

Jan. 10, 1939.

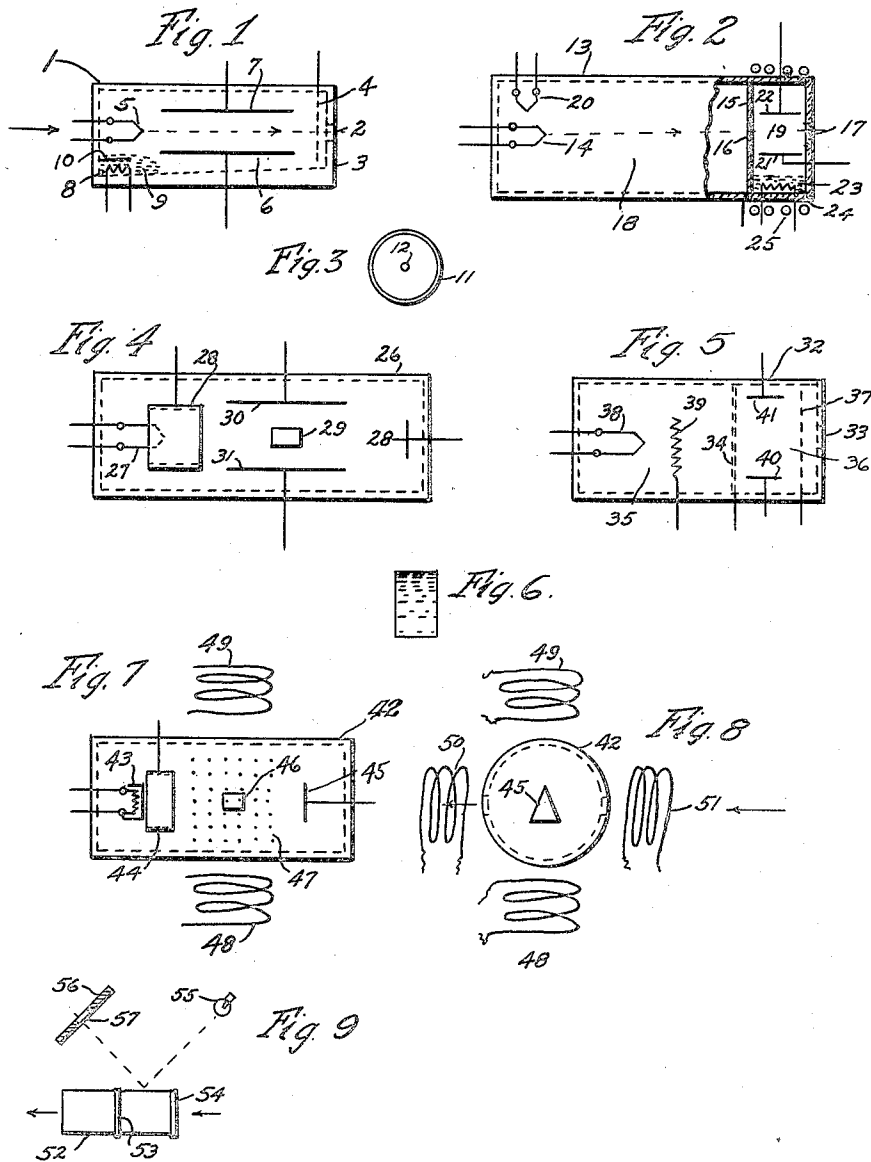
A. G. THOMAS

2,143,095

ELECTRONIC DEVICE

Filed June 7, 1937

2 Sheets-Sheet 1



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Inventor

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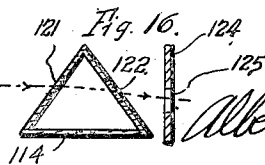
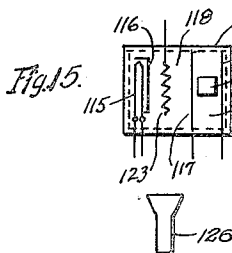
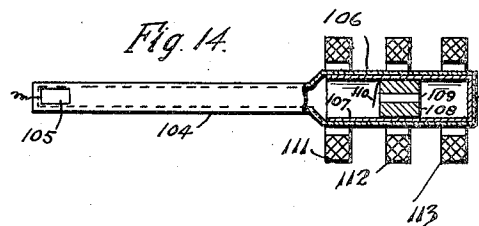
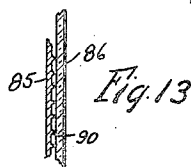
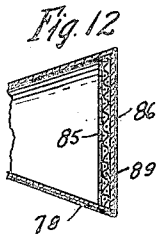
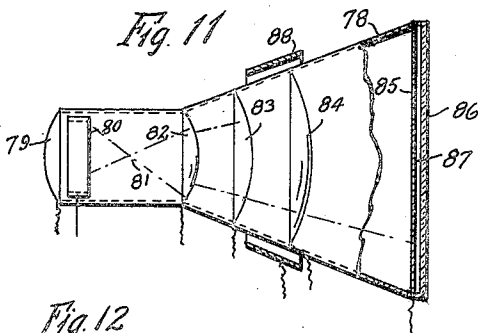
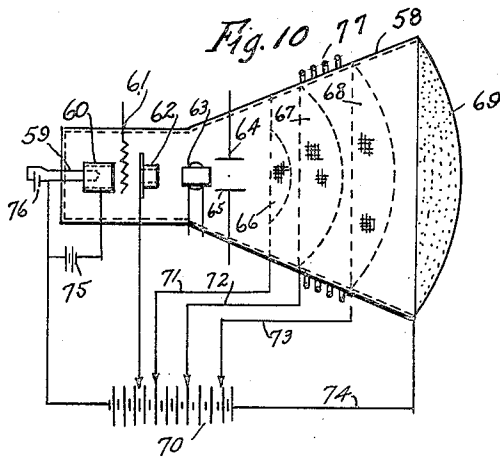
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,143,095

ELECTRONIC DEVICE

Albert G. Thomas, Lynchburg, Va.

Application June 7, 1937, Serial No. 146,772

4 Claims. (Cl. 250-150)

This invention relates to electronic devices.

An object is to provide light valves to vary light beams in proportion to electrical impulses.

Another object is the provision of amplifying tubes to increase the size of television images.

A further object is to provide novel screens for television.

An additional object is to provide combination screens for television and sound.

10 A still further object is the provision of an electronic tube in which the gas pressure may be varied.

Other objects will appear in the description.

In the drawings:

15 Figure 1 is an elevation of a light valve employing a colored gas.

Figure 2 is an elevation, in part section, of a light valve employing a colored gas in a separate chamber.

20 Figure 3 is a plan view of a wire electrode in a cylindrical electrode.

Figure 4 is an elevation of a light valve in which electrons are deflected toward and from a window.

25 Figure 5 is an elevation of a light valve employing electronic bombardment of a gas.

Figure 6 is an elevation of a window with graduated shading.

30 Figure 7 is an elevation of a light valve with a wedge-shaped electron beam.

