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LUMINESCENT APPARATUS AND METHOD OF DEVELOPING LUMINESCENCE

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Fig. 1.

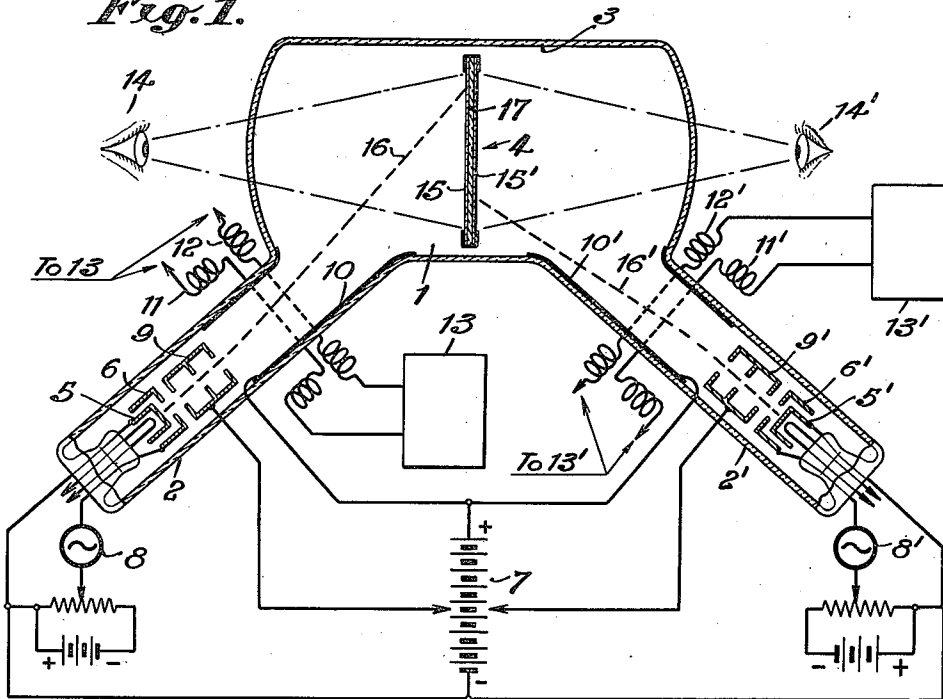


Fig. 2.

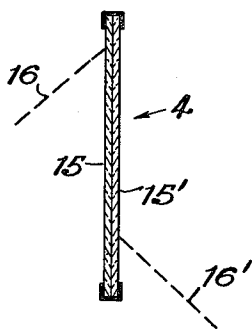
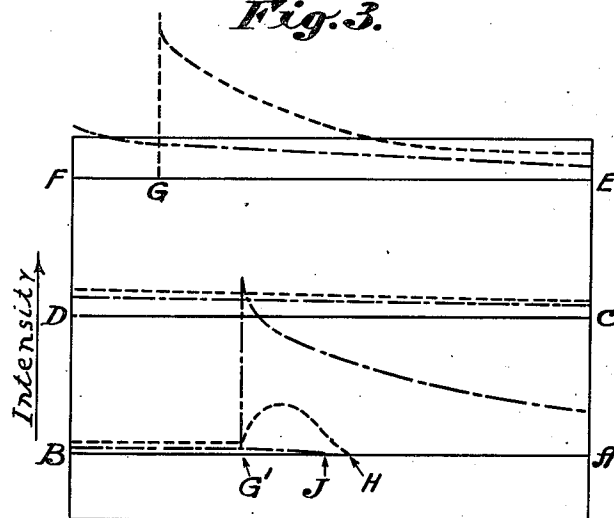


Fig. 3.



