July 11, 1961 D. A. CUSANO 2,992,349

FIELD ENHANCED LUMINESCENCE SYSTEM

Filed Oct. 24, 1957

Fig. 1.

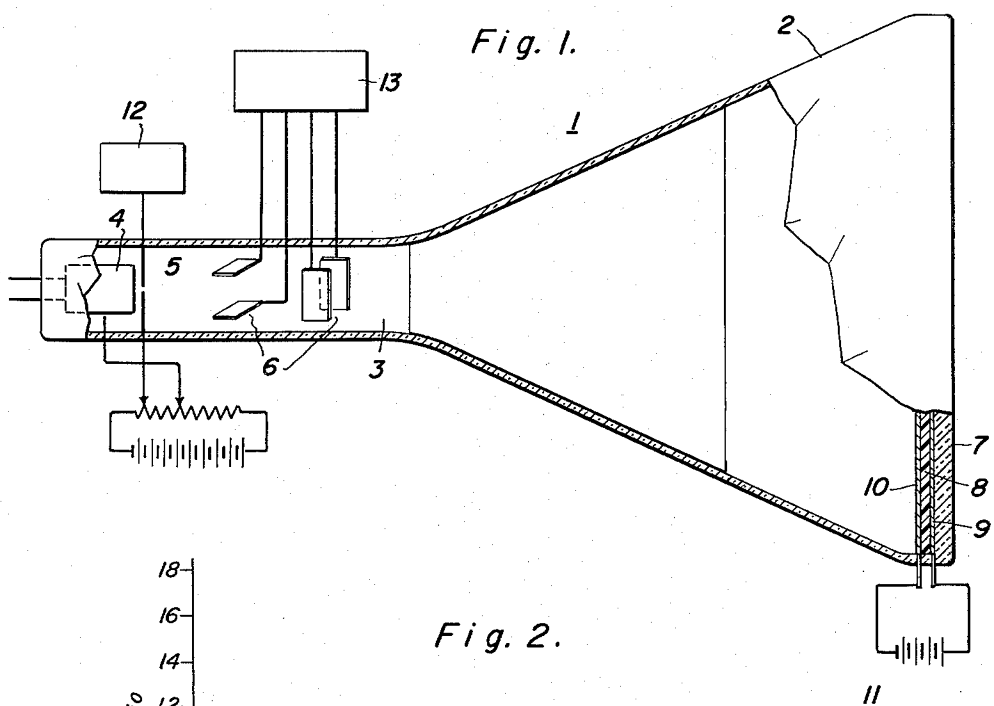


Fig. 2.

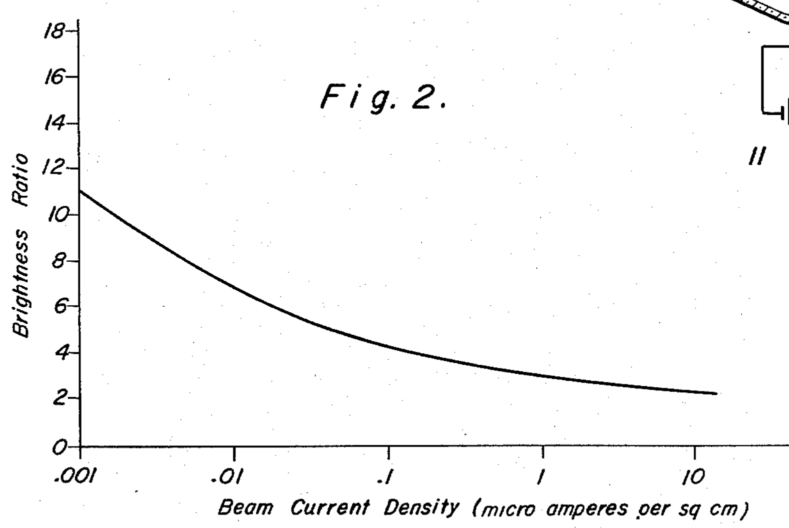
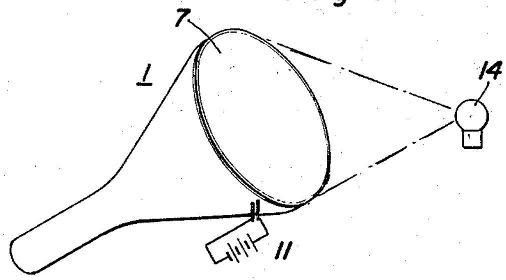


