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PHOTOELECTRIC CONTROL

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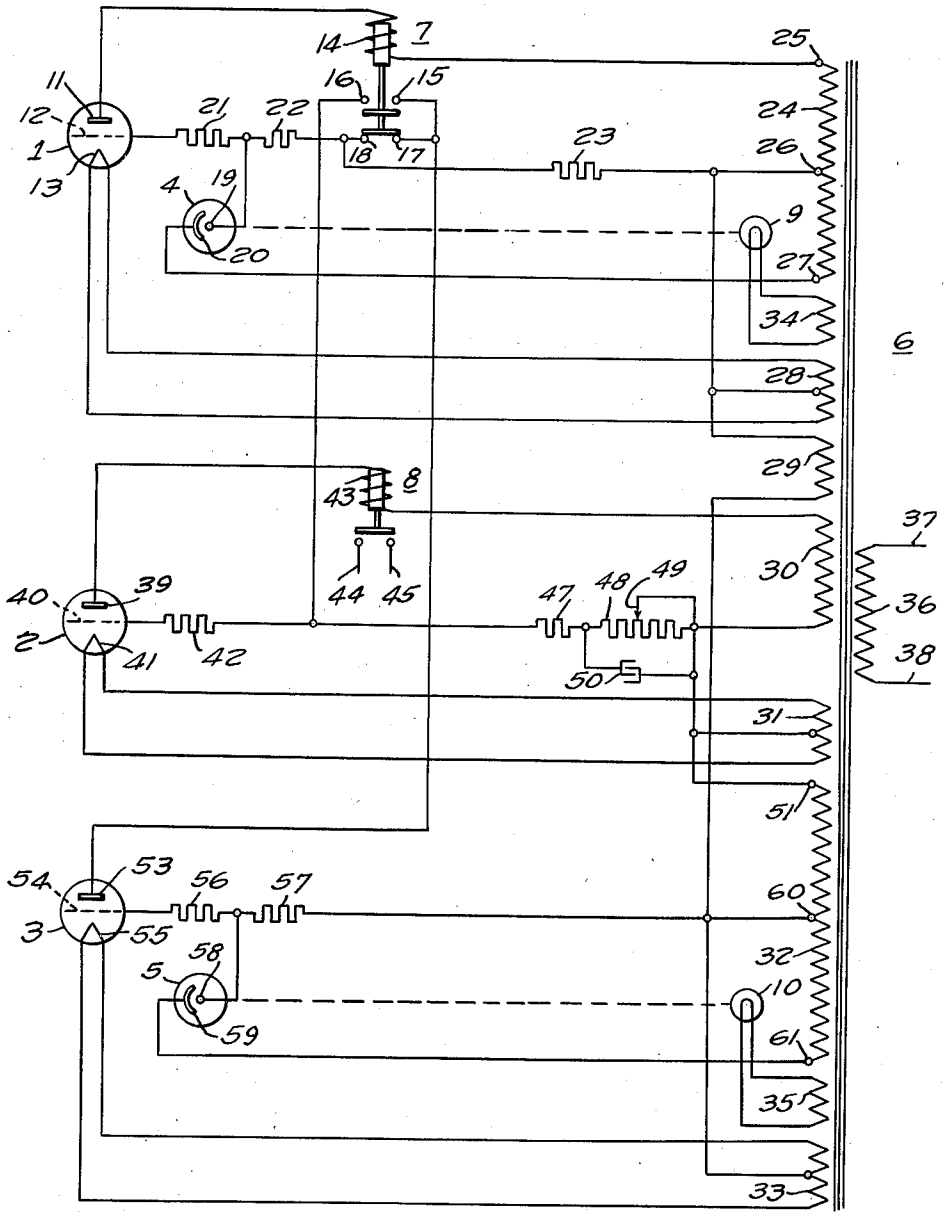

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PHOTOELECTRIC CONTROL

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My invention relates to photo-electric control equipment and, in particular, to arrangements in which a circuit is to be energized in response to the interruption of a pair of light beams in a certain sequence, but to remain deenergized when the same light beams are interrupted in the opposite sequence.

