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PHOTO-SENSITIVE TUBE

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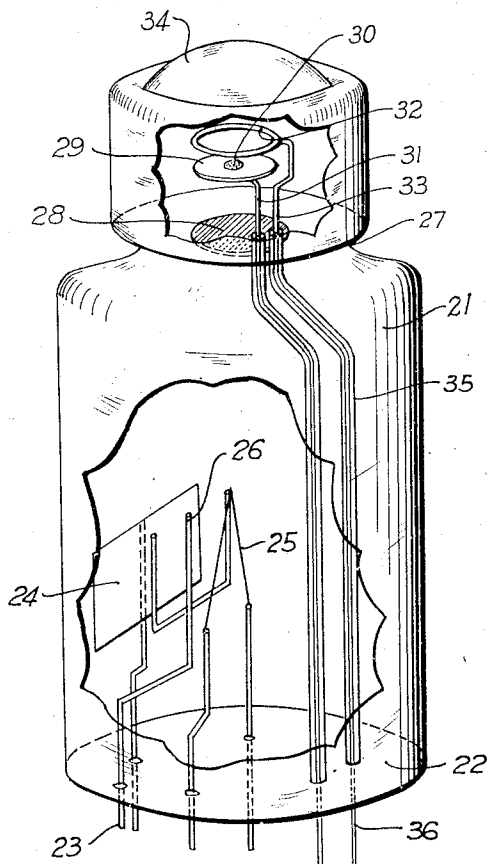


Fig. 2

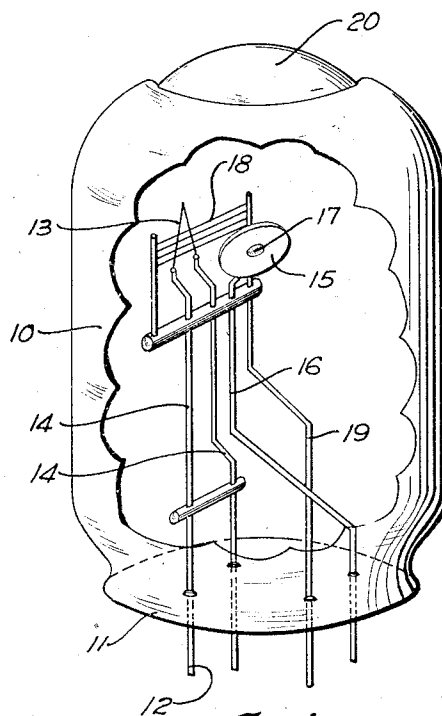


Fig. 1

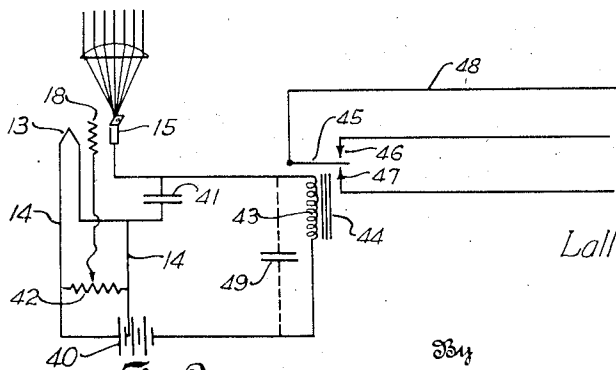


Fig. 3

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334

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PHOTOSENSITIVE TUBE

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8 Claims. (Cl. 250—41.5)

This invention relates to new and useful improvements in photo-sensitive tubes, and in particular to that class of tubes which may be designated as photo-sensitive relaxation oscillators.

One object of this invention is to provide an improved photo-sensitive tube in which a source of light is utilized to break a series of oscillations and thereby control or actuate by means of relays or other suitable equipment, certain instruments or devices which it is desired to operate in accordance with varying light conditions.

It is another object of this invention to provide an improved photo-sensitive tube wherein light rays are directed onto a photosensitive surface so as to cause the surface and the space between it and the filament to become blanketed or clouded with photoelectrons emitted from the surface due to the impinging of the light rays, whereby an oscillating discharge between the surface and any other element in the tube is prevented and current ceases to flow to the tube.

Still another object of this invention is to provide an improved photo-sensitive tube wherein the photo-sensitive surface is separated from the balance of the tube, so that photo-sensitive material may be placed thereupon by sputtering or in any other suitable manner, without depositing a photo-sensitive material upon the balance of the elements in the tube. The separation is not primarily for control of the photo-sensitive material as some previous similar devices have been but is put in this form so that various gas fillings, or a vacuum, may be used irrespective of the condition prevailing in the oscillating triode. This aids both in use and in manufacture, and, further, it permits a flexibility of use with auxiliary circuits.