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LUMINESCENT APPARATUS AND METHOD
OF DEVELOPING LUMINESCENCEHumboldt W. Leverenz, South Orange, N. J., as-
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13 Claims. (Cl. 250-150)

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My invention relates to luminescent apparatus and particularly to tubes and systems wherein a luminescent phosphor screen is scanned by beams of radiant energy, such as cathode ray beams. Luminescent tubes are known wherein a luminescent phosphor screen is provided for developing light under scansion with an electron beam or other beam of radiant energy, such as ultra-violet light beam. Such phosphor screens are characterized in that, when excited by the radiant energy, light is liberated in response thereto which is useful in portraying the path of the beam or occurrences during its traversal of the screen in which case the beam of radiant energy may be modulated in accordance with an unknown phenomena. Such tubes are in extensive use for the recreation of television picture replicas. Hereafter I will use the term "luminescence" to refer to the light and the property of a phosphor developing light in response to incident energy excitation, and I will use the term "fluorescence" to refer to the light developed during excitation, and the term "phosphorescence" to refer to the light liberated by a phosphor subsequent to or following the cessation of excitation. The term "luminescence" will therefore be used to include both fluorescence and phosphorescence.

The majority of luminescent screens are characterized in the fact that they exhibit both fluorescent and phosphorescent properties, the liberated light intensity after cessation of excitation often being a considerable percentage of the fluorescent light intensity liberated during excitation. This fact as well as the fact that the fluorescent and phosphorescent light may be of different colors is well known. For many applications of such tubes this inherent property of a phosphor to exhibit both fluorescence and phosphorescence is a definite disadvantage in that the phosphorescence may mask the phenomena which it is desired to portray by means of the fluorescent characteristics of the phosphor.

It is, therefore, an object of my invention to provide luminescent apparatus wherein the effects of fluorescence and phosphorescence may be differentiated. It is another object to provide a tube and method of operation wherein the phosphorescence of the material may be controlled or minimized in a definite time sequence with respect to the excitation of the phosphor to fluorescence. It is a still further object to provide a tube wherein masking of the fluorescent light by the phosphorescent light is avoided without diminution of the fluorescent light, and it is

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a still further object to provide a tube wherein the effective period of phosphorescence may be limited to a predetermined length of time.

In accordance with my invention I provide a method of developing luminescent light having fluorescent and phosphorescent components over an extended area in a predetermined scanning sequence including a step of extinguishing the phosphorescent component of the luminescent light during a predetermined time following the excitation of the fluorescent light. Further in accordance with my invention I provide suitable apparatus for performing my method incorporating a composite luminescent screen scanned on opposite sides by beams of radiant energy separated in time sequence, one component of the phosphor screen scanned by one beam having a definite spectral emission with respect to that of the phosphor component scanned by the second beam.

These and other objects, features and advantages of my invention will become apparent when considered in view of the following description of my apparatus and method of operation when taken in connection with the accompanying drawing wherein:

Figure 1 shows a type of tube and apparatus made and operated in accordance with my invention and particularly suited to my method of developing light;

Figure 2 is an enlarged view of a composite phosphor screen suitable for use in the tube of Figure 1; and

Figure 3 shows the enclosed outline of a target area scanned by an electron beam together with two phosphorescent decay curves explaining my invention.

While I will describe one particular embodiment of an apparatus suitable for performing my method of developing luminescent light, it will be appreciated that my method of operation is not limited to the particular embodiment set forth hereinafter, but that the method may be performed with other types of apparatus and in fact may be performed entirely by hand. Such an embodiment of my method will be described following the particular references to the apparatus shown in Figure 1 wherein the tube 1 comprises an evacuated envelope having two neck portions 2 and 2' and an intermediate cylindrical portion 3 enclosing a composite phosphor screen which will be described hereinafter in considerable detail as to its preferred components and method of construction. The composite phosphor screen 4 is so positioned that it may be

