Feb. 27, 1968 J. BRAMLEY ET AL 3,371,243

ELECTROLUMINESCENT VOLTAGE DEVICE

Filed Dec. 30, 1952 4 Sheets-Sheet 1

Fig. 1.

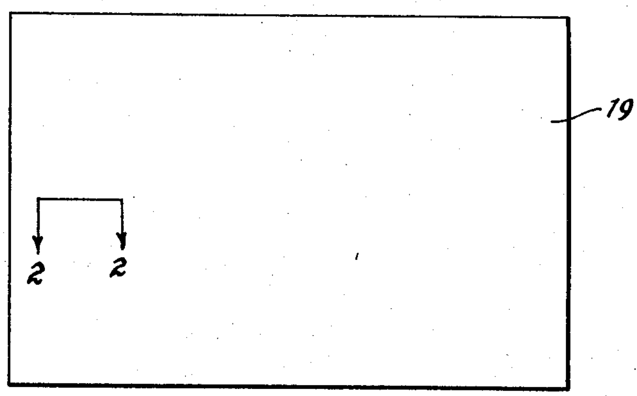


Fig. 2.

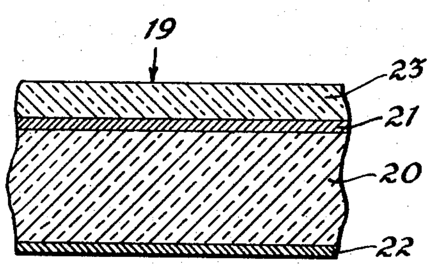


Fig. 3.

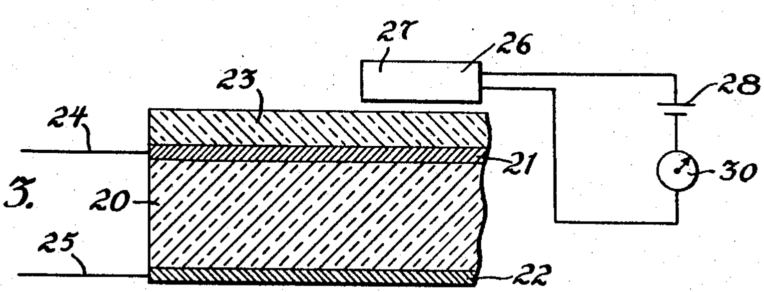
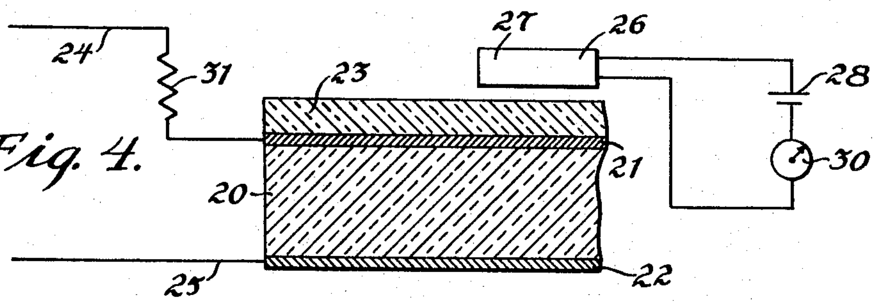


Fig. 4.



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ELECTROLUMINESCENT VOLTAGE DEVICE

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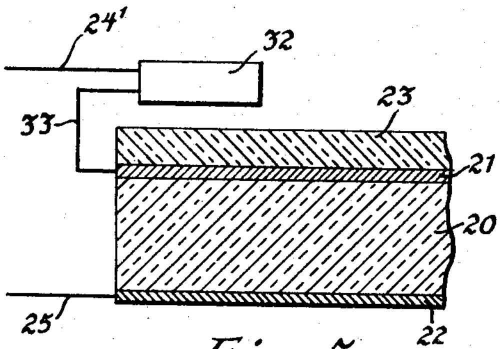


Fig. 5.

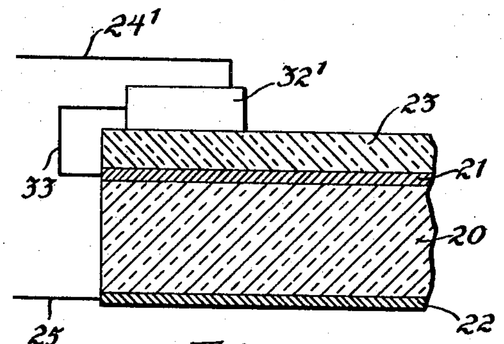


Fig. 6.

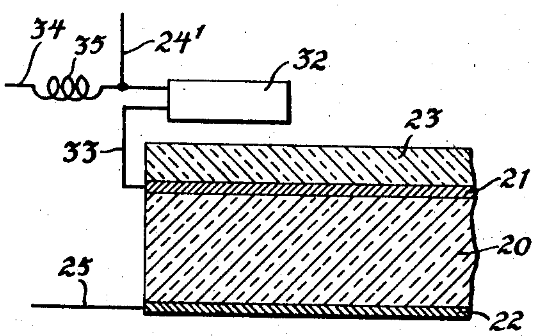


Fig. 7.

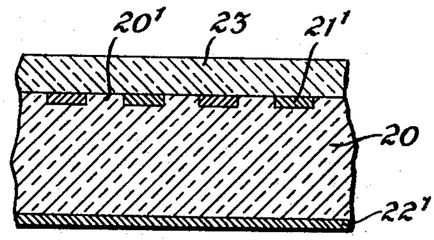
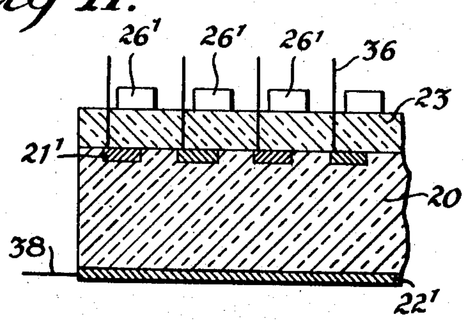


Fig. 8.

Fig 11.



