May 1, 1951 E. D. SPIERER 2,551,225

COLD CATHODE TUBE AND CIRCUITS FOR THE USE THEREOF

Filed Feb. 1, 1949 2 Sheets-Sheet 1

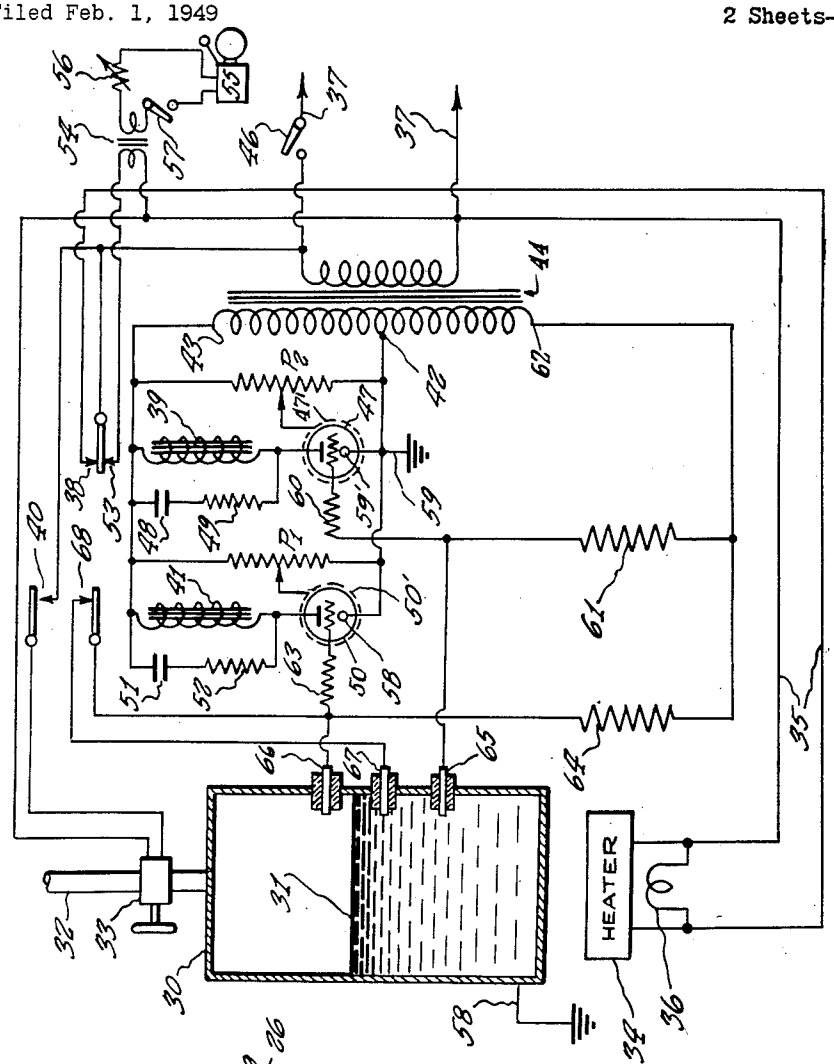


Fig. 2

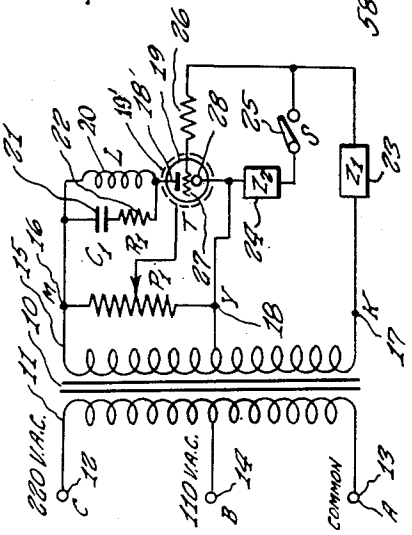


Fig. 1

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COLD CATHODE TUBE AND CIRCUITS FOR THE USE THEREOF

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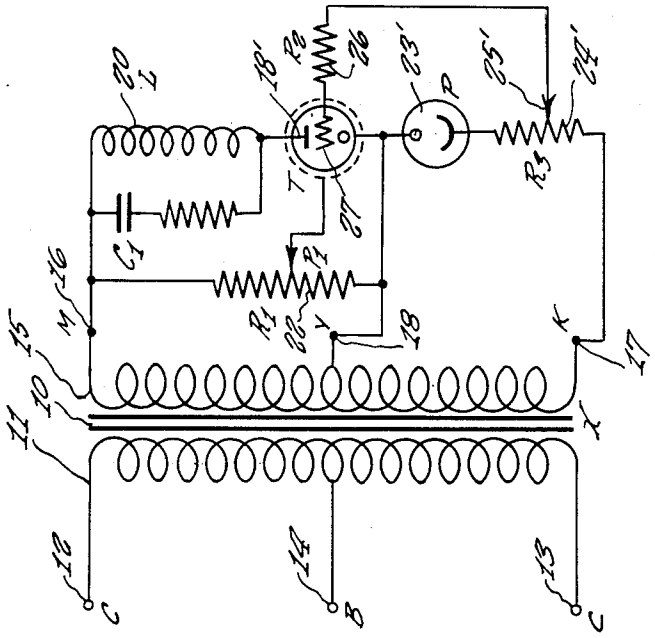


