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PICKUP TUBE SYSTEM

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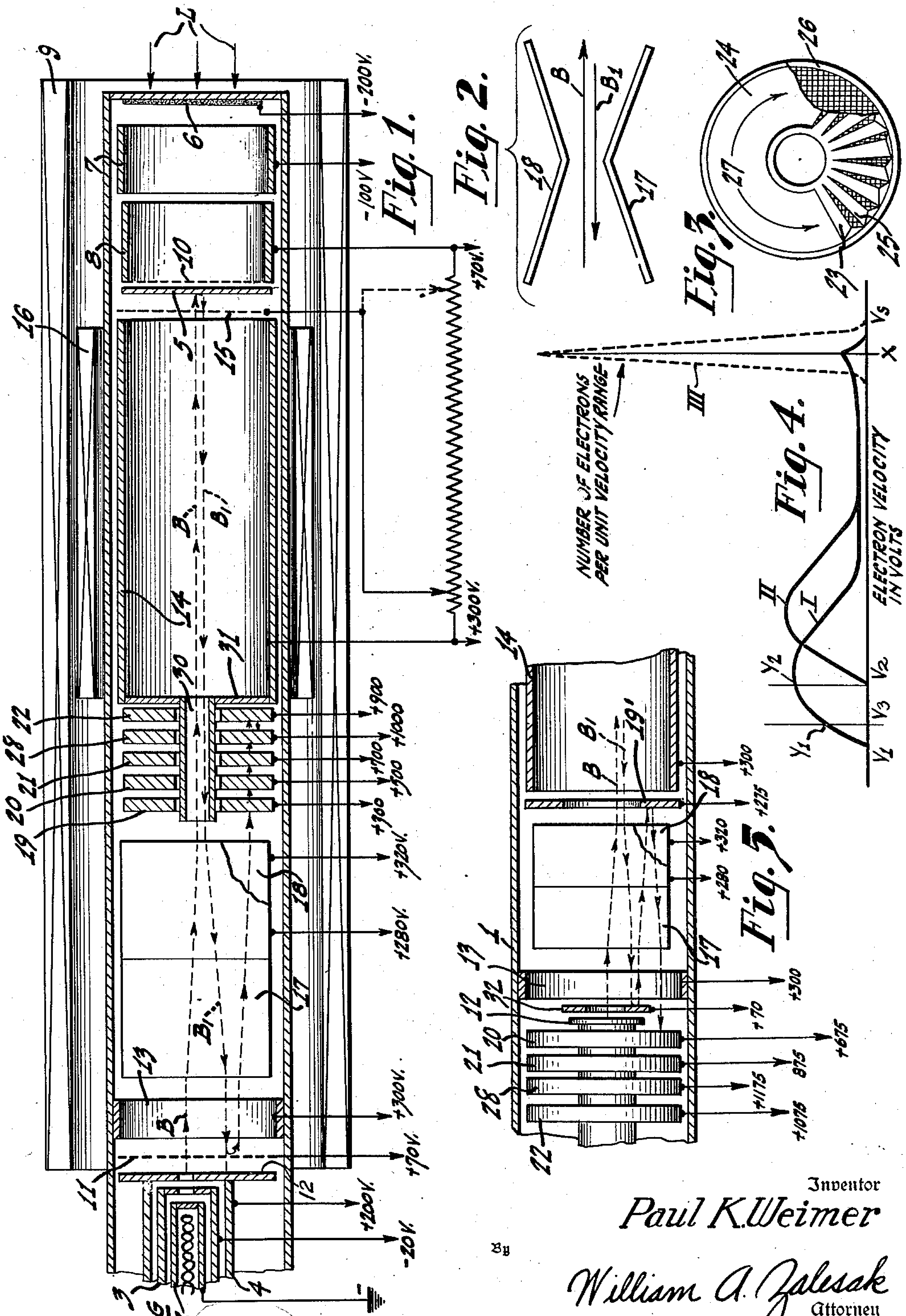

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PICKUP TUBE SYSTEM

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14 Claims. (Cl. 315—11)

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This invention relates to pick-up tubes and more particularly to tubes employing electron multipliers for improved sensitivity and simplification of the video amplifier.

