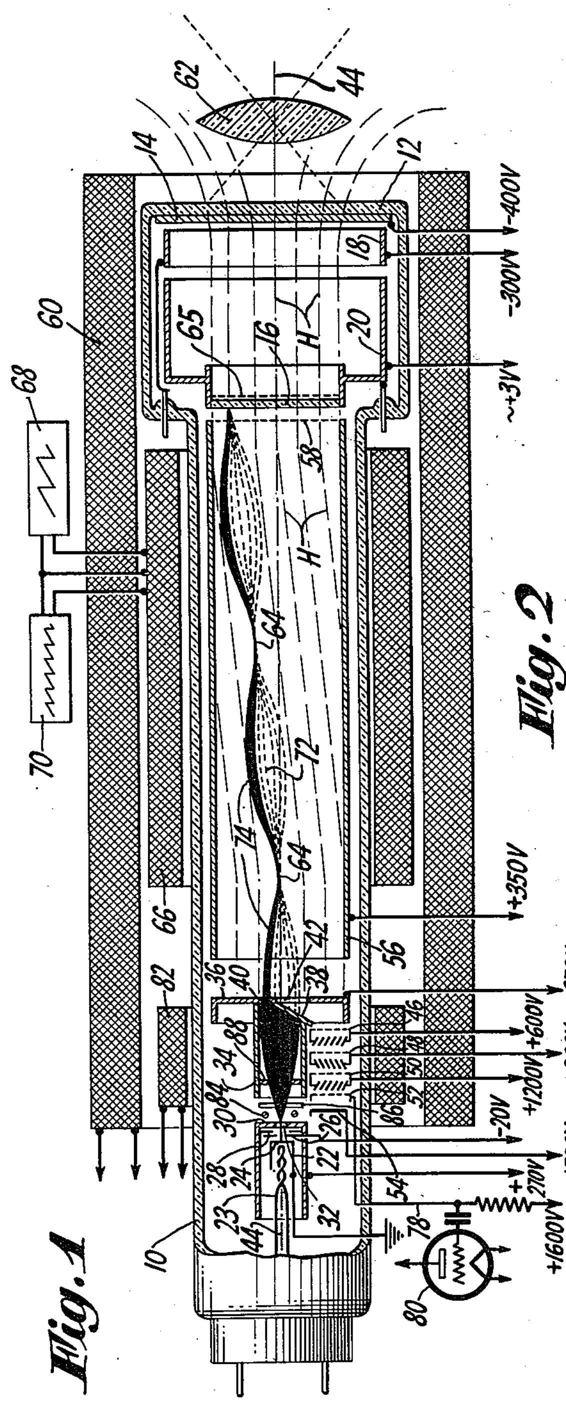
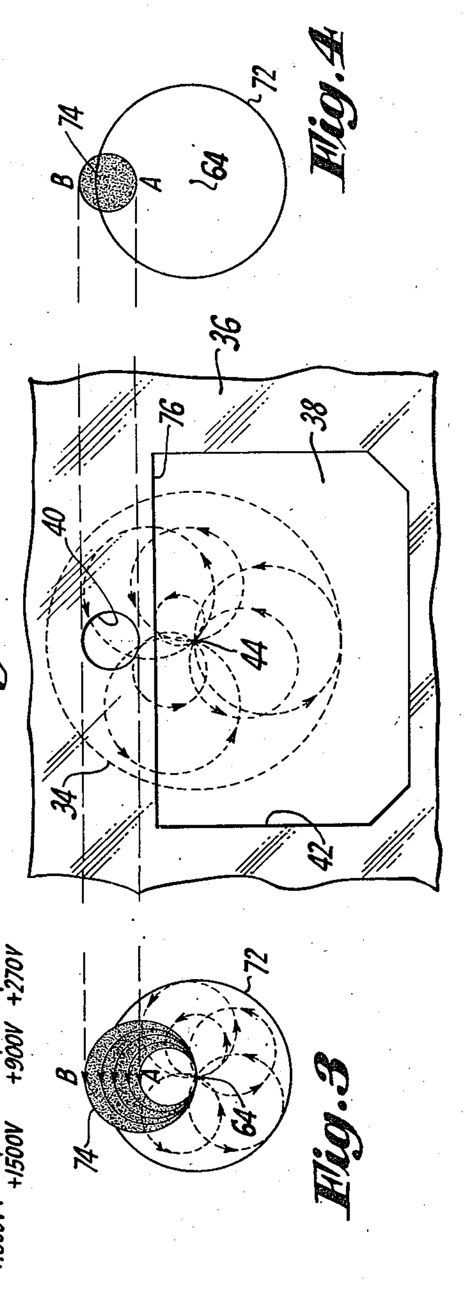
Dec. 18, 1951 P. K. WEIMER 2,579,351

