

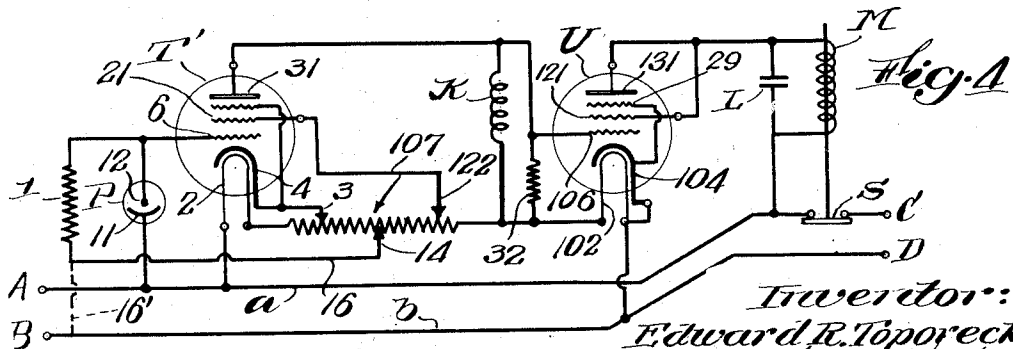
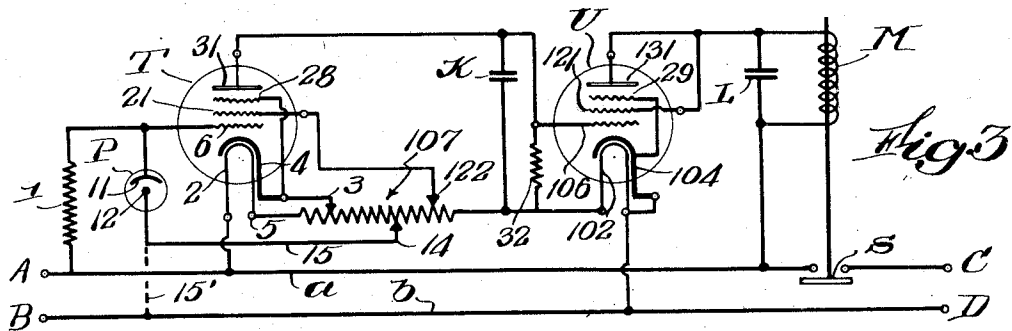
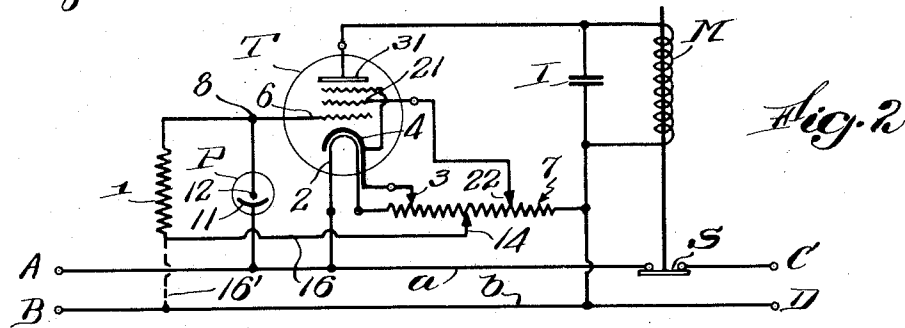
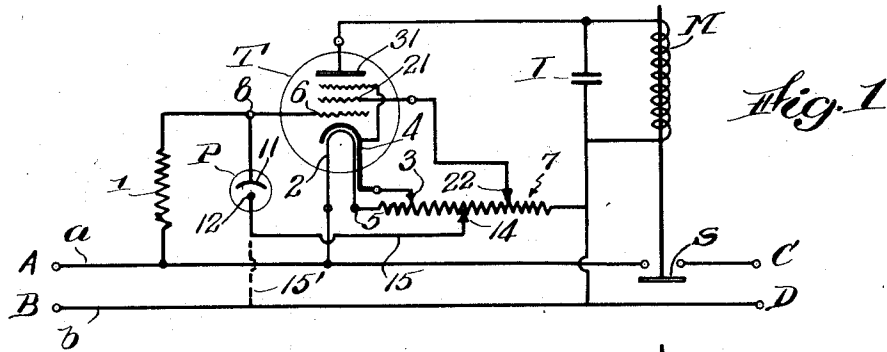
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E. R. TOPORECK

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PHOTOELECTRIC RELAY

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Inventor:
Edward R. Toporeck
by Robert L. Gresham & Woodbury
his Attys.

