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ELECTROLUMINESCENCE DEVICES

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FIG. 1

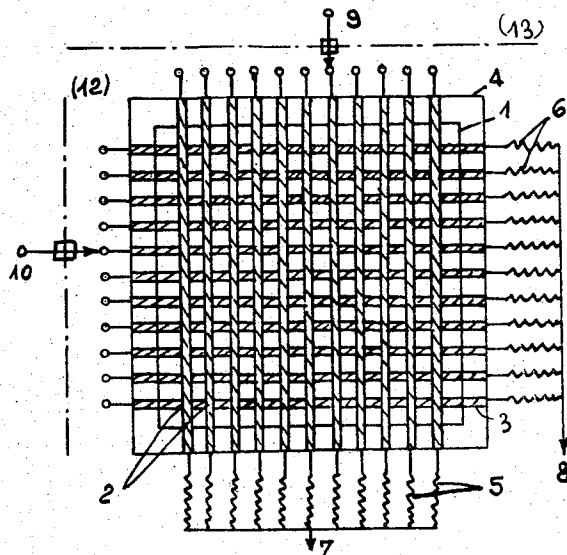


FIG. 2

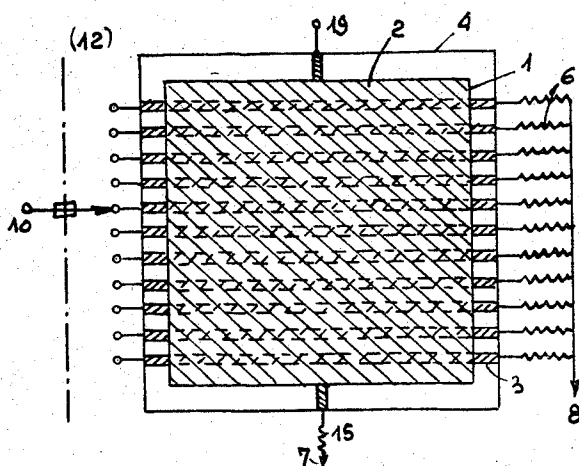


FIG. 3

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ELECTROLUMINESCENCE DEVICES

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5 Claims. (Cl. 315—169)

The present invention relates to improvements in electroluminescence devices of the kind including at least one thin semi-dielectric layer of an electroluminescent composition inserted between a pair of conducting armatures, one of which at least is translucent and across which is applied an A.C. potential difference of higher peak level than the threshold of activation of the said electroluminescent material. It must be well understood that, in the present specification and claims, the term "A.C." will be used for denoting any wave shape having a variation in time which is not the continuous change of a D.C. amplitude-modulated current, and for instance a rectangular wave-form, a saw-toothed waveform or a wave form comprising a sequence of voltage pulses, as well as a waveform proper.

Such method and means for preparing such electroluminescent devices as composite slabs including a thin layer of electroluminescent material, for instance a monocrystalline layer of all-oxide compositions such as described in my copending application Ser. No. 631,226 are presently known, and such slabs may be provided of a substantial display surface if and when required, as it is for instance described in my other copending application Ser. No. 631,224. Further, I have disclosed in my copending application Ser. No. 631,223 a more elaborate structure wherein quite a satisfactory degree of illumination can be obtained for display from the association to the basic sandwich a further photomultiplicative sandwich.

In my present invention, I provide an electroluminescence device which adapts such electroluminescent structures to a surface-distributed display of electrical signals, for instance pulse coded signals or amplitude-modulated signals, and to this end, I form at least one of the above-mentioned conducting armatures or electrodes as a network of conducting lines applied onto the surface of the thin semi-dielectric electroluminescent layer, each of these lines being at one end thereof connected to a terminal for the application thereto of an incoming signal and at the other end thereof being connected to a resistance matching the value of the characteristic impedance of the elementary delay line defined by the conducting line in its cooperation with the remaining part of the electroluminescent structure. And further, I apply a D.C. voltage to any and all of the said conducting lines through the said matching resistances so as to provide a constant potential to these lines when no input signal is received and also to provide a zero potential difference between these armatures during such a condition of the inputs thereof.

In the accompanying drawings, Fig. 1 shows a cross-section of a conventional electroluminescence structure, and Figs. 2 and 3 shows two illustrative embodiments of my invention including electroluminescence structures derived therefrom.

In Fig. 1, a semi-dielectric layer of electroluminescent material is shown at 1 between a pair of metallic films 2

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and 3 acting as armatures thereof. As such a structure will not be self-supporting in most cases, a dielectric base plate 4 is used for such a mechanical function.