ISOCON PICKUP TUBE

Filed Aug. 30, 1949





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ISOCON PICKUP TUBE

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13 Claims. (Cl. 315—11)

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This invention relates to pickup tubes used for converting visual images into electrical impulses, and more especially to tubes of the orthicon type in which a cathode ray beam approaches a target electrode at substantially zero velocity. In particular, the invention relates to tubes which utilize the portion of the electron beam scattered from the target electrode to produce a video signal. Such a tube is described in my co-pending application U. S. Serial No. 792,944, filed December 20, 1947, now Patent No. 2,545,982. My invention relates particularly to an improvement for such tubes.

The television pickup tube described in the above-mentionad co-pending application is one in which an optical image is focussed upon a photocathode electrode of the tube to provide a photoemission from all portions of the photocathode in proportion to the light intensity thereon. The photoelectrons released by the optical image are focussed onto one side of a glass target electrode where, by secondary emission, a charge pattern is produced correspondingly respectively to the optical image focussed on the photocathode. The opposite side of the glass target electrode will simultaneously receive a potential distribution corresponding to the distribution of charges on the other face of the target electrode. This opposite face of the target is scanned by an electron beam in a well-known manner to cause electrons to be deposited on the target face in proportion to the potential distribution. The scanning electron beam is caused to approach the target surface at close to zero velocity and electrons deposited upon areas of positive potential lower the target area to cathode potential at which point the unused portion of the beam is electrostatically reflected back toward the electron beam source. Some of the electrons which strike the target electrode are scattered away from the target surface and will return toward the beam source in paths separate from the electrostatically reflected portion of the beam. The number of scattered electrons from each point of the target surface are proportional to the potential of that target portion and will thus vary from point to point according to the potential distribution on the scanned target surface area. Thus, when the scattered electrons are separated from the reflected portion of the electron beam and collected and amplified there is produced an electrical output signal of the tube. A pair of electrostatic deflecting plates are mounted between the gun and target to separate the incident beam

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from the return beam so that the scattered electron components of the return beam can be more easily separated out.

The type of pickup tube described above and in my co-pending application and which utilizes the scattered portions of the electron beam for the video signal, utilizes electrostatic acceleration of the beam in combination with a magnetic focussing field between the electron source and the target electrode. This combination causes the electrons of the beam to travel in helical paths between the electron source and the target, which meet at common nodal points on the beam axis. The tube described in my co-pending application is one which provides structure to give a transverse velocity to the electrons of the beam so that the helical paths of electrons approaching and reflected from the target are eccentric to and entirely on one side of the beam axis. However, the electrons of the beam, which are scattered from the target electrode leave the target in all directions and return toward the electron source in helical paths symmetrically disposed about the beam path. At a point midway between two common nodal points of the beam, the symmetrically arranged helical paths of the scattered electrons are separated from the eccentric return paths of the reflected portion of the beam.

However, in the pickup tube described above, it has been found to be desirable that the beam electrons approaching the target should not possess an excessively large spread of transverse velocity components, since that fraction of the beam which acquires a large amount of helical motion does so at the expense of its velocity or energy components perpendicular to the target. This fraction of the beam is of no value in discharging the target since these electrons have insufficient energy to reach the target. Although these excess electrons return from the target as a part of the reflected return beam and are separated from the symmetrically disposed scattered beam portion, their presence in the reflected beam may have a deleterious effect on the picture signals in two ways: (1) they may increase the background noise of the output signal as a result of some of these electrons being scattered into the symmetrical portion of the returning beam by their double passage through a close mesh screen mounted transverse to the beam paths adjacent the tube target; and (2) electrons approaching close to the target may be deflected by the charge pattern on the target to give a spurious output signal if the eccentric reflected beam portion is not properly separated from the scatered symmetrical portion of the return beam.

In the type of pickup tube described above, unfortunately the means used to give the transverse velocity to the electron beam also gives to the beam a larger energy spread than is desirable. Even though the energy spread of the beam emerging from the electron gun may not be large, say 1 volt or less, the resultant energy spread, after adding the required transverse velocity may become as large as 5 or 10 volts.

It is therefore an object of my invention to provide an improved pickup tube using scattered electrons to provide a video signal.

It is a further object of my invention to provide an improved television pickup tube which utilizes an electron beam to which is added a velocity component transverse to the beam path.

It is another object of my invention to provide an improved television pickup tube which uses an electron beam having a given velocity transverse to the beam path which lies within a predetermined velocity range.

