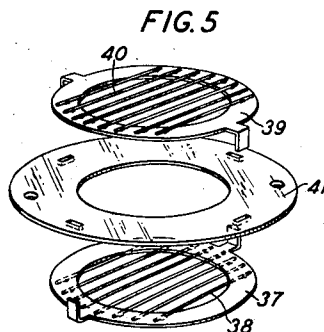
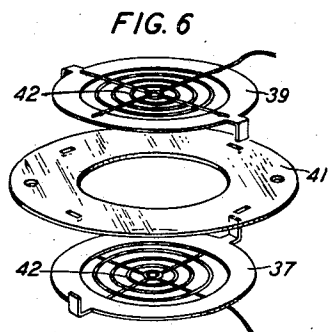
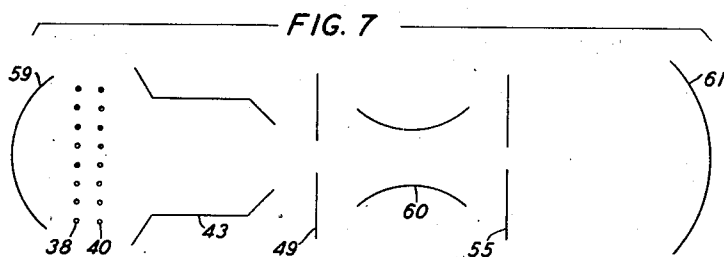
R. C. WINANS

2,299,047

ELECTRONIC DISCHARGE DEVICE

Filed June 25, 1940

2 Sheets-Sheet 2



INVENTOR
R. C. WINANS
BY
Otto C. Kiesel
ATTORNEY

UNITED STATES PATENT OFFICE

2,299,047

ELECTRONIC DISCHARGE DEVICE

Robert C. Winans, Chatham, N. J., assignor to
Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application June 25, 1940, Serial No. 342,193

14 Claims. (Cl. 250-163)

This invention relates to electronic discharge devices and more particularly to cathode ray or beam projection devices for use in television systems, measuring circuits, velocity modulators and electronic switching apparatus.

In these and other allied arrangements, the projected beam in the electronic device originates in an electron gun and the output is determined by the size, current intensity and distortionless quality of a beam or spot produced on a screen, target or receptive surface in the discharge device. A primary consideration in the production of efficient devices is to eliminate stray electron paths so that substantially the total electrons emanating from the cathode source are guided in their travel and are concentrated in the beam striking the receptive surface. Furthermore, in many applications, the beam is modulated by a control voltage and it is essential that this function be performed by varying the current linearly without changing the size or quality of the spot on the screen.

The principal object of the invention is to attain a high beam current output to increase the efficiency and adaptability of electronic devices.

A further object of the invention is to produce linear variation in the beam current for modulation purposes without affecting the size or quality of the spot on the receptive surface of the device.

These concepts are achieved in accordance with this invention by a fabricated assembly of cooperating elements in an electron gun arrangement having a large area cathode or electron source capable of producing a copious supply of electrons mounted at one end of an enclosing vessel to form a beam for projection toward a receptive surface or screen arranged at the opposite end of the vessel. An axially symmetrical system of cooperating electrodes is positioned adjacent the cathode, the electrodes being superimposed progressively in front of the cathode to form the gun structure. These electrodes control, focus, accelerate and collimate the electrons to effect the high concentration of electrons in the beam so that a maximum beam current results and an intense actinic spot is produced on the screen.

A feature of the invention relates to the relationship and shape of a concentrator or focusing electrode with respect to the cathode and anode whereby the electrons emanating from the large surface area of the cathode are collected with minimum diversion and focussed to a cross-over point slightly beyond the anode.

Another feature is concerned with the spacing and assembly of the modulator or control grid and the accelerating grid or electrode intermediate the cathode and the concentrator to increase the control and current output of the device.

A further feature of the invention relates to the configuration of the collimating electrode and its location between the accelerating anodes to rectify the paths of electrons projected through it by dissipating the radial velocity component and reinforcing the axial component by the potential gradient distribution of the electrode.

Still another feature is concerned with applying fluorescent coating material to the surfaces of the anodes to indicate the degree and frequency of divergent electrons adjacent the apertures of the anodes in order that corrective potentials may be applied to promote greater paraxial flow of electrons in the beam projected through the device.

