Sept. 15, 1959 W. C. WHITE 2,904,695

PHOTOELECTRIC APPARATUS

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Fig. 1

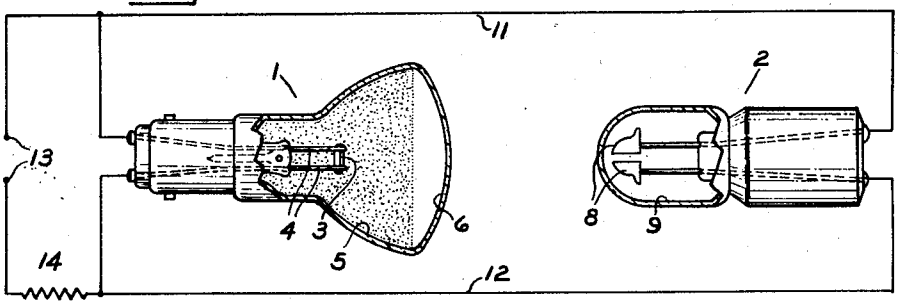


Fig. 2

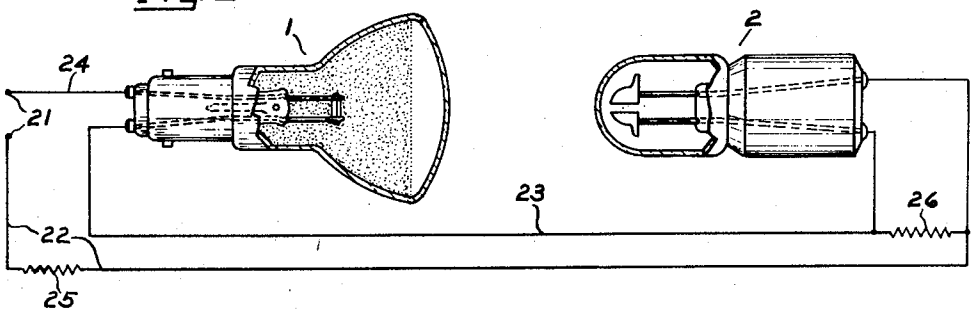


Fig. 3

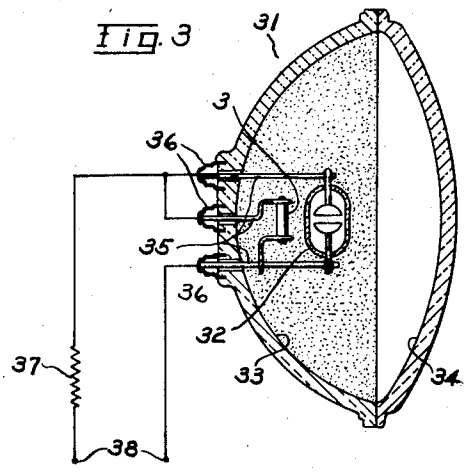
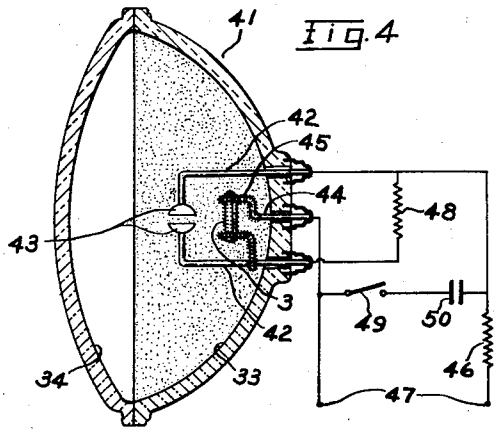


Fig. 4



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2,904,695

PHOTOELECTRIC APPARATUS

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Application December 11, 1952, Serial No. 325,278

2 Claims. (Cl. 250—206)

This invention relates in general to photoelectric apparatus, and more particularly to combinations of photo-conductive elements with electric lamps to constitute photoelectric control or translation devices.