In most types of pick-up tubes employing a multiplier, the video signal does not have as high a signal-to-noise ratio as should be expected from theoretical considerations. For example, in the type using a beam returning from the target toward the gun, the returning electrons are proportional to the fraction of the beam not absorbed at the target and hence are greatest in the dark part of the picture. Also, the percentage modulation of the return beam is usually less than 50% because of the failure of the beam to be completely absorbed in the most positive (white) part of the target. This means that the output signal contains a background noise current due to "shot" effects proportional to the beam current. The noise is therefore greatest in the dark portion of the image. A more desirable arrangement would be one in which the noise at all signal levels is no more than the shot noise for that signal or modulation current. The output current, and therefore the noise, would then drop to zero in the dark portion of the picture. This desirable result has been obtained in the known dissector type of tube, but it is extremely insensitive because of lack of storage.

In my improvement I obtain the desired result with signal storage in cathode ray beam tubes by taking advantage of the variable velocities of the electrons in the return beam. Electrons emitted by, or leaving, the less positive dark areas of the image move toward the gun at higher velocities than those emitted by, or leaving, the light areas, the velocity of which will vary inversely with the degree of whiteness.

The returning electrons are passed into a velocity selector to absorb all the higher velocity electrons from the dark areas and transmit to the multiplier the lower velocity electrons from the white areas, or vice versa when desired.

It is an object of my invention to devise a storage type of tube in which the noise is zero for the dark portion of the target.

Another object of the invention is to devise a multiplier type of storage tube in which the electrons proceeding from the target are passed into a velocity selector and only the lower velocity electrons are multiplied.

Another object of the invention is to provide a pick-up tube in which the modulation is one hundred per cent.

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Other objects of the invention will appear in the following description, reference being had to the drawings, in which:

Figure 1 is an illustration of a cathode ray beam tube embodying my invention.

Figure 2 is a plan of the lifting plates used in the tube.

Figure 3 is a plan view of a multiplier dynode used in the tube of Figure 1.

Figure 4 is a series of graphs showing the volt velocities of the electrons.

Figure 5 is a modification.

Referring to Fig. 1 of the drawing, the pick-up tube comprises an evacuated envelope 1 containing a cathode ray beam gun G made up of a cathode 2, a grid 3 and a first anode 4. The grid and first anode have small apertures through which the beam B passes in its travel towards the target 5 at the other end of the envelope. A charge image is formed on the front side of the target (that is, the side remote from the gun) by photoelectrons emitted from photocathode 6 by light energy L from an object imaged thereon by well-known means, not shown. The photoelectrons are accelerated by electrostatic ring anodes 7, 8 toward the target 5 and are focused thereon by the uniform magnetic axial field of coil 9. A screen or grid 10, which may be conductively secured to the anode 8, collects the secondary electrons bombarded from the front side of the glass target 5 by the photoelectrons, but this grid may be isolated from such anode and given a suitable potential independent of other electrodes.

A selector electrode which may be a grid or screen 11 is placed adjacent the end 12 of the first anode 4 of the gun G and in front of this selector grid is placed a ring anode 13. I may use a wall coating, but to simplify manufacturing and assembling methods I prefer to use a metal cylinder 14 having the same function as the wall coating. Fine mesh screen or grid 15 is located between the target 5 and the end of anode cylinder 14. A suitable spacing for this grid from the target in the usual size of pick-up tube is one-quarter inch. In most uses of the tube, the grid is run at the same potential as the cylinder anode 14 and therefore it may be mounted directly on the end of this cylinder. However, for some uses, as will later be described, the grid 15 should be run at considerably lower potential and therefore it has been shown isolated from the cylinder, with a potential lead that will permit it to be adjusted to desired values from the cylinder potential to potentials considerably therebelow.

