Feb. 13, 1934. W. D. COCKRELL 1,947,189

CONTROL APPARATUS FOR VAPOR ELECTRIC DISCHARGE DEVICES

Filed July 26, 1933

Fig. 1.

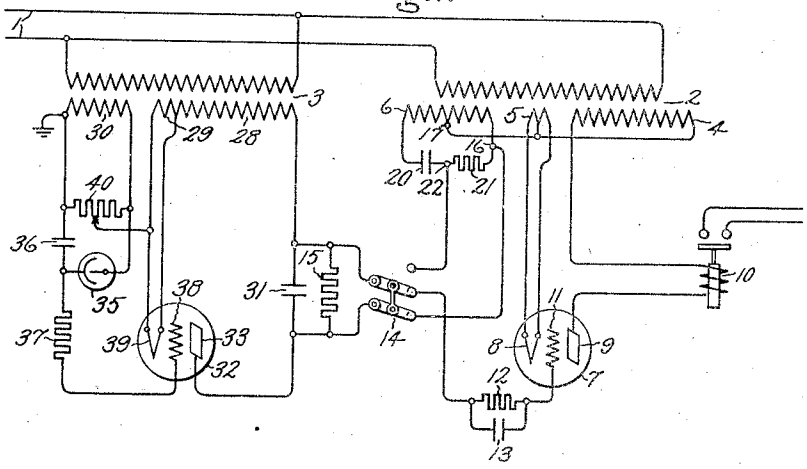


Fig. 2.

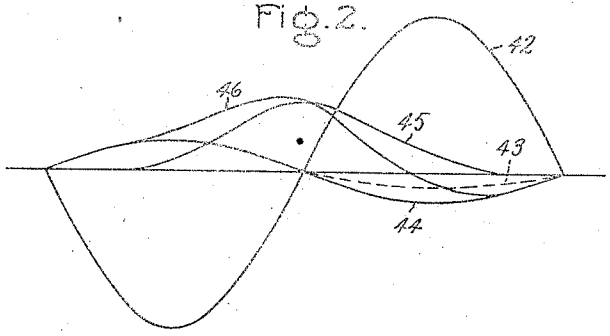
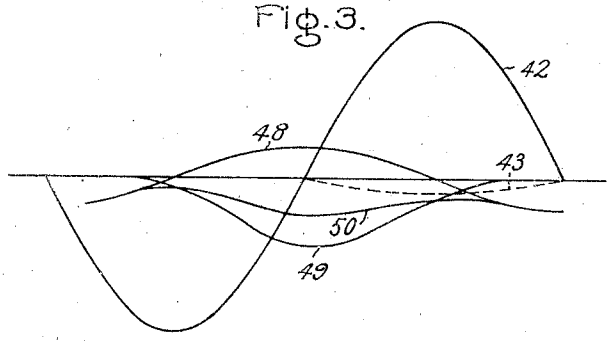


Fig. 3.



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CONTROL APPARATUS FOR VAPOR ELECTRIC DISCHARGE DEVICES

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Application July 26, 1933. Serial No. 682,231

7 Claims. (Cl. 250—41.5)

My invention relates to control apparatus for vapor electric discharge devices operated on alternating current. It relates particularly to apparatus for the control of such devices through a rectifying electron discharge amplifier under the control of a photoelectric device. One object of my invention is to provide improved apparatus of this character which is simple in construction, reliable, efficient, and sensitive in operation, and inexpensive to manufacture. Another object is to provide improved apparatus of this character which when controlled by a photoelectric device is adapted to be employed to respond either to an increase in light or to a decrease in light. My present invention is a continuation-in-part of my copending application Serial No. 526,677, filed March 31, 1931.

My invention will be better understood from the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Referring to the drawing, Fig. 1 is a circuit diagram illustrating one embodiment of my invention; and Figs. 2 and 3 are diagrams illustrating the characteristics of the apparatus shown in Fig. 1 when used respectively to respond to an increase in light and to respond to a decrease in light.

In the drawing I have shown at 1 a source of supply of alternating current which, for example, may be at 110 volts, 60 cycles per second, and connected to this supply are the primary windings of the transformers 2 and 3. The former has a secondary comprising windings represented at 4, 5, and 6. At 7 is the vapor electric discharge device to be controlled having its cathode 8 connected to be supplied with heating current from the winding 5. The anode 9 thereof connects through the load device 10 which, for example, may be a relay with one end of the winding 4, the opposite end of which connects with the midpoint of winding 5. The voltage applied to the grid 11 of device 7 is that due to the combination of a uniform bias wave obtained from the winding 6 and that of a variable bias obtained from the apparatus, to be described later, in response to the operation of the photoelectric device.