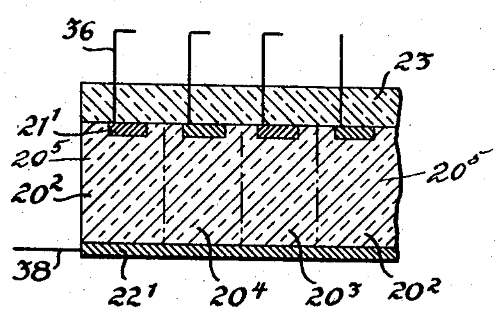
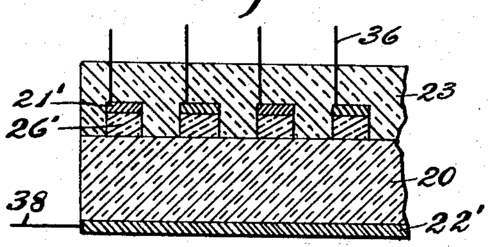


Fig. 11.a.

Fig. 12.



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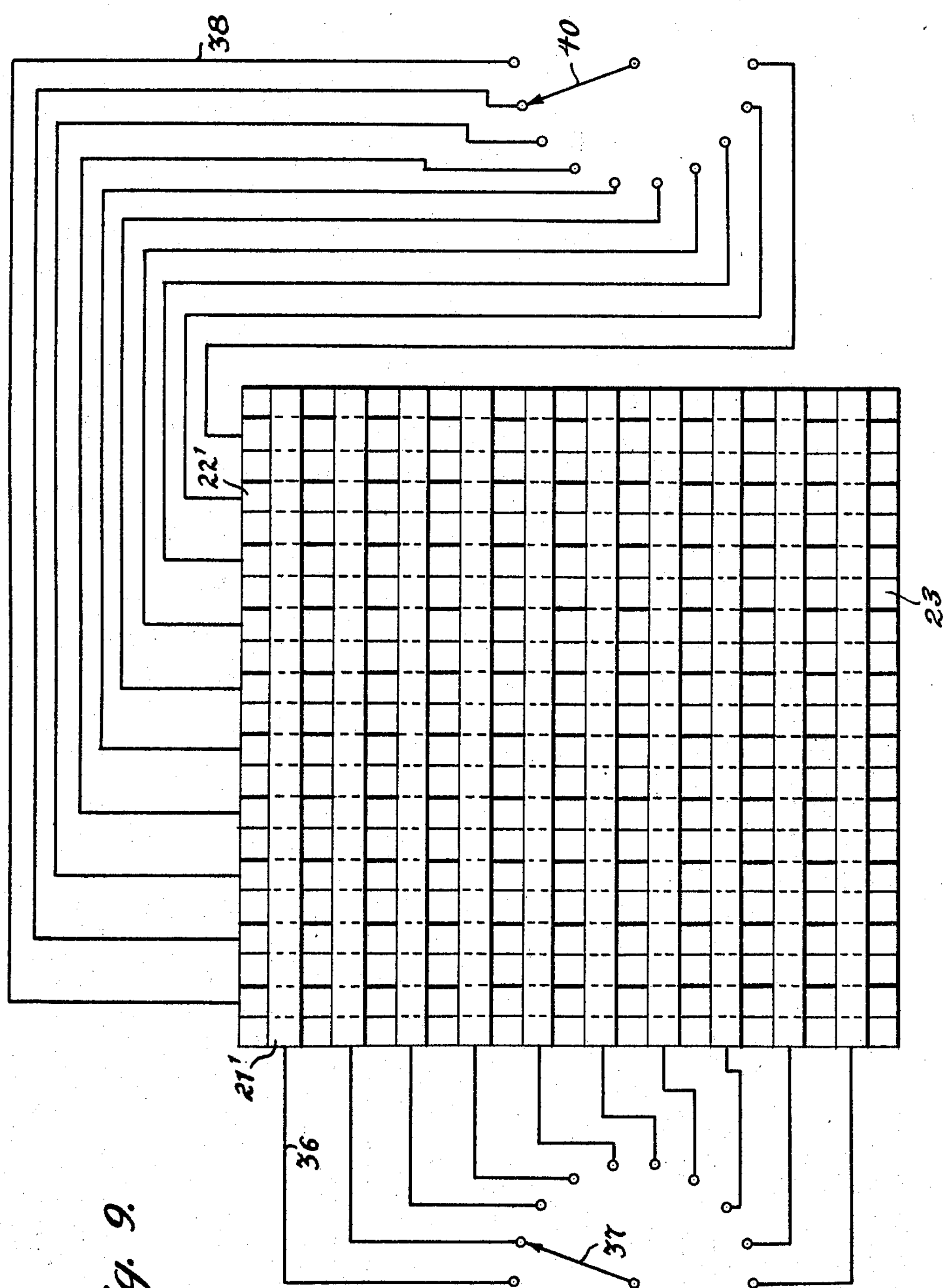

Fig. 9.