A further object of my invention is to provide a television pickup tube utilizing an electron beam and means for providing a desired transverse velocity to the beam.

It is a further object of my invention to provide a television pickup tube utilizing an electron beam which is limited in its velocity transverse to the beam path within a desired energy spread.

It is another object of my invention to provide a television pickup tube, utilizing the scattered component of an electron beam and which is of simplified construction and operation.

This application describes a television pickup tube of the type described above which utilizes the scattering effect of an electron beam from the surface of a target electrode, and in which the scattered electrons are separated from the incident and reflected electron beams to provide a video signal. This tube of my invention incorporates within the electron gun of the tube a means for selecting a portion of the electron beam having transverse velocities lying within a desired range. This velocity selector structure comprises a tubular portion of the electron gun having a limiting aperture at the end thereof closest to the target electrode. This aperture is formed in a plate closing this end of the tubular electrode and is eccentric to the axis of the electron beam emerging from the gun so that the portion of the beam passing through the masking aperture will have transverse velocities lying within a desired range. By positioning the masking aperture at any desired distance from the beam axis, it is possible to select electrons of any desired transverse velocity range.

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 understood by reference to the following description taken in connection with the accompanying drawing, in which:

Figure 1 is a sectional view of an improved television pickup tube according to my invention.

Figures 2, 3 and 4 are diagrammatic sketches showing electron paths of the beam of the tube of Figure 1.

Figure 1 discloses a television pickup tube according to my invention. The tube comprises

essentially an evacuated envelope **10** which is closed by a face plate **12** at one end thereof. On the inner surface of the face plate **12** is deposited in any well known manner, a photosensitive surface **14** comprising a layer formed for example, of silver-silver oxide, caesium and caesium oxide, as is well known in the art. Such a photosurface **14**, however, need not be limited to the material mentioned above but may be one having a panchromatic response and formed according to the co-pending application of Ralph Johnson, Serial No. 79,328, filed March 3, 1949.

Within the tube envelope **10** is mounted a thin glass target **16**, formed in a manner described in the patent to Albert Rose, No. 2,473,220, filed August 16, 1941. Between the photosurface **14** and the glass target film **16** are respectively disposed tubular electrodes **18** and **20**, for focussing the photoemission from the surface **14** on to the target **16**.

Mounted within the other end of the tube envelope **10** from the photosurface **14**, is an electron gun structure for forming and accelerating an incident beam of electrons onto the surface of the glass target **16**. The gun structure disclosed in Figure 1 comprises essentially of an indirectly heated cathode cylinder **22** coated at a closed end **24** with electron emitting material such as the mixed oxides of barium and strontium, as is well known in the art. The emitting surface **24** is maintained at a suitable temperature by a heater filament **23** mounted within the cathode cylinder **22**. A control electrode **26** is formed as an apertured plate closely spaced from the cathode surface **24**. An accelerating electrode formed by a second apertured plate **28** is coaxially aligned with the control electrode **26** along the axis of the electron gun. A third electrode **30**, is spaced from the cathode surface beyond the accelerating electrode **28**. The electrode **30** has a small limiting aperture **32** aligned with the gun axis **44**, for defining the cross-sectional size of the electron emission from the cathode surface **24**. In tubes of the type described, the aperture **32** is formed with a diameter of approximately two mils. Spaced between the target electrode **16** and the electron gun structure described above, is an additional beam control means comprising essentially of a tubular electrode **34** open at the end adjacent to the beam defining electrode **30** and closed at the opposite end thereof by an apertured plate **36**, and a slanting wall portion **38**, as shown in Figures 1 and 2. The plate **36** has a masking aperture **40** positioned eccentrically to the axis **44** of the electron gun structure. A second aperture **42** within the plate **36** provides an opening into a region outside of the tubular member **34**. Within this region are positioned a plurality of multiplier sections **46**, **48**, **50**, **52** and **54**. Multiplier sections **46**, **48** and **50** comprise essentially of radially extending dynode plates arranged as overlapping spokes of a semi-circular section. As shown, each of the sections is provided with a fine mesh screen overlying the dynode plates. **54** is the final stage of the multiplier and comprises essentially of a single dynode plate, while **52** is a fine mesh screen for collecting the secondary emission from the dynode plate **54**. The first stage of the multiplier section described, is the face of the wall section **38** facing the aperture **42**. Coaxially mounted with the electron gun parts and positioned between the plate **36** and target **16** is a tubular electrode **56** to provide acceleration of the electron beam and to aid in focussing the beam on the target 16. Electrode 56 may also be formed as a wall coating on the inner surface of the tube envelope 10. Mounted across the end of the tubular electrode 56, adjacent the target electrode 16 is a fine mesh screen 58. Surrounding the envelope 10 of the tube is a magnetic focussing coil 60 which is constructed so as to provide a magnetic field H within the tube envelope 10 whose lines of force are essentially parallel to the gun axis 44.

