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J. E. JOHNSON

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ELECTROLUMINESCENT-PHOTOLUMINESCENT-PHOTOSENSITIVE APPARATUS

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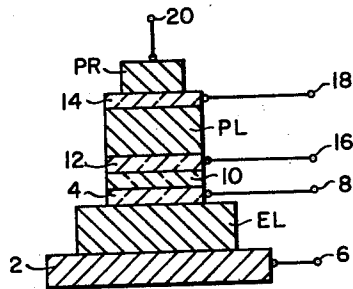


Fig. 1.

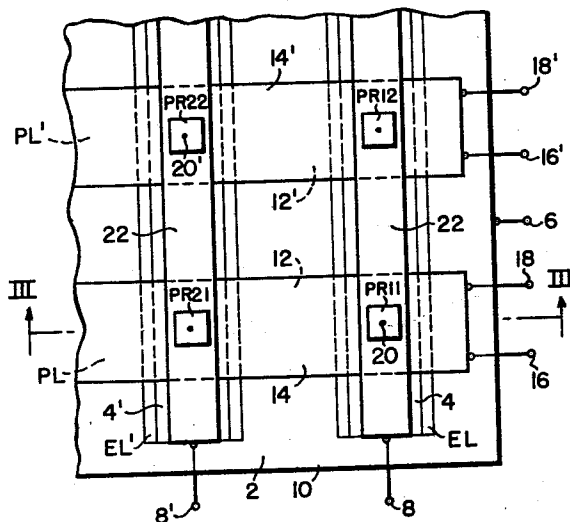


Fig. 2.

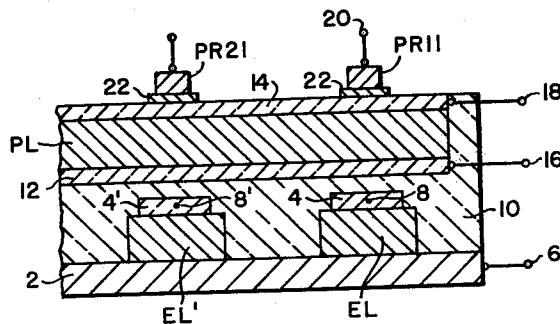


Fig. 3.

WITNESSES

Edwin E. Bassler
James H. Young

INVENTOR

Joseph E. Johnson

BY *Ernest P. Kijfel*
ATTORNEY

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ELECTROLUMINESCENT-PHOTOLUMINESCENT-PHOTO-RESPONSIVE APPARATUS

Joseph E. Johnson, Churchill Boro, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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The present invention relates to coincidence switching apparatus, and more particularly to electroluminescent-photoresponsive coincidence switching apparatus.

In information display systems where a matrix of rows and columns are utilized to distribute the desired information, the problem arises of activating the selected element or elements of the matrix without activating non-selected elements. Thus, if we have a matrix of X_m rows and Y_n columns of elements, and if it is desired to activate the elements of the X_i row and the Y_j column, an electrical signal must be supplied to the X_i row and Y_j column. However, the activating signals must be applied in such a manner that the element X_iY_{j+1} , for example, or other neighboring elements are not also activated at the same time. The problem is particularly acute in electroluminescent screen display apparatus where present methods of using diode or ionic switches do not provide the required degree of discrimination, but rather give a side lighting effect around the element desired to be illuminated, in that, the necessary isolation between rows and columns of elements is not provided by the use of such switching devices.

It is therefore an object of the present invention to provide new and improved switching apparatus which provides the desired degree of isolation between rows and columns of a matrix.

It is a further object of the present invention to provide a new and improved information display matrix which provides for the selection of the desired element without activating undesired elements.

It is a further object of the present invention to provide new and improved information modulating apparatus in which a modulating function may be provided without interference with other elements of an array.

Broadly, the present invention provides information modulating and switching apparatus, wherein: photoresponsive elements are activated to provide the switching or modulating function in response to the coincidence of excitation of electroluminescent and photoluminescent elements.

These and other objects will become more apparent when considered in view of the following specification and drawings, in which:

FIG. 1 is a side view of one element of the present invention;

FIG. 2 is a top view of the matrix of the present invention; and

FIG. 3 is a section view of the matrix arrangement at the section line III-III, FIG. 2.

