ELECTROLUMINESCENT IMAGE DEVICE

Filed June 24, 1954

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ELECTROLUMINESCENT IMAGE DEVICE

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Application June 24, 1954, Serial No. 439,018

9 Claims. (Cl. 315—166)

This invention relates to the production of images, and especially of varying images, in an electroluminescent material.

Such images can be produced in an electroluminescent phosphor layer which has a series of conducting lines on one side of it and another series of such lines on the other side, the two series being at an angle to each other, the angle preferably being 90°. At least one of the series of conducting lines is preferably made of light-transmitting conducting material.

If a voltage source is connected between one line on one side of the phosphor layer and another line on the other side, the phosphor should luminesce in the neighborhood of the point where they cross. The capacity effects between wires, however, are generally such that not only the cross-over point, but also several of the wire-crossing points around the point where the actually “live” wires or conductors cross luminesce in addition, thereby producing halation and reducing the sharpness of the image, if not completely obscuring it.

I have found that the luminous spot can be confined to the point where the two “live” wires cross, if the wires include a rectifying layer or coating on and in series with each of the wires of one series, with preferably a set of such rectifiers for each series.

In order to allow the luminous spot to be shifted from point to point in the phosphor layer in response to a received signal, and varied also in amplitude according to that signal, the wires of one series can be connected to different points along a delay line, and the wires of the other series connected to different points on another delay line. Then if a direct current bias is used in series with the rectifiers, and adjusted so that the voltage across the phosphor layer is a fixed value below that required for electroluminescence, and a pulse sent along each delay line, the sum of the voltages of said pulses being equal to said fixed value, then in response to an additive series signal there will be no electroluminescence at a given instant except at the cross-over point of the two wires on which the pulse voltage exists at that instant, as long as the signal is of smaller voltage than the sum of the pulse voltages. The signal will thus only be effective at a particular point at a particular instant, and if the signal is in synchronism with the pulses, a desired image can be reproduced from the signal on the phosphor layer, by successively illuminating different points at the same or different intensities.

The sum of the two pulses does not have to be equal to the voltage necessary to excite the phosphor to the threshold of luminescence; it can be somewhat below that value, if desired, and the signal amplitude changed accordingly, especially if the signal is D. C. The signal voltage can be alternating, and of a frequency sufficiently above the frequency of the pulses as to avoid interfering with the pulses. In other words, the alternating current is similar to a carrier frequency for the signal; the amplitude of the alternating current is modulated to produce the signal. The phosphor layer can be a layer containing a mixture of phosphor particles and solid dielectric material, for example a phosphor particle embedded in a dielectric material. If the dielectric material is omitted, the conductive lines can be in direct contact with the phosphor particles and in that case the signal voltage can be modulated direct current, instead of alternating current.

Other advantages, features and objects of the invention will be apparent from the following specification taken in connection with the attached drawing in which:

Figure 1 is a schematic circuit diagram of one embodiment of my device; and

Figure 2 is a cross-sectional view of the electroluminescent portion of the device.

In Figure 1, the electroluminescent phosphor layer 1 has the series 2, 4, 6, 8, etc., of wires running vertically on one side of the layer 1, and the other series 3, 5, 7, 9 running horizontally on the other side of the layer 1. The latter series is connected respectively to the rectifiers 13, 15, 17, 19, etc., and through them to the condensers 24, 25, 26, 29, etc., and through them to the biasing voltage 11. Induction coils 30, 31, 32, 33, 35, etc., are connected between each condenser 13, 15, 17, 19, and between the terminal resistance 11 and the pulse transformer 20, so the combination forms a delay line, properly terminated in resistance 11, and fed with voltage pulses from the pulse transformer 20.