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PHOTOELECTRIC RELAY

Edward R. Toporeck, South Weymouth, Mass.,
assignor to Photoswitch Incorporated, Cam-
bridge, Mass., a corporation of Massachu-
setts

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The present invention relates to improvements in photoelectric relays of the type where the changing conductivity of a photoelectric device effects the actuation of a circuit controlling element, such as a switch. It is the main object of my invention to provide apparatus of this kind which is especially simple, rugged, and economical in operation, and yet inexpensive, and which is sensitive and stable, and provides considerable amplification. In one aspect, my circuit is especially suited for operation, without any special current rectifying provisions, from an alternating current supply line, for example from the circuit which it is to control; its operation requires only a very small current drain from that line, and it is very sensitive to small variations of light intensity, operating, for example, a lamp circuit switch in response to a light intensity change as low as about 0.001 lumen. In another aspect, my circuit can be easily changed from operation upon response to an increase of illumination of the photoelectric element to operation responding to a decrease in that illumination.

These and other objects, advantages and features of my invention will be better understood from the following description, by way of example, of several typical embodiments thereof, with reference to a drawing in which:

Figs. 1 and 2 are circuit diagrams illustrating two embodiments, respectively, of a relay device employing a single amplification step; and

Figs. 3 and 4 are corresponding embodiments employing two stages of amplification.

Referring to Fig. 1, A and B are terminals of a system supplying, to conductors a, b, for example, alternating current of the usual voltage and frequency. T is an electron discharge tube, preferably of the "beam power amplifier" type (as for example "25L6" described on page 107 of the "RCA Receiving Tube Manual", 1937); however, any tube having similar characteristics will be satisfactory.

The heater element 2 of cathode 4 of tube T is supplied with current from lines a, b, through a resistor 7 suitably reducing the line voltage. Assuming the usual supply voltage of 110 v., a resistor of about 300 ohms will be satisfactory for this purpose. Cathode 4 is preferably connected to a tap 3 near the heater terminal 5 of resistor 7, but it may lead directly into that terminal.

Grid 6 is connected to terminal A through conductor 8 and resistance 1. A light sensitive element, for example a photoelectric cell P of the usual type with cathode 11 and anode 12 is con-

nected between 8 and tap 14 of resistor 7 through conductor 15 or, as an alternative shown at 15' in dotted lines, directly to line b. Resistance 1 should be of a magnitude similar to that of the photocell resistance; a resistor of about 40 megohms was found suitable in the present embodiment. The screen electrode 21 is connected to another tap 22 of resistor 7, and it is important, according to one phase of my invention, to maintain the potential of screen electrode 21 lower than about 20 v. by accordingly adjusting this tap. This has the purpose of keeping the positive ions at a minimum, as otherwise, they would collect on control electrode 6 and interfere with proper operation of the device.

Anode 31 is connected to line b through relay magnet M, preferably having in this instance an impedance of about 2000 ohms, to match the characteristics of tube T. Connected in parallel to magnet M is an impedance I, in the present instance a condenser of about 8 microfarads.

Magnet M is arranged to operate a switch S, here shown in a position normally interrupting the current supply to apparatus which may be connected to terminals C and D of line a, b.

Taps 3, 14 and 22 are preferably sliders since it is important for the proper operation of this circuit to establish a certain relation of the potentials of cathode and control electrode, as will appear from the following explanations.

This circuit operates in the following manner, assuming that lines a, b are supplied with alternating current.

If photocell P is dark, and terminal A negative, plate 31 becomes positive. However, tap or slider 3 is so adjusted that the potential of cathode 4 is higher than the potential of grid 6 as controlled by resistance 1; hence, since the control grid 6 is sufficiently negative relatively to cathode 4, current can not flow in magnet M, and switch S remains in its previous position, for example open as shown.