These and other features and characteristics of this invention will be more clearly understood by reference to the following detailed description taken in connection with the accompanying drawings:

Fig. 1 is a perspective view of one form of an electronic device in accordance with this invention with a portion of the vessel broken away to illustrate the internal electrode assembly;

Fig. 2 is a view in cross-section of the electrode assembly of Fig. 1 showing the configuration of the electrodes and the mounting thereof,

Fig. 3 is an enlarged view in cross-section of the cathode assembly taken on line 3-3 of Fig. 2;

Fig. 4 illustrates the cathode assembly in perspective with a portion of the shell cut away to show the various details;

Fig. 5 is a perspective view of the details of the mounting of the grid electrodes as shown in Fig. 2 with the elements in suspended relation;

Fig. 6 shows a perspective view of a modified arrangement of the assembly of the grids; and

Fig. 7 is a diagrammatic view of a different form of the device in accordance with this invention, in which modifications in the electrode construction are shown.

Referring to the drawings and Figs. 1 and 2 particularly, the electronic discharge device of this invention has an enclosing vessel 10 with a stem 11 formed at its inner end into a press portion 12 in which various leading-in wires are sealed and brought out external to the vessel to a plurality of terminals 13 on the lower end of a base 14 attached to the vessel adjacent the stem.

In order to realize a high beam current output

in devices, for example, in television and electronic switching, it is essential to increase the number of emitted electrons or to cause a larger fraction of the emitted electrons to be projected into the beam. The first requirement may be satisfied by increasing the area of the emission source and the second requirement will result by decreasing the percentage of electrons collected by the electrode system in collimating the beam. Since the spot size determines the desirability of a specific device for a particular application, the size being more critical in television than in switching devices, due to aberration, it is evident that merely realizing both requirements will not fulfill manifest difficulties in applying the device to widely variant purposes. Furthermore, in television the control or modulation of the beam is important and should be linear with the applied voltage and have a sharp cut-off to obtain good contrast in the picture or other representation which is televised. Another requirement of the modulating system is that the quality and size of the spot on the screen or target will not vary as the beam is modulated.

The objective of this invention is the development of an electron gun to meet the requirements enumerated above and one aspect will be described in connection with Figs. 1 and 2 which embody the completely assembly of the gun. The primary essentials of the electron gun of this invention are the cathode or electron source, a concentrator element, a pair of accelerating electrodes or anodes, and a collimating electrode between the anodes. A fluorescent screen or target is provided in the vessel either applied to the dome end of the vessel or mounted independently of the vessel, but in position to be irradiated by a beam of electrons projected from the gun assembly. If desired a deflector system may be interposed between the gun assembly and the screen to sweep the beam over the complete area of the screen.

The cathode assembly or electron source is shown more clearly in Figs. 3 and 4 and comprises a cylindrical shell 15 having a diameter of about one inch with closure caps 16 and 17 extending across opposite ends of the shell. The cap 16 is provided with a pair of aligned apertures 18 through which extend rigid conductors 19 and 20 carrying bent stub wires 21 and 22 which are welded to the centers of a pair of oppositely disposed arcuate arms 23 and 24 arranged at reverse angles with respect to each other to form a supporting structure. A plurality of strands of coiled tungsten heaters 25, 26 and 27 are mounted between the arms, the heater 25 being connected to the low ends of the arms 23 and 24, the heater 26 being attached to the high ends of the arms and the heater 27 being connected to the centers of the arms so that the strands radiate from a common axis and distribute heat energy to the complete area of the closure cap 17. This cap is provided with an electron emissive coating 28 formed of compounds of alkaline earth metal, such as oxides of barium and strontium, which when activated produces a copious supply of electrons capable of generating an electron current of large magnitude.

The cathode structure is centrally supported by a rigid rod 29 which is attached to the lower closure cap 16 by an eyelet 30. The cathode is surrounded by a cup shield 31 which is also secured to the rod 29 by an eyelet fastening 32, the shield being provided with apertures for the free passage of the conductors 19 and 20 of the heater

assembly. The cathode and shield construction is mounted on a mica disc 33 which is carried by a pair of parallel support rods 34 and 35 extending from a pair of clamping collars 36 embracing the stem 11 of the vessel. The heater is connected to a pair of leading-in wires in the press 12 and the cathode and shield being electrically connected together are attached to a leading-in wire mounted in the press.