Fig. 3.



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2,992,349

FIELD ENHANCED LUMINESCENCE SYSTEM

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The present invention pertains to information portraying devices and systems, and more particularly to such devices and systems in which information or intelligence carried by cathode rays is reproduced and intensified within a screen comprising a solid luminescent material.

It is well known that luminescent solids may be excited to luminescence by the incidence of cathode rays. Information portraying devices and systems utilizing the phenomenon of solid state luminescence under the excitation of cathode rays have not heretofore been completely satisfactory because of the difficulty in obtaining high intensity images therefrom without the use of excessively high beam currents. The low efficiency of luminescence obtainable from cathode ray stimulated solid luminescent bodies has long stood as an obstacle to the development of practical and efficient information portraying devices and systems utilizing such light emitting solids.

This difficulty is due, in part, to the fact that, in present-day information portraying devices and systems in which a solid body is excited to luminescence by radiant energy, the cathode rays energy must not only carry the information to the light emitting body, but must also supply the energy to that body to cause the emission of light therefrom. Due to this mode of operation, it is impossible to obtain high brightness images from cathode ray excited luminescent materials without irradiating these materials with electrons of such high energies that the use of such devices and systems is inefficient and often prohibitive.

Accordingly, it is an object of the invention to obtain high intensity luminescent images from cathode ray irradiated luminescent solids.

A further object of the invention is to obtain high intensity visible light images from solid state luminescent materials irradiated by low intensity information containing cathode rays.

A further object of the invention is to provide information containing cathode ray information portraying devices and systems in which a greater amount of energy is obtained from the luminescent screen than is incident thereupon.

A further object of the invention is to provide a high brightness cathode ray tube.

Briefly stated, one embodiment of my invention comprises a cathode ray tube including a phosphor screen comprising a continuous, homogeneous, cathodoelectroluminescent phosphor layer disposed between, and in contact with, two conducting electrodes, at least one of which is light transmissive. A source of unidirectional potential is applied to the two conducting electrodes and information-containing cathode rays are directed upon the cathodoelectroluminescent phosphor from a suitable source. When the cathodoelectroluminescent phosphor layer is subjected to information-containing cathode rays, and a unidirectional voltage is applied between opposite surfaces thereof, an amplified visible image is obtained by the luminescent emission thereof. Since the energy required to produce this image is derived from the unidirectional voltage source rather than from the incident cathode rays, the light emitted by the cathodoelectroluminescent screen may contain greater energy than the incident cathode rays. Thus, an energy gain may be obtained utilizing cathodoelectroluminescence. As a result, the brightness of light emitted by the cathode ray tubes of the invention is much greater than that obtainable from conventional cathode ray tubes. Cathodoelectroluminescence may be defined as luminescence controlled by cathode rays and powered by a unidirectional electric field.

In accord with another feature of the present invention a further increase in the intensity of light obtained from a cathode ray and unidirectional field excited screen is obtained by simultaneously irradiating the screen with ultra-violet light.

The novel features believed characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the attached drawings in which:

FIG. 1 shows a cathode ray tube illustrative of one embodiment of my invention;

FIG. 2 is a graphical representation of the enhanced emission of certain cathodoelectroluminescent phosphors which may be used in constructing the device of FIG. 1; and

FIG. 3 illustrates an alternative embodiment of the invention.

