April 26, 1949. H. W. LEVERENZ 2,468,714

RADAR INDICATOR

Filed April 17, 1946 2 Sheets-Sheet 1

Fig. 1

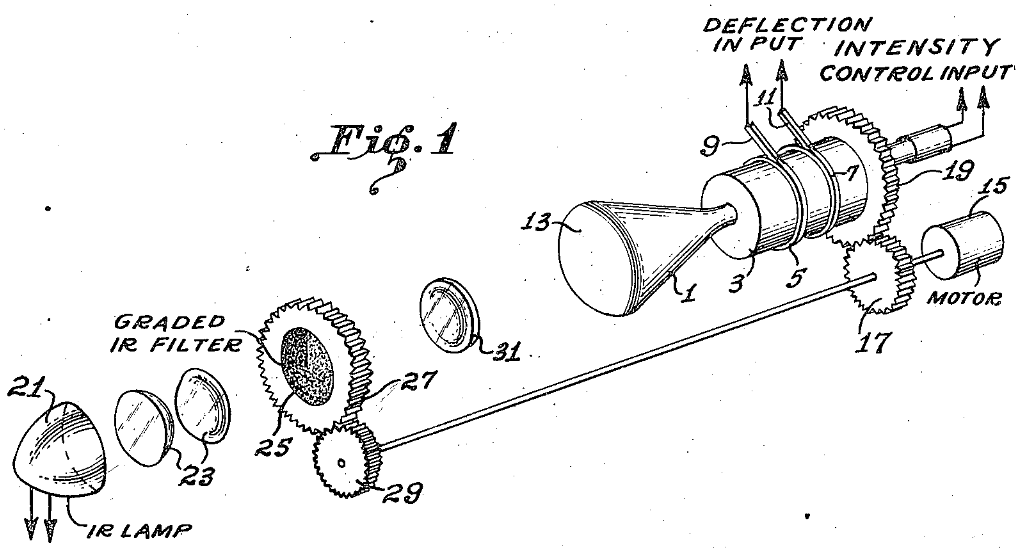

Fig. 4

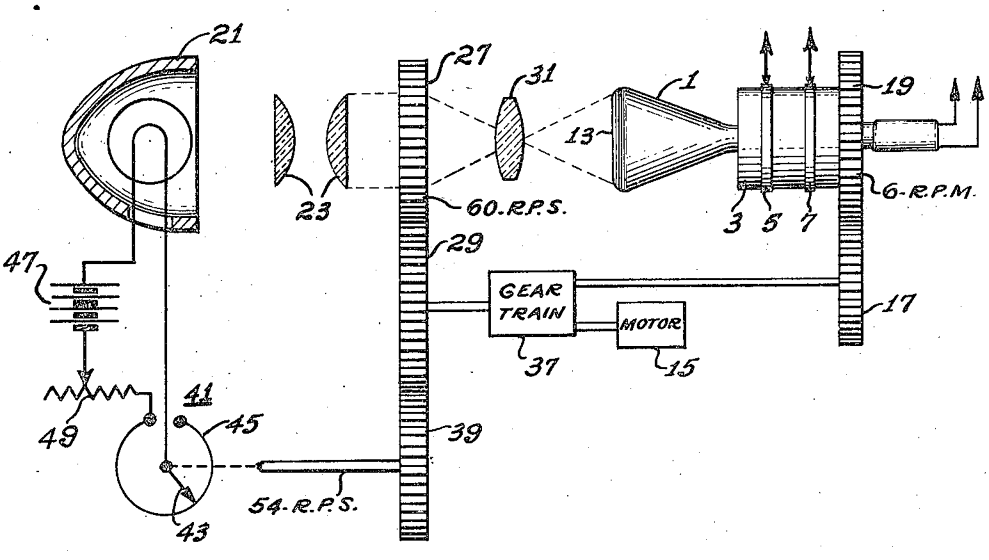

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Fig. 2

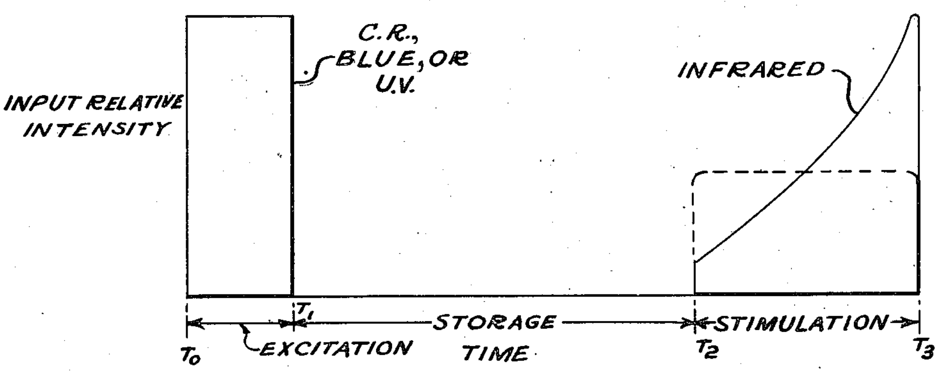


Fig. 3

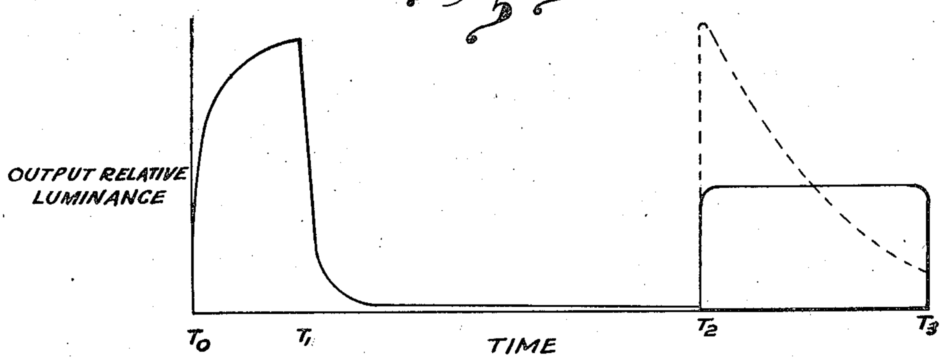
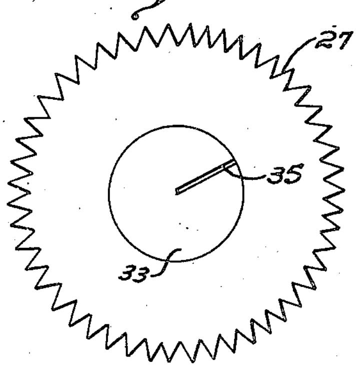


Fig. 5



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UNITED STATES PATENT OFFICE

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RADAR INDICATOR

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Application April 17, 1946, Serial No. 662,797

6 Claims. (Cl. 250—1)

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This invention relates to cathode ray indicator systems, and more particularly to improvements in systems of the type in which the image to be exhibited is traced out during an extended scanning period, as in certain types of "radar" indicators. When the scanning period is of the order of one-tenth second or less, all parts of the image appear visible simultaneously owing to persistence of vision. With longer scanning periods, special long-persistence screens are employed.

The materials used in the screen, and their proportions, are selected to provide as nearly as possible the best compromise between maximum luminescence of the image during the scanning period and minimum carry-over of an image into the following scanning period. Principally as a result of the remarkable tolerance of the human eye to variations in brightness, such compromises can be effected with reasonable success. However, a different screen material, or phosphor, is required for optimum results with each different length of scanning period. In many applications of cathode ray tubes, such as oscillography and radar indication, it is desirable to use scanning periods of variable or different lengths.

The principal object of the present invention is to provide improved methods of and means for cathode ray indication which afford images of substantially constant luminance.

Another object of the present invention is to provide improved methods of and means for cathode ray indication which afford images whose luminance and persistence can be varied at will.

Another object of this invention is to provide improved methods of and means for cathode ray indication which exhibit negligible carry-over of an image from one scanning period to the next.

