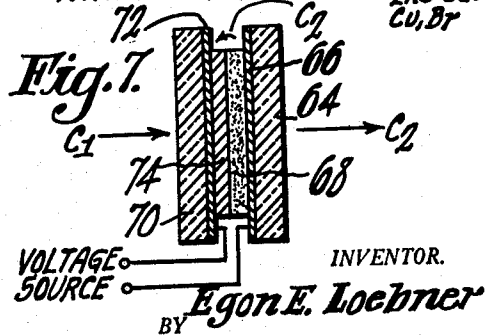
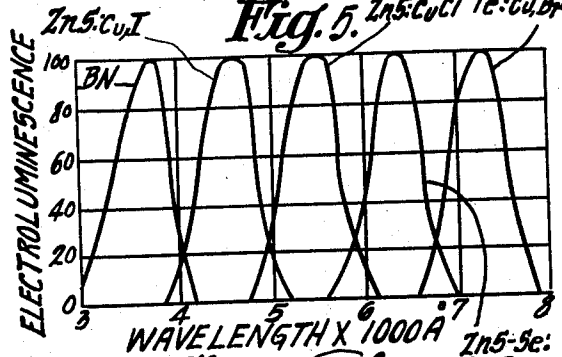
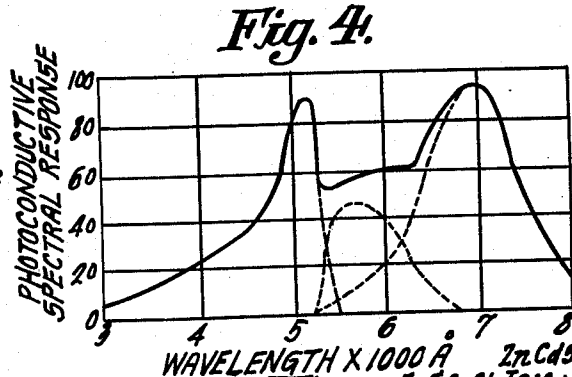
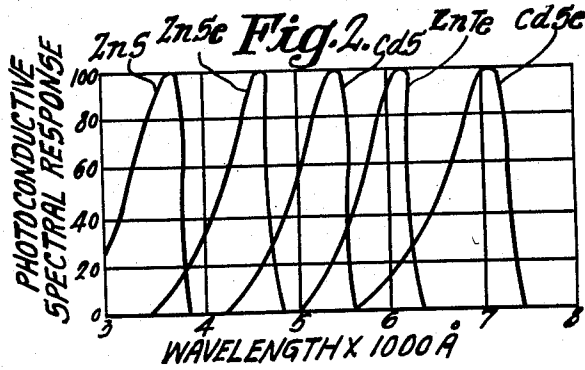
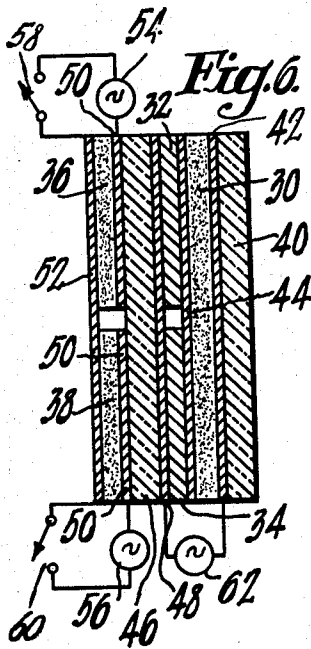
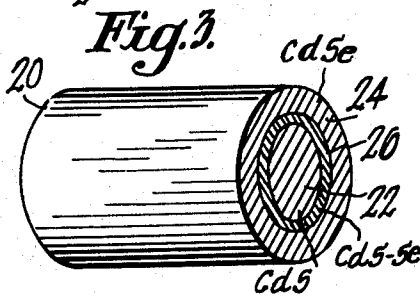
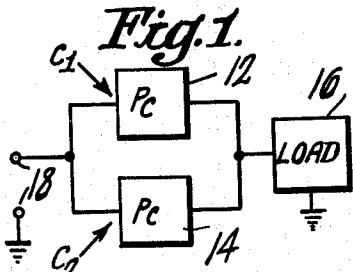