Figure 8 is an end view of the valve of Figure 7 and showing field coils to produce a rotating field.

35 Figure 9 is an elevation in part section of a crystal light valve.

Figure 10 is an elevation of a television tube with a plurality of screens for enlarging images.

40 Figure 11 is an elevation, in part section, of a television tube with curved plates for enlarging images; also with a novel screen.

Figure 12 is a fragmentary sectional view of a gaseous screen with mesh wire adjacent.

Figure 13 is a variation from the construction shown in Figure 12.

45 Figure 14 is an elevation, in part section, of an electronic tube with a movable piston to vary the pressure of gas in the tube.

Figure 15 is an elevation of a light valve employing refraction effects in a gas.

50 Figure 16 is an end sectional view of the envelope of Figure 15.

55 In Figure 1, tube 1 is made of opaque material except for an area 2 in end 3, which area is made of transparent glass or other material. Anode 4 is in the form of a perforated element although

it may be a metal ring. Cathode 5 is designed to furnish both light and electrons and may be made of tungsten. Plates 6 and 7 are placed on either side of the electron path between cathode 5 and anode 4 and these plates may be charged by a suitable input circuit. Heating element 8 is placed in a depression in tube 1 so that material 9 may be heated to become colored vapor or a gas. A suitable material is iodine which readily sublimates to form a dark colored vapor to obstruct light passing from filament 5 through anode 3 and transparent section 2. Other materials which may be used are finely powdered carbon, or other "smoke" producing materials. The carbon powder may be agitated by heat or by an electrically vibrated diaphragm 10 or other device, so that the space in tube 1 will be saturated with the iodine or carbon particles.

