Aug. 18, 1936. H. C. THOMPSON 2,051,188

TUNING INDICATOR TUBE

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Fig. 1

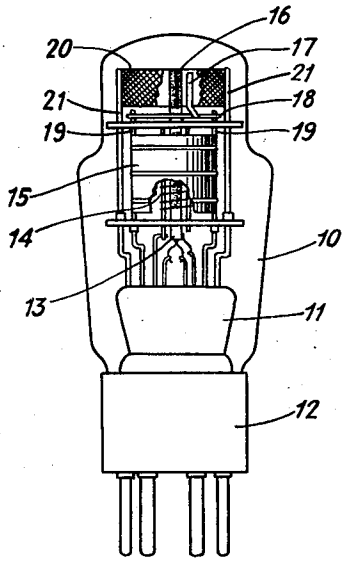


Fig. 2

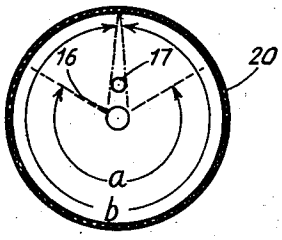


Fig. 3

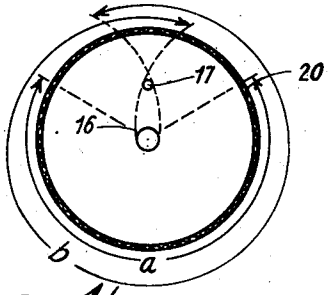


Fig. 4

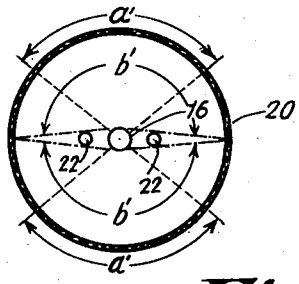


Fig. 9

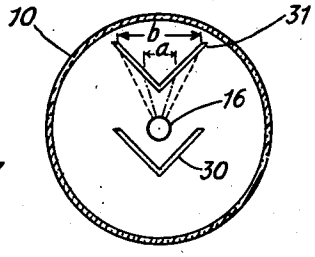


Fig. 5

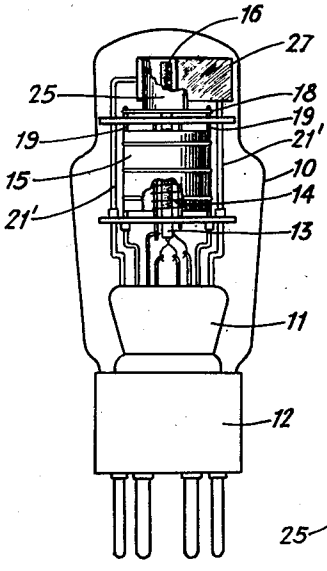


Fig. 6

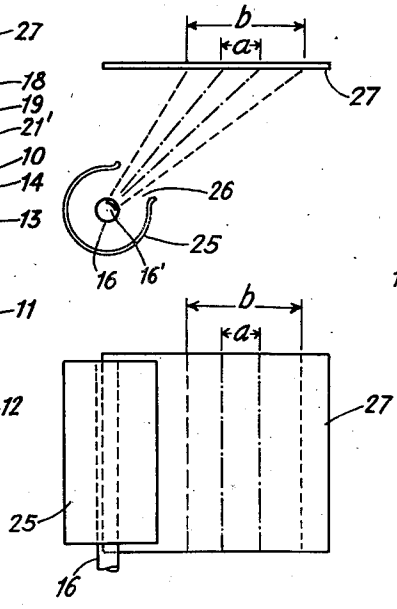
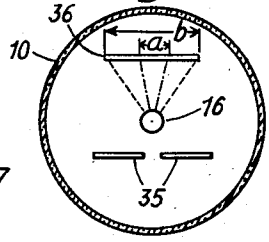