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E. E. LOEBNER
WAVELENGTH SELECTIVE RADIATION RESPONSIVE
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WAVELENGTH SELECTIVE RADIATION RESPONSIVE SYSTEMS AND DEVICES

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13 Claims. (Cl. 250—213)

This invention relates to systems utilizing radiations of various wavelengths, and in particular to systems and devices adapted to respond to radiations in selected spectral regions only.

Materials which have the property of changing their electrical impedance in response to the incidence of radiations are well known in the art and are collectively referred to as photoconductors. This property may be observed by placing a photoconductive material between two electrodes and applying a potential difference between such electrodes. It will be found that the photoconductive material has a very high electrical impedance when the photoconductive material is shielded from all radiations. However, when radiations, visible or invisible, to which the material is sensitive are allowed to impinge upon the photoconductive material the impedance of such material, will be found to decrease substantially. It will also be found that such photoconductive response of the photoconductive material is dependent upon the intensity of the incident radiations, the wavelength of the incident radiations, and the voltage applied thereacross.

The above-described photoconductors have been used in many ways in the prior art. For example, cells comprising photoconductive material between two electrodes have been widely used to control electrical devices in accordance with the incidence of radiations on such cell. More recently, electroluminescent materials (i.e. materials which emit radiations in response to an electric field applied thereacross) have been used in conjunction with the photoconductive materials to provide light amplifiers and radiation reproducing and storage devices of various kinds. In all of such devices, the variation of the impedance of the photoconductive material in accordance with the intensity of radiations incident thereon has been utilized. Therefore, the primary objective of the art has been to produce and utilize photoconductors having a response covering a wide spectral region, or, in other words, photoconductors which will respond to as many different wavelengths as possible. Such wide band response has the effect of increasing the sensitivity of the photoconductors since low levels of radiations of a great number of different wavelengths will produce the same result as a high level of radiations of a single wavelength.

Thus, the wavelength selectivity of photoconductors, although known, has not been exploited to any great extent. Photoconductive materials having a broad spectral region of response have been used to respond to two or more different wavelengths of radiation. More recently the selectivity of photoconductors has been used to enable the amplification of a certain wavelength of radiation independently of other wavelengths or the conversion of certain wavelengths of radiation into other wavelengths. However, the wavelength selectivity of photoconductive response has not been utilized in its best advantage.

It is an object of this invention to provide devices capable of producing radiations in response to the in-

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cidence of any one or all of two or more selected spectral regions only of radiation.

It is a further object of this invention to provide devices capable of producing or storing radiations in a selected spectral region in response to the incidence of any one or all of two or more selected spectral regions only of radiation.

It is still another object of this invention to provide new and useful systems and devices wherein information is carried by combinations of distinct spectral regions of radiation.

Briefly, one embodiment of this invention comprises a first radiation responsive element, the electrical impedance of which is decreased by the incidence thereon of radiations in a given spectral region only, and a voltage responsive element electrically connected in series with such first radiation responsive element. A second radiation responsive element, the electrical impedance of which is decreased by the incidence thereon of radiation only in another spectral region different from said given spectral region, is directly electrically connected in parallel with the first radiation responsive element and in series with the voltage responsive element. In operation the incidence of radiation in either spectral region will reduce the impedance of one of the radiation responsive elements thus causing the voltage responsive element to be actuated. According to one feature of this invention, a single photoconductive element, adapted to have a maximum response in two or more different spectral regions only, may be used in place of the parallel connected photoconductive elements.