An electromagnetic deflecting unit 16 deflects the beam B to scan the target. This unit contains coils developing fields at right angles to each other and to the field of focusing coil 9, but the two coils are not shown, as their construction and arrangement are well known. The scanning may be horizontal and vertical, spiral, or any other type.

The electron stream B_1 returning from the target toward the gun, which will be called the returning beam, is composed of secondary electrons of various velocities, shown in the graphs of Fig. 4, which has electron velocities in volts for abscissas and number of electrons per unit velocity range for ordinates. The abscissa V_s is space potential but, as shown in Fig. 4, it is not fixed and applies to any space potential in the tube. By using the proper space potential for any position in the tube, the curves will apply. Graph I gives the velocity distribution of the secondary electrons emitted from the white (or most positive) parts of the target, while graph II is the corresponding velocity distribution for electrons from the black (or most negative) parts of the target. Graphs I and II are substantially identical, but since "white" elemental areas of the target have higher average potentials than "black" areas, the electrons from white areas are subjected to a smaller accelerating force and graph I lags graph II. For shades intermediate white and black, the velocity curves would be inbetween graphs I and II, but these are not illustrated. Graph III, shown in dotted lines, indicates the velocity of the electrons of the primary beam B. These vary only to a small extent in velocity from space potential V_s.

To separate the primary beam B from the return beam B_1, lifting plates 17, 18 are spaced apart and placed between the electrode 13 and the cylinder anode 14. These flare preferably outwards at each end from the tube axis, as shown in Fig. 2.

Between the lifting plates and the cylinder anode 14 is placed the multiplier, which may consist of as many stages as desired, four being shown and designated by reference characters 19, 20, 21 and 22 The multiplier stages may be of any type, but I prefer to use the general form disclosed in my application filed September 16, 1944, Serial No. 554,494, now U. S Patent 2,433,941, in which the dynode consists of a plurality of radial vanes 23 struck up from a disc 24 of good secondary-emitting metal, such as silver-magnesium alloy, at approximately 30° angles, as indicated in Fig. 3. These vanes are cut from the disc 24 at one side and have radial openings 25 through which the emitted secondaries pass to the succeeding stage. On the entering side of the stages a fine mesh screen 26 is placed to shield the secondaries emitted by the vanes from previous potentials, which assures that they will be drawn through the openings 25 by the higher potentials of the succeeding electrodes. The vanes 23 and disc 24 are broken away at one side to show this screen. The multiplier stages are not sectioned in the horizontal plane of Fig 1. The stamped vanes are not illustrated in the portion 27 of the discs 24, as this sector of the dynodes is not in the path of the return beam, as will later be made apparent. In general, however, it will be advisable, from an assembling standpoint, to stamp the vanes throughout the entire disc. The stage 28 of the multiplier consists only of a frame containing a screen similar to screen 26 of Fig. 3, as it is a collector only, as will be later explained. The multiplier dynode and collector units have central openings 29 to pass over a tube 30 fitted in the end 31 of the electrode 14.

The various electrodes of my improved tube may be mounted in any known way, preferably in the way shown in the applications of Stanley V. Forgue, one filed January 28, 1946, Serial No. 643,925, which is now United States Patent 2,441,315, issued May 11, 1948, and the other one filed February 7, 1946, Serial No. 646,075, which is now United States Patent 2,460,381, issued February 1, 1949. The voltages applied to the electrode will be known to those skilled in the art, but I have indicated in the drawing suitable voltages for satisfactory operation.