Fig. 4

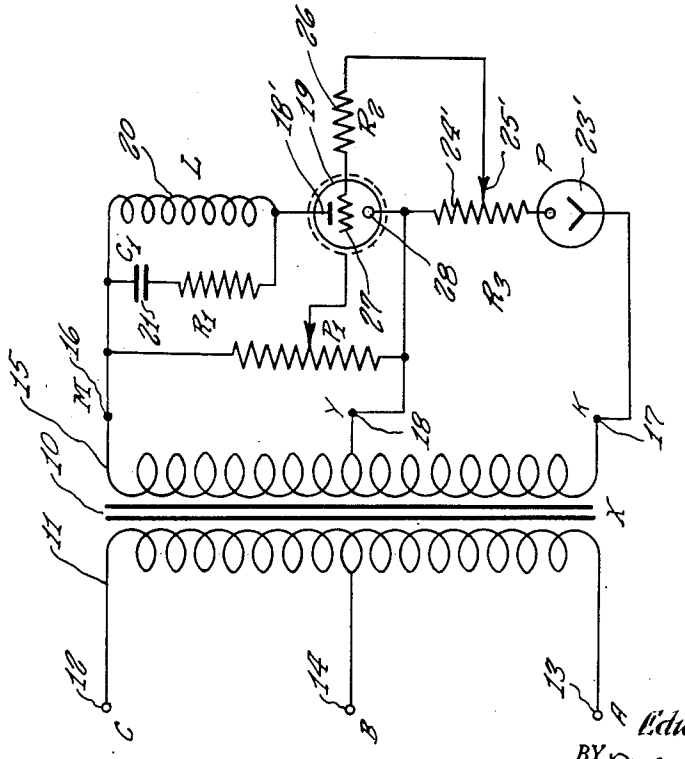


Fig. 3

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UNITED STATES PATENT OFFICE

2,551,225

COLD CATHODE TUBE AND CIRCUITS FOR THE USE THEREOF

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Application February 1, 1949, Serial No. 73,976

10 Claims. (Cl. 315—269)

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This invention relates to electronic tubes of the type known as gas filled cold cathode tubes, and particularly to electrical apparatus, such as control circuits of improved sensitivity utilizing an improved construction of the cold cathode type tube.

This application is a continuation-in-part of my prior and copending application, Serial No. 699,277, filed September 25, 1946, now abandoned for Cold Cathode Triode Tube Circuits, and is intended as a substitute therefor.

Triode cold cathode type tubes customarily contain the following elements: a cold cathode, a main anode and a starter electrode. The starter electrode, in conventional operation, is normally operated at a potential sufficiently positive to cause it to function as an additional anode. Cold cathode type tubes are normally filled with one or more gases selected from the group of inert gases, comprising neon, argon or krypton.

In the operation of tubes of this type, a discharge between the main anode and the cathode is normally visually indicated by a glow appearing within the tube, the color of the glow being determined by the nature of the gas contained within the tube. For example, a tube containing neon will give a glow of a reddish hue, while a tube containing argon will give a purple or blue color.

An important operating characteristic of the cold cathode type tube is dependent upon the fact that ionization of the gas within the tube may be initiated by a relatively small amount of electrical energy supplied to the starter electrode; this initial ionization will, in turn, permit the formation of an electrical discharge between the main anode and the cathode, this discharge having a decidedly greater energy content than the energy supplied to the starter electrode. The current flow resulting from the main discharge between the main anode and the cathode is normally of sufficient amperage to operate electro-magnetic devices included in the circuit containing the tube, such, for example, as the energizing coil of a relay.

Conventional circuits, in which tubes of this type have been employed, have customarily been arranged so that the energizing potential applied to the starter electrode has been positive with respect to the cathode potential, but less positive than the potential upon the main anode. In order to initiate the main discharge, i. e. from the main anode to the cathode, with the conventional practice just described, it has been necessary to employ a starting potential of approximately 85 volts, and the resistance in series with the starter electrode has been limited, practically, to a maximum of approximately 20 megohms.

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An object of this invention is to provide a novel method of operating a cold cathode type tube which will require decreased starting potentials.