Fig. 10



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Fig. 7

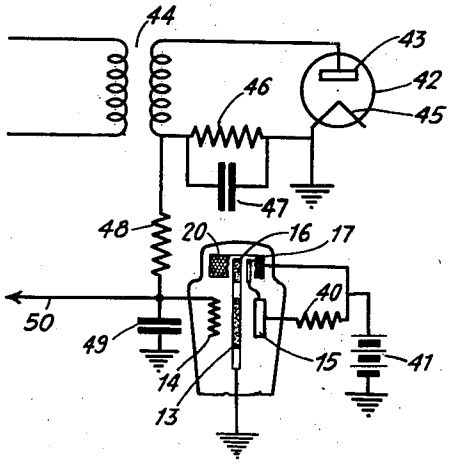


Fig. 8

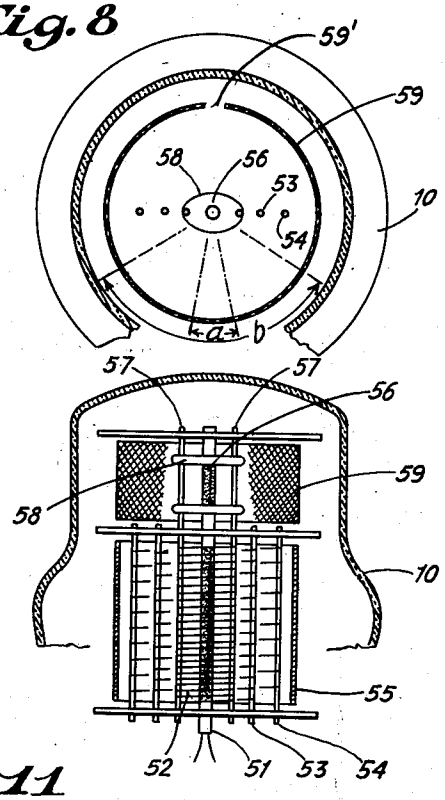
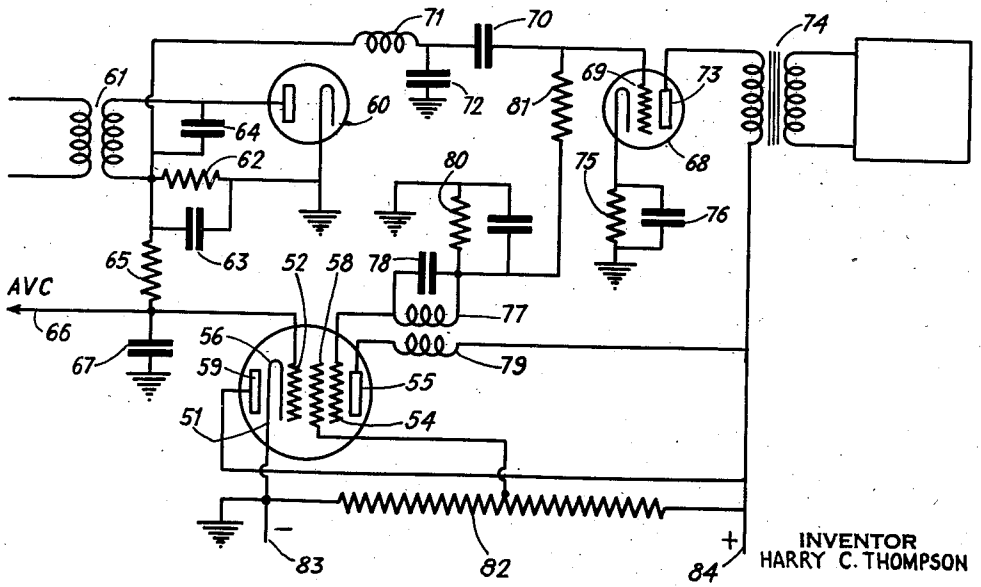


Fig. 11



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UNITED STATES PATENT OFFICE

2,051,188

TUNING INDICATOR TUBE

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Application June 27, 1935, Serial No. 28,665

10 Claims. (Cl. 250—27.5)

My invention relates to electron discharge devices, more particularly to such devices useful as visual indicators of voltage and having a fluorescent electrode which is rendered luminous, and has the appearance of a pattern of light which may be of constant height and varying width and which changes in response to the change in the magnitude of the applied voltage, a device of this character being particularly useful as a tuning indicator in radio receiving sets.

It is an object of my invention to provide an improved electron discharge device of the kind described, which is particularly suitable for use as a visual tuning indicator in a radio receiving set and in which resonance is indicated by a brilliant luminous glow on an electrode.

