Oct. 21, 1941.

H. IAMS

2,259,507

ELECTRONIC RELAY DEVICE

Filed Dec. 19, 1936

Fig. 1

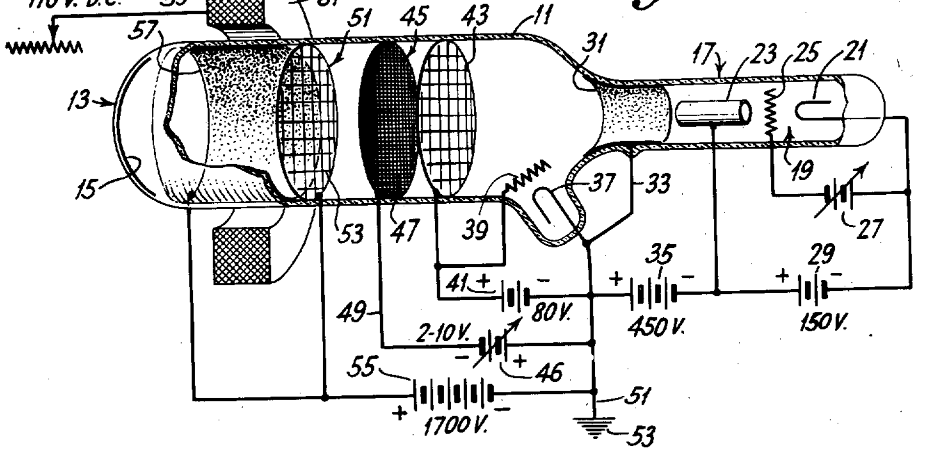


Fig. 2

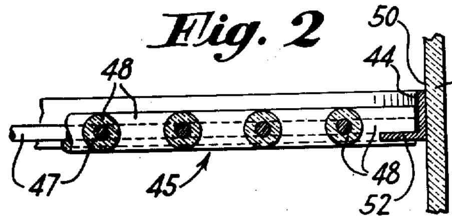


Fig. 3

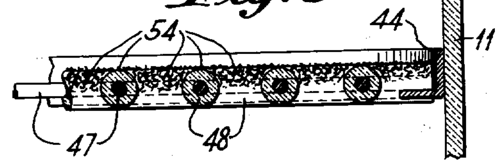
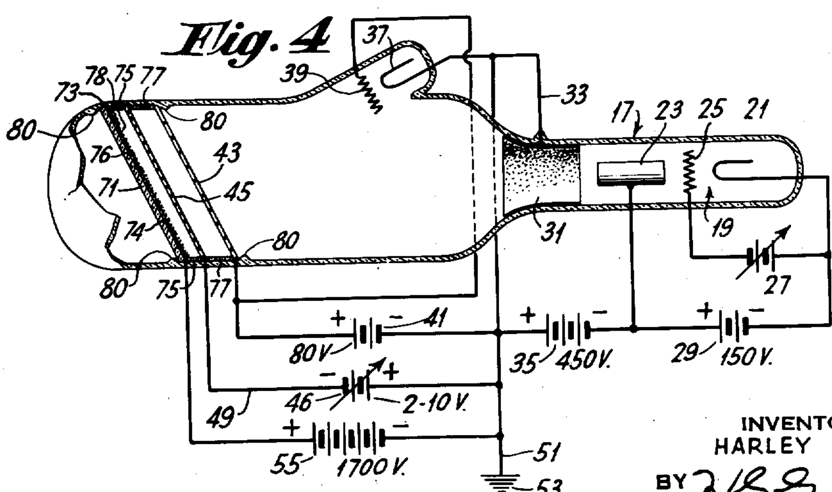


Fig. 4



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UNITED STATES PATENT OFFICE

2,259,507

ELECTRONIC RELAY DEVICE

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Application December 19, 1936, Serial No. 116,689

27 Claims. (Cl. 178—7.5)

This invention relates to an electronic relay device which is controlled by a concentrated electron beam.

More specifically the present invention relates to electron tubes and particularly to electron tubes of the so-called cathode ray type. Such tubes may be used for reproducing any electrical phenomena and find particular use in television systems, both as receiving and transmitting instrumentalities, in connection with the production of electro-optical images, although these devices also are useful in oscillograph installations where electrical transients are to be observed. With such a type tube or electronic device, and considering a light producing tube for the purpose of this description, provision is made whereby the lights and shadows of the subject of which an image is to be reproduced are converted into corresponding electro-optical effects through the conversion of the light of the image or subject at the point of transmission into electrical signals which then are adapted to control in any desired manner an electron beam in such a type tube in accordance with the varying signal strengths.

In the past, it has been customary in the reproduction of electro-optical effects by electronic tubes of the cathode ray type to develop a concentrated electron beam which is projected axially and longitudinally of the tube so as to impinge upon a luminescent screen to produce upon the screen both a phosphorescent and a fluorescent effect, with a result that light is developed. The intensity of the light is determined, for example, by the electron density per elemental area of the impinging cathode ray or electron beam or it is determined by the velocity with which the impinging cathode ray beam traverses the luminescent screen or, it is controlled, for example, by the cross-sectional area of the electron beam, that is to say, the beam density, as it impinges upon the luminescent screen. The foregoing examples of spot brilliance control methods are merely illustrative and are not intended to cover all forms of intensity control for an electron beam but rather are intended merely as representative of various ways and means which may be and have been adopted for the purpose.