A modification according to this invention may comprise in addition to one or more of the embodiments, above described, a source of radiations matched to each of the spectral regions involved and which is adapted to be modulated to provide radiations in different spectral regions in accordance with certain desired information, the voltage responsive element providing an output of a desired nature.

This invention will be more completely understood when the following detailed description is read in conjunction with the appended single sheet of drawing wherein:

Figure 1 is a schematic representation of an embodiment of this invention;

Figure 2 is a graph showing generalized photoconductive response curves for a number of well-known photoconductive materials;

Figure 3 is an idealized perspective view partially in cross-section of a cylindrical photoconductive crystal which may be used according to this invention;

Figure 4 is a graph showing a generalized photoconductive response curve of the photoconductive crystal shown in Figure 3;

Figure 5 is a graph showing the generalized electroluminescent radiation curves for a number of well-known electroluminescent materials;

Figure 6 is a cross-sectional view of a device constructed in accordance with the subject invention; and

Figure 7 is a cross-sectional view of a storage device constructed in accordance with this invention.

Referring to Figure 1 there is shown a pair of photoconductive or radiation responsive elements or cells 12 and 14 electrically connected in parallel with each other, and a load 16 electrically connected in series with the parallel connected elements or cells 12 and 14. When a voltage source 18 is connected across the series parallel circuit, it will be seen that the voltage will be divided between the load 16 and the parallel connection of the radiation-responsive elements 12 and 14. As is characteristic of parallel circuits, the voltage appearing thereacross will be determined primarily by the element 12

or 14 having the lowest impedance and its relative magnitude as compared to that of the load 16. It may be assumed that when the radiation responsive elements 12 and 14 are shielded from all radiations they will have approximately the same very high impedance, as is characteristic of such materials. Thus, if the impedance of the load is much smaller than either of the impedances of the elements 12 and 14 the voltage appearing across the load 16 will be some small portion of the applied voltage and the load 16 may be chosen or adapted to be insensitive to such small voltage.

In operation, radiations C_1 to which one of the radiation responsive elements 12 or 14 is sensitive are caused to impinge upon such elements. Similarly, radiations C_2 to which the other responsive element is sensitive are caused to impinge on said other element. Such radiations will cause a substantial decrease in the impedance of the selected element and thus a decrease in voltage appearing across the parallel connected elements 12 and 14 and an increase in the voltage appearing across the load 16. Thus, the load 16 may be adapted to be excited by such increase in voltage, or at such increased voltage, to give a desired output. It will be seen that the incidence of radiation upon either of the radiation responsive elements 12 or 14 will produce the above described redistribution of voltages in the circuit. It will also be seen that the incidence of radiations C_1 and C_2 upon both of the radiation responsive elements 12 and 14 will produce a corresponding redistribution of voltages in the circuit.

According to this invention each of the radiation responsive elements 12 and 14 is composed of a material which is sensitive to radiations in a given spectral region only. Thus, where the spectral region in which the first element 12 is sensitive does not appreciably overlap the spectral region in which the second element 14 is sensitive, an output may be induced only by the incidence thereon of radiations in either one or both of the two spectral regions. Referring to Figure 2, there is shown a graph of the generalized response curves of a number of known radiation responsive materials. The radiation or photoconductive response of the materials is plotted against the wavelength of the incident radiations. It will be seen from the graph of Figure 2 that a number of combinations of materials could be selected for use as the radiation responsive elements 12 and 14. Thus, the embodiment of this invention shown in Figure 1 may be adapted to respond to radiations in either one or both of two different spectral regions but not to radiations in any other spectral region. Such a device may be used to detect the presence of radiations in either or both spectral regions and to give an output in accordance therewith.