In general my invention comprises an envelope having within it a straight thermionic cathode having two separate electron emitting sections around one of which are positioned at least one grid and an anode. Around the other section are mounted the visual tuning indicator elements comprising a straight control electrode preferably in the form of a rod parallel to the cathode, and an anode which may be flat or cylindical and may be of sheet or of mesh material and coated with material which fluoresces in response to electron bombardment. In operation the electrons flow from the cathode to the anode with sufficient velocity to bombard the plate and render it luminous. The control electrode is electrically connected to the anode surrounding the grid and the elements of the tube are so connected in a radio receiving circuit that when the circuit is tuned to resonance with an incoming signal the luminous portion of the indicator anode is of a predetermined size. In one form of the device the connection is such that the luminous portion of the anode is of a maximum width and hence the dark space of minimum width when the circuit is tuned to resonance, the height remaining constant.

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 drawings in which Figure 1 shows an electron discharge device embodying my invention with parts broken away to show details of construction; Figures 2 and 3 are top views of Figure 1 and graphically showing changes in the light pattern in response to different voltage changes; Figure 4 is a top view of a modification of the construction shown in Figure 2 and embodying my invention; Figure 5 shows an electron discharge device embodying a modification of my invention with parts broken away to show details of construction; Figure 6 is an enlarged top and side view showing details of construction of the voltage indicating elements of the tube shown in Figure 5; Figure 7 shows a circuit arrangement using a tube made in accordance with my invention; Figure 8 shows a top view and a vertical section of a still further modification of an electron discharge device embodying my invention; Figures 9 and 10 are top views of further modifications of the tuning indicator elements of the electron discharge device shown in Figure 8; and Figure 11 is a circuit embodying the electron discharge device shown in Figure 8.

The electron discharge device or tuning indicator tube shown in Figure 1 comprises an evacuated envelope 10 provided with the usual stem and press 11, and base 12. Supported from the press are a cathode 13, preferably the conventional indirectly heated equipotential type, a grid 14 and anode 15 surrounding the cathode.

In accordance with my invention I mount in the dome portion of the envelope 10 the visual indicating portion of the tube comprising a cathode, a rod-like control electrode and an anode in the form of an open ended cylinder surrounding said cathode and control electrode and provided with a coating which fluoresces when subjected to electron bombardment. While the anode having the fluorescent coating may be of the mesh type and viewed from the outside, I may make it of sheet material and coat only the inside, the luminescent portion being viewed from the upper open end of the coated anode.

In Figure 1 the cathode 13 is extended into the dome portion of the envelope and has a second emitting section 16 for supplying the electrons in the visual indicating device. A control electrode 17, which may be a rod-like member or of sheet material set edgewise to the cathode, is supported from a cross bar 18 electrically connected to the side rods 19 of the anode 15. This control electrode determines the pattern of the luminescent portion of the anode 20, which is shown as made of mesh material and coated with any conventional luminescent material, and is supported by rods 21 extending from the press.

In operation the voltage on the anode 15 is applied to the control electrode 17, the voltage on this electrode determining the width of the pattern of light on the anode 20, the height of the

pattern of light being constant and equal to the height of the anode.

Referring to Figure 2, which shows a top view of the tuning indicator portion of the invention shown in Figure 1, the beam control electrode 17 is so biased that when no signal is being received the voltage difference between the control electrode 17 and the anode 20 is such that only the portion of the anode between the broken lines *a* is luminescent. As the set is tuned to resonance the voltage difference between the anode 20 and the electrode 17 becomes less, so that the control effect of the electrode 17 on the electrons leaving the cathode 16 is less, permitting electrons from the cathode 16 to reach more of the anode 20 so that when the set is tuned to resonance the anode is luminous around its entire surface as shown by lines *b*.

In Figure 3 the beam control electrode 17 is made so positive that the edges of the beam from the cathode overlap each other. The result is that at the overlapping sections the luminosity is made more intense than on other portions of the anode 20. In this way the range of the indicator device can be increased because the screen can be used more than once; once for the conditions where a dark space or gap exists between the boundaries of the luminescent portion of the anode and once again for the overlapping.

Instead of depending upon the width of the luminescent portion of the anode to indicate voltage changes the dark space is preferably depended upon to indicate voltage conditions in this form of my invention. This arrangement has several advantages over those types of indicating devices in which the width alone of the luminescent portion of the anode is depended upon to indicate resonance. The range of the indication can be made all the way from zero dark space width to the maximum gap of bright areas substantially equal to the screen width. Thus the beam edges can be made to move thru a distance substantially equal to the full width of the target if proper control voltages are used. As pointed out above the range of the indicating device can be extended by making use of the overlapping characteristic described in Figure 3. The most important feature, however, is that the device can be used to very precisely indicate voltage conditions, inasmuch as the eye is very sensitive to changes in beam width in the neighborhood of zero width, that is, where the beam edges just touch.

