April 10, 1951 W. R. RAMBO 2,548,818

THERMIONIC OVERVOLTAGE PROTECTION CIRCUIT

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FIG. 1

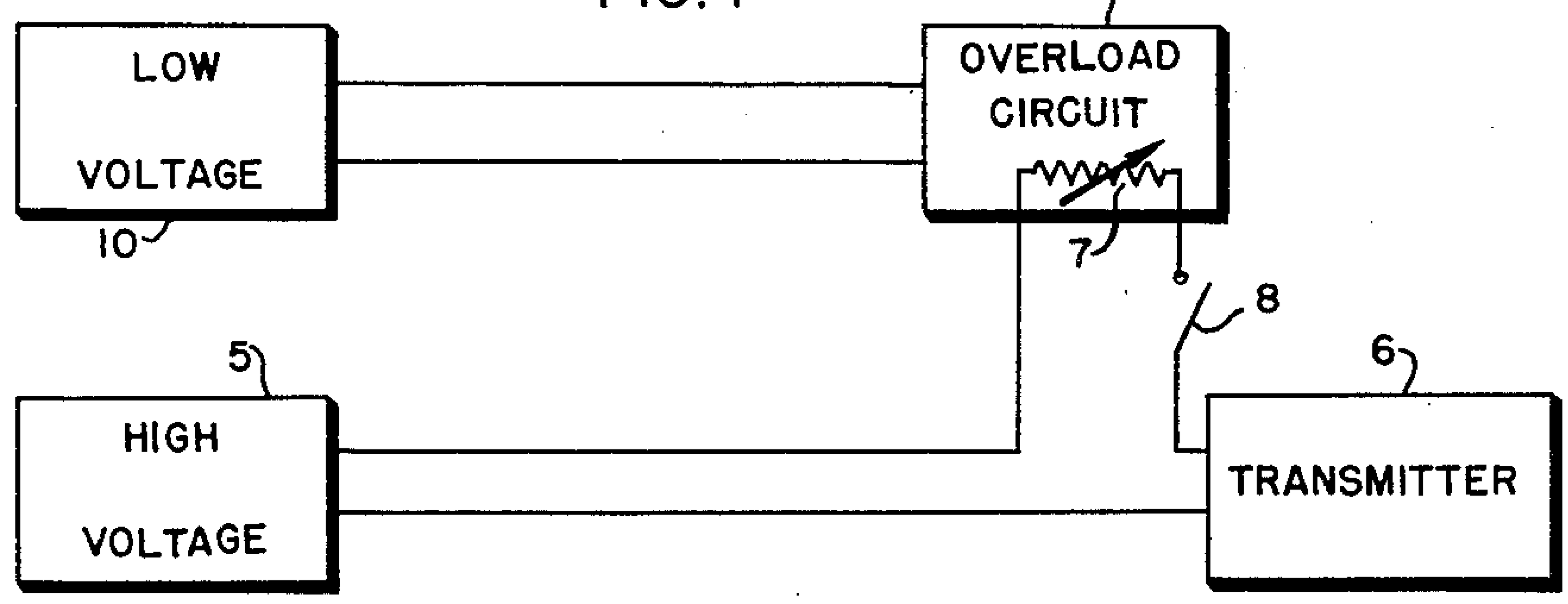
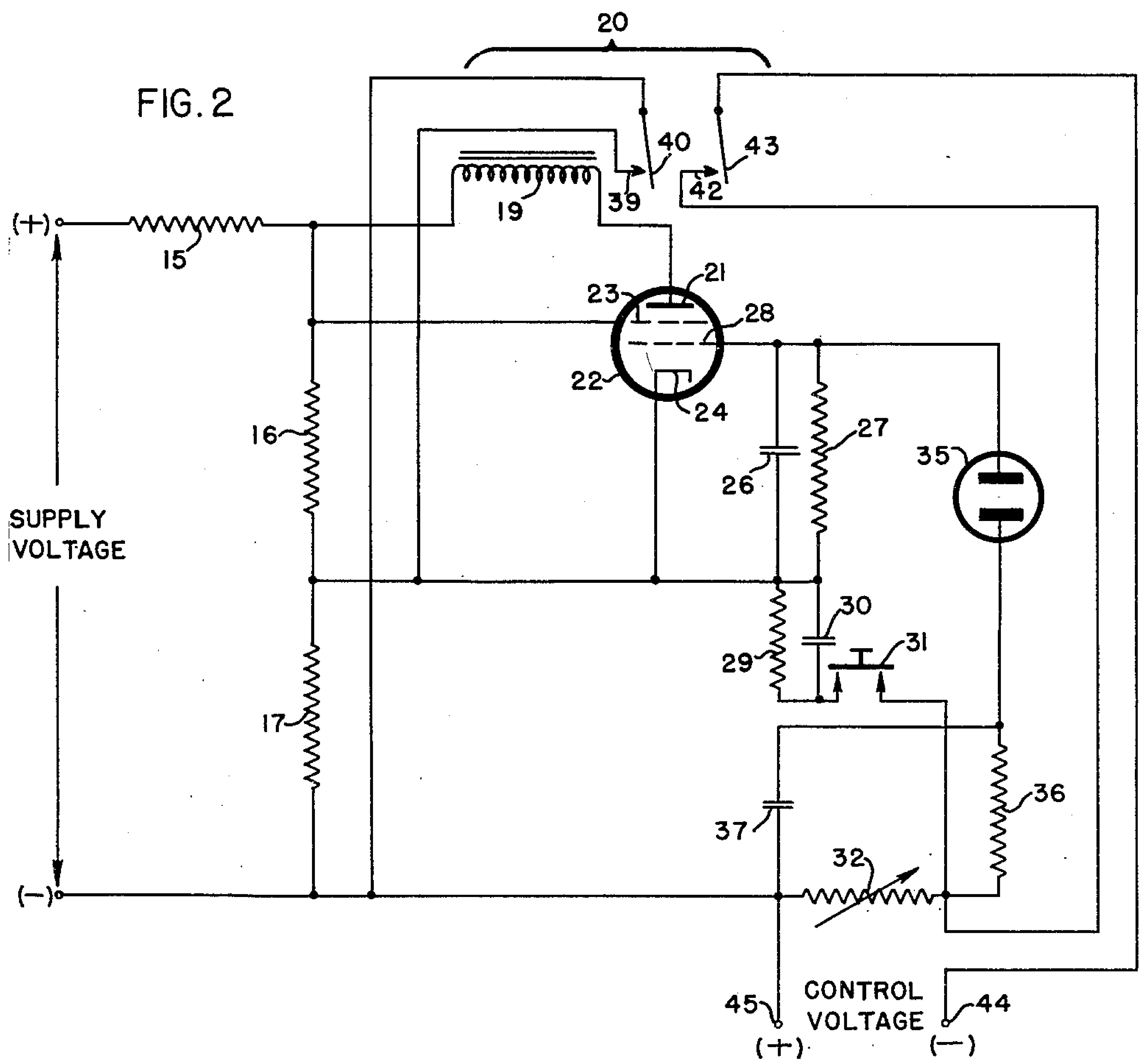