The photo-electric control equipment covered by this disclosure comprises two photo-tubes together with associated amplifying tubes, the purpose of which is to obtain a sequence-operated relay together with a time-delay circuit by which the final relay will be operated if the photo-tubes are darkened in the proper sequence but interlocked in such a way that the final relay will be unaffected if the photo-tubes are darkened in the opposite sequence. Such an arrangement may be used, for example, to open a door when the approach of a person from one direction interrupts a pair of light beams in one order of sequence, whereas the door is not affected by interruption of the light beams in the opposite sequence.

The single figure of the drawing is a schematic diagram of a circuit embodying the principles of my invention.

Referring to the single figure, the apparatus comprises three thyratron tubes 1, 2 and 3; a pair of photo-emissive tubes 4 and 5; relays 7 and 8 operating in the anode circuit of the tubes; a transformer 6 with a multiplicity of windings; exciter lamps 9 and 10; and resistors and capacitor as further described in detail.

Tube 1, photo-emissive cell 4, and transformer 6 cooperate to maintain relay-winding 14 deenergized, and its contacts in the position shown in the drawing, when tube 4 is illuminated, in a manner now to be explained. The cathode 13 of thyratron 1 is excited by winding 28 of transformer 6. The cathode return circuit of this tube is connected to terminal 26 of transformer winding 24. The anode 11 of thyratron 1 is connected to coil 14 of relay 7 and excited by the winding 24 of the transformer 6 connected between terminals 25 and 26. The grid 12 of the thyratron 1 is connected to a current limiting resistor 21 and then to the anode 19 of the photo-emissive cell 4. The cathode 20 of the photo-emissive cell 4 is connected to the transformer winding 24 at terminal 27. The instantaneous polarities of the transformer windings are as noted in the figure, and it is then apparent that the grid 12 of the thyratron 1 is biased negative when the photo-emissive cell 4 is illuminated by an exciter lamp such as 9 connected to transformer winding 34.

On the other hand, when illumination of cell 4 ceases, relay winding 14 is energized to open contacts 17, 18 and close contacts 15, 16 in the following manner. It will be noted that the grid 12 is connected to a resistor 22 and that the grid circuit returns to the cathode through resistor 23 and back to the cathode return terminal 26. Therefore, if the photo-emissive cell 4 is darkened, the current flowing through the resistors 22 and 23 will decrease and the grid 12 will then be biased toward zero. This phenomenon causes a thyratron tube to become conducting between the cathode and anode. Under such conditions, the anode current energizes coil 14 of relay 7, causing the contacts 15 and 16 to close and the contacts 17 and 18 to open.

It will be noted that a somewhat similar circuit to that just described consists of thyratron 3, the photo-emissive cell 5 and the winding 32 of transformer 6. The cathode 55 is excited by winding 33 of the transformer 6 and the cathode returns to terminal 60 of the transformer winding 32. It will be noted that when the relay 7 is energized by the previously described function, the contacts 15 and 16 close to connect the anode 53 of thyratron 3 to resistors 47 and 48, and finally to terminal 51 of transformer winding 32. The grid 54 is connected to a current-limiting resistor 56 and then to anode 58 of the photo-emissive cell 5. The cathode 59 of the photo-emissive cell 5 is connected to terminal 61 of transformer winding 32. The instantaneous polarities of the transformer winding 32 are as indicated in the figure. It is then apparent that when the photo-emissive cell 5 is excited by a lamp such as 10, connected to transformer winding 35, the grid 54 will be biased negative with respect to the cathode 55, thereby preventing the flow of anode current. When the photo-emissive cell 5 is darkened, flow of current through the resistor 57 will decrease, thereby biasing the thyratron grid 54 toward zero and the anode 53 will then allow current to pass through this circuit. Current from the anode 53 flows through contacts 15 and 16 of relay 7 and through the resistors 47 and 48. The circuit is then completed to the winding 32 at terminal 51.

Thyratron 2, relay 8, resistor 48, together with capacitor 50, and transformer winding 30 constitute a circuit which introduces a time-delay in response of a relay 8, controlling the interconnection of the leads 44 and 45 from a load-circuit to changes in the illumination of photo-

cells 4 and 5, the purpose of which will be described below. Cathode 41 of thyratron 2 is excited by transformer winding 31, and the cathode circuit is returned to transformer winding 30 by terminal 51. The grid 40 of the thyratron 2 is connected to a current-limiting resistor 42 and returns to the cathode circuit through the resistors 47 and 48. It is then apparent that when no current is flowing through the resistors 47 and 48, the grid 40 of the thyratron 2 is normally biased at zero, allowing the maximum current to flow in the anode circuit. Therefore, when thyratron 1 conducts no current through relay-winding 14, and the contacts of the latter stand as shown in the drawing, coil 43 of relay 8 is energized by the flow of current from the anode 39, excited by transformer winding 30.

