June 9, 1959 — A. G. VAN DOORN ET AL — 2,890,376

IMAGE PRODUCING DISCHARGE DEVICE

Filed July 8, 1955 — 3 Sheets-Sheet 1

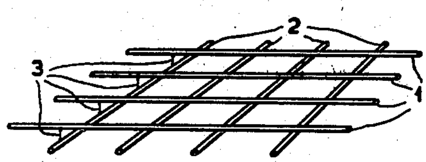

FIG.1

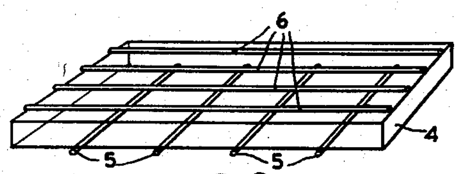

FIG.2

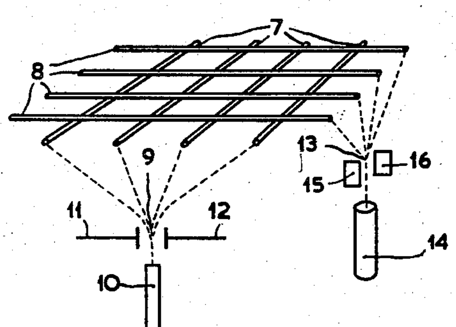

FIG.3

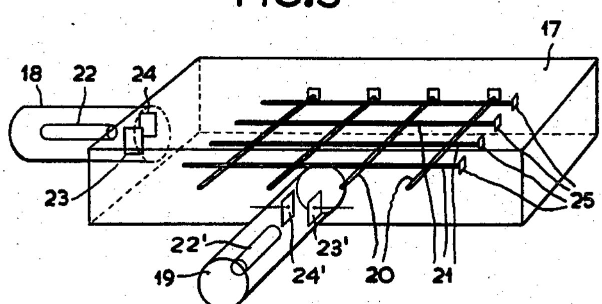

FIG.4

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IMAGE PRODUCING DISCHARGE DEVICE

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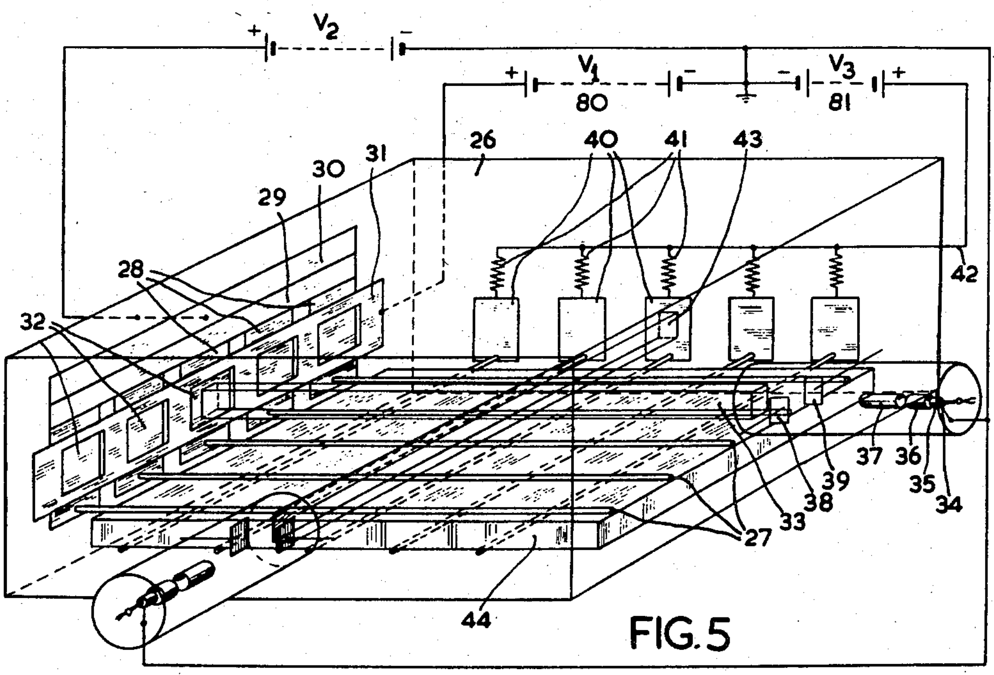

FIG.5

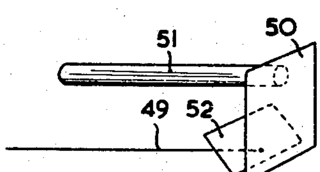

FIG.6

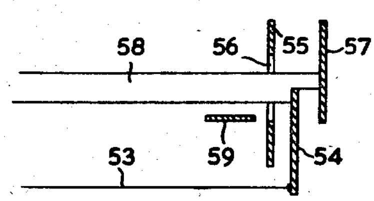

FIG.7

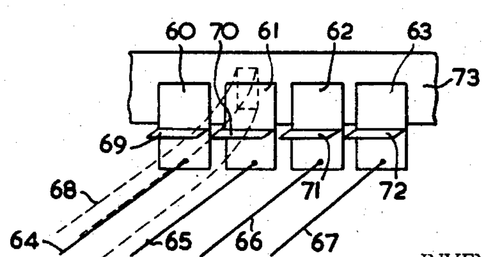

FIG.8

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IMAGE PRODUCING DISCHARGE DEVICE