In FIG. 1 a cathode ray tube illustrative of one embodiment of the invention is represented generally as **1**. Tube **1** includes an evacuable envelope having a conical section **2** and a neck portion **3**. Within neck portion is a cathode gun **4**, a modulating electrode **5** and a set of deflection plates **6**. Cathode rays impinge upon faceplate **7** upon which there is located a cathodoelectroluminescent phosphor layer **8** sandwiched between a pair of continuous conducting electrodes **9** and **10**. A source of unidirectional potential, represented generally by battery **11** is connected to impress a uniform unidirectional voltage transversely across the entirety of layer **8** by means of electrodes **9** and **10**.

A beam of electrons is generated by electron gun **4** and modulated so as to contain information or intelligence by control electrode **5** to which signal energy is supplied by video output circuit **12**. The modulated electron beam is swept in a raster pattern by deflection plates **6** which are supplied a sweep signal by sweep generator **13**. A raster pattern is thus impressed upon cathodoelectroluminescent layer **8** through electron-permeable layer **10**. Cathodoelectroluminescent layer **8** is excited to luminescence and a visible image is viewed through light transmissive layer **9** and faceplate **7**.

Conducting layer **9** may conveniently comprise any visible-light transmissive, conducting layer such as tin oxide, but is preferably a thin layer of reduced titanium dioxide. Conducting layer **9** may be formed upon base plate **3** by the chemical reaction in a closed chamber, between titanium tetrachloride and water vapors which are brought into admixture with one another in close juxtaposition to the plate while the latter is heated to approximately 150° C. to 200° C. Film **9** may have a thickness of about .1 to 1 micron, but its thickness is not critical and may be as thin as is compatible with good electrical conductivity or as thick as is compatible with reasonable visible light transmissivity. As deposited, titanium dioxide layer **9** is not highly conductive but may be rendered conducting by the subsequent deposition thereupon of a cathodoelectroluminescent layer, or may be rendered conducting by the method disclosed and claimed in U.S. Patent No. 2,717,844 to L. R. Koller.

Cathodoelectroluminescent phosphor layer **8** may be any luminescent phosphor which exhibits the phenomenon of cathodoelectroluminescence. The phenomenon of cathodoelectroluminescence may be briefly described as that property of certain phosphors which imparts to them the ability to exhibit, under the concurrent stimulation of incident cathode rays and a transversely impressed uniform unidirectional electric field, applied by electrodes in direct contact with opposite surfaces of a phosphor layer so that charge transport may occur therethrough, light emission which is of a high intensity greater than that obtainable utilizing cathode ray bombardment alone and which may contain greater energy than, the controlling cathode rays. The phenomenon of cathodoelectroluminescence, which I have discovered, derives its efficiency from the principle that the energy which is responsible for the luminescent emission from the cathodoelectroluminescent layer is derived from the electric field impressed upon the cathodoelectroluminescent layer, while light emission is initiated and controlled by the incident cathode rays. The incident information-containing cathode rays need supply only sufficient energy to the cathodoelectroluminescent phosphor to initiate and control cathodoelectroluminescent emission, and need not supply the energy required to sustain the emission. In the operation of the screens of the invention, the energy of the incident cathode rays may be quite low, but nevertheless cause high intensity light to be emitted from cathodoelectroluminescent layer **8**.

