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ELECTRO-OPTICAL SYSTEM
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2,785,316

FIG. 1

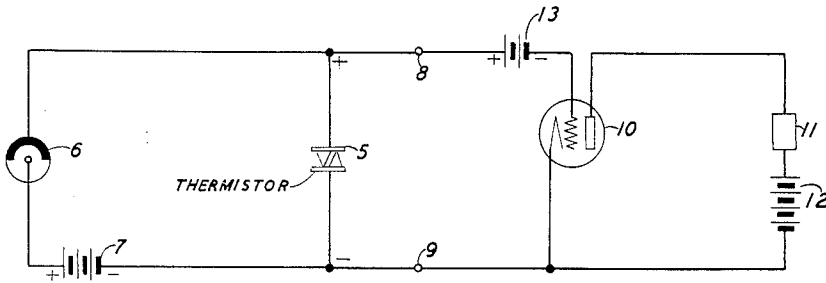


FIG. 2

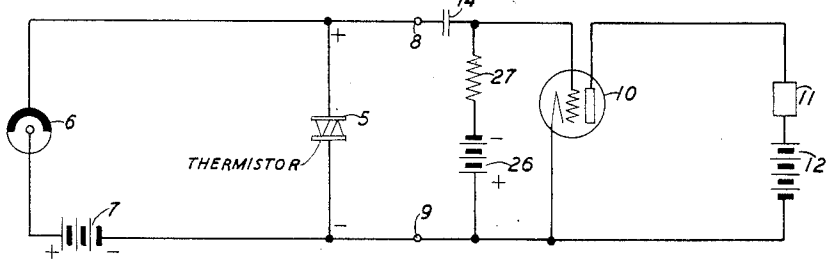


FIG. 3

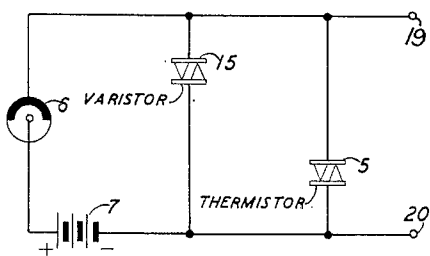


FIG. 4

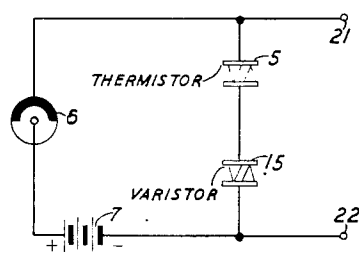
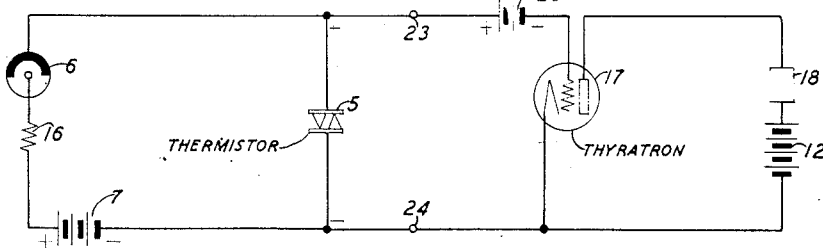


FIG. 5



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ELECTRO-OPTICAL SYSTEM

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This invention relates to electro-optical systems and more particularly to electro-optical systems having non-linear response characteristics.

An object of the invention is to provide an improved electro-optical system in which the response to a given illumination changes with time.

Another object of the invention is to provide an electro-optical system making use of a thermistor to modify the response to light.

In an example of practice of the invention a photoelectric cell, a self-heating thermistor and a source of direct current are connected in a closed series circuit, the voltage drop across the thermistor being amplified in a vacuum tube amplifier for energizing a load device such as an electric heater. A suitable self heating thermistor is disclosed in G. L. Pearson Patent 2,276,864, issued March 17, 1942. Such a thermistor at low values of current therethrough corresponding to low illumination acts substantially like a fixed resistance. At higher values of current corresponding to higher values of illumination the resistance decreases as the illumination increases. However, if the illumination is changed rapidly from any given value in this higher range of values the thermistor acts substantially like a fixed resistance corresponding to its resistance at said given value of illumination. This arrangement may be used to differentiate between light impulses incident on the photoelectric cell at high and low frequencies, the response to low frequency impulses being lower than to high frequency impulses of the same intensity. This arrangement may also be used to produce peaked electrical impulses from square-topped light impulses.

By using thermistors and quick acting varistors in various combinations other response characteristics may be obtained.

A thermistor, as the term is used in this application, refers to a resistive device made from conductive or resistive materials which exhibit a large change of resistance for a small change in temperature. Such materials have conductivities lying between the conductive values normally associated with conductors and insulators. Thermistors may have either a positive or negative temperature coefficient of resistance.