The battery 10 is in series with the common terminal 21 of the delay line so formed, and the signal transformer 36 is also in series, as is the common terminal 33 of the delay line formed by the condensers 22, 24, 26, 28 and the choke coils 38, 39, 40, 41, 42, together with the terminal resistor 43 and the input pulse transformer 44 for feeding the line. The condensers 22—28, connected at one end of each to the common terminal 33 are connected at the other ends to the conductors 22—28 through the rectifiers 12—18, condenser 22 being connected to rectifier 12 and to conductor 2, condenser 24 being connected to rectifier 14 and terminal 4 and so forth.

In Fig. 1, the circuit shown has the rectifiers in the circuit external to the lamp, in order that the function of the rectifiers with respect to the pulses and bias could be explained more clearly. The external rectifiers have the advantage of allowing the use of a bias voltage to keep the applied signal voltage off the wires except for the two on which pulses are applied at a particular instant.

The use of a rectifying coating or layer 52 as in Fig. 2, and as represented by the dotted lines in Fig. 1, which also indicate the capacity between wires, eliminates the need for the external rectifiers and gives the same effect, but in addition reduces the halation due to capacity effects between wires. The capacity between cross-overs at 51, 70, and 71 would, in series, be connected across the capacity at 52, and luminesce at reduced intensity, except that at least one of the rectifying layers at the cross-overs would be in the back-direction and hold off the voltage.

The electroluminescent layer 1 and its immediate surroundings are shown in further detail in the cross-sectional view of Figure 2. The conductor 4 is shown fixed to the glass front piece 45. The electroluminescent layer 1 is shown over conductor 4 and the other conductors 3, 5, 7, 9, are shown over the electroluminescent layer. The rectifiers 12—18 and 13—19 of Figure 1 can be separate from the conductors 2—8 and 3—9, but if desired they can be formed on the back of conductors 2—8 and/or 3—9, as shown in Fig. 2. If the conductors 3, 5, 7, 9, for example are of aluminum, selenium rectifying layers 53—57 can be formed on the aluminum in the manner customary in the selenium rectifier art, and then the counter-rectodors 63—67 placed over them, respectively. Several selenium rectifiers in series may be required to stand the voltage used on the electroluminescent layer.

The various electrodes may be sprayed onto the elect-
troluminescent layer 1 through a screen or stencil cut out to give the desired pattern, and the electrons 2—8 can be sprayed directly on the glass plate 45 if desired. Either one or both sets of electrodes should be of conductive glass painted light transmission therethrough, the lower electrodes 2—8 being preferably light-transmitting in the figure.

The various parts of the electroluminescent layer and its associated electrodes can be made up as shown, for example in an outstanding patent application, Serial No. 365,617, filed July 2, 1953 by Richard M. Rulon.

In operation, the battery 11 biases the rectifiers, and the sum of the pulses received by the lines from pulse transformers 20 and 44 is sufficient to remove the bias to bring the rectifiers up to the voltage at which they pass current, and so bring the electroluminescent lamp up to at least the voltage threshold of its luminescent curve.

When the signal is introduced by the signal transformer 36, it will cause the electroluminescent layer 1 to luminesce at the point where the wires carrying the pulse at that instant “cross.” The wires do not actually touch of course, because the two series of wires 2—8 and 3—9 are on opposite sides of the electroluminescent layer.

For example, suppose the pulse from transformer 20 is at a particular instant on wire 7, and the pulse from the other transformer 44 is at the same instant on wire 4, then the cross-over point 50 of conductors 7 and 4 will be made luminous by the additional voltage from signal transformer 36, and its brightness will depend on the signal voltage of that transformer at that instant.

An instant later, the pulse from transformer 44 will have moved to wire 7 while the slower pulse of transformer 20 will still remain on wire 6; accordingly, point 51 will light up, and of course next point 52, and then point 60.

A new pulse will then start out from pulse transformer, and travel from wire 2 toward wire 5, but now the longer and slower pulse of transformer 20 will have moved downward to wire 5, so that points 61, 62, 70, 71 and 72 will now be illuminated in turn.