Referring to FIG. 1, a three element switching device with isolation between the input and output circuits is shown. The fabrication of the device of FIG. 1 may be such that the base plate 2 is a conducting material such as aluminum. Upon the base plate 2 is sprayed an electroluminescent layer EL, which may comprise a phosphor such as boron nitride. A boron nitride phosphor which emits an ultraviolet when excited by varying electric field is shown in U.S. Patent No. 2,921,218, issued on January 12, 1960. Onto the electroluminescent layer EL is applied a transparent conducting layer of, for example, aluminum or gold. This layer 4 may be semi-transparent, but must pass ultraviolet light from the electroluminescent layer EL. To the base plate 2 is

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soldered the terminal 6, and to the conducting layer 4 is soldered the terminal 8. By the application of an alternating potential across the terminals 6 and 8, the electroluminescent layer EL will luminesce and depending upon the phosphor used will radiate light of a particular wavelength, for example as in the present case, emission will be in the ultraviolet range.

The transparent insulating layer 10 is then sprayed over the conducting layer 4. The insulating material is transparent and may, for example, be a polyvinyl chloride acetate plastic. Next, a transparent conducting strip 12, similar to the conducting layer 4, is applied to the insulating layer 10. A photoluminescent layer PL is then applied onto the conducting layer 12. The photoluminescent layer PL may, for example, be a phosphor material such as cadmium sulfide, which has the characteristic that it radiates light in all directions when it receives light in the blue or ultraviolet range from the electroluminescent layer EL. The light emitted from the photoluminescent layer PL is generally of a lower energy level than the light emitted from the electroluminescent layer EL, and thus is generally of a longer wavelength. To the photoluminescent layer PL is applied the transparent conducting layer 14, which may, for example, be of gold or aluminum. Contacts 16 and 18 are soldered to the conducting layers 12 and 14, respectively. The phosphor of the photoluminescent layer PL has such a characteristic that if a direct current of sufficient voltage is applied to terminals 16 and 18 no light will be radiated from the photoluminescent layer when it receives light from the electroluminescent layer EL. The "charge quench" type of phosphor is such that when a direct electric field of sufficient magnitude is applied across the phosphor no light will be radiated therefrom. Thus, whether the photoluminescent layer PL radiates light or not may be controlled by an electric field applied across the terminals 16 and 18. A single-crystal cadmium sulfide having the desired photoluminescent characteristics is described in the article "Control of Luminescence by Charge Extraction," by Daniel, Schwartz, Lasser and Hershinger, Physical Review, September 1, 1958, pp. 1240-44.

To the conducting layer 14 is bonded a photoresponsive element PR. The photoresponsive element PR may, for example, comprise a well known device such as a silicon or germanium photo diode which changes conductive states in response to light of the wavelength emitted by the photoluminescent layer PL. The terminal 20 is soldered to the top of the photoresponsive element PR. Thus, an output circuit is provided between the terminals 18 and 20, that is, across the photoresponsive element PR. Characteristics of the photoresponsive element PR are such that if the photoluminescent layer PL emits light through the transparent layer 14 to the photoresponsive element PR, the photoresponsive element PR will be in its conducting or low impedance state so that the switching action occurs between the terminals 18 and 20. If no light is emitted from the photoluminescent element PL, then the photoresponsive element PR remains in its high impedance or low conductivity state and provides an open circuit between the terminals 18 and 20.

In order to provide the switching operation between the terminals 18 and 20 of the photoresponsive element PR, there must be a coincidence of excitation potential applied to the electroluminescent layer EL across the terminals 6 and 8, and also no biasing current should be applied to the terminals 16 and 18 of the photoluminescent layer PL. Therefore, if switching action is desired across the terminals 18 and 20, an excitation signal is applied to the terminals 6 and 8 which causes the electroluminescent element EL to emit light of an ultra-