In order to cause the resultant luminous spots to cover a field of view, that is, to trace a two dimensional image upon the luminescent screen, the developed electron beam or cathode ray is caused to be swept simultaneously across the luminescent screen in two mutually perpendicular paths according to any desired pattern of traversal. The movement of the electron beam or cathode ray across the luminescent screen is accomplished by the aid of mutually perpendicular electrostatic deflecting fields, mutually perpendicular electromagnetic deflecting fields, or a combination of electrostatic and electromagnetic deflection means. The developed electron beam after being formed is suitably focussed into a sharply defined spot of desired size and configuration upon the screen so that as the control beam sweeps the screen and traverses it according to any desired pattern (such patterns, for example, may be a series of parallel adjacent paths, an interlaced series of parallel paths, a series of prallel paths alternately changing direction along the path of a spiral, or many other forms), there will be produced either the image of some subject from which controlling signals were initially developed or there will be produced a trace of some electrical phenomenon which is to be represented.

With the prior art devices, however, it has been found that a practical limit of beam current is soon reached without attaining desired optimum spot brilliance with the result that it is very difficult, if not entirely impossible, to increase substantially the brilliance of the resulting luminescent effect because the beam current cannot well be increased. This relatively small beam current is the result of the small size of cathode emitter which is necessary if satisfactory focusing of the resultant cathode ray and a minimum amount of spherical aberration is to be obtained, and conventional types of large size emitters, which would permit high beam currents, would thus tend to sacrifice definition for high luminosity. The lack of adequate brilliance also is due partly to the fact that the developed electron beam or cathode ray sweeps the luminescent screen very rapidly and impinges upon each elemental section thereof only for a very short time period for the purpose of producing the luminescent effect. Not only does the resultant apparent brilliance of the luminescent effect with such types of devices of the prior art fail in many instances to reach a desired optimum brilliance, but also there results from such types of image producing electronic devices a certain flicker effect and apparent line structure of the luminescent trace which is to a greater or lesser degree objectionable and annoying to the observer.

Therefore, an object of the present invention has been that of developing ways and means for limiting and avoiding substantially the flicker and "line structure" effects in electronic light producing devices.

A further object of the invention is to provide ways and means and a new method for obtaining the effect of continuity of illumination over the entire luminescent screen area without deliberately changing the character of the luminescent material from a relatively short to an unusually long time decay period.

A further object of the invention is to provide a method of and ways and means for maintaining continuity of electronic bombardment of a luminescent screen over long periods of time and still to provide ways and means for controlling the resultant continuity of the luminescent spots in accordance with some controlling signal.

A further object of the invention is to provide ways and means for flooding a screen structure, such as the luminescent screen, continuously with high velocity electrons to cause light to be developed upon the screen surface, and then to control the intensity of the developed light at each elemental area of the luminescent screen structure in accordance with some controlling signal.

Still other objects of the invention are to provide ways and means for and a method of intensifying substantially the brilliance of electro-optical effects developed by electronic bombardment upon a luminescent screen of an electronic device.

Still further objects and advantages of the invention will immediately suggest themselves and become apparent to those skilled in the art from reading the following specification and claims in connection with the accompanying drawing, wherein

Fig. 1 illustrates conventionally one form of electronic device for accomplishing the aims and objects of the invention as above noted;

Fig. 2 represents a partial sectional view through the insulated grid structure of Fig. 1 and shows a part of the tube wall;

Fig. 3 is a view similar to Fig. 2 but shows a modified form of insulated grid structure; and,

Fig. 4 is a modification of the arrangement of Fig. 1.

In the preferred embodiment of the present invention, ways and means are provided for developing within an electronic tube of the cathode ray type a signal controlled and focussed electron beam or cathode ray which is to be directed upon the luminescent screen structure of the tube. This controlled electron beam is then caused to be swept over the entire area of the luminescent screen structure by suitable electron beam developing means of the character hereinabove mentioned. In addition to the controlled intensity electron beam, the luminescent screen structure of the cathode ray tube is also arranged to be subjected to or "flooded" over substantially its entire area by uncontrolled intensity or, in other words, constant density flow, electrons of suitable velocity to cause luminescence from the screen structure. The uncontrolled intensity electrons are so directed toward the screen structure as to tend to cause normally high brilliance illumination from all elemental areas of the screen structure.

As will be herein pointed out in more detail when considering the structural arrangements of the suggested forms for the invention, there is interposed between both electron sources, that is, the uncontrolled source and the electron beam source, a series of electrodes on at least one of which electro-static charges are built up in accordance with the intensity of the electron of the controlled electron beam. These produced electrostatic charges, in turn, control the number of uncontrolled electrons which can pass through to the luminescent screen. In this way, there is provided intermediate each electron source and the luminescent screen which is to produce light representative of some subject, a valve or insulating grid structure which controls the total number of electrons which will strike or bombard the luminescent screen at all times. The charges which are built up on the electrodes intermediate the two electron sources and the luminescent screen are dissipated in the interval between successive traversals of each elemental area of the electrode intermediate the electron source and the screen so that the electron beam as it traverses the electrode serves to modulate, so-to-speak, the uncontrolled electron stream, and thus vary the brilliance of the luminous spots produced.

Referring now more particularly to the drawing for a full and complete understanding of certain specific forms which this invention may assume, there is provided an envelope 11 having at one end a tubular portion which may be substantially cylindrical or which may be of truncated cone-shaped exterior, and at one end 13, that is, an interior surface thereof, of this tubular or cone-shaped portion there is provided a coating of luminescent material 15 on the interior surface. The enlarged section 11 of the envelope is then arranged to merge with the neck portion 17 which is also preferably of tubular cylindrical formation and which is sealed at one end. Within the neck portion 17 of the tube envelope, there is arranged the electron gun structure 19 for developing an electron beam. The gun structure 19 is conventionally illustrated herein and may be of any desired form, for example, the general form shown and described by copending application of John C. Batchelor, Serial No. 584,924 filed January 6, 1932 or, where desired, may be of other suitable design as taught by Chevallier, Maloff, Epstein and others.