The radiation responsive cells or elements 12 and 14 may each comprise a large crystal of a radiation responsive material to which two electrodes are attached, as is known in the art. Each of such elements 12 and 14 may also comprise radiation responsive material in the form of crystals of powder particle dimensions bound together by a suitable matrix into a layer or stratum and sandwiched between two electrodes, or they may comprise a layer of radiation responsive material sintered onto one electrode and another electrode in contact therewith, such as are described in applications of Frederick H. Nicoll, Serial No. 527,476, filed August 10, 1955 and now abandoned, and Soren M. Thompson, Serial No. 473,001, filed December 3, 1954 now U.S. Patent number 2,765,381.

Certain structural and electrical advantages may be obtained through the use of a single radiation responsive element having a response in either of two different spectral regions, in place of the two separate elements hereinabove described. For example, two layers, as described above, each of a different radiation responsive material, may be sandwiched, side by side, between the

same two conductors, in which case the element as a whole would exhibit the response of both materials.

Figure 3 shows a single cylindrical crystal 20 having a response in either of two different spectral regions, which may also be used to replace the parallel connected radiation responsive elements. Such a crystal may be produced by modifying the spectral response of a crystal 22 of a first radiation responsive material by forming on at least one surface thereof a layer 24 of a second radiation responsive material in the same crystal structure as that of the first material. A preferred method for modifying the spectral response of a cadmium sulfide crystal, for example, comprises heating a crystal thereof supported over a quantity of selenium at a temperature of about 700° C. The selenium volatilizes and reacts with the cadmium sulfide forming a layer 26 of cadmium selenosulfide in a surface layer. A similar process may be carried out in the production of a sintered layer on an electrode, in which case a sintered layer would be produced having a response similar to that of the single crystal 20 described above.

Referring to Figure 4, a graph of the photoconductive response of the crystal 20 plotted against wavelength is shown. It will be seen that the response curve has two peaks of response, one in each of two different spectral regions. However, it will also be seen that the crystal exhibits a lesser degree of response in the spectral region between such peaks. Such intermediate response is probably due to the response of the interface region 26 between the separate crystal and the surface layer thereon. The response curve of the crystal 22 has been completed in dotted lines in Figure 4 as has been the response curve for the surface layer 24. The curve consisting entirely of dotted lines is believed to represent the response of the interface region 26 mentioned above. It is desirable to reduce the response curve of such interface region 26 to a negligible value in order to enhance the selectivity of the crystal with respect to spectral response. Such reduction can probably be accomplished by adjusting the process to minimize the thickness of such interface region 26. However, the effects of such intermediate response can also be minimized through the proper design and operation of the device, as described hereinafter.

The operation of an embodiment of this invention is complicated by the fact that the magnitude of the response of a radiation responsive material is a function of both the wavelength of the incident radiations and the intensity of such radiations. The graphs shown in Figures 2 and 3 are normalized graphs representing the response of the various materials when the intensity of the various wavelengths of radiations are held constant. Thus, it will be seen that high intensity radiations of a wavelength to which a given material is relatively insensitive may produce the same response as low intensity radiations of a wavelength to which the material is more sensitive. Furthermore, since the graphs shown in Figures 2 and 4 were evolved by subjecting the various radiation responsive materials, sequentially, to different radiations each in a very narrow band, they do not necessarily represent the response which the radiation responsive material would show to each wavelength of radiation if all of the wavelengths of the radiations were present on the material at the same time. Thus, it will be seen that this invention does not completely eliminate the necessity for radiation shielding in all embodiments. To state the matter more broadly, it is not the primary purpose of this invention to eliminate the necessity of radiation shields in radiation responsive devices. Embodiments of this invention must be very carefully designed and operated in order to take advantage of the selectivity of the photoconductive materials as represented by the graphs shown in Figures 2 and 4.