In operation, a scene to be televised is focussed by any appropriate lens system 62, on to the semi-transparent photocathode layer 14. The photoemission from surface 14 is accelerated toward the target surface 16 by the cylindrical electrodes 18 and 20. In a successfully operated tube of the type described, electrode 18 is operated at approximately 100 volts positive to the photosurface 14 while electrode 20 is maintained at approximately 400 volts positive with respect to the photosurface 14. The axially parallel magnetic field H provided by the coil 60 will maintain the photoemission from surface 14 in essentially parallel paths so that the electrons will strike the surface of target 16 in essentially the same spacial distribution as the photoemission had in leaving surface 14. The velocity of the electrons striking surface 16 is sufficiently great to provide a secondary emission having an emission ratio greater than 1. A fine mesh screen 65, closely spaced from the surface of target 16, acts as a collector for this secondary electron emission.

In a successfully operated tube of the type shown in Figures 1 and 2, and described above, the control electrode 26 is operated at some appropriate potential, negative to the cathode 22 to limit the emission from cathode surface 24 to the desired amount. Electrodes 28 and 30 are maintained at a common potential by being electrically connected together and at a potential of approximately 270 volts positive, relative to the cathode electrode 22. Also, the cylindrical electrode 34 is maintained at the same potential of approximately 270 volts positive. The accelerating field of the electrode 28 causes the emission from cathode surface 24 to form a cross-over point in the space between electrodes 28 and 30. The defining aperture 32 in plate 30 is positioned within the field of the focussing coil 60 and so that the common axis 44 of electrodes 26, 28, and 30 coincides, within this portion of the gun structure, with the electron beam path as well as with a line of force of the magnetic field H of coil 60. By operating the control electrode 26, with a negative grid bias close to cathode potential, the electron beam passing through the defining aperture 32 will be composed of electrons having a sufficient velocity component transverse to the axis 44 such that the electron beam will spread and essentially fill the cross-section of the tubular electrode 34 as is diagrammatically shown by the black area in Figure 1.

Thus, the electron beam passing through the defining aperture 32 will be composed of electrons having a transverse velocity component ranging anywhere from 0 volts to 10 volts. As is well known in the art, those electrons having a velocity component parallel to the beam path and also a velocity component transverse to the beam path 44 will follow spiralling paths due to the presence of the magnetic field H of coil 60 whose field lines are parallel to the beam paths. The spiralling path of each electron will have a diameter proportional to its transverse velocity and an axis parallel to the beam path. Furthermore, each spiralling electron path on each revolution will pass through the beam path. Due to its small size, defining aperture 32 may be considered as a point source on gun axis 44 of the electron emission. As the electrons leave aperture 32, each electron entering field H and having a transverse velocity component will take a spiral path, as described above. These spiral electron paths will intersect each other at common or nodal points 64, on the beam path between aperture 32 and the target 16. By adjusting the magnetic field of coil 60 one of these common or nodal points can be made to coincide with the surface of target 16, so that the incident electron beam will be brought into focus at this point.

Figure 2 represents by dotted circles a sectional view of the spiral paths which the electrons take upon leaving the defining aperture 32 and approaching the masking aperture 40 of plate 36. The plate 36 is positioned at a point midway between the defining aperture 32 and the first nodal point 64 of the incident electron beam. At this point, the incident electron beam has reached its greatest cross-sectional area due to the range of transverse velocities that the electrons of the beam will have. The closure walls 38 and 36 of tubular electrode 34 will mask off all portions of the electron beam except that portion which passes through aperture 40 and is indicated in Figure 1 as 74. The size of aperture 40 and its position above the axis 44 of the beam path will determine what range of transverse velocities, the incident beam portion passing through aperture 40 will have. In the successfully operated tube described, the aperture 40 is arranged to select an incident beam portion having a range of transverse velocities between 1 and 3 bolts. The electrons of the incident beam portion 74 passing through aperture 40 will continue to spiral in paths above the beam path 44 as is diagrammatically shown by the heavy black path in Figure 1.

The beam portion 74 upon passing through limiting aperture 40 will have a circular cross-sectional area as indicated by the stippled area between A and B of Figure 4. However, the spiral paths of the electrons of this beam portion 74 will all lie on one side of the beam path 44, and will meet at common nodal points 64 on the beam path. The spiral paths taken by the electrons of portion 74 are indicated in two dimensions respectively by the black portions of Figure 1 and the stippled portion of Figure 3. At points or antinodes, mid-way between the nodal points 64, the beam portion 74 will assume the circular cross-sectional area shown between A and B in Figure 4.

