June 25, 1946. H. W. LEVERENZ 2,402,761

CATHODE RAY TUBE SYSTEM AND METHOD OF OPERATION.

Filed July 23, 1942

Fig. 1.

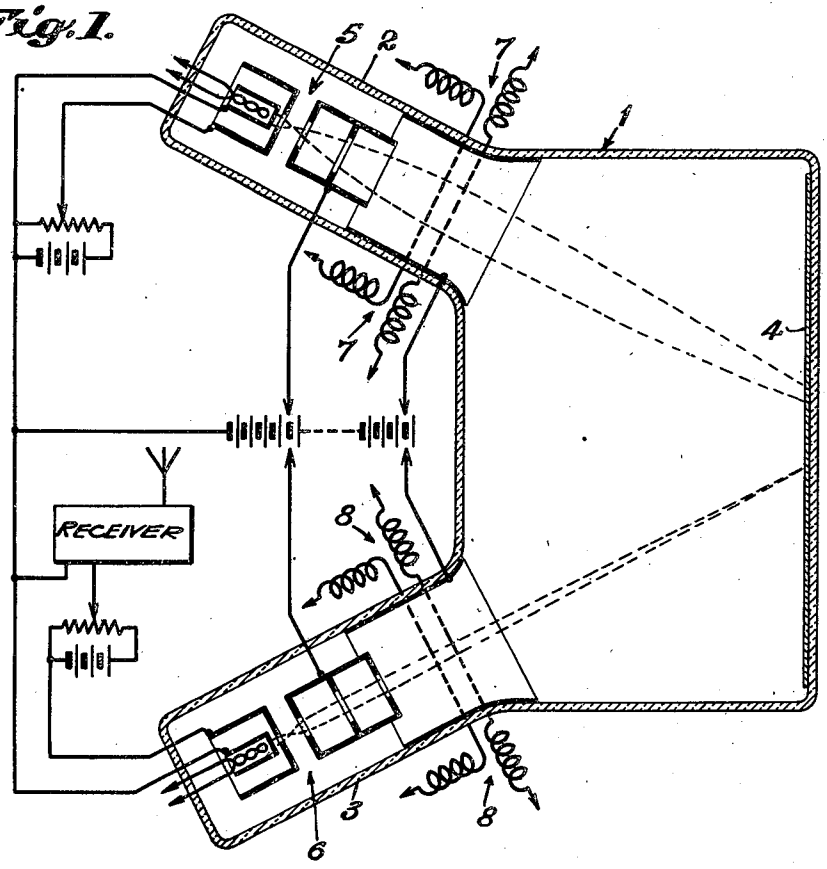


Fig. 2.

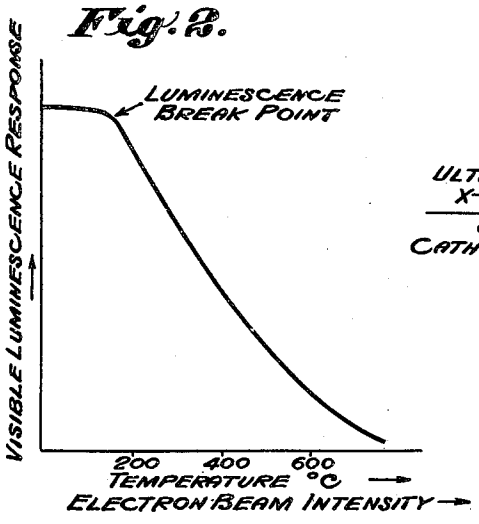
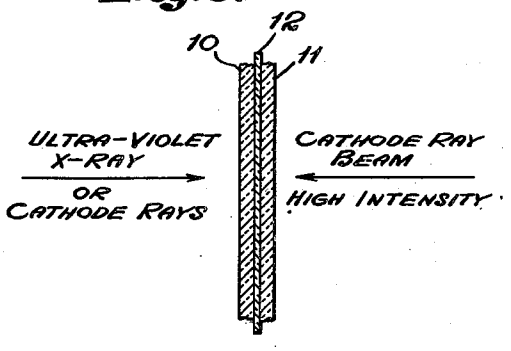


Fig. 3.



