Feb. 6, 1951 R. E. JOHNSON 2,540,621

ELECTRON GUN STRUCTURE

Filed Feb. 19, 1948

Fig. 1

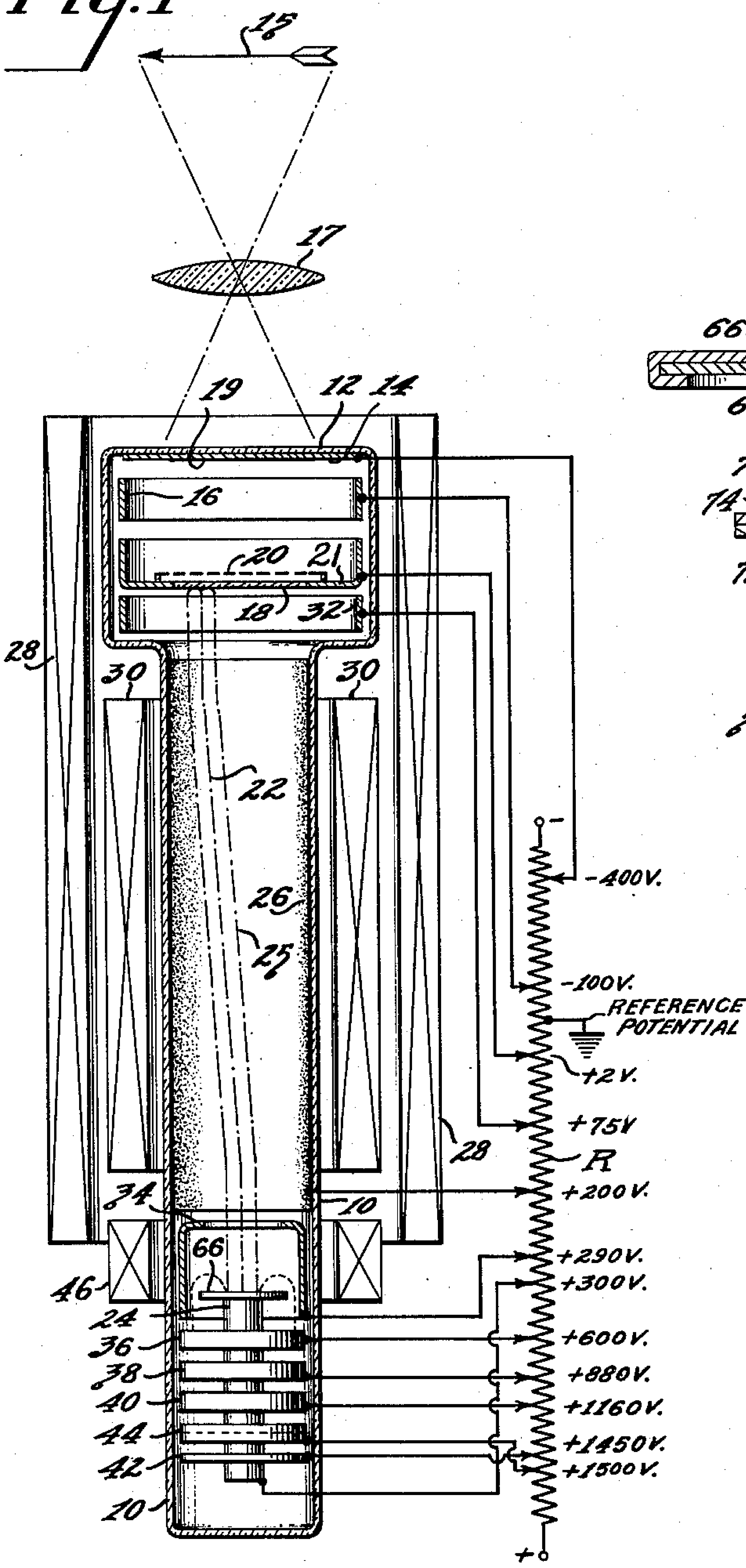
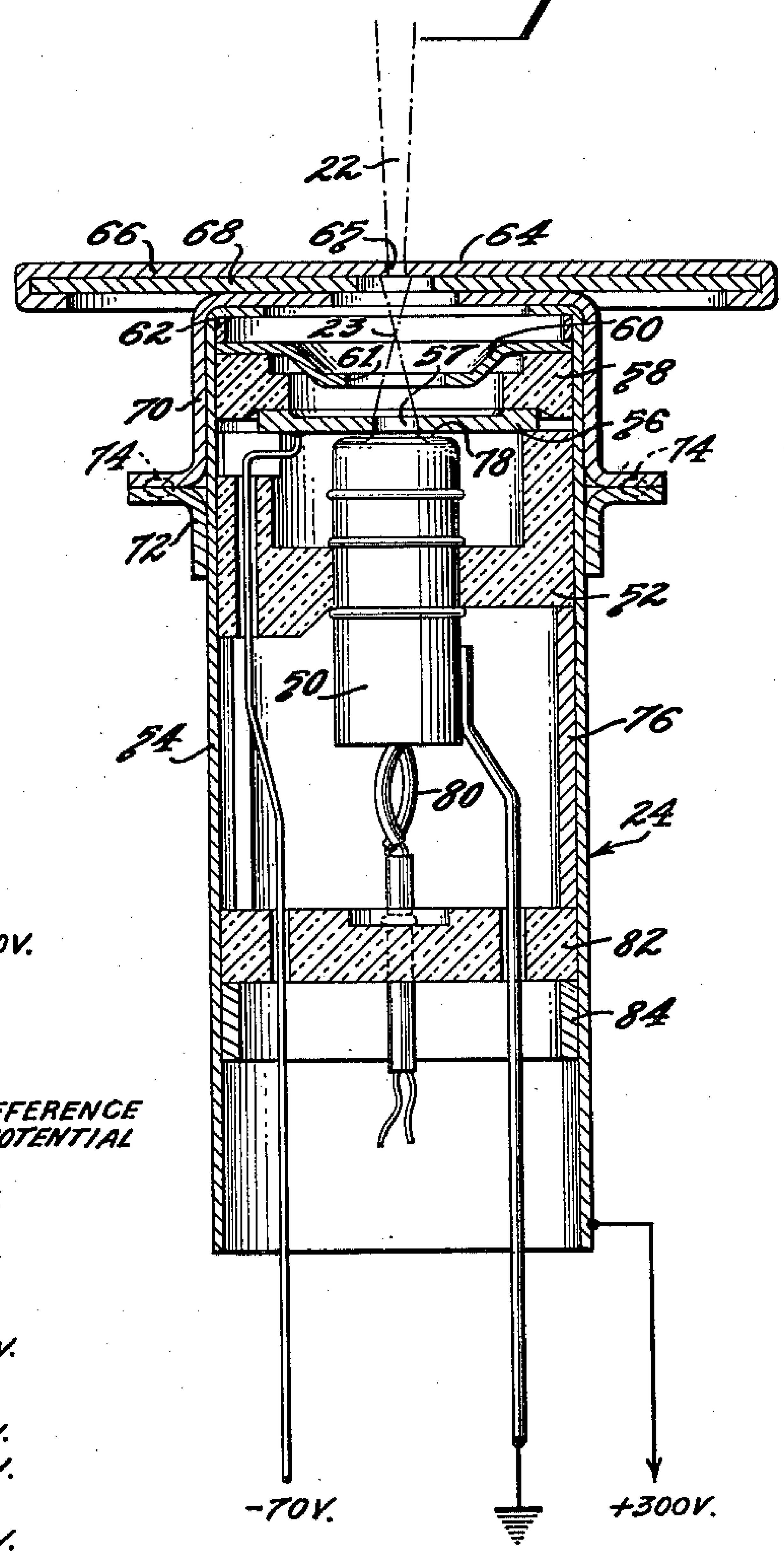