In Figure 4 a pair of control rods 22 is used instead of a single rod 17, giving a pattern of light for untuned and tuned conditions as indicated by broken lines *a'* and *b'*.

In the modification shown in Figures 5 and 6 the tuning indicator portion of the electron discharge device made in accordance with my invention, includes a control electrode 25 in the form of a cylinder provided with a longitudinal opening 26 thru which electrons pass from the cathode 16 having emitting portion 16' to the flat coated anode 27 supported by rods 21' extending from the press 11. The less negative this control electrode is biased with respect to the anode the wider will be the luminescent area on the anode 27 inasmuch as the beam of electrons from the cathode becomes less sharply focused than when the negative bias on the control electrode is large. In this embodiment of my invention the luminescent portion of the voltage or tuning indicator may be viewed from the side of the tube with ease. The emitting area 16' of the cathode 16 is confined as shown to prevent the control electrode 25 drawing any substantial amount of current.

The application of an electron discharge device made in accordance with my invention to a radio circuit is shown in Figure 7. Normally the anode 15 of the triode section of the tube is electrically connected thru a resistor 40, to a source of voltage 41. The indicator anode is connected directly to the source of voltage 41. With no voltage on the grid 14 a certain predetermined amount of current flow thru the triode section of the tube causes a drop in resistor 40, so that the voltages applied to anode 15 and indicator anode 20 have the greatest differential, the voltage on anode 15 being at the lower potential. The voltage on anode 20 does not change while that on the anode 15 decreases, due to the drop thru resistor 40. This makes the control electrode 17 negative with respect to anode 20, thus reducing the width of the luminescent portion of the anode 20. As the voltage on the control grid 14 increases in the negative direction the current flow to the anode 15 decreases so that the voltage drop thru the resistor 40 decreases. Under these circumstances the voltage differential between anode 15 and indicating anode 20 decreases so that the control electrode 17 becomes less negative with respect to the anode 20. This permits the width of the luminescent portion to increase. Thus the luminescent portion increases as the negative bias on the control grid 13 increases. This characteristic of the tuning indicator tube is made use of when connected to a conventional automatic volume control circuit. The rectifier tube 42 has an anode 43 connected to one side of the radio frequency or intermediate frequency transformer 44 coupled to the receiving circuit not shown, and a cathode 45 connected thru a grid leak 46 and by-pass condenser 47 to the other side of the transformer 44. The cathode side of the transformer 44 is connected thru resistor 48 to control grid 14 of the tuning indicator tube. A radio frequency by-passing condenser 49 connects the grid to ground, and the conductor 50 may be connected to other parts of the circuit to provide automatic volume control. As the receiving circuit is tuned to resonance and rectification takes place thru the tube 42, the cathode side of the radio frequency transformer becomes negative with respect to ground due to the current thru resistor 46. This negative voltage is applied to the control grid 14 as a negative bias with the result that the current thru the triode portion of the tube is reduced, thus causing the width of the luminescent portion of the tuning indicator anode 20 to increase as explained above. In this arrangement the control electrode is positive with respect to the cathode. Several advantages follow from this arrangement over that in which the control electrode is biased negatively with respect to the cathode. The boundaries of the electron beams are sharp and well defined. There can be a high concentration of electrons at the edges of the luminous areas so that the luminosity is uniform. The high current to the luminescent portion of the screen can be obtained at low voltages and hence a high luminosity is the result. A positive control electrode is suitable for direct coupling to an amplifier, that is it may be directly connected to the plate of an ampli-

fier tube as shown in Figure 1 for example. Furthermore, a tube made in accordance with my invention is not critical to variations in cathode temperatures and is susceptible for use with alternating and direct voltages and currents.

Figure 8 shows a still further modification of my invention having an electrode assembly of the pentode type and a tuning indicator electrode assembly of a different construction from the other embodiments of my invention. In this embodiment the cathode 51 is surrounded by control grid 52, screen grid 53 and suppressor grid 54, all of which are in turn surrounded by anode 55. In this arrangement cathode 51 is extended upwardly to provide a second emitting portion 56 for supplying electrons for the tuning indicator portion of the tube. The grid side rods 52 are also extended upwardly into the tuning indicator portion of the tube and provided with a pair of control elements 58 in the form of spaced elliptically shaped wires positioned opposite the ends of the emitting portion of the upper end of the cathode. In this arrangement the electron beam or beams to the luminescent anode 59 can be varied both in width and in height depending upon the positioning of the control rings or elliptically shaped wires 58 and the voltages applied to the control grid 52. In this embodiment the anode may be of mesh material and viewed from the exterior. The anode 59 is preferably split at 59' to prevent intense heating during high frequency exhaust so that the fluorescent material is not baked off the anode.