A further object is to provide, in systems of the described type, methods of and means for achieving the foregoing objects substantially independently of the scanning period durations, and of the normal concave-upward phosphorescence characteristic of luminescent materials.

Another object is to provide methods of and means for efficient utilization of substantially all of the available image-forming energy in a luminescent indicator system.

The foregoing objects are fulfilled by the invention described and claimed in copending U. S. patent application Serial No. 657,692, filed March 29, 1946, by H. W. Leverenz, and entitled Cathode ray indicator systems. However, it is necessary to delay the presentation of each image by the length of one scanning period. This delay is undesirable, since in some cases it may amount to 30 seconds or more. It is a further and an important object of the present invention to achieve all of the aforementioned objects while immediately and continuously presenting the incoming information as it is obtained.

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The invention will be described with reference to the accompanying drawings, wherein:

Figure 1 is a schematic diagram of a cathode ray indicator system embodying the present invention,

Figures 2 and 3 are graphs showing the characteristics of an infrared sensitive phosphor used in the system of Figure 1,

Figure 4 illustrates a modification of the system of Figure 1, and

Figure 5 shows the details of a rotatable slit structure used in the system of Figure 4.

Refer to Figure 1. The system illustrated is of the radial deflection type, commonly used in radar systems for providing a map-like "PPI," or plan position indication. A cathode ray tube 1 is provided with a rotatable deflection yoke 3 surrounding the neck of the tube 1 and provided with slip rings 5 and 7. Brushes 9 and 11 engage the rings 5 and 7. It is sufficient for an understanding of the present invention to note that the brushes 9 and 11 are connected to a source of deflection voltage, not shown, which energizes the deflection yoke to drive the cathode ray beam of the tube 1 so that the point where it strikes the screen 13 moves rapidly back and forth along a radial line on the screen. The direction of the radial line depends upon the angular position of the yoke 3.