In order to describe adequately the characteristics of phosphors which exhibit the phenomenon of cathodoelectroluminescence, the phenomenon will be described and the characteristics necessary in order that the phenomenon exist will be set forth. Cathodoelectroluminescence is a process which depends, for its operation, upon the principle of photon generation and multiplication within phosphor layer **8**. When a cathodoelectroluminescent layer, such as layer **8**, is in contact with a pair of conducting electrodes, one of which is preferably metallic and at least one of which is permeable to incident cathode rays, a uniform electric field is established within the phosphor layer which is transverse thereto. When incident cathode rays fall upon the cathodoelectroluminescent layer, the already-existing electric field existing in the vicinity of the cathode, or negatively maintained electrode, is increased due to the formation there of a space charge by electrons originally bound to the crystal lattice, but freed by incident high energy electrons. This increased electric field in the vicinity of the cathode results in the injection of a large number of free electrons from the metallic cathode **10** into the cathode-adjacent region of the phosphor layer. These injected electrons are then transported through the phosphor layer under the acceleration of the electric field to excite activator centers within the phosphor, causing the release of a much greater number of photons of radiant energy than are released by cathode ray bombardment alone. Thus, in cathodoelectroluminescence, an actual charge transport or current flow occurs through the phosphor film. This current is increased by the creation of electron avalanches by inelastic collisions as the distance from the cathode increases. Cathodoelectroluminescence is therefore a phenomenon involving a unidirectional current flow through the phosphor as is opposed to electroluminescence wherein luminescence is excited by an electric field alone with on unidirectional flow of current but only displacement current which ordinarily occurs in capacitors.

In order that the current flow which is required for cathodoelectroluminescence occur, the phosphor layer **8** must satisfy several requirements. First, in order that current flow occur, there must be direct electrical contact between phosphor layer **8** and the electrodes **9** and **10** which must be electrically continuous in order that the field through layer **8** be uniform. Secondly, since cathodoelectroluminescence depends in part upon the creation of electron avalanches and charge transport through the phosphor, there must be a continuity of electrical properties throughout the phosphor layer. In other words, layer **8** must be composed entirely of phosphor material in an orderly crystalline array with no interstices. For this reason, conventional luminescent phosphor layers in which microcrystals of luminescent materials are suspended in powder dielectrics or are settled out into a heterogeneous mass by conventional liquid settling or equivalent techniques, do not exhibit cathodoelectroluminescence. Cathodoelectroluminescence may be achieved only in phosphor layers which are composed entirely of the luminescent phosphor utilized and which are homogeneous, continuous, crystalline, non-granular and exhibit uniform electrical properties throughout. If, for example, the electrical properties throughout the phosphor are not uniform, charge transport may not occur and cathodoelectroluminescence may not be observed.

Layers of phosphor which may be utilized in the creation of cathodoelectroluminescent intensifying cathode ray tubes in accord with the invention may be prepared by chemically reacting the vapors containing phosphor constituents and a selected activator in the vicinity of the substrate upon which the layer is formed to cause the crystallization from the vapor phase of a continuous, homogeneous, crystalline, non-granular layer composed entirely of the chosen activated phosphor. Alternatively, phosphor layers may be formed by spraying the constituent materials upon a heated substrate to cause the chemical reaction therebetween and the deposition thereupon of a uniform, crystalline, homogeneous activated phosphor layer. These methods of formation of phosphor layers are disclosed in greater detail in Patent No. 2,685,530 to Cusano and Studer. Cathodoelectroluminescent phosphor layers may also be formed upon a suitable substrate by vacuum evaporation techniques to cause the condensation, upon a suitable substrate, of a continuous, homogeneous, non-granular phosphor layer. In general, any method of phosphor preparation which results in the formation of a homogeneous, continuous, non-granular phosphor layer upon a suitable substrate is suitable.

The phenomenon of cathodoelectroluminescence may be observed with members of the zinc-cadmium sulfoselenide family including zinc sulfide, cadmium sulfide, zinc selenide, cadmium selenide, or mixtures thereof such as zinc-cadmium sulfide, zinc-cadmium selenide, cadmium sulfo-selenide, zinc-cadmium-sulfo-selenide and zinc sulfo-selenide, activated with manganese, arsenic, phosphorus or antimony and a halogen, or one of these phosphors activated with two or more of the foregoing activators and a halogen.