Photoelectric cells can generally be classified, according to type, as photo-voltaic, wherein a voltage is actually generated upon exposure to light, as photo-emissive, wherein electron emission varies in accordance with the incident light, and as photo-conductive, wherein the conductance of the cell varies in accordance with the incident light. The invention is more particularly concerned with the photo-conductive type of cell generally comprising photo-sensitive semi-conductors which, in the absence of light, may be virtual insulators but which become electrically conductive in the presence of light rays such as rays in the visible light spectrum and adjacent infra-red and ultra-violet regions. An excellent photo-conductive element of this type is a cadmium sulfide crystal substantially free from lattice distortion, as described in the copending application Ser. No. 190,801, filed October 16, 1950, of John Edward Jacobs, now Patent No. 2,706,790, entitled X-Ray Detection and assigned to the same assignee as the present invention.

An object of the present invention is to provide novel photoelectric translation and control apparatus.

Another object is to provide photoelectric control and translation apparatus of marked simplicity and comprising as principal elements a photo-conductive element and an electric lamp.

Yet another object of the invention is to provide photoelectric control and translation devices enclosed within sealed vitreous envelopes in unit constructions.

In accordance with the invention, a photo-conductive element such as a cadmium sulfide crystal and an electric lamp such as a neon glow lamp, are paired and arranged for mutual control. This is effected by physically arranging the photo-conductive element so as to be irradiated by the lamp, and by connecting both the element and the lamp in a common electrical circuit so as to achieve electrical reaction of the one upon the other. For instance, when a photo-conductive cell and a neon glow lamp having comparable voltage and current characteristics are so arranged and connected in a parallel circuit, a low frequency flashing of the lamp may be achieved, thus providing in effect an extremely simple form of flasher. If the cell and the lamp are connected in series, a photoelectric relay of a lock-in type results and which is extremely simple of construction. In accordance with other features of the invention, a combination of a photo-conductive element and a lamp may be sealed into a vitreous envelope, forming a unit structure having the advantages of simplicity, ruggedness and low cost.

The foregoing objects and other advantages and features of the invention will become apparent from the following description and accompanying drawings. The features of the invention believed to be novel will be more particularly pointed out in the appended claims.

In the drawing:

Fig. 1 shows a photo-conductive cell and a discharge lamp physically arranged for interaction and electrically connected in the basic parallel combination of the invention.

Fig. 2 illustrates diagrammatically the corresponding series combination.

Fig. 3 is a cross-sectional view of a sealed photoelectric unit connected in an arrangement corresponding to that of Fig. 1, the circuit connections being diagrammatically illustrated.

Fig. 4 shows a modification of the unit of Fig. 3 and connected in a modified series combination.

Referring to Fig. 1, a photo-conductive cell **1** and an electric discharge lamp **2** are physically disposed to achieve irradiation of the photo-cell by the lamp. The photo-cell, as illustrated, is similar to one described in copending application Ser. No. 312,761 of George E. Inman, filed October 2, 1952, entitled Photoelectric Device, now Patent No. 2,740,875, and assigned to the same assignee as the present invention. It comprises a cadmium sulfide crystal **3** which is supported on lead wires **4** at the focal point of a silvered reflector type bulb **5** having a clear end face **6**. As described in the Inman application, the crystal may be supported by pointing its ends and enclosing them in loops formed on the ends of the lead wires, the junctures being coated with a suitable binder such as formed by the application of a colloidal suspension of carbon in alcohol. If desired the current rating of the photo cell may be increased by filling the envelope **5** with a gas of high thermal conductivity such as helium to augment the heat dissipating capacity of the crystal. The photo-cell may conduct a current of the order of a few milliamperes with the application of 100 volts across it when irradiated, the current being substantially nil under dark conditions.