The operation of my improved tube is as follows:

Radiant energy L, light for example, proceeding from an object to be televised, forms an image on the photocathode 6. Photoelectrons produced by this imaged energy are accelerated by electrodes 7 and 8 towards the target 5 and are focused on the front face thereof by the axial focusing field of coil 9. The target may be any two-sided type, but preferably it is made of a semi-conducting material such as disclosed in the application of Albert Rose, filed September 20, 1940, Serial No. 357,543, for which a continuation was filed November 28, 1945, Serial No. 631,441, now United States Patent 2,506,741, issued May 9, 1950. The photoelectrons proceed through the screen 10 and bombard secondary electrons from the front side of the target 5, the secondaries being collected by the screen 10. Thus, a charge image is built up on the front side of the target corresponding to the light image formed on the photocathode 6, which produces a potential image on the gun side of the target. The white areas have, of course, higher potential than black areas.

The beam B from the gun G is accelerated towards the target by the wall coating and other electrodes, but is deflected downwards in Fig. 1 of the drawing by the lifting plates 17 and 18, for this is the action of electrostatic plates having different potentials when located in an electromagnetic field such as produced by the coil 9. The difference in potential between these plates is such as to deflect the beam B to the central axis of tube 30. After issuing from this tube, the beam is subject to the scanning fields of deflecting unit 16, so that the target 5 is scanned thereby. The beam electrons bombard secondary electrons from the target substantially uniformly over the scanned surface. The velocity of the secondary electrons is not uniform, but has the distribution shown in Fig 4. The secondary electrons emitted from "white" and "black" areas of the target are accelerated by the fields of screen 15 and anode 14 toward the gun G at different velocities. The velocities are greater for electrons emitted by black areas, because there is a greater potential difference between the accelerating electrodes and these areas of the target than between those electrodes and the white areas, due to the potential image on the target surface. Hence, graph II is shifted ahead of graph I in the direction of velocity increase, as shown in Fig. 4.

The electrons in return beam B_1 are accelerated by the fields of screen 15 and anode 14 along a path adjacent the path of primary beam B until they reach the field between lifting plates 17 and 18, which deflects them downwards away from beam B. When they reach the vicinity of screen or grid 11, which has approximately the potential of the black areas of the target, no electron having velocity in volts below V_2 in Fig. 4 can pass through the screen. The electrons having velocities in volts below V_2 are reflected back by this electron mirror and accelerated towards the multiplier dynode. This means that the number of electrons represented by $V_2Y_2V_1$ is reflected and the remaining electrons from the white areas and all the electrons from the black areas pass the screen and are collected by the end 12 of the first anode 4. In passing through the field of lifting plates 17 and 18, the reflected electrons are further deflected downwards, as indicated in the drawing.

The electrons pass through the screen 26 in stage 19 and bombard secondary electrons from the under surface of the vanes 23, as shown in Fig. 3. These secondary electrons are shielded from previous electrodes by the fine mesh screen 26 and are accelerated through the opening 25 in the dynode, through the screen 26 of stage 20 and bombard the under surface of the vanes 23 thereof. In the same way, the electrons are further multiplied by stages 21 and 22. The secondary electrons issuing from the final stage 22 are collected by the screen in collector 28.

It will thus be seen that, with my improved pick-up tube, the electrons having velocities above a predetermined value are rejected and the electrons having velocities below that value are utilized. The "shot" noise, which is the most troublesome noise in conventional pick-up tubes employing a multiplier, is only that of the modulated part reflected into the multiplier. Since the modulation is 100% and the polarity is such that no electrons enter the multiplier in the dark, the noise is zero in the dark.

In general, the tube would be operated so that secondary electrons would be accepted and utilized for the full potential swing of target 5. However, in certain cases it is advantageous to select a narrower range given by less than the full votage swing of the target, for example, to control the gamma of the tube. This may be accomplished by changing the voltage of screen 15 to a lower potential, so that electrons whose velocity is less than V_3 do not pass through the screen 15. This voltage should be slightly higher than target potential. Then, electrons with velocities below, say, V_3 would not pass the screen 15, but would return to target 5. Thus, the electrons reaching the multiplier would be indicated by curve portion $V_2Y_2Y_1V_3$. By adjusting the voltage of this screen, one can readily clip the white signals in the picture, such as the area $V_3Y_1V_1$, and thus control the gamma of the tube, while obtaining the advantages of the invention as previously referred to herein.