In Figure 9 the control electrode 30 is an L-shaped member on one side of the electron emitting cathode 16 and the luminescent anode is similarly shaped with the coating on the side facing the cathode. Figure 10 shows an arrangement very similar to that shown in Figure 9 except that the control electrodes 35 and anode 36 are flat.

In the embodiments shown in Figures 9 and 10 the control electrodes 30 and 35 are connected to the grid of the pentode section as in Figure 8, so that they are biased negatively with respect to the cathode. The luminescent portions between the lines *a* and *b* in Figures 9 and 10 indicate the luminescent portions when the circuit in which the tube is used is tuned and untuned to an incoming signal.

A circuit employing the embodiment of my invention shown in Figure 8 is shown in Figure 11. This circuit includes an automatic volume control arrangement and suppressor arrangement for the audio amplifier. A diode detector is coupled to a radio or intermediate frequency transformer connected to a radio receiving circuit. The audio frequency amplifier tube is also coupled to this radio or intermediate frequency transformer. The tube embodying my invention is connected in an oscillating circuit. The circuits connecting the three tubes are such that with no signal passing thru the intermediate transformer the tube made according to my invention oscillates and impresses on the audio frequency tube a bias such that it is completely suppressed. When a signal is being received a negative bias is developed by the diode detector and this bias is impressed on the control grid of the tuning indicator tube, causing it to stop oscillating and thus removing the bias from the audio frequency tube permitting it to function. The bias developed by the diode detector then alone controls the audio amplifier tube to impress the signal frequency upon the audio amplifier tube. The tuning indicator portion of the tube embodying my invention will have a minimum sized pattern when the set is tuned to resonance, because the control grid is most negative under these conditions.

In the circuit the diode detector 60 has its anode and cathode connected to opposite side of the intermediate or radio frequency transformer 61, the cathode being connected to one side of the transformer thru the resistor 62 and by-passing condensers 63. Condenser 64 and the secondary of the transformer 61 provide a tuned circuit, preferably tuned to the intermediate frequency. The cathode side of the radio frequency transformer 61 is connected to the control grid 52 of the tuning indicator tube thru the resistor 65. Conductor 66 may be connected for automatic volume control. A radio frequency by-passing condenser 67 is connected between the control grid 52 and ground. The audio frequency amplifier tube 68 has its control grid 69 coupled to the cathode side of the secondary of transformer 61 thru the condenser 70 and the radio frequency choke 71, radio frequency currents being by-passed by condenser 72. The anode 73 of the amplifier tube is connected to the audio frequency transformer 74 and to the positive side of the D. C. power supply. The cathode is connected to ground thru a biasing resistor 75 and by-passing condenser 76. The tuning indicator tube has its suppressor grid 54 connected to an oscillating circuit inductance 77 and capacitance 78 which are connected to ground thru resistor 80. The feedback coil 79 connected to the anode 55 feeds energy into the oscillating circuit to maintain oscillations. With the indicator tube oscillating the bias developed by the drop in resistor 80 is impressed on the control grid 69 of the amplifier tube thru resistor 81 so that while the indicator tube is oscillating a sufficiently high negative bias is applied on the control grid 69 of the audio amplifier tube to completely suppress it. Voltage to the screen grid 53 of the tuning indicator tube is supplied from the voltage divider 82 connected across the D. C. power supply lines 83 and 84. When the tuning indicator tube stops oscillating the bias developed across the resistor 80 is removed from the grid 69 of the audio amplifier tube so that the grid can be influenced in a normal manner by the voltage developed across the resistor 62 so that the amplifier functions in the conventional manner.

Whether or not the indicator tube oscillates depends upon a signal being impressed on the detector tube. With no signal being impressed on the detector 60 thru the transformer 61 there is no voltage drop across the resistor 62 and hence no bias applied to the control grid 52 of the indicator tube. This permits current thru the tube and it oscillates and impresses a bias voltage on the control grid of the audio amplifier tube suppressing it as described above. During periods when a signal is being received the bias applied to the control grid of the tuning indicator tube stops its oscillations so that the audio amplifier can function in a normal manner. When no signal is being received the luminescent portion of the anode of the indicator is of greatest width, while when a signal is being received it is of minimum width.