Another object of this invention is to provide a novel method of operating a cold cathode triode tube, which will permit the utilization of greater resistances in series with the starter electrode.

The values and operational characteristics, above set forth, apply to the types of cold cathode triode relay tubes customarily employed in conjunction with an energizing coil of a relay, which is actuated by the current flow through the tube, for example, such commercially available tubes as the OA4G and the 1C21, the OA4G tube employing argon as the inert gas, and the 1C21 tube employing neon.

The high starting electrode potentials necessary for operation in the conventional circuits and under conventional practices place a limitation upon the sensitivity of a control circuit utilizing cold cathode triode tubes of the type described above. Another object of this invention is the provision of improved electrical control circuits which utilize cold cathode type tubes having greatly increased sensitivity and greatly improved characteristics.

A further object of this invention is the provision of improved electrical control circuits utilizing cold cathode type tubes and operating these tubes in such a manner that the tubes exhibit a sensitivity greater than that exhibited by cold cathode tubes when operated in the conventional manner.

A further object of this invention is the provision of an improved construction for cold cathode type tubes which results in improved operating characteristics and increased sensitivity.

Another object of this invention is to provide improved means and methods for the operation of cold cathode type relay tubes to obtain greater sensitivity than could heretofore be obtained with respect to minimum starting potentials and to the current requirements of such tubes.

Still another object of this invention is to provide an electrical control circuit, having included therein a cold cathode type tube, wherein the starting circuit is effective when closed through conductive elements having extremely high values of resistance.

A further object of this invention is to provide a water level control system including an elec-

trical circuit employing cold cathode relay tubes, responsive to the water level and operated by currents passing through the water system, even when such water possesses relatively high resistance values.

Another object is the provision of a light-responsive electric control circuit having improved sensitivity characteristics.

An additional object of this invention is to provide a light-responsive electric control circuit employing cold cathode type tubes having improved sensitivity characteristics, and including a manually controlled sensitivity adjustment.

Further objects and advantages of this invention will be apparent from the following specification, and from reference to the annexed drawings, and will be pointed out in the appended claims.

Referring to the drawings:

Figure 1 is a circuit diagram of a control circuit embodying the principles of this invention;

Fig. 2 is a schematic representation of an automatic water level control device or indication, employing the control circuits of this invention;

Fig. 3 is a circuit diagram of a light-responsive circuit employing a control circuit embodying the present invention; and

Fig. 4 is a circuit diagram of another light-responsive circuit employing this invention.

In order to obtain improved sensitivity characteristics such as have not been heretofore obtained in cold cathode tubes, a cold cathode tube of substantially different construction is provided in accordance with and embodying the present invention. This improved cold cathode type tube is provided with the same elements found in a conventional cold cathode type tube, namely: a main anode, a cathode, and a starter electrode, and has in addition, another electrode, preferably located externally of the glass envelope containing the other tube elements.

The novel and preferred construction may be obtained by modifying a conventional type tube. This is accomplished by the addition of an external electrode which may be suitably provided by externally coating a major portion at least of the glass envelope of a conventional cold cathode type tube with a suitable conducting material, such, for example, as a layer of colloidal graphite or a metal or other conductive layer or film as might be provided by metal spraying. A minor part of the glass envelope of the tube may, if desired, be left uncoated to permit visual observation of the tube elements and to permit visual observation of the aforementioned glow, as indicative of the main discharge. The external electrode may be conveniently connected to one terminal of the tube. This connection may be accomplished by extending a narrow band or streamer of the same conducting material over the surface of the usual non-conducting base of the tube so as electrically to connect the external electrode to the terminal to be used. In the coating operation, and in the application of the conducting material over the base of the tube, it is desirable to avoid leading the coating over sharp edges, as this may tend to break the circuit. To overcome this difficulty it is preferred that the edges of the base be bevelled in order to eliminate such sharp edges. In addition, the external electrode when formed of sensitive materials could easily be damaged by rubbing or other contact in handling. The application of several layers of shellac or other non-conducting plastic material over the external electrode is preferred for protective purposes.

In the specific construction set forth herein, the external electrode functions in part as an aid to a means for ignition and also serves to increase the sensitivity of the tube by causing a partial ionization of the inert gas contained therein, and in addition serves to shield the tube from the effects of external electrical fields. Thus the external electrode functions to cause partial ionization and to pre-condition the tube for extremely sensitive response characteristics. The internal or starting electrode is employed to increase the amount of ionization and furthermore provides a ready means to control the initiation of the main discharge between the main anode and the cathode.