Since the target 5 has no adjacent electrode of relatively low potential to which the beam electrons can drive the potentials of the black and white areas, the landing electrons merely change their absolute potentials, leaving their difference of potential the same. Hence, the beam does not, in the example given, discharge the target. The charge image is discharged by the distribution of secondary electrons produced by the photoelectrons when the picture image changes from black to white, and vice verse, as disclosed in my application filed August 3, 1945, Serial No. 608,663, which is now Patent No. 2,537,250, granted January 9, 1951.

In Fig. 5 I have shown a different location for the multipliers. In this embodiment the disc electrode 32 is run near target potential. The electrons of B_1 of higher velocity land thereon and are not utilized, but this electrode is an electron mirror for those of lower velocity and they are reflected and are accelerated to the electrode 19', which constitutes the dynode of the first stage of the multiplier. The secondary electrons emitted in this dynode are accelerated and deflected below the disc 32 into the second stage 20 of the multiplier, which may be constructed and arranged around the gun similar to the arrangement described in my said application Serial No. 554,494, except that in this figure, as well as in Figs. 1 and 2, it is preferable to stamp the dynode discs with a greater number of radial blades than there indicated. The voltages applied to the electrodes in this modification would be known to those skilled in the art, but I have indicated satisfactory voltages in the drawing.

In describing the operation I have indicated that the reflecting electrodes or electron mirrors 11 of Fig. 1 and 32 of Fig. 5 should have the potential of the elemental target areas. As a practical matter, this is rather difficult to determine due to contact potentials, which may equal several volts in some cases. This, of course, is known to those skilled in the art and the potential of the electron mirror will be adjusted until the desired response is obtained.

I claim:

1. An electron tube comprising, an evacuated envelope containing a cathode, a grid and an anode adapted to form a cathode ray beam, a target adapted to have a potential pattern in the path of said beam and to emit secondary electrons with a range of velocities under bombardment of the electrons of said beam, an additional anode for accelerating the beam electrons to said target and said secondary electrons away therefrom, a selector electrode interposed in the path of said secondary electrons for directing into one path the electrons having velocities on one side of an intermediate velocity in said range and into another path the electrons having velocities on the other side thereof and a collector electrode collecting for the electrons of one path only.

2. An electron tube comprising, an evacuated envelope containing a cathode, a grid and an anode adapted to form a cathode ray beam, a target in the path of said beam adapted to have a potential pattern and to emit secondary electrons with a range of velocities under bombardment by the electrons of said beam, means for scanning said beam over said target to produce said secondary electrons, an additional anode for accelerating the beam electrons to said target and said secondary electrons away therefrom, a selector electrode interposed in the path of said secondary electrons to repel the electrons having velocities on one side of an intermediate velocity in said range and an electrode positioned between said selector electrode and said target for collecting the repelled electrons.

3. A television pickup tube comprising, an evacuated envelope containing a cathode, a grid and an anode adapted to form a cathode ray beam, a target in the path of said beam adapted to emit secondary electrons with a range of velocities under bombardment by the electrons of said beam, means for scanning said beam over said target to produce said secondary electrons, an additional anode for accelerating the beam electrons toward said target and the secondary electrons away therefrom, a photocathode adapted to produce a white and black potential

pattern on said target corresponding to a photo image being televised, said potential pattern causing the acceleration by said additional anode to be greater for secondary electrons from black than from white potential areas, an electron mirror interposed in the path of the secondary electrons, lead means connected to said electron mirror for joining said mirror to a source of potential equal to a potential between that of said black and white target areas, whereby said secondary electrons of low velocities are reflected, and an electrode positioned between said mirror and said target for collecting said reflected electrons.