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Patented June 25, 1946 2,402,761

UNITED STATES PATENT OFFICE

2,402,761

CATHODE-RAY TUBE SYSTEM AND METHOD OF OPERATION

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Application July 23, 1942, Serial No. 451,984

1 Claim. (Cl. 178—7.5)

1

My invention relates to cathode ray tubes, methods of operation, and systems, and particularly to tubes and systems incorporating targets of the luminescent material type.

It is known that alkali halides such as potassium chloride have the property of coloring and developing color centers to form a "dark trace" under electron bombardment. Thus, when such an alkali halide target is scanned by an electron beam, electrons are injected into the crystal lattices, thereby modifying the light absorbing properties of the halide so that when illuminated, a dark trace having relatively good contrast with respect to a uniform light background from an auxiliary light source is obtained. The recent development of aircraft position and indicating equipment utilizing cathode ray tubes wherein the electron beam of the tube is sequentially pulsed to form on the target a dark trace representative of the position or trajectory of the aircraft necessitates the development of high contrast between the areas of the target indicating aircraft position and distances with respect to the surrounding areas of the target. While the halide type of target has certain advantages over heretofore known luminescent targets such as described in my copending application Serial No. 383,893, filed March 18, 1941, notably in reduction of flash ratio, greater contrast, and in addition a tube having greater life, it is necessary to provide better operation and to avoid early tube replacement.

Inasmuch as received signals representative of the air craft position and distance are transient, it is necessary to portray the information of which these signals are representative over a relatively long period of time following their reception. For example, the persistance of the portrayed intelligence must be of the order of two seconds to one minute. The conventional halide targets do not give entirely satisfactory contrast over this desired period. Furthermore, the ordinary halide targets have an inherent disadvantage in that repeated bombardment or very strong bombardment by cathode rays produces a permanent discoloration after a very short period of use. In addition, such halides decompose liberating halogen ions which destroy the cathode.

It is an object of my invention to provide a more efficient dark trace tube and system for portraying transient phenomena over a relatively long period of time. Another object is to provide a tube and system having better life and greater contrast than obtainable in tubes and systems

2

used heretofore. Another object is to provide an improved tube and system operable without an auxiliary light source. A further object is to provide a method of developing dark traces of transient phenomena wherein the phenomena may be observed over a relatively long period of time; and it is a still further object to provide a tube and system having high contrast and a low flash ratio.

These, and other objects, features, and advantages of my invention will be apparent from the following description and the accompanying drawing wherein,

Fig. 1 shows a cathode ray tube incorporating a target structure and system made and operated in accordance with my invention;

Fig. 2 shows a curve useful in explaining my invention; and,

Fig. 3 shows a portion of another suitable target structure for use in the tube of Fig. 1.

In accordance with my invention, I excite a luminescent screen to uniform high brilliancy by one means or by a group of means, such as cathode rays, ultra violet, or X-ray radiation and then de-excite pattern areas of the brilliantly excited total area with a high current density electron beam which in effect "burns" the luminescent screen momentarily, thereby forming a dark trace on the brilliantly illuminated area. More particularly, in accordance with my invention, I provide a tube and system having a luminescent screen of phosphor material which has good recovering power following cathode ray excitation beyond the current saturation level of the phosphor and I excite the phosphor screen to uniform high brilliancy either by scanning the screen with an electron or radiant energy beam or by subjecting it to a flood of electrons, ultraviolet or other exciting energy. Further, in accordance with my invention, I maintain the intensity of such excitation near the saturation level of the phosphor and I then scan the phosphor screen with a high intensity electron beam of sufficient density to exceed the current saturation level of the phosphor to an extent sufficient to momentarily "burn" the screen. The recovery of the phosphor screen material to its original efficiency may be controlled by varying the nature of the phosphor, the particle size of the phosphor, thermal insulation of the phosphor particles from each other and from the tube wall. screen thickness, heat capacity of the screen, and temperature of the screen.