A new pulse from transformer 20 will then start out on line 3, and the process be repeated along that conductive line.

It is clear that the pulse from transformer 20, which we may call the vertical pulse for convenience, must be longer than that from transformer so that it will be effective on a single horizontal wire until the pulse from the latter transformer goes on wire 2 to wire 8, and that the pulse must travel more slowly so that it will, for example, move only from wire 2 to wire 5 while the pulse from the other transformer goes from wire 2 to wire 8.

Although for convenience only 4 conductors are shown on one side of the electroluminescent layer 1 and 5 on the other side, any number desired for a given type of image may be used. For example, 500 lines per side might be used, as in television. That would require a delay line of many sections, unless the line was made up of a long cylinder and the wires tapped off at different points along the cylinder.

The rectifying layers such as 53—57 in Fig. 2, are shown only on the electrodes on one side of the electroluminescent layer 1, but are preferably used on the conductors 2—8 on the other side also.

Another form of electroluminescent image device can be made by using one transparent electrode of continuous surface on one side of an electroluminescent layer such as 1, and a mosaic of separate points of photoresistive or photoconducting material, such as selenium, on the other, with the points of the mosaic in contact with a transparent conductive layer. An image could then be focussed onto the mosaic and would appear in amplified form on the electroluminescent layer, the resistance of the different points of the mosaic being dependent on the brightness of the image of that point and thereby varying the voltage across the electroluminescent layer, a fixed voltage being applied between the two transparent conductive plates.

In Fig. 2, the conductors 3, 5, 7, 9, are linear conductors extending from one side to the other of the active portion of the electroluminescent layer 1, just as conductors 2, 4, 6, 8, etc., do in Fig. 1. Conductors 63—67 as shown in Fig. 2, however, do not extend all the way across the electroluminescent layer, but are broken between the cross-over points, so that they exist only as a series of separated areas over each cross-over point. This is necessary in order to force the current to go from junction 51 to 70, say, in Fig. 1 through the rectifying layer. The arrangement is shown in Figure 3.

What I claim is:

1. An electroluminescent image-producing device comprising an electroluminescent phosphor layer, a series of conductive lines on one side of said layer, another series of conductive lines on the other side of said layer, said series being insulated from each other, and the projection of one series of lines upon the other being at an angle thereto, and a rectifier connected to each of the lines in at least one of said series.

2. The combination of claim 1, and a delay line connected to said one series of lines through said rectifier, the different wires in the series being connected to different points on the delay line so that a pulse along the line will reach them sequentially, a second delay line connected to said other series of lines, the same sequential manner, a terminal of one delay line being connected to a terminal of the other delay line through means for producing a signal voltage in series therewith.

3. The combination of claim 2, in which the pulse delay produced by one delay line is as large as the time required for the pulse along the other delay line to travel along the whole series of conductors connected to that line.

4. The combination of claim 3, in which a bias voltage is connected in series with the delay lines and in which the sum of the pulse voltages is approximately equal to the bias voltage.

5. An electroluminescent image-producing device comprising an electroluminescent phosphor layer, a transparent electrically-conductive layer on one side thereof, and a rectifying layer on the other side thereof.

6. In combination, first and second series of parallel separated electrical conductors, the first-series conductors being oriented at an angle with respect to the second-series conductors, the projection of each first-series conductor on a cross-over point thereto, the cross-over points defined by all first-series conductors and any one second-series conductor constituting a set of cross-over points, the number of sets corresponding to the number of said second-series conductors; an electric circuit associated with each point and interconnecting the first and second series of conductors defining said point, said circuit including in serial connection a rectifier and an electroluminescent layer.

7. The combination of claim 1 in which the rectifier is connected to each of the lines in each of said series.

8. The combination of claim 6 in which the rectifier is a rectifying layer.

9. The combination of claim 6 in which the rectifier is a rectifying layer and in which the electroluminescent layer includes an electroluminescent phosphor embedded in a dielectric material.

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