April 26, 1932. D. D. KNOWLES 1,855,637

GLOW DISCHARGE TUBE

Filed May 31, 1927

Fig. 1.

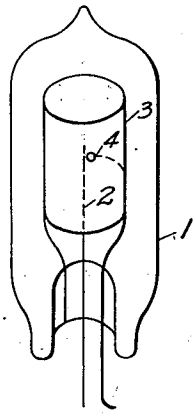


Fig. 2

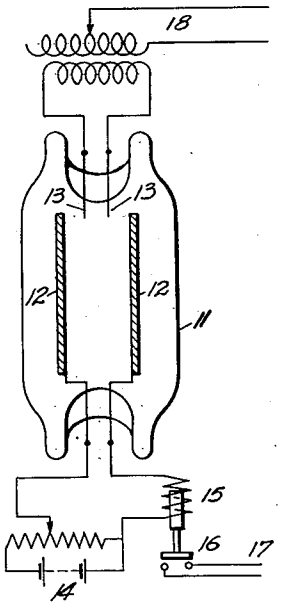


Fig. 3.

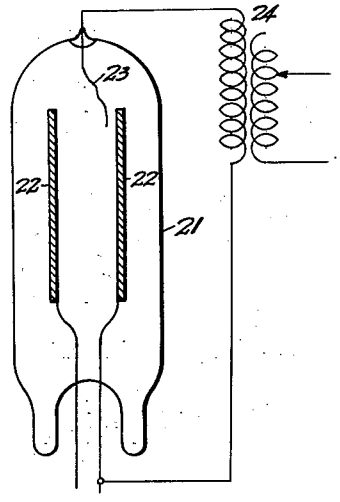
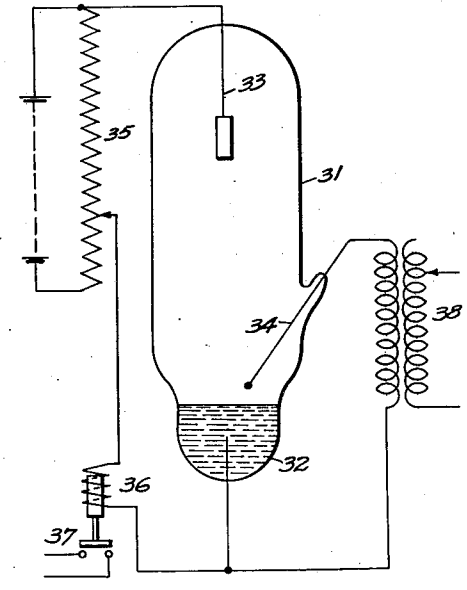


Fig. 4.



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UNITED STATES PATENT OFFICE

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GLOW DISCHARGE TUBE

Application filed May 31, 1927. Serial No. 195,163.

My invention relates to electric discharge tubes and more particularly to such tubes designed to act as relays permitting, a small change of energy to control the flow of much larger energies.

An object of my invention is to provide a relay by which relatively large amounts of energy may be controlled by an actuating cause of relatively small energy.

Another object of my invention is to provide a vacuum-tube relay which will render the circuit of its main electrodes non-conductive when a voltage below a certain critical value is impressed upon a control electrode and which will render the circuit of the main electrodes conductive when this impressed voltage is but slightly exceeded.

A further object of my invention is to produce an electrical-discharge tube in which the voltage between the electrodes remains constant over a considerable range of current, and in which the voltage needed to initiate current flow is not greatly higher than the aforesaid constant value.

Other objects of my invention will become apparent on reading this specification, taken in conjunction with the appended drawings, in which;

Figure 1 is an elevational view of a discharge tube embodying one form of my invention,

Fig. 2 is an elevational view of a discharge tube embodying my invention in another form, and cooperating apparatus and circuits indicated diagrammatically.

Fig. 3 is a similar view, showing a further modification of my invention, and

Fig. 4 is a similar view, showing another form of my invention.

An electrical-discharge tube having, as one electrode, an axial rod and, as a cooperating electrode, a cylinder surrounding said rod, the two being enclosed in a vacuum-type tube containing gas at a relatively low pressure, has been found to operate, at substantially constant voltage across its electrodes, over a considerable range of current. However, to initiate current flow in tubes of this description, it has heretofore been necessary to apply, between the electrodes, a considerably higher voltage than the constant value already referred to.