A tube and system incorporating my invention is shown in Fig. 1, the tube comprising an evac-

uated envelope 1 preferably having two arm or neck sections 2 and 3 oppositely disposed from a phosphor screen 4 of material or materials referred to hereinafter. In the modifications of my invention wherein the screen 4 is initially excited to uniform high brilliancy by cathode rays, the neck portion 2 may incorporate an electron gun 5 either of the the focusing or non-focusing conventional types. The neck section 3 is provided with an electron gun 6 to develop and project a focused electron beam upon the screen 4 immediately following or during excitation to high brilliancy. Each of the electron guns 5 and 6 are supplied with conventional operating voltages as shown, provision being made to signal modulate the electron gun 6 as by conventional grid control. Such modulation may be effected by electronic means whereby upon reception of signal a high beam current is obtained whereas for no signal the gun operates substantially at cut-off. I have shown in Fig. 1 deflection means 7 for scanning the electron beam from the gun 5 over the screen 4 although it is not necessary to use such scanning means when the gun 5 is designed to produce an unfocused electron beam provided the entire effective area of the screen 4 is subjected to electron bombardment near the current saturation level of the screen material. Further scanning means 8 however are necessary to deflect the focused electron beam from the gun 6 over the effective areas of the screen 4 to produce the dark trace when the areas are subjected to excitation from the gun 6 beyond the current saturation level of the phosphor. In operation the electron gun 5 either sprays a defocused wash of electrons on the screen 4 to keep the luminescence output of the screen near the current saturation level or else rapidly scans the screen to obtain the same effect when considered in conjunction with the persistence of the human eye. The second electron gun 6 operates independently of the first with respect to scanning speed, pattern, modulation, voltage, and spot size and "burns" the transitory dark trace on the bright background. Consequently, by modulating the current intensity of the electron beam from the gun 6, such as by reducing the electron gun 6 grid bias during reception of signals, the dark trace representative of the signals is produced, provided the current intensity is sufficient to exceed the current saturation level of the phosphor screen material and decrease the luminescence of the bombarded screen element. The decrease in luminescence is probably largely due to raising the temperature of the phosphor particles above the temperature "break-point," although the luminescence may be simultaneously reduced by a reduction in secondary emission efficiency of the phosphor.

The decrease in luminescence may be explained by reference to Fig. 2 which is a curve representing the decrease in luminescence with increase in temperature, that is, increase in electron beam intensity. While effects other than an increase in temperature accentuate loss of luminescence, this curve shows that for a representative phosphor material, such as zinc sulphide, the luminescence decreases rapidly upon exceeding a critical temperature termed the "luminescence break-point." Therefore in operation the screen is excited to such a degree and the temperature is such that prior to de-excitation by the high intensity electron beam the visible luminescence output is as represented to the left of the "break-point" whereas after de-excitation the luminescence is to the right of the "break-point." The term "current saturation level" is thus equivalent to the term "luminescence break-point" and the term "equivalent current saturation level" is similarly equivalent to this break-point whether electron, ultra violet or other excitation means with or without auxiliary heating of the screen is utilized to initially excite the screen to a high degree of luminescence prior to de-excitation to form the dark trace.

Various phosphor materials may be utilized for the screen 4 although it is essential that the luminescent material have good recovering power following formation of the dark trace. Oxygen-containing phosphors, such as manganese-activated zinc silicate or other silicates, germanates, aluminates, and gallates are generally preferable to sulphur-containing phosphors. However, such sulphides as zinc sulphide, silver-activated zinc sulphide, copper-activated zinc cadmium sulphides, as well as seleno-sulphides may be used to advantage for certain applications, especially at low voltages where sulphides afford greater luminescence efficiency.

As indicated above, the excitation of the screen 4 to uniform high brilliancy may be by means other than cathode ray excitation such as by ultraviolet, ionic-bombardment or X-ray excitation. For example, by making the tube face or foundation on which the screen 4 is deposited of ultraviolet transmitting material such as Vycor glass, quartz or Corning 974 HW glass the screen may be excited to a high level of brilliancy from an external ultraviolet source predominant in wave lengths of 2537 A. or 3650 A., depending upon the type of phosphor used, either in addition to or in place of excitation from the electron gun 5. If ultra violet or X-ray excitation alone be employed, an external or internal means may be provided to raise the temperature of the screen to the "break-point" shown in Fig. 2.

It must be appreciated that it is essential to excite the phosphor screen substantially to the saturation level either by cathode ray or other excitation means prior to cathode ray bombardment beyond the current saturation level for dark trace formation because the screen must be on the threshold of burning prior to producing the transient burning effect by further electron bombardment. This bombardment effectively reduces the efficiency of the screen so that there is an actual loss of luminescence to form the dark trace. For maximum contrast the initial excitation should be preferably at least 90% of the maximum excitation obtainable at current saturation so that the electron beam developing the transient phenomena in the form of the dark trace may produce a trace which is high in contrast and of a persistence sufficient for the intended use such as indicated above.