Forming a thin conducting layer into a network of conductors which do not intersect may be made, as it is well-known per se, by the so-called photo-etching printing technique. A photosensitive layer is first deposited over the metallic film, an optical image is projected thereon and the photograph which results of this action is developed, washed and dried. The image is that of the required pattern of lines, so that the resist of the photosensitive film only remains upon the lines to be finally obtained. Etching by an acid is then made until the parts which are not protected by the said resist are completely removed. Of course, the conducting lines may then be reinforced through the application thereto of a galvanic plating process.

Such an operative step may be applied to a metallic firm armature which has been made onto the semi-dielectric layer of electroluminescent material. However, it is preferred to make the networks of conducting lines according to the one or the other of the following methods:

A metallic film is first deposited upon the base plate 4, and this film is photo-etched as said herein above. Then the electroluminescent material is deposited thereupon, through any suitable process of operation, and finally the other armature is deposited and etched over the thus obtained sandwich.

As an alternative thereto, the deposition of the first (and if required the second) conducting network is made by using the so-called silk screen technique, viz. by depositing a mixture of powdered metal and ceramic flux of low melting point through an array of silk yarns reproducing the "negative" network of the required conducting pattern. After this deposition is made, the network is baked upon the base plate for securing it thereto.

When one of the armatures of the structure may be made strongly light reflecting, the following steps may be carried out: The base plate is made of a high temperature melting material, for instance glass or ceramics or strongly enamelled metal. The pattern of conductors is prepared thereupon, for instance by deposition through a silk yarn screen of a mixture of powdered silver, or of platinum tetrachloride, within an essential oil of clove or camomile. When silver is used, a low-temperature melting enamel is added to the said mixture. When platinum is used, the weight ratio of the tetrachloride in the said mixture is of about 12% by weight. After the deposition is made, the temperature of the base plate is slowly raised, from a high frequency inductive heating thereof for instance, up to the complete elimination of all the aromatic carbides in the said essential oil, then the temperature is suddenly raised up to the melting point of the remaining components so that the melted product strongly adheres to the base plate.

A deposition of rhodium of suitable thickness for polishing it up to the optical degree is thereafter made over the conducting lines. Such a deposition may be easily made by placing the base plate and the conducting pattern thereon within a galvanoplastic bath consisting of sulphuric acid and ammonium rhodantride and containing 23% of rhodium. When the anode is made of platinum, the current density of about .5 ampere per square decimetre and the temperature maintained in the bath is of about 40° C. a film of rhodium having a thickness of about 5 microns is obtained within 20 minutes. Such a thickness is satisfactory for the subsequent polishing operation.

The electroluminescent layer and then the other armature of the device may be made thereon as hereinbefore

explained. The said other armature may for instance consist of aluminium evaporated under vacuo.

Any kind of pattern may be obtained and for instance, in the embodiments shown in Figs. 2 and 3, the conducting lines are parallel straight lines in each one of the armature network, as the raster to be obtained is supposed to be a Cartesian coordinates one. If the said raster is to be of the polar kind, for instance, one of the patterns of lines will be made of concentric circles and the other one will consist of radial lines; and so forth.

Referring to Fig. 2, the two conducting line patterns 2 and 3 are made for acting as armatures to a semi-dielectric plate 1. Each conductor 2 is terminated upon a resistance 5 and each conductor 3 is terminated upon a resistance 6. All resistances 5 are connected to a high battery voltage at point 7 and all resistances 6 are similarly connected to a high battery voltage at point 8. These voltages are equal, so are supposed to be all the resistances of the Fig. 2. The conductors 2 are separately connected to respective terminals of a first switch (13) and the conductors 3 are similarly separated connected to respective terminals of a second switch (14). These are sequence switches, of course embodied in an all-electronics equipment, when practiced, according to any well-known techniques. The said switches will be used for scanning the overall pattern of the electroluminescent device. To such end, an activation voltage may be applied at the input 9 of the switch (13) and another activation voltage may be similarly applied to the input 10 of the switch (12), as and according to such schemes as it will be hereinbelow described.

Each conducting line acts, with respect to its operative association with the remaining structure, as an artificial delay line. First of all, it is imperative for a correct operation of the device, that each one of the resistances 5 and 6 matches the electrical impedance of each corresponding line, so that any pulse applied to one of the said conductors cannot be reflected back into the structure. Of course, these resistances further avoid that a pulse can be galvanically transmitted from one of the conductors to the networks to which it has been applied to any other one of the said conductors.