It is of considerable importance that proper potential and phase relationships be established between the internal and external electrodes. Improved results have been obtained when the potential applied to the external electrode is in phase with the main anode supply. It has also been found advantageous to keep the potential applied to the starter electrode 180° out of phase with the potential applied to the external electrode at all times. Thus the starter electrode potential is negative with respect to the cathode potential; while at the same time, the external electrode potential and the main anode potential are positive with respect to the cathode potential. This status is maintained while the tube is conducting. By the use of an external electrode and by employing varied phase relationships, the sensitivity of the tube and the stability of tube performance are greatly enhanced. The employment of the external electrode greatly reduces, and in many cases eliminates, the fluttering which is frequently common in the operation of previously known cold cathode type tubes, and which leads to unstable operation of such tubes and to poor control characteristics.

The novel construction of the cold cathode type tube described above yields improved characteristics with respect to the potential required by the starter electrode and with respect to the permissible resistance which may be included in the starter circuit. When employing the novel types of tubes according to the present invention, there is required only approximately 65 volts to be applied to the starter electrode to "trigger" the main discharge. In an arrangement as above described it is furthermore possible to include resistances in the neighborhood of 100 megohms in series with the starter electrode, which result in very small currents flowing through the starter electrode circuit. In addition, the novel construction provides a trigger tube circuit having greater sensitivity and stability, and requiring a much smaller amount of electrical energy for starting purposes than has been required in the case of previously conventional circuits.

In Fig. 1, there is illustrated a preferred embodiment of a control circuit embodying the principles of this invention. Transformer 10 provides a convenient method of deriving the requisite potentials and phase relationships from power sources of the type usually encountered, namely 110 volts or 220 volts, alternating current. Primary winding 11 is designed to have 220 volts impressed across the outer terminals 12 and 13 thereof, and is provided with a center tap 14, so that 110 volts may be impressed between this tap and each of the main terminals. When the full

primary winding 11 is utilized, the transformer 10 has substantially a 1:1 ratio; and when used upon a 110 volt supply, i. e. utilizing the center tap 14, it has a step-up ratio of 1:2. Thus when properly connected to a power source of either 110 or 220 volts A. C., the secondary winding 15 delivers about 220 volts between the terminals 16 and 17 thereof, while the center tap 18 provides a potential for the tube operating circuit of 110 volts and a potential for the tube starting circuit of 110 volts, the latter potential always being 180° out of phase with the potential applied to the operating circuit.

A gas-filled, cold cathode, relay tube 19, which may be a type OA4G or 1C21 modified in accordance with this invention or may be an integral unit embodying the construction of this invention, has its cathode 28 directly connected to the center tap 18 of the transformer secondary and its anode 18' connected to one terminal of the energizing coil of the relay 20, the other terminal of this relay coil being returned to end-tap 16. The external electrode 19' of the tube 19 is connected to the movable arm of a potentiometer P_1, which in turn is connected across the 110 volt supply between center tap 18 and end-tap 16 of the transformer secondary. This arrangement serves to provide the external electrode 19' with a potential in phase with the main anode potential and having a value determined by the potentiometer setting. Relay coil 20 is shunted by a holding circuit comprising condenser 21 in series with a resistor 22. As the tube 19 only conducts during the portion of the cycle during which the main anode is positive, the energy stored in condenser 21 maintains the relay coil in an energized condition, by slowly discharging through resistor 22 when the tube 19 is non-conducting. Resistor 22 likewise safeguards the tube from an abnormal flow of plate current, which may occur through an accidental lowering of the impedance of some of the circuit elements hereinafter described.

The starting circuit, connected across terminals 17 and 18 of the secondary of the transformer, comprises impedances 23 and 24, which may be either resistances or capacitances, or by other circuit elements composed of a combination of the two. When the switch 25 is closed, these two impedances are connected in series across the starting winding, i. e. the portion of the transformer secondary included between taps 17 and 18, so that they function as a voltage dividing network, providing a voltage of less than 110 volts between the tap 18 and a point intermediate the two impedances. Impedance 24 is preferably greater than one-half the value of impedance 23 for the voltages and the types of tubes mentioned above. The terminal of impedance 23 not connected to the terminal 17 of the transformer 10 is permanently connected through a resistor 26 to the starting electrode 27 of the tube 19.