The yoke 3 is rotated continuously by a motor 15, through gears 17 and 19. Thus the cathode ray beam successively traces a series of radial lines on the screen 13, completely scanning a circular area thereon during each revolution of the yoke 3. The intensity of the beam is controlled by the input signal, so that variations in the input are represented by corresponding variations in the intensity of the beam at different points on the screen.

The screen of the tube 1 is coated with a stimulable phosphor, which has the ability to store energy supplied to it directly or indirectly by the cathode ray beam, and release energy in the form of visible light when stimulated. One example of such a phosphor is strontium sulphide containing small amounts of samarium and cerium. This material will absorb and store cathode ray energy, and give up a portion of the stored energy as visible light when irradiated by infrared.

Another example of stimulable phosphor is described in copending U. S. patent application Serial No. 595,146, filed May 22, 1945, by H. W. Leverenz, and entitled Phosphor material. This phosphor has the characteristic of being excited or sensitized by blue, green, or ultraviolet light, and stimulated by infrared or heat.

Figure 2 shows the input to an elementary body of the stimulable phosphor on the screen 13 during a typical cycle of excitation, storage and stimulation. During the period T_0 to T_1, the phosphor is excited, either by the cathode ray beam directly, or by blue or ultraviolet light from a primary screen. Some of the exciting energy is converted immediately to visible light, as indicated in Figure 3 by the portion of the graph between T_0 and T_1. A portion of the exciting energy is stored in the phosphor, where it remains during the period T_1 to T_2.

During the period T_2 to T_3, infrared energy is applied to the phosphor. In the practice of the present invention, the infrared intensity is increased during this period, to compensate for the decrease in stored energy and so maintain substantially constant output luminance. The solid line portion of the curve between T_2 and T_3 of Figure 2 shows the variation in intensity of infrared stimulation and the corresponding solid line portion of the curve of Figure 3 shows the resulting output.

If the infrared stimulation were constant from T_2 to T_3, as shown by the dash line in Figure 2, the stimulated output would decrease as the available energy diminished, as indicated by the dash line curve of Figure 3. In order to obtain optimum utilization of the stored energy, and prevent carry-over of images from one scan to the next, the integrated intensity of stimulation (i. e. the total amount of infrared energy during the period T_2 to T_3) is adjusted to substantially exhaust the stored energy within the stimulation period.

Returning to Figure 1, an infrared lamp 21 is directed through condensing lenses 23 to a graded infrared filter 25. The filter 25 is a circular wedge, whose transmission through any radical element is a predetermined function of the angular position of that element in the filter. Thus, with the filter in the position shown in Figure 1, transmission is at a minimum along the vertical line up from the center, and increases in the counterclockwise direction to a maximum adjacent the line of minimum transmission. The filter 25 is connected through gears 27 and 29 to the motor 15, to be rotated thereby in synchronism with the deflection yoke 3. A lens 31 projects an infrared image of the filter 25 on the screen 13, in coincidence with the circular scanning pattern of the cathode ray beam.

In the operation of the system of Figure 1, the cathode ray beam of the tube 1 scans on the screen 13 a circular pattern comprising a series of radial lines, as described above. The filter 25 is positioned with respect to the yoke 3 so that little or no infrared is projected on the line being scanned by the cathode ray beam. The adjacent line which has just been scanned is exposed to relatively weak infrared, and previously scanned lines receive more intense irradiation, in accordance with the length of time since they were last scanned. Thus each element of the image is treated substantially as indicated by the solid line curve of Figure 2, and provides a substantially constant luminance throughout the scanning cycle, as shown by the solid line curve of Figure 3.

The intensity of the infrared lamp 21 is adjusted in accordance with the length of the scanning cycle to substantially exhaust the energy stored in an image element of average intensity by the time it is to be scanned again. If the scanning repetition rate is to be changed, it is only necessary to raise or lower the infrared intensity accordingly to maintain constant image luminance and minimum carry-over. Since substantially all the available energy of each image element is used during the current scanning cycle, the image brightness is substantially greater than that obtained in prior art practice with long persistence screens.

In the system of Figure 4, wherein elements corresponding to those in Figure 1 are designated by corresponding reference numerals, a graded infrared filter is not required. The gear 27 carries instead an opaque mask 33 (see Figure 5), provided with a radial slit 35. The gear 27, instead of being driven at the same speed as the yoke 3, is coupled to the motor 15 through a gear train 37 providing a speed ratio of, for example, 600 to one. A further gear 39 is provided, in engagement with the gear 29, and designed to rotate at a speed equal to the difference in the speeds of the gear 27 and the yoke 3. Thus, if the yoke 3 is rotated at 6 R. P. M. (0.1 R. P. S.), the mask 33 rotates at 60 R. P. S. and the gear 39 rotates at 54 R. P. S.