The control or modulation of the electron current in the vicinity of the cathode is important in television and some oscillograph applications and the modulated electrons must be energized by attraction to impart speed to the electrons in order to focus the cloud of electrons into a beam. These functions are performed, in accordance with this invention by introducing a grid unit closely adjacent to the cathode planar surface in which the grid close to the cathode surface is the modulating electrode and the grid away from the cathode is the accelerating electrode. This grid assembly or unit is shown more clearly in Fig. 5 in which the modulator electrode consists of an annular metallic flat ring 37 provided with a grating 38 of parallel wires which are welded at opposite ends to portions of the ring. The accelerating or focussing grid consists of another annular flat ring 39 provided with a wire grating 40. These grids have integral bent ear portions which fit into slots in a mica ring 41 so that the grids are positioned on opposite sides of the mica spacer and therefore are closely spaced with respect to each other. The mica ring 41 is supported on the upright rods 34 and 35 in axial relation with respect to the cathode and in close spaced relation therewith. A modification of the grid unit is shown in Fig. 6 in which the grid rings are provided with circular gratings 42 to obtain different characteristics in the control and acceleration of the beam of electrons emitted from the cathode. Connections may be provided for each grid to the respective leading-in conductors in the press 12 in order to apply suitable potentials to these electrodes in the operation of the device.

The next element of the electron gun assembly in the progression from the cathode is the concentrator electrode 43 formed of a tubular member having a diameter greater than the cathode diameter and provided with a flared skirt portion 44 which extends out to the periphery of the accelerator grid 39. The skirt portion forms a shield for divergent electrons passing through the grid elements so that these electrons are returned to the grids or are shunted into the beam projected through the concentrator. The skirt portion is provided with a plurality of hook members 45 which are clamped in slots in a mica disc or ring 46 secured to the upright rods 34 and 35 to support the concentrator element in coaxial symmetry with the grid unit and the cathode assembly. The concentrator is provided with a constricted throat portion 47 to facilitate influential flow of electron paths in the beam of electrons in an axial direction. The concentrator element is electrically connected to the cathode assembly by a coupling wire 48 so that the concentrator element is maintained at cathode potential. The throat opening should not be less than one-half the diameter of the main portion of the concentrator element in order that the cross-over of the beam is closely adjacent to the exit of the concentrator element.

An anode disc 49 having a central aperture in focal position with respect to the concentrator

element 43 is secured to a mica ring 50 and mounted in interspatial relation approximately one-half inch from the exit of the concentrator element by securing the mica disc to the up-
rights 34 and 35. The size of the aperture in the anode 49, in relation to the proportions of the other elements of the gun structure so far de-
scribed, is approximately one-quarter inch so that all the diverging electrons in the beam after passing through the cross-over, beyond the con-
centrator element, are permitted to enter the anode aperture in the progression of the beam through the device. The accelerating field gen-
erated by the anode 49 is supplied by a connect-
ing wire 51 which is attached to a leading-in wire in the stem so that an accelerating positive po-
tential of the order of 100 to 300 volts may be ap-
plied to the anode. In order to facilitate large beam current in the stream of electrons and ap-
ply corrective measures to reduce dissipation of
electrons to the electrode surface in accordance
with this invention, the anode may be coated
toward the throat of the concentrator element
so that any stray electron paths striking the
fluorescent material will be indicated quantita-
tively and the voltage applied to the anode may
be corrected to reduce or eliminate the dissipa-
tion indicated.

A mica ring 52 is arranged laterally with re-
spect to the anode assembly and is attached to
the uprights 34 and 35 in space relation to the
anode assembly to support a thick-walled col-
limator element 53 having a suitable length for
complete collimation of the beam of electrons
passing therethrough and supplied with suitable
potentials through a conductor 63 for producing
the proper distribution of the potential gradient,
whereby the radial velocity component is dissipa-
ted and the axial component is reinforced so
that no electrons are absorbed from the beam in
its travel through the collimator element. The
element 53 is made relatively thick to increase
the potential distribution and at its lower end is
flared at 54 to a larger diameter approximately
one and a half times the diameter of the internal
dimension of the element to correct a sharp
change in the field adjacent the entrance of the
collimator. The potential distribution along the
axis is roughly proportional to the square of the
distance along the axis and the radial gradient
is approximately a function of the second deriva-
tive of this potential distribution. As the de-
gree of the axial variation is increased the gra-
dient increases so that the desired axial distribu-
tion may be produced when the form of the ele-
ment approaches a unipotential surface where
the gradient is at least a third degree function
of the axial distance and exhibiting a minimum
voltage point at the plane of minimum diameter
of the electrode. If the electrons reach the axis
at the minimum voltage point, their subsequent
paths are paraxial and complete collimation can
be accomplished without collecting any electrons.
This produces a high beam current and a beam
of small diameter. With a positive potential
of low magnitude, of the order of 5 to 12 volts,
the collimator 53 performs its function of focussing
the electrons of the beam into paraxial paths but
with a variable potential or slightly negative po-
tential, the collimator 53 functions as a control
element and produces a definite cut-off at about
6 volts negative.