The system here described is intended to maintain the load circuit open at leads 44 and 45 while both photo-emissive cells 4 and 5 are illuminated, and to cause these contacts to close only when the photo-cell 4 is made dark before photo-cell 5 is darkened.

When the thyratrons 1 and 3 are operated, voltage drop occurs across resistors 47 and 48 which is in a direction such as to bias the grid 40 of thyratron 2 in the negative direction. When the grid 40 of thyratron 2 is biased negative, the flow of current through its anode 39 will immediately decrease to zero during the first half cycle of the alternating-current supply 37 and 38, connected to the transformer primary winding 36. Coil 43 of relay 8 is thereby deenergized, allowing contacts 44 and 45 to be immediately closed. These contacts are connected in the load circuit which is to be controlled. The load circuit has thus been closed by darkening cell 4 and cell 5 successively.

It will be noted that a capacitor 50 is connected across the resistor 48 and that this resistor is varied by means of the adjustable contact 49. It is then apparent that capacitor 50 is charged by the voltage drop occurring across the resistor 48 and that the value of voltage to which the capacitor is charged is dependent upon the adjustment of the slider 49.

When, after the above-described cycle of operations, the photo-emissive cell 4 is illuminated but photo-emissive cell 5 remains dark, the grid 12 of the thyratron 1 is biased negative, thereby stopping the flow of current from the anode 11. This then deenergizes the coil 14 of relay 7, immediately opening contacts 15 and 16 and closing contacts 17 and 18. However, when the photo-emissive cell 5 is illuminated, the anode 53 of thyratron 3 will no longer pass current and the flow of current through resistors 47 and 48 immediately stops. Therefore, it is apparent that the flow of current through resistors 47 and 48 is immediately terminated either by illuminating the cell 5 to stop the flow of current through anode 53 or by illuminating cell 4 to deenergize the relay 7. In either case, the flow of current through resistors 47 and 48 is stopped.

The voltage drop across the resistor 47 is immediately decreased by the action just described above, but the capacitor 50 causes the voltage drop across resistor 48 to be maintained. It is, therefore, apparent that the grid 40 of thyratron 2 is kept biased negative because of the voltage occurring across the previously charged capacitor 50. Therefore, the thyratron 2 does not become conducting immediately, but coil 43 of relay 8 remains deenergized for a certain time after the photo-emissive cells 4 and 5 are illuminated. The capacitor 50 discharges through the resistor 48 and the voltage drop across the resistor 48 gradually decreases, allowing the bias on grid 40 of thyratron 2 to return toward zero. The time required for this voltage to decrease sufficiently to allow thyratron 2 to become conducting is dependent upon the value of the resistor 48. The value of this resistance is adjusted by means of the slider 49, and it is then apparent that the time required for this function to take place is readily adjustable by means of the variable resistor 48.

When the bias on grid 40 of thyratron 2 decreases sufficiently to allow the thyratron to become conducting, the coil 43 of relay 8 is again energized and leads 44 and 45 open the circuit to the apparatus being controlled by the photoelectric device.

The above description of operation applies when the photo-emissive cell 4 is darkened previously to darkening the cell 5. This is the sequence in response to which it is intended to cut off current flow in the load by opening leads 44 and 45.

When, on the other hand, the cell 5 is darkened before the cell 4, the following interlocking takes place to prevent operation of the relay 8.

The lower terminal 60 of transformer winding 29 is connected to the cathode return terminal 60 of transformer winding 33 connected to cathode 55 of thyratron 3. Terminal 26 of transformer winding 29 is connected to anode 53 of thyratron 3 through the normally closed contacts 17 and 18 of relay 7 and resistor 23. The instantaneous polarities of the various transformer windings must be as indicated in the figure. It is then apparent that if the photo-emissive cell 5 is darkened, the grid 54 of thyratron 3 will be biased toward zero by resistor 57 and its anode 53 will pass current through contacts 17 and 18 of relay 7, resistor 23 and transformer winding 29.