In accordance with my invention, the voltage required to initiate current flow may be reduced to a value much nearer the constant operating voltage by partly bridging the space between the cylindrical electrode and the electrode at its axis by means of a relatively small auxiliary electrode. The effect of this electrode is to reduce the starting voltage, but it has relatively little effect on voltages in the operating range of current. It, therefore, renders possible the construction of a relay tube which will conduct practically no current on voltages up to, and slightly above its operating voltage, but which will be rendered conductive by rise of voltage to values only moderately higher than the foregoing value, and which will then conduct considerable amounts of current at that same impressed voltage. Such a discharge device constitutes a relay extremely sensitive to relatively small over-voltages.

Referring to Fig. 1 of the drawings, my relay tube consists of a vacuum-tight container 1 of conventional form in which are sealed a central electrode 2, which may be in the form of a small rod, and a cooperating electrode 3, which may be in the form of a hollow cylinder surrounding the electrode 2. The tube 1 is evacuated by well-known methods and preferably filled with neon gas at a pressure of approximately one one-hundredth of an atmosphere. The interior surface of the cylindrical electrode is preferably coated with an alkali-metal, for example, potassium. A tube of such a structure as has so far been described has the property of conducting current over a considerable range at constant voltage impressed between the electrodes. The voltage required to initiate current flow, however, is approximately twice the stable operating voltage. I have found that, by attaching to the interior of the electrode 3, a small auxiliary electrode 4, projecting far enough to nearly bridge the space between the cylindrical electrode and the central electrode, the starting voltage will be reduced to within approximately 20% of the stable operating voltage of the tube. If

this auxiliary electrode 4 is of relatively small area, compared with the cylinder 3, its presence has but little effect on the stable operating voltage and it serves merely to reduce the starting voltage of the tube.

I have found that the effectiveness of the starting electrode 4 may be increased by placing a small amount of an alloy of an alkali metal with a metal of high melting point, such as magnesium upon its tip.

With a discharge tube made up in accordance with these directions, a voltage of 80 to 85 volts will be found sufficient to initiate current flow, while the tube will be found to operate over a considerable range of current at approximately 70 volts.

It will readily be apparent to those skilled in the art that these values will depend to some extent on the dimensions of the tube and the pressure and character of the gas used as a filler, and that, by varying these quantities, any value of voltage desired, within certain ranges, may be obtained.

If such a tube be connected in series with any current-responsive device and with a source of electromotive force of say 70 volts, practically no current will flow through the circuit including its electrodes. However, if this voltage be raised to, say, 85 volts, the break-down voltage will be exceeded, and current will flow through the tube in amounts limited solely by the resistance of the external circuit. Such circuit arrangements, therefore, constitute a highly sensitive and quickly-responsive voltage-controlled relay.

Referring to Fig. 2, an evacuated container 11 of an ordinary type is provided with a pair of spaced main electrodes 12 which are supported on wires which may be sealed through one end thereof, in a well-known manner. A second pair of electrodes 13 may be sealed through the other end of the tube and made to project into close proximity to the electrodes 12, as shown in Fig. 2. The distance separating the electrodes 13 may, if desired, be made substantially less than that separating the electrodes 12. The tube so constructed is exhausted by well-known methods and may be filled with neon or argon gas, or a mixture thereof, at a pressure of approximately one-hundredth of an atmosphere. The tube so constructed constitutes another form of sensitive relay and may be utilized as such by connecting, to the main electrodes 12, a source of variable electromotive force 14 in series with a solenoid 15 arranged to control the contacts 16 in a circuit 17, the current of which it is desired to control.

The auxiliary electrodes 13 are, in turn, connected to a source of electromotive force 18 in response to which it is desired to control the circuit 17. A source of electromotive force 18 may conveniently be arranged to be variable. When the electromotive force impressed across the electrodes 13 rises sufficiently to cause ionization of the gas in the tube in their neighborhood, the ions so produced will be attracted by the main electrodes 12 and will cause a discharge of electricity to take place between them under the pressure of an electromotive force from the source 14, which, in the absence of the discharge between control electrodes 13, is insufficient to cause appreciable current flow between main electrodes 12. The current flow between the electrodes 12, in response to initiation of current between electrodes 13, will operate the relay 15 to open or close the contact 16, as may be desired, and to thereby control energy flow in the circuit 17.