Fig. 2



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ELECTRON GUN STRUCTURE

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7 Claims. (Cl. 250—27.5)

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This invention relates to television pickup tubes and in particular to a novel electron beam generator gun structure for use in such tubes.

One type of television pickup tube uses a low velocity electron beam which is scanned across a target electrode to discharge or neutralize a charge pattern comprising a distribution of positive electrostatic charges on the target surface. If velocities of emission and contact potential are neglected, the equilibrium of the target is determined by the potential of the electron gun cathode electrode. The current in the beam is determined by that required to completely discharge the most positive areas of the target. The scanning electron beam approaches the target at nearly zero velocity. The negative beam will strike and discharge the positively charged areas of the target and charge the target areas negatively until the surplus portion of the beam is repelled back along the tube axis. Thus, an electron beam of uniform density scans the target while a non-uniform or modulated beam is returned to the cathode end of the tube where it is collected and amplified as the output signal.

The spot formed by the intersection of the scanning electron beam with the target must not only be small but the scanning beam must be one in which the velocity component of the electrons normal to the target is as nearly uniform as possible. This is equivalent, if spurious potential gradients along the target surface to to be avoided, to requiring the angle of incidence of the beam to be constant over the target surface. At normal incidence, a given beam current will charge a target area more negatively before it is repelled than when the beam approaches the target at other angles of incidence.

The beam is unable to discharge certain areas completely when the incidence angle is too far from the normal, leaving these areas positively charged while other areas are not completely discharged. The inability of the beam to land in areas where it should land produces shading. The loss of picture contrast implies a loss of detail. When the beam landing is impaired the sharpness of the picture is impaired. This would result from a selective landing of the beam at points on the target of relatively high potential. That is, there is a loss of true video signal and consequently disruption of resolution due to selective landing of the beam on target areas of higher potential.

A conventional electron gun structure comprises a positively charged accelerator electrode having an aperture therethrough coaxial with and spaced from an electron emitting cathode surface. Positioned between the accelerating electrode and the cathode is a negatively biased control electrode. A gun of this type produces a large range of electron velocities. The components of the electron beam having low axial velocities are in large part the electrons coming from the outer circumferential portions of the cathode surface. The electron lens formed by the cathode and the negative grid in a conventional gun structure draws on or uses these low velocity components of the electron beam. The large electron velocity range inherent in this construction will produce a beam, in which the components strike the target at various angles of incidence to produce the above described spurious shading in the transmitted picture. It is desirable therefore that television pickup tubes utilizing a low velocity scanning beam be operated with a beam having the smallest possible range of electron velocities.

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It is therefore an object of my invention to provide an improved television pickup tube.

It is a further object of my invention to provide an improved electron gun structure for use in a television pickup tube.

It is another object of my invention to provide an improved electron gun structure for producing a cathode ray beam with a small range of electron velocities.

It is, furthermore, an object of my invention to provide an improved television pickup tube in which the target is scanned at all points by an electron beam, a large part of which has the same component of velocity normal to the target.

It is also an object of the invention to have the component of the velocity normal to the target represent a very large part of the total velocity in the beam.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be undertsood by reference to the following description taken in connection with the accompanying drawing, in which:

Figure 1 is a sectional view of a television pickup tube made according to my invention; and

Figure 2 is a sectional view of an electron gun assembly used in the television pickup tube shown of Figure 1.

Figure 1 discloses a television pickup tube for producing a video signal for transmission. The tube comprises an envelope 10 preferably of glass. At one end of the tube is positioned a photocathode electrode 14, formed as a photosensitive coating on the inner surface of a transparent face plate 12, closing the end of the tube envelope 10. This photocathode 14 may be of any conventional type well known in the art. Positioned adjacent to the photocathode 14 is an accelerating electrode 16 and axially spaced therefrom is a cup shaped electrode 21 for supporting a glass target electrode 18. Between the target electrode 18 and the photocathode 14, is a very fine screen mesh 20, closely spaced from the surface of the glass target 18, facing the photocathode 14 and conductively supported by the cup-shaped electrode 21. This much of the tube forms the image section of the television pickup tube.

An object 15, which is to be televised, is focused by an appropriate optical system, represented at 17, in Figure 1, as an optical image 19 on the photocathode electrode 14. The photocathode 14 and the accelerating electrode 16 are preferably biased, respectively, at approximately a negative 400 volts and a negative 320 volts relative to the potential of the support electrode 21 which in turn is maintained at close to 2 volts positive relative to a reference or ground potential. This arrangement produces an accelerating field between photocathode 14 and the glass target 18. A focusing coil 28 surrounds the envelope of the tube, as shown, and forms a uniform focusing field whose lines of force are parallel to the axis of the tube.

The optical picture 19 focused upon the sensitized photocathode surface 14 releases electrons in quantities relative to the intensity of the incident light. These electrons pass through the accelerating field of electrode 16 and strike at high velocity the surface of the glass target 18. The magnetic focusing field of coil 28 directs the photoelectrons from electrode 14 along straight paths to the glass target 18. The velocities at which the photoelectrons strike the glass surface 18 cause a secondary emission greater than unity of electrons from the glass surface. The fine mesh screen 20 acts as a collector electrode of the secondaries emitted from the glass surface 18.