Still another object of the invention is to provide a photo-sensitive tube with an extremely high control ratio and at the same time capable of supplying relatively large currents at low voltages for actuation of relays, and which is operable on either A. C. or D. C. current, and which is especially serviceable in the range below twenty volts.

Yet another object of the invention is to provide an improved photo-sensitive tube having means for concentrating light from an exterior source onto a photo-sensitive surface whereby the photo-sensitive surface is utilized at a level of illumination at which its activity is relatively high, and whereby the tube is rendered fairly sensitive to sources of light which would produce only a slight, non-linear effect on the usual photo-sensitive tube.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawing, in which an example of the invention is shown, and wherein:

Figure 1 is an isometric view, partially broken away, of a tube constructed in accordance with this invention.

Figure 2 is a similar view of a modification of the invention, and

Figure 3 is a view of a sample wiring diagram.

In the drawing, the numeral 10 designates the gas-filled shell or envelope of the tube, the envelope being formed of glass or some other suitable material. Mercury vapor or any other suitable gas may be utilized to fill the tube, it being desirable to use a gas having an ignition voltage characteristic within the range in which it is desired to operate the tube. If desired, the envelope may be masked upon the inside or outside with some suitable type of opaque and/or conducting coating (not shown), said coating, in some instances, improving certain desirable operating characteristics of the tube.

The envelope 10 is provided with the usual base 11 through which the usual connection prongs 12 extend. The tube is provided in its interior with a filament 13 connected by suitable leads 14 to a pair of the prongs 12. Also, a plate 15 is disposed in the tube in relatively close proximity to the filament 13, and is connected by a lead 16 to another of the prongs 12. The plate 15 is substantially disk-shaped in form and is disposed at an angle to the longitudinal axis of the tube. It is to be noted, of course, that the plate 15 may be of any desirable shape or size. A small spot of photo-sensitive material 17 is disposed in the center of the plate 15. This photo-sensitive material may be of any material which emits electrons under the action of light, such as caesium or other alkaline earth material capable of producing photoelectrons under the influence of light.

A grid 18 is disposed between the filament 13 and the plate 15, and is connected by a lead 19 to the fourth prong 12. A convex lens 20 is mounted in the upper end of the envelope 10 so as to have its optical axis in alignment with the longitudinal axis of the tube. The lens 20 is of such radius of curvature, and is so spaced from the photo-sensitive spot 17, as to have the principal focus of the lens coincide with the loca-

tion of the spot 17. Thus, light falling upon the lens 20 is concentrated from the entire surface of the lens into an intense spot of light which falls upon the photo-sensitive spot 17.

In operation, the filament 13 is heated through the leads 14 to a temperature sufficient to produce an ample supply of electrons by thermal emission, and a voltage is placed between the leads 14 and 16, and thus between the filament 13 and plate 15. The leads 14 and 16 are also shunted exteriorly of the tube through a suitable condenser (not shown), so that an intermittent discharge or oscillating discharge takes place between the filament and the plate, the plate of course carrying the positive charge. The charge on the condenser builds up from the source of voltage until the charge reaches the break-down or ignition voltage of the tube, at which time the condenser discharges through the gap between the filament and the plate. After the voltage has dropped to the point of extinction of the arc between filament and plate, this discharge will be broken and the condenser will commence to charge again until an ignition voltage is reached. Thus, an oscillating discharge is instituted within the tube.

The rapidity or frequency of this discharge is determined by the particular design of the tube and will depend upon the voltage applied and upon the resistance and capacitance of the various leads both within the tube and the associated circuit and equipment (not shown). The grid 18 serves as a control, and any desirable voltage may be placed thereupon so as to increase or decrease the break-down or ignition voltage of the tube.

It is pointed out that the oscillating discharge takes place only when the tube is not exteriorly illuminated and that the light given off by the discharge and by the filament 13 is not of sufficient intensity as to block operation of the tube by affecting the photo-sensitive spot 17. This light is sufficient, however, to raise the point of arc extinction almost to the point of the break-down voltage so that the arc is extinguished rather quickly as the voltage between the plate and the filament begins to drop. However, as light impinges upon the tube along its longitudinal axis, it is concentrated by the lens 20 into an intense spot upon the photo-sensitive substance 17, thereby causing said substance to commence the emission of electrons.