The electric lamp **2** is preferably a discharge lamp having a striking voltage higher than its operating voltage. A suitable lamp is a standard neon glow lamp of ¼ watt rating comprising a pair of electrodes **8** sealed within a glass bulb **9** containing neon gas at a pressure of a few millimeters. The spectral distribution of a neon discharge does not correspond with the peak spectral sensitivity of the cadmium sulfide crystal **3**. In order to improve the efficiency of the system, the inside of the bulb **9** of lamp **2** may be coated with a phosphor providing a greenish light, for instance a zinc sulfide phosphor having a spectral emission close to the optimum response wave-length of the cadmium sulfide crystal. The discharge lamp **2** may have a starting or breakdown voltage in the range from 80 to 90 volts (D.C. or peak A.C.) and an operating voltage drop of 50 to 60 volts with a current of a few milliamperes.

The photo-cell **1** and the lamp **2** are connected in parallel across a pair of conductors **11**, **12** which lead to a pair of input terminals **13**, one of the conductors, **12** in the drawing, being in series with a resistor **14**. The voltage applied across terminals **13** must be higher than the striking or breakdown potential of lamp **2**, and resistance **14** must have a value at least high enough to regulate the current through the lamp. For instance, the voltage at terminals **13** may be the usual 115 to 120

volts A.C. commercial supply providing a peak voltage of approximately 165 volts, and resistance 14 may have a value of the order of ¼ megohm. Under these conditions, if the crystal is sufficiently illuminated from some outside source, for instance by daylight illumination, it by-passes such a large proportion of current that the voltage remaining after the voltage drop across resistance 14 is insufficient to strike glow lamp 2. If, however, the crystal is in darkness, then lamp 2 immediately lights up but the radiation therefrom at once actuates the cadmium sulfide crystal of photocell 1 which in turn short-circuits lamp 2. Thus a relaxation circuit type of oscillation is set up. This oscillation will cease, of course, if enough additional steady light reaches the photo-cell. The repetition or flashing frequency is quite low, generally a few cycles per second and is due in general to the inherent sluggish recovery of the cadmium sulfide crystal after its exposure to light. The frequency can be varied by changing the magnitude of the voltage applied at terminals 13 and the size of resistor 14. The range of repetition of frequency may also be extended in the usual fashion by connecting additional impedances in the circuit such as a resistor in parallel with discharge lamp 2.

Referring to Fig. 2, the same photo-conductive device 1 and electric discharge lamp 2 are connected in a series circuit across input terminals 21 by means of conductors 22, 23 and 24. A resistor 25, which may have a value of approximately ¼ megohm, is connected into conductor 22 so as to be in series with the photo-cell and the lamp across terminals 21, and another resistor 26 which may have a value of a few megohms is shunted across lamp 2. This combination may be termed a lock-in circuit; the circuit is static in the dark because insufficient current is passed by the photo-cell to operate the lamp. If, however, the photo-cell is illuminated, even for an instant, its conductivity increases and it passes enough current to strike lamp 2 which thereafter illuminates the photo-cell whose conductivity is thereby maintained at a high level. The purpose of the resistor 26 shunting the lamp is to prevent the leakage current through the photo-cell under dark conditions, from striking the lamp and causing a weak glow.

Referring to Fig. 3 there is shown a sealed structure 31 including mounted therein a cadmium sulfide photoconductive crystal 3 and an electric discharge lamp such as a double-ended neon glow tube 32. As illustrated, the sealed unit is formed of a vitreous envelope of a type similar to the sealed beam reflector lamps in use for automobile headlights, and consisting of a rear paraboloidal internally silvered reflector 33 and a front lens 34. The cadmium sulfide crystal 3 is preferably mounted substantially at the focal point of the reflector, being supported on lead wires 35 welded into the usual thimble type seals 36. Three seals are used, one being common to one side of the crystal and to one side of the lamp: this arrangement makes it possible to connect the crystal and the lamp in parallel or in series as desired. In order to provide for efficient cooling of the crystal, a gas of high thermal conductivity such as helium may be sealed within the envelope formed by reflector 33 and lens 34.