Resistor 23 is connected in the grid circuit of thyratron 1 between the grid resistor 22 and the cathode return terminal 26. Therefore, when the photo-emissive cell 5 is darkened before the contacts 17 and 18 of relay 7 are opened, the voltage drop occurring across resistor 23 is connected into the grid circuit of thyratron 1, and the instantaneous polarity occurring across the resistor 23 is in the proper direction to bias the grid 12 of thyratron 1 negative and thereby prevent it from conducting current even though the photo-emissive cell 4 is darkened. In this manner, the thyratron 1 is prevented from energizing coil 14 of relay 7 even though both of the photo-emissive cells 4 and 5 have been darkened. Since the contacts 15 and 16 of relay 7 do not close, there can be no flow of current through the resistors 47 and 48, and under the conditions described, the thyratron 2 remains conducting and leads 44 and 45 of relay 8 are not closed.

In this manner, the circuits are interlocked so that operation of relay 8 is prevented when the two cells 4 and 5 are darkened in the reverse sequence.

In addition to darkening the two cells 4 and 5 in the correct sequence, it is also necessary that both of these cells be kept dark for a certain length of time in order to complete the operation of relay 8. If the cell 4 is darkened, relay 7 will be immediately operated by the procedure previously described. However, it has also been

described that the relay 7 will be immediately deenergized when the photo-emissive cell 4 is again sufficiently illuminated. Therefore, if the photo-emissive cell 4 is darkened and again illuminated previously to darkening the cell 5, the contacts 17 and 18 of relay 7 will reclose prior to darkening of the cell 5. As has also been previously described, when the contacts 17 and 18 of relay 7 are closed, the anode 53 of thyratron 3 is connected to the winding 29, and even though the cell 5 is darkened, there can be no flow of current through resistors 47 and 48 to render the thyratron 2 non-conducting. It is then obvious that relay 8 is not operated unless both of the cells 4 and 5 are darkened and in the proper sequence.

In addition to the desirable features of interlocking just described, there is an additional useful feature of the equipment. If either one of the exciter lamps 9 and 10 should burn out while leads 44 and 45 are closed, the relay 8 will soon open leads 44 and 45 to deenergize the load circuit. Opening of leads 44 and 45 is normally a result of illuminating either one of the two photo-emissive cells 4 or 5, and this function has been previously described. However, if the lamp exciting the cell 5 should burn out and later be followed by burning out the lamp exciting cell 4, the leads 44 and 45 of relay 8 will be opened and the load circuit be deenergized. The only failure of the two exciter lamps 9 and 10 that will cause the load circuit to become energized will be when the lamp exciting the cell 4 burns out prior to the lamp exciting the cell 5. Since this particular combination of failure is only one chance out of the four possible combinations, and further since there is little chance that both exciter lamps will be burned out at the same time, there is little danger that the external control circuit will become energized by failure of the exciter lamps.

One application of the photo-electric equipment just described is to open a door in response to the approach of a passenger from one direction. The photo-emissive cells 4 and 5 are placed in the entrance and spaced the desired distance apart. The door may be opened by an electric motor energized whenever current flows through the leads 44 and 45, such motor operated doors being too well known to require separate description.

It can be seen that if a person approaches the door, thereby interrupting the beams from the exciter lamps 9 and 10 in the proper sequence to first darken the photo-emissive cell 4, and then darken the cell 5 and maintaining both cells dark simultaneously, the relay 8 will close leads 44 and 45, and cause the door to open, as has been previously described.

The person will continue moving through the doorway and the cells 4 and 5 will again be illuminated, but as has been previously shown, the leads 44 and 45 of relay 8 will remain open for a time delay sufficient to allow the person to pass through the doorway before the mechanism allows the door to close.

It is important to note that a similar set of photo-electric cells and light sources to cells 4, 5 and lamps 9, 10 (which may be referred to as 4*a*, 5*a*, 9*a*, 10*a*) may be installed on the opposite side of the door, to cause it to open when approached by a passenger from the opposite side. After the person previously described as entering from the side of cells 4, 5 has passed through the doorway and later interrupts the beams from sources 9*a* and 10*a*, darkening the cells 4*a* and 5*a* in the sequence of 5*a* prior to 4*a*, the relay 8*a* is not operated and, therefore, the door is not re-opened by the passing of traffic in this direction.