Filed July 8, 1955 3 Sheets-Sheet 3

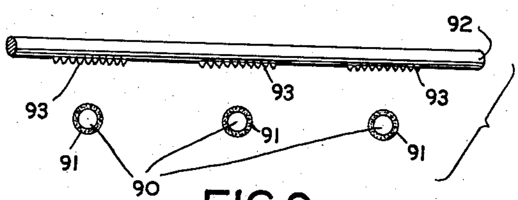

FIG.9

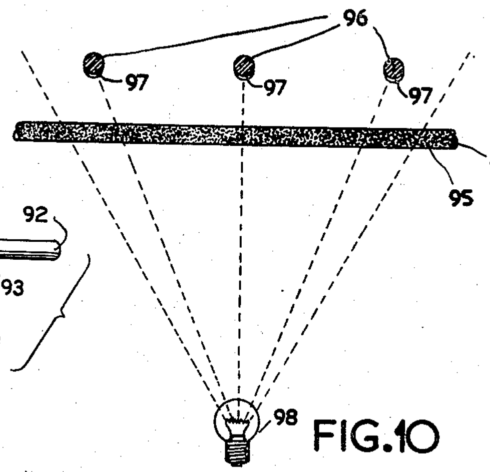

FIG.10

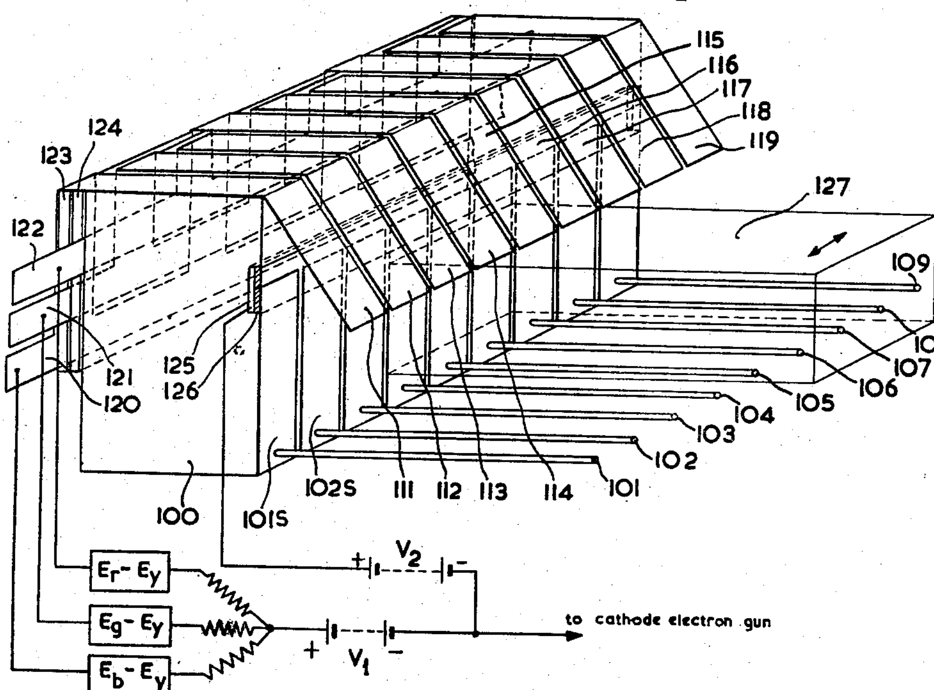

FIG 11

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IMAGE PRODUCING DISCHARGE DEVICE

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Application July 8, 1955, Serial No. 520,846

Claims priority, application Netherlands July 20, 1954

25 Claims. (Cl. 315—12)

This invention relates to a device of the electric discharge type of which discrete points can be caused to luminesce to produce a desired visible image.

In image reproduction systems, such as television, radar, facsimile transmission, oscillography and the like, a cathode-ray tube is frequently employed, in which a concentrated electron beam strikes a phosphor screen to produce light. In order to draw the required image, it is necessary for the electron beam to be deflected in two directions, so that each desired point of the image surface can be impacted by the beam. This is generally realized by means of a deflection system which is usually arranged near the electron gun producing the beam. If it is also necessary to vary the intensity of the luminous spot on the image screen, as in television, this may be attained in a simple manner by varying the voltage of one electrode in the electron gun, as a rule, the so-called Wehnelt cylinder, which is frequently referred to simply as the control-grid. Such tubes enable the production of excellent images of high luminous intensity and rich in contrasts. However, an important drawback of such devices is that the requirements for the geometrical construction of the electron gun are very severe, in order to obtain a sharply defined luminous spot of high light intensity, of which the shape and the luminous intensity do not vary when the spot is deflected across the image screen. Further, if electro-magnetic deflection is employed, the deflection coils must be wound in a manner such that astigmatism is minimized. There is a further limitation of no less importance in that large images require a very considerable length of the tube. It is therefore very difficult to incorporate the tube in a cabinet, and the weight of the tube is materially increased.

The invention provides a new solution to the problem of composing an image, in which the disadvantages set out above are reduced to a considerable extent.

The principle underlying the invention is that instead of using an image surface of which any point can be caused to luminesce, use is made of an image surface of which only discrete points are excitable to produce light under particular conditions. This is achieved in accordance with the invention by employing a pair of grids, each of which is constituted only of wires which do not intersect one another. The grids are arranged substantially parallel to one another in such a manner that each wire of one of the grids crosses or intersects all of the wires of the other grid. Thus, viewed from a direction at right angles to the surfaces of these grids, a very large number of crossings or intersections are obtained; the areas of these crossing can be selectively luminesced in various ways, as will be set out more fully hereinafter.

The composition of an image by means of a system employing crossed wires requires that, in some way or other, two wires, i.e., one of each grid, must be energizable at will so that it may be definitely determined which crossing is to produce light at a particular moment. It is obvious that the desired wires may be selected or switched-in in various ways, but in any event, a very rapid switching

or selection action is required. In accordance with the invention, use is therefore made of two electron beams for successive switching of the grid wires, each of which is associated with one of the two grids and each of which is deflected in a single direction. Consequently, by deflection of the two electron beams, each discrete point of the image surface can be excited to produce light. In accordance with a further aspect of the invention, the light is produced by providing a potential difference between the two wires selected to produce the light point; to this end, electrons are supplied to a wire of one grid and electrons withdrawn from a wire of the other grid. If the electrons were supplied to or withdrawn from only one grid wire, a potential difference would obtain at all crossings of this wire with the wires of the other grid. Consequently, one would obtain not one luminescent dot, but as many luminescent dots as there are crossings of this wire with the wires of the other grid.