If photocell P remains dark, and terminal A changes to positive, plate 31 is connected to negative terminal B. Hence, tube T blocks current flow therethrough, magnet M remains deenergized, and switch S is not affected.

If photocell P is now illuminated, and terminal A negative, plate 31 will be positive. The photocell, being illuminated and its resistance therefore considerably reduced, will establish a current path from connection 8 to line b, so that the potential of control grid 6 becomes more positive than that of cathode 4, and current can flow

through the tube. Magnet M will be energized and switch S closed.

If photocell P remains illuminated and terminal A changes to positive, plate 31 will be negative and the tube unable to supply current to magnet M. However, impedance I has stored energy during the previous half cycle when A was negative, which energy is now released, maintaining M energized and S closed.

The circuit according to Fig. 1 will be employed if the relay is to be operated when a light shines on the photocell, for example for operating a signaling device (connected to C, D) of a gasoline station when the headlights of an approaching automobile illuminate the photocell.

If, to the contrary, the switch is to be operated when the photocell is darkened, the connections are changed, in very simple manner, to constitute a circuit according to Fig. 2. In this circuit, all elements may be exactly the same as those indicated with similar identification marks in Fig. 1 but photocell P is connected to line a whereas resistor 1 is connected to tap 14 or directly to line b, as indicated at 16 and 16'.

In this instance, the operation is analogous to that above described, with the difference that, when the photocell is dark and constitutes a high resistance, current will continuously flow through magnet M, holding switch S, for example, in closed position, as shown in Fig. 2. When the photoelectric element is illuminated and its resistance decreased, the potential of control grid 6 approaches that of line a, becoming more negative than that of the cathode, interrupting current flow through the relay magnet and causing the switch to be opened.

Referring to Fig. 3, a circuit according to another phase of my invention will now be described. This circuit employs two amplifier tubes T and U, respectively, the connections of tube T being identical with those of tube T in Fig. 1, as indicated by the similar identification marks used.

In this embodiment, I prefer to use as tube T a pentode (for example type 6J7, page 83 of the above-identified publication) or a similar high gain amplifier tube, and as tube U an amplifier pentode (for example type 25L6, page 105 of the above publication), or a similar power amplifier tube. In this instance, resistor 107 (corresponding to element 7 of Fig. 1) is connected between heater element 2 of tube T and heater element 102 with cathode 104 of tube U. Anode 31 of tube T is connected in series with a resistance 32 (here of about 1 megohm, approximately equal to the internal resistance of T and forming the plate load of voltage amplifier T) and heater element 102, to line b. In parallel with load 31 is connected an impedance K, for example a condenser of about 0.1 microfarad. The potential across load 32 is applied to control grid 106 of tube U. Plate 131 of tube U is connected to line a in series with relay magnet M arranged for operating switch S. In order to match tube U, magnet M will suitably have an impedance of about 3000 ohms. Although not absolutely essential for the proper operation of this circuit, an impedance L, for example a condenser of about 8 microfarads, may be connected in parallel to magnet M.

Describing now the operation of the circuit according to Fig. 3, it may again be assumed first that photocell P is dark and that terminal A is negative. With no light on the photocell its impedance is high and the control grid 6 of

tube T is thus at a small positive potential with respect to line a. Also, since the plate 31 of tube T is connected to line b it has a positive potential. The adjustment of tap 3 on the resistor 107 is now made so that, as described with reference to Fig. 1, due to the difference in potential between control grid 6 and cathode 4 only a small current flows in the plate circuit of tube T. This small current causes an accordingly small voltage drop across load resistor 32. Since one terminal of resistor 32 is connected to control grid 106 of tube U, and the other terminal to heater 102, and because the voltage drop in that heater approximates that across resistor 32, the control grid and the heater are in this instance at about the same potential. The plate 131 of tube U being connected to line a which is negative, no current will pass through relay M.