In the conventional form shown, the gun structure comprises an electron source 21, known as the cathode, which source may be either directly or indirectly heated. From this source electrons are emitted and drawn into an electron ray or cathode ray beam by the action of the voltage drop occurring between the tubular anode 23 and the electron source or cathode 21. Intermediate the cathode and anode is a grid or control electrode 25 to which signals are applied in any desired manner. For convenience of illustration, the grid or control electrode has been illustrated as connected to the cathode by way of a variable voltage source 27 although in actual operation it will be understood that the grid may be either directly coupled with the output of a suitable signal amplifier, such as a television video signal amplifier, or may be capacitively or transformer coupled to such an amplifier so that controlling signals are applied in the input circuit between the control electrode and the cathode. The anode 23 is maintained at a positive potential relative to the cathode 21 by way of the voltage source conventionally illustrated at 29.

In order to provide a converging electrostatic field which will focus the electron stream issuing through the anode 23 into a sharply defined spot upon the luminescent screen 15 or elsewhere in the tube, for example, upon the insulating grid structure later to be described, there is provided a second anode 31 which is usually in the form of a metallic coating about the wall of the tube and, therefore, of larger internal diameter than the first anode 23. Terminal connection to this second anode 31 is made by way of the connection 33 so that the second anode is then supplied with voltage from a source 35 which is preferably of the order of approximately three to six times the magnitude of the voltage source 29 for the first anode. In this way, as has been taught in the art, the electrons forming the beam are caused to be accelerated in their motion toward the luminescent screen 15 and at the same time there is developed between the anodes 31 and 23 a converging electrostatic field which causes the electron beam to focus itself as a sharp spot or point upon the luminescent screen or upon any electrode intermediate the luminescent screen and the second anode, as desired. It will be appreciated that the point at which the ray or beam developed can be brought to focus is a function of the converging effect of the electrostatic field developed between the anodes 31, 23. Therefore, by suitably changing the ratio of the voltages upon the two anodes relative to the cathode 21 wide variations in focussing can be obtained.

Also positioned within the tube envelope 11 and preferably in an outwardly protruding section thereof out of the path of the main cathode ray discharge is a second cathode 37 from which an electron stream is emitted. This cathode also may be of the direct or indirect type, either type falling clearly within the scope of the invention but the conventional form of direct heater is illustrated merely for convenience. Electrons emitted from the cathode 37 but not controlled by any signal or the like as to intensity are accelerated in the direction of the screen 15 by the application of a suitable positive potential upon a grid or accelerating electrode 39 positioned adjacent the cathode 37 and intermediate the cathode and the luminescent screen 15. Voltages for accelerating the electron stream issuing from the cathode 37 are supplied by way of a voltage source 41. It will be noted in the illustration of the invention in Fig. 1 that the second cathode 37 is maintained at a potential corresponding to that of the second anode 31 so that the first cathode 21 is negative with respect to the second cathode 37. Also for the purpose of accelerating the electrons of both the controlled stream issuing from the second anode 31 and the undirected stream issuing beyond the grid electrode 39, there is positioned transversely of the tube a second accelerating electrode 43. This electrode 43 is formed preferably as a metallic ring which rests substantially upon the inner surface of the tube wall and there is strung between the edges of this ring-like electrode member a series of widely spaced wires. The electrode 43 is maintained preferably at the same potential relative to the second cathode 37 as the accelerating grid 39. As the arrangement has been shown, no signals or controlling voltages are applied to the grid electrode 39 for the purpose of controlling the density of the electron stream passing through the tube toward the luminescent screen since it is desired that the electrons from the source 37 which shall ultimately strike or impinge upon the luminescent screen 15 shall be uncontrolled as to intensity until they reach the insulated grid structure 45.

Positioned intermediate the accelerating electrode 43 and the luminescent screen 15 there is provided what is herein termed an insulated grid structure 45. This insulated grid 45 is maintained slightly negative with respect to the electron emitting cathode electrode 37. The negative potential is obtained by the voltage source 46 connected between the wires of the grid 45 and the cathode 37.

The insulated grid 45, whose construction is shown more particularly by Fig. 2, comprises preferably a ring-like outer supporting element 44 which preferably rests against the inner surface 50 of the tube wall 11. The ring like member 44 has one edge 52 bent or flanged inwardly so that it can be secured or welded to the wires 47 of the mesh to support the mesh, and strung from its outer ring-like member are a great number of fine mesh wires 47. The wires forming the mesh 47 for the insulated grid electrode 45, after the mesh has been suitably rolled and flattened so that the wires thereof are substantially flat, are preferably coated with a suitable insulating material 48. The insulating material will then also coat the flange 52 of ring 50, as shown. The enameling process may be carried forward to a predetermined degree by dipping the mesh-like grid into enamel to provide a coating of enamel thereon of desired and suitable thickness. This insulator in the case of the enamel coating is then baked in suitable manner prior to assembling the tube. When the tube is assembled the mesh and support ring are positioned within the tube and fit tightly therein. In the glass blowing process the tube wall may be heated to cause the glass of the tube wall 11 to fit tightly about the ring 44 to hold and position it.

According to the construction herein provided, the material which coats the wires or mesh 47 of the insulated grid is an insulator 48 of suitable kind and/or description. This material is preferably enamel which is a coating on the wires of such a thickness and so prepared that any electrostatic charges which accumulate thereon shall have the property of being able to leak away through to the inner conducting wires of the mesh within a predetermined time period. If, for example, the repetition rate of scanning the luminescent screen 15 is at thirty cycles per second, then the charges which accumulate on the enameled mesh 47 of the insulated grid shall be capable of being substantially dissipated in a time period just slightly less than the 1/30 of a second time assumed for the cycle of scansion.