The target 18 is a thin sheet of low resistivity glass. The emission of secondary electrons from the surface of the glass target 18 leaves areas of the surface of the target struck by the photoelectrons positively charged. The insulation properties of the glass target are such that there is little or no electrical conduction along the glass surface. Consequently, there is formed on the surface of the target facing the photocathode 14 a positive potential distribution corresponding to the distribution of light and shadow of the optical image 19 focused upon the photocathode 14.

The opposite side of the glass target 18 is scanned, during tube operation, by a low velocity electron beam 22 formed by an electron gun structure 24 mounted at an opposite end of the tubular envelope 10. The cathode 50 of the electron gun structure 24, shown in detail in Figure 2, is maintained at the reference or ground potential referred to above. The electron beam 22 is constrained by the axial field of coil 28 to follow a path along the axis of the tube when no deflecting fields are applied. Conductive electrode coating 26 on the inner surface of the tube envelope is maintained at around 200 volts positive, relative to the reference potential, to sustain within the enclosed area a uniform electrostatic field. A decelerating electrode 32, adjacent the glass target 18, is maintained during tube operation at around 75 volts positive potential, relative to the reference potential, for maintaining a decelerating field to slow down the electrons of beam 22 so that they approach the glass target at close to zero velocity.

The beam 22 is caused to scan the surface of target 18 by 2 pairs of magnetic deflection coils on axes normal to each other. The fields of the coils 30 are perpendicular to each other and to the axis of the tube 10. It will be understood that the deflection coils 30 will have periodically varying voltages applied thereto, for example, by sawtooth generators (not shown) of suitable frequencies, to produce line and frame scansion. Due to possible misalignment of the gun structure 24 relative to the tube axis, an alignment coil 46 is provided to maintain a small magnetic field perpendicular to the axis of the electron beam. Rotation of the coil 46 around the stem of the tube envelope 10 will tend to correct any misalignment of the electron beam relative to the axis of the tube as it leaves the electron gun 24.

As beam 22 scans across the face of the glass target 18, sufficient electrons land to maintain the scanned target surface at cathode or reference potential. The remainder of the beam approaching the target at close to zero velocity is reflected by the target surface to form a return beam 25. This return beam 25 will pass back along the same path as the incident beam 22 and will strike a large intercepting dynode surface 66 forming the first stage of a multiplier unit described in detail in Patent No. 2,443,941, issued January 6, 1948, to Paul K. Weimer. The dynode surface 66 is maintained at 300 volts positive relative to target 18 and is also sensitized to produce amplification of the return beam 25 by a secondary emission greater than unity. An electrode 34 which is also maintained at around 290 volts positive forms a field free space around the dynode surface 66 so that the secondaries emitted from the sensitized surface 66 are not drawn with the primary scanning beam to the target but are persuaded to pass into an accelerating field of a second dynode electrode 36 maintained at 600 volts positive relative to target 18. A third, fourth and fifth dynode of the multiplier unit are provided respectively at 38, 40 and 42, so as to amplify the return beam in successive stages. Each dynode, respectively, is an apertured electrode of successively higher positive potential and having sensitized or electron emitting surfaces so that the electrons strike each dynode at sufficient velocity to set up a secondary emission greater than unity. Multiplier electrodes 38, 40 and 42 may be respectively maintained during tube operation at 880 volts positive, 1160 volts positive and 1450 volts positive relative to reference or ground potential. A collector screen electrode 44 may be maintained at around 1500 volts positive.

While the wall coating 26 and the various electrodes and dynodes associated with the tube, as described above, may have various desired potentials, the potentials respectively mentioned for each electrode represent those used in a successfully operated tube of the disclosed type. As shown in Figure 1, the electrodes may be connected to appropriate points of a potentiometer or bleeder resistance R, connected at its ends to a source of direct current potential.

In the operation of the tube of Figure 1, the scene 15 to be transmitted is focused on the transparent photocathode 14. Photoelectrons are released in direct proportion to the brightness of the various parts of the scene. The photoelectrons strike the target with sufficient velocity to cause a secondary emission ratio greater than unity as described above and form a positive charge pattern on the target 18; the more positive areas corresponding to the highlights of the scene. The glass of target is sufficiently thin that each positive area on the photocathode side will attract incident electrons of scanning beam 22 to a corresponding opposite area on the beam side of the target. At the same time that the charge pattern is being formed on the photocathode side of target 18, the beam of electrons 22 is scanned across the opposite side of the target and deposits sufficient electrons to neutralize the positive area of the target to the reference or cathode potential. The glass target 18 is chosen with a resistivity low enough that electrostatic charges deposited on opposite sides of the glass are neutralized by conduction through the glass during a frame time of around $\frac{1}{30}$ of a second. The target is also thin enough so that these charges do not spread laterally, in a frame time, sufficiently to impair the resolution of the charge pattern.