The design considerations in embodiments of this invention are thus divided into three main areas. First, of

course, is the selection of pairs or groups of photoconductive materials which have a very marked wavelength selectivity in spectral regions that do not appreciably overlap each other. The second consideration is the selection and adaptation of a load that will enhance the selectivity of the radiation responsive material. Since all radiation responsive materials have a certain level of conduction even in the dark (i.e. without the incidence of radiations) the load must not respond to such dark level conduction. Similarly, the load must not respond to the slight changes in the impedance of the radiation responsive materials that might occur when radiations bordering on or slightly overlapping with the region of spectral response of the material impinge upon such material. Thus, it will be seen that the load may be adapted to enhance the selectivity of the radiation responsive material by designing it to respond only when a certain maximum of impedance decrease (or radiation response) occurs in the radiation responsive material.

The third area of design consideration is concerned with the radiations which are allowed to impinge upon the radiation responsive materials. The ideal situation would be to have a source or sources of radiations in a plurality of spectral regions which are exactly matched to the spectral regions of response, respectively, of the radiation responsive materials. Thus, if the radiation responsive materials were properly chosen, the overlap of the spectral regions of response, and thus, of the spectral regions of the radiations would be such that each radiation responsive element would respond only to the radiation having a spectral region matching its own and not to the other radiations. Thus, shielding would only be necessary to protect the radiation responsive elements from external or ambient radiations.

According to this invention, electroluminescent elements are very advantageously used either as the load for the radiation responsive elements or as a source of radiations for activating the radiation responsive elements, or both. Electroluminescent elements comprise a layer or stratum of certain well-known phosphors between a pair of electrodes. The application of a voltage to such electrodes will produce an electric field between the electrodes and through the phosphor layer. Such electric field will induce radiations from the electroluminescent phosphor. It is known that an electroluminescent cell may be adapted to have a certain threshold voltage below which no appreciable radiations will be produced and above which radiations will be produced and which will vary in intensity with the magnitude of such voltage. It will be seen that by adjusting the threshold voltage of the electroluminescent element, a certain amount of selectivity may be obtained.

Furthermore, it is known that different electroluminescent materials will electroluminesce in different spectral regions. In fact, it has been found that the spectral regions of certain electroluminescent materials correspond favorably to the spectral regions of response of certain of the radiation responsive materials. Therefore, ideal sources of radiations are provided by electroluminescent materials for embodiments of this invention. Referring to Figure 5, a graph is shown which represents the spectral regions covered by the radiations from certain electroluminescent materials. By comparing the graph of Figure 5 with the graph of Figure 2 it will be seen that certain of the spectral regions of electroluminescence substantially duplicate certain of the spectral regions of response of the radiation responsive materials.

Referring to Figure 6 an embodiment of this invention is shown in which electroluminescent materials are used both as the load and as sources of radiation in two different spectral regions. An electroluminescent load element 30 is arranged in electrical contact with a pair of radiation responsive elements 32 and 34. The radiation responsive elements are in turn arranged in radiation receiving relationship to a pair of electroluminescent

source elements 36 and 38. The spectral response of each of the radiation responsive elements 32 and 34 are matched respectively to the spectral regions of electroluminescence of each of the electroluminescent source elements 36 and 38. It will be seen that at any given level of radiation intensity from the source elements 36 and 38 the efficiency of operation will be determined by the degree of matching of the spectral regions of response and electroluminescence.