In this connection, it should be noted that the insulated grid 45 is connected by way of conductor 49 to the high side of the voltage source 35 through the variable biasing source 46 so that the insulated grid 45 is, as above stated, slightly negative relative to the cathode 37. The first anode 23 and the cathode 21 all operate in the assumed form negative relative to ground potential (that is, potential at point 53) while cathode 37 and the second anode 31 operate at ground potential. The grid member 39 and the accelerating electrode 43 operate at a point positive relative to the ground 53 by the voltage supplied from voltage source 41.

Interposed between the insulated grid structure 45 and the luminescent screen 15 is an accelerating anode 51 which is also in the form of a ring which rests against or is supported by the inner surface of the tube envelope 11. Between the outer ring of the accelerating anode 51 there is stretched a coarse wire mesh 53. The accelerating anode is maintained highly positive relative to the accelerating electrode 43 and the accelerating grid 39 by virtue of the voltage source 55 so that electrons passing beyond the insulated grid 45 are accelerated to high velocities by the voltage gradient existing between the insulated grid 45 and the accelerating anode 51. Since the anode 51 is a coarse wire mesh, as indicated, the electrons passing beyond the insulated grid 45 and moving rapidly toward the screen 15, due to the accelerating field, pass directly through this anode toward the luminescent screen 15 to impinge thereupon. The anode 51 can, naturally, be formed of a fine wire mesh and the interstices of the mesh can be accurately aligned with the openings in the insulated grid mesh 47.

In the area of the tube intermediate the accelerating anode 51 and the luminescent screen 15, there is also applied to the inner surface of the tube envelope 11 a coating of conducting material 57. This coating may be what is known in the art under the trade name "Aquadag," or it may be a silver coating which may or may not be blackened on its inner surface. Blackening of this silver coating, however, will serve to reduce any internal light reflections which might otherwise be initiated due to electronic bombardment of the luminescent screen 15 by the electron beams passing through the accelerating anode 51 and the accelerating coating 57. Preferably, although not necessarily, the coating 57 and the anode 51 are maintained at the same potential, as indicated. In some instances the coating 57 may be positive relative to the anode 51 where greater velocity of beam impact is desired and, likewise, where a change in focusing, to vary image size for example, is desirable the coating can even be negative relative to the anode 51. Where additional focussing of the electrons passing between the accelerating anode 51 and the luminescent screen structure 15 is desirable, a focussing coil 59 wound upon a yoke 61 may be arranged to surround the end of the tube adjacent the luminescent screen and intermediate the screen and the accelerating anode. This focussing coil 59 may be energized with substantially constant voltage energy from a direct current supply means, where desired, so that a substantially constant intensity electromagnetic field is developed to concentrate the electron stream upon the luminescent screen. It is, however, to be understood that electrostatic focussing of the impinging electrons on the luminescent screen may be obtained by approximately selecting and designing the electrodes 57 and 51 and making an appropriate selection of the voltages applied thereto. For example, anode 51 may then be a metal ring having a length and diameter equal substantially to the internal diameter of the tube, and the coating 57 or the inner surface of the tube envelope may have a length equal to twice the tube diameter at the coating area. Under these conditions, the ring 51 will be operated only slightly positive relative to the insulated grid 45 and the full anode voltage will be applied to the coating 57.

Fig. 1 of the drawings does not show any means for deflecting the electron stream or beam flowing longitudinally of the tube and normally projected along the tube axis through the cooperative action of the first anode 23 and the second anode 31, but it should be understood that such deflecting fields may be provided at any point along the tube axis as may be desirable. It is suggested that suitable deflecting means be positioned between the first anode 23 and the second anode 31. Such deflecting fields, as above noted, may be developed by the use of purely electrostatic or purely electromagnetic means or a combination of both. Suitable energizing voltages or currents are applied to the deflecting means in order that the electron beam projected longitudinally of the tube shall be caused to sweep across the insulated grid structure 45 according to any desired pattern of traversal depending of course upon the wave formation of the electrical energy supplied to the deflecting means.

In the operation of a tube of the type shown by Fig. 1 of the drawing, for example, the beam of electrons resulting from the emitted electrons from the source 21 being drawn into a beam by the first anode 23 and the second anode 31 are caused by the deflecting fields (not shown) to sweep the insulated grid structure 45 in the desired pattern. Signals are applied to the control grid 25 to modulate the developed electron beam so that the electron beam which impinges upon the insulated grid structure 45 shall be a beam controlled in intensity in accordance with a signal to be represented electro-optically on screen 15 at the end 13 of the tube. As the controlled intensity electron beam scans the insulated grid structure 45, a pattern of charges representing the image to be produced on screen 15 is left on the surface of the insulator 48 in the wire mesh 47 of the insulated grid 45. This electrostatic charge, like the impinging beam, is proportional to the intensity of the electron stream flowing longitudinally of the tube and will substantially leak away under normal operating conditions, as above noted, during the time interval between successive scannings of the same elemental area of the insulated grid structure 45. Simultaneously, there is being produced from the electron source 37 and accelerated by the grid 39 and the accelerating electrode 43 toward the insulated grid structure 45 a second stream of electrons having an area substantially equal to the internal diameter of the tube and high density.

This latter-named stream of electrons is projected as a dispersing stream of electrons, although of high density, which normally floods the insulated grid structure 45 and would normally tend to penetrate equally all the interstices of the mesh 47 except for the negative potential applied thereto by the source 46 which biases the insulated grid substantially to cutoff.

The intensity controlled electron stream issuing from anodes 23 and 31 is, however, scanning the mesh 47 of the insulated grid 45 and impinges thereupon at a relatively high impact velocity. The controlled intensity electron beam when striking the insulated (enamel) surface 48 of the insulated grid 45 causes secondary electrons to be emitted from the impact surface. The number of secondary electrons released by the impact of the scanning beam being greater than one secondary electron per arriving primary electron which causes the enamel surface to acquire at different elemental areas thereof as it is scanned a positive potential relative to the wires 47 upon which the enamel or insulating coating is supported. There is thus developed between the surface of the enamel or insulator 48 and the supporting mesh conductor 47 and electrostatic charge which, as above described, will be substantially dissipated due to leakage within the time period between successive traversals of the same elemental section or area of the mesh by the scanning electron beam.