In operation, element 8 is supplied with current to sublime the iodine or to vibrate diaphragm 10, as the case may be, and cathode 5 is connected to a suitable source so that it will become heated to give off electrons and light. Anode 4 is connected to a suitable source which is also connected to cathode 5 so that anode 4 is positively charged with respect to the cathode. The plate 7 may be in the form of an extended cylinder as shown in Figure 3, in which the plate is represented by cylinder 11 which would be coaxial with tube 1, and plate 6 would be in the form of a wire or loop 12 placed coaxially in cylinder 11.

Normally the iodine vapor will fill the space between cathode 5 and anode 4 so that light will be obstructed but when plates 6 and 7 are charged the iodine molecules will be electrostatically deflected from the central path so that light will pass from filament 5, through perforated anode 4 and so out of transparent window 2. This is true since the electrons will charge the iodine vapor. The greater the charge on plates 6 and 7 the greater the displacement of the iodine molecules within a given time so that the device will act as a light valve. Plates 6 and 7 may be charged oppositely or similarly. It is obvious that a magnetic field may be employed to deflect the charged vapor.

The cathode end of tube 1 may be transparent so that light from an external source may be passed through the valve. In that case cathode 5 need not be bright but will serve merely to supply electrons to charge the iodine vapor.

Plate 11 of Figure 3 may be made of screening if desired.

Heating coil 8 may be extended to heat the whole tube 1 so that condensation of the vapor

will not take place while in use. After the current is cut off the vapor will condense until the tube is heated again.

In Figure 2 opaque tube 13 has transparent section 17 and thin aluminum wall 15 is sealed to tube 13 to form compartments 18 and 19. Compartment 18 is evacuated. Transparent section 16 is sealed into wall 15. Cathode 20 is provided so that if it is heated it will produce electrons which will be attracted to aluminum wall 15 which is made positive with respect to cathode 20, by means of a suitable electrical source. Filament 14 is provided to produce light which may pass through transparent sections 16 and 17 and so out of tube 13.

Plates 21 and 22 in chamber 19 may be charged to deflect the particles of material 23 which is heated or agitated by electrical coil 24 so that chamber 19 is filled with molecules of iodine, or some other dark substance, or fine carbon particles, may be employed. These particles or vapor are charged by high speed electrons from cathode 20 passing through wall 15 so that the vapor in chamber 19 will be electrically charged. Therefore the vapor may be deflected by plates 21 and 22 so that more or less light will pass through window 17, in accordance with the charges on the plates 21 and 22. Heating coil 24 may warm windows 16 and 17 to prevent condensation on these windows. Instead of plates 21 and 22, the charged molecules or atoms may be deflected by magnetic coil 25 which may be concentric as shown or placed in any suitable position.

In choosing material 23 it should not be of such a nature that it will readily react chemically with elements of the tube.

Figure 4 illustrates a light valve tube 26 which contains a gas such as neon or the like, at low pressure so that the gas will glow brightly when struck by electrons from cathode 27 which is surrounded by cylinder 28 which may be charged negatively to focus the electrons in a narrow beam. Anode 28 is charged positively with respect to cathode 27 so that a thin beam of electrons will pass from cathode 27, past transparent window 29 and thence to anode 28. These electrons will cause the gas in front of window 29 to glow and emit light through the window. But if plates 30 and 31 are electrically charged, the electrons will be deflected above or below window 29, or both, so that the gas in line with window 29 will not be so brightly illuminated. Therefore the device will act as a light valve since the amount of shift of the electron beam will vary in accordance with the charges on plates 30 and 31. Tube 26 should be opaque except for window 29. It is obvious that a magnetic field could be used to deflect the electrons. The distance between cathode 27 and anode 28 may be made very short if desired, so that the electron beam will penetrate the vapor sufficiently.

In Figure 5 opaque tube 32 has transparent window 33 and aluminum wall 34 is sealed into tube 32 to form an evacuated compartment 35, and compartment 36 containing a gas such as helium or other suitable gases that glow under electronic bombardment. Wire mesh element 37 is sealed in tube 32 with a suitable lead so that it can be made positive with respect to cathode 38 and aluminum wall 34. Grid 39 is provided to control the electron stream passing from cathode 38 to and through aluminum wall 34, since this wall is connected to a suitable source so as to be positively charged with respect to cathode 38. Electrons passing through wall 34 will be

further attracted to mesh 37 which is at still higher potential, and in passing through the gas or gases contained in chamber 36, the electrons will cause the gas to glow and to emit light. The intensity of the light passing through window 33 will be in proportion to the electronic bombardment and so the device will act as a light valve. The perforated element 37 will let light pass but if placed immediately in front of window 33 it will attract electrons all the way through the gas. This element may be a ring surrounding window 33 instead of a screen or grid.