The plate 15 during arcing is positive in charge and the electrons emitted are negative in charge. Thus, during the dark portion of the oscillation cycle, the electrons are not discharged by the positive charge of the plate, but form a blanket around the plate and greatly increase the ignition voltage of the tube, since a much higher voltage is required to cause an arc between the filament and the plate while the cloud of electrons is present. The action of these negative electrons is similar to the action of the negative potential of the grid 18 in that said electrons increase the break-down potential of the tube. Since the grid is adjusted to such a value that the periodic break-down is barely being maintained, the action of light increases the break-down potential to such a value that said periodic break-down cannot occur and the current flowing to the plate 15 is small or is substantially shut off. In this manner the tube acts as an electric valve to allow current to flow while in the absence of exterior light, but to shut off the current in the presence of exterior light.

It is manifest, that the lens 20, by concentrating the available light into an intense spot, causes the tube to be sensitive and to operate at a much lower light intensity than possible with other photo-sensitive tubes.

In Figure 2, there is shown a modification of the invention, in which the photo-sensitive surface is placed in a separate compartment from the balance of the tube elements. The tube shown in Figure 2 is provided with the usual envelope 21, having a base 22 with prongs 23 projecting therethrough. A plate 24, a filament 25 and a grid 26 are mounted within the envelope 21 and connected by suitable leads to certain of the prongs 23.

The envelope 21 is formed with a stricture 27 near its upper end and a suitable insulating member 28 is positioned at the stricture 27 so as to separate the envelope into a lower and upper compartment, the lower compartment being occupied by the plate, filament and grid.

A second plate 29, having a spot of photo-sensitive material 30 at its center, is mounted in the upper compartment, and is connected to a suitable lead 31. A ring electrode 32 is positioned above the plate 29 and connected to a suitable lead 33, while a convex lens 34 is mounted or integrally molded in the upper end of the envelope 21 above the plate 29 and electrode 32. The leads 31 and 33 extend downwardly through the lower compartment of the envelope, being insulated with glass tubing 35 or some similar substance, and having their lower ends connected to prongs 36, which project from the lower end of the tube.

The provision of the separate upper compartment to contain the photo-sensitive surface, allows the photo-sensitive substance to be sputtered thereupon without the possibility of some of the material depositing upon other elements in the tube such as the plate or grid, or upon the leads thereof. Thus, when light strikes the tube only the desired spot becomes photo-sensitive and emits electrons. If there were any chance deposits of the photo-sensitive material upon other elements of the tube, they might emit electrons so as to affect the sensitivity or other operating characteristics of the tube, or render the tube inoperative. Also, the separate compartments allow the use of different gases and/or pressures in the two chambers so that varied operating characteristics may be obtained.

The operation of this modified form of the invention is substantially the same as that of the form shown in Figure 1, with the exception that the electrode 32 is suitably connected to the grid 26 so as to place a negative charge upon the grid when light strikes the photo-sensitive spot 30, whereby the ignition voltage of the tube is increased over that voltage available between the plate 24 and the filament 25.

These tubes may be utilized in various fashions. An instance of such an use would be to connect a relay in circuit with the plate 15 and the filament 13 as shown in Figure 3 of the drawing.

In Figure 3, the tube shown in Figure 1 is utilized. The leads 14 are connected across a portion of a battery 40, while the filament 13 and the plate 15 are connected across the entirety of the battery. A condenser 41 is shunted across the leads of the filament and the plate, while the grid 18 is connected to a rheostat or variable resistance 42 shunted across the leads 14. The connection between the battery 40 and the plate 15 extends through the coil 43 of a relay 44, which has the usual spring-mounted armature

45 adapted to contact leads 46 and 47 in an open and a closed position, respectively. A wire 48 is connected to the armature to complete the circuit. The relay 44 may be of the slow-opening type provided with a shading slug (not shown), or a condenser 49 may be shunted across the coil 43, as shown in dotted lines, to cause the relay to remain closed an instant after the circuit through the coil has been broken.

In the absence of exterior light, the condenser 41 charges from the battery 40, until the breakdown voltage of the tube is reached, at which time the tube arcs or discharges and the voltage drops to the point of extinction, after which the condenser 41 again charges, etc. The filament 13 is heated from a portion of the battery so as to emit electrons and make possible the arcing or discharge of the tube. Thus the condenser 41 causes the tube to oscillate or operate intermittently, so that the arc may be broken when desired. Other means than the condenser may be utilized for such purposes.

The potential of the grid may be adjusted by means of the variable resistance 42 so as to set the break-down voltage and other operating characteristics of the tube.