Since the electrodes 13 are in a circuit quite separate from the electrodes 12 and the circuit 17, the latter circuit may be controlled responsive to voltages and currents quite different from, and independent of, itself. For example, the control source 18 may be alternating current and the source 14 be direct current or vice versa. The current flow in the circuit 17 is thus rendered controllable by the circuit 18 which may be entirely different in character.

Fig. 3 shows a different modification of the relay tube shown in Fig. 2 and comprises an enclosing tube 21 for main electrodes 22. Instead of such control electrodes as 13 in Fig. 2, the current flow in the device of Fig. 3 is initiated by a discharge between the single electrode 23 and one of the main electrodes 22, thus, dispensing with one of the control electrodes utilized in the Fig. 2 modification. The control circuit 24, corresponding in function to the source 18 in Fig. 2, is connected between one of the main electrodes 22 and the single control electrode 23. Otherwise, the circuit connections of Fig. 3 may be the same as those of Fig. 2.

Fig. 4 shows still another embodiment of my invention and comprises a vacuum-type container 31 having a mercury electrode 32 at one end and a main cooperating electrode 33. A control electrode 34 may be provided, having its terminus in close proximity to the mercury electrode 32. Between the main electrodes 32 and 33 is connected a source of variable electromotive force 35, and a relay solenoid 36 may be arranged to control contacts in a circuit 37, the energy flow through which it is desired to control. However, a tube of the type illustrated in Fig. 4 can readily carry currents as high as 25 amperes and, for many purposes, this tube can therefore control the power current of the circuit 37 without the need of using such a relay as 36.

Between the mercury electrode 32 and the control electrode 34 is connected a source of varying electromotive force 38 which is energized from the circuit which is intended to control current flow in the circuit 37.

The above described container is evacuated in a manner well-known in the art and is filled with a noble gas to a pressure of approximately one-hundredth of an atmosphere.

The source of electromotive force 35 is adjusted to such value that it is just incapable of causing current flow between the main electrodes 33 and 32. The source of electromotive force 38 is likewise so adjusted that, normally it is just incapable of producing a discharge between the control electrode 34 and the mercury electrode 32. When the electromotive force of the source 38 is varied to control the circuit 37, it is so arranged that the voltage rises sufficiently to initiate a discharge between the electrodes 34 and 32. Once this has happened, the ions thus produced result in current flow from the source 35 through the electrodes 33 and 32 and the relay 36. The current in the relay 36 controls suitable contacts governing the circuit 37.

Since the source 38 is wholly separate from the source 35, the frequency or voltage of the two may be wholly different. Specifically, either one may be an alternating voltage or a direct-current voltage, and their magnitudes and frequencies are quite independent of each oher.

It is found that current flowing through the circuit between the electrodes 32 and 33 responds instantaneously to current flow in the auxiliary electrode circuit, and that the relay thus produced has practically no time lag.

It will be recognized by those skilled in the art that many modifications of the precise structure which I have here described and illustrated in my invention may be made without departing from the broad principles thereof. I accordingly desire that the terms of the claims be given the broadest reasonable interpretation, and be limited solely by their expressed terms or by the prior art.

I claim as my invention:

1. A rectifier comprising a vacuum-tight container having a pair of electrodes, one of which is of substantially larger area than the other spaced apart therein, and an arm projecting from a comparatively small surface on said larger area electrode and partly bridging the gap between said electrodes.

2. A rectifier comprising a vacuum-tight container having a pair of electrodes spaced apart therein, one of which is of a substantially larger area than the other, a gaseous atmosphere therein having a pressure of approximately one-hundredth of an atmosphere and a slender projecting arm on the larger area electrode disposed to partly bridge the gap between said electrodes.

3. A rectifier comprising a vacuum-tight container having a hollow electrode, a second electrode inside said hollow electrode and a slender arm projecting from a small area on said hollow electrode and partly bridging the gap between said electrodes.

4. A rectifier comprising a vacuum-tight container filled with gas at a pressure of substantially one one-hundredth of an atmosphere, a hollow electrode therein, a second electrode inside said hollow electrode and an arm projecting from a comparatively small area on said cylindrical electrode partly bridging the gap between said electrodes.

In testimony whereof, I have hereunto subscribed my name this 26th day of May, 1927.

DEWEY D. KNOWLES.