violet wavelength which is transmitted through the transparent conducting layer 4, the transparent insulating layer 10 and the transparent conducting layer 12 to the photoluminescent layer PL. With no bias applied across the terminals 16 and 18, the photoluminescent layer PL will emit light of a longer wavelength which will be transmitted through the transparent conducting layer 14 to the photoresponsive element PR. Upon receipt of the light emitted from the photoluminescent layer PL, the photoresponsive layer PR will change from its low conducting state to its high conducting state to provide a low impedance circuit or switching action through the terminals 18 and 20. The switching operation then may be used to activate external circuitry as desired. It should be noted that by applying a biasing signal across terminals 16 and 18 of less than quenching strength, the output appearing across the terminals 18 and 20 may be modulated in accordance with the biasing signal applied to the terminals 16 and 18; thus providing less than the switching action at the output terminals 18 and 20. Also, the exciting signals applied to terminals 6 and 8 may be controlled to vary the output appearing at the terminals 18 and 20. However, for normal switching action the coincidence of the conditions described above must take place in order to provide the switching function and isolation between neighboring elements of a matrix of such elements as will next be explained below.

In FIGS. 2 and 3, a matrix of rows and columns that can be used as an information display array are shown. Onto the metal base plate 2, which may for example be aluminum, are sprayed strips EL, EL', etc. an electroluminescent phosphor which for example may be boron nitride. The strips EL, EL', etc. of electroluminescent material form the rows of the matrix. Next, the transparent conducting strips 4, 4', etc. are applied to each of electroluminescent strips EL, EL', respectively. The terminal 6 is soldered to the base plate 2. The terminals 8, 8', etc. are connected to the conducting strips 4, 4', etc. respectively, to provide the row terminations. An insulating layer, which for example may be a polyvinyl chloride acetate plastic, is then sprayed as a filler between the electroluminescent elements EL, EL', etc. the conducting strips 4, 4', etc. and the base plate 2. Next, transparent conducting strips 12, 12', which may be of gold or aluminum, are applied at right angles to the electroluminescent strips EL, EL', etc. over the conducting strips 12, 12', etc. are applied strips PL, PL', etc. of photoluminescent material such as cadmium sulfide, with the photoluminescent strips PL, PL' forming the columns of the matrix. The overlapping sections of the electroluminescent and photoluminescent strips thus form active areas of the matrix. Other conducting strips 14, 14', etc. are applied to the tops of the photoluminescent strips PL, PL', etc., respectively. Terminals 16, 16', etc. are soldered to the conducting strips 12, 12', etc., respectively, and terminals 18, 18', etc. are soldered to the conducting strips 14, 14', etc. to provide column termination for the matrix. Over each of the active areas at the intersection of the electroluminescent and photoluminescent strips, photoresponsive elements PR11, PR12, PR21, PR22, etc. are fixed. The photoresponsive elements may be well known devices such as silicon photo diodes. A conducting layer 22 is provided to hold the individual photoresponsive elements PR11, PR12, PR21, PR22, etc. in place. The conducting layer 22 may for example be an epoxy resin in which particles are suspended. Output terminals 20, 20', etc. are then soldered to each of the photoresponsive elements PR11, PR12, etc. with the output circuit being provided between the terminals 18, 18', etc. and the terminals 20, 20', etc. of the particular photoresponsive element PR.

Thus, if it is desired to provide the switching action at the active area of the matrix defined by the photoresponsive element PR22, an exciting signal would be applied across the terminals 6 and 8', thus causing the elec-

toluminescent strip to radiate ultraviolet light at the active area associated with the photoresponsive element PR22. In order that the photoluminescent material associated with the active area radiate light in response to the ultraviolet light from the electroluminescent material, no bias potential should be applied to the terminals 16' and 18' which are connected across the active area of the photoluminescent material associated with the photoresponsive element PR22. If no bias potential is provided across the terminals 16' and 18', the photoresponsive area will radiate light of a longer wavelength than that radiated by the electroluminescent area. When the light from the photoluminescent area is received by the photoresponsive element PR22, the element will change from a low to a high conducting state, thus completing an output circuit between the terminals 18' and 20'. The switching action appearing across the terminals 18' and 20' then may be used in external circuitry, for example, to energize an electroluminescent cell of a screen matrix.

Although the present invention has been described with a certain degree of particularity, it should be understood that the present disclosure has been made only by way of example and that numerous changes in the details of fabrication and the combination and arrangement of elements and materials may be resorted to without departing from the scope and spirit of the present invention.