The magnitude of the electrostatic charge developed is a function of the electron density of the signal controlled scanning beam whose electron density varies in accordance with the magnitude of the control signal applied to the control grid 25.

Thus, with the signal controlled and focussed cathode ray scanning beam traversing the insulated grid 45, the biasing effect of source 46 on elemental areas of the insulated grid 45 is overcome by the positive electrostatic charges produced on the enamel or insulating surface 48 by the controlled intensity scanning beam Whenever the insulators or enameled areas 48 are at a positive potential relative to the above mentioned cut-off potential, the high density electron flow from the source 37 will penetrate the interstices of the insulated grid 45 and be accelerated toward the luminescent screen 15. In accordance with the above explanation of operation, which it is believed is the theory upon which the device operates, which the signal controlled scanning electron beam traverses each elemental area of the insulated grid 45 with great rapidity to leave the elemental areas positively charged, as above specified, the high density electron stream from source 37 continues to flow through the mesh 47 toward the luminescent screen 15 for an appreciable time period subsequent to the time when the scanning beam leaves each elemental area of the insulated grid 45. Thus, the electro-optical image produced upon the luminescent screen 15 by the electron beam impact is of greatly increased optical brilliance.

While the above is the preferred method of operation, it is also possible to consider that the device may operate in such a manner that the scanning electron beam releases less secondary electrons from the insulating surface 48 of the insulated grid 45 at each point of impact than there are arriving primary electrons. This would be particularly applicable where the insulated grid structure 45 has the mesh wires 47 coated with a material of low secondary emitting properties, such as carbon. In such event the wires 47 would be enameled and then the enameled surface coated with isolated particles 54 of the carbon. This form of the insulated grid is shown particularly by the sectional view of Fig. 3, although it will be appreciated that the device shown by Fig. 3 may operate as a high secondary emission type, and in accordance with the above theory, where the isolated coating material is, for example, oxidized silver particles coated with caesium.

Where less secondary emission is assumed, as with the particle coating of Fig. 3, being in the form of carbon, the strongly negative field due to low secondary emission from the carbon particles will be sufficient to overcome and overbalance the positive field which would be developed by the scanning beam impinging upon those portions of the enamel not coated with the carbon. For the case of low secondary emission, it is possible to omit the biasing source 46 so that the uncontrolled intensity electrons developed from the source 37 would normally be accelerated by the field developed between the accelerating anode 51 and the insulated grid 45 so as to strike the luminescent material 15 with substantial velocity and to cause thereby light to be emitted or developed at the screen. However, in accordance with the electrostatic charges acquired by the insulated grid structure 45 due to the scanning beam traversing this grid structure, the grid becomes negative over various elemental sections thereof by amounts which are proportional to the intensity of the electron beam impinging thereupon. Thus, the insulated grid acts as a control grid, so-to-speak, to control the final effect of the electronic emission from the electron source 37. The insulated grid 45 thus varies the number of electrons from the uncontrolled source 37 which are able to penetrate the insulated grid 45. In this way, the luminescent screen 15 is dark or light over various elemental sections in accordance with the intensity of the electron beam from the source 21, but the luminescence of the screen is maintained due to the continuity of the controlled electron stream thereupon so that the luminescent screen is excited substantially all the time rather than a brief instant as is customary in the prior art. In this way, there has been developed according to the present disclosure an insulated grid surface the potential of which is varied from point to point as the density of light and shadow upon the subject being transmitted changes, and this grid structure then acquires a charge, as above described, for controlling the number of electrons from a diffusely radiating emitter which strike the luminescent screen behind the controlling element.

In a modified form of the arrangement shown by Fig. 4, structurally the system is substantially as shown by Fig. 1 except that the luminescent screen is tilted with respect to the position shown by Fig. 1, and electrode members 45 and 43 are supported closely adjacent each other and the screen. In this form, the luminescent screen is formed upon an insulating sheet, such as the mica base 71, which has stretched across the surface thereof adjacent the electron sources a conducting wire mesh 73 (shown as dots on the surface). The luminescent material 78 is placed upon this side of the insulating sheet 71 and the light developed by beam impact is viewed through the insulating sheet or base 71. In practice it has been found that an insulating base, such as the mica sheet 71, may have substantial rigidity even though the thickness is of the order of 0.005 inch and accordingly substantially no light absorption will be found. In this form of the arrangement, separate mica spacer elements in the form of rings 75 separate the accelerating anode in the form of the wire mesh 73 having ways conductors 74 and woof conductors 76 from the insulated grid 45, and the accelerating electrode 43 is separated from the insulated grid 45 by an additional mica spacing ring 77. Other forms of spacing rings and the like may be used where desired, and such may be lava, bakelite, and other forms. The entire assembly may be held in place by slightly crimping the tube wall, as at 80, when the tube is assembled. As the electrons from the uncontrolled source impinge upon the luminescent screen structure and are controlled in the manner described in connection with Figs. 1 through 3, the luminescent material 15 upon the plate structure becomes both luminescent and phosphorescent. This form of device is frequently desirable because the construction permits a more uniform distribution of the high density uncontrolled electron stream from source 37 over the insulated grid structure 45. With, however, the luminescent screen structure tilted at an angle with respect to the direction of propagation of the controlled electron beam, it is then usually desirable to correct for the so-called keystone distortion which results normally due to the inclination of the plane upon which the image appears. Such forms of keystone correction are well known in the art and need not herein be explained in detail.