An additional control grid may be placed in chamber 36 or plates 40 and 41 may be provided so that they may be charged simultaneously with grid 39, to deflect electrons out of line with window 33 and so to reduce the intensity of light passing through that window, or vice versa.

Figure 6 shows a window of graduated opacity so that a stream of glowing gas may be shifted up to reduce the light, or down to increase the amount of light passing through the window.

In Figure 7, opaque tube 42 has indirectly heated cathode 43, focusing ring 44 and anode 45, a front view of which is shown in Figure 8. This anode is wedge-shaped and the emitting surface of cathode 43 is similarly shaped so that a beam of electrons of triangular cross section will pass from cathode 43, past transparent window 46 in opaque tube 42, and on to anode 45.

Cross magnetic field 47, produced by energizing coils 50 and 51 will deflect the triangular beam of electrons up or down with reference to window 46 so that the density of the electron beam passing this window will be varied in accordance with variations in the strength of magnetic field 47. Tube 42 contains gas such as helium, hydrogen or the like, at low pressure, so that the gas that is struck by electrons will glow. Therefore there will be a glowing column of gas of varying cross section between the cathode and anode and the column of electrons and ions will be shifted with relation to window 46 so that a greater or lesser amount of light will pass through this window in accordance with the strength of magnetic field 47 so that the device will act as a light valve if magnetic field 47 is produced by coils through which variable currents can be passed.

Focusing ring 44 may be charged negatively to prevent too much spreading of the electrons. Electrostatic plates may be used to shift the beam, instead of a magnetic field.

The electrons and gas ions may be shifted by means of a rotary magnetic field produced by energizing field coils 48, 49, 50, 51, with out-of-phase alternating currents in proper sequence, in well-known manner. This rotating field will sweep across the electron beam and will check and deflect the beam so that the light produced in the gas near window 46 will be varied.

In Figure 9, crystal 52 may be of Rochelle salt, quartz, or similar material. Metal band 53 is clamped around the center of the crystal and metal band 54 around an edge. Suitable wires from an electric circuit may be connected to bands 53 and 54 so that the crystal will be distorted in shape in accordance with the current. Then light from lamp 55 will be reflected from the surface of the crystal in varying degree so that the amount of light passing through hole 57 in opaque shield 56 will be varied. The light may also be refracted through the crystal or the intensity of the light transmitted through the crystal

tal may vary with the potential between bands 53 and 54, especially if polarized light is used.

Figure 10 illustrates a television receiving tube in which the electronic images are enlarged by secondary emission, so that the final visible image will be as large as desired.

Flared tube 58 is evacuated and has cathode 59, focusing ring 60, control grid 61, and perforated anode 62, as usual, so that an electron "gun" is provided to project a beam of electrons past magnetic coil 63 and electrostatically charged plates 64 and 65. The magnetic field set up by coil 63 and a similar coil not shown, and the electrostatic field between plates 64 and 65 will cause the electron beam to scan target 66, when currents and potentials of suitable frequency are applied to coils 63, and plates 64 and 65 respectively. Such construction is well-known in the art.

Target 66 is of spherical contour and is made of fine wire screening, preferably coated with a substance such as cesiated silver, barium oxide or the like, so that a copious supply of secondary electrons will be emitted from target 66 when struck by the electrons from cathode 59. Progressively larger targets 67 and 68 are also of spherical contour and are constructed in similar manner to target 66 so that a progressively greater number of electrons will be liberated as the targets of greater area are struck by the electrons. In this way the electron density of the enlarged electron image may be maintained or actually increased so that the final visible image produced on fluorescent screen 69 will be of sufficient brightness although it is of relatively large area. Screen 69 is formed by coating the end of glass tube 58 with willemite or other fluorescent material.

Screens 66, 67, and 68 are made with spherical contour so that the secondary electrons, as well as some primary electrons, will leave the surfaces radially so that distortion of the image will not result. The electrical field established between the targets by battery 70 assists in the travel of electrons in normal directions. Targets 66, 67, and 68 are connected to battery 70 at points of progressively higher potential, with respect to cathode 59, by means of wires 71, 72, and 73. Screen 69 may also be connected to battery or other source 70 by wire 74, at still higher potential if desired, or a mesh anode similar to target 68 may be placed close to screen 69 to assist in attracting and aligning electrons.