In a manner similar to that described above, the beam portion, passing through aperture 40 is focussed by the magnetic field on to the surface of the glass electrode 16. This incident electron beam portion is caused to be scanned over the glass surface of the target 16 by any appropriate means, such as for example by two pairs of magnetic coils represented at 66, which are respectively connected to appropriate circuits 68 and 70, providing respectively frame and line scansion, in a manner well known in the art. Screen 58 is of a fine mesh and is mounted, as indicated, in an out of focus position, so that it will not be resolved by the beam. Screen 58 functions to provide a uniform field gradient in front of the target electrode 16.

As the incident electron beam portion 74 approaches the target electrode 16, it is slowed down to almost zero velocity due to the field of electrode 20, which is maintained, as described above, at approximately 3 volts positive with respect to the cathode 22. Electrons from the incident beam portion will land on the surface of target 16 and drive the potential of the target surface negatively. However, since the range of transverse velocities of the incident electron beam portion 74 striking the target surface 16 is between 1 to 3 volts, the target surface will fall only to a minimum potential of 1 volt above cathode potential at which the electron beam portion 74 will be reflected from the target surface.

The secondary emission initiated by the photoelectrons striking the surface of target 16, will leave on that surface of the target, a charge distribution proportional to the intensity of the light focussed upon the photosurface 14. This charge distribution will vary between the 1 volt to which the target is driven by the scanning electron beam portion and a positive 3 volts which is the potential of the collector screen 65, electrically connected to the electrode 20. This charge distribution on the photocathode side of target 16 will maintain a corresponding potential distribution on the scanned side of the target surface. The incident electron beam portion 74 which is scanned across the target surface will deposit electrons from the beam in those areas of the target which have a potential greater than 1 volt, and the beam portion will be electrostatically reflected entirely from those portions of the target surface having a potential of 1 volt.

As described in the application of Albert Rose, cited above, the conductivity of the glass target 16 is so chosen that in the frame time between scans, the electrons deposited by the incident beam portion will pass through the extremely thin cross-section of target 16 to neutralize the positive charge on the opposite side. At the same time, however, only a negligible amount of the charge can spread transversely of the target.

It is well known that an incident electron beam impinging on a metal plate or on an insulator with only a volt or two of bombarding energy is not completely absorbed. The secondary emission ratio for insulators may be as high as 8:10 or 9:10. It has been found that true secondary emission does not occur unless the bombarding energy exceeds some critical voltage characteristic of the bombarded material, and which is normally of the order of 5 to 10 volts. For voltages below this value, the electrons escaping from the surface are primary electrons, which are reflected without energy loss. In the tube of Figure 1, as the electron beam portion strikes those portions of the target 16, which are charged above 1 volt, some of these striking beam electrons are scattered from the surface of the target and will have angles of reflection anywhere from 0° to 90°. This electron reflection thus need not be specular, and, the term "scattered electrons" is applied to these non-specularly reflected electrons when the low velocity beam portion 74 strikes the target 16.

The portion of the electron beam 17 which is electro-statically reflected by the target 16, without striking the target, will return essentially in the same spiral paths as the incident beam portion, which is diagrammatically shown in the stippled area of Figure 3. However, the electrons, which do strike the target surface and are scattered in all directions, will be returned toward the electron gun in spiral paths which will be symmetrically arranged about the beam path and indicated by the dotted circles in Figure 3. The diameter of these spiral paths will be determined by the transverse velocities given to the scattered electrons and will vary from 0 to the spiral path taken by an electron with maximum transverse velocity. The spiral paths of these reflected electrons will be enclosed in an envelope 72, shown in Figure 3. Furthermore, all of the spiral paths of the reflected electrons will also pass through the beam path at the nodal points 64. The maximum spiral path which can be obtained by the scattered electrons will be determined by the potential of the electrode 20, which is the maximum potential to which the surface of target 16 can be driven by the secondary emission. Only those electrons of the scanning beam which have a transverse velocity equal to or less than this maximum potential value of electrode 20 will be able to land on the target surface and be scattered therefrom. The potential of electrode 20 can be adjusted so as to be slightly less than those electrons of the scanning beam, which have maximum transverse velocities. Thus, in Figures 3 and 4, the envelope 72 of the scattered electron beam does not enclose all of the reflected beam electron paths 74.