If manganese is utilized as the principal activator for phosphor layer **8**, the manganese should be present in proportions from 0.1 to 5% by weight together with 0.1 to 5% by weight of a halogen preferably chlorine. If arsenic, phosphorus or antimony are utilized as the principal activator in the devices of the invention, these materials should be present in proportions of from 0.01 to 1% weight of phosphorus, arsenic or antimony, together with 0.01 to 1% by weight of a halogen, preferably chlorine. While chlorine is preferably the halogen used, other halogens such as bromine and iodine may be used as well in the same proportions.

Although cathodoelectroluminescent phosphor layer **8** may be prepared in a number of days, it is preferably prepared by the vapor reaction technique described and claimed in U.S. Patent No. 2,685,530 to Cusano and Studer.

As an example of this method, base plate **7**, coated with a thin film **9** of titanium dioxide, is suspended in a reaction chamber and heated to a temperature of from 500° C. to 700° C. but preferably to approximately 620° C. in an evacuated reaction chamber. A charge of material comprising the phosphor cation as for example elemental zinc, a halogen containing constituent, as for example, zinc chloride, and a luminescence activator containing constituent, as for example, manganese chloride, is continuously fed into an evaporation vessel wherein the charge is vaporized. Vapors of the phosphor cation, a halogen, and a luminescence activator arise and are mixed with vapors of a gas containing the phosphor anion, as for example, hydrogen sulfide. The gas and the vapors react chemically at the surface of the heated base plate and deposit, by vapor deposition, a thin, transparent, continuous, crystalline, non-granular, cathodoelectroluminescent phosphor layer thereupon, which in this instance is zinc sulfide activated with manganese and chlorine (ZnS:Mn, Cl). To produce a selenide phosphor, H_2Se may be used.

The process of the vapor deposition of cathodoelectroluminescent layer **8** is carried out at a controlled rate for a preselected period of time which is selected to deposit the desired thickness layer upon base plate **7**. Conveniently phosphor layer **8** may be from 1 to 100 microns thick depending upon the energy, and hence, the penetrating power of the cathode rays utilized. For cathode rays accelerated through a potential of 15 kilovolts, a layer thickness of approximately 1 to 10 microns is utilized.

In one specific example of the formation of a cathodoelectroluminescent image presentation device in accord with the invention, a Pyrex glass base plate approximately 3 inches in diameter having thereon a several tenths micron thick layer of titanium dioxide was suspended in an evacuated reaction chamber and heated by an external heater to a temperature of approximately 620° C. A flow of hydrogen sulfide into the reaction chamber was initiated to establish therein an atmosphere of hydrogen sulfide at approximately 1 millimeter of mercury pressure. A charge consisting of 25 grams of zinc, 12.5 grams of zinc chloride and 0.50 gram of manganese chloride is slowly and continuously fed into the reaction chamber and evaporated in the evaporation vessel which is maintained at a temperature of 680° C., the introduction of the charge being spaced over a period of 30 minutes. The vapors of the charge react with the hydrogen sulfide gas over the 30 minute period to deposit upon the titanium dioxide coated glass base plate a film of manganese and chlorine activated zinc sulfide approximately 10 microns thick.

Upon the deposition of the zinc sulfide cathodoelectroluminescent phosphor layer upon the glass base plate, the titanium dioxide film, which originally is non-conducting, is lowered in resistivity to a value of approximately 1000 ohms per square. This value is very small as compared with the resistvity of cathodoelectroluminescent phosphor layer **8**, and enables the titanium dioxide film to be utilized as an electrode as hereinbefore described. A thin aluminum layer **10** approximately 0.1 micron thick is then evaporated on layer **8**, and the faceplate assembly is assembled in cathode ray tube **1**.