Based upon the principles outlined above, an electrical device according to the invention, the image surface of which can be caused at discrete points to luminesce, may be constituted as follows. The electric discharge device comprises a first, substantially flat grid member having only wires which do not intersect with one another, and a plurality of secondary-emission electrodes equal in number to the number of wires of the grid and each of which is connected directly to one of these wires. There is also provided a first electron gun producing an electron beam, a first deflection system for causing the beam to scan the secondary-emission electrodes, and a counterelectrode or collector to receive the emitted secondary electrons. Apart from this structure of electrodes, which will be referred to hereinafter as "the first system," the discharge device also comprises a "second system" including a second grid member which is substantially parallel to the plane of the first grid and which has only wires which do not intersect one another, but which wires are each arranged to cross all of the wires of the first grid. In addition, the second system includes a plurality of auxiliary electrodes equal in number to the number of wires of the second grid, together with a second electron gun producing an electron beam and a second deflection system for causing the second beam to scan the auxiliary electrodes. Apart from these two systems, which enable a determination of the discrete points of the image surface to be luminesced, the discharge device includes means to convert a potential difference occurring at a particular image point between the crossed wires into light, either visible or invisible, as desired.

The invention also relates to a system including the discharge device described above, in which an electrical signal is supplied to the first deflection system which determines which wire of the first grid is energized or connected or switched-in, a positive bias voltage V1 is supplied to the counter-electrode, and an electrical signal is supplied to the second deflection system, which determines which wire of the second grid is switched-in. In order to stabilize the operation of a discharge device according to the invention, it may, in some cases, be desirable to connect each wire of the first grid through a high-ohmic resistor to a common point of positive potential V2, which is lower than V1. The wires of the second grid may also be connected through high-ohmic resistors to a common point having a positive bias voltage V3. If the electron beams move in a plane parallel to the grid surfaces and at a small distance therefrom, the use of such resistors is of particular value; otherwise, the potential of the grid wires, which would then not be constant, would produce unwanted deflections of the electron beams. The bias voltages V2 and V3 need not be equal to one another. In order to simplify the further description of the invention, a discharge device in which both the wires of the first grid and those of the second grid are connected through such high-ohmic resistors to points of positive bias voltages V2 and V3, respectively, will be described hereinafter. As a rule, the voltage is calculated with respect to the cathodes of the electron guns.

The device according to the invention exhibits the following important advantages. The image points are no longer determined by the impact of an electron beam on a luminescent screen, but only by the intersections of two wires. These intersections will always have the same form and the same dimensions. The electron beams of the guns are employed only as switching means for the wires. Consequently, their only requirement is that a quantity of electrons can be transported to strike either a secondary emission electrode or an auxiliary electrode. The shape of the cross-section of the beams at the instant of impact on these electrodes is therefore in principle not important. The beam may thus be ribbon-shaped, instead of being circular, as was required with the known devices. This has the advantage that more electrons can be transported. A further advantage is that the electron beams need be deflected only along one direction over the secondary emission electrodes or the auxiliary electrodes. Consequently, there is no need for complicated deflection systems, particularly, where, as here, the shape of the beam cross-section is not very important, so that it may vary upon deflection. Further, one of the most important advantages is that the dimensions of the discharge tube according to the invention may be materially smaller than those of the tubes hitherto used. This is partly due to the fact that the shape of the point of impact of the beam and the method of deflecting the electron beam need not fulfill severe requirements, and partly due to the general geometrical construction of the complete electrode system. Hence, the total length of the device from the electrode struck by the beam to the cathode of the electron gun may be small. If the direction of the electron guns is at right angles to the surface of the grids, the three dimensions of the discharge device according to the invention are determined substantially entirely by the length of the image to be produced, the width thereof, and the length of the electron gun plus the deflection means. A particularly advantageous embodiment of a discharge tube according to the invention has a still smaller dimension in a direction at right angles to the grid surfaces, since in this embodiment the direction of the electron beams and hence that of the electron guns is not at right angles to the grid surfaces but parallel thereto. Thus a completely flat, box-shaped discharge tube is obtained, which can be readily incorporated in a cabinet having a small depth. In this embodiment, the two electron beams required may even be caused to pass in front of the grids.

The invention will now be described with reference to the accompanying drawing, in which:

Figs. 1, 2 and 3 are views of constructions illustrating the principles underlying the invention;

Fig. 4 is a perspective view of one form of discharge device according to the invention, in which the electron beams are directed parallel to the grid surfaces;

Fig. 5 is a perspective view showing details of the construction illustrated in Fig. 4;

Fig. 6 shows diagrammatically another embodiment of a single electrode of the device illustrated in Fig. 5;

Fig. 7 shows still a further embodiment of the electrode system of Fig. 5, in which current distribution is obtained;

Fig. 8 is a view of another embodiment of the electrode system of Fig. 5;

Fig. 9 is a view of a detail of a construction according to another embodiment of the invention;

Fig. 10 shows a detail of a further embodiment of the invention;

Fig. 11 illustrates the use of the invention in a tube for colour television.

Referring now to the drawing, Fig. 1 shows a pair of grids each having wires designated by reference numerals 1 and 2, respectively. The wires 1 of the first grid are located in a flat plane, and the wires 2 of the second grid in a different flat plane which is parallel to the plane of the wires 1. With this construction, a large number of crossings or intersections of the wires 1 and 2 are formed. At these crossings, the distance between two wires of the two grids is designated by the reference numeral 3. If the potentials of a particular wire 1 and of a particular wire 2 are raised and reduced, respectively, a voltage difference is produced at their crossing, which difference may be employed to produce a luminous effect at that area. This may, for example, be obtained in the following manner.

Between the wires, provision is made of a layer of electro-luminescent material 4, as is shown in Fig. 2, in which the wires are now designated 5 and 6, respectively. A suitable material is, for example, copper activated zinc sulfide. It is known that an electro-luminescent material produces light when it is disposed between two electrodes between which a potential difference exists. Consequently, if at a crossing between a wire 5 and a wire 6 such a voltage difference is produced, the luminescent material at this crossing and only at this crossing will become luminescent. Thus, if in some way or other, the wires 5 and 6 are energized or switched-in, a luminous phenomenon may be produced at any crossing. It is obvious that in this manner an image may be composed by switching-in the wires 5 and 6 of the two grids in a particular order of succession. Instead of using wires, conductive strips may be provided on the electro-luminescent material. In this latter case, the material will have to be electrically insulating.