The spiral paths of the reflected portion 74 of the electron beam and that of the scattered portion 72 of the beam will meet in the common nodal points 64 as described. However, at an antinode or point midway between the nodal points 64 along the beam path, the reflected portion of the beam and the scattered portion of the returning beam will have cross-sectional areas shown in Figure 4 by the respective overlapping circles 74 and 72. The positioning of electrode 36 at an antinode of the electron beam provides a manner for separating the reflected beam portion 74 from the scattered beam portion 72. As shown in Figure 2, aperture 42 is arranged with a separation edge 76 positioned so as to permit as large a portion as possible of the scattered beam 72 to pass through and yet completely separate the reflected beam portion 74 from the scattered beam portion. Due to the non-coincidence of the electrostatic field between electrodes 56 and 20, and the magnetic field of coil 60, in the region adjacent the target 16, there occurs a slight scanning of the return beam 74 over the surface of electrode 36. For this reason, the separation edge 76 is not positioned exactly on the edge of the return beam 74 but is spaced therefrom a small distance, as disclosed in a comparison of Figures 2 and 4.

As described in my Patent No. 2,545,982 cited above, the electrons scattered from the target surface 16 are always proportional in number to the electrons deposited by the beam on the target surface and hence to the potential pattern on the target surface. Thus, as the electron beam is scanned across the surface of target 16, a beam 72 of scattered electrons modulated according to the charge pattern on electrode 16, is returned from the target surface toward the electrode 36 and separated by aperture 42 from the reflected beam. This scattered beam portion which passes through the aperture 42 falls upon the exposed surface of plate 38, which is sensitized to provide a secondary emitting surface. Since these electrons of the scattered portion of the beam will strike plate 38 at close to 270 volts there will be produced a secondary electron emission, having an emission ratio greater than unity. These secondary electrons will pass successfully into the second, third, fourth and fifth stages of the multiplier section indicated respectively at **46**, **48**, **50** and **54**. The final secondary emission from stage **54** is collected by the screen electrode **52**, which is connected into an output circuit **78** and amplified by a conventional amplifier tube **80** as the video signal. The multiplier electrodes may be given any appropriate voltages such as for example, those used in the successfully operated tube described above. Such voltages may be, for example, 600 volts positive for the second stage **46** of the multiplier, 900 volts positive for the third stage **48**, 1200 volts positive for the fourth stage **50** and 1500 volts positive for the fifth stage **54**, and 1600 volts positive for the collector electrode **52** of the multiplier.

The velocity selector or masking diaphragm **36** in the manner described above, thus selects the electrons of the beam, which have the desired transverse velocity range for optimum tube operation. An alignment coil **82** is positioned as shown in Figure 1 between the defining aperture **32** of the electron gun and the velocity selector diaphragm **36**. The purpose of the alignment coil **82** is to compensate for possible mechanical misalignment of the tube by providing a small transverse magnetic field so that by adjustment, the field H of coil **60** may be aligned to pass through the defining aperture **32** and through the aperture **42** of the velocity selector diaphragm **36**. Thus, if necessary, the alignment coil will provide means for bending the magnetic field passing through aperture **32**, so that it will also pass through a position corresponding to the beam axis **44** in the plane of the velocity selector diaphragm **36**. By making this adjustment, the electrons having the desired transverse velocities will be passed through the velocity selector aperture **42**. Also, in this manner, the beam axis **44** can be adjusted in the plane of diaphragm **38** to provide the correct positional relationship of the separation edge **76** to the returning beam portions **72** and **74** as well as to compensate for any structural misalignment of the gun or apertures.

In previous television pickup tubes of the type described in my co-pending application Serial No. 792,944, the resultant energy spread of the electrons after the required television velocity has been given to the beam may become as large as 5 to 10 volts. The disclosure above describes a structure incorporating a velocity selector diaphragm **36** for limiting this energy spread in a transverse direction to any value desired. The use of the novel velocity selector diaphragm **36** described above, thus eliminates from the scanning electron beam those electrons having an excessively large spread of velocity components perpendicular to the target. As described above, these electrons have no value in discharging the target, since due to their transverse velocities, they are unable to reach the target surface, but their presence in the scanning beam may have a deleterious effect on the picture. These electrons of excessive helical motion may increase the background noise of the output signal as a result of their being scattered into the scattered beam portion **72** by their double passage through the wall screen **58**. While only a small fraction of the electrons striking the screen wires will be reflected with the proper velocity, so that they can get into the multiplier, the actual number doing this will become appreciable, if the incident beam is excessively large. Furthermore, electrons of the scanning beam which approach close to the target are at times deflected out of their normal return paths by charges on the target. If the prior return beam is improperly positioned with respect to the separation edge **76**, some of these deflected electrons will pass into the multiplier giving a spurious output signal. An excess number of electrons in the beam of this type will enhance this effect.