A varistor, as the term is used in this application, refers to a variable resistance device which may assume a variety of forms. It is always a conductive or semiconductive device, never an electron emissive device. A thermistor is a specific form of varistor. Other forms of varistors suitable for use with thermistors in certain embodiments of this invention, their compositions and method of manufacture are described in McEachron Patent 1,822,742, issued September 8, 1931. This form of varistor is of the compressed and fired silicon carbide and clay type and, so far as can be determined, exhibits a variable resistance instantly responsive to current changes so that the resistance decreases as the current

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increases above some predetermined minimum value below which the resistance remains substantially constant.

This invention will now be described in more detail having reference to the accompanying drawing.

Fig. 1 is a schematic circuit of an embodiment of the invention including a thermistor direct coupled to a vacuum tube amplifier;

Fig. 2 is a schematic circuit of a modified embodiment of the invention including a thermistor condenser coupled to a vacuum tube amplifier;

Fig. 3 is a schematic circuit of an embodiment of the invention in which a thermistor and varistor are connected in parallel;

Fig. 4 is a schematic circuit of a modified embodiment of the invention in which a thermistor and a varistor are connected in series; and

Fig. 5 is a schematic circuit of an embodiment of the invention in which a thermistor is direct coupled to a thyatron and a protective resistance is connected in series with the photoelectric cell.

The same reference characters are used to indicate identical elements in the several figures of the drawing.

In the embodiment of the invention illustrated in Fig. 1 a thermistor 5 is connected in series with a photoelectric cell 6 and a source of direct current such as battery 7. To the terminals 8 and 9 of the thermistor 5 is connected the input circuit of a vacuum tube amplifier 10. The grid of amplifier 10 is connected through biasing battery 13 to terminal 8 and the cathode of amplifier 10 is connected to terminal 9. A load device 11 in series with a source of direct current such as battery 12 is connected to the anode and cathode of amplifier 10.

The thermistor 5 is of the kind disclosed in Pearson Patent 2,276,864, supra. For small values of current flowing through the thermistor 5, as when the illumination of photoelectric cell 6 is low, the resistance of the thermistor is practically constant. Over this range of current or illumination the voltage between terminals 8 and 9 is practically proportional to the illumination. For higher values of current flowing through the thermistor 5, as when the illumination is increased, the resistance of the thermistor decreases providing the illumination changes slowly enough so that the steady value of resistance may be reached for each value of illumination. Under these conditions the voltage across terminals 8 and 9 is no longer proportional to the illumination and the sensitivity may be said to be reduced as the illumination increases. The characteristic of the thermistor 5 in this range of illumination may be such that for equal percentage changes in illumination equal changes in voltage across terminals 8 and 9 occur. However, if the changes in illumination occur rapidly the resistance of the thermistor 5 even at the higher values of illumination can not change so that the thermistor acts like a fixed resistance. For rapid changes of illumination the sensitivity remains substantially constant and the voltage across terminals 8 and 9 changes in proportion to the changes in illumination.

The arrangement of Fig. 1 has several advantageous characteristics. With an amplifier 10 of limited input voltage range a much larger range of illumination values may be utilized without overloading the amplifier providing that the changes in the illumination occur slowly. If the changes occur rapidly a larger response is obtained in the load device 11. Because of this characteristic a square topped light impulse may be converted into a peaked electric impulse, the peak corresponding to the front side of the light impulse. This is due to the fact that the resistance of a thermistor is reduced with time

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for any given current value. Consequently, the voltages across terminals 8 and 9 for any given value of illumination is reduced with time measured from the instant when the illumination starts or is increased suddenly. Furthermore if the photoelectric cell 6 is illuminated intermittently, for example for signaling purposes, the higher the frequency of interruption the greater will be the current in the load device 11 for any given peak value of illumination. Thus high frequency light impulses may be distinguished from low frequency impulses on an amplitude discrimination basis.

The arrangement of Fig. 2 is much like that of Fig. 1 but the amplifier 10 is condenser coupled to the terminals 8 and 9. A condenser 14 is connected between the grid of amplifier 10 and the terminal 8. A negative biasing battery 26 connected in series with a grid leak resistance 27 is connected between the grid and cathode of amplifier 10. In this arrangement only the alternating current components of the voltage across the thermistor 5 are impressed on the grid and cathode of amplifier 10. For any given amplifier larger variations in illumination may be utilized without overloading the amplifier. In this arrangement also square-topped light impulses may be converted into peaked current impulses and rapid impulses of light on the photoelectric cell may be distinguished from slower impulses on an amplitude discrimination basis.