While I have indicated the preferred embodiment of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means

limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:—

1. An electron discharge device having an envelope enclosing an electron emitting cathode, an anode adjacent said cathode and having a surface coated with fluorescent material exposed to direct view for receiving electrons from said cathode, and a control electrode comprising a conductor parallel to the cathode and having a portion between said cathode and said anode for determining the portion of the coated surface of said anode reached by electrons from said cathode.

2. An electron discharge device having an envelope, a straight thermionic cathode in said envelope for emitting electrons, an anode substantially coextensive with said cathode and having a fluorescent coating exposed to direct view for receiving electrons from said cathode, a control electrode comprising a straight rod conductor parallel to the cathode and having a portion between said cathode and said anode for determining the width of the fluorescent portion of said anode depending on the voltage applied to said control electrode.

3. An electron discharge device comprising an envelope enclosing an electron emitting cathode, an open ended tubular fluorescent anode surrounding the cathode, and a control electrode comprising a conductor parallel to the cathode and between said cathode and said anode for producing on said anode a beam of substantially constant length and of a width depending on the voltage applied to said control electrode.

4. An electron discharge device having an envelope enclosing a straight thermionic electron emitting cathode, an anode adjacent said cathode and having a fluorescent coating thereon, a control electrode comprising a pair of straight conductors parallel to the cathode and having a portion between said cathode and said anode for determining the extent of the anode reached by the electrons emitted by the cathode.

5. An electron discharge device having an envelope, a cathode within said envelope having two electron emitting sections, an open ended tubular mesh anode surrounding one of the electron emitting sections and provided with a fluorescent coating and a control electrode between said anode and said cathode and comprising a conductor parallel to the cathode for producing on the anode a beam of substantially constant length and of a width depending on the voltage applied to said control electrode, a grid and a second anode surrounding the other of said electron emitting sections of said cathode and an electrical connection between said second anode and said control electrode.

6. An electron discharge device having an envelope, a cathode within the envelope having a plurality of electron emitting surfaces along its surface, a grid and anode surrounding one of said electron emitting surfaces and an open ended tubular fluorescent anode surrounding another of the electron emitting surfaces of said cathode and a control electrode positioned between said fluorescent anode and the other electron emitting surface and comprising a conductor parallel to the cathode and connected to the anode surrounding the grid for producing on said fluorescent anode a beam of substantially constant length and of a width depending upon the voltage applied to said control electrode thru the anode around the grid.

7. An electron discharge device having an envelope, a straight thermionic cathode within said envelope for emitting electrons, a flat anode adjacent the cathode and coextensive therewith and coated with a material which fluoresces when struck by electrons from said cathode and a control electrode comprising a cylindrical member having a portion intermediate said anode and said cathode and coextensive with said cathode and anode and having a longitudinal slot along one side thereof whereby the electrons from said cathode pass thru said slot to said anode to render a portion of said anode luminous, the width of the luminescent portion of the anode struck by said electrons being dependent on the voltage applied to said control electrode.

8. An electron discharge device comprising a cathode having two separate emitting sections, a grid and anode surrounding one of said electron emitting sections, an anode surrounding the other of said emitting sections and coated with a fluorescent material, and a control electrode comprising a straight conductor positioned between the other emitting section of said cathode and the anode coated with luminescent material and electrically connected to and supported by the anode surrounding said grid.

9. An electron discharge device comprising a cathode having two separate emitting sections, a control grid having side rods parallel to said cathode and an anode positioned around one of said emitting sections, a fluorescent anode positioned around the other omitting section to receive electrons from said other emitting section, the side rods from the control grid being extended between the other emitting section and said fluorescent anode whereby voltages applied to said control grid will determine the area of the fluorescent anode reached by electrons from the other emitting section of said cathode.

10. An electron discharge device comprising a cathode having two separate emitting sections, a control grid having side rods and an anode positioned around one of said emitting sections, a fluorescent anode positioned around the other emitting section to receive electrons from said other emitting section, the side rods of said control grid being extended between the other emitting section and said fluorescent anode and a pair of members mounted transversely on and electrically connected to said side rods at opposite ends of said other emitting section whereby voltages applied to said control grid will determine the area on said fluorescent anode reached by electrons from the other emitting section on said cathode.

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