I claim as my invention:

1. In switching apparatus operative with exciting signals and modulating signals, the combination of: electroluminescent means comprising an electroluminescent phosphor material, such electroluminescent means being operative to emit light when said exciting signals are applied thereto; photoluminescent means comprising a photoluminescent phosphor disposed in physical relationship to said electroluminescent means to receive light therefrom, said photoluminescent means being operative to emit light in response to the reception of light from said electroluminescent means, said photoluminescent means further being operative to emit light in proportion to said modulating signals applied thereto; and photoresponsive means disposed in physical relationship to receive light from said photoluminescent means and being responsive thereto but being unresponsive to light from said electroluminescent means, said photoresponsive means being operative to change conductive states in response only to light received from said photoluminescent means.

2. In switching apparatus operative with exciting signals and biasing signals, the combination of: electroluminescent means comprising an electroluminescent phosphor material, such electroluminescent means being operative to emit light of a first wavelength when said exciting signals are applied thereto; photoluminescent means comprising a photoluminescent phosphor disposed in physical relationship to said electroluminescent means to receive light of said first wavelength therefrom, said photoluminescent means being operative to emit light of a second wavelength in response to the reception of light of said first wavelength from said electroluminescent means, said photoluminescent means further being operative to not emit light when said biasing signals are applied thereto; and photoresponsive means disposed in physical relationship to receive light of said second wavelength from said photoluminescent means and being responsive thereto but being unresponsive to light of said first wavelength from said electroluminescent means, said photoresponsive means being operative to change from a low conductive state to a high conductive state only when light is received from said photoluminescent means.

3. In switching apparatus operative with exciting signals and modulating signals, the combination of: an electroluminescent device comprising an electroluminescent phosphor material, said electroluminescent device being operative to emit light of a first wavelength when said exciting signals are applied thereto; a photoluminescent

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device comprising a photoluminescent phosphor disposed in physical relationship to said electroluminescent device to receive light of said first wavelength therefrom, said photoluminescent device being operative to emit light of a second wavelength in response to the reception of light of said first wavelength from said electroluminescent device, said photoluminescent device further being operative to emit light in proportion to said modulating signals applied thereto; and a photoresponsive device disposed in physical relationship to receive light of said second wavelength from said photoluminescent device and being responsive thereto but being unresponsive to light of said first wavelength from said electroluminescent device, said photoresponsive device being operative to provide a modulated output function by changing conductive states in response to the modulating signals to said photoluminescent device.

4. In coincidence switching apparatus operative with exciting signals and biasing signals, the combination of: an electroluminescent device comprising an electroluminescent phosphor material, said electroluminescent device being operative to emit light of a first wavelength when said exciting signals are applied thereto; a photoluminescent device comprising a photoluminescent phosphor disposed in physical relationship to said electroluminescent device to receive light of said first wavelength therefrom, said photoluminescent device being operative to emit light of a second wavelength in response to the reception of light of said first wavelength from said electroluminescent device, said photoluminescent device further being operative to not emit light when said biasing signals are applied thereto; and a photoresponsive device in physical relationship to receive light of said second wavelength from said photoluminescent device and being responsive thereto but being unresponsive to light of said first wavelength from said electroluminescent device, said photoresponsive device being operative to change from a low conductive state to a high conductive state on the coincidence of the application of exciting signals to said electroluminescent device and no application of biasing signals to said photoluminescent device.

5. In coincidence switching apparatus operative with exciting signals and biasing signals, the combination of: electroluminescent means operative to emit light of ultraviolet wavelengths when said exciting signals are applied thereto; photoluminescent means disposed in physical relationship to said electroluminescent means to receive light therefrom, said photoluminescent device being operative to emit light of longer wavelengths than said electroluminescent device in response to the reception of light of said ultraviolet wavelengths from said electroluminescent means, said photoluminescent means further being operative to not emit light when said biasing signals are applied thereto; and photoresponsive means disposed in physical relationship to receive light from said photoluminescent means and being responsive thereto but being unresponsive to light of said ultraviolet wavelengths from said electroluminescent means, said photoresponsive means being operative to change from a low conductive state to a high conductive state on the coincidence of the application of exciting signals to said electroluminescent means and no application of biasing signals to said photoluminescent means.