In Fig. 3, the unit 31 is shown with the elements connected in a parallel combination, which combination is connected in series with a resistor 37 across terminals 38. This arrangement corresponds to that illustrated in Fig. 1 and will flash in a similar fashion. The neon lamp 32 may, if desired, also be mounted reasonably close to the focus of the reflector whereby the device 31 may serve as a directional flasher. It will also be appreciated of course that device 31 may be connected in a series combination corresponding to that of Fig. 2.

In Fig. 4, the unit 41 comprises a vitreous envelope similar to that of Fig. 3 and including a silvered reflector 33 and front lens 34. However in order to achieve a more economical construction, instead of including a sealed neon lamp within the unit, a pair of longer lead wires 42 are provided having bent inner end portions which support electrodes 43 in close proximity to each other. The vitreous envelope 41 is then filled with a suitable ionizable medium such as neon or a mixture of neon and argon at a low pressure. The cadmium sulfide crystal 3 is connected across one of the leads 42 and an intermediate lead 44. In order to prevent a glow discharge from occurring directly from one of the lead wires or electrodes to the crystal, a protective insulating sheath may be provided such as an insulating dielectric coating 45, shown as a fine speckling in the drawing, covering the crystal and the adjacent portions of the lead or support wires.

The unit 41 of Fig. 4 may be connected in a parallel combination corresponding to the arrangement of Fig. 1, or in a series combination corresponding to the arrangement of Fig. 2. As illustrated, the unit is connected in a series circuit including a resistor 46, across terminals 47. The resistor 48 connected in parallel with the electrodes 43 prevent any glow across the electrodes under dark conditions due to leakage current through the crystal 3. It will be appreciated, that as so far described and with switch 49, which may be used to connect a capacitor 50 in shunt with the series combination of electrodes 43 and crystal 3, left open, the arrangement of Fig. 4 corresponds in general to that of Fig. 2 and will remain static under dark conditions until illuminated by light from some extraneous source. If, however, the photoelectric crystal is illuminated even momentarily, it will pass current and a glow discharge will occur across electrodes 43, in turn illuminating the crystal and so maintaining its conductivity.

If however switch 49 is closed so as to connect capacitor 50 into the circuit, and on the condition that a direct current source of voltage is connected across terminals 47, the operation is modified and the electrodes 43 provide one flash of light which discharges capacitor 50 and then extinguishes itself. Thereafter the capacitor recharges slowly from the voltage source through resistance 46 and the unit may be flashed again by temporarily illuminating it from some outside source. Thus, the unit of Fig. 4 as connected and with switch 49 closed, operates as a slave flasher which will respond with a single flash of light each time it is momentarily illuminated but which will otherwise remain extinguished. It will be appreciated that under these conditions, if the flasher unit of Fig. 3 is arranged to illuminate the unit of Fig. 4 the latter will respond with a single flash of light for every flash of the former.

While certain specific embodiments of the invention have been shown and described, it will, of course, be appreciated that various modifications may be made without departing from the invention. The specific form and configuration of the crystal and of the lamp which have been described, and of the bulb into which they are sealed, are to be considered as illustrative only and not as limitative examples. The appended claims are accordingly intended to cover any such modifications coming within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A photoelectric device comprising a sealed vitreous container having a reflecting surface, lead wires projecting into said container, and a photo-conductive crystal element and electric discharge means supported within said container on said lead wires, said photo-conductive element being supported substantially at the focal point of said reflecting surface, and being responsive to radiation produced by said discharge means.

2. A photoelectric device comprising a sealed vitreous container having a reflecting surface, lead wires projecting into said container a pair of electrodes and a

photo-conductive crystal element supported on said lead wires near the focal point of said reflecting surface, an ionizable gaseous filling within said container, a protective sheath around said photo-conductive element insulating it from said ionizable filling, said photo-conductive element being responsive to radiation produced by a discharge between said electrodes.

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