The negative terminal of battery 70 is connected to cathode 59 and focusing ring 60 is made negative with respect to cathode 59 by means of battery 75. Cathode 59 is heated by means of battery or other source 76.

This tube will therefore reproduce television images of large size without diminution of brightness. Any or all of targets 66, 67, 68 and screen 69 may be plane instead of curved. If curved they need not be of exact spherical contour but may be so shaped as to distribute the electrons in any desired manner. For instance, they may be curved so as to compensate for the natural tendency of the electrons to repel each other and so to spread out. Magnetic coil 77 may be energized and wound around tube 58 or placed to assist in focusing the electrons or in maintaining an electron pattern. Targets 66, 67, and 68 are suitably attached to the inside of the tube.

In Figure 11 an enlarging tube somewhat similar to that of Figure 10 is shown. Flared tube 78 has spherically curved cathode 79 and focusing

element 80 which may be of any suitable design and may be charged to bring the electrons from cathode 79 to a focus 81 from which they will diverge to strike solid anode target 82 which is spherically curved and which may be constructed of any suitable material and coated on the convex side to emit secondary electrons freely. The coating material may be thorium, barium oxide, or the like or the targets may be made of thin aluminum which is a good secondary emitter. Cathode 79 will project electron images of actual light images thrown upon it.

Progressively larger spherically curved targets 83 and 84 are made similarly to target 82 and they are connected in a suitable circuit so that they will be at progressively higher potentials relative to cathode 79. Therefore an electron image striking target 82 will be re-radiated from the convex side of this target by means of an increased number of secondary electrons traveling radially to strike the larger concave area of target 83. Then a still larger number of secondary electrons will travel radially from the convex face of target 84 and these electrons will diverge to strike thin aluminum wall 85 sealed to tube 78 to form thin compartment 87 between the wall and the transparent glass end face 86 of tube 78. A suitable gas such as helium or hydrogen may be enclosed in space 87 so that it will glow when struck by the electrons. The amount of light produced will vary with the density or speed of electronic bombardment and therefore, with a practically constant speed the glowing gas will reproduce a image in keeping with the electron image striking wall 87 which may be charged to a higher positive potential relative to cathode 79 than the potential of any of the targets 82, 83, or 84. It will be seen therefore that an enlarged electron image of sufficient electron density to form a bright visible image will be produced, which image may be viewed through transparent wall 86.

A willemite screen may be used instead of the novel gas screen but the gas will respond very rapidly and brightly to electron bombardment and a gas or mixture of gases may be chosen so that an approximately black and white image will result.

Cathode 79 may be of very thin construction so that the image may be focussed on the convex face or the cathode may be thermionic as shown in Figure 10 and the electron beam may be caused to scan the targets as before. If desired the electron image may be transferred directly to target 82 without deversing the image by focusing means.

Ring 88 may surround the electron path, inside or outside of tube 78. This ring may be charged to assist in directing the electrons, if desired. Targets 82, 83, and 84 may be planar and wall 85 and end 86 may be suitably curved, if desired.

As shown in Figure 12, wire screen 89 may be placed in the space formed between wall 85 and end wall 86 of tube 78. This screen will serve to support the walls against air pressure and may serve as an anode also. It will likewise tend to break up the gas into pockets to localize the effects of electron bombardment.

As illustrated in Figure 13, pockets may be formed by having projections 90 on wall 85, or similar projections could be formed on the inner surface of wall 86.

In Figure 14, glass tube 104 contains a gas such as neon at low pressure and electrode 105 is provided at one end. The other end is pref-

erably enlarged to form cylindrical wall 106 in which is fitted metal cylinder 107 which serves as the other electrode. Piston 108, preferably of iron, is slidable in cylinder 107 and is provided with channel 109 which may be closed by check valve 110 when the piston is moved to the left. Solenoidal field coils 111, 112, and 113 are placed as shown and surround cylinder 106 so that they may be energized in any order to move piston 108 at will, in cylinder 107. Therefore the gas in tube 104 may be put under greater or lesser pressure so that the character and degree of light output from the glowing gas, will be varied. Ordinarily the valve 110 and channel 109 will not be required but if a dense gas is used the valve will serve to allow gas that leaks behind piston 108 to escape into tube 104, when the piston is moved to the right.