4. A television pickup tube comprising, an evacuated envelope containing a target, a cathode, a grid and an anode adapted to form a cathode ray beam means for scanning said beam over said target to produce secondary electrons, a photocathode adapted to produce a white and black potential pattern on said target corresponding to a photo image to be televised, said potential pattern causing the acceleration by said additional anode to be greater for secondary electrons from black than those from white potential areas, an electron mirror interposed in the path of the secondary electrons, lead means connected to said electron mirror for joining said mirror to a source of potential equal to a potential between that of said black and white target areas, whereby said secondary electrons of low velocities are reflected, and an electron multiplier positioned between said mirror and said target for collecting electrons reflected by said mirror.

5. A television pickup tube comprising, an evacuated envelope containing a cathode ray beam gun, a target in the path of said beam adapted to emit secondary electrons with a range of velocities under bombardment of the electrons by said beam, an additional anode for accelerating the beam electrons toward said target and the secondary electrons away therefrom, a photocathode adapted to cause said target to emit electrons and produce a charge image thereon, electric field producing means for scanning the cathode ray beam of said gun over said target, an electrode interposed in the path of said secondary electrons to repel those having velocities below an intermediate velocity in said range and attract those having velocities at or above said intermediate velocity, and a multiplier dynode positioned between said electrode and said target in the path of said repelled electrons.

6. A television pickup tube comprising, an evacuated envelope containing a target, an electron gun for producing a cathode ray beam, a photocathode for causing said target to emit electrons and produce a white and black potential pattern corresponding to a photo image being televised, means for scanning said beam over said target, an anode for causing the cathode ray beam to bombard secondary electrons from said target with initial movement away from said target at a range of velocities, said secondary electrons being accelerated away from the target by said anode and said potential pattern causing the acceleration to be greater for electrons from black than from white potential areas, lifting plates for deflecting said secondary electrons out of the path of said beam, an electron mirror interposed in the path of the deflected secondary electrons for attracting the electrons from black areas and for reflecting the electrons from white areas, and an electron multiplier positioned out of the path of the beam and in the path of the reflected electrons.

7. A television pickup tube comprising, an evacuated envelope containing a cathode, a grid and an anode adapted to form a cathode ray beam, a target, a photocathode for causing said target to emit electrons and produce a white and black potential pattern corresponding to a televised photo image means to scan said beam over said target, a second anode for accelerating the electrons of said beam to said target to cause it to emit secondary electrons at a range of velocities, said potential pattern causing the acceleration to be greater for electrons from black than from white potential areas, lifting plates for deflecting said secondary electrons out of the path of said beam, an electron mirror interposed in the path of the deflected secondary electrons for attracting substantially all the secondary electrons from said black potential areas and for reflecting at least a part of the electrons from said white potential areas, and an electron multiplier positioned between said mirror and said target for collecting said reflected electrons.

8. A television pickup tube comprising, an evacuated envelope containing a cathode ray beam gun, a target at one end of said envelope, a photocathode for causing said target to emit electrons and produce a charge image thereon, a multiplier having a plurality of multiplier dynodes, means to scan said beam over said target, an electrode for accelerating the electrons of the cathode ray beam of said gun to said target to bombard secondary electrons therefrom at a range of velocities, said electrode accelerating said secondary electrons away from said target, lifting plates for deflecting said secondary electrons out of the path of said beam, an electron mirror in the path of the deflected secondary electrons adapted to reflect those having velocities below an intermediate velocity in said range and attract those having velocities above said intermediate velocity, the first dynode positioned between said mirror and said target of said multiplier attracting the repelled electrons and successive dynodes thereof attracting secondary electrons emitted by previous dynodes thereof.