As a specific positive area of the target surface, struck by the scanning beam 25, is returned to reference or ground potential, it will reflect the excess portion of the scanning beam to form a modulated electron return beam 25, which has a varying density determined by the charge pattern of target 18. The returning electrons of beam 25 will closely follow the lines of the magnetic focusing field formed by coil 28 back toward the gun 24 and strike dynode surface 66 to generate a larger number of secondary electrons. The several stages of the electron multiplier, as described above, amplify this modulated return beam 25 to form the video signal, which is taken off of the collector 44.

Figure 2 shows in detail the structure of an electron gun, according to my invention, for use in a television pickup tube of the type described above. A tubular cathode electrode 50 is coaxially mounted within a supporting cylinder 54. The mounting means comprises a ceramic support member 52 fixed to the cathode tube 50 and fitted within the support cylinder 54 and arranged, as disclosed in Figure 2, to space a closed end 78 of cathode tube 50 from an apertured control grid disc 56 with an opening 57, axially aligned with the tubular cathode 50. Also, mounted with the cylinder 54, is a second apertured electrode 60 axially spaced within the supporting tube 54 by the ceramic ring 58. The apertured electrode 60 is spaced by a metal ring 62 from a partially closed end of the supporting cylinder 54. The several electrode parts, described above, are mounted within the support cylinder 54 by successively inserting them within the support cylinder, starting with the metal spacing ring 62. These parts then are locked within supporting cylinder 54 by a retainer ring 76 welded, or fixed by any other means, to the inner surface of cylinder 54. Mounted within the cathode tube 50 is a heater filament 80, which extends, as is shown, from an open end of the cathode tube 50. Heater filament 80 is supported from a supporting ceramic disc 82, locked in position against the ring 76, by a second retainer ring 84 welded, or fixed, to the inner surface of supporting tube 54. A third apertured electrode 64 is mounted on the partially closed end of the support cylinder 54. This electrode 64 comprises an apertured supporting cup 70 having an apertured support plate 68 coaxially fixed to the bottom surface thereof, as is shown in Figure 2. Covering the supporting plate 68 is a thin highly

polished metal sheet 66, preferably of a silver magnesium alloy, which forms the secondary emissive surface for the first dynode electrode. Through the center of the plate 66 along the axis of the gun is formed a very small aperture 65 which provides masking for the electron beam of the gun 24. The masking aperture 65 limits the cross-sectional area of the electron beam to a small center core portion which passes through aperture 65 as the beam 22.

Electrode 56 is preferably maintained at a negative potential, relative to cathode potential, to provide a control for the electron emission from the cathode 50. The closed end 78 of the cathode tube 50 is covered with an activated material to provide a source of electron emission. The material may be a mixture of the oxides of barium and strontium and may be applied to cathode surface 78, as is well known in the art. During tube operation, heater filament 80 maintains the activated cathode surface 78 at a temperature sufficient to provide for an emission of electrons. The cathode is maintained at reference potential, during tube operation and electrode 60 is preferably maintained at around 300 volts positive, relative to the cathode electrode. This electrode 60 draws the electron emission from the cathode surface 78; forms it into a beam 22 and accelerates it to high velocity before the crossover point of the beam at 23. Electrode 60 and masking electrode 64 are maintained at the same potential through the conductivity of the metallic spacer ring 62.

Ordinarily in television pickup tubes of the type described, the electrons of the scanning beam emerge from the electron gun at high velocity and with transverse velocity components, whose energy may range from zero to a volt or more. As each electron of the beam emerges into the magnetic focusing field of the tube, it will describe a helix. Also, because of the magnetic focusing field, the beam will converge to a focus at several nodal points between the gun and target. Those electrons with the greatest transverse component of velocity will spiral to the greatest distance from the beam axis and will approach the target at the greatest angles of incidence. The electrons which possess transverse energy have acquired this energy at the expense of their longitudinal or axial energy and will thus also approach the target at a smaller normal velocity component. Hence, the electrons of the beam, which have acquired the greatest transverse velocity component, will not be enabled to reach the target before reflection. Thus, a scanning beam of electrons having a large range of velocities will not discharge a positive area of the target as completely as one in which the electron velocity range is smaller and in which the velocity component normal to the target of the electrons is as nearly uniform as possible. If the scanning beam fails to discharge each positive area of the target completely, not only will there be produced on the target undesirable potential gradients, which will result in spurious shading of the video signal, but there will be a larger unused portion of the return beam, which will result in poorer modulation of the return beam and also will contribute to the noise output of the multiplier without adding to the signal.