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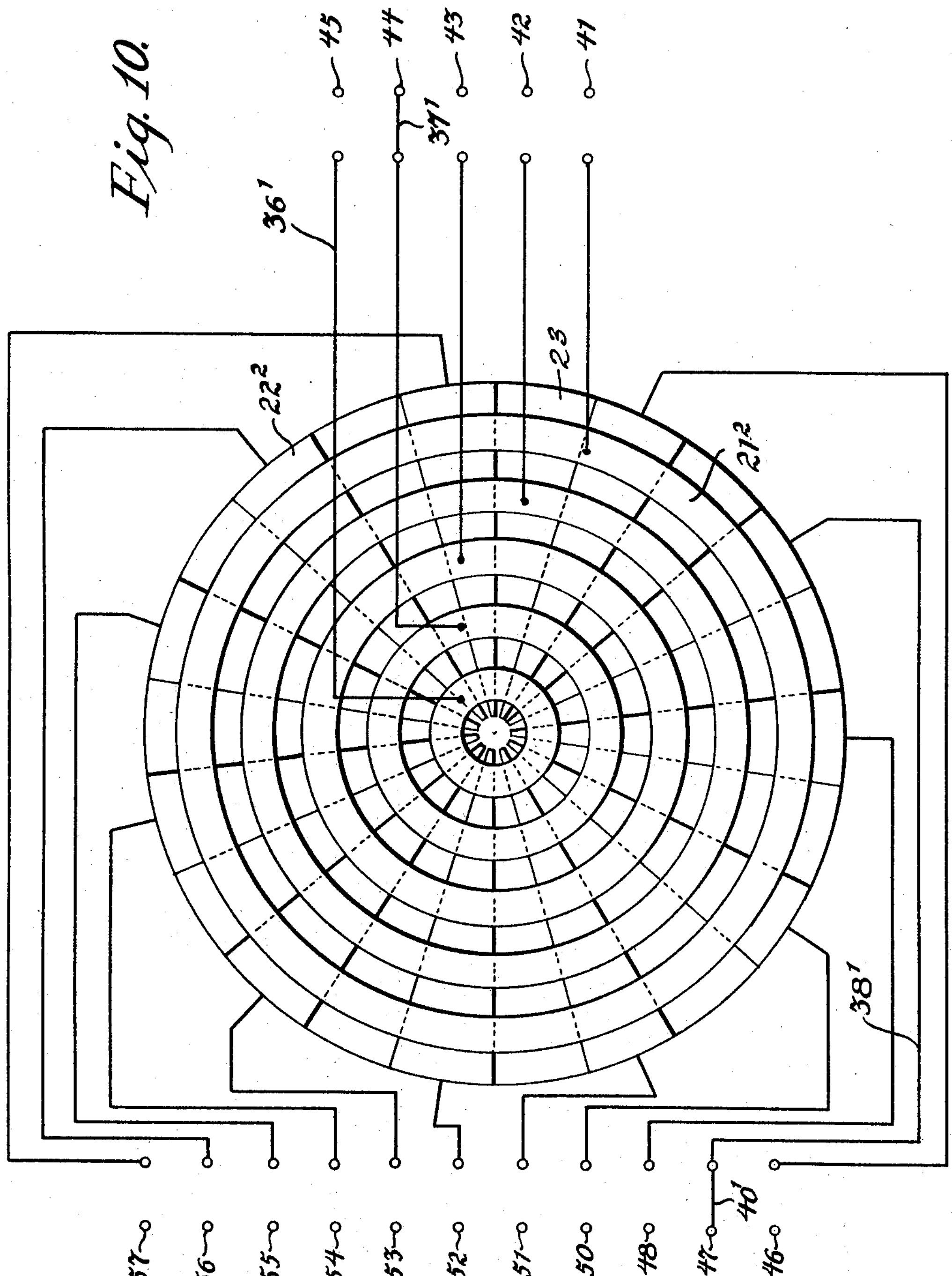
Fig. 10.



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United States Patent Office

3,371,243

Patented Feb. 27, 1968

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3,371,243
ELECTROLUMINESCENT VOLTAGE DEVICE

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Filed Dec. 30, 1952, Ser. No. 328,757
29 Claims. (Cl. 315—169)

The present invention relates to devices responsive to voltage, which may be employed either as voltmeters, voltage or transient indicators, viewers or screens.

A purpose of the invention is to produce a voltmeter or voltage indicator of very high impedance.

A further purpose is to produce a voltmeter of extremely rugged construction.

A further purpose is to render phosphor dispersed in a semitransparent dielectric layer luminous by applying a voltage across conducting layers on opposite sides of the dielectric layer, one of the conducting layers preferably being semitransparent.

A further purpose is to apply a mirror on the conducting layer opposite to the semitransparent conducting layer to direct most of the light through the semitransparent conducting layer.

A further purpose is to render an electroluminescent, semitransparent dielectric layer with impurity centers dispersed therein luminous by applying a voltage across conducting layers on opposite sides of the dielectric layer, one of the conducting layers preferably being semitransparent.

A further purpose is to employ a dielectric having a phosphor content of between 1 and 25 percent on the weight of the mixture and preferably about 10 percent.

A further purpose is to use an electroluminescent dielectric, with impurity centers dispersed therein, having a breakdown voltage greater than 30,000 volts per centimeter.

A further purpose is to employ the dielectric in a thickness between 0.01 millimeter and 0.1 millimeter.

A further purpose is to use a semitransparent conductor layer on the side on which the light is to be observed.

A further purpose is to provide a protecting dielectric layer over the semitransparent conducting layer.

A further purpose is to measure the light given off by the phosphor by a photometer.

A further purpose is to interpose a series impedance between the multilayer element of the invention and the source of voltage.

A further purpose is to connect the voltage being indicated to the multilayer element through a photosensitive element receiving light from the multilayer element.

A further purpose is to provide a maintaining voltage across the multilayer element and the photoconductive element to maintain luminescence once it is initiated.

A further purpose is to apply a first set of conducting strips desirably of semitransparent character on one side of electroluminescent semitransparent dielectric layer having impurity centers dispersed therein and a second set of conducting strips on the other side of the dielectric layer and running at an angle to the strips of the first set, and to cause luminescence at a coincidence point by applying a voltage across one of the strips of one set and one of the strips of the other set.

A further purpose is to apply a first set of conducting strips desirably of semitransparent character on one side

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of the dielectric layer having the dispersed phosphor and a second set of conducting strips on the other side of the dielectric layer and running at an angle to the strips of the first set, and to cause luminescence at a coincidence point by applying a voltage across one of the strips of one set and one of the strips of the other set.

A further purpose is to modulate the voltage applied to different strips of the respective sets.

A further purpose is to modulate the frequency of alternating current applied across the different strips of the different sets.

A further purpose is to avoid danger of distortion or wandering spot positions and to avoid difficulty with abnormally large spots on the screen.

A further purpose is to obtain longer life of a screen.

A further purpose is to secure greater resistance of a screen to shock and vibration.

A further purpose is to energize a screen at a voltage less than one thousand volts.

A further purpose is to avoid the flicker present in the oscilloscope particularly for television purposes.

A further purpose is to obtain a screen which will not require appreciable depth so that it can be employed as a thin panel or picture, thus reducing the depth of a television set (the dimension away from the wall).

A further purpose is to selectively energize phosphor of a particular color by providing strips of dielectric side by side having phosphors of different colors dispersed therein, suitably arranged in sets, such as red, blue and green, and to energize a particular color at a particular location by choice of the conducting strips on the two sides of the dielectric which are energized, a particular conductor strip being individual to a particular color at a particular coincidence point.

Further purposes appear in the specification and in the claims.

In the drawings I have chosen to illustrate a few only of the numerous embodiments in which my invention may appear, selecting the forms shown from the standpoints of convenience in illustration, satisfactory operation and clear demonstration of the principles involved.

FIGURE 1 is a front elevation of the device of the invention, suitably employed as a voltage indicator, transient indicator, television screen, radar screen, or the like.