If the photocell remains dark but terminal A becomes positive and B negative, the control grid 6 of tube T is also positive but the plate 31 connected to b is negative so there is no current flow through the resistor 32. However, the plate of tube U being connected to the positive line a is therefore positive with respect to cathode 104 and, since the control grid is connected to the heater 102, current flows in this circuit and through relay magnet M. Therefore, with the photocell dark, pulses of current pass through relay magnet M, each pulse lasting for one-half cycle. In order to keep the relay in operation, it could be made of such a mechanical construction that it will operate on the average value of these pulses of current; however, the preferred way of securing proper operation is to provide an electrical means to store a part of the energy and then supply the current during the half cycle when the tube is not conducting, as for example impedance L.

With the photocell illuminated and terminal A negative, the following conditions prevail: The photocell resistance is now much lower and hence the voltage drop across its terminals is lowered so that the control grid 6 of tube T is now more positive with respect to the cathode 4 than it was when the cell was dark. The plate 31 of tube T is positive, being connected to line b, and current flows in this plate circuit. This means that resistor 32 has a voltage across its terminals, and, because of the direction of current flow, that end of the resistor which is connected to the control grid 106 of tube U is negative with respect to the other end that is connected to the heater 102. In other words, the illumination of the photocell causes the control grid 106 of tube U to become more negative than before. However, plate 131 of tube U being connected to the negative line a, no current flows through magnet M.

When the photocell remains illuminated and terminal A becomes positive, plate 31 of tube T is connected to the negative side b of the line and no current flows in its plate circuit. However, the current that existed in the plate circuit of tube T during the first half of the cycle charged condenser K. Therefore, during the second half of the cycle, now under discussion, or as soon as the voltage across resistance 32 drops below that of the condenser K, the latter discharges through the resistance 32 as long as there is any charge left, thus maintaining the negative voltage on the control grid 106 of tube U. The size of this condenser is so determined that the time constant of the closed circuit K—32 will permit the negative voltage to be maintained on the control grid 106 of tube U over the portion of the cycle

when there is no current in the plate circuit of tube T. The plate of tube 8 is connected to line a and hence positive; nevertheless, with the control grid sufficiently negative, no current will flow through relay magnet M.

It will be noted that impedances K and L cooperate in storing electrical energy, L to maintain current flow in magnet M when the photocell is dark, and K maintaining a voltage across resistance 32 and blocking current flow through tube U and magnet M, while the photocell is illuminated.

The circuit shown in Fig. 4 is similar to that of Fig. 3 with the exception that a suitable tube T' is connected as explained with reference to Fig. 2, in order to deenergize relay magnet M if the illumination of the photocell decreases. The operation is similar to that described above with reference to Figs. 2 and 3, and should now be understood without further explanation.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. Photoelectric relay apparatus comprising a current source with two terminals, an electron discharge device having a cathode, an anode and a control electrode, an impedance connected between one of said terminals and said control electrode, a photoelectric device connected between said control electrode and the other one of said terminals, an impedance joining said cathode and one of said terminals, a controlled circuit connected between said anode and said terminal to which the cathode impedance is connected, a relay in said controlled circuit and a relay circuit operated by said relay, said impedances being mutually adjusted to render the control electrode potential higher or lower than the cathode potential when said photoelectric device is illuminated to degrees varying its impedance to be higher or lower, respectively.

2. Photoelectric relay apparatus comprising a current source with two terminals, an electron discharge device having a cathode, an anode and a control electrode, an impedance connected between one of said terminals and said control electrode, a photoelectric device connected between said control electrode and the other one of said terminals, an impedance joining said cathode and one of said terminals, a relay connected between said anode and said terminal to which the cathode impedance is connected, an impedance in parallel to said relay, and a relay circuit controlled by said relay, said impedances being mutually adjusted to render the control electrode potential higher or lower than the cathode potential when said photoelectric device is illuminated to degrees varying its impedance to be higher or lower, respectively.

3. Photoelectric relay apparatus comprising an alternating current source with two terminals, an electron discharge device having a cathode, an anode and a control electrode, an impedance connected between one of said terminals and said control electrode, a photoelectric device connected between said control electrode and the other one of said terminals, an adjustable impedance substantially lower than said first-mentioned impedance connected between said cathode and said second terminal, a relay connected between said anode and said second terminal, and an impedance in parallel to said relay, said

impedances being mutually adjusted to render the control electrode potential higher or lower than the cathode potential when said photoelectric device is illuminated to degrees varying its impedance to be higher or lower, respectively.