The control circuit illustrated in Fig. 1 operates as follows:

A voltage of proper magnitude and in phase with the main anode potential is applied to external electrode 19' of the tube 19. Switch 25 is assumed to be closed and thus the potential difference between the starter electrode 27 and cathode 28 of the tube 19 is equivalent to the potential drop across impedance 24. It is also assumed that substantially no current flow takes place through resistor 26, so that the potential upon the starter electrode 27 is not diminished

by any voltage drop in this resistor. It is to be noted that the voltage applied to the starter electrode is 180° out of phase with the voltage applied to the external electrode 19' and to the main anode 18', i. e. the starter electrode 27 is negative when the external electrode and main anode are positive. Owing to the voltage dividing action of the two impedances 23 and 24, the peak voltage impressed upon the starting electrode 27 is not of sufficient magnitude to initiate the main tube discharge, being in the case of the novel tube types of the present invention, below 65 volts. However, when the switch 25 is opened, the voltage dividing network ceases to be effective, and the full 110 volts derived from transformer terminals 17 and 18 is applied to the starting electrode 27 via impedance 23. Thus when the switch 25 is opened, a potential difference of 110 volts appears between the starting electrode 27 and the cathode 28. This potential of the starting electrode 27 is sufficient to cause a current flow from the cathode to the starting electrode, which current flow initiates ionization of the gaseous filler, and the resulting ionization permits the formation of the main discharge between the main anode 18' and the cathode 28.

The relay function of tube 19 is as follows. The voltage applied to the starting electrode 27 is sufficient to trigger the tube, thereby initiating the main tube discharge between cathode 28 and main anode 18'. The value of resistor 26 is usually so high relative to impedance 23, that no voltage drop of appreciable magnitude occurs in this impedance.

Upon the occurrence of the main tube discharge, relay coil 20 is energized. When the voltage cycle alternates, making anode 18' negative, the tube discharge will, of course, cease. However, during the interval of no-current flow, holding condenser 21 serves to maintain the relay coil 20 energized, by discharging therethrough, via resistor 22. Thus relay coil 20 will remain in an energized condition during the non-conducting half cycle as long as the switch 25 remains open.

Upon the closure of switch 25, the circuit resumes the condition originally described, impedances 23 and 24 constituting a voltage divider, and the voltage consequently impressed upon starter electrode 27 is reduced below a value sufficient to initiate the main tube discharge, the main discharge ceasing during the next alternation of the cycle rendering anode 18' negative. During the operation of this device, the presence or absence of the characteristic flow discharge in tube 19, affords a visual indication of the energization or non-energization of the relay coil 20.

In Fig. 2 there is illustrated an automatic boiler control or indicator means employing an electrical control circuit of the type illustrated in Fig. 1.

The employment of a gas-filled cold cathode relay tube of the specific construction taught herein, and included in an electrical control circuit wherein the voltage applied to the starter electrode is 180° out of phase with the potential applied to the external electrode and the main anode, provides a device peculiarly sensitive to currents of small amperage passing through an aqueous medium, even when such medium has a relatively high resistance value. The illustrated circuit will operate with a minimum of fluctuation and variation irrespective of the varying resistance fluctuations inherent in the water

contained in the boiler. This feature is of particular importance in view of the fact that the resistance characteristics of boiler feed water vary considerably.

In Fig. 2, the boiler 30 is subject to automatic control with respect to the level of water maintained therein. Loss of water with a resultant lowering the water level within the boiler causes automatic replenishment from a suitable supply, until the level again reaches a predetermined point. Failure of the water replenishment operation brings about a cessation of the operation of the boiler heating device, when the water level falls below a predetermined danger point.

Boiler 30 is partly filled with water, the level of which it is desired to maintain within certain limits, the optimum level being indicated at 31. The boiler is filled from a suitable water supply via pipe 32 and valve 33, the latter being of the remotely controlled type, such as that employing an electrically actuated solenoid. The boiler is heated by any suitable means, diagrammatically indicated at 34. It is assumed that this heating means is likewise electrically controlled, and operates only when electrical energy is supplied thereto through conductors 35, an indicating lamp 36 being shunted across these conductors, as well known in the art. Controlling energy flows into the heating device only when the circuit between conductors 35 and the main conductors 37 connected to the power source is closed, such closure taking place via the upper contact 38 of a relay 39, which contact is arranged to be normally closed when the relay is de-energized. The circuit actuating valve 33, by connection thereof to power leads 37, is normally open, and is closed via upper contact 40 of a relay 41, this contact being normally open when relay 41 is de-energized.

The gas tube relay circuits of this device are generally of the type described in Fig. 1 and have the output discharge circuits thereof connected between mid-tap 42 and upper terminal 43 of the secondary winding of a transformer 44, the primary 45 of which is fed from the main power supply via leads 37 and main control switch 46. Relay coil 39 is energized when gas relay tube 47 is triggered, the relay coil 39 being shunted by a holding circuit comprising condenser 48 and resistor 49, which functions as previously explained in connection with Fig. 1. Another gas relay tube 50 similarly controls the energization of relay coil 41, shunted by another holding circuit including capacitor 51, and resistor 52, functioning in similar fashion. The cold cathode type tubes illustrated in this figure are shown as conforming to the improved construction of this invention.