FIGURE 2 is a fragmentary enlarged section of FIGURE 1 on the line 2—2.

FIGURES 3 to 8 are views corresponding to FIGURE 2 illustrating variations.

FIGURE 9 is a front elevation of the screen of FIGURE 8.

FIGURE 10 is a front elevation of a variant form of screen according to the invention.

FIGURES 11 and 12 are views corresponding to FIGURE 2 showing further variations.

FIGURE 11*a* is a view corresponding to FIGURE 11 and showing a variation.

The present invention is designed to function as a voltage responsive device. It may be used as a voltmeter, or an indicator of voltage such as a transient indicator, an emergency voltage alarm to indicate that some structure not intended to be energized has become energized as due to a short circuit, or a screen, indicator, viewer or dial, applicable for example in connection with television and radar devices, or to replace an oscilloscope (kinoscope).

The invention has many advantages over the cathode ray tube, and over existing voltmeters of the standard moving coil type. It is extremely rugged, and not sensitive to vibration or shock. It has a high impedance, making it valuable for many applications where a high impedance device is desired. The space requirement is not large and particularly the depth requirement is small, thus making it possible to reduce greatly the depth at present required by the oscilloscope.

Furthermore the device of the invention is capable of construction in large sizes, making viewing screens possible which are as large as pictures or as large as motion picture screens.

In all of the forms of the invention, the fundamental characteristics present in the device of FIGURES 1 and 2 are employed. A dielectric layer **20** extends suitably over the whole area of the screen, panel or viewer **19** and has a thickness which is preferably in the range between 0.01 millimeter and 0.1 millimeter. The dielectric is very desirably of a character which has a high breakdown voltage, that is higher than 30,000 volts per centimeter. The device operates at a voltage below the breakdown voltage, and, if the structural requirements permit, the thickness may be even less than 0.01 millimeter with corresponding reduction in voltage, or it may be greater than 0.1 millimeter with corresponding increase in voltage.

The dielectric **20** must, of course, be provided with impurity centers, which contribute to the activation of the dielectric so that the material can become electroluminescent. The impurity centers may also function to induce a state of semiconductivity in the dielectric either per se or as a result of strong electric fields or of radiation.

An electroluminescent material is defined as a material capable of emitting radiation under the action of a strong electric field below its breakdown potential.

The dielectric is semitransparent, and by that it is meant that it is at least semitransparent, since it may of course be fully transparent.

Various materials for the dielectric may be used, depending on the particular requirements. Glass is suitable, permissibly glass having a low melting point and being highly divided and the like. Sheets of semitransparent crystalline salts may also be used, of which zinc sulphide is a suitable example. Transparent plastic or resin dielectrics may be employed, of which polystyrene and shellac are examples respectively.

Dispersed throughout the dielectric **20** may be a phosphor, which may in the most general form be any phosphor which is energized by subjecting it to the electric field here used. Obviously a wide variety of phosphors are available, and any suitable material can be employed, the examples given merely being suggestive. Where the dielectric is a vitreous material such as glass, zinc silicate, or zinc beryllium silicate, magnesium activated, are desirable phosphors. If a crystalline salt dielectric, such as zinc sulphide or zinc sulphoselenide is used, the dielectric impregnated with copper activator to act as impurity centers will suitably be its own phosphor. For dispersion in a plastic, such as polystyrene, or a resin, such as shellac, the phosphor will suitably be zinc sulphide, lead and copper activated.

The concentration of phosphor dispersed in the dielectric will vary with the particular surface requirements but in general should be between 1 and 25 percent of the weight of the mixture of dielectric and phosphor. The lower concentrations of dielectric are usually less desirable because the light intensities are lower, although they are suitable for indicating purposes where the presence of light alone is sufficient. The higher concentrations of phosphor are less desirable because they tend to lower the dielectric properties and interfere somewhat with the transparency. For most purposes it is best to use a concentration of phosphor of about ten percent by weight.

The character of phosphor will depend also on the time of the repeat cycle. If the device is simply an indicator it may be desirable to use persistent phosphor, but in applications having short shift-over time as in television and radar, phosphors of short duration will be preferable. Phosphors of various durations as well known in the art are applicable in the present invention.

On one side of the dielectric layer **20** containing the dispersed phosphor is placed a conducting layer **21**. Where the luminescence is to be viewed from the edge of the dielectric it may be permissible to employ an opaque conducting layer **21**, but in most cases the light from the phosphor should pass through the conducting layer **21**, and the conducting layer **21** should be semitransparent. By this it is meant that it should be at least semitransparent, although it may permissibly be transparent.

The manner of applying the conducting layer **21** to the dielectric will depend upon the character of the dielectric, and the character of the conducting layer. Evaporated metallic layers such as aluminum, silver and gold are suitable for application to any of the dielectrics, the order of thickness being 10^{-5} centimeters so that the metallic layers are semitransparent. In the case of coatings on glass, semitransparent conducting layers are made as described in: Leverenz, Yuminescence of Solids (1950) 471; Pittsburgh Plate Glass Company Technical Glass Bulletin No. 15 on "Nesa Coated Glass"; Corning Glass Works Bulletin on "E.H. Coated Glass" and T. W. Littleton U.S. Patent 2,118,795, granted May 24, 1938. In one procedure, tin chloride is used to deposit tin oxide. Any other suitable character of conducting layer **21** may be used.

On the opposite side of the dielectric layer **20** from the conducting layer **21**, a conducting layer **22** is placed, which may suitably be of the same character as the conducting layer **21**, except that, since it does not ordinarily need to be semitransparent, it may be thicker, there being no exact limit on thickness. For example, it could be as thick as 1/8 inch, in which case it would provide a structural support for the device. In this case, of course, the conducting layer **22** would be a metallic sheet or plate, such as copper, stainless steel, aluminum, or other suitable electrically conducting structural metal or alloy.

It is preferred to provide a mirror surface on the face of the conducting layer **22** which is directed toward the dielectric layer **20** so that substantially all light will be reflected out through the conducting layer **21**. For this purpose it is preferable to use an evaporated layer of aluminum or silver or a highly polished surface on a sheet of stainless steel, silver or gold, or a chemically deposited silver mirror surface.

