June 27, 1944. W. F. WOLFNER, 2D 2,352,240

ELECTRONIC APPARATUS

Filed May 19, 1941

Fig. 1

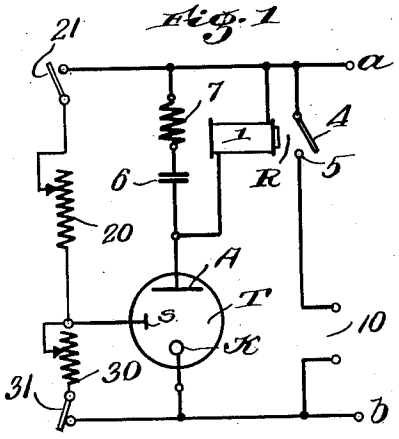


Fig. 2

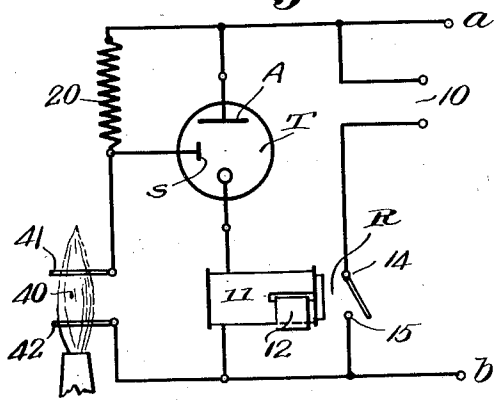


Fig. 3

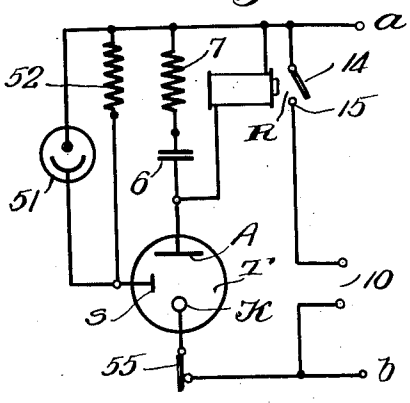
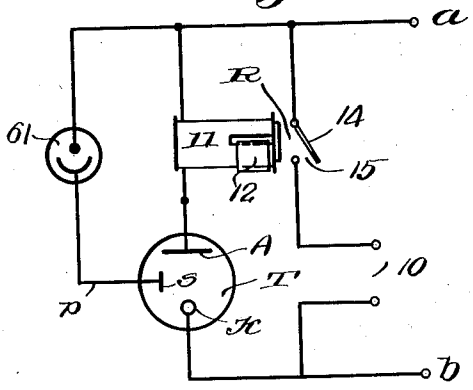


Fig. 4



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2,352,240

ELECTRONIC APPARATUS

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Application May 19, 1941, Serial No. 394,232

2 Claims. (Cl. 250—41.5)

This invention deals with electronic apparatus of the glow discharge type, and particularly with the utilization of such apparatus for operating detecting, control, relay or similar electric apparatus.

As well known, electronic tubes of this type comprise in addition to cathode and anode in a gas filled envelope, a control electrode or starter anode which initiates current flow through the tube if a certain potential is applied to the control electrode, whereupon the tube becomes fully conductive whereas, if supplied with alternating current, it is substantially non-conductive so long as the potential level of the control electrode remains below that value; if it is supplied with direct current, the tube will remain conductive so long as an effective potential difference is applied to cathode and anode.

It is the object of the invention to provide a very sensitive and yet reliable circuit incorporating such tubes which is easily adaptable to varying operating conditions and especially suitable for detecting such operating conditions, as for example the burning of a flame, with the simplest possible means requiring low cost of operation and maintenance.

Although other tubes can be used for this purpose, I prefer to employ glow-discharge tubes with cold cathode which require practically no energy while being held in readiness for operation and which, during operation with alternating current, consume only a small amount of control energy supplied to cathode and control electrode for effecting a glow discharge and hence an ionized current path between cathode and control electrode, which path renders and maintains the tube conductive.