FIG. 2



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THERMIONIC OVERVOLTAGE PROTECTION CIRCUIT

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My invention relates in general to protective devices and more particularly to circuits for control of excess voltages and currents in electronic apparatus.

In many types of electrical equipment it is necessary to guard against voltages and currents higher than those normally present in the equipment. This is especially true in circuits employing extremely high voltages and currents in which a small percentage deviation in the input energy may produce a large variation in the voltages present in the system. Hence, to avoid arcing, flashovers, and burnout in circuit components, it is customary to employ automatic apparatus to break high voltage or high current circuits when there is danger of overload. These devices may take a number of forms ranging from simple circuit breakers to almost completely electronic circuits.

Accordingly, one of the objects of the present invention is to provide a protective device for electrical apparatus.

Another object is to provide a sensitive and reliable electronic protective circuit.

Still another object is to provide an electronic protective circuit which may be readily constructed with standard components.

These and further objects of my invention will be apparent to those skilled in the art upon reference to the following specification, claims, and to the drawings in which:

Fig. 1 is a block diagram showing the application of my invention to a transmitter.

Fig. 2 is a schematic diagram of a preferred embodiment of my invention.

Referring now to Fig. 1, one use of a protective circuit such as my invention comprises is shown in block diagram form. A high voltage supply source **5** is connected to a transmitter **6** through a variable resistor **7** and a switch **8** which form a part of overload circuit **9**. A low voltage supply **10** provides a power source for overload circuit **9**. When the voltage of source **5** increases to a point where damage is likely to occur in transmitter **6**, the voltage across resistor **7** attains a value sufficient to cause operation of overload circuit **9** which opens switch **8**, removing the high voltage from transmitter **6**.

The details of an overload circuit constructed according to the principles of my invention are shown in Fig. 2, to which reference is now made. Voltage from a source such as low voltage supply **10** in Fig. 1 is applied across a voltage divider network consisting of serially connected resistors **15**, **16**, and **17**. Connection is made from the

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junction of resistors **15** and **16** through coil **19** of relay **20** to anode **21** of vacuum tube **22**. Screen grid **23** of vacuum tube **22** is connected to the more positive end of resistor **16** while cathode **24** is connected to the less positive end of the same resistor, thereby maintaining a voltage differential between screen grid and cathode. Capacitor **26** and resistor **27** are connected in parallel between control grid **28** and cathode **24** of the tube. Connection is made from cathode **24** through resistor **29**, having capacitor **30** in parallel therewith, and reset switch **31** to one side of variable resistor **32**, the other side of which is connected directly to the negative terminal of the input supply voltage. A glow discharge tube **35** is connected, in series with a resistor **36**, between control grid **28** and the junction of switch **31** with resistor **32**. Capacitor **37** is connected in shunt with the series combination of resistors **32** and **36**. Contact **39** of relay **20** is connected to the more positive end of resistor **17** and arm **40** of the relay is connected to the less positive end of the same resistor. Contact **42** is connected between resistors **32** and **36** and arm **43** is connected to terminal **44** which may be adapted for external connection to a circuit which it is desired to protect. A similar terminal **45** is connected to the same end of resistor **32** to which capacitor **37** is tied.

Before the circuit is energized, the contacts of relay **20** are open so that the high voltage circuit of which contact **42** and arm **43** form a part is broken. When the supply voltage is applied to the protective circuit, the voltage appearing across resistor **17** of the series voltage divider causes the neon glow tube **35** to ignite. The current through glow tube **35** must flow through resistor **27**, thereby setting up a voltage drop sufficient to bias grid **28** of the tube beyond cut-off potential with respect to cathode **24**. Therefore, no current flows in coil **19** of relay **20** and the contacts of the relay remain open. To apply high voltage to the protected circuit, reset switch **31** is closed. When this is done, the voltage which maintains ionization in tube **35** is temporarily short-circuited through capacitor **30**, which may be several microfarads in capacity, thus extinguishing tube **35**. When the grid bias on the tube is removed in this fashion, plate current flows in the tube, the initial surge of current charging capacitor **30** and closing the contacts of relay **20**. The closing of contacts **39** and **40** short-circuits resistor **17** which initially supplied ionization voltage for glow tube

35 so that the latter remains nonconducting until there is an abnormal change in circuit conditions. Contacts 42 and 43 close simultaneously with contacts 39 and 40 thus completing the high voltage circuit.

When the protected circuit draws current from the high voltage supply, a small voltage drop occurs across resistor 32. This voltage is impressed on glow tube 35 since no current is now flowing in resistors 36 and 27. If for any reason there is an abnormal increase in supply voltage or a short circuit in the protected device so that the current through resistor 32 increases beyond a predetermined point, the voltage impressed on glow tube 35 will be sufficient to initiate ionization therein. Thereupon, tube 22 is again biased beyond cut off allowing the contacts of relay 20 to open, breaking the high voltage circuit. Ionization voltage for tube 35 is then supplied by the drop across resistor 17, maintaining vacuum tube 22 in a nonconductive state until reset switch 31 is closed. It will be noted that resistor 32 is variable so that the "trip-out" point may be selected at will.