The light may be produced at the desired crossings not only by using electro-luminescent material, but also by other means. For example, if the wires of one of the grids are shaped in a particular form, for example, with sharp edges or points, and if means are employed to render this grid negative during the operation of the device relative to the other grid, a so-called "cold" or "field" emission will occur at a particular voltage difference from the negative wires to the wires of the other grid. Now, by coating the wires of the other grid with a material which produces light upon electron impact, like the well known phosphor materials, e.g. willemite, a luminescent image will also be produced.

As an alternative, the wires which become negative during the operation of the device may be coated with one of the well known photo-emissive materials, e.g. caesium oxide. If a source of radiation is provided inside or outside the tube to excite this photo-emissive material, emission of the electrons from the wires thus coated will be produced. Only at the point where a positive field gradient prevails will a directional photo-current be produced and will the photo-electrons reach the positive wire. Consequently, this will occur only at a crossing of a negative wire and a positive wire. Again, if the positive wires are coated with a phosphor material which will luminesce upon electron impact, a luminous image may be composed.

There is a possible further alternative in which the tube or at least the part thereof between the grids is filled with a suitable gas e.g., neon or krypton, under a particular pressure e.g., 10^{-1} of mercury, in a manner such that at a suitable voltage difference produced at a crossing, a luminescing gas discharge will be produced at that area.

Although in the foregoing description, reference is made to "light," it is obvious that this does not necessarily mean visible radiation, though this would be the preferred arrangement. Alternatively, use may be made of a radiation which is not visible to the human eye, since this radiation may be converted by various well-known means into visible light. Also, for particular purposes, such a conversion may not even be necessary.

For example, in the case of photographs used for facsimile transmission.

Fig. 3 shows diagrammatically how particular grid wires can be energized or switched-in by means of electron beams. In this figure, the wires of one grid are designated 7 and the wires of the other grid 8. The ends of the wires 7 can be switched-in by an electron beam 9, which may be produced by an electron gun 10 and deflected over the ends of the grid wires 7 by an electrostatic deflection system comprising plate-shaped electrode 11 and 12. The ends of the wires 8 may be switched-in in a similar manner by an electron beam 13, which is produced in an electron gun 14 and deflected by means of a set of deflection plates 15 and 16. Of course, instead of using electrostatic deflection systems, one may use electromagnetic deflection systems.

The position of the electron guns may be chosen within wide limits. This is illustrated in Fig. 4. Referring to that figure, reference numeral 17 designates a box-shaped envelope of a discharge tube according to the invention. This box-shaped envelope is provided with two side cylindrical branches 18 and 19 communicating with the interior. The box 17 contains two grids 20 and 21. The branch 18 contains an electron gun 22 and a set of deflection plates 23 and 24. Thus a beam may be obtained and deflected from that branch, this beam extending substantially parallel to the planes of the grids 20 and 21. On the side opposite the branch 18, the wires of the grid 21 are connected to upright plates 25. The electron beam of the gun 22 may thus cooperate with these plates 25 and selectively switch-in the wires of the grid 21. In a completely similar manner, an electron gun 22′ and a set of deflection plates 23′ and 24′ in the branch 19 cooperate with the wires of the grid 21. Instead of providing plates 25, the ends of the grid wires may be bent, so that the electron beams can impact on these ends.

In the embodiments shown the grids have wires extending parallel to one another in each grid, and the wires of the different grids cross each other at right angles. This is, however, not necessary. What is merely necessary is that crossings are produced all over the image surface, however obtained.

It has been explained in principle how discrete points of an image surface of a discharge device according to the invention may be selected and caused to luminesce by raising the potential of a wire of one grid and reducing the potential of a wire of the other grid. This may be accomplished in the following manner. The potential of an electrode is increased by connecting it to an emitting electrode. With a discharge device according to the invention, it is, of course, not practical to use a filament wire as the emitting electrode, since in this case it would be very difficult to provide an increased potential at a particular wire. In accordance with the invention, the wires of one of the two grids, termed the first grid, are each connected to a secondary-emission electrode. A plurality of such secondary-emission electrodes are arranged in one plane alongside but spaced from one another within the tube. By means of the electron beam from the first gun, secondary emission can be selectively produced from any secondary-emission electrode at a given instant. If more electrons are produced than impact this electrode, which is readily attained with conventional secondary-emissive materials, the potential of this secondary-emission electrode will increase and hence also that of the grid wire connected thereto. The potentials of the other wires, which are connected to non-impacted secondary-emission electrodes, remain at predetermined levels, since each wire and hence each secondary-emission electrode is connected through a high-ohmic resistor to a common point having a positive potential V2. A suitable secondary-emission material is, for example, magnesium oxide.

In this connection, it may be observed that these high-ohmic resistors may be provided inside or outside the electric discharge device. They will preferably be arranged inside the tube, where they are connected to a single electrode, which in turn is connected via a current supply wire to the external circuit. Thus, a large number of through-connections in the envelope is avoided. The high-ohmic resistor may, in this case, be constituted by a portion of a semi-conductive strip. Also the secondary electrons must, of course, be collected, and to this end a counter-electrode is provided in the proximity of the secondary emission electrodes, which counter-electrode may be connected to a positive voltage V1, which exceeds V2.

Fig. 5 shows one such embodiment of the system comprising secondary-emission electrodes and counter-electrodes. In this figure, reference numeral 26 designates part of the envelope of the discharge device. The wires of one grid are designated 27. They are each connected to one of a series of secondary emission electrodes 28. These secondary-emission electrodes are in turn connected through a common semi-conductive strip 29 to a conductive strip 30, which may have a positive potential V2 applied thereto. In front of the series of secondary-emission electrodes 28, there is provided a counter-electrode 31, in which apertures 32 are provided. Reference numeral 33 designates an electron beam which originates from an electron gun composed of a cathode 34, a control electrode 35, an accelerating anode 36 and a final anode 37 associated with a deflection system, consisting of two plates 38 and 39. By means of the deflection system, the beam can be selectively directed to any one of the secondary-emission electrodes 28 through the apertures in the counter-electrode 31. The latter is connected to a point of a voltage source 80 having a voltage V1, which exceeds V2. Secondary emission from the impacted electrode will cause the potential of the latter to be increased, while the potentials of the remaining electrodes, and wires secured thereto, will remain the same. The resistance between each of the secondary emission electrodes 28 and the source of potential V2 should be of the order of 10^8 ω.