My specific electron gun structure improves the operation of the type of television pickup tube described by reducing the range of electron velocities in the scanning beam. The sections of the beam having low axial velocities consist of electrons coming from the outer circumferential areas of the cathode. The specific gun structure, shown in Figure 2, tends to eliminate these electrons having the greatest transverse velocity component and thus reduce the electron velocity-range of the beam. Control electrode 56 is closely spaced from the sensitized electron emitting surface 78 of the cathode 50 and is maintained at a constant negative bias of around a —70 volts, relative to cathode potential, during tube operation. In one example of the electron gun shown in Figure 2, the cathode to control electrode spacing is close to 0.0075 inch. To overcome the blocking effect produced by this large negative bias of grid 56 and its close spacing from the cathode, and also, to provide a strong positive field to draw sufficient electrons from the center of the cathode, I have positioned the accelerating grid 60, at the high positive potential of 300 volts positive, close to grid 56. Accelerating grid 60 is closely spaced from electrode 56 by a distance of around 0.031 inch. The aperture 57, in grid 56, has a diameter of around 0.045 inch, so that the effective emitting area of the cathode surface 78, which can "see" the large positive field of the accelerating electrode 60 through aperture 57, is relatively small, and the beam, drawn from this small area at the center of the cathode emitting surface, has a narrow range of electron velocities.

This electrode arrangement results in several advantages. The presence of a control grid closely spaced from the cathode emitting surface and having a large negative bias suppresses emission of beam electrons from the outer circumferential area of surface 78 and which would have the lowest axial velocities. Also, the small effective emitting surface of the cathode produces an electron beam having less dispersion as electrons in coming from a small cathode area follow more parallel paths. This results in a beam of smaller cross-sectional area. The accelerating grid 60, maintained at high positive potential, "pulls" a sufficiently large beam current from this small emitting portion of the cathode surface and also accelerates the electrons to their greatest velocity, before their cross-over at 23. This produces an effective "packing" of the electrons, since in going through the cross-over point at high velocity, there is less tendency of the beam to spread from mutual electron repulsion. The masking aperture 65 selects only the core of the electron beam diverging from the cross-over point 23. The masking aperture 65 is in the order of 0.002 inch and is carefully aligned with apertures 61 and 57, so that the center of the beam will pass through the masking electrode 64. Furthermore, the small masking aperture 65 eliminates any diverging electrons from the outer areas of the effective cathode emitting surface and passes electrons having more uniform velocities. This selection of the beam core results in a scanning beam having a smaller velocity range.

Another advantage of the novel electrode arrangement, of Figure 2, is the maintaining of a high potential in the region of the beam cross-over point 23. It is well recognized, that a better focus of an electron beam is obtained the higher the potential of the field is, at the cross-over point. The spaced electrodes 60 and 64 are maintained at a common potential of 300 volts positive, relative to cathode or references potential. This is the highest accelerating potential imposed on the beam 22, between cathode 50 and target 18. Electrode 60 is recessed to form a substantial region between it and the limiting electrode 64 in which cross-over 23 point is formed. The spacing of electrodes 60 and 64 in the tube described is not very critical and is in the order of 0.117 inch. The spacing between the accelerating electrode 60 and control electrode 56, as well as their relative potentials, control the cross-over point 23. In the particular gun described, if accelerating electrode 60 is closer than 20 mils from electrode 56, the cross-over will extend into aperture 65 of masking electrode 64. This will result in a poor beam, as the effect of the limiting or masking aperture would be lost, and the beam would have wide divergence. Best results are obtained, when the cross-over point 23 is as close to electrode 64 as possible, without being in aperture 65 or beyond. In the tube described, the spacing between electrodes 56 and 60 is close to 31 mils.

The above described arrangement of electrodes 56, 60 and 64 maintains a cross-over region at a high uniform potential, instead of at intermediate potential between that of cathode 50 and that of electrode 64, as would be true without the presence of electrode 60. During tube operation the potentials of electrodes 56 and 60 are maintained at constant values, and will not undergo any potential changes which would tend to alter the position of the cross-over point.