In another specific example of the information of the cathodoelectroluminescent presentation tube, the same apparatus as used in the previously described example is utilized, the titanium dioxide coated base plate is maintained at a temperature of 600° C. and the reaction chamber is maintained in an atmosphere of hydrogen sulfide at 600 microns pressure. A layer 10 microns thick is deposited upon a 6" diameter Pyrex glass plate by continuously feeding into the evaporation boat over a period of 30 minutes a mixture consisting of 4.5 grams of red phosphorus, 25 grams of zinc chloride, and 50 grams of powdered metallic zinc. A 0.1 micron layer of aluminum is evaporated on this layer and the faceplate assembled into a cathode ray tube.

In another specific example, a 10 micron thick layer is formed upon a 6" diameter titanium dioxide coated Pyrex glass plate maintained at a temperature of 600° C. in an atmosphere of 600 microns of hydrogen sulfide while a mixture consisting of 1.13 grams of arsenic, 25 grams zinc chloride and 50 grams of metallic zinc was fed into the evaporation boat over a period of 30 minutes.

In another specific example, a 20 micron thick layer is formed on a 6" diameter titanium dioxide coated Pyrex glass plate maintained at a temperature of 600° C. in an atmosphere of 600 microns of hydrogen sulfide gas while a mixture consisting of 2.25 grams of antimony, 25 grams of zinc chloride, and 50 grams of powdered metallic zinc was fed into the evaporation boat over a 30 minute period.

In another specific example, a 20 micron thick layer was formed upon a 6" diameter titanium dioxide coated Pyrex glass plate maintained at a temperature of 600° C. in an atmosphere of 600 microns of hydrogen sulfide gas while a mixture consisting of 0.25 gram of manganese chloride, 2.25 grams of red phosphorus, 25 grams of zinc chloride, and 50 grams of powdered metallic zinc was fed into the evaporation boat over a period of 45 minutes.

In another specific example, a 20 micron thick layer was formed upon a 6" diameter titanium dioxide coated Pyrex glass plate maintained at a temperature of 600° C. in an atmosphere of 600 microns of hydrogen sulfide while a mixture consisting of 0.25 gram of manganese chloride, 1.13 grams of arsenic, 25 grams of zinc chloride and 50 grams of powdered metallic zinc was fed into the evaporation boat over a period of 45 minutes.

In another specific example, a 20 micron thick layer was formed upon a 6" diameter titanium dioxide coated Pyrex glass plate maintained at a temperature of 600° C. in an atmosphere of 600 microns of hydrogen sulfide gas while a mixture consisting of 0.25 gram of manganese chloride, .70 gram of antimony, 25 grams of zinc chloride and 50 grams of powdered metallic zinc was fed into the evaporation boat over a 45 minute period.

In the above examples after the deposition of phosphor layer **8**, as described above, a thin coating of a suitable conducting material **10** having a sufficiently small thickness as to be penetrable or transparent to the incident cathode rays is applied over the phosphor layer. Conveniently, conducting layer **10** may comprise an easily volatilizable metal, as for example, aluminum, silver or gold. When such metals are used the thickness is chosen to result in little energy loss to the incident cathode rays and may be approximately 0.1 micron thick for a 15 kilovolt electron beam. Such metals may be deposited by well known methods, as for example by vacuum evaporation or sputtering. The assembly of faceplate **7** and layers **9**, **8**, and **10** is then assembled into a cathode ray tube as illustrated in FIG. 1.

To achieve intensified images in operating tube **1**, the average field strength established within layer **8** should be approximately 10^4 to 10^5 volts per centimeter. Battery **11** is connected with transparent conducting film **9** positive, and metallic conducting film **10** negative. For 5 to 30 kilovolt electron beams, wherein the cathodoelectroluminescent film may conveniently be 10 microns thick, voltage source **11** may supply approximately 100 volts. For higher energy beams, cathodoelectroluminescent layer **8** may be thicker and battery **11** may conveniently supply a higher voltage.