If a person approaches the door in the direction first passing through the beams from sources 9*a* and 10*a*, darkening cells 4*a* and 5*a* in the sequence named, the door will be opened by the closing of leads 44*a* and 45*a* of relay 8*a*. Likewise, the door is caused to remain open a sufficient length of time for the person to enter the threshold but passing through the beams illuminating cells 5 and 4 in the sequence named will not cause the door to be re-opened by the passing of traffic in this direction.

The above application of the equipment is described purely for the purpose of establishing the merits of the equipment and is not in any way intended to be limited in scope of application to this system of door control.

I further do not wish to be limited to the field of door operating control, since the advantages of the apparatus are apparent for such purposes as the moving of material on a conveyor in a given direction, directional flow of material past a given point, various forms of interlocking and other applications on which the principle would be useful.

In accordance with the patent statutes, I have described a particular embodiment of my invention, but the broad principles thereof are applicable in many ways which will be evident to those skilled in the art.

I claim as my invention:

1. A light-responsive control circuit comprising an electrical discharge tube having a control electrode and a pair of principal electrodes, means for energizing said electrodes, a photo-electric cell connected to said means to cause said control electrode to render said discharge tube non-conductive when said photo-cell is iluminated, but to render said discharge tube conductive when said photo-cell is dark, a relay energized by current flow through said discharge tube to close a first pair of contacts when said discharge tube is conductive and to close a second pair of contacts when said discharge tube is non-conductive, a second electrical discharge tube having a pair of principal electrodes and a control electrode, a second photo-electric cell connected to the last-mentioned control electrode to render said second electrical discharge tube non-conductive when said second photo-electric cell is illuminated while leaving said second discharge tube conductive when said second photo-electric cell is dark, a third electrical discharge tube having a pair of principal electrodes and a control electrode and having in its output circuit a relay adapted to open a pair of contacts in a load circuit when said third electrical discharge tube is energized, a resistor connected to the control electrode of said third electrical discharge tube, a source of voltage connected in series with said resistor and with the first-mentioned pair of contacts and with said second discharge tube and of such polarity that the voltage drop of current flowing through said resistor impresses a negative voltage on the control electrode of said third discharge tube, and a source of voltage and a resistor in series with the second-mentioned pair of contacts and with said second discharge tube of such polarity as to impress a negative voltage on the control electrode of said first discharge tube when the second-mentioned pair of contacts is closed.

2. A light-responsive control circuit compris-

ing an electrical discharge tube having a control electrode and a pair of principal electrodes, means for energizing said electrodes, a photo-electric cell connected to said means to cause said control electrode to render said discharge tube non-conductive when said photo-cell is illuminated, but to render said discharge tube conductive when said photo-cell is dark, a relay energized by current flow through said discharge tube to close a first pair of contacts when said discharge tube is conductive and to close a second pair of contacts when said discharge tube is non-conductive, a second electrical discharge tube having a pair of principal electrodes and a control electrode, a second photo-electric cell connected to the last-mentioned control electrode to render said second electrical discharge tube non-conductive when said second photo-electric cell is illuminated while leaving said second discharge tube conductive when said second photo-electric cell is dark, a third electrical discharge tube having a pair of principal electrodes and a control electrode and having in its output circuit a relay adapted to open a pair of contacts in a load circuit when said third electrical discharge tube is energized, a resistor shunted by a capacitor connected to the control electrode of said third electrical discharge tube, a source of voltage connected in series with said resistor and with the first-mentioned pair of contacts and with said second discharge tube and of such polarity that the voltage drop of current flowing through said resistor impresses a negative voltage on the control electrode of said third discharge tube, and a source of voltage and a resistor in series with the second-mentioned pair of contacts and with said second discharge tube of such polarity as to impress a negative voltage on the control electrode of said first discharge tube when the second-mentioned pair of contacts is closed.