It has been suggested above that by operating the control electrode **26** near cathode potential, the electron beam of the gun is provided with a sufficient transverse spread so as to provide electrons of the desired transverse velocity spread. However, if insufficient electrons are provided having the correct helical motion to pass through the masking aperture **40**, it may be desirable to use 2 pairs of short deflection plates respectively indicated at **84** and **86** in Figure 1, and mounted adjacent to the defining aperture **32**. By applying appropriate d. c. potentials respectively to the plates **84** and **86**, the electron beam may be shifted to any desired angle relative to the beam path **44**. In this manner, the desired velocity range may be obtained.

The tube disclosed above and in Figure 1 need not be confined to the type of electron gun described, but may be of any desired type which will provide electrons having a transverse velocity spread sufficient to pass through the aperture **40**. Furthermore, the electrode cylinder **34** may be modified by placing within the cylinder an apertured diaphragm **88** between the ends of the tubular member **34** so as to prevent electrons which strike the inner walls of the tubular electrode **34** from being reflected and scattered through the beam masking aperture **40**. Such an expedient would be particularly desirable with an electron gun structure providing a widely diverging electron beam and where the total beam striking the walls of the tubular electrode **34** may exceed by many times the number of beam electrons transmitted through the aperture **40**. If electrons scattered from the walls of electrode **34** pass through aperture **40** they would possess considerably more helical motion than would be desired and would contribute to background noise as described above.

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 is:

1. An electron discharge device comprising an envelope, means including a cathode electrode within said envelope for forming and directing an incident beam of electrons along an axial path, a target electrode mounted transversely to the path of said incident electron beam and adapted to be maintained near cathode potential for scattering and reflecting respective portions of said incident electron beam, and electrode means mounted between said cathode electrode and said target electrode and having an aperture for separating said scattered beam portion from said reflected beam portion, said means having another aperture for limiting the cross-sectional areas of said incident beam.

2. An electron discharge device comprising an envelope, means including a cathode electrode within said envelope for forming and directing an incident beam of electrons along a path, a target electrode mounted transversely to the path of said incident electron beam and adapted to be maintained near cathode potential for scat-

tering and reflecting respective portions of said incident electron beam, and electrode means mounted between said cathode electrode and said target electrode for separating said scattered beam portion from said reflected beam portion, said means including an aperture positioned eccentrically of said incident beam path for limiting the cross-sectional area of said incident beam.

3. An electron discharge device comprising an envelope, means including a cathode electrode within said envelope for forming and directing an incident beam of electrons along an axial path, a target electrode mounted transversely to the path of said electron beam and adapted to be maintained near cathode potential for scattering and reflecting respective portions of said incident electron beam, means for causing the electrons of said incident beam to assume spiral paths through common nodal points along said beam axis, said means including an apertured electrode mounted in the path of said incident beam and between two of said nodal points, said apertured electrode having a first aperture positioned eccentrically of said beam axis for limiting the cross-sectional area of said incident beam and a second aperture for separting said scattered beam portion from said reflected beam portion.

4. An electron discharge device comprising an envelope, means including a cathode electrode within said envelope for forming and directing an incident beam of electrons along an axial path, a target electrode mounted transversely to the path of said electron beam and adapted to be maintained near cathode potential for scattering and reflecting respective portions of said incident electron beam, means for causing the electrons of said incident beam to assume spiral paths through common nodal points along the axis of said beam, said means including an electrode having a portion extending transversely and entirely across said incident beam path between two of said nodal points, said electrode portion having an aperture positioned eccentrically of the axis of said beam path for limiting said incident beam to a portion eccentric of the axis thereof and a second aperture for separating said scattered beam portion from said reflected beam portion.

5. An electron discharge device comprising means including a cathode electrode for forming and directing an incident beam of electrons along an axial path, a target electrode mounted transversely to the path of said electron beam and adapted to be maintained near cathode potential for scattering and reflecting respective portions of said incident electron beam, a first means for causing the electrons of said incident beam to assume spiral paths through common nodal points along the axis of said beam, said first means including an electrode having a portion extending transversely and entirely across said incident beam path between two of said nodal points, said electrode portion having an aperture positioned eccentrically of said beam path axis for limiting said incident beam to a portion eccentric of the axis thereof, said transverse electrode including means for separating said scattered beam portion from said reflected beam portion.