As a protection against damage to the conducting layer **21** which is exposed toward the observer, and also to protect the observer against electric shock, a semitransparent dielectric layer **23** is applied on the side of the conducting layer **21** remote from the dielectric layer **20**. The dielectric layer **23** will preferably be thin so as not to cut off much light, and will desirably be a glass sheet or a plastic layer of transparent dielectric such as polystyrene, methylmethacrylate, urea-formaldehyde and polyvinylchloride.

The element, as shown in FIGURES 1 and 2, which is employed with some modifications in the other forms, is for the sake of convenience referred to elsewhere herein as a multilayer element, and consists of the electroluminescent dielectric layer **20** with impurity centers dispersed therein, and the conducting layers **21** and **22** on the opposed sides thereof.

The voltage to be measured, indicated, or otherwise employed, is applied between the conducting layers **21** and **22** and should not exceed the breakdown voltage of the dielectric **20** in the particular thickness used, but should be greater than the normal cut-off voltage, that is, the minimum voltage which will render luminous the electroluminescent dielectric with impurity centers dispersed therein.

It will be evident that the device of FIGURES 1 and 2 can extend over considerable areas, the only limitations being increase in capacity and increase in leakage current, and can be mounted substantially flat against or adjoining walls, without requiring the depth away from the observer which is necessary in an oscilloscope.

In using the device as a voltmeter, the voltage being indicated or measured is applied by leads **24** and **25** respectively to the conducting layers **21** and **22**. The pulse may be either AC or DC, providing it rises above the normal cut-off voltage, that is, the voltage necessary to make the phosphor luminous under the impedance conditions present. Above the normal cut-off voltage the quantity of light is roughly proportional to the square of the voltage and therefore is used as a measure of voltage. A photometer **26** is employed, which in the simple form comprises a photocell pick-up **27** in series with a battery **28** and a current measuring instrument **30** of desired sensitivity, desirably a microammeter of moving coil type. If the photometer operates on alternating current, an oscilloscope is preferably used at **30** and an alternating current source is used instead of the battery.

It is best to use the device of the invention in series with an impedance **31** so that the pulse being measured is impressed on the series combination of the multilayer element and the impedance, and the applied voltage is divided between the multilayer element and the impedance, only a fraction of the total voltage being impressed across the multilayer element.

In the embodiment of the voltmeter shown in FIGURES 3 and 4 the multilayer element is again composed of two conducting layers **21** and **22** with an electroluminescent dielectric **20**, with impurity centers dispersed therein, sandwiched between the two conductors.

The multilayer element itself has a very high impedance, and therefore if the impedance **31** is to function as a voltage divider it must be an extremely high impedance.

The invention is applicable as shown in FIGURES 5 and 6 to a specialized type of voltmeter known as a transient indicator. A lead **24'** from one side of the voltage being measured is connected to one terminal of photocell **32**, the other terminal of the photocell being connected by lead **33** to conducting layer **21**. Instead of the photocell **32**, a unitary photoconductive element **32'** may be employed, as shown in FIGURE 6. In either of the forms of FIGURES 5 and 6, the light produced in the electroluminescent dielectric with impurity centers dispersed therein passes through the conducting layer **21** and reduces the impedance of the photoconductive element **32** or **32'**. If all applied voltage ceases, the light will be seen only intermittently, but if some applied voltage remains, even though it is not at the peak, the voltage applied across the multilayer element is a larger proportion of the total voltage because the photoconductive element reduces its impedance when it is lighted. Therefore if the remaining voltage applied across the multilayer element is greater than the cut-off voltage, the luminescence will remain for an additional period of time.

In the form of FIGURE 7 the transient indicator will trigger and remain luminous. In this form in addition to the lead **24'** applied to the input side of the photocell **32**, a lead **34** from a suitable source through impedance **35** is applied to the input side of the photocell to introduce a maintaining voltage across to the lead **25**. In view of the high impedance of the photocell **32** when the electroluminescent dielectric with impurity centers dispersed therein is not luminous, the maintaining voltage between the leads **34** and **25** is insufficient to permit the multilayer element to be luminous, but when the transient voltage across between leads **24'** and **25** renders the dielectric luminous, the light received in photocell **32** reduces its impedance to such an extent that a higher fraction of the maintaining voltage is applied across the multilayer element, and this being above the cut-off voltage, maintains the multilayer element luminous indefinitely.

The impedance **35** prevents the transient from being dissipated in the maintaining circuit.

The invention is widely applicable in screens and viewers, as shown n FIGURES 8 to 12 inclusive.

In the form of FIGURES 8 and 9, the conducting layer on one side of the dielectric is not continuous, but consists of a series of separate strips **21'** side by side and desirably parallel. They are insulated from one another by the intervening portions **20'** of the dielectric layer **20**. The strips **21'** will very desirably be semitransparent although since light can pass through the spaces between the strips it will be evident that light is visible at the front even though the strips **21'** are opaque.

Any suitable way of applying the strips can be employed, one method to evaporate a suitable metal such as aluminum, gold or silver on the dielectric through a mask consisting of separated ribs which prevent the evaporated metal from coating the areas between the strips.

On the opposite side of the dielectric layer **20** containing the dispersed phosphor is placed a series of conducting strips **22'** which are side by side in spaced relation and preferably parallel but which desirably are transverse to or at least at a substantial angle to the strips **21'**. Thus there is for each strip **21'** a point of coincidence with each strip **22'** and if one strip **21'** and one strip **22'** only are energized at a particular instant, the phosphor is luminous at that point of coincidence only. It is therefore merely necessary to carry out individual leads **36** from the individual strips **21'** to a selector switch **37** and to carry out individual leads **38** from each of the strips **22'** to a selector switch **40**, in order to be able to energize any chosen coincidence point having desired X and Y coordinates. Thus a raster or picture can be formed on the screen by successively energizing different coincidence points at short time intervals within the presistence of vision period, similar to the raster produced by the osclloscope. This can be combined with the usual scanning tecnique to produce a large number of energized coincidence points in a short time interval. Thus the screen is applicable for animated electric signs, animated pictures, motion pictures, radar viewing screens, television screens and the like.

Of course the switches **37** and **40** are merely diagrammatic, and will take any desired form. In the case of electric signs they may be sign flashers, such at rotary commutator switches and they may be switching tubes such as the well known 12-position Phillips switching tube, or they may be step selector switches of the type commonly employed in telephone exchanges.