3. A light-responsive control circuit comprising an electrical discharge tube having a control electrode and a pair of principal electrodes, means for energizing said electrodes, a radiation-responsive device connected to said means to cause said control electrode to render said discharge tube non-conductive when said radiation-responsive device is illuminated, but to render said discharge tube conductive when said radiation-responsive device is dark, a relay energized by current flow through said discharge tube to close a first pair of contacts when said discharge tube is conductive and to close a second pair of contacts when said discharge tube is non-conductive, a second electrical discharge tube having a pair of principal electrodes and a control electrode, a second radiation-responsive device connected to the last-mentioned control electrode to render said second electrical discharge tube non-conductive when said second radiation-responsive device is illuminated while leaving said second discharge tube conductive when said second radiation-responsive device is dark, a third electrical discharge tube having a pair of principal electrodes and a control electrode and having in its output circuit a relay adapted to open a pair of contacts in a load circuit when said third electrical discharge tube is energized, a resistor connected to the control electrode of said third electrical discharge tube, a source of voltage connected in series with said resistor and with the first-mentioned pair of contacts and with said second discharge tube and of such polarity that the voltage drop of current flowing through said resistor impresses a negative voltage on the control electrode of said third discharge tube, and a source of voltage and a resistor in series with the second-mentioned pair of contacts and with said second discharge tube of such polarity as to impress a negative voltage on the control electrode of said first discharge tube when the second-mentioned pair of contacts is closed.

4. A light-responsive control circuit comprising an electrical discharge tube having a control electrode and a pair of principal electrodes, means for energizing said electrodes, a radiation-responsive device connected to said means to cause said control electrode to render said discharge tube non-conductive when said radiation-responsive device is illuminated, but to render said discharge tube conductive when said radiation-responsive device is dark, a relay energized by current flow through said discharge tube to close a first pair of contacts when said discharge tube is conductive and to close a second pair of contacts when said discharge tube is non-conductive, a second electrical discharge tube having a pair of principal electrodes and a control electrode, a second radiation-responsive device connected to the last-mentioned control electrode to render said second electrical discharge tube non-conductive when said second radiation-responsive device is illuminated while leaving said second discharge tube conductive when said second radiation-responsive device is dark, a third electrical discharge tube having a pair of principal electrodes and a control electrode and having in its output circuit a relay adapted to open a pair of contacts in a load circuit when said third electrical discharge tube is energized, a resistor shunted by a capacitor connected to the control electrode of said third electrical discharge tube, a source of voltage connected in series with said resistor and with the first-mentioned pair of contacts and with said second discharge tube and of such polarity that the voltage drop of current flowing through said resistor impresses a negative voltage on the control electrode of said third discharge tube, and a source of voltage and a resistor in series with the second-mentioned pair of contacts and with said second discharge tube of such polarity as to impress a negative voltage on the control electrode of said first discharge tube when the second-mentioned pair of contacts is closed.

5. A light-responsive control circuit comprising an electrical discharge tube having a control electrode and a pair of principal electrodes, means for energizing said electrodes, a radiation-responsive device connected to said means to cause said control electrode to render said discharge tube non-conductive when said radiation-responsive device is illuminated, but to render said discharge tube conductive when said radiation-responsive device is dark, a relay energized by current flow through said discharge tube to close a first pair of contacts when said discharge tube is conductive and to close a second pair of contacts when said discharge tube is non-conductive, a second electrical discharge tube having a pair of principal electrodes and a control electrode, a second radiation-responsive device connected to the last-mentioned control electrode to render said second electrical discharge tube non-conductive when said second radiation-responsive device is illuminated while leaving said second discharge tube conductive when said second

radiation-responsive device is dark, a load circuit and a circuit-interrupter therein which is kept open except when a control element is energized by current flow, and means to connect a control element adapted when energized to keep said first pair of contacts open in series with a source of voltage and with said second set of contacts and the principal electrodes of said second discharge tube.

6. A light-responsive control circuit comprising an electrical discharge tube having a control electrode and a pair of principal electrodes, means for energizing said electrodes, a radiation-responsive device connected to said means to cause said control electrode to render said discharge tube non-conductive when said radiation-responsive device is illuminated, but to render said discharge tube conductive when said radiation-responsive device is dark, a relay energized by current flow through said discharge tube to close a first pair of contacts when said discharge tube is conductive and to close a second pair of contacts when said discharge tube is non-conductive, a second electrical discharge tube having a pair of principal electrodes and a control electrode, a second radiation-responsive device connected to the last-mentioned control electrode to render said second electrical discharge tube non-conductive when said second radiation-responsive device is illuminated while leaving said second discharge tube conductive when said second radiation-responsive device is dark, a load circuit and a circuit interrupter therein which is kept open except when a control element is energized by current flow, and means to connect said control element in series with an energizing source through said first set of contacts and the principal electrodes of said second discharge tube.