The scanning operation may, for instance, be as follows: through the switch (12), for instance, enters the information signal applied at 10. The said switch (12) displaces this information signal from line 3 to line 3 at such a speed that any bit thereof is seen from the concerned conductor as an electrical pulse. If the speed were to be lower, it would be preferred to provide a prior sampling of amplitude-modulated pulses in the said information signal, when it consists of an amplitude modulated signal. However, of course, the information signal may be a pulse coded one and the speed of the switch (12) so adjusted as to coincide with the frequency or repetition rate of the pulse periods of the said signal.

Each applied pulse will raise, through the forefront thereof at least, the potential of the conductor 3 up to a voltage of a peak value not able to produce an effective activation of the semi-conducting material under the conducting line, with respect to the constant voltage applied to the other network of conductors 2, viz. on the other side of the semi-dielectric layer 1. Similarly, a selecting voltage is applied to the input 9 of the switch (13), which, if alone, cannot produce the electroluminescence of the semi-dielectric material by lowering the voltage on any column conductor 2 of the said second network. When, however, both these signals are applied at coincident time instants, to one line 3 and one column 2, the voltage difference across the semi-dielectric material 1 at the crossing point between these pattern elements will be such that, at the instant of coincidence of these pulses, the small part of the semi-dielectric material included or inserted therebetween is actually activated and a light emission occurs therefrom. When for instance, one column conductor 2 is energized during a time inter-

val during which all the terminals of the switch (12) are scanned, the input signal at 10 will be distributed along the said column 2, each bit of information being placed at one of the points of intersection (in three-dimensions) of the two patterns defined by the selection of the said column in the second armature. It must be appreciated that such a device as herein contemplated does not possess any storage property per itself.

When the input signal is a modulated one, it must be further noticed that, in contradistinction with the conventional operation of the cathode ray oscillographs, the dimension of the surface of the light spot will remain constant, being determined by the areas of the conductors of the said armatures only, whereas in a C.R. tube, as well-known, the spot has its size varied in accordance with the depth of modulation of the information signal applied thereon.

Actually, in such an arrangement as shown in Fig. 2, the delays in the elementary delay lines must be made as small as possible for an increased efficiency of the complete device. Such a condition may be adjusted by the adjustment of thickness of the semi-dielectric layer and the relative surfaces of the conductors facing through the said semi-dielectric material.

Such an arrangement will preferably be used for the displaying of pulse-coded signals, and for such a case, it would be an imperative condition that no substantial couplings occur between the conducting lines, through the semi-dielectric material in order that the display remains quite neat. Of course, such capacitive couplings exist but, due to the above disclosed provisions, they do not substantially affect the efficiency of the display. First, as said, each pulse will be absorbed in the terminal resistance of any conducting line, no random current will occur through galvanic leads. Secondly, and due to the said impedance individual matching, together with the above adjustments for a quite low delay time in each conductor, the current coincidence at a cross point between two activated conductors of distinct armatures occurs practically at the very instant of the leading edge of the activating pulses (at least for the shorter and of quicker switching action pulse). On the other hand as any conductor on each side of the activated one in a network is terminated upon a substantial value of resistance, any voltage pulse transferred from or through a parasitic coupling from the truly activated conductor will be applied to a delay network (the coupling stray capacity and the said end resistance). This will damp the leading edge. Further, each and any pair of conductors which are not activated are maintained from the D.C. high voltage supply to a substantially zero difference, this will greatly counteract the influence of the stray coupling voltages. It is quite apparent that, if the conductors were left un-terminated, on the one part, and the input voltages were not actual pulses, on the other part, these reasons of correct operation will totally disappear and, actually, not one spot will be illuminated but a complete area of an overall cross-shape around the line and column actually energized. With a device according to my invention, on the other hand, I have obtained for the above-stated provisions, with an all-oxide composition of semi-dielectric material, a ratio of lights emitted by the selected cross point and any one of its immediate neighbours of at least 50. The stray transferred voltage was not higher than one third of the average pulse value of the voltage between the conductors selecting the said cross-point.

In the operation of the device, if a D.C. biasing voltage of for example +15E is applied at 7 with respect to terminal 8, which voltage is less than that required for producing luminescence, and a peak control voltage of -15E is applied at terminal 9, a signal having a peak voltage of +25E applied to terminal 10 would result in a voltage, between the point at which the energized electrodes 2, 3 crossed, equal to 25E sufficient to cause luminescence at that point. Looking down the energized elec-

trode 2, there will be zero potential at the point of crossing with any unenergized electrode 3. Looking laterally along energized electrode 3, there would be only a potential difference of 10E at any point of crossing with unenergized electrode 2, a voltage which is even less than the biasing voltage and insufficient to cause luminescence. Thus, there is no possibility of any luminescence at any point except at the point of crossing of two energized conductors. Furthermore, in view of the matching resistances terminating conductors 2, 3, a switching or signal pulse applied at one end of the conductors respectively, will be completely absorbed without reflection, since such reflection, if present, would cause spurious luminescence at some later time, at the point of crossing between the originally energized conductors, even though at least one of the switches 9 and 10 has already moved to energize a succeeding conductor.