Instead of dividing the conducting layers **21** and **22** into strips on rectilinear coordinates, they may be divided according to any other system, for example employing annular strips **21²** of progressively larger diameter for one conducting set of strips arranged side by side and radial segmental strips **22²** of general wedge shape for the other conducting strips. This latter type of subdivision as shown in FIGURE 10 connects by leads **36'** to a selector switch **37'** and by leads **38'** to a selector switch **40'**, the selector switches here being shown as step by step switches.

The device may be used as an adjunct to an oscilloscope instead of to replace the oscilloscope, for example by placing the screen of the invention in parallel with the oscilloscope and using it as an enlarger.

It is desirable in some cases to apply different voltages between different conducting strips **21'** and **22'** or **21²** and **22²**, and this can readily be done with the step by step switching, the applied voltage for example on terminals **41** to **45** and **46** to **57** being progressively different, either to allow for differences in leakage currents, or to obtain different colors from illumination of the phosphors or different intensities of phosphor illumination. Thus a mixture of phosphors may be employed, which in some areas are energized by a lower voltage which favors luminescence by one phosphor and in other areas are energized by a higher voltage which causes luminescence of another phosphor. In this way voltage modulation is employed on the different strips. In some instances a change in intensity or a change in hue is preferably introduced by difference in frequency. In this case the frequencies applied to the terminals **41** to **45** and **46** to **57** may vary to create different intensities or different color effects in different areas, the differences in intensities and color effects being obtained either from the same phosphor or preferably from a mixture of phosphors.

The invention has a great advantage over the oscilloscope when used in the forms of FIGURES 8 and 9 and FIGURE 10 because there is no danger that distortion or other conditions will cause the spot to wander or will create a spot of abnormally large size. Furthermore the structure is of longer life than the oscilloscope, will operate at potentials below a thousand volts and in some cases well below such potentials, while the oscilloscope ordinarily will not, and is much more sturdy and resistant to vibration and shock. The device of the invention also eliminates flicker which is objectionable, particularly for television, and is capable of being employed in large relatively thin structures such as signs.

For the purpose of erasing it is merely necessary to reduce the voltage to zero for a few microseconds in the case of a non-persistent phosphor as in the retracing time of a television scanner. On the other hand, a display can be frozen by maintaining the same sequence of energizing and omitting the erasure.

The invention is applicable also inside the cathode ray tube, as well as for use independently.

The structure as shown, for example, in FIGURES 8 and 9, can be employed with photometers **26'** placed at various coincidence points of the conducting strips **21'** and **22'**, in order to indicate luminescence at particular areas, as for example in radar applications. The individual photometers **26'** may record or may trigger alarms or signals as desired. The arrangement with the photometers **26'** is shown diagrammatically in FIGURE 11.

The elements at **26'**, instead of being photocells, can simply be blocks of photoconductive material provided with suitable leads to the indicating circuits and responding to change in impedance when light is present.

The invention is applicable for presentation of color by a screen, as already explained, through modulation of voltage or frequency. Color presentation is also accomplished, as shown in FIGURE 12, by dividing the dielectric layer $\mathbf{20^2}$ into a series of strips $\mathbf{20^3}$, $\mathbf{20^4}$ and $\mathbf{20^5}$, arranged side by side but including only dispersed phosphor of different colors in the different strips. Thus strips $\mathbf{20^3}$ may have phosphor fluorescing red, strips $\mathbf{20^4}$ fluorescing blue and strips $\mathbf{20^5}$ fluorescing green, and these strips recur in repeated cycles over the entire screen. Each conducting strip **21'** extends along one of the dielectric strips $\mathbf{20^3}$, $\mathbf{20^4}$, or $\mathbf{20^5}$ having the particular color of phosphor. Thus the selector switches **37** and **40** determine not only the location of luminescence, but each of the strips **21'** which will cause luminescence of a particular color is to be energized in coincidence with the proper one of the strps **22'** which determines the location. Any suitable definite pattern of color strips may be employed, but in each case preferably only one color of phosphor adjoins a particular conducting strip **21'**.

It will thus be evident that the invention makes it possible for the designer to create screens of a wide variety of sizes and contours adapted to many uses in signal communication and amusement devices.

Although the embodiment shown in FIGURE 12 has

been discussed with the dielectric **20** in the form of strips $\mathbf{20^3}$, $\mathbf{20^4}$, and $\mathbf{20^5}$, having phosphors of different colors dispersed in them, the same embodiment is applicable to the case where the strips $\mathbf{20^3}$, $\mathbf{20^4}$, and $\mathbf{20^5}$, which luminesce in different colors, are composed of electroluminescent semitransparent dielectrics with impurity centers, the dielectrics and impurity centers in the different strips being selected so that the strips luminesce in the desired colors.

It is obvious that in the embodiments shown in FIGURES 8, 9, 10 and 12 the electroluminescent dielectric with impurity centers dispersed therein at the point of intersection of the selected conducting strips X' and Y' of the set, **21'** and **22'** will radiate as long as the large potential difference is applied between them. However, by applying the storage effect discussed on page 11 in reference to FIGURES 5 and 6 this restriction can be relaxed. In this way any particular point of intersection can be made to radiate by applying a high voltage pulse between the two conducting strips X' and Y' intersecting at this point. The same point will continue to radiate after the voltage pulse has passed if a moderate potential difference is applied between the same two strips X' and Y'. If such a moderate potential is applied before a high voltage pulse, it will produce only weak, if any, radiation. On the other hand, if it is applied immediately after the high voltage pulse has passed, it will cause the radiation to continue with at least moderate intensity as long as this moderate potential is maintained.

In FIGURE 11*a* the coincidence points of the conducting strips **21'** and **22'** have variable impedances, suitably photoconductors, **26'** positioned between the conducting strips **21'** and the electroluminescent semitransparent dielectric **20**. The variable impedance **26'** can be simply blocks of photoconductive material making electrical contact to the strips **21'** at the area of coincidence. These photoconducting blocks **26'** are also positioned so that part of the electrical potential difference between any two conducting strips X' and Y' is applied across the block **26'** lying at the point of coincidence and part through the electroluminescent semitransparent dielectric **20**.

In this structure the peak potential difference applied between X' and Y' reduces the impedance of the corresponding element **26'** so that a greater fraction of the potential difference applied between X' and Y' is applied across the electroluminescent dielectric **20**. The moderate value to which the peak potential falls can be selected so that the electroluminescent dielectric **20** continues to radiate as long as that moderate potential is applied. The moderate value for the voltage may be so low that no radiation would be produced if it were applied without the previous action of a high voltage pulse.