According to an important aspect of the invention, I connect such a tube directly to a current supply source in such a manner that the response can be determined exactly and with permanent adjustment independent of the load or tube current so that certain operation of a responsive or control element such as a solenoid is insured; this arrangement may normally provide or hold in readiness either the current path through or the potential supply to cathode and starting anode, both of which conditions are necessary for initiating current flow through the tube which will begin as soon as the additionally necessary potential or current, respectively, are applied. By properly correlating detecting circuit and tube characteristics it is even possible, according to another aspect of the invention, to dispense with such provisions, that is, have neither current path nor potential supply initially in readiness but provide both directly when the detecting circuit is conditioned for making the circuit responsive. This last-mentioned modification is the simplest possible circuit of this type and therefore especially valuable under certain operating conditions.

These and other objects and aspects of my invention will be apparent from the following descriptions of several practical embodiments thereof by way of example, this description refers to a drawing showing in Figs. 1 to 4 diagrams of these embodiments.

In Fig. 1 two line terminals *a*, *b* indicate a source of alternating current supplying a tube T (for example of R. C. A. type OA4–G) with cathode K, anode A and starting anode *s*. Between anode A and terminal *a* is connected a controlled circuit with a load appliance, for example relay unit R with magnet 1 and switch 4, 5 normally interrupting an actuating circuit 10 connected to source *a*, *b*. A condenser 6 is connected in parallel to magnet 1 in order to retain the latter energized during the half cycles when the tube current is interrupted. A resistance 7 is provided in series with condenser 6, for the purpose of limiting the peak current through 6 at the instance when tube T becomes conductive; without this resistance, condenser 6 would at that moment practically short circuit the supply.

Connected between starting anode *s* and anode terminal *a*, and starting anode *s* and cathode terminal *b* is a controlling circuit with two impedances 20 and 30, respectively, one or both of which may be variable. In the present instance both impedances are indicated as variable, and in series therewith may be arranged switches 21 and 31, respectively.

The impedances 20 and 30 can be so controlled that the control value of the potential difference between *b* and *s* is either higher or lower than its starting value; one or both resistances may be rendered normally infinite by means of switches 21 and 31. The control value of the current flowing at any time through electrode *s* may likewise be higher or lower than the starting value, depending upon the operation of the circuit in question, as will appear more clearly hereinafter.

Assuming, for example, that switches 21 and 31 are closed, impedances 20 and 30 can be so correlated that the above-mentioned potential difference between *b* and *s* will maintain tube T normally non-conductive, and relay R deener-

gized, which condition is indicated by the non-glowing state of the tube.

If the potential level of *s* relatively to K is now raised to the starting value by decreasing impedance **20** relatively to impedance **30**, the starting energy can be applied since a starting current path is provided through **20**; tube T becomes conductive and glowing, energizing magnet **1** which closes switch **45** of controlled circuit **10**.

In certain practical instances it may be preferable to render the tube conductive by closing normally open switch **21** with **31** closed, or by opening switch **31** while **21** remains closed. In the first instance, impedance **20** is normally infinite and the starting potential normally available through impedance **30**; in the second instance, the tube will be normally conductive with a starting current path always provided by impedance **20** and the potential of *s* maintained sufficiently high due to the infinite value of resistance **30**. By closing switch **31**, the potential level of *s* is reduced below the starting value, and tube T becomes non-conductive.

Circuits of the latter type are especially valuable for example for purposes of flame control, and a practical arrangement of this character is shown in Fig. 2. In this figure impedance **30** and switch **31** are represented by a detecting arrangement consisting of two probes **41**, **42** extending into a flame **40**. The impedance **20** so dimensioned with regard to the impedance of flame **40** that *s*, so long as the flame is burning, will be at a potential level low enough to prevent tube T from becoming conductive. As soon as the flame is extinguished, the potential level of *s* raises and since a current path is permanently provided through **20**, the tube will become conductive and relay R will energize circuit **10**, for example for ringing an alarm or closing a fuel supply valve.

The control circuit may be continuously energized by providing, instead of condenser **6** (Fig. 1), a split magnet **11** with heavily shaded pole **12**.

By taking proper safeguards according to another aspect of the invention, the circuit can be operated without impedance **30**, and two such arrangements are shown in Figs. 3 and 4.