When relay coil 39 is energized, the upper contact 38 is opened, thereby cutting off the heat supplied to the boiler. Simultaneously, lower contact 53 is closed, completing the primary circuit of signalling transformer 54. Across the secondary of this transformer is connected a bell 55, or other suitable indicating or alarm means, via a controlling resistor 56 and a switch 57.

Extending into boiler 30 are three control electrodes 65, 66 and 67, each located at a predetermined level, and suitably insulated from the body of the boiler, so that the circuit from each electrode to ground is completed through the water in the boiler and a ground connection 58, made to the body of the boiler, the cathodes 59' and 58 of tubes 47 and 50 respectively also having a common ground at point 59.

Tube 47 has the control or starting electrode thereof connected through limiting resistor 60 and voltage divider resistor 61 to the other terminal 62 of the secondary winding of transformer 44, this winding affording approximately 110 volts between the mid-tap 42 and each end thereof, terminals 43 and 62 being opposite in phase. Tube 50 also has its control electrode connected through a limiting resistor 63 and a voltage divider resistor 64 to terminal 62. Each of the tubes 47 and 50 have their external electrodes 47' and 50' connected to the movable arms of the potentiometers P_2 and P_1 respectively, in a manner similar to that described in Fig. 1.

The lowest boiler electrode 65 is connected to a point between resistors 60 and 61, while the upper boiler electrode 66 is connected to a point between resistors 63 and 64. The intermediate boiler electrode 67 is connected to electrode 66 through the normally closed lower contact 68 of relay 41.

The device of Fig. 2 embodies two relay control circuits of the type previously described in connection with Fig. 1, the voltage dividers in the respective control circuits of the two gas relay tubes being comprised, respectively, by resistor 61 together with the water in the boiler making contact with electrode 65, and resistor 64, together with the boiler water making contact with electrodes 66 or 67, as hereinafter explained.

With the water at a normal level, as indicated at 31 in the drawing, the voltage divider circuits reduce the voltages applied to the control electrodes of both tubes below the critical actuating potentials required to initiate the tube discharges. Under these conditions, contacts 38 are closed and the heater 34 is in operation. Likewise contacts 68 are closed and electrodes 66 and 67 are inter-connected. When the water level falls below electrode 67, the voltage divider circuit including resistor 64 is opened, whereby ignition voltage, corresponding substantially to the full voltage available from transformer taps 62 and 42 is applied to tube 50, thereby firing this tube, actuating relay 41, breaking the connection between electrodes 66 and 67, and opening valve 33 by the closure of contact 40.

Water now enters the boiler, the level in which rises until contact with electrode 67 is again established. However electrode 67 is electrically isolated, because contacts 68 are now open. Accordingly the water level continues to rise until electrode 66 is reached, when the reestablishment of the voltage divider circuit including resistor 64 extinguishes tube 50, thereby de-energizing relay 41, closing valve 33 and reconnecting electrodes 66 and 67. The control circuit is now re-established in its original form, which it will maintain until the circuit through electrode 67 is again broken by water level 31 falling below this electrode.

If the water level in the boiler is not restored, after falling below electrode 67, which may arise from some failure in the operating cycle just described, or due to a failure of the water supply, the water level will continue to fall until it goes below electrodes 65, this last electrode being located at a point in the boiler below which it would be dangerous to allow the water to fall. A falling of the water level below electrode 65 will destroy the voltage divider circuit including resistor 61, so that full ignition voltage from transformer terminal 62 is then applied to tube 47, thereby firing this tube and actuating relay

39. Consequent opening of contacts 38 will cause a cessation of the operation of heater 34, thereby saving the boiler from possible harm due to a dangerously low water level therein. The simultaneous closure of contacts 53 will complete the circuit to the primary of transformer 54, thereby actuating signal device 55, switch 57 being normally closed and resistor 56 being adjusted to any suitable desired operating point. Manual opening of switch 57 will stop the alarm signal.

When the foregoing series of operations due to a dangerously low water level have taken place, refilling of the boiler with water will cause relay tube 47 to extinguish, when contact 65 has again been covered by the rising water level, thus re-establishing the voltage divider circuit including resistor 61, in the manner already described in connection with the operation of relay tube 50. Such extinguishing of tube 47 will de-energize relay 39, thereby permitting the manual closure of switch 57 without causing the alarm means 55 to operate and causing heater 34 again to function.

The filling of the boiler proceeds as follows. Since the water level is still below electrode 67, the circuits of gas tube relay 50 are still functioning as previously described, so that filling valve 33 does not close until the water level has once more reached electrode 66, at which time relay tube 59 is again extinguished in the manner previously described, thereby closing valve 33 and restoring the entire system to a normal operating condition.