7. A light-responsive control circuit comprising an electrical discharge tube having a control electrode and a pair of principal electrodes, means for energizing said electrodes, a photo-electric cell connected to said means to cause said control electrode to render said discharge tube non-conductive when said photo-electric cell is illuminated, but to render said discharge tube conductive when said photo-electric cell is dark, a relay energized by current flow through said discharge tube to close a first pair of contacts when said discharge tube is conductive and to close a second pair of contacts when said discharge tube is non-conductive, a second electrical discharge tube having a pair of principal electrodes and a control electrode, a second photo-electric cell connected to the last-mentioned control electrode to render said second electrical discharge tube non-conductive when said second photo-electric cell is illuminated while leaving said second discharge tube conductive when said second photo-electric cell is dark, a load circuit and a circuit interrupter therein which is kept open except when a control element is energized by current flow, and means to connect said control element in series with a source of voltage and with said first set of contacts and the principal electrodes of said second discharge tube.

8. In combination, a first radiation-responsive device, a first set of contacts which are closed when said first radiation-responsive device is highly energized except when a blocking element is energized, a second set of contacts which are closed whenever said first set of contacts are open, a second radiation-responsive device, a first circuit interrupter which is maintained in open circuit condition whenever said second radiation-responsive device is highly energized and which is maintained in conductive condition when said second radiation-responsive device is not highly energized, a load circuit and a second circuit interrupter therein which is kept non-conductive except when a control element is energized, and means to connect said control element in series with an energizing source through said first set of contacts and said second circuit interrupter, and to connect said blocking element in series with said second set of contacts and said second circuit interrupter.

9. In combination, a first radiation-responsive device, a first circuit interrupter which is maintained in a non-conductive condition when said radiation-responsive device is highly energized and which is in a non-conductive condition when said radiation-responsive device is not highly energized, a first set of contacts which are closed when said first circuit interrupter is in a conductive condition and are open when it is in a non-conductive condition, a second set of contacts which are open when said first circuit interrupter is in a conductive condition and which are closed when it is in a non-conductive condition, a second radiation-responsive device, a second circuit interrupter which is maintained in open circuit condition whenever said second radiation-responsive device is highly energized and which is maintained in conductive condition when said second radiation-responsive device is not highly energized, a load circuit and a third circuit interrupter therein which is kept non-conductive except when a control element is energized, and means to connect said control element in series with an energizing source through said first set of contacts and said second circuit interrupter.

10. In combination, a first radiation-responsive device, a first set of contacts which are closed when said first radiation-responsive device is highly energized except when a blocking element is energized, a second set of contacts which are closed whenever said first set of contacts are open, a second radiation-responsive device, an electrical discharge tube having a pair of principal electrodes and a control electrode and connected to be maintained in a non-conductive condition when said second radiation-responsive device is highly energized and to be maintained in a conductive condition when said second radiation-responsive device is not highly energized, a load circuit and a circuit interrupter therein which is kept open except when a control element is energized, and means to connect said control element in series with an energizing source through said first set of contacts and said electrical discharge tube, and to connect said second set of contacts in series with said electrical discharge tube and said blocking element.

11. In combination, a first radiation-responsive device, a first set of contacts which are closed when said first radiation-responsive device is highly energized except when a blocking element is energized, a second set of contacts which are closed whenever said first set of contacts are open, a second radiation-responsive device, an electrical discharge tube having a pair of principal electrodes and a control electrode and connected to be maintained in a non-conductive condition when said second radiation-responsive device is highly energized and to be maintained in a conductive condition when said second radiation-responsive device is not highly energized, a load circuit and a circuit interrupter therein

which is kept open except when a control element is energized, and means to energize said control element through said first set of contacts and said second electrical discharge tube.

12. In combination with a first radiation-responsive device and circuit connections thereto adapted to maintain a first set of contacts closed and a second set of contacts open when said device is irradiated, a second radiation-responsive device and means rendered conductive only when said second radiation-responsive device is irradiated, a circuit energized in response to closure of said first set of contacts and to conductivity of said means, and means energized when said second set of contacts is closed and the first-mentioned means is conductive to prevent closure of said first set of contacts.

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