A decrease in potential at an electrode can be obtained only when electrons are supplied to this electrode. The grid opposite the grid of which the wires are connected to the secondary-emission electrodes, termed hereinafter the second grid, must, consequently, receive electrons from a source of electrons. This may be realized in a very simple manner by connecting them to auxiliary or electron-receiving electrodes, which are mounted to be struck by the electron beam from the second electron gun. Thus, a structure is obtained in which a series of auxiliary electrodes is provided in the device opposite the second electron gun and the associated deflection system. Now, by suitable energization of the deflection system, a particular auxiliary electrode can be struck by the beam, in which case the potential of this electrode and of the grid wire connected thereto drops. The auxiliary electrodes not struck and the wires connected thereto remain at a predetermined positive potential, since they are all connected through high-ohmic resistors to a source of positive voltage V3. These high-ohmic resistors, 10^9 ohms being a typical value, may be provided inside or outside the discharge device and be constituted, if desired, by parts of semi-conductive strips. Fig. 5 shows diagrammatically also this second system. The auxiliary electrodes 40 of the second system are each connected through a high-ohmic resistor 41, to a common current supply wire 42. This supply wire 42 may be connected in turn outside the tube to a source 81 having a voltage V3. Reference numeral 43 designates an electron beam which is produced by an electron gun of a construction similar to that cooperating with the first system and which may be deflected by means of a deflection system over the electrodes 40. By the construction described in connection with Fig. 5, it will be possible to achieve potential differences between the energized wires of the order of 250 volts. Reference numeral **44** designates a layer of electroluminescent material which emits radiation when excited by this voltage.

Instead of the electroluminescent layer **44** in Fig. 5 a shallow closed box may be used filled with a suitable gas, e.g. neon or krypton or a mixture thereof, at a pressure such that due to the potential difference set up at a crossing point a tiny luminescing gas discharge is generated.

Instead of using the special secondary-emission electrodes **28** and the auxiliary electrodes **40** of Fig. 5 the terminations of the grid wires connected to these electrodes may be employed, these terminations being bent at right angles to intercept the electron beam. Further, in lieu of supplying electrons to the second grid by directing the electron beam from the second gun to the grid wires or auxiliary electrodes connected directly thereto for direct current, the electron beam may be caused to strike separate auxiliary electrodes provided in the tube opposite the ends of the wires of the second grid wherein these electrodes have secondary-emission properties. Such an embodiment is shown in Fig. 6, in which **49** designates a single grid wire. The auxiliary electrode is designated by **50**; it is struck by an electron beam **51**. If the electrode **50** possesses secondary-emission properties on the side facing the wire and if it is at a potential V4 during operation—V4 being lower than the potential of the wire **49**—the secondary electrons produced by the beam **51** from the electrode **50** will travel to the wire **49**, the potential of which will thereby be reduced. It is assumed that a high-ohmic resistor connected to the electrode **49** has a value such that the secondary electrons are not conducted away too rapidly, so that the potential of the wire **49** remains substantially constant. Further, in order to improve the collection of the secondary electrons, additional electrode **52** may be connected to the wire **49** as shown in the figure. This additional electrode **52** may, for example, be replaced by the widening of an end of the wire **49** bent at right angles. This construction has the advantage that only one secondary-emission electrode is required for all the wires.

By means of a discharge device of the kind described with reference to the foregoing figures, each discrete point of the image surface, i.e. each crossing of the wires of the two grids, may be caused to luminesce by supplying suitable signal voltages to the two electron guns and the associated deflection systems. In many cases, for example with radar and oscillography, this will suffice; but in other cases, for example television and facsimile transmission, it is furthermore required that in addition the intensity of the light produced at a point is controlled. This may be achieved in several ways.

There are available two electrode systems and the associated grids. The signal controlling the luminous intensity may be applied to one of the two systems. There will first be described an arrangement in which the intensity control-signals are applied to the first system. The most simple control is, of course, that in which the control voltages are applied to a control grid provided in the electron gun, for example, a Wehnelt cylinder. Thus, the intensity of the electron beam can be varied and hence the secondary emission of the electrode struck by this beam, and hence also the potential of the grid wire connected thereto. The value of the increase in potential of this wire depends, of course, upon the intensity of the electron beam. It is assumed again that the charge cannot be dissipated very rapidly due to the high-ohmic resistors.

A further method of controlling the intensity of the secondary emission resides in that the current transmitted by the beam is distributed, in accordance with the intensity control-signal, over the secondary-emission electrode and an additional collecting electrode. Such an embodiment is shown in a cross-sectional view in Fig. 7. In this figure, reference numeral **53** designates a single grid wire, which is connected to a secondary-emission electrode **54**. In front of this electrode **54**, which is at a potential V1, provision is made of a counter-electrode **55** with a window **56**. An additional electrode **57** is arranged behind and to the side of the secondary-emission electrode **54**. An electron beam **58** may be deflected by a deflection system (not shown) over the series of secondary-emission electrodes along a direction at right angles to the plane of the drawing. As is evident from the figure, part of the electron flow is collected by the secondary-emission electrode **54** and another part is collected by the additional electrode **57**. The ratio of the current distribution of these parts is determined by the potential of a deflection electrode **59**, which is provided alongside the beam **58** and to which the intensity control-signal is applied. This electrode **59** may be common to all the secondary-emission electrodes. Instead of arranging it near the secondary-emission electrode, it may be arranged near the electron gun. It need not, in the latter case, be very large, so that it has a lower capacity and it will thus operate more satisfactorily at higher frequencies.

Instead of using two electrodes **54** and **57**, only the electrode **54** with secondary-emission properties could be utilized, in which case the surface facing the electron beam could be prepared in a manner such that the secondary-emission coefficient is not the same at all points. In this case, the secondary-emission current would depend upon the area where the beam **58** strikes the electrode **54**, so that the desired control may be carried out by means of the deflection electrode **59**. If desired, use may also be made of the fact that secondary emission varies with the angle at which the primary electrons strike the secondary-emission surface.