In case the electroluminescent dielectric with impurity centers **20** is a variable semiconductor, the function of the variable impedance **26'** can be assumed by the electroluminescent dielectric **20** itself. In this class of electroluminescent dielectric with impurity centers the radiation is emitted at the conductor—dielectric interface, i.e. at the interface between **21'** and **22'** respectively and **20** as shown in FIGURE 8. Thus any reduction in the volume impedance of the electroluminescent dielectric **20** will allow a greater fraction of the potential difference between X' and Y' to be applied at the interface with a corresponding increase in light output.

In this discussion variable semiconductor means a semiconductor whose impedance can be reduced either by the direct action of an intense electric field or by the action of radiation.

In view of our invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of our invention without copying the process and apparatus shown, and we, therefore, claim all such insofar as they fall within the reasonable spirit and scope of our claims.

Having thus described our invention what we claim as new and desire to secure by Letters Patent is:

1. The method of rendering a screen luminescent in different colors, which comprises applying a voltage selectively and simultaneously to one of a first group of semitransparent conducting strips side by side and to one of a second group of conducting strips side by side and at an angle to the strips of the first group across an electroluminescent semitransparent dielectric layer having impurity centers, making the dielectric layer and impurity semi-conductor, which layer is electroluminescent in different colors in different areas and becomes luminous in such different colors when different pairs of strips are energized, thereby selectively generating light of different colors in the dielectric.

2. In a voltage indicator, a semitransparent dielectric having electroluminescent phosphor dispersed therein, a semitransparent conducting layer on one side of the dielectric layer, a conducting layer on the other side of the dielectric layer, a photoconductive element operatively positioned to receive light generated in the dielectric layer to cause its impedance to fall as it is illuminated, a circuit connection to one side of the photoconductive element from a source of voltage, a circuit connection from the other side of the photoconductive element to one of the conducting layers and a circuit connection from the source of voltage to the other conducting layer.

3. In a voltage indicator, an electroluminescent semitransparent dielectric layer having impurity centers dispersed therein, making the dielectric layer an impurity semi-conductor, a semitransparent conducting layer on one side of the dielectric layer, a conducting layer on the other side of the dielectric layer, a photoconductive element operatively associated to receive light generated in the dielectric layer to cause its impedance to fall as it is illuminated, a circuit connection from a source of voltage being indicated to one side of the photoconductive element, a circuit connection from a source of maintaining voltage to the one side of the photoconductive element, a circuit connection from the other side of the photoconductive element to one of the conducting layers, a circuit connection from the other side of the source of voltage being indicated to the other conducting layer and a circuit connection from the other side of the maintaining voltage to the other conducting layer.

4. In a voltage indicator, a semitransparent dielectric layer having electroluminescent phosphor dispersed therein, a semitransparent conducting layer on one side of the dielectric layer, a conducting layer on the other side of the dielectric layer, a photoconductive element operatively associated to receive light generated in the dielectric layer to cause its impedance to fall as it is illuminated, a circuit connection from a source of voltage being indicated to one side of the photoconductive element, a circuit connection from a source of maintaining voltage to the one side of the photoconductive element, an impedance in circuit with the connection from the source of maintaining voltage, a circuit connection from the other side of the photoconductive element to one of the conducting layers, a circuit connection from the other side of the source of voltage being indicated to the other conducting layer and a circuit connection from the other side of the maintaining voltage to the other conducting layer.

5. An information presenting screen with a viewing surface consisting of a multiplicity of spaced apart areas, each area comprising a semitransparent dielectric layer including an electroluminescent phosphor, a semitransparent conducting layer on one side of the dielectric layer, a conducting layer on the other side of the dielectric layer and a photoconductive element responsive to the light from the phosphor in circuit with the two previously mentioned conducting layers in the area, which two previously mentioned conducting layers in at least one particular area are energized simultaneously to each other, whereby light is generated in the dielectric layer in any such particular area and the impedance in the circuit through any such particular area is reduced after the light is generated.

6. In a multilayer screen, an electroluminescent semitransparent dielectric layer having impurity centers dispersed therein and having phosphors which produce different colors in different areas, making the dielectric layer an impurity semi-conductor, a plurality of conducting strips extending side by side in one direction on one side of the dielectric layer, and a plurality of conducting strips extending side by side in a different direction on the other side of the dielectric layer, each strip on one side having a coincidence point with a strip on the other side at which luminescence is produced, light of different colors being produced in the electroluminescent dielectric layer at different coincidence points.

7. In a screen, a plurality of sets of semitransparent dielectric strips arranged side by side, the successive strips within each set having electroluminescent phosphors which produce different colors dispersed therein, a semitransparent conducting strip extending along one side of each dielectric strip, a plurality of conducting strips side by side extending along the other side of the dielectric at an angle to the conducting strips on the one side, each conducting strip on one side having a coincidence point with a conducting strip on the other side at which luminescence of a particular color is produced corresponding to the phosphor there located, and means for selectively energizing one of the strips on one side and one of the strips on the other side simultaneously to select a predetermined color of luminescence at a particular point which is produced by generation of light in the dielectric.

8. A phosphor screen comprising a first grid of spaced parallel conductors, a second grid of spaced parallel conductors in spaced electrically insulated relationship with said first grid, the conductors of said second grid being axially aligned at substantially a right angle to the axes of the conductors of said first grid, and a phosphor layer positioned between said grids, said phosphor being an electroluminescent phosphor emitting light in phase with the applied voltage.

9. A phosphor screen as claimed in claim 8 in which the phosphor is activated zinc sulfide.

10. A phosphor screen comprising a first grid of spaced parallel conductors, a second grid of spaced parallel conductors in spaced electrically insulated relationship with said first grid, the conductors of said second grid being positioned at substantially a right angle to the conductors of said first grid, and a layer of phosphor positioned between said grids, said phosphor being selected from the group consisting of zinc sulfide, zinc selenide, cadmium sulfide, cadmium selenide, and mixtures thereof, and being activated with an activator selected from the group consisting of silver, copper, manganese, aluminum, and mixtures thereof.