But I also provide, on the other hand, to use the delaying characteristic of the conductors in an armature network, as shown in Fig. 3, more particularly when I have to display a continuous amplitude-modulated signal, for instance and the said signal is available with a single polarity. I establish the electro-luminescent structure with one of the armatures thereof as a pattern of parallel lines (for instance) and establish the other armature as a conventional continuous film. In the drawing, this armature is supposed to be the armature 2. The said armature is provided with a terminal 19 for the application thereto of my information signal and is supplied by the same high battery voltage as hereinbefore through a resistance 15. Of course, the input signal may consist of modulated or unmodulated pulses if required, this will not change the operation per se. The input 10 of the switch 12 will receive very short and sharp pulses or pips, one for each step thereof (whether or not these steps are sequential or controlled from some more complex program).

Each pip will travel along the delay line comprising the conductor line to which it has been applied and the delaying property of the said line is naturally enhanced by the mere presence of a continuous film opposite the conductor on the other side of the semi-dielectric 1. It is the width of the said pip which, in such a case, determines the width of any spot of light on the displaying surface. Of course, the polarity of the said pip is opposite to that of the information signals applied to the continuous armature 2. When, during a travel of a pip along conducting line, each time a coincidence of voltages occurs between the pip and the input signal on the other armature, sufficient to activate the semi-dielectric material, a spot of this latter is illuminated at a level proportional to the amplitude of the said input signal above the threshold of activation of the electroluminescence in the said material. Here again, the conditions are satisfied for a substantially negligible stray illumination around each illuminated spot as, if on the one hand the capacitive couplings between the adjacent points are enhanced, on the other hand, the selection pulses are sharper and shorter than in the first case, which condition re-establish a satisfactory balance when the above-detailed provisions are effective.

I claim:

1. An electroluminescent device of the kind including a semi-conducting layer of electroluminescent material, an electrode on each surface of the layer, at least one of said electrodes comprising a plurality of separated parallel conductors extending at an angle to one dimension of

the other electrode, a source of constant D.C. biasing potential, one end of each said electrode being connected respectively to said source through a matching impedance including an impedance matching resistance for each conductor, means for applying transient control voltage pips to selected conductors of the one electrode at the unterminated end thereof and means for applying control voltages to the unterminated end of the other electrode, whereby said device produces a light spot only at selected points.

2. An electroluminescence device according to claim 1 in which the other electrode also comprises a plurality of separated parallel conductors such as to determine a plurality of activated points at the spatial crossings of the conductors of the two electrodes, said means for applying voltages to the two electrodes including means for distributing to the input terminals of the one and the other of the said networks two separate control voltages of opposite directions, with appropriate relative rates of distribution such that the time delay intervals of any and all of the elementary delay lines defined by the said conductors are negligible with respect to the time intervals of application of any and all of the control voltages to the said terminals.

3. An electroluminescence device according to claim 1 in which only one of the said electrodes comprises a plurality of separate parallel conductors defining a scanning pattern therefor, and each of the elementary delay lines defined from the said conductors being of substantial delay with respect to activating voltage pips applied to the inputs of the said conductors in accordance with a desired pattern, the control voltages applied to the other electrode being information signals.

4. An electroluminescence device in accordance with claim 1 wherein the one and the other of the said electrodes are substantially pellicular, and the semidielectric layer is a monocrystalline slab of an all-oxide electroluminescent composition.

5. An electroluminescent device of the kind including a semi-conducting layer of electroluminescent material, an electrode on each surface of the layer, at least one of said electrodes comprising a plurality of separated parallel conductors extending at an angle to one dimension of the other electrode, a source of constant D.C. biasing potential, one end of each said electrodes being connected respectively to said source through a matching impedance, including an impedance matching resistance for each conductor, means for applying transient control voltage pips to selected conductors of the one electrode at the unterminated end thereof and means for applying control voltages to the unterminated end of the other electrode, whereby said device produces a light spot only at selected points, said control voltages being of such amplitude and polarity with respect to each other and to said D.C. biasing potential, that the voltage between an unenergized conductor and the other electrode is reduced to an amplitude insufficient to produce luminescence of the device at other than said selected points.

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