With the intensity control described above, it is necessary that the potential of the wire of the second grid which is energized should not or substantially not vary with the current between the two switched-in wires; this current will be termed hereinafter the discharge current. This will be the situation when the auxiliary electrode of the wire of the second grid which is energized has secondary-emission properties. However, it is possible to obtain a potential of the wires of the second grid which is independent of the discharge current by so-called current distribution. In this case, auxiliary electrodes may be used, which are connected directly for direct currents to the wires of the second grid. The term "current distribution" is to be understood to mean that the potential of thee auxiliary electrode energized and hence that of the switched grid wire determines what part of the current of the second electron beam will strike the auxiliary electrode. To this end, it is necessary that near the auxiliary electrode, there should be provided an additional deflection electrode which is conductively connected for direct current with the auxiliary electrode and which is arranged in a manner such that deflection of the beam causes a larger or smaller part thereof to strike the auxiliary electrode. A part of the electrode system exhibiting this characteristic is shown in Fig. 8. In this figure, reference numerals **60**, **61**, **62** and **63** designate the auxiliary electrodes connected to the wires **64**, **65**, **66** and **67**. The electron beam is designated by **68**. Each auxiliary electrode has a transverse partition **69**, **70**, **71** and **72** respectively, which extends alongside the electron beam **68**. Due to the potential of the parts **69** to **72**, the beam will be deflected. Behind and above the auxiliary electrodes is arranged a common collecting electrode **73**. The potential of each grid wire and hence of the deflecting parts **69** to **72** determines how much of the electron beam **68** will strike the auxiliary electrodes **60** to **63** and how much will strike the collecting electrode **73**. It is evident that thus the potential of the grid wires **64** to **67** becomes substantially independent of the discharge current, since a distribution equilibrium will be established. The electrode **73** is, of course, not strictly required, but, as a rule, it will be desirable to provide that the electrons not collected by the auxiliary electrode will not travel freely about in the tube. The construction shown in Fig. 8 may, of course, be also varied in a manner such that the additional deflection of the beam takes place in the same direction in which the series of auxiliary electrodes is scanned. To this end, the deflecting transverse partitions of the auxiliary electrodes may be provided on the other sides of these electrodes.

The above constructions involve control of the intensity of the discharge in the first system. It is, however, possible to carry out this control in the second system. This has the advantage that no particular measures are required to render the potential of the first grid independent of the discharge current, since the wires of the first grid are connected in any event to a secondary-emission electrode. As with the control in the first system, control in the second system may be accomplished by a grid in the electron gun or by means of an additional deflection system provided alongside the auxiliary electrodes or near the electron gun, the potential of this deflection system, which is determined by the intensity control-signal supplied thereto, determining how much of the electron beam from the second electron gun will strike the auxiliary electrode. The larger this amount the lower will be the potential of the grid wire connected to the auxiliary electrode. As with the control in the first system, the electron beam may be deflected by means of the additional deflection system in a direction which does not coincide with the direction in which the electron beam is deflected by the other deflection system associated with this electron gun, and which is preferably at right angles thereto. However, as an alternative, these two directions may be caused to coincide. With all methods described above for the control of the intensity of the discharge by supplying signals to electrodes of the second system, it is possible to utilize or not to utilize secondary-emission. It is only essential that the quantity of electrons striking the grid wires should vary with the intensity control-signal. Also in connection with control in the second system, use may be made of a varying secondary-emission factor, either by a variation of the angle of incidence of the second beam on a secondary-emission auxiliary electrode, or by a variation of the secondary-emission coefficient over this surface at different points.

In Fig. 9 of the drawing part of a number of crossing grid wires is shown for an embodiment of the invention which does not use electroluminescent material. In this Fig. 9, **90** designates a cross-section of three wires of the first system, the potential of which is raised during operation of the tube. The wires **90** are coated with a layer **91** of a material luminescing under electron impact, such as willemite. Reference numeral **92** designates a wire of the second system, the potential of which is lowered during operation of the tube. This wire **92** is provided with sharp points **93** on the side of the wires **91**. At a crossing of a wire **90** which has become positive and a wire **92** which has become negative "cold" or "field" emission will occur with the wire **92** functioning as the cathode and the wire **90** as the anode. Then electrons strike the luminescent coating **91** of that particular wire **90**, which thus shows a luminescent point.

Fig. 10 shows another embodiment of the invention which does not use electroluminescent material. With reference numeral **94** part of a wire of the first system is designated, which is coated with a material **95**, e.g. willemite, luminescing under electron impact. Three cross-sections of wires **96** of the second system are shown, which on the sides facing the wire **94** are covered with photo emissive material, e.g. caesium oxide. A source of radiation **98** which may be placed inside or outside the tube throws its rays on the coatings **97** and thus provokes an electron emission. If at a particular crossing of a wire **94** and a wire **96** a suitable potential difference prevails these emitted electrons will flow in the direction of the wire **94** and strike the luminescent coating **95**, which thereupon emits its particular radiation. The source **98** may be so chosen that its radiation does not excite directly the luminescent coating **95** on the wires **94**.

The arrangements and discharge devices described above may be used for the reproduction of television images. In this case, the two sets of grid wires are energized either by means of so-called step voltages or by means of saw-tooth voltages, which are applied to the deflection systems of the two guns. These voltages are then synchronized by means of incoming synchronizing pulses. In this instance, it is advantageous to make the number of grid wires equal to the number of lines of the image to be reproduced. During the tracing of one line, the same grid wires may be used. The transition of the electron beam from one grid wire to the next wire may thus be synchronized with the line synchronizing pulses. In this case, the number of grid wires is minimized.

A device according to the invention may also be suitable for the reproduction of color images. To this end, the system described above may be provided with a multiple grid. As a rule, three primary colors will be employed, and hereinafter such a system will be described for the sake of simplicity.