A second anode 55 in the form of an apertured
disc is mounted on a mica ring 56 which is at-

tached to the uprights 34 and 35, the aperture in
the anode being approximately the size of the
final spot to appear on the screen or fluorescent
surface of the device. As shown the aperture in
the second anode is smaller than the aperture in
anode 49. The second anode 55 is also provided
with a fluorescent coating for the same purpose
as described in connection with the anode 49. A
conductor 62 is attached to the anode in order to
supply an accelerating potential thereto of the
same value or greater than the potential on the
first anode 49. A metallic disc 57 is supported by
a mica disc 58 from the uprights in axial sym-
metry with the gun electrodes and is provided
with a fluorescent coating to serve as a screen or
target for the reception of the beam through the
electron gun assembly.

The diagrammatic form of the device of this
invention shown in Fig. 7 embodies the various
features of the gun assembly previously de-
scribed but includes certain modifications to rep-
resent the application of the invention to a dif-
ferent form of device. The cathode emitting
surface 59 is made spherical to facilitate the
focussing of the electrons towards the axis and
reduce the radial gradient of stray electrons.
The grids 38 and 40, the concentrator 43 and the
two anodes 49 and 55 represent elements previ-
ously described in connection with Figs. 1 and 2
so that further description may be dispensed
with in connection with these electrodes. The
modification of the collimator element in Fig. 7
shows the collimator 60 with an internal diam-
eter varying at opposite ends so that sharp fields
adjacent the two anodes 49 and 55 are corrected
and the presence of the minimum voltage point
is shifted to the center of the collimator which
is of minimum diameter. This produces a radial
gradient toward the axis over the entire length
of the collimator so that the beam is focussed
paraxially toward the second anode 55 and then
projected toward a screen 61 which may be
formed on the end of the vessel in accordance
with usual cathode ray tube practice.

While the invention has been described with
respect to specific combinations of electrodes in
the electron gun of this invention, it is, of course,
understood that various modifications may be
made in the detailed configuration and spacing
of the elements without departing from the scope
of this invention as defined in the appended
claims.

What is claimed is:

1. An electronic discharge device comprising
an enclosing vessel, an electron receiving target
at one end thereof, and a beam projecting gun
at the other end for initiating and accelerating
a beam of electrons towards said target, said gun
including a series of axially symmetrical elec-
trodes extending toward said target, comprising
an electron emissive cathode, a pair of apertured
anodes spaced beyond said cathode, and a tubular
collimator element having a uniform diameter
boundary and a varying diameter inner throat
directed toward at least one of said anodes.

2. A beam translating device comprising a ves-
sel having an electron responsive screen at one
end, and an electron projection gun at the other
end, said gun including an emissive source of
large surface area, a pair of spaced grid ele-
ments adjacent said source adapted to control
and accelerate the flow of electrons from said
source respectively, an apertured anode in axial
alignment with said source, a hollow concen-
trator element interposed between said grids and

said anode and having one portion extending outwardly to the periphery of said grids and the other end concentrated toward the aperture of said anode, and a collimator electrode spaced beyond said anode.

3. A beam translating device comprising a vessel having an electron responsive screen at one end, and an electron projection gun at the other end, said gun including an emissive source of large surface area, a pair of spaced grid elements adjacent said source adapted to control and accelerate the flow of electrons from said source respectively, an apertured anode in axial alignment with said source, a hollow concentrator element interposed between said grids and said anode and having one portion extending outwardly to the periphery of said grids, a collimator electrode spaced beyond said anode, and a second apertured anode mounted adjacent said collimator electrode.

4. A beam translating device comprising a vessel having an electron responsive screen at one end, and an electron projection gun at the other end, said gun including an emissive source of large surface area, a pair of spaced grid elements adjacent said source adapted to control and accelerate the flow of electrons from said source respectively, an apertured anode in alignment with said source, a hollow concentrator element interposed between said grids and said anode and having one portion extending outwardly to the periphery of said grids, a collimator element spaced beyond said anode, a pair of supports extending along said vessel, and a plurality of spaced insulating discs secured to said supports, said discs individually forming a mount for each respective electrode.

5. An electronic beam projection device comprising an enclosing vessel, a fluorescent screen mounted at one end of said vessel, and an electron beam gun extending toward said screen, said gun including a cathode assembly composed of a hollow shell, closure caps at opposite ends thereof, an electron emissive coating on the outer surface of one of said caps, a heater element therein having oppositely positioned arcuate arms, a plurality of heater strands connected to diagonal ends and the centers of said arms, and conductors extending through the other closure cap and connected to said arms.