The cross-over point 23 is never a single point on the gun axis. Since the electrons emitted from the cathode surface 78 leave at different velocities and pass through non-uniform portions of the focusing electrostatic field between the cathode surface 78 and electrode 60, there will be produced an aberration or a spreading of the focus point 23 along the gun axis. Point 23 represents more correctly a region of electron cross-over points. Since this crossover region of the electron beam occurs in the field free space between electrodes 60 and 64, not only is the crossover formed at a high potential to give a better focus of beam 22 on target 18, but all portions of the electron beam will form a crossover at the same potential which provides a more uniform focus of the beam on target 18.

The electron gun structure as disclosed in Figure 2 has proved to be of considerable advantage in television pickup tubes, which utilize a low velocity scanning beam. The particular structure, described in detail above, provides an electron beam, which has a small range of electron velocities, and one of small cross-sectional area. The portion of the electron beam 22 having large transverse velocities are eliminated by the control electrode 56 closely spaced from the cathode emitting surface 78 and maintained at a large constant negative potential during tube operation, by providing a small effective electron emitting cathode area, and by utilizing a small masking aperture to eliminate the components of the electron beam diverging from the cross-over point. Furthermore, the electron beam is maintained concentrated and of minimum cross-section by the small emitting cathode area, and by the action of accelerating lens 60 to accelerate the electrons to their greatest velocity before cross-over, which reduces the tendency of beam divergence from mutual repulsion of the electron charges. By forming the cross-over of the electron beam in a field-free space, between electrodes 60 and 64, there results less aberration and divergence of the beam focus at the target 18.

All of this results in a concentrated electron scanning beam of small cross-section having a small cross-over point producing a sharper focus at the target. My new gun structure gives better alignment of the electron beam components, produced by a greater packing of the electrons in the beam. Less dispersion of the electron beam gives a better picture resolution through a more efficient discharge of the target.

While certain specific embodiments have been illustrated and described, it will be understood that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

What I claim as new is:

1. An electron gun structure comprising, a cathode electrode having an activated surface for providing a source of electrons, an apertured accelerating electrode adapted to be positively biased relative to said cathode electrode and spaced from said cathode electrode, an apertured control electrode adapted to be biased at a constant negative potential relative to said control electrode and positioned in spaced and face-to-face relationship to said accelerating electrode between said accelerating electrode and said cathode electrode, an apertured masking electrode positioned on the other side of said accelerating electrode, the apertures of said electrodes and said activated cathode surface arranged in alignment to provide a straight line path for said electrons, means electrically connecting together said accelerating and masking electrodes to form a field free space therebetween, said accelerating electrode and control electrode both positioned and arranged relative to said cathode electrode to form the electrons from said cathode electrode into an electron beam with a crossover point in said field free space, the aperture of said masking electrode being smaller than the apertures in said control and accelerating electrodes to permit only the passage of a center portion of said electron beam after its divergence from said crossover point, the aperture of said control electrode being smaller than the activated surface of said cathode and smaller than the aperture of said accelerating electrode.

2. An electron discharge device comprising, an envelope, a cathode electrode within said envelope adapted to be connected to a source of electrical potential for providing an electron emission, a masking electrode spaced in said envelope from said cathode electrode, a control electrode positioned in said envelope between said cathode and said masking electrode, and an accelerating electrode in said envelope in spaced and face-to-face relationship between said control and masking electrode, said control, masking and accelerating electrodes each having an aperture therethrough, said apertures being in alignment to provide rectilinear passage for said electron emission from said cathode electrode, means connected to said control electrode for connecting said control electrode to a source of constant negative potential relative to said cathode potential, means for connecting said accelerating and masking electrodes to a common source of constant positive potential relative to said cathode potential to provide a field-free space therebetween, said accelerating electrode being positioned relatively close to said negative control electrode to provide with said control electrode an electrostatic field for forming said electron emission into an electron beam having a crossover point in said field-free space during tube operation, the aperture through said accelerating electrode being larger than the aperture through said control electrode.