For obtaining the uniform bias wave I connect the grid 11 through the protective resistor 12 shunted by the capacitor 13 and through the reversing switch 14 with winding 6 of transformer 2. When the vapor device is to be used to pass current and operate the relay 10 in response to a predetermined light increase, the reversing switch is thrown down, as illustrated, whereby the grid connects through the resistor 12 and the resistor 15 with the right-hand end 16 of winding 6, the midpoint 17 of this winding being connected with the winding 5. Thus during the positive half cycles of the alternating voltage supply, namely, those half cycles during which the vapor device may pass current, the left-hand end of winding 4 is positive and the right-hand end of winding 6 is negative, hence a negative bias is applied to the grid from transformer winding 6.

For obtaining a uniform grid bias having a desired phase relation when the apparatus is used to operate the relay 10 in response to a predetermined decrease in light I provide an impedance in shunt with the winding 6 comprising the capacitor 20 and the non-inductive resistor 21, these members being constructed to have substantially the same impedance value at the frequency employed. To operate the apparatus in response to a predetermined light decrease, the reversing switch is thrown up so that the grid connects through the switch and resistors 12 and 15 with the mid-point 22 of the impedance bridged across the winding 6.

For supplying to grid 11 a variable biasing voltage in accordance with the amount of light, I have provided the transformer 3 with the three secondary windings 28, 29, and 30, and connect a reactance device, preferably a capacitor such as shown at 31, in series with winding 28 and the rectifying electron discharge amplifier 32. The capacitor 31 is bridged across the resistor 15 through which it may discharge. The anode 33 of the amplifier 32 connects through the capacitor 31 with that end of winding 28 which is negative when anode 9 of the vapor device is positive, hence the capacitor 31 receives a charge only during the negative half cycles. The photoelectric device 35, which is represented as being a photoelectric tube, is connected to be supplied by the winding 30 through the capacitor 36, the cathode of the photo device being connected through the resistor 37 with the grid 38. The cathode 39 is connected to be heated from the winding 29, and through the potentiometer 40 it connects with the anode of the photo device 35. Variations in the negative bias of the grid 38 and hence the sensitivity of the apparatus is effected by moving the arm of the potentiometer 40 in the well understood manner.

I shall now describe the operation of the apparatus shown in Fig. 1, assuming that it is to be operated in accordance with an increase in light, that is, the relay 10 is to be caused to close in response to a predetermined increase in light

received by the photoelectric device 35, and assuming that the reversing switch 14 is thrown to the left. The curve 42 in Fig. 2 represents the voltage applied to the anode 9 of the vapor device 7 and the dotted line 43 represents the tripping voltage of that device. Because of the connection of the right-hand end of winding 6 through the reversing switch and resistor 15 with the grid 11 there is applied to the grid a negative biasing voltage represented by the curve 44 which is in phase opposition to curve 42. Since the capacitor 31 is charged through each successive negative half cycle when the light is above a predetermined quantity and since it discharges through the resistor 15 during the first half of the following positive half cycle, the voltage drop across the resistor 15 results in a bias voltage applied to the grid 11 having the form represented by the curve 45. The actual voltage applied to the grid 11 is the algebraic sum of the voltages represented by curves 44 and 45 which is shown as the curve 46. Thus it will be seen that the grid is strongly positive at the instant that the anode voltage becomes positive and the vapor device is turned on at the very beginning of each positive half cycle. With the reversing switch thrown to the left, therefore, the relay 10 is energized with a maximum current to close when the amount of illumination reaches a predetermined value.

When it is desired to employ the apparatus to operate the relay 10 in response to a predetermined decrease in the amount of illumination of the photo device, the reversing switch is thrown to the rght. In this position of the reversing switch the biasing voltage applied to grid 11 from the winding 6 is shown by the curve 48 of Fig. 3, where curves 42 and 43 are the same as in Fig. 2. This curve, it will be noted, is displaced substantially 90° behind the corresponding curve 44 of Fig. 2, making it lead the anode voltage wave 42 by substantially 90°. This positioning of the voltage wave 48 is effected through the use of the impedance comprising the capacitor and resistor combination 20 and 21 bridged across the winding 6, and also to the fact that winding 5 is connected to the midpoint of winding 6.