The various electrical values of the components of this device are in accordance with the principles discussed in connection with Fig. 1, so that a repetition of the detailed description thereof is not deemed here necessary. For example, transformer 44 may have a tapped primary winding, to allow the use thereof upon power circuits of various voltages. Likewise, since voltage divider resistors 61 and 64 have much higher values of resistance than do the respective water paths completed via the various electrodes in the boiler, the resistance ratios discussed in connection with the circuit of Fig. 1 are here satisfied. The visible glow discharges of the two relay tubes afford visual monitoring of the system.

Figs. 3 and 4 illustrate two light-responsive electrical control circuits utilizing the principles of this invention. In Fig. 3 all elements are similar to those in Fig. 1, and bear similar reference characters, except that the voltage dividing circuit has in lieu of impedance 24 of Fig. 1, a resistance 24'; and in lieu of impedance 23 of Fig. 1, a photo-electric cell 23'. Variable tap 25' substitutes for switch 25 of Fig. 1 and is adjusted so that the portion of 24' thereabove bears to the part therebelow, and to the dark photo-cell in series therewith, an impedance ratio satisfying the conditions discussed in connection with Fig. 1. The previously discussed sensitivity of the circuit of this invention allows the use of relatively high resistance for 24', thereby increasing the effective output of the cell, and thereby the overall sensitivity of the device.

The operation of the light-sensitive relay circuit is according to that already described in Fig. 1, in that an increase of out-of-phase voltage upon the starting electrode 27 triggers the gas filled tube. The voltage divider circuit is adjusted, according to the characteristics of the photo-cell, the voltage between 17 and 18 being reduced, if needed, as in the case of gas type photo-cells. Tap 25' is adjusted to apply less than starting voltage to tube 19, when the cell is dark. Illumination of the cell lowers the impedance thereof increases the IR drop across resistor 24', and consequently raises the voltage at tap 25' to a value sufficient to fire the gas relay tube. Tap 25' may be adjusted to give either a small or a great difference of potential from the firing voltage, thereby determining the degree of excitation of the cell 23' which will be needed to trigger the tube.

Fig. 4 is identical with Fig. 3, except that elements 23' and 24' have been reversed in position. In this form, the photo-cell 23' is normally illuminated, and tap 25' adjusted to place upon starting electrode 27 a potential below that needed to fire the tube, by a degree corresponding to the sensitivity desired. Darkening of cell 23' increases the impedance thereof and raises the potential upon tap 25', so as to trigger tube 19, thereby making the device operative upon decrease of illumination, instead of upon an increase thereof, as was the case in Fig. 3. In both Figs. 3 and 4, the relay holding circuit functions as previously described for Fig. 1, resistor 26 here acting additionally to safeguard the photo-cells.

While I have shown and described certain forms and uses of this invention, many others will be apparent to those skilled in the art, and I wish to be limited only by the scope of the appended claims, which are to be construed validly, as broadly as the state of the prior art permits.

What is claimed is:

1. An electrical control circuit, comprising a gas filled cold cathode type tube including an anode, a cathode, a starter electrode and an external electrode, of the type wherein the starter electrode is normally used for effecting a starting discharge between said starter electrode and said cathode, means for applying an alternating operating voltage to said anode and said cathode, circuit means for applying an alternating potential to said external electrode which in phase with the operating voltage applied to said anode and said cathode, starting circuit means for applying an alternating potential out of phase with said alternating operating voltage to the starter electrode and which provides a current path through said starter electrode and said cathode, and means for causing said starting circuit means to carry current flowing from said cathode to said starter electrode and adapted to ionize gas in the tube sufficiently between said cathode and said starter electrode to cause the tube to become conductive with current flowing between said anode and said cathode.

2. An electrical control circuit, comprising a gas filled cold cathode type tube including an anode, a cathode, a starter electrode and an external electrode, of the type wherein the starter electrode is normally used for effecting a starting discharge between said starter electrode and said cathode, means for applying an alternating operating voltage to said anode and said cathode, circuit means for applying an alternating potential to said external electrode for increasing the sensitivity characteristics of said tube, said alternating potential being in phase with the operating voltage applied to said anode and said cathode, starting circuit means, including a voltage dividing network, for applying an alternating potential 180° out of phase with said alternating operating voltage to the starter electrode and which provides a current path through said

starter electrode and said cathode, and means for causing said starting circuit means to carry current flowing from said cathode to said starter electrode and adapted to initiate sufficient ionization of the gas within the tube between said cathode and said starter electrode to cause the tube to become conductive with current flowing from said anode to said cathode.