The relay may be of any desirable type and thus may operate in many different fashions. Current flows through the coil of the relay when the tube is not exposed to exterior light. However, in the presence of light the current is stopped and the armature of the relay moves to an open position, to open or close contacts as the case may be. This operation is in accordance with the description given hereinbefore.

The tube may be used in many other applications, and under many varying conditions.

What I claim and desire to secure by Letters Patent is:

1. A light responsive system including, an envelope, a plurality of electrodes in the envelope, one of said electrodes having a photo-sensitive area, a source of electrical potential connected between the latter electrode and another electrode so as to cause under normal conditions a stream of electrically-charged particles to flow between the two electrodes, a condenser connected across said two electrodes for applying the electrical potential intermittently thereto, whereby an intermittent current flows between said two electrodes, and means embraced by said envelope for directing light upon the photo-sensitive electrode so as to raise the discharge potential of the system and substantially stop the flow of electrically-charged particles in said system.

2. A light responsive system including, a gas-filled envelope, a filament in the envelope, a circular plate disposed at an angle and bearing a photo-sensitive area in the envelope, a grid in juxtaposition to the filament and plate, leads from the various electrodes, a lens mounted in the envelope so as to converge a beam of light from an exterior source onto the photo-sensitive area of the plate, means connected across the filament and plate for heating the filament, means for placing a potential between the filament and the plate, means connected to the grid for applying a variable control potential to the grid, and a condenser connected across the plate and filament leads for intermitting the potential thereacross so as to cause an intermittent discharge of the system, the photo-sensitive area acting under exterior light to block the discharge and shut off the current flowing through the system.

3. A light responsive system including, an envelope having a plurality of gas-filled separate compartments, a photo-sensitive plate in one compartment, a ring electrode adjacent said plate, a plate, a filament and a grid in another compartment, all of the electrodes having leads, a lens supported by the envelope for concentrating light from an exterior source onto the photo-sensitive plate, and a condenser connected across the plate and ring electrode for intermitting a potential across the photo-sensitive plate and the ring electrode to cause an intermittent discharge of the system, the photo-sensitive plate acting under the influence of exterior light to raise the discharge potential of the system above that supplied by means of the condenser and thus shut off the intermittent discharge of the system and thereby control a discharge between the plate and the filament in the second compartment.

4. A light responsive system including, an envelope, a plurality of electrodes in the envelope, one of the electrodes having photo-sensitive means associated therewith, a source of electrical potential connected between two of said electrodes to cause under normal conditions a stream of electrically-charged particles to flow between the two electrodes, a condenser connected across the two electrodes for applying the electrical potential intermittently to the electrodes to permit an intermittent current flow therebetween, and means for directing light upon the photo-sensitive means to raise the discharge potential of the system and substantially stop the flow of said electrically-charged particles.

5. A light responsive system including, an envelope divided into a plurality of chambers, a plurality of electrodes in two of the chambers, photo-sensitive means within one of the chambers, a source of electric potential connected between two of the electrodes in each chamber for causing a flow of electrically-charged particles between said two electrodes, and a condenser connected across said two electrodes for applying the electrical potential intermittently to the electrodes so as to cause an intermittent discharge of the system, the photo-sensitive means acting under the influence of exterior light to raise the discharge potential of the system above that applied by the intermittent means and thereby shut off the intermittent discharge of said system by controlling the discharge between the electrodes in the other chamber.

6. A light responsive system including, an envelope, a plurality of electrodes in the envelope, a source of electrical potential connected between two of the electrodes for causing a stream of electrically-charged particles to flow between said two electrodes, a condenser connected across said two electrodes for applying the electrical potential intermittently to the electrodes so that an intermittent current flows therebetween, and photo-sensitive means within said envelope and acting under the influence of exterior light to raise the discharge potential of the system and substantially stop the flow of electrically-charged particles.

7. A light responsive system including, a gas filled envelope, a filament in the envelope, a plate in said envelope, the plate having a photo-sensitive area, a grid in juxtaposition to the filament and plate, leads from said filament, plate and grid, means connected across the filament and plate for heating the filament, means connected across the filament and plate for applying a potential between said filament and plate, means

connected to the grid for applying a variable control potential to the grid, and a condenser connected across the leads of the plate and filament for intermitting the potential therebetween so as to cause an intermittent discharge of the system, the photo-sensitive area acting under the influence of exterior light to raise the discharge potential of the system so as to block the discharge

and thereby substantially stop the current flowing through the system.

8. A light responsive system as set forth in claim 7 wherein the means for applying a variable control potential to the grid includes a variable resistance.

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