The foregoing description has considered only electron density variation of the scanning electron beam as the controlling factor in producing the electrostatic charge effects. However, it is desirable also to consider constant electron densities with variable velocities of the electrons impact upon the insulated grid surface or of variable velocity traversal of the insulated grid structure by the scanning beam. These two variable velocity conditions require either a constant velocity of impact of the scanning beam on the insulated grid 45 with a variable rate of traversal or a constant rate of traversal of the insulated grid 45 by the scanning beam and a variable velocity of impact. For the first of these conditions, the received video signals which are to be electro-optically reproduced are caused to control or modify the action of the beam deflecting system, for example, as taught by Rosing (see U. S. 1,161,734 for example). In the second form of velocity modulation (i. e. control of velocity of impact), the received signal could be applied in series with voltage source 35 so as to change the potential of the cathode 21 relative to the insulated grid 45. While this might cause a slight defocussing of the scanning beam upon the insulated grid 45 such defocussing would not be at all serious. However, defocussing of the scanning beam can be minimized by connecting the second anode 31 directly to the positive terminal of source 35 (rather than to cathode 37 as shown by Fig. 1) and then introducing the video signal intermediate the point of connection of the second anode 31 to the source 35 and the cathode 37 which is normally maintained at the same potential as the anode 31 relative to the cathode 21.

In some instances, it may be desirable to operate the cathode 37 slightly positive relative to the anode 31 in order to prevent any current flow from anode 31 to cathode 37 and also to permit more effective directing of the diffused high density electron stream issuing from cathode 37 upon the insulated grid. This may be done in Fig. 1 by connecting a biasing source (not shown) in the line 33 with the positive terminal point connecting with cathode 37. Where variations in impact velocity are relied upon for control, this biasing source is connected in series with the video signal input between the source 35 and the cathode 37 in such manner that cathode 37 is at a positive potential relative to anode 31.

While the invention has been described particularly in its relation to a television system, it finds application in many other fields, for example, in oscillograph apparatus. In such usage it is frequently desirable to maintain the visible phenomena upon the luminescent screen 15 for a longer period of time in order that more than a single wave formation may be observed. In such use the time constant of the system, that is, the period of charge leakage from the insulated grid 45 may be longer or shorter than above described. This is done by varying the specific resistance of the insulating coating 48 on the mesh 47 of the insulated grid 45 and, for example, there may be substituted for the suggested enamel other materials such as aluminum-oxide (Al_2O_3), calcium-fluoride (CaF), mica, or any other material having substantial insulating properties.

In some cases, it may be desirable to replace the luminescent material 15 by other forms of recording surfaces which may include a photographic film or plate responsive to electronic energization as well as any form of insulating base upon which previously dusted particles are displaced and any form of metal surface which is changed in color by electronic impact.

Further, while suggested operating voltages and conditions have been illustrated and suggested by the showings of Figs. 1 and 4 it is, of course, to be appreciated that the values chosen are merly illustrated by way of example since, in practice, wide variations may be found desirable. Therefore, all such values are to be regarded solely as illustrative and not in any sense limiting.

Many other and varied modifications of the invention are, of course, possible without departing from the spirit and scope as it is hereinabove explained. It is, therefore, believed that the invention should be construed broadly in the light of the foregoing disclosure and that any and all modifications as fall clearly within the spirit and scope of the herein appended claims may be used as desired.

Having now described the invention, what is claimed as new and what is desired to secure by Letters Patent is the following:

1. The method of producing electro-optical effects which comprises producing a bidimensional electrostatic image of a subject, varying the intensities of the electrostatic charge of elemental areas of the electrostatic image in accordance with signalling modulation and uniformly flooding the signal modulated electrostatic image with an electron flow to produce a magnified intensity electronic duplicate.

2. An electronic image reproducing system comprising a bidimensional electrostatic charge collecting electrode member to store an image in two coordinates, means for directing a substantially spatially uniform electron flow through the charge collecting electrode member, an electron responsive target element positioned to receive the electrons projected through the charge collecting electrode member, and signal controlled means for electronically controlling the electronic flow through said member to said target element.

3. In a cathode ray image producing system, means to produce a sharply concentrated electron beam, an insulated grid structure of substantially image area interposed in the path of said beam, means for signal modulating the concentrated electron beam, means for causing said electron beam to sweep said insulating grid structure in two dimensions to produce thereupon at various elemental areas varying intensity electrostatic charges varying in accordance with the intensity of the controlled electron beam during traversal, means for producing an uncontrolled intensity and constant density electron flow for flooding said insulated grid structure and permeating the same in varying degrees dependent upon the magnitude of said produced charges, and means for accelerating the permeating electrons for producing electron activated representa-

tions of the variations of charge on said insulated grid structure.

4. The method of controlling electronic activation of an electron target which comprises the steps of projecting toward the target a signal controlled concentrated electron stream, simultaneously projecting a substantially spatially uniform electron stream toward the target to flood normally the entire target, and controlling the electron stream reaching the target at a surface intermediate the target and the source of each electron stream by the signal controlled electron stream.

5. In an electron tube, a bidimensional grid structure adapted to have produced repeatedly over the surface thereof electrostatic charges of varying magnitude to represent light values of related elemental areas of a bidimensional subject varying between black and white and also of varying decreasing magnitude measured by the time interval between successive repetitions of the charges, means to flood the grid structure area with an uncontrolled substantially constant intensity electron flow, and means to produce from the uncontrolled electron flow, as modified by the electrostatic charges, an electronic duplicate of the instantaneous electrostatic charges in magnified intensity.

6. The method of controlling electronic activation of a bidimensional target which comprises the steps of projecting toward the target a concentrated electron ray, controlling the intensity of the projected concentrated electron ray by signal energy, projecting a flooding electron stream toward the target to flood the entire target, and controlling the flooding electron stream reaching the target at a surface intermediate the target and the source of each electron stream by the signal controlled concentrated electron ray.