The phosphor screen 4 may be of the composite type as disclosed in my above mentioned copending application operating on the cascade principle. In accordance with this prior teaching a layer of luminescent material having predetermined absorption and emission spectra is provided adjacent a second phosphor layer having an absorption spectrum overlapping the emission spectrum of the first layer. Alternatively, an electron barrier layer may be utilized between the two aforementioned phosphor layers as described in my copending application Serial No. 417,269, filed October 31, 1941.

Referring to Fig. 3, which shows diagrammatically, such a screen corresponding to and replac-

ing the screen 4 of Fig. 1, the first phosphor layer 10 comprises material such as silver-activated zinc sulphide or other phosphor having an energy absorption spectrum in the violet or ultraviolet region and an emission spectrum in the blue or near violet region. The second layer 11 comprises phosphor material having an excitation spectrum overlapping the emission spectrum of the layer 10. The two layers may be separated by an electron barrier layer 12 as shown, although use of this barrier layer is not essential.

In operation of the structure of Fig. 3 the phosphor layer 10 is excited to uniform high brilliancy by ultraviolet light, X-rays, cathode rays, or other corpuscular or radiant energy, the luminescence being over a spectral range overlapping the spectral absorption range of the layer 11. The layer 11 being exposed to this luminescence of the layer 10 produces additional luminescence of longer wave length than that of layer 10, the excitation of layer 10 being sufficient to render the layer 11 highly luminescent. Heating means should be provided, such as by direct heating or by infra-red, to keep the temperature of layer 11 near the "break-point" shown in Fig. 2. Following excitation of layer 11 by this means, I project a high intensity electron beam having the properties of the beam from the electron gun 6 of Fig. 1 upon the layer 11 and scan the beam thereover to produce the dark trace. I control the intensity of the beam incident on the layer 11 maintaining it above the current saturation level of the phosphor material comprising the layer 11 so that desired areas of the layer 11 are "burned" to render the dark trace visible on the general luminescent background of the layer 11. The barrier layer 12 is provided to prevent the beam incident upon the layer 11 penetrating within the layer 10, although the velocity of this beam and the thickness of the layer 11 may be controlled during manufacture to prevent such penetration without use of the barrier layer 12.

As stressed above, and for maximum contrast, it is desirable that the layer 11 be excited to within approximately 90% of the equivalent current saturation level under which the layer 11 would be initially excited by a cathode ray beam to enable the high intensity beam incident thereon to produce a dark trace of good visibility.

A further modification of my invention com-

prises a tube such as shown in Fig. 1 except having only one electron gun such as the gun 6 and a single layer screen, such as the screen 4. I operate such a tube by scanning the screen over a raster area at a rate greater than the persistence of vision such as in conventional television Kinescope tubes, the raster area being excited at or near maximum luminescence by maintaining a low bias on the electron gun control grid. The signal to be converted into a dark trace is then superimposed on the control grid in a positive potential direction with respect to the electron gun cathode to reduce the grid bias and increase the beam current. The dark trace then comprises a series of dark dots or short lines along the raster lines and due to persistence of vision and of "burning" is viewed as a true dark trace.

My method of operation comprises in essence developing luminescence of high intensity approaching the equivalent current saturation of a phosphor and reducing the effective luminescence by exceeding the current saturation level of the phosphor. Furthermore, it will be appreciated that a great number of phosphors may be utilized in performing this method of operation and that I am not limited to the particular apparatus described inasmuch as the initial excitation may be by corpuscular or undulatory energy produced in a number of ways and the excitation beyond the current saturation characteristic may be produced electronically or ionically from various types of structures either of the thermionic of photo-ionic type.

I claim:

A cathode ray tube and system comprising a tube having two electron guns and a luminescent screen oppositely disposed from said electron guns, means to develop a beam of electrons from one of said guns of sufficient intensity to render said screen highly luminescent, means to develop a beam of electrons from the other of said guns of greater intensity than said first beam and of an intensity exceeding that necessary to obtain maximum luminescence when incident upon said screen and means to scan said second beam over said screen to develop a dark trace observable by contrast with the high luminescence produced by said first beam.

HUMBOLDT W. LEVERENZ.