3. An electron discharge device comprising, electrode means including a cathode for directing electrons as a beam along a predetermined path, a target in the path of said beam adapted to have charges established thereon, means adjacent for establishing a magnetic field axially of said beam path, said cathode having an electron emitting surface, a first electrode positioned closely adjacent said cathode surface and having a single aperture registering with a central portion of said emitting surface and adapted to have a negative potential applied thereto, a second electrode spaced from and in face-to-face relationship to said first electrode and having an aperture aligned with the aperture in said first electrode, the aperture of said second electrode being of larger diameter than the aperture of said first electrode, and a third electrode positioned adjacent said second electrode and having an aperture coaxial with the apertures of said first and second electrodes but smaller than either of the apertures thereof, lead means connected to said second and third electrodes to provide a common positive potential thereto to form the electron beam from said cathode into a crossover between said last two apertured electrodes.

4. An electron discharge device comprising, an elongated envelope, a target at one end of said envelope and an electron gun assembly at the other end of said envelope for directing a stream of electrons toward said target, said gun assembly including a tubular member closed at one end, an elongated cathode having an emitting surface and an insulating member supporting said cathode within said tubular member, a first electrode supported within said tubular member closely adjacent the emitting surface of said cathode, said first electrode having a single aperture aligned with a small central portion of said emitting surface, a second electrode positioned in spaced and face-to-face relationship to said first electrode within said tubular member, said second electrode having a depressed portion positioned closely adjacent said first electrode, said depressed portion having an aperture aligned with the aperture in said first electrode but of larger diameter, said tubular member having an aperture in its closed end coaxially aligned with the apertures of said first and second electrodes and smaller than the other two apertures, and an insulating spacer member insulatingly supporting the first electrode within the tubular member, said second electrode being electrically and conductively connected with said tubular member.

5. An electron discharge device having an elongated envelope, a target positioned adjacent one end of said envelope, a photosensitive surface applied to the inside of said envelope adjacent said target for emitting photo electrons directed toward said target during operation of said device, an electron gun assembly positioned at the other end of said envelope for directing an electron beam toward the other side of said target, said gun assembly having means for generating a beam of electrons in which the majority of said electrons approach said target normally and including a cathode electrode having an emitting surface, a first apertured electrode spaced closely adjacent said cathode and having an aperture registering with the central portion of said emitting surface, a second electrode having a larger aperture registering with first said aper-

ture and a third electrode spaced from said second electrode and having an aperture coaxial with the apertures in said first and second electrodes, lead means connected to said electrodes to maintain said first electrode at a negative potential with respect to said cathode electrode and to maintain said second and third electrodes at a common positive potential with respect to said cathode, and means surrounding said cathode for receiving returned electrons from said target.

6. A television transmitting tube comprising, an evacuated envelope, an electron gun assembly mounted within said envelope for providing an electron beam along a path, a target electrode mounted within said envelope transversely to said electron beam path, said electron gun assembly including a tubular supporting member and a cathode electrode within said tubular member, an apertured plate electrode positioned transversely within said tubular member and adjacent said cathode electrode, insulating means fixedly supporting said cathode and plate electrodes within said tubular member, lead means connected to said apertured plate electrode to provide a negative potential thereto during tube operation for controlling electron emission from said cathode, an accelerating electrode within said tubular member and in electrical contact therewith, said accelerating electrode having an aperture aligned with the aperture of said plate electrode, lead means connected to said accelerating electrode to provide a positive potential thereto during tube operation for accelerating and focusing the electrons from said cathode, plate means intercepting the electron beam path and closing one end of said tubular member, said plate means having an aperture therethrough smaller than the apertures of said control and accelerating electrodes for limiting the size of the electron beam.

7. An electron discharge device comprising an electron gun means for directing electrons as a beam along a predetermined path, a target in the path of said beam adapted to have charges established thereon, means establishing a magnetic field axially of said beam path and between said gun and target, said electron gun means including a cathode electrode having an electron-emitting surface, a first electrode positioned closely adjacent said cathode surface and having a single aperture registering with a central portion of said emitting surface, lead means connected to said first electrode and said cathode electrode for biasing said first electrode to a constant negative potential relative to the potential of said emitting cathode surface, a second electrode spaced from and in face-to-face relationship to said first electrode and having an aperture aligned with the aperture in said first electrode, the aperture of said second electrode being of larger diameter than the aperture of said first electrode, a third electrode positioned on the opposite side of said second electrode from said first electrode, said third electrode having an aperture co-axial with the apertures of said first and second electrodes but smaller than either of the apertures thereof, lead means connected to said second and third electrodes for positively biasing said second and third electrodes to a common potential relative to said cathode surface to form the electrons from said cathode-emitting surface into a cross-over between said second and third apertured electrodes.

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