scanned by an electron beam on each side thereof, such as developed by electrode structures located within the neck portions 2 and 2'. The electron beam developing means positioned in each of the neck portions 2 and 2' may be substantially identical and include cathodes 5-5' preferably of the type which may be indirectly heated by a filamentary heater. The cathodes 5-5' may each be surrounded by a control grid or intensity modulating electrode 6-6' connected to the usual biasing battery, such as through a potentiometer as shown, and to the negative terminal of the potential source 7. It will be appreciated that the control electrode leads may be provided in series with a source of modulating potential 8-8' although for certain applications to which my method and system is particularly adapted it is necessary to apply modulating potentials to only one of the grid electrodes, such as the grid electrode 6. However, for other applications the modulating sources may be entirely eliminated. The electrons liberated by the cathodes 5-5' and controlled by the electrodes 6-6' are accelerated and directed toward opposite sides of the phosphor screen 4 by first anodes 9-9' connected to an intermediate point on the potential source 7 for purposes of beam focusing and by second anodes 10-10' connected to the positive terminal of the potential source 7 so that the beam comprising the electrons is focused on the luminescent phosphor screen 4. Intermediate the anodes 9-9' and the screen 4 and preferably surrounding the respective neck portions 2-2', I provide mutually perpendicular deflection means, such as the vertical deflection coils 11-11' and horizontal deflection coils 12-12', to deflect each of the beams over the extended area of the screen 4 in such a manner that the areas scanned by one beam on one side of the screen are directly opposite the areas scanned by the other beam but at a somewhat later predetermined time. The deflection coils 11 and 12 are connected to a conventional deflection supply circuit shown at 13. This deflection supply circuit may comprise conventional sawtooth generating circuits or may comprise a time axis supply connected to one set of coils with an unknown wave form applied to the other set of coils. Similarly the deflecting coils 11'-12' may be connected to a separate conventional source of deflection supply as circuit shown at 13' which may likewise develop sawtooth current forms under control of the deflection supply 13 in such a manner that the electron beam from the cathode 5' scans over the same areas on the right side of the screen 4 as the areas scanned on the left side but at a predetermined time following the scanning on the left side. Obviously electrostatic means may be substituted in whole or in part for the magnetic means for beam deflection and means may be provided for "keystone correction," which is desirable when the electron beam scans an inclined target.

In accordance with my invention I provide a luminescent phosphor screen 4 either as shown in Figure 1 or Figure 2 comprising a composite phosphor or phosphor coated member. In either event the screen 4 is so positioned that it may be viewed by an observer at 14, although where both electron guns are angularly displaced the screen may be viewed such as by an observer at 14', as referred to more particularly below. More particularly the structure shown in Figure 2 may comprise a luminescent phosphor screen having two layer components, such as the phosphor layer

15 adapted to be scanned by the electron beam 16 from the cathode 5 and a phosphor layer 15' adapted to be scanned by the electron beam 16' from the cathode 5'. These phosphor layers may be self-supporting within a frame member or may be on opposite sides of a thin transparent foundation as later described. The layers 15 and 15' are wholly dissimilar phosphor materials having different spectral emission characteristics. The layer 15 may be of any suitable material having peaked spectral emission characteristics in the visible or ultraviolet portions of the spectrum and may be those materials having relatively great phosphorescence following excitation. Various inorganic phosphors, such as manganese-activated zinc silicate, zinc beryllium or zirconium silicate, copper or silver activated zinc or cadmium sulphides or various other materials having a visible spectral emission under excitation may be used for the layer 15. I provide the layer 15', however, of a material having relatively rapid phosphorescent decay characteristics with high luminescence, such as in the red or infrared portions of the spectrum, capable of accelerating or extinguishing the phosphorescence of the material comprising layer 15. The material comprising the layer 15' is preferably chosen to have the same or somewhat shorter phosphorescence than the layer 15 and may to advantage comprise chromium activated aluminum oxide, chromium activated aluminum beryllate, chromium activated zinc-beryllium aluminate and manganese activated magnesium silicate. All of these materials have an excitation band in the red or infra-red portions of the spectrum so that the light liberated by the elemental scanned areas of the layer 15' becomes incident upon opposite areas of the layer 15. Such opposite areas having been previously scanned by the beam 16 may still be liberating phosphorescent light, and the luminescence from the layer 15' rapidly accelerates this liberation of light thereby rapidly extinguishing the phosphorescence from the layer 15.

The layers 15 and 15' are preferably of such thickness and the velocity of the electron beams from the cathodes 5 and 5' are so chosen that the electrons do not penetrate to the full thickness of the individual layers scanned by the respective beams and into the opposite layer. More accurately these factors are chosen so that the electron beam does not penetrate to any large extent into and excite the layer underlying the layer scanned by the particularly electron beam. The light liberated in response to each scanning is, therefore, characteristic of the excitation band of only the layer which is scanned. Thus, while I will later refer to the layer 15 as a cascade layer, it will be appreciated that this layer or any multiple layers replacing the layer 15 are of such thickness with respect to the electron beam velocity from the cathode 5 that penetration of electrons capable of producing luminescence in the layer 15' is minimized.