Fig. 3 illustrates a light sensitive arrangement, impedance **20** being represented by a phototube **51** and a resistor **52** in parallel thereto; the other elements are the same as in Fig. 1. The value of **52** is such that the current which is normally permitted to pass through electrode *s* and cathode K is below the value sufficient to supply the necessary starting energy. It will be noted that the starting electrode may well be above the starting potential level without being able actually to start the tube, since the current between *s* and K is kept below the value necessary for ionizing the tube.

In Fig. 3, when phototube **51** is illuminated and hence its impedance lowered, the current flowing between *s* and *a* will reach the starting value and tube T becomes conducting. Once the tube is started, the current passed by **52** will be sufficient to maintain it conductive although the starting anode potential may drop below the starting value, until the supply circuit is interrupted, as for example by means of switch **55**. Hence, magnet **1** remains energized even if the phototube should again become essentially non-conductive, this alternating current circuit being suitable when commencement of a supervised condition is required to maintain energization of a control circuit regardless of the duration of that condition.

In Fig. 4, impedance **30** is permanently infinite; and impedance **20** and switch **21** are represented by a phototube **61**; otherwise the circuit may be similar to that of Figs. 1 or 2. So long as tube **61** is dark, neither starting potential nor starting current will be effective at *s*. If the phototube is of a suitable type and sufficiently illuminated to pass the starting current, and to apply to *s* the potential necessary for starting, tube T will become conductive and relay R energized. This circuit, therefore, permits selection of its operating range merely by correlation of the characteristics of the two absolutely necessary elements, namely detecting means (as for example the photocell) and amplifying tube; no special setting or adjustment elements need be provided and this equipment is, therefore, especially inexpensive and rugged.

It will now be apparent that circuit variations of the type of Fig. 1, with normally closed switches **21** and **31**, make control current flow through or control potential applied to electrode *s*, or both, normally available but normally maintain at least one of them below the starting value; that the type according to Fig. 2 makes the control current normally available and depends for operation on the control potential level of *s*; that the type according to Fig. 3 makes the control potential normally available and depends for operation mainly upon the control current; and that the type according to Fig. 4 has normally neither control current nor potential available so that the detecting element has to provide both at their starting values before it can assume control of the circuit. It will also be apparent that some of the herein described embodiments of my invention can be operated with tubes whose control element does not carry current and is effective merely through its potential level. Such tubes may, for example, be controlled by electrostatical elements outside of the tube envelope.

It will further be understood that suitable ohmic capacitive or inductive impedances will be used at **20** and **30**, in accordance with the character of the particular embodiment.

Still further, operation of these circuits with direct current is possible, in which case initiation of a certain supervised condition will maintain the control circuit energized regardless of the duration of this condition; as pointed out above, the same mode of operation is possible with alternating current if the modification according to Fig. 3 is used.

It will finally be noted that the operation of these circuits is independent of the load value since the critical potential difference between cathode and control electrode is independent of the tube conductivity.

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. Electronic relay apparatus comprising an alternating current source, a gas filled electron discharge tube having a cold cathode connected to one and an anode connected to the other terminal of said source and a starter anode causing said tube to become conductive when the control values of both potential difference, and current flowing, between said cathode and said starter anode exceed predetermined starting values respectively, a controlled circuit including means responsive to the conductivity of said tube con-

nected to said source in series with said anode and said cathode, a controlling circuit including a normally high control impedance connected between said anode terminal and said starter anode and a comparatively low impedance parallel to said control impedance, said controlling circuit normally maintaining said potential control value and retaining said current control value below its starting value, and means for raising said current control value above its starting value by decreasing said control impedance and increasing the current flowing therethrough from said source.

2. Electronic relay apparatus comprising an alternating current source, a gas filled electron discharge tube having a cold cathode connected to one and an anode connected to the other terminal of said source and a starter anode causing said tube to become conductive when the control values of both potential difference, and current flowing, between said cathode and said starter anode exceed predetermined starting values respectively, a controlled circuit including means responsive to the conductivity of said tube connected to said source in series with said anode and said cathode, a controlling circuit including a phototube connected between said anode terminal and said starter anode and a resistor in parallel to said phototube, said controlling circuit normally maintaining said potential control value and retaining said current control value below its starting value, and said current control value being raised above its starting value by decreasing the impedance of said phototube and hence increasing the current flowing therethrough from said source, upon increased illumination of the phototube.

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