7. In an electronic device wherein there is provided a luminescent surface, an electron permeable charge collecting electrode, an electron source for producing a focused beam of electrons, and a second source of flooding electrons, the method of controlling the energization of the luminescent surface which includes the steps of sweeping the charge collecting electrode in two directions of traverse by the focused electron beam, producing charges varying over each elemental area of the charge collecting electrode in accordance with the electron density of the sweeping electron beam, substantially uniformly flooding the entire area of the charge collecting electrode by the dispersely projected electrons and directing the dispersely projected electrons through the charge collecting electrode to the luminescent surface in accordance with the magnitude of the charge produced upon the charge collecting electrode.

8. In an electronic device wherein there is provided an electron responsive signal utilization surface, an electron permeable charge collecting electrode, an electron source to produce an electron beam, and a second source of dispersely projected electrons of substantially uniform cross sectional area density, the method of controlling the energization of the signal utilization surface which includes the steps of sweeping the charge collecting electrode by the electron beam, controlling the number of beam electrons reaching each unit area of the collecting electrodes, producing from the electrons reaching the collecting electrode varying charges over each elemental area of the collecting electrode in accordance with the number of beam electrons reaching the electrode, flooding the entire area of the charge collecting electrode by the dispersely projected electrons, and directing the dispersely projected electrons through the charge collecting electrode to the signal utilization surface in accordance with the magnitude of the charge produced upon the charge collecting electrode.

9. In a system for producing observable effects upon a luminescent screen having positioned adjacent thereto an electron permeable control member, the method of intensifying the resultant luminescent transient which comprises the steps of projecting a focused controlled intensity electron beam upon the electron permeable control member, producing upon the electron permeable control member surface a series of electrostatic charges varying in accordance with variation in the intensity of the projected electron beam so that the charges are proportional to the spatial illumination of an object, flooding the electron permeable control member with uncontrolled intensity constant density electron stream, varying the uncontrolled intensity constant density electron stream permeating the electron permeable control member in accordance with the charges produced thereupon by the controlled intensity electron beam, accelerating the electron flow permeating the electron permeable control member, and producing luminous effects from the accelerated electron flow.

10. In a system for reproducing transients on an electron responsive screen having positioned adjacent thereto an electron permeable control member composed of a plurality of mutually insulated elemental areas having a predetermined leakage therebetween, the method of intensifying the resultant transient effect which comprises the steps of flooding the electron permeable control member with a stream of constant density electrons adapted to pass therethrough, accelerating the permeating electron stream in the direction of the screen for producing indications thereupon, developing a signal controlled concentrated electron beam, projecting the signal controlled concentrated electron stream toward the electron permeable control member, tracing the concentrated electron beam across the surface of the electron permeable control member so as to scan the same in two substantially perpendicular directions, developing from the scansion of the electron permeable control member electrostatic charges thereupon, controlling the electron quantity of the flooding electron stream passing the electron permeable control member per elemental area in accordance with the magnitude of the electrostatic charge produced by the concentrated beam, and dissipating the charge induced upon the electron permeable control member by the concentrated electron beam by way of the leakage path between the elemental areas of the electron permeable control member during the time interval between successive impacts of the concentrated electron beam at identical elemental areas.

11. In a system for reproducing transients on an electron responsive screen having positioned adjacent thereto an electron permeable control member composed of a bidimensional array of a plurality of mutually insulated elemental areas having a predetermined leakage therebetween, the method of intensifying the resultant transient effect which comprises the steps of flooding the electron permeable control member with a stream of substantially constant density electrons

adapted to pass therethrough, accelerating the permeating electron stream in the direction of the screen for developing luminous effects thereupon due to impact, scanning the electron permeable member by a signal controlled scanning beam to produce electrostatic charges therefrom which are representative of a subject, and controlling the magnitude of the flooding electrons passing through elemental sections of the electron permeable member in accordance with the electrostatic charge thereat developed.

12. The method of producing images which comprises the steps of developing a signal controlled electron beam, producing an electrostatic image of a subject under the control of said beam, substantially all elemental areas of said image being represented as electrostatic charges with the magnitudes of charge for any predetermined light valve capable of varying with time, uniformly flooding the electrostatic image with electrons for producing from all instantaneous conditions of the electrostatic image a current image of an intensity substantially magnified with respect to the current strength required to produce the electrostatic image.

13. A cathode ray tube comprising an envelope containing a luminescent screen defining a picture area, an apertured grid adjacent and parallel to said screen, said grid being conductive and covered with a layer of charge retaining material, an electron gun including a cathode and an anode cooperating therewith to define an electron beam of elemental cross-section, a second electron gun comprising a cathode and an anode cooperating therewith to define an electron beam of picture area cross-section, both of said guns being positioned to direct electrons emitted therefrom on said screen through said grid with said beam of picture area cross-section registering with said picture area of said screen, and deflection means associated solely with said first anode and cathode.

14. An electron image amplifier comprising an envelope containing means for generating a spatially uniform electron flow, an apertured member in the path of said flow, means for producing on said member a charge image spatially representing the spatial illumination of an object, and means for collecting electrons in elementary areas of the electron stream passing through said apertured member.

15. In an electron tube an apertured insulated grid, an electron emitting element to emit a spatially uniform flood of electrons, means to project the emitted flood of electrons through said apertured grid, means to produce on said apertured grid a bidimensional electrostatic charge image representative of a picture, a target element located on the side of said apertured grid opposite the source of flooding electrons, and means to focus electrons passing through said grid upon said target.

16. In an electron tube an apertured insulated grid, a thermionic cathode to emit a spatially uniform flood of electrons, means to project the thermionically emitted electrons through said apertured grid, means to produce on said apertured grid a bidimensional electrostatic charge image representative of a picture, a target electrode located on the side of said apertured grid opposite said thermionic cathode, and means to focus electrons passing through said grid upon said target.