3. An electrical control circuit, comprising a transformer having a center tapped secondary; a load circuit connected between the center tap and a first end tap of the secondary of said transformer including a gas filled cold cathode type tube having an anode, a cathode, a starter electrode and an external electrode, of the type wherein the starter electrode is normally used for effecting a starting discharge between said starter electrode and said cathode, and an electrical load means which is series connected in the anode circuit of said tube; said transformer and the connections thereto providing a source of alternating operating voltage for said load circuit; circuit means for applying an alternating potential to said external electrode in phase with said operating voltage including a potentiometer connected between said center tap and said first end tap of said transformer; starting circuit means connected to said center tap and a second end tap of said transformer for applying an alternating potential, 180° out of phase with said alternating operating voltage applied to said load circuit, to said starter electrode and which provides a current path through said starter electrode and said cathode, said starting circuit means including a voltage dividing impedance network to control the magnitude of the potential applied to the starter electrode, and means for causing said starting circuit means to carry current flowing from said cathode to said starter electrode and adapted to ionize gas in the tube sufficiently between said starter electrode and said cathode to cause the tube to become conductive with current flowing from said anode to said cathode, said last mentioned current flow energizing said electrical load means.

4. An electrical control circuit, comprising a gas-filled cold cathode type tube including an anode, a cathode, a starter electrode and an external electrode, of the type wherein the starter electrode is normally used for effecting a starting discharge between said starter electrode and said cathode, means for applying an alternating operating voltage to said anode and said cathode, circuit means for applying an alternating potential to said external electrode, said alternating potential being in phase with the operating voltage applied to said anode and said cathode, starting circuit means for applying an alternating potential, out of phase with said alternating operating voltage, to said starter electrode and which provides a current path through said starter electrode and said cathode, said starting circuit means including a voltage dividing impedance network to control the magnitude of the potential applied to said starter electrode, a light-responsive variable impedance included in said network for determining the magnitude of the potential applied to said starter electrode, and means for causing said starting circuit means to carry current flowing from said cathode to said starter electrode and adapted to ionize gas in the tube sufficiently between said cathode and said starter electrode to cause the tube to become conductive with current flowing from said anode to said cathode.

5. An electrical control circuit according to claim 4, wherein said light-responsive variable impedance comprises a photo tube so arranged in said network as to cause said cold cathode type tube to conduct when the intensity of light received by the photo tube surpasses a predetermined value.

6. An electrical control circuit according to claim 4, wherein said light-responsive variable impedance comprises a photo tube so arranged in said network as to cause said cold cathode type tube to conduct when the intensity of light received by the photo tube falls below a predetermined value.

7. An electrical control circuit, comprising a gas filled, cold cathode type tube including an anode, a cathode, a starter electrode, and an external electrode, of the type wherein the starter electrode is normally used for effecting a starting discharge between said starter electrode and said cathode, means for applying an alternating operating voltage to said anode and said cathode, circuit means for applying an alternating potential to said external electrode which is in phase with the operating voltage applied to said anode and said cathode, said circuit means including a potentiometer resistance connected substantially in parallel with said anode and said cathode and a variable tap contacting said potentiometer resistance connected to said external electrode, starting circuit means for applying an alternating potential, out of phase with said alternating operating voltage, to said starter electrode to provide a current path through said starter electrode and said cathode, and means in said starting circuit means for varying the potential on said starter electrode in respect to the potential of said cathode so as to provide a predetermined potential on said starter electrode adequate to fire said tube.

8. An electrical control circuit, comprising a gas filled, cold cathode type tube including an anode, a cathode, a starter electrode and an external electrode, of the type wherein the starter electrode is normally used for effecting a starting discharge between said starter electrode and said cathode, means for applying an alternating operating voltage to said anode and said cathode, circuit means for applying an alternating potential to said external electrode which is in phase with the operating voltage applied to said anode and said cathode, starting circuit means for applying an alternating potential, out of phase with said alternating operating voltage, to said starter electrode to provide a current path through said starter electrode and said cathode, said starting circuit means including a voltage divider circuit, an intermediate point of which is connected to said starter electrode, and means for shifting the division of voltage in said voltage divider circuit, so as to increase the potential of said starter electrode to a value sufficient to cause the tube to fire.

9. An electrical control circuit in accordance with claim 8, in which said voltage divider circuit comprises split impedances including two series-connected branches, the junction of which branches is connected to said starter electrode, one of said branches including a photo cell, said impedances and the impedance of said photo cell being of such value that the potential of said starter electrode may be changed by change in the light condition to which said photo cell is subjected so as to fire the tube.

10. An electrical control circuit in accordance

with claim 8, wherein said voltage divider circuit comprises a potentiometer resistance and a photo cell connected in series, and wherein said starter electrode is connected to an adjustable tap contacting said potentiometer resistance, the impedance of said potentiometer resistance and said photo cell being such that the potential of said starter electrode may be varied by the light condition to which said photo cell is subjected between a potential sufficient to fire the tube and a potential insufficient to fire the tube, and so that the light condition effective to fire the tube is a variable which can be determined by the setting of said tap on said potentiometer resistance.

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