Unlike cathodoluminescent and electroluminescent phosphors which generally utilize other activators than are utilized in the cathodoelectroluminescent phosphor layers of the invention, and are generally of the suspended phosphor powder in dielectric type, cathodoelectroluminescent phosphor layer **8** displays only weak luminescence with the application of the electric field thereto, in the absence of incident cathode rays. This has been found to be true for values of field strength as high as approximately 10^5 volts per centimeter. The same phosphor layer is brought to only weak luminescence when scanned by impinging information-containing cathode rays. This luminescence, as is well known, always possesses less energy than the kinetic energy of the incident cathode rays. When, however, a unidirectional field of the proper polarity, as described above, is impressed upon the cathodoelectroluminescent phosphor layer, the brightness of this weak luminescent image is substantially increased, and is observed to increase by a factor of as much as an order of magnitude over the intensity of the image produced by an electron beam alone. Under the proper conditions the energy emitted by the phosphor layer can be greater than the kinetic energy of the exciting cathode ray beam.

FIG. 2 of the drawing illustrates the increased brightness obtainable from cathode ray tubes constructed in accord with the present invention. The curve of FIG. 2 is a plot of the ratio of brightness of the light emitted from the device of FIG. 1 with battery 11 connected to the brightness of the device with battery 11 disconnected as a function of beam current density. The ratio expressed is, therefore, the ratio of brightness obtained from a device constructed in accord with the present invention to brightness obtained from a conventional cathode ray tube of similar construction. As may be seen from FIG. 2, tubes constructed in accord with the invention show up to 11 times the brightness exhibited by conventional cathode ray tubes at low current densities.

Cathodoelectroluminescent image intensification attained in the devices of the present invention, is to be distinguished from various transient effects such as the Gudden-Pohl or Lenard effects in which momentary enhancement of luminescence is attained by the application to, or removal of, an electric field from a luminescent phosphor. Such phenomena depend upon the effects of storage of electrons at trapping energy levels, and are transient in nature only. Cathodoelectroluminescence, on the other hand, is a steady state phenomenon which results in the continuous intensification of cathodoluminescent information and images.

It may readily be seen, therefore, that the cathodoelectroluminescent effects of the invention are neither simple electroluminescent effects nor simple cathodoluminescent effects, but rather, dependent upon the concurrent excitation of certain phosphors by cathode rays and an applied undidirectional electric field. As mentioned hereinbefore, since the applied electric field supplies the energy to produce luminescence, and the incident cathode rays trigger and control this luminescence, a potentially greater amount of energy is derived from the screens than is incident thereupon in the incident cathode rays.

A further embodiment of the invention is illustrated diagrammatically in FIG. 3 of the drawing. In FIG. 3 cathode ray tube 1 as illustrated in FIG. 1 is similarly connected and a unidirectional electrical field supplied to cathodoelectroluminescent layer 8 by means of unidirectional voltage source 11. Cathodoelectroluminescent layer 8 is further irradiated with a uniform intensity of ultra-violet from ultra-violet source 14. In this embodiment of the invention, the hereinbefore-discussed increase in the brightness of luminescent images obtained from cathodoelectroluminescent layer 8 may be achieved utilizing greater thickness cathodoelectroluminescent layers than may be utilized in the embodiment of FIG. 1. In the embodiment of FIG. 1 the enhancement of the brightness light output is dependent upon the penetrating power of the cathode rays for the creation of the initial free electrons which eventually excite the phosphor to luminesce. The penetrating power of these electrons is not too great in extremely thick luminescent films. For mechanical properties, however, it may be desirable that thicker films be utilized. According to this alternative embodiment of the invention, therefore, I utilize a very thick cathodoelectroluminescent layer as, for example, from 10 to 100 microns thick and obtain luminescent images therefrom utilizing relatively low electron beam velocities as, for example, 25 kilovolts by simultaneously impressing a unidirectional electron field upon the cathodoelectroluminescent layer and likewise simultaneously irradiating the cathodoelectroluminescent layer 8 through transparent conducting layer 9 with a uniform intensity of ultra-violet as for example 3650

A.U. wavelength light. The irradiation of the thick cathodoelectroluminescent layer with ultra-violet so decreases the resistivity thereof, that the low voltage electrons can much more radically increase space charge, thus facilitating the production of greatly enhanced cathodoelectroluminescent images from thick cathodoelectroluminescent films utilizing moderately low cathode ray energy beams.