The gear 39 is coupled to a rheostat 41 which includes a rotatable contact 43 in engagement with a resistor element 45. The element is in the form of a nearly complete circle, so that as the shaft 39 rotates, the resistance provided by the rheostat decreases from a maximum value to substantially zero, then, after a brief open-circuit, resumes the maximum value and repeats the cycle.

The rheostat 41 is connected between the infrared lamp 21 and its supply source 47. A second rheostat 49, which may be manually operable, is included in series with the rheostat 41.

The operation of the system of Figure 4 is as follows:

The lens 31 projects an infrared image of the slit 35 on the screen 13. This image is rotated, by the rotation of the gear 27, at a speed so high that if it were visible, it would appear as a circular disk on the screen, owing to persistence of vision. However, the intensity of the image of the slit varies throughout each revolution because of the variation in resistance of the rheostat 41. Since this occurs at a rate differing from the speed of rotation of the slit by the speed of the yoke 3, the point of maximum intensity rotates at the yoke speed, and the infrared irradiation of each radial line on the screen 13 is substantially the same as in the system of Figure 1, except that it comprises a series of relatively high-frequency pulses. The rheostat 49 is adjusted to provide substantial exhaustion of stimulable luminance during a scanning cycle, as described in connection with Figure 1.

It will be apparent that the invention is not limited to radial deflection or PPI type scanning, but may be applied with equal advantages to other types of cathode ray indicators such as, for example, those in which the scanning pattern comprises a series of parallel, instead of radial, lines. In some cases, the infrared scanning may follow the cathode ray scanning point by point rather than line by line as described above.

Summarizing briefly, the present invention provides constant or controllable luminance of a cathode ray image by exciting a screen provided with a stimulable phosphor, storing therein each element of the image as it is received. The screen is stimulated to release the stored energy as light. The intensity of stimulation of each element is varied in accordance with the elapse of time after its excitation to maintain constant luminance, or luminance varying in a predetermined manner, until the subsequent corresponding element is received.

I claim as my invention:

1. In a cathode ray visual display system of the type in which a chronological series of images are exhibited during respective sequential scanning periods, each of said images being built up during the corresponding scanning period by successive presentation of its elements in a predetermined order, a screen including a body of infrared stimulable phosphor, means for applying exciting energy to areas of said phosphor corresponding to each of said image elements as presented, to store energy at points in said phosphor to represent said image, a source of infrared energy, means for applying energy from said source to scan said areas of said phosphor in said predetermined order with an intensity increasing at each said area as a predetermined function of the passage of time after storage of said energy therein.

2. In a visual display system of the type in which a chronological series of images are exhibited during respective sequential scanning periods, each of said images being built up during the corresponding scanning period by successive presentation of its elements in a predetermined positional order, a screen including a body of stimulable phosphor, and means for applying said image elements to said phosphor as presented to store energy therein representing an image; a source of stimulating radiation, means for applying radiation from said source to scan the elements of said stored image in said predetermined positional order with an intensity increasing at each element as a predetermined function of the passage of time after storage of said element.

3. In a visual display system of the type in which an image is built up by successive presentation of its elements in a predetermined order during a scanning period, a screen coated with an infrared stimulable phosphor, means for applying said image elements to said phosphor as presented to store energy therein representing an image, a source of infrared radiation, and means for applying radiation from said source to said screen to irradiate each element of said stored image with an intensity corresponding in a predetermined manner to its respective position in said predetermined order.

4. In a visual display system of the type in which an image is built up by successive presentation of its elements in a predetermined order during a scanning period, a screen coated with a stimulable phosphor, means for applying said image elements to said phosphor as presented to store energy therein corresponding to said image, a source of stimulating radiation, and means for applying radiation from said source to said screen to irradiate each element of said stored image with an intensity corresponding in a predetermined manner to its respective position in said predetermined order.

5. The method of exhibiting a visual image which is built up during a scanning period by successive presentation of its elements in a predetermined order upon a body of stimulable phosphor, comprising the steps of applying stimulating energy to each elementary image area in said body with an intensity which is a predetermined function of its position in said order of presentation, and increasing said intensity at each of said elementary image areas throughout said scanning period.

6. The method of exhibiting a visual image which is built up during a scanning period by successive presentation of its elements in a predetermined order, comprising the steps of storing energy representing an image of each of said elements as presented, liberating the energy representing each said elementary image with stimulating energy having an intensity which is a predetermined function of the position of the element in said order of presentation, and increasing said intensity throughout said scanning period.

HUMBOLDT W. LEVERENZ.

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