4. Photoelectric relay apparatus comprising an alternating current source with two terminals, an electron discharge device having a cathode, an anode and a control electrode, an impedance connected between one of said terminals and said control electrode, a photoelectric device connected between said control electrode and the other one of said terminals, an adjustable impedance substantially lower than said first-mentioned resistance connected between said cathode and said first terminal, a relay connected between said anode and said first terminal, and an impedance in parallel to said relay, said impedances being mutually adjusted to render the control electrode potential higher or lower than the cathode potential when said photoelectric device is illuminated to degrees varying its impedance to be higher or lower, respectively.

5. Photoelectric relay apparatus comprising a current source with two terminals, an electron discharge device having a cathode, an anode and a control electrode, an impedance connected between one of said terminals and said control electrode, a photoelectric device connected between said control electrode and the other one of said terminals, an impedance connected between said cathode and one of said terminals, a load impedance connected between said anode and the terminal to which said cathode is connected, a second electronic device having a cathode, a control electrode whose potential is derived from said load impedance, and an anode feeding into a controlled circuit containing a relay, and a relay circuit operated by said relay, said two first-mentioned impedances being mutually adjusted to render the control electrode potential of said second electronic device lower than the potential of its cathode when the impedance of said photoelectric device is reduced.

6. Photoelectric relay apparatus comprising an alternating current source with two terminals, an electronic discharge device having a cathode, an anode and a control electrode, an impedance connected between one of said terminals and said control electrode, a photoelectric device connected between said control electrode and the other one of said terminals, an impedance connected between said cathode and one of said terminals, a load impedance connected between said anode and the terminal to which said cathode is connected, an equalizing impedance in parallel to said load impedance, a second electronic device having a cathode, a control electrode whose potential is derived from said load impedance, and an anode feeding into a controlled circuit containing a relay, and a relay circuit operated by said relay, said two first-mentioned impedances being mutually adjusted to render the control electrode potential of said second electronic device lower than the potential of its cathode if said first electronic device feeds into said load impedance, and said equalizing impedance supplying energy to said load impedance when the first electronic device blocks current flow thereto.

7. Photoelectric relay apparatus comprising an alternating current source with two terminals, an electronic discharge device having a cathode, an anode and a control electrode, an impedance connected between one of said terminals and

said control electrode, a photoelectric device connected between said control electrode and the other one of said terminals, an impedance connected between said cathode and one of said terminals, a load impedance connected between said anode and the terminal to which said cathode is connected, an equalizing impedance in parallel to said load impedance, a second electronic device having a cathode, a control electrode whose potential is derived from said load impedance, and an anode feeding into a controlled circuit containing a relay, a second equalizing impedance in parallel to said relay, and a relay circuit operated by said relay, said two first-mentioned impedances being mutually adjusted to render the control electrode potential of said second electronic device lower than the potential of its cathode if said first electronic device feeds into said load impedance, said first equalizing impedance supplying energy to said load impedance when said first electronic device reduces current flow thereto, and said second equalizing impedance supplying energy to said relay when current flow in said controlled circuit diminishes.

8. Photoelectric relay apparatus comprising a current source with two terminals, an electron discharge device having a cathode, an anode, a control electrode, and a screen electrode, an impedance connected between one of said terminals and said control electrode, a photoelectric device connected between said control electrode and the other one of said terminals, a cathode impedance connected between said cathode and one of said terminals, a controlled circuit including a relay connected between said anode and said terminal to which the cathode impedance is connected, and an impedance connected between said screen electrode and said terminal to which the cathode impedance is connected and dimensioned to keep the screen electrode potential below the ionization potential of the residual gas in the discharge device, said two first-mentioned impedances being mutually adjusted to render the control electrode potential higher or lower than the cathode potential when said photoelectric device is illuminated to degrees varying its impedance to be higher or lower, respectively.

EDWARD R. TOPORECK.