6. An electronic beam projection device comprising an enclosing vessel, a fluorescent screen mounted at one end of said vessel, and an electron beam gun extending toward said screen, said gun including a large area cathode assembly, and a grid unit adjacent said cathode assembly involving a pair of flat annular metallic members, open gratings extending across said members, an insulating spacer ring between said members, and clips on said members clamping said members to said ring.

7. An electronic beam projection device comprising an enclosing vessel, a fluorescent screen mounted at one end of said vessel, and an electron beam gun extending toward said screen, said gun including a large area cathode assembly, a grid unit comprising a modulating electrode and an accelerating electrode mounted adjacent said cathode, a funnel shaped concentrator element positioned beyond said grid unit, the larger end of said element being adjacent said accelerating grid, and a metallic connection between said element and said cathode.

8. An electronic beam projection device comprising an enclosing vessel, a fluorescent screen

mounted at one end of said vessel, and an electron beam gun extending toward said screen, said gun including a large area cathode assembly, a grid unit mounted adjacent said cathode, and a hollow concentrator element positioned beyond said grid unit, said element having a flared skirt portion extending over the grid area.

9. An electronic beam projection device comprising an enclosing vessel, a fluorescent screen at one end of said vessel, and an electron beam gun extending toward said screen, said gun including a large area cathode assembly, a grid unit mounted adjacent said cathode, and a hollow concentrator element positioned beyond said grid unit, said element having a depending flared portion of larger diameter than said element and a throat portion of smaller diameter than said element.

10. An electronic discharge device comprising an enclosing vessel, an electron responsive target at one end thereof, and a beam projecting gun at the other end for initiating and accelerating a beam of electrons towards said target, said gun comprising an electron emissive cathode, an anode, a second anode spaced from said first-mentioned anode, a collimator element between said anodes, and a fluorescent coating on said anodes for indicating the extent of divergence of electron paths toward said responsive target.

11. An electronic discharge device comprising an enclosing vessel, an electron responsive target at one end thereof, and a beam projecting gun at the other end for initiating and accelerating a beam of electrons toward said target, said gun comprising an electron emissive cathode, a pair of apertured anodes in axially symmetrical relation with respect to said cathode, a collimator element between said anode, and a coating of fluorescent material on the surface of each of said anodes directed towards said cathode.

12. An electronic beam translating device capable of producing high beam current comprising an enclosing vessel, an electron gun mounted within said vessel and including a large plane area cathode for emitting a copious supply of electrons, a hollow concentrator element superimposed beyond said cathode having means for deflecting divergent electrons toward the axis of said element, an apertured anode spaced from said element, a tubular collimator electrode beyond said anode having a flared wall at one of its ends and a length suitable for complete collimation of the beam of electrons passing there-through, and a target beyond said collimator for the reception of the beam as a uniform spot of high intensity.

13. An electronic beam translating device capable of producing a high beam current comprising an enclosing vessel, an electron gun mounted within said vessel and including a large plane area cathode for emitting a copious supply of electrons, a hollow concentrator element superimposed beyond said cathode, means on said element for deflecting divergent electrons toward the axis of said element, an apertured anode spaced from said element, and an equipotential tubular collimator electrode beyond said anode having a substantially uniform inner diameter except at one end where the diameter is greater to correct sharp changes in potential gradient toward the axis.

14. An electronic beam projection device comprising a vessel having a stem at one end, an axially symmetrical electrode assembly mounted beyond said stem including a plane equipotential

cathode capable of emitting a copious supply of electrons, a shielding shell surrounding said cathode, a central support for said cathode and shell, a mica spacer for centering said cathode with respect to said vessel, a plane control electrode, a plane accelerating electrode, a mica spacer interposed therebetween and centering said control and accelerating electrodes with respect to said cathode, a tubular concentrator element, a mica spacer encircling said element, said element having a flared portion intermediate its mica spacer and said accelerating electrode and a frusto-conical portion on the other end thereof, an apertured disc anode in spacial

relation to said frusto-conical portion, a mica spacer secured to said anode, a thick-walled tubular collimator having its inner surface enlarged adjacent said anode, a mica spacer encircling said collimator, a second apertured disc anode spaced from the opposite end of said collimator, a mica spacer secured to said second anode, a metallic target, a mica spacer attached thereto, and a pair of uprights extending from said stem and aligning all of said mica spacers to form a unit extending longitudinally of said vessel.

ROBERT C. WINANS.