9. A television pickup tube comprising, an evacuated envelope containing a cathode ray beam gun, a target, a multiplier between said gun and said target having a metal tube at its center, a plurality of multiplying dynodes around said metal tube, means for causing said target to emit electrons and produce a charge pattern thereon with a potential pattern for white and black areas corresponding to a photo image being televised, electric field producing means cooperating with said gun for projecting the beam through said tube onto said target, means for scanning said beam over said target to cause the target to emit secondary electrons with initial movement toward said tube at a range of velocities, said secondary electrons being accelerated toward said gun through said tube by said field producing means and said gun, said potential pattern causing the acceleration to be greater for electrons from black than from white potential areas, an electron mirror adjacent to, and at one side of, said gun, lifter plates for deflecting said secondary electrons to said mirror and from said mirror toward the dynodes of said multiplier, the dynodes of the multiplier adapted to attract the reflected electrons thereinto and produce secondary electrons therefrom.

10. An electron tube system comprising an

evacuated envelope having a semi-conducting target adapted to emit electrons with a range of velocities, electric field producing means for accelerating said electrons away from said target, a selector electrode and a signal electrode and a voltage supply source connected to said target, said means, said selector electrode and said signal electrode, the voltage applied to said selector electrode producing a potential to repel electrons along one path having velocities on one side of an intermediate velocity in said range and to pass electrons along another path having velocities on the other side of said intermediate velocity, said signal electrode being positioned in one of said paths to attract the electrons therein.

11. An electron tube system comprising an evacuated envelope having a glass target adapted to emit electrons with a range of velocities, electric field producing means for accelerating said electrons away from said target, a selector electrode and an electron multiplier dynode and a voltage supply source connected to said target, said means, said selector electrode and said multiplier dynode, the voltage applied to said selector electrode producing a potential to repel electrons along one path having velocities on one side of an intermediate velocity in said range and to pass electrons along another path having velocities on the other side of said intermediate velocity, said multiplier dynode being positioned in one of said paths to attract the electrons therein.

12. An electron tube system comprising an evacuated tube having a cathode ray beam gun, a target adapted to have a potential pattern and positioned to be bombarded by the electrons of the beam of said gun for production of secondary electrons with a range of velocities, means for scanning said beam over said target, a selector electrode spaced from said target and a collector electrode spaced from said selector electrode, and a voltage supply source connected to the anode of said gun, said selector electrode and said collector electrode, the voltage applied to said selector electrode producing a potential to repel along one path secondary electrons having velocities on one side of an intermediate velocity in said range and to pass electrons having velocities on the other side of said intermediate velocity, said collector electrode being positioned in one of said paths to attract the electrons therein.

13. An electron tube system comprising an evacuated tube having a cathode ray beam gun, a target adapted to have a potential pattern and positioned to be bombarded by the electrons of the beam of said gun for production of secondary electrons with a range of velocities, means for scanning said beam over said target, a selector electrode spaced from said target and an electron multiplier dynode spaced from said selector electrode, and a voltage supply source connected to the anode of said gun, said selector electrode and said electron multiplier dynode, the voltage applied to said selector electrode producing a potential to repel along one path electrons having velocities on one side of an intermediate velocity in said range and to pass electrons having velocities on the other side of said intermediate velocity, said electron multiplier dynode being positioned in one of said paths to attract the electrons therein.

14. An electron tube system comprising an evacuated tube having a cathode ray beam gun, a target adapted to have a potential pattern and positioned to be bombarded by the electrons of the beam of said gun for production of secondary electrons with a range of velocities, means for scanning said beam over said target, a selector electrode spaced from said target and an electron multiplier having a plurality of dynodes spaced from said selector electrode, and a voltage supply source connected to the anode of said gun, said selector electrode and the dynodes of said multiplier, the voltage applied to said selector electrode producing a potential to repel along one path electrons having velocities on one side of an intermediate velocity in said range and to pass electrons having velocities on the other side of said intermediate velocity, the first dynode of said multiplier being positioned in one of said paths to attract the electrons therein.

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