11. A phosphor screen as claimed in claim 10 in which the activator is copper.

12. A phosphor screen as claimed in claim 10 in which the phosphor is zinc sulfide activated with copper.

13. A phosphor screen comprising a first grid of spaced parallel metallic conductors, a second grid of spaced parallel transparent conductors in spaced electrically insulated relationship with said first grid, the conductors of said second grid running at substantially a right angle to the conductors of said first grid, and a phosphor layer positioned between said grids, said phosphor being selected from the group consisting of activated zinc sulfide, zinc selenide, cadmium sulfide, cadmium selenide, and mixtures thereof.

14. A phosphor screen comprising a first grid of spaced parallel conductors, a second grid of spaced parallel conductors in electrically insulated relationship with said first grid, the conductors of said second grid running at substantially a right angle to the conductors of said first grid, and a phosphor layer positioned between grids, said

phosphor being selected from the group consisting of zinc sulfide, zinc selenide, cadmium sulfide, and mixtures thereof, and a source of current for energizing said conducting grids, said current being at a potential slightly above the in-phase emission threshold voltage of said phosphor.

15. An electroluminescent screen comprising a layer of a phosphor which emits light in phase with an applied electric field, a first grid composed of a plurality of non-intersecting conductors contacting one surface of said layer, a second grid composed of a plurality of nonintersecting conductors contacting the opposite surface of said layer, said grids being so oriented that projections of both grid structures form an intersecting pattern and switching means for selectively applying a voltage at least slightly above the in-phase emission threshold voltage of said screen to said conductors.

16. An information presenting screen having a viewing surface consisting of a multiplicity of areas, each area comprising a semitransparent dielectric area including an electroluminescent phosphor, a semitransparent conducting layer on one side of the dielectric layer, a multiplicity of spaced apart conducting layers on the other side of the dielectric layer, and a variable impedance in circuit with each conducting layer, each variable impedance being responsive to the potential applied between the conducting layer and the terminal of the variable impedance remote from its contact with the spaced apart conducing layer with which it is in circuit.

17. An electroluminescent display device comprising a layer of electroluminescent material whose emission color varies with the frequency of the field applied thereto, at least one electrode on one side of said layer, and at least two electrodes on the other side of said layer and electrically insulated from each other.

18. An electroluminescent display device comprising a layer of electroluminescent material whose emission color varies with the frequency of the applied field, at least one electrode on one side of said layer and at least two electrodes on the other side of said layer and electrically insulated from each other, at least some of said electrodes being of transparent conductive material.

19. An electroluminescent display device comprising a layer of electroluminescent material whose emission color varies with the frequency of the field applied thereto, at least one electrode on one side of said layer, and a series of electrodes on the other side of said layer, each electrode in said series being insulated from at least some of the other electrodes in said series and being shaped to a predetermined pattern, and means for applying potential in sequence to some of the electrodes in said series.

20. An electroluminescent display device comprising a layer of electroluminescent material whose emissive color varies with the frequency of the field applied thereto, means for making electrical connection to one side of said layer, means for making electrical connection to a portion of the other side of said layer, and means for making electrical connection to another portion of said ther side electrically insulated from said first-mentioned portion.

21. An electroluminescent display device comprising a layer of electroluminescent material whose emission color varies with the frequency of the field applied thereto, at least one electrode on one side of said layer, at least two electrodes on the other side of said layer and electrically insulated from each other and means for supplying a potential of different frequency to each of said electrodes.

22. An electroluminescent display device comprising a layer of electroluminescent material whose emission color varies with the frequency of the alternating potential applied thereto, at least one electrode on one side of said layer, and a series of electrodes on the other side of said layer, each electrode in said series being insulated from at least some of the other electrodes in said series and being shaped to a predetermined pattern, means for applying alternating potentials to said electrodes and

means for sequentially changing the frequency of the potential applied to some of said electrodes in said series.

23. An lectroluminescent display device comprising a layer of copper-and-lead activated zinc sulfide electroluminescent material whose emission color varies with the frequency of the field applied thereto, at least one electrode on one side of said layer, and at least two electrodes on the other side of said layer and electrically insulated from each other.

24. A frequency responsive circuit comprising a first pair of terminals, an electroluminescent cell having a second pair of terminals and a variable impedance element having a third pair of terminals connected electrically in series and in radiation coupled relationship between said first pair of terminals, and means connected to said first pair of terminals and impressing an alternating voltage across said variable impedance element and said electroluminescent cell.

25. An electroluminescent device comprising an electroluminescent capacitor, said capacitor including a dielectric member comprising an electroluminescent phosphor and a pair of electrodes contacting spaced surface regions of said member, a photoconductive member having an impedance which varies as a function of radiation emitted from said electroluminescent phosphor positioned in spaced relationship and in radiation coupled relationship with said electroluminescent capacitor, and a pair of electrodes contacting spaced surface regions of said photoconductive member.

26. An electroluminescent device comprising an electroluminescent capacitor, said capacitor including a dielectric layer comprising an electroluminescent phosphor and a first pair of conducting electrodes in extended area contact with spaced surface regions of said dielectric layer, a photoconductive member having an impedance which varies as a function of radiation emitted from said electroluminescent phosphor positioned in spaced relation and in radiation coupled relation with said electroluminescent capacitor, and a second pair of conducting electrodes in extended area contact with spaced surface regions of said photoconductive member.

27. An electroluminescent device comprising a light transmitting base plate, an electroluminescent capacitor mounted on one major surface of said base plate and including a dielectric member comprising an electroluminescent phosphor and a first pair of conducting electrodes at least one of which is light transmitting contacting opposite surfaces of said dielectric member, a photoconductive member having an electrical impedance which varies as a function of radiation emitted from said phosphor mounted on the opposite major surface of said base plate, and a second pair of conducting electrodes contacting spaced surface regions of said photoconducting member.

28. The device of claim 26 in which one of said first pair of electrodes is electrically connected to one of said second pair of electrodes to provide a three terminal circuit element.

29. A screen comprising, in combination, an electroluminescent semitransparent dielectric layer having impurity centers dispersed therein, making the dielectric layer an impurity semi-conductor, a plurality of separate conducting strips extending in one direction on one side of the dielectric layer, a plurality of separate conducting strips extending in another direction on the other side of the dielectric layer, each conducting strip on one side having a coincidence position with a conducting strip on the other side, means for selectively energizing one strip on one side and another strip on the other side to create luminescence at the coincidence point by generating light in the dielectric layer, and impedance means for lowering the impedance and sustaining the generation of light in the dielectric layer, in circuit with the means for selectively energizing the strips.

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