In the arrangement of Fig. 3 a varistor 15 is connected in parallel with the thermistor 5 so that the voltage across terminals 19 and 20 is dependent upon the characteristics of both of these devices. The varistor 15 is a quick acting device of the kind disclosed in McEachron Patent 1,822,742, supra. The arrangement of Fig. 3 may be used with the amplifiers 10 of Figs. 1 and 2 by connecting the amplifier to terminals 19 and 20 instead of to terminals 8 and 9. With the arrangement of Fig. 3 square-topped light impulses can be converted into peaked electrical impulses, the peaks being more nearly the same amplitude for a given percentage change in illumination for all values of illumination within the range of illumination within which the varistor resistance varies.

In the arrangement of Fig. 4 the varistor 15 is connected in series with the thermistor 5 so that the voltage across the terminals 21 and 22 is also dependent upon the characteristics of both of these devices, being at any instant the sum of the voltages across the two devices for any given value of current. The arrangement of Fig. 4 may be used with the amplifiers 10 of Figs. 1 and 2 by connecting the amplifiers to terminals 21 and 22 instead of to terminals 8 and 9. The effect of the arrangement of Fig. 4 as a pulse sharpener is intermediate between that of Figs. 1 and 2 and that of Fig. 3.

In the arrangement of Fig. 5 the thermistor 5 is connected in series with the photoelectric cell 6, the source of direct current such as battery 7 and a protective resistance 16. To the terminals 23 and 24 across the thermistor 5 is connected the input circuit of thyatron 17. The control grid of thyatron 17 is connected through negative biasing battery 25 to terminal 23 and the cathode of thyatron 17 is connected to terminal 24. A load device 18 in series with the source of direct current such as battery 12 is connected between the anode and cathode of the thyatron 17. This circuit functions much like that of Fig. 1 except that the device 18 is operated only when the thyatron 17 fires. However, when the thyatron 17 fires the resistance between the cathode and grid becomes very low so that substantially the full voltage of battery 7 would be impressed on photoelectric cell 6 were it not for resistor 16. Resistor 16, therefore, protects the cell 6 when the thyatron fires. If it is desired to use this circuit in such a way that the thyatron is fired repeatedly some arrangement must be provided in the load device 18 or elsewhere to reduce the voltage between the anode and cathode after each firing so as to restore the thyatron to its controllable condition. Simple

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well-known means is a quick acting slow release relay which opens the anode to cathode circuit when the thyatron fires. Another arrangement is to supply the firing current from a charged condenser which is slowly charged after each firing.

Other electro-optical arrangements comprising thermistors come within the purview of this invention.

What is claimed is:

1. An electro-optical system comprising a series arrangement of elements including a light sensitive electric device and a self heating resistive element connected in series with said device, the resistance of said resistive element changing appreciably with temperature, and means connected to said series arrangement, said means being adapted to utilize changes in the voltage developed in one of said elements due to changes in illumination of said light sensitive electric device.

2. An electro-optical system comprising a thermistor, a photoelectric cell and a source of direct current connected in series, and a vacuum tube amplifier having an input circuit connected in shunt of said thermistor.

3. An electro-optical system comprising a thermistor, a photoelectric cell and a source of direct current connected in series, and a vacuum tube amplifier having an input circuit including a series condenser connected in shunt of said thermistor.

4. An electro-optical system comprising a thermistor and a varistor of the quick acting type connected in parallel, a photoelectric cell and a source of direct current connected together in series and to said thermistor and varistor and means to utilize the voltage drop across said thermistor and varistor in parallel.

5. An electro-optical system comprising a thermistor, a varistor, a photoelectric cell and a source of direct current connected in series, one terminal of said thermistor being connected to one terminal of said varistor, and means to utilize the voltage drop across both said thermistor and varistor.

6. An electro-optical system comprising a thermistor, a photoelectric cell, a source of direct current and a resistor connected in series, and a thyatron having an input circuit conductively connected to the terminals of said thermistor, the resistance of said resistor being large enough to protect said photoelectric cell from excessive voltage when said thyatron fires.

7. An electro-optical system comprising a thermistor and a varistor of the quick acting type connected in parallel, a photoelectric cell and a source of direct current connected together in series and to said thermistor and varistor, and a vacuum tube amplifier having an input circuit connected in shunt of said thermistor and varistor in parallel.

8. An electro-optical system comprising a thermistor, a varistor, a photoelectric cell and a source of direct current connected in series, one terminal of said thermistor being connected to one terminal of said varistor, and a vacuum tube amplifier having an input circuit connected in shunt of said thermistor and varistor in series.

9. An electro-optical system comprising a thermistor and a varistor of the quick acting type connected in parallel, a photoelectric cell and a source of direct current connected together in series and to said thermistor and varistor, and a vacuum tube amplifier having an input circuit including a series condenser connected across said thermistor and varistor in parallel.

10. An electro-optical system comprising a thermistor, a varistor, a photoelectric cell and a source of direct current connected in series, one terminal of said thermistor being connected to one terminal of said varistor, and a vacuum tube having an input circuit including a series condenser connected across both said thermistor and varistor.

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