To prevent penetration of electrons from one layer to another which might excite the other layer, the phosphor layers 15 and 15' may be separated by a small but finite distance on opposite sides of an electron barrier 17. Thus, as shown in Figure 1 the layers 15 and 15' may be on opposite sides of a thin glass or other infra-red transparent electron barrier 17 serving as a foundation for the two layers. The separation between the layers 15 and 15', however, should be as small as possible and preferably equal to or less than

the electron beam diameter to prevent loss of resolution. Otherwise spreading of the luminescence from the layer 15' tends to accelerate the extinction of phosphorescence before such action is desired.

I have referred above to the use of cascade phosphor layers, the principal mode of operation of which is fully described in my copending application, Serial No. 383,893, filed March 18, 1941. Such screens in principle comprise a series of layers of different phosphor materials having different spectral emission characteristics and related spectral absorption characteristics whereby, following excitation of one layer, the second layer is excited at a lower frequency by the luminescent light of the preceding layer. Such a multiple cascade phosphor system may be substituted for the layer 15, with the layer of the cascade having the highest frequency or shortest wavelength spectral response facing the electron beam 16 and the layer having the lowest frequency spectral response facing the layer 15'. In such a combination the layer 15' is of a phosphor having a lower frequency or longer wavelength spectral response than the nearest adjacent layer of the cascade screen.

The various chromium and manganese activated materials referred to above are suitable for use with phosphor layers of either the single or cascade type having a useful emission spectra over a wide range of frequencies and I have chosen these phosphor materials because their spectral absorption band lies outside of the visible spectrum so that the composite screen may be viewed from the scanned side of the layer 15' such as by an observer at 14'. If, however, the layer 15 is to be observed directly such as by an observer at 14, the layer 15' may comprise phosphors having absorption spectra overlapping the emission spectra of the layer or layers 15. Such phosphors include silver or copper activated zinc-cadmium sulphide or relatively high cadmium content and silver or copper activated zinc sulpho-selenide.

In operation of my method and system elemental areas of the layer, or series of layers represented by the layer 15, are scanned in a predetermined sequence, such as by the electron beam 16, elemental areas of the layer 15' opposite said elemental areas of the layer 15 being scanned at a predetermined time later for the purpose of extinguishing the phosphorescent light developed by the layer 15. This scanning sequence and the resultant action will be fully appreciated by reference to Figure 3 wherein the lines AB, CD and EF represent three elemental lines scanned on opposite sides of the phosphor screen 4 by the two electron beams. It will be assumed that electrons are simultaneously scanning widely separated areas at any instant of time for which the instantaneous position of the beam 16 is shown at point G and the instantaneous position of the electron beam 16' is shown at G'. The dashed-line curve originating at the point G is representative of the phosphorescence developed by the electron beam 16 and it will be noted that the ordinates representative of phosphorescent intensity decrease from G to E, from D to C and from B to G; it being assumed that the electron beam 16 has previously scanned the lines AB, CD and E to the point G. The phosphorescent intensity along these lines is thus shown by the ordinates from the line to the dashed lines and it will be noted that the intensity gradually decreases with time to the point G' but is of finite

value at the point G'. The electron beam 16', however, from the cathode 5' has reached the point G' along the scanning line AB at the time the electron beam 16 has reached the point G.