The bias voltage due to the potential drop across resistor 15 while photo tube 35 is illuminated is represented by curve 49 which it will be noticed is in the opposite phase to the corresponding curve 45 of Fig. 2. This is due to the reversal brought about by the reversing switch 20. The voltage actually applied to the grid 11 is the combined or algebraic sum of the voltages represented by curves 48 and 49 which in Fig. 3 is represented by the curve 50. This curve, it will be seen, remains negative to the trip voltage curve 43 throughout the positive half cycle. Hence as long as the photo tube 35 is illuminated to a predetermined degree the vapor device 7 does not pass current and the relay 10 remains open. As the illumination of the photo device 35 decreases, a point is reached at which the combined voltage applied to the grid 11 will become less negative than the tripping voltage and cause the vapor device 7 to be tripped and the relay 10 to become energized. Adjustment of the apparatus to cause the relay to operate at various degrees of illumination or lack of illumination of the photoelectric device 35 may be accomplished by varying the position of the arm of the potentiometer 40.

With the apparatus which I have illustrated and described above it will be seen that by merely throwing the reversing switch 14 to the left or to the right I am able to employ the same apparatus without further adjustment to cause the relay 10 to close either in response to a predetermined light increase on the photo device or to close in response to a predetermined light decrease thereon. As shown by Fig. 2 when the apparatus is used to respond to a light increase the vapor device is tripped or turned on at the very beginning of each positive half cycle since the voltage curve 46 is positive at the instant that the anode voltage passes zero at the beginning of the positive half wave. As shown by Fig. 3 when the apparatus is used to respond to a light decrease the vapor device 7 is prevented from being tripped or passing current through the positive half cycle for the grid voltage curve 50 is more negative than the tripping curve 43 through the entire positive half cycle, and when it is tripped the tripping point occurs in the first half of the positive half cycle.

I have chosen the particular embodiment described above as illustrative of my invention and it will be apparent that various other modifications may be made without departing from the spirit and scope of my invention which modifications I aim to cover by the appended claims.

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

1. In combination, a source of alternating current supply, a grid controlled vapor electric discharge device connected to be energized from said supply and operative on the positive half cycles thereof, a reactance device, rectifying means for supplying current thereto from said supply during the negative half cycles, means for supplying a bias voltage from said source and means for applying to said grid the voltage across said reactance device combined with said bias voltage.

2. In combination, a source of alternating current supply, a grid controlled vapor electric discharge device connected to be energized from said supply and operative on the positive half cycles thereof, a reactance device, a variable impedance device, a rectifying electron discharge device controlled thereby and connected to supply current to said reactance device from said source during the negative half cycles, means for supplying a bias voltage from said source and means for combining said bias voltage with the voltage across said reactance device and supplying the combined voltage to said grid.

3. In combination, a source of alternating current supply, a grid controlled vapor electric discharge device connected to be energized from said supply and operative on the positive half cycle thereof, a capacitor, rectifying means for supplying charging current thereto from said supply during the negative half cycles, means for supplying a bias voltage to said grid from said source and means for supplying to said grid simultaneously the voltage across said capacitor.

4. The combination of a source of alternating current supply, a grid controlled vapor electric discharge device energized therefrom and arranged to pass current during the positive half cycles, a photoelectric device and means cooperating therewith for causing said vapor device to pass current in response to a predetermined increase in light affecting said photo device, said means comprising a capacitor arranged to be charged from said supply during the negative half cycles thereof, means for producing a voltage wave in phase opposition to said supply and

means for applying said voltage wave and the voltage across said capacitor to said grid.

5. The combination of a source of alternating current supply, a grid controlled vapor electric discharge device energized therefrom and arranged to pass current during the positive half cycles, a photoelectric device, an electron discharge amplifier controlled thereby, a capacitor connected in series with said amplifier and arranged to be charged from said supply during the negative half cycles thereof, means for applying the voltage across said capacitor to said grid and means for simultaneously biasing said grid with a voltage wave from said supply and substantially in phase opposition to said positive half cycles.

6. The combination of a source of alternating current supply, a grid controlled vapor electric discharge device energized therefrom and arranged to pass current during the positive half cycles, a photoelectric device and means cooperating therewith for causing said vapor device to pass current in response to a predetermined decrease in light affecting said photo device, said means comprising a capacitor arranged to be charged from said supply during the negative half cycles thereof, means for obtaining a leading voltage wave from said supply and means for combining said wave with the voltage wave across said capacitor and applying the combined wave to said grid.

7. The combination of a source of alternating current supply, a grid controlled vapor electric discharge device energized therefrom and arraned to pass current during the positive half cycles, a photoelectric device and means cooperating therewith for causing said vapor device to pass current in response to a predetermined decrease in light affecting said photo device, said means comprising a capacitor arranged to be charged from said supply during the negative half cycles thereof, means for obtaining a voltage wave from said supply which leads the voltage thereof and is substantially in quadrature therewith and means for applying said voltage wave and the voltage across said capacitor to said grid.

WILLIAM D. COCKRELL.