17. A cathode ray tube reproducer comprising means for projecting a main beam of electrons towards an area upon which a picture is to be reproduced so as to bombard the whole picture area, an electrode which is permeable to said main beam interposed in the path of said main beam, means obliquely positioned with respect to the means for projecting the main beam of electrons for scanning said electrode by a signal controlled concentrated cathode ray beam whereby said electrode receives electron density controlling potentials at different elemental areas thereof.

18. A cathode ray tube comprising means for continuously projecting a main beam of electrons, a perforated electrode interposed in the path of said main beam, an electron gun obliquely positioned with respect to the means for projecting the main beam of electrons for projecting a concentrated cathode ray beam upon said electrode, means adapted to cause said concentrated beam to scan said electrode and means adapted to be operated by image signals for effecting modulation of the concentrated scanning beam, said interposed electrode being so constructed that the potentials of the different elemental areas thereof may be controlled by the scanning cathode ray beam whereby the electron intensity in the corresponding parts of the main beam passed by said electrode may be correspondingly controlled.

19. Apparatus as claimed in claim 18 and wherein the interposed electrode which is scanned is a perforated electrode constructed to constitute a mosaic of elemental condensers.

20. In a system for producing observable transients on a luminescent screen having positioned adjacent thereto an electron permeable control member, the method of intensifying the resultant luminescent transient which comprises the steps of flooding the electron permeable control member with a beam of electrons adapted to pass therethrough to produce upon the luminescent screen an observable indication, producing a concentrated electron beam and projecting the same at an oblique angle with respect to the flooding beam of electrons toward the electron permeable control member, tracing the concentrated electron beam across the surface of the electron permeable control member so as to scan the same according to a predetermined pattern of traversal, producing from the scansion of the electron permeable control member electrostatic charges thereupon and controlling the electron density of the flooding electrons passing the electron permeable control member per elemental area in accordance with the magnitude of the electrostatic charge produced by the concentrated beam.

21. In a system for producing observable transients on a luminescent screen having positioned adjacent thereto an electron permeable control member composed of a plurality of mutually insulated elemental areas having a predetermined leakage therebetween, the method of intensifying the resultant luminescent transient which comprises the steps of flooding the electron permeable control member with a beam of electrons adapted to pass therethrough to produce upon the luminescent screen an observable indication, producing a concentrated electron beam and projecting the same at an oblique angle with respect to the flooding beam of electrons toward the electron permeable control member, tracing the concentrated electron beam across the surface of the electron permeable control member so as to scan the same according to a predetermined pattern of traversal, producing from the scansion of the

electron permeable control member electrostatic charges thereupon, controlling the electron density of the flooding electrons passing the electron permeable control member per elemental area in accordance with the magnitude of the electrostatic charge produced by the concentrated beam, and dissipating the charge induced upon the electron permeable control member by the concentrated electron beam by way of the leakage path between the elemental areas of the electron permeable control member during the time interval between successive impacts of the concentrated electron beam at identical elemental areas.

22. The method of reproducing images upon a target which comprises the steps of directing a broad beam of electrons toward the luminescent screen, said broad beam of electrons having substantially constant electron density per unit area in a plane transverse to the axis of said beam, modifying the electronic density of said elemental areas of said broad beam of electrons by interposing an electric charge replica of the image to be reproduced, and impacting the modified beam upon the target to reproduce a picture.

23. The method of reproducing images upon a luminescent screen which comprises the steps of obliquely directing a broad beam of electrons toward the luminescent screen, said broad beam of electrons having substantially constant electron density per unit area in a plane transverse to the axis of said beam, modifying the electronic density of said elemental areas of said broad beam of electrons by interposing an electric charge replica of the image to be reproduced, and impacting the modified beam upon the luminescent screen to reproduce a picture.

24. The method of reproducing images which comprises the steps of receiving electrical signals representative of an image to be reproduced, flooding an electron sensitive surface with a broad beam of electrons, directing a narrow beam of electrons toward said surface, controlling the spatial position of said narrow beam by locally generated oscillatory energy, controlling the intensity of said narrow beam of electrons by the received signals, interposing under the influence of the controlled intensity electron beam an electric charge image of the image to be reproduced and utilizing the interposed electric charge to regulate the number of electrons per elemental area of said broad beam reaching said surface and thereby reproduce a picture.

25. Apparatus for reproducing images comprising a luminescent screen, means for directing a broad beam of electrons of substantially constant density per unit cross-sectional area toward the luminescent screen, said broad beam of electrons having substantial constant electron density per unit area, means for modifying the electronic density of said elemental areas of said broad beam of electrons by interposing an electric charge replica of the image to be reproduced, and means for impacting the modified beam upon the luminescent screen.

26. Apparatus for reproducing images comprising a luminescent screen, means for obliquely directing a broad beam of electrons of substantially constant density per unit cross-sectional area toward the luminescent screen, said broad beam of electrons having substantially constant electron density per unit area, means for modifying the electronic density of said elemental areas of said broad beam of electrons by interposing an electric charge replica of the image to be reproduced, and means for impacting the modified beam upon the luminescent screen.

27. Apparatus for reproducing images comprising an electron sensitive surface, means for receiving electrical signals representative of an image to be reproduced, means for flooding said electron sensitive surface with a broad beam of electrons of substantially constant density per unit cross-sectional area, means for directing a narrow beam of electrons toward said surface, means for controlling the intensity of said narrow beam of electrons by the received signals, and means for utilizing the controlled beam to produce an electric charge image of the image to be reproduced, and means to regulate the number of electrons per elemental area of said broad beam reaching said surface under the influence of the charge image.

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