6. An electron discharge device comprising means including a cathode electrode for forming and directing an incident beam of electrons along an axial path, a target electrode mounted transversely to the path of said electron beam and adapted to be maintained near cathode potential for scattering and reflecting respective portions of said incident electron beam, a first means for causing the electrons of said incident beam to assume spiral paths through common nodal points along the axis of said beam, said first means including an electrode having a portion extending transversely and entirely across said incident beam path between two of said nodal points, said electrode portion having an apertured positioned eccentrically of said beam path axis for limiting said incident beam to a portion eccentric of the axis thereof, said transverse electrode including means for collecting said scattered beam portion.

7. An electron discharge device comprising means including a cathode electrode for forming and directing an incident beam of electrons along an axial path, a target electrode mounted transversely to the path of said electron beam and adapted to be maintained near cathode potential for scattering and reflecting respective portions of said incident electron beam, a first means for causing the electron of said incident beam to assume spiral paths through common nodal points along the axis of said beam, said first means including an electrode having a portion extending transversely and entirely across said incident beam path between two of said nodal points, said electrode portion having an aperture positioned eccentrically of said beam path axis for limiting said incident beam to a portion eccentric of the axis thereof, said transverse electrode including a second aperture spaced from said first aperture and positioned in the path of said scattered beam portion.

8. An electron discharge device comprising means including a cathode electrode for forming and directing an incident beam of electrons along an axial path, a target electrode mounted transversely to the path of said electron beam and adapted to be maintained near cathode potential for scattering and reflecting respective portions of said incident electron beam, a first means for causing the electrons of said incident beam to assume spiral paths through common nodal points along the axis of said beam, said first means including an electrode having a portion extending transversely and entirely across said incident beam path between two of said nodal points, said electrode portion having an aperture positioned eccentrically of said beam path axis for limiting said incident beam to a portion eccentric of the axis thereof, said transverse electrode including a multiplying dynode positioned in the path of said scattered beam portion and having a second aperture spaced from said first aperture and positioned in the path of said scattered beam portion between said target electrode and said multiplying dynode.

9. An electron discharge device comprising electron gun means including an electron source for forming and directing an incident beam of electrons along an axial path, a target electrode mounted transversely to the axis of said incident electron beam path, said electron gun means including a second electrode mounted between said electron source and said target and positioned to intercept said incident electron beam, said second electrode having an aperture therethrough eccentric to said electron beam axis for limiting said incident electron beam to a portion eccentric of the axis thereof.

10. An electron discharge device comprising electron gun means including an electron source for forming and directing an incident beam of

electrons along an axial path, a target electrode mounted transversely to the axis of said incident electron beam path, said electron gun means including a second electrode mounted between said electron source and said target and positioned to intercept said incident electron beam, said second electrode having an aperture therethrough eccentric to said electron beam axis for limiting said incident electron beam to a portion eccentric of the axis thereof and also including an electron multiplying dynode positioned in the path of said electrons scattered from said target electrode.

11. An electron discharge device comprising electron gun means including an electron source for forming and directing an incident beam of electrons along an axial path, a target electrode mounted transversely to the axis of said incident electron beam path, said electron gun means including a tubular electrode positioned coaxial with said beam path and between said electron source and said target electrode to intercept said incident electron beam therein, means closing the opening through said tubular electrode, said closure means having an aperture therethrough eccentric to said electron beam axis for limiting said incident electron beam to a portion eccentric of the axis thereof.

12. An electron discharge device comprising means including a cathode electrode within said envelope for forming and directing an incident beam of electrons along an axial path, a target electrode mounted transversely to the path of said electron beam and adapted to be maintained near cathode potential for scattering and reflecting respective portions of said incident electron beam, means for causing the electrons of said incident beam to assume spiral paths through common nodal points along said beam axis, said last named means including means for maintaining a magnetic field parallel to said gun axis and a second electrode mounted between said electron source and said target, said second electrode positioned to intercept said incident electron beam and having an aperture therethrough eccentric to said electron beam axis for limiting said incident electron beam to a portion eccentric of the axis thereof.

13. An electron discharge device comprising an envelope, means including a cathode electrode within said envelope for forming and directing an incident beam of electrons along an axial path, a target electrode mounted transversely to the path of said electron beam and adapted to be maintained near cathode potential for scattering and reflecting respective portions of said incident electron beam, a first means for causing the electrons of said incident beam to assume spiral paths through common nodal points along said beam axis, said first means including means for maintaining a magnetic field parallel to said gun axis and a tubular electrode positioned within said envelope coaxial with said beam path and between said electron source and said target electrode to intercept said incident electron beam therein, means closing the opening through said tubular electrode, said closure means having an aperture therethrough eccentric to said electron beam axis for limiting said incident electron beam to a portion eccentric of the axis thereof.

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REFERENCES CITED

The following references are of record in the file of this patent:

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Number	Name	Date
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