6. In coincidence switching apparatus operative with exciting signals and biasing signals, the combination of: an electroluminescent device comprising an electroluminescent phosphor material, said electroluminescent device being operative to emit light of a predetermined wavelength when said exciting signals are applied thereto; a photoluminescent device comprising a photoluminescent phosphor disposed in physical relationship to said electroluminescent device to receive light of said predetermined wavelength therefrom, said photoluminescent device being operative to emit light of a wavelength longer than said predetermined wavelength in response to the re-

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ception of light of said predetermined wavelength from said electroluminescent device, said photoluminescent device further being operative to not emit light when said biasing signals are applied thereto; and a photoresponsive device disposed in physical relationship to receive light of said longer than predetermined wavelength from said photoluminescent device and being responsive thereto but being unresponsive to light of said predetermined wavelength from said electroluminescent device, said photoresponsive device being operative to change from a low conductive state to a high conductive state on the coincidence of the application of exciting signals to said electroluminescent device and no application of biasing signals to said photoluminescent device.

7. In a coincidence switching matrix of rows and columns forming active areas and operative with exciting signals and biasing signals, the combination of: a plurality of strips of electroluminescent material disposed in a plane to form the columns of said matrix; a plurality of strips of photoluminescent material disposed in a plane with respect to said strips of electroluminescent material to form the rows of said matrix, with the overlapping sections of said strips forming the active areas of said matrix, said electroluminescent material being responsive to emit light of a first wavelength from the associated active area in response to said exciting signals being applied across the active area of said electroluminescent material, said photoluminescent material being responsive at the associated active area to emit light of a second wavelength upon reception of light of said first wavelength from the associated active area of said electroluminescent material, said photoluminescent material further being operative not to emit light if said biasing signals are applied to the associated active area; and a plurality of photoresponsive elements disposed at each active area adjacent said strips of photoresponsive material so that said elements may receive light of said second wavelength from said photoresponsive material and are responsive thereto but are unresponsive to light of said first wavelength from said electroluminescent material, said photoresponsive elements being operative to provide a switching action at a desired active area of said matrix by changing from a low to a high conducting state in response to the coincidence of exciting signals being applied across the associated active area of said electroluminescent material and no biasing signals being applied across the associated active area of said photoluminescent material.

8. In a coincidence switching matrix of rows and columns forming active areas and operative with exciting signals and biasing signals, the combination of: a plurality of electroluminescent strips disposed in a plane to form the columns of said matrix; a plurality of photoluminescent strips disposed in a plane with respect to said electroluminescent strips to form the rows of said matrix, with the overlapping sections of said strips forming the active areas of said matrix, said electroluminescent strips being responsive to emit light from the associated active area in response to said exciting signals being applied across the active area of said electroluminescent strips, said photoluminescent strips being responsive at the associated active area to emit light upon reception of light from the associated active area of said electroluminescent strips, said photoluminescent strips further being operative not to emit light if said biasing signals are applied to the associated active area; and a plurality of photoresponsive elements disposed at each active area adjacent said photoresponsive strips so that said elements may receive light from said photoresponsive strips and are responsive thereto but are unresponsive to light from said electroluminescent strip, said photoresponsive elements being operative to provide a switching action at a desired active area of said matrix by changing from a low to a high conducting state in response to the coincidence of exciting signals being applied across the associated active area of said electroluminescent strips and no bias-

ing signals being applied across the associated active area of said photoluminescent strips.

9. In an information distributing matrix of rows and columns forming active areas and operative with exciting signals and modulating signals, the combination of: a plurality of electroluminescent strips disposed in a plane to form the columns of said matrix; a plurality of photoluminescent strips disposed in a plane with respect to said electroluminescent strips to form the rows of said matrix, with the overlapping sections of said strips forming the active areas of said matrix, said electroluminescent strips being responsive to emit light from the associated active area in response to said exciting signals being applied across the active area of said electroluminescent strips, said photoluminescent strips being responsive at the associated active area to emit light upon reception of light from the associated active area of said electroluminescent strips, said photoluminescent strips further being operative to emit light in proportion to said modulating signals applied to the associated active area; and a plurality of photoresponsive elements disposed at each active area adjacent said photoresponsive strips so that said elements may receive light from said photoresponsive strips and

are responsive thereto but are unresponsive to light from said electroluminescent strips, said photoresponsive elements being operative to provide a modulated output function at a desired active area of said matrix by changing conducting states in response to said exciting signals being applied across the associated active area of said electroluminescent material and said modulating signals being applied across the associated active area of said photoluminescent strips.

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