In general, it is not necessary to provide triple the number of wires for the two grids, but it will suffice to triple only the number of wires of one grid. It is obvious that with this grid, three electron beams may be employed so that each color may be reproduced separately. Such a discharge device is, however, rather complicated. A simpler solution is possible employing two electron guns, and in which the number of wires of the first grid is tripled and three adjacent wires of this grid are always simultaneously energized. These three wires are coated with three different luminescent materials, which produce the primary colors upon electron impact, or they cooperate with three similar electro-luminescent substances. If a common counter-electrode is provided for the secondary-emission electrodes of the first grid of all wires associated with one color, a simultaneous reproducing system may be obtained by supplying to this counter-electrode suitable color intensity signals, and a signal for the total brightness to the intensity control-electrode of the second system. Now, if E_y designates the total brightness signal, and E_r, E_g and E_b the intensity signals for the different colors, the signals E_r—E_y, E_g—$_y$ and E_b—E_y are supplied to the counter electrodes of the first system. To the intensity control-electrode of the second system is supplied the signal E_y. Thus, the voltages E_r, E_g and E_b are obtained between the wires.

In Fig. 11 the above described system with only the number of grid wires corresponding to the first grid in the other figures is shown tripled. This grid is composed of a large number of parallel wires, part of which is shown and designated with the reference numerals **101**—**109**. These wires are connected to secondary emissive strips which for the sake of simplicity will here be designated with the reference numerals **101*s***, **102*s*** etc. These strips are fastened to a block **100** of insulating material, e.g. that known under the trade name "Kersima," and cooperate with counterelectrodes **111**—**119** which collect the secondary electrons. The electrodes **111**—**119** are equally fastened to the block **100** and in fact consist of the obliquely bent teeth of three camlike strips **120**, **121**, and **122**. Thus the electrodes **111**, **114** and **117** are directly connected to each other as well as the electrodes **112**, **115** and **118** and the electrodes **113**, **116** and **119**. At the back-side of the block **100** the strips **120**, **121** and **122** are insulated from each other by insulating strips **123** and **124**, e.g. consisting of mica.

The secondary emission strips **101*s*** to **109*s*** are connected to a metal strip **125** by the intermediary of a semiconducting strip **126**.

The electron beam is designated with **127**; it is deflected in the direction of the double pointed arrow and has a dimension in the deflection direction such that it can strike three secondary emission strips at the same time.

The grid wires **101**—**109** cooperate with the wires of a second grid (not shown) extending in directions perpendicular to the wires **101**—**109**. This part of the electrode system is exactly identical to that shown in the foregoing figures.

To explain the working of the color television tube it is supposed that the light is generated in the way illustrated in connection with Fig. 10. Thus the wires of the second grid have sharp points to provoke under suitable voltages, "cold" or "field" emission. The wires **101**, **104** and **107** are covered with blue luminescing material, e.g. titanium activated calcium-magnesium-silicate, the wires **102**, **105** and **108** with green luminescent material, e.g. copper-activated zinc-sulfide and the wires **103**, **106** and **109** with red luminescent material, e.g. bismuth-activated calcium pyrophosphate.

In the figure the beam **127** falls on the secondary emission strips **104***s*, **105***s* and **106***s* and due to the emitted secondary electrons contact will be established with the strips **114**, **115**, and **116** and thus with the modulating sources providing the signals E_b—E_y, E_g—E_y and E_r—E_y. The wires **104**, **105** and **106** will therefore equally obtain the potentials E_b—E_y, E_g—E_y and E_r—E_y. At a point where these wires cross a wire of the second grid which, in the manner explained in connection with the other figures, is brought to a potential E_y, light will be generated corresponding to E_b, E_g or E_r.

As explained in connection with Fig. 5 the counter-electrodes **111**—**119** must be connected to a D.C. voltage **V1** and the secondary emission strips to a D.C. voltage V1, V1 being greater than **V2**.

Between the obliquely bent strips **111** to **119** screening means may be necessary to avoid interaction of the color switching signals.

While we have described our invention in connection with specific embodiments and applications, other modifications thereof will be readily apparent to those skilled in this art without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An electrical device comprising a first grid member and a second grid member each comprising non-intersecting conductive members, the conductive members of the first grid providing with the conductive members of the second grid a plurality of crossings, means associated with said crossings for luminescing when a potential difference between said conductive members exists at said crossings, and means including electron beam producing means to raise the potential of a conductive member of said first grid and to lower the potential of a conductive member of said second grid, thereby to produce a potential difference therebetween at their crossing and thus produce a luminescing spot thereat.

2. An electrical discharge device comprising a first grid of spaced substantially parallel conductors, a second grid of spaced substantially parallel conductors in spaced relationship with said first grid, the conductors of said second grid providing with the conductors of said first grid a plurality of crossings, means associated with the conductors at said crossings for producing radiation when a given potential difference is established between crossed conductors, first electron beam producing means associated with said first grid for withdrawing electrons selectively from the conductors thereof, and second electron beam producing means associated with said second grid for supplying electrons selectively to the conductors thereof, whereby simultaneously withdrawing electrons from a conductor of said first grid and supplying electrons to a conductor of said second grid establishes at their crossing a potential difference sufficient to generate radiation thereat.

3. A device as set forth in claim 2 wherein one of the electron beam producing means includes means for controlling the intensity of the beam.

4. An electric discharge device as claimed in claim 8 in which the light-producing means includes a layer of electro-luminescent material disposed between the two grids.

5. An electric discharge device as claimed in claim 2 in which the radiation producing means comprises a layer of luminescent material on the conductors of the first grid facing the second grid, said conductors of the second grid having sharp edges, whereby the potential difference between the conductors of the grids will cause electrons to be emitted from the second grid and excite the luminescent material to produce light.

6. An electric discharge device as claimed in claim 2 wherein the radiation-producing means comprises a gas filling between the two grids, whereby the potential differences between the two grids produces a luminescent gas discharge.