A structure according to this embodiment may comprise a first sheet of glass 40 upon one surface of which a transparent conductive coating 42 has been formed as by the deposition of the vapors of stannic acid, water and methanol thereon. The electroluminescent load 30 may be placed in contact with the transparent conductive coating and may comprise a layer of particles of zinc sulfide with activator proportions of copper and coactivator proportions of iodine suspended in a transparent electrical insulating material such as ethyl cellulose. A second transparent conductive coating 44 may be applied to the electroluminescent load 30 and may comprise a thin layer of silver paste for example. The radiation responsive elements 32 and 34 may be applied to the second transparent conductive coating 44 in the form of adjacent layers or coatings each covering a portion of the area of the electroluminescent load 30. The radiation responsive elements may comprise photoconductive crystals of powder particle dimensions bound together by a suitable matrix, or layers of photoconductive material sintered in situ. The first radiation responsive element 32 may be composed of zinc sulfide and the second radiation responsive element 34 may be composed of cadmium sulfide, for example. A second sheet of glass 46 having a transparent conductive coating 48 formed on one major surface thereof, as described with respect to the first sheet of glass, is positioned with the coating 48 in electrical contact with both radiation responsive elements 32 and 34. The opposite major surface of the second sheet of glass 46 is provided with two spaced and electrically insulated conductive coatings 50 each corresponding in area and position to one of the radiation responsive elements 32 and 34. The pair of electroluminescent source elements 36 and 38 may be applied, one to each of the conductive coatings 50 and coextensive therewith, in the form of layers or coatings of electroluminescent material as described with reference to the electroluminescent load 30. The source element 36, which is coupled to the first radiation responsive element 32, may be composed of electroluminescent boron nitride, for example, and the source element 38, which is coupled to the second radiation responsive element 34, may be composed of (ZnS:Cu,Cl) zinc sulfide with activator proportion of copper and coactivator proportions of chlorine, for example. A conductive coating 52 may then be applied to, and extending over, both electroluminescent source elements 36 and 38. A different voltage source 54 and 56 may be connected between the conductive coating 52 and each of the conductive coatings 50 on the opposite side of the source elements 36 and 38 and switching means 58 and 60 may be provided to enable the energization of either of the source elements 36 and 38 separately. Another voltage source 62 may be connected between the first transparent conductive coating 42 and the third transparent conductive coating 48.

It will be seen that the spectral region of electroluminescence of the boron nitride material of which the first source element 36 is composed substantially matches the spectral region of response of the zinc sulfide material of which the first radiation responsive element 32 is composed and that the spectral region of electroluminescence of the ZnS:Cu,Cl material of which the second source element 38 is composed substantially matches the spectral region of response of the cadmium sulfide

material of the second radiation responsive element 34. It will be seen, furthermore that the spectral region of electroluminescence of the load 30 is intermediate the spectral regions of response of the radiation responsive elements 32 and 34.

In operation, if either of the switches 58 or 60 are closed, the source element 36 and 38 corresponding thereto will be turned on and radiation therefrom will impinge upon the radiation responsive elements 32 and 34. The impedance of only one radiation responsive element will be appreciably decreased by radiations from each of the source elements 36 and 38, however, due to the spectral region matching above described. Such decrease in impedance of one of the radiation responsive elements 32 and 34 will result in a change in the voltage appearing across the electroluminescent load 30 and will cause an electroluminescent output therefrom. Furthermore, the electroluminescence emitted by the load 30 will not affect the impedance of the radiation responsive elements 32 and 34 due to the mismatch of spectral regions described above.

Thus, it will be seen that by proper adjustment of the thickness of the various layers and the voltages applied thereacross, this embodiment of the invention may be adapted to produce radiations only in response to the energization of either one or both of the source elements. Similarly, proper mismatching of spectral regions may be used to modify the output of the structure, as desired.