The electron beam 16' produces luminescence of which the phosphorescent component is shown by the dash-dot line of Figure 3. This phosphorescent component is light of low frequency, preferably being in the red or infra-red portion of the spectrum and is usually of lower frequency than the phosphorescent light from the layer 15. Consequently the light from the layer 15' is incident upon the layer 15 at the point G' and since the phosphorescence of the layer 15 at the point G' is still of finite value, the energy developing the phosphorescence in the layer 15 at the point G' is rapidly dissipating as shown by the hump in the curve following the point G'. The phosphorescence of the layer 15 following the point G' is, therefore, rapidly accelerated and extinguished and becomes practically zero at the point H so that from H to A of the scanning line AB and from F to G of the scanning line EF the screen 15 is developing no useful light. Obviously this arrangement allows the positive extinction of the phosphorescent light developed by the layer 15 prior to the redevelopment of luminescence by the scanning beam 16. Consequently the period of phosphorescence of the line 15 may be controlled over a wide time range, limited only by the maximum time period between sequential scanning of the same area and a minimum time period necessary for the extinction of the phosphorescence by the beam 16' represented by the scanning time between points G' and H.

As shown by Figure 3 the phosphorescent decay period of the layer 15' is shorter than the phosphorescent decay period of the layer 15 and the phosphorescent intensity of the layer 15 may be considered substantially zero following the point J so that this layer is in condition to be reexcited without any holding over of light emission from a previous scan.

From the above it will be evident that I have provided a system and method whereby the period of phosphorescence of a luminescent screen may be controlled within definite time limits and that the extinction of the phosphorescence may be limited to confined areas. Previous arrangements for the extinction of phosphorescence have limited the useful light output of the device. Thus, it has been proposed to utilize a filter transparent to fluorescence but opaque to phosphorescence or to use a flood of infra-red light over the entire phosphor screen area to extinguish the phosphorescence. Obviously such arrangements are definitely disadvantageous in that they are continuously effective and considerably decrease the light output which may be utilized to advantage.

While I have described my system and method with particular reference to phosphor excitation by cathode ray beam means and with particular reference to a preferred structure utilizing electron beam generating means, it will be appreciated that my method and apparatus is not limited to the forms specifically described. For example, my method may be very efficiently performed by scanning a beam of ultra-violet light over opposite sides or over one side with electron excitation over the other side of a composite phosphor screen wherein the ultra-violet light is scanned by the use of mirrors or by a scanning spot from a cathode ray tube having an ultra-violet emitting phosphor screen. Furthermore, my method may be performed efficiently by man-

usually moving a light beam from flashlights held in the hand by each of two persons on opposite sides of a composite phosphor screen in such a manner that the light beam developing the longest wavelength light on the phosphor screen follows the other light beam. Therefore, in view of these many modifications in apparatus and the fact that various expedients may be utilized in following my method, my invention should not be limited to the particular apparatus or to the sequence of steps described except as set forth in the appended claims.

I claim:

1. Apparatus for developing luminescent light comprising a luminescent target having phosphor material exposed on opposite sides thereof, means facing each side of said target to subject each of said sides to a beam of luminescence exciting energy, the said phosphor material on one side of said target having a spectral emission, when excited, of higher frequency than the said phosphor material on the other side of said target and means to scan said beams of exciting energy over similar paths on opposite sides of said target and at non-opposite points at any instant of time along said paths.

2. Apparatus for developing luminescent light and extinguishing phosphorescent light comprising a composite phosphor screen of extended area, said screen including oppositely disposed phosphor materials excitable to luminescence under incident excitation at different wavelengths, means to scan elemental areas of the extended area of the phosphor material excitable at the shorter wavelength with a beam of radiant energy to develop luminescence including a phosphorescent component, and means to scan elemental areas of the other phosphor material opposite said first-mentioned elemental areas at a time within the phosphorescent decay period following scanning of said first scanned material.

3. Apparatus for developing luminescence and suppressing phosphorescence comprising a luminescent screen having oppositely disposed layers of phosphors, one of said phosphors having a luminescent excitation band of relatively high frequency, the other phosphor having a band extending into the infra-red portion of the spectrum, and means to scan opposite elemental areas of said phosphors during sequential periods of time with luminescence exciting energy whereby the phosphorescence of the high frequency emitting phosphor is accelerated.

4. Apparatus for developing luminescence and suppressing phosphorescence comprising a luminescent screen having oppositely disposed layers of phosphors, one of said phosphors having a luminescent and phosphorescent excitation band of relatively high frequency, the other phosphor having an excitation band extending into the infra-red portion of the spectrum, and means to scan opposite elemental areas of said phosphors with luminescence exciting energy during sequential periods of time, the scanning of the high frequency phosphor preceding the scanning of the said other phosphor whereby the phosphorescence of the high frequency emitting phosphor is accelerated.