While I have described above certain specific embodiments of my invention, many modifications and changes will immediately occur to those skilled in the art. It will be appreciated, therefore, that by the appended claims I intend to cover all such modifications and changes as fall within the true spirit and the scope of the foregoing disclosure.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A high brightness cathode ray intensifying device comprising: an evacuable envelope having at one end thereof a luminescent screen, said screen including only a phosphor layer consisting entirely of cathodoelectroluminescent material which is continuous, crystalline, homogeneous and nongranular and a pair of conducting electrodes contacting opposite surfaces of said cathodoelectroluminescent phosphor, at least one of said electrodes being electron permeable; and means at another end of said envelope for generating, modulating, focusing and deflecting a beam of cathode rays over said screen to directly irradiate and excite said phosphor layer and initiate emission therefrom.

2. A high brightness cathode ray image intensifying device comprising: an evacuable envelope having a face plate at one end thereof; a transparent conducting layer deposited upon said face plate; a phosphor layer deposited upon said transparent conducting layer, said phosphor layer being composed only of cathodoelectroluminescent phosphor material which is continuous, crystalline, homogeneous and nongranular; an electrically conductive electron permeable layer deposited over the exposed surface of said cathodo-electroluminescent phosphor layer; and means at another end of said envelope for generating, focusing, modulating and deflecting a beam of cathode rays over said face plate which directly irradiate said phosphor layer.

3. A high brightness cathode ray intensifying device comprising: an evacuable envelope having a face plate at one end thereof; a phosphor layer disposed adjacent said face plate, said phosphor layer consisting only of a cathodoelectroluminescent phosphor which is continuous, crystalline, homogeneous and nongranular; a pair of conducting electrodes in contact with opposite surfaces of said layer so as to directly contact the cathodoelectroluminescent phosphor, at least one of said electrodes being electron permeable; and means for impressing a uniform unidirectional electric field transversely across said phosphor layer.

4. A high brightness cathode ray image intensifying device comprising an evacuable envelope having a face plate at one end thereof; a transparent conducting layer deposited upon said face plate; a phosphor layer deposited upon said transparent conducting layer, said phosphor layer consisting only of a cathodoelectroluminescent phosphor which is continuous, crystalline, homogeneous and nongranular; an electrically conductive, electron permeable layer deposited over the exposed surface of said cathodoelectroluminescent phosphor layer; means at another end of said envelope for generating, focusing, modulating and deflecting a beam of cathode rays over said face plate to directly irradiate and excite said phosphor layer and initiate emission therefrom; and means for impressing a uniform unidirectional electric field transversely across said phosphor layer.

5. A high brightness cathode ray intensifying device comprising an evacuable envelope having a face plate at one end thereof; a phosphor layer disposed adjacent

said face plate, said phosphor layer being composed only of a cathodoelectroluminescent phosphor which is transparent, continuous, homogeneous and nongranular and selected from the group consisting of the sulphides and selenides of zinc, cadmium and mixtures thereof activated with a halogen and a material selected from the group consisting of manganese, arsenic, antimony and phosphorus; and a pair of electrically conductive electrodes directly contacting opposite surfaces of said phosphor layer so as to directly contact the cathodoelectroluminescent phosphor, at least one of said electrodes being electron permeable; and means at another end of said envelope for generating, modulating, focusing and deflecting a beam of cathode rays over said face plate to directly irradiate said phosphor layer and initiate emission therefrom.

6. The device of claim 5 wherein the phosphor is zinc sulfide activated with manganese and chlorine.

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