Referring to Figure 7, a structure according to another embodiment of this invention is shown. The device shown in Figure 7 is a storage device which makes use of the parallel connection, or the double peak response of a radiation responsive material according to this invention. The device shown in Figure 7 may comprise a first sheet of glass 64 having a transparent conductive coating 66 applied to one surface thereof by any suitable method, for example, by the deposition of the vapors of water, methanol and stannic acid thereon. A given electroluminescent material may then be applied to such transparent conductive coating in the form of a layer 68. For example, the electroluminescent material may comprise particles of zinc sulfide with activator proportions of copper and coactivator proportions of chlorine and may be suspended in a transparent insulating material, such as ethyl cellulose, for example, and sprayed or painted or otherwise applied to such transparent conductive coating. A second sheet of glass 70 may be provided with a transparent conductive coating 72 upon which a sintered layer 74 of radiation responsive material having a double peak response similar to that shown in Figure 4 may be applied, for example. The two layers 68 and 74 are then placed in contact with each other and a voltage source is connected between the two transparent conductive coatings 66 and 72. It will be seen that no radiations will be induced in the electroluminescent material so long as there are no radiations incident upon the layer 74 of radiation responsive material. However, if the device is exposed to radiations C_1 in a spectral region to which the radiation responsive material 74 is sensitive, electroluminescence will be induced in the electroluminescent material. According to one feature of the structure shown in Figure 7, the electroluminescent material may be chosen so that the spectral region of the radiations C_2 produced thereby corresponds to one of the spectral regions in which the radiation responsive material is sensitive. Thus, if the thickness of the layers 68 and 74 is properly adjusted to enable a gain of more than unity due to the feedback of the radiation C_2 from the electroluminescent material to the radiation responsive material, storage can be obtained. That is, once radiations have been induced from the electroluminescent material in response to the incidence of radiations in a spectral region to which the radiation responsive material is sensitive, such radiation will con-

tinue even after the actuating radiations are no longer incident upon the radiation responsive material, due to the feedback of radiations from the electroluminescent material to the radiation responsive material. Thus, it will be seen that a device is provided which is adapted to be actuated by radiations in one spectral region and to store in radiations of another spectral region but will not react to radiations in any other spectral region even one which may be intermediate that of the actuating radiations and that of the storage radiations.

It will be seen that there has been provided herein new electroluminescent devices and systems which are capable of making use of the wavelength selective properties of radiation responsive material in combination with certain light sources to enable the translating of information in the form of radiations of various wavelengths into an output of a desired type. Such systems and devices will have wide use in certain storage applications wherein it is desired to store given information or images. Furthermore, such devices and systems will be useful in logic and calculator systems. According to this invention, the amount of information which may be carried in a given radiation beam may be increased in accordance with a number of spectral regions which are used.

What is claimed is:

1. A wavelength-selective radiation responsive device comprising a first sheet of transparent insulating material, two spaced, transparent conductive coatings on one major surface of said sheet, two elements of electroluminescent material, each of said elements of electroluminescent material being in electrical contact with only one of said coatings, an electrical conductor extending over both of said elements of electroluminescence material and in electrical contact therewith, a transparent conductive coating on the other major surface of said first sheet, two elements of radiation responsive material on said conductive coating on said other surface of said sheet, each of said elements of radiation responsive material corresponding in size and position to said elements of electroluminescent material, an electrical conductor extending over said elements of radiation responsive material and in electrical contact therewith, a layer of electroluminescence material on said conductor extending over said elements of radiation responsive material, and a second sheet of glass having a transparent conductive coating on one major surface thereof positioned with said conductive coating in electrical contact with said layer of electroluminescent material, each of said elements of electroluminescent material being adapted to emit a different spectral region only of radiations and each of said elements of radiation responsive elements being adapted to respond to a different spectral region only of radiations, said spectral regions of said electroluminescence being matched to said spectral regions of response of correspondingly positioned elements of electroluminescent material and radiation responsive material, respectively.

2. An electrical apparatus comprising a source of radiations in each of a plurality of different spectral regions, radiation responsive means in radiation receiving relationship with said source of radiations, said radiation responsive means exhibiting a decrease in electrical impedance in response to radiations in said plurality of different spectral regions only, and electroluminescent means, having a certain threshold voltage above which a desired output will occur, said radiation responsive means being electrically connected to said electroluminescent means in such manner that said electroluminescent means will emit light over its entire emitting area when said radiation responsive means is excited in any of said spectral regions, each of said plurality of spectral regions and the response of said radiation responsive means and said threshold voltage of said electroluminescent means being such as to provide a desired output for the incidence of any one of said plurality of spectral regions of radiations on said radiation responsive means.