5. Apparatus as claimed in claim 4 wherein the phosphor having a relatively high frequency excitation band is of a material having a longer phosphorescent decay time than that of the phosphor having a band extending into the infra-red portion of the spectrum.

6. Apparatus for developing luminescent light

comprising an evacuated envelope, a pair of oppositely disposed electron sources in said envelope, a composite luminescent phosphor screen having a phosphorescent material excitable under incident electrons in the visible portion of the spectrum facing one of said electron sources and a material excitable in the infra-red portion of the spectrum facing the other of said sources, means to scan electrons over elemental areas of said first-mentioned material to excite visible luminescence including a phosphorescent light component and means to scan electrons from said second source over elemental areas of said second-mentioned material opposite said first-mentioned areas within a time following said first-mentioned scanning less than the phosphorescent decay period of said first-mentioned material.

7. Apparatus for developing luminescent light and suppressing phosphorescent light comprising an evacuated envelope, a pair of oppositely disposed electron sources in said envelope, a composite luminescent phosphor screen having a layer of phosphorescent material excitable under incident electrons in the visible portion of the spectrum facing one of said electron sources and a layer of material excitable in the infra-red portion of the spectrum facing the other of said sources, means to scan electrons over elemental areas of said first-mentioned material layer to excite visible luminescence including a phosphorescent light component, means to scan electrons from said second source over elemental areas of said second-mentioned material layer opposite said first-mentioned areas within a time following said first-mentioned scanning less than the phosphorescent decay period of said first-mentioned material and means between said material layers to prevent excitation of one material layer by electrons incident upon the other material layer.

8. Apparatus for developing luminescent light comprising a luminescent phosphor layer of material excitable under incident energy in the visible portion of the spectrum, a second layer contiguous with said first layer excitable and emitting energy in the infra-red portion of the spectrum, dual means to sequentially subject directly opposite elemental areas of said layers to incident luminescence exciting energy the time period between excitation of opposite areas being within the phosphorescent decay time of said first-mentioned layer, and means to prevent undesirable excitation of both of said layers by one of said dual means.

9. Apparatus for developing luminescent light comprising a luminescent phosphor layer of material excitable under incident energy in the visible portion of the spectrum, a second layer contiguous with said first layer excitable and emitting energy in the infra-red portion of the spectrum, dual means to sequentially subject directly opposite elemental areas of said layers to incident luminescence exciting energy the time period between excitation of opposite areas being within the phosphorescent decay time of said first-mentioned layer, each of said layers being of sufficient thickness to absorb substantially all of the energy incident on the respective layers whereby undesirable excitation of both of said layers by each of said dual means is prevented.

10. The method of developing and controlling luminescent light comprising the steps of developing luminescent and phosphorescent light over displaced elemental areas in space in predetermined sequence and developing luminescence of

longer wavelength than said developed light over elemental areas adjacent with said first-mentioned areas at a finite time following the first development of luminescence.

11. The method of developing and controlling the intensity of light comprising the steps of developing light having a fluorescent and a phosphorescent component over displaced elemental areas in space in predetermined sequence and developing luminescence of longer wavelength than the phosphorescent component of said developed light over elemental areas contiguous with said first-mentioned areas at a finite time following the first development of the fluorescent light component.

12. The method of developing light of predetermined phosphorescent decay period including the steps of developing phosphorescence over elemental areas displaced one from the other in coplanar relation, and developing light of longer

wavelength than said phosphorescence over elemental areas in coplanar relation and adjacent said first-mentioned areas during the unobjectionable decay period of said phosphorescence and at a finite time following the initial development of phosphorescence.

13. The method of developing light of predetermined phosphorescent decay period including the steps of simultaneously developing fluorescence and phosphorescence over elemental areas displaced one from the other in coplanar relation, and subsequently developing fluorescence and phosphorescence of longer wavelength than the first developed phosphorescence over elemental areas adjacent said first mentioned areas during the decay period of said first developed phosphorescent light and at a finite time following the development of said first mentioned fluorescence.

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