7. An electric discharge device comprising an envelope, a substantially flat first grid in said envelope and constituted of a plurality of spaced parallel wires, a plurality of secondary-emission electrodes each coupled to one of the wires of said first grid, first beam producing means in said envelope for producing a first electron beam, first deflection means for causing the first beam to scan the secondary-emission electrodes to selectively raise the potential of the wires coupled thereto, means in the vicinity of said secondary-emission electrodes for collecting electrons produced thereby upon being impacted by the beam, a second grid mounted in the envelope substantially parallel to the first grid and constituted of a plurality of spaced parallel wires, each of the wires of said second grid crossing substantially all of the wires of said first grid and defining therewith a plurality of crossings, a plurality of auxiliary electrodes each coupled to a wire of the second grid, second beam producing means in said envelope for producing a second electron beam, second deflection means for causing the second beam to scan the auxiliary electrodes to selectively reduce the potential of the wires coupled thereto, and means in the envelope associated with said first and second grids for producing light at the crossings at which differences of potential exist.

8. An electric discharge device comprising an envelope, a substantially planar first grid in said envelope and constituted of a plurality of spaced parallel conductors, a plurality of secondary-emission electrodes each coupled to one of the conductors of said first grid, first beam producing means for producing a first electron beam mounted in said envelope such that the beam path extends substantially parallel to and over the planar grid, first deflection means for causing the first beam to scan the secondary-emission electrodes to selectively raise the potential of the conductors coupled thereto, means in the vicinity of said secondary-emission electrodes for collecting electrons produced thereby upon being impacted by the beam, a second grid mounted in the envelope substantially parallel to the first grid and constituted of a plurality of spaced parallel conductors, each of the conductors of said second grid crossing substantially all of the conductors of said first grid and defining therewith a plurality of crossings, a plurality of auxiliary electrodes each coupled to a conductor of the second grid, second beam producing means for producing a second electron beam mounted in said envelope such that the beam path extends substantially parallel to and over the planar grid, second deflection means for causing the second beam to scan the auxiliary electrodes to selectively reduce the potential of the wires coupled thereto, and means in the envelope associated with said first and second grids for producing light at the crossings at which differences of potential exist.

9. An electric discharge device as claimed in claim 7,

in which the secondary-emission electrodes constitute part of the wires of the first grid.

10. An electric discharge device as claimed in claim 9, in which the secondary-emission electrodes are constituted by bent ends of the grid wires.

11. An electric discharge device as claimed in claim 7 in which the auxiliary electrodes constitute part of the wires of the second grid.

12. An electric discharge device as claimed in claim 11, in which the auxiliary electrodes are constituted by bent ends of the grid wires.

13. An electric discharge device as claimed in claim 7, in which the auxiliary electrodes exhibit secondary-emission properties and are mounted opposite and spaced from the ends of the wires of the second grid.

14. An electric discharge device as claimed in claim 3 in which the auxiliary electrodes include a portion extending alongside the electron beam and adapted to deflect the beam and thereby determining how much of the beam will strike the auxiliary electrode, and an additional electrode is provided capable of collecting that part of the beam which does not strike the auxiliary electrode.

15. An electric discharge device as claimed in claim 8 in which an additional deflection system is provided to control how many of the electrons from the first beam producing means will strike the secondary-emission electrodes.

16. An electric discharge device as claimed in claim 15 in which the additional deflection system is mounted near the beam producing means and deflects the beam in a direction at right angles to that due to the first deflection system associated with this beam producing means.

17. An electric discharge device as claimed in claim 8 in which an additional deflection system is provided to control how many of the electrons from the second beam producing means will strike the auxiliary electrodes.

18. An electric discharge device as claimed in claim 17 in which the additional deflection system is mounted near the beam producing means and deflects the electron beam in a direction at right angles to that due to the second deflection system associated with this beam producing means.

19. An electric discharge device as claimed in claim 7 in which a plurality of luminescent substances which emit light of different colors upon being excited by electrons are applied in a regular array to the wires of the first grid and all the secondary emission electrodes of the wires of the first grid having the same luminescent substance are associated with common collecting means.

20. An electric discharge device as claimed in claim 7 in which a plurality of electro-luminescent substances which luminesce in different colors are provided associated with the first grid, and all the secondary-emission electrodes associated with the same luminescent substance have common collecting means.

21. An electric discharge device comprising a substantially flat first grid constituted of a plurality of spaced parallel wires, a plurality of secondary-emission electrodes each coupled to one of the wires of said first grid, first beam producing means for producing a first electron beam, first deflection means for causing the first beam to scan the secondary-emission electrodes to selectively raise the potential of the wires coupled thereto, means in the vicinity of said secondary-emission electrodes for collecting electrons produced thereby upon being impacted by the beam, a second grid mounted substantially parallel to the first grid and constituted of a plurality of spaced parallel wires, each of the wires of said second grid crossing all of the wires of said first grid and defining therewith a plurality of crossings, a plurality of auxiliary electrodes each coupled to a wire of the second grid, second beam producing means for producing a second electron beam, second deflection means for causing the second beam to scan the auxiliary electrodes to selectively reduce the potential of the wires coupled thereto, means associated with said first and second grids for producing light at the crossings at which differences of potential exist, means for applying an electric signal to said first deflection means to select a wire of the first grid to be energized, means for applying another electric signal to said second deflection means to select a wire of said second grid to be energized, means for applying positive voltages to said secondary emission and auxiliary electrodes, and means for applying a positive voltage to the collecting means for the electrons produced by the secondary-emission electrodes, said voltage on said collecting means being higher than the voltage on said secondary-emission electrodes.

22. A device as claimed in claim 21 in which a high-ohmic resistor is connected to each wire of the first grid, and the resistors are all coupled to a common positive voltage.

23. A device as claimed in claim 21 in which a high ohmic resistor is connected to each wire of the second grid, said resistors all being connected to a common positive voltage.

24. A device as claimed in claim 21 in which means are provided for applying a signal to the collecting means to control the quantity of light produced between the two grids.

25. A device as claimed in claim 21 in which means are provided for applying an intensity control signal to the beam-producing means to control the light intensity.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,890,376 June 9, 1959

Adriaan Gerard van Doorn et al

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 63, for "10^{-1} of mercury," read -- 10^{-1} cm of mercury, --; column 8, line 49, for "thee" read -- the --; column 10, line 48, for "E_g—$_y$" read -- E_g—E_y --.

Signed and sealed this 1st day of December 1959.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

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Commissioner of Patents

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