Such a tube will be useful in achieving spectacular effects in lighting, as for advertising signs. The same principle may also be used to vary the gas pressure of television or radio tubes, in order to change the characteristics of such tubes. The piston 108 may be displaced by means of an exterior permanent magnet which may be moved near cylinder 106.

In Figure 15, light valve envelope 114 of triangular cross section is preferably made of glass but may be of metal or other material. It has cathode heater 115 which heats triangular shaped electron emitting cathode surface 116, so that a beam of electrons of triangular cross section will be attracted to aluminum anode plate 117 which is sealed into tube 114 to form evacuated chamber 118 and gas filled chamber 119. Additional metal plate 120 may be provided to assist in pulling electrons through the gas or gases in chamber 119. The plates 117 and 120 are of triangular shape to conform to the cross section of envelope 114, a cross sectional end view of which is shown in Figure 16.

Windows 121 and 122 of clear glass, quartz or the like are sealed in envelope 114 which may otherwise be opaque, so that light may be passed crosswise through chamber 119. The triangular gas body in chamber 119 will act as a prism to refract light and the amount of refraction will depend to a certain degree on the electrical condition of the gas. For instance, if the gas is ionized or bombarded it will diffract the light differently from neutral gas.

If the electrons from cathode 116 are passed through aluminum plate 117 at high speed, by making this plate positive with respect to cathode 116, then the gas in chamber 119 will be bombarded by these electrons and will become ionized or excited in proportion to the bombardment, the degree of which can be regulated by control grid 123. Plate 120 may be at still higher potential relative to cathode 116, than plate 117 so that the electrons will tend to penetrate the gas.

Therefore the refracting index of the gas will be regulated by the electrical condition of control grid 123 and the device will act as a light valve if the light beam is arranged so that it is shifted toward or away from windows 121 and 122, by potential fluctuations of grid 123. An outside opaque plate 124 with opening 125 may be utilized so that windows 121 and 122 would not be necessary, in which case envelope 114 could be of clear glass.

Polarized light may be used and wall 117 could be eliminated so that the gas would fill tube 114 uniformly but by retaining separating aluminum wall 117, the electrons can be accelerated to very high speed in evacuated chamber 118 so that they will pass through wall 117 and will penetrate the gas in chamber 119 to a considerable depth. The gas in this chamber may be made as dense as desired.

The varied absorption effect of gases for certain wave lengths of light under different electrical conditions, may be employed. The shorter wave lengths are more attenuated in passing through some ionized gases than some of the longer wave lengths. Therefore this effect may be used or it may be combined with the refraction effect. In case ultra violet light is used it may be caused to strike fluorescent material and to re-emit light. It is obvious also that variations in reflection properties of a gas may be employed, under different electrical conditions of the gas.

X-ray tube 126 may be employed to assist in ionizing the gas. If wall 117 is eliminated the gas ions, if negatively charged, will tend to collect near plate 120 so that a somewhat vacuous space near cathode 116 will result. The electrons can be accelerated in this space.

If a gas producing positive ions, such as hydrogen, is used, a negatively charged mesh or plate may be used to concentrate the gas around it.

What I claim is:

1. An electron discharge tube comprising: a cathode, electron accelerating means, a luminescent screen adapted to emit light in proportion to the degree of electron bombardment, a plurality of secondary-emitting elements between said cathode and said screen, each said element, in a direction from said cathode toward screen, being of larger area than the preceding element, and means for scanning the smallest said element in order to produce secondary electrons to strike the next larger said element.

2. An electron discharge tube comprising: a cathode, electron accelerating means, a luminescent screen adapted to emit light in proportion to the degree of electronic bombardment of said screen, a plurality of secondary emitting elements of progressively larger area in a direction from said cathode toward said screen and placed between said cathode and said screen, said elements being curved so that electrons will be incident upon and emitted from said elements in directions substantially normal to the surfaces of said elements.

3. An electron discharge tube comprising: a cathode, electron accelerating means, a fluorescent screen, and a plurality of solid secondary-emitting elements of progressively larger area in a direction from said cathode toward said screen, and placed between said cathode and said screen.

4. An electron discharge tube comprising: a cathode, electron accelerating means, a fluorescent screen, and a plurality of solid secondary-emitting elements of progressively larger area in a direction from said cathode toward said screen, said elements being convex toward said screen and placed between said cathode and said screen.

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