3. A wavelength selective radiation responsive device comprising electroluminescent means and radiation responsive means, said radiation responsive means having a variable impedance characteristic in response to radiant energy and having pronounced maximum response in at least two different spectral regions as compared to a substantial spectral region of substantially lower response intermediate said regions of maximum response, said radiation responsive means being electrically connected to said electroluminescent means in such manner that said electroluminescent means will emit light over its entire emitting area when said radiation responsive means is excited in either of said different spectral regions.

4. A device as in claim 3, wherein said radiation responsive means comprises a plurality of radiation responsive elements connected in parallel with each other and having said pronounced maximum responses in different spectral regions.

5. A device as in claim 3, wherein said radiation responsive means includes a single body of material having a double peaked response.

6. A wavelength selective radiation responsive device comprising an electroluminescent element, first and second photoconductive elements, conductive means electrically connecting said photoconductive elements in parallel with each other and in series with said electroluminescent element so that said electroluminescent element will emit light when either of said photoconductive elements is excited, said first photoconductive element having a maximum photoconductive response in one relatively narrow band of wavelengths of light only, and said second photoconductive element having a maximum photoconductive response substantially only in a different relatively narrow band of wavelengths.

7. A wavelength selective radiation responsive device comprising a pair of spaced apart sheet-like electrodes, a layer of electroluminescent material intermediate said electrodes, and photoconductive layer means intermediate said electroluminescent layer and one of said electrodes, said photoconductive layer means having pronounced maximum photoconductive response in at least two different spectral regions as compared to a substantial response in the spectral region of substantially lower response intermediate said regions of maximum response, said photoconductive layer means being electrically connected to said electroluminescent layer in such manner that said electroluminescent layer will emit light over its entire emitting area when said photoconductive layer means is excited in either of said spectral regions.

8. A device as in claim 7, wherein said photoconductive means comprises two layers of different material arranged along side each other.

9. A device as in claim 7, wherein said photoconductive means comprises a single body of material having a double peaked response.

10. A device as in claim 9 wherein said photoconductive material is responsive to light falling within two relatively narrow bands of wavelengths only, and said electroluminescent material is adapted to emit light falling substantially within one of said wavelength bands only.

11. A wavelength selective radiation responsive device comprising a pair of spaced apart sheet-like electrodes, a layer of electroluminescent material intermediate said electrodes, first and second photoconductive layer means intermediate said electroluminescent layer and one of said electrodes and arranged along side each other, said first photoconductive layer having a maximum photoconductive response in a first relatively narrow band of wavelengths only and said second photoconductive layer having a maximum photoconductive response in a second and different narrow band of wavelengths only, a first electroluminescent cell adjacent to said first photoconductive layer and capable of emitting light which is matched only to the response of said first photoconductive layer, and a second electroluminescent cell adjacent to said second photoconductive layer and capable of emitting the light which is matched only to the response of said second photoconductive layer.

12. A device is in claim 11, wherein said electroluminescent layer is formed of a material which emits light falling outside said first and second narrow bands.

13. A device as in claim 3, wherein said electroluminescent means is adapted to emit light falling within said intermediate region.

References Cited in the file of this patent

UNITED STATES PATENTS

2,641,712	Kircher	June 9, 1953
2,742,550	Jenness	Apr. 17, 1956
2,768,310	Kazan et al.	Oct. 23, 1956
2,779,811	Picciano et al.	Jan. 29, 1957

FOREIGN PATENTS

157,101	Australia	June 16, 1954
---------	-----------	---------------

OTHER REFERENCES

Orthuber et al.: "A Solid-State Image Intensifier," Journal of the Optical Society of America, vol. 44, No. 4, pp. 297-299, April 1954.

Quarterly Review No. 3, Fellowship on Computer components #347, Mellon Institute of Industrial Research, pp. VI-9, VI-10, Figs. VI-4, VI-5. Date 1951.