If an overload should still exist when reset switch 31 is closed, capacitor 30 will be charged by the surge of current through tube 22 which also closes relay 20. Contacts 39 and 40 short-circuit resistor 17, however the voltage across resistor 32 is sufficient to re-establish ionization in glow tube 35. Therefore vacuum tube 22 will again be blocked and the contacts of relay 20 will open. If switch 31 is still held closed, conduction cannot occur in tube 22 until the charge on capacitor 30 has leaked off. This takes place relatively slowly so that normally pressure on switch 31 will be released before relay 20 closes again. Thus my circuit provides protection even during the time in which the reset switch is in the closed position.

In many cases, momentary overloads are not sufficient to damage the protected equipment, and hence it is desirable that relay 20 should not be operated unless an overload persists longer than a predetermined duration. When momentary surges of voltage occur across resistor 32 they serve only to charge capacitor 37 and hence do not provide ionization voltage for tube 35. The length of time for which an overload must endure before the high voltage circuit is broken is determined by the time constant of resistor 36 and capacitor 37.

Capacitor 30 provides an automatic time delay before which relay 20 may not be reset after having opened. When switch 31 is closed and capacitor 30 is charged by the surge of current through tube 22, the overload may have persisted, in which case the relay contacts will immediately open and cannot be reset until capacitor 30 is discharged sufficiently for glow tube 35 to be extinguished. This time delay is chiefly dependent upon the capacity of capacitor 32 and the value of resistor 29.

It has been pointed out hereinbefore that an outstanding advantage of my circuit lies in the fact that the relay is operated by a sudden current differential rather than a gradual one. Other advantages which have not previously been mentioned are: maintenance of the operating accuracy of the circuit regardless of changes in tube characteristics caused by ageing; the practicability of utilizing a relatively heavy duty relay which requires a large current differential for operation; the possibility of resetting the control relay when the current in the protected circuit has decreased as little as 1 percent below the "trip-out" value.

While there has been described hereinabove what is at present considered to be a preferred embodiment of the present invention, it will be obvious to those skilled in the art that changes and modifications may be made therein without exercise of inventive ingenuity. Hence, I claim all such modifications and adaptations as may fall fairly within the spirit and scope of the hereinafter appended claims.

What I claim is:

1. A protective device for electrical apparatus including a normally conducting thermionic vacuum tube having anode and cathode electrodes and at least one control electrode, a normally energized electromechanical relay having circuit switch contacts in a control voltage circuit, means for connecting the energizing coil of said relay in the anode-cathode circuit of said vacuum tube for normal energization and activation of said control voltage thereby, a normally non-conducting glow-discharge tube, means for connecting said glow-discharge tube in the control electrode-cathode circuit of said vacuum tube so that said glow-discharge tube when conductive causes said control electrode to be biassed beyond cut-off potential with respect to said cathode, means for developing voltages substantially proportional to voltages in the electrical apparatus to be protected, means for utilizing the voltages thus developed to effect ionization in said glow-discharge tube, and means intermediate said developing means and said glow tube for delaying the utilization of the developed voltages, thereby deenergizing said electromechanical relay to remove the applied voltage from said apparatus to be protected when said voltages increase beyond a predetermined value only after a given interval.

2. Apparatus in accordance with claim 1 wherein said means for developing voltages substantially proportional to voltages in the electrical apparatus to be protected comprise resistive means forming a portion of the circuit for conducting energy to said electrical apparatus to be protected.

3. In a protective circuit for electrical apparatus a thermionic vacuum tube having anode and cathode electrodes and at least one control electrode, a gaseous glow-discharge tube, means for connecting said glow-discharge tube in the control electrode-cathode circuit of said thermionic tube so that when said glow-discharge tube is conductive said control electrode is biassed negatively with respect to said cathode so that current flow in said thermionic tube is blocked, voltage developing means, means for utilizing the developed voltage to render said glow-discharge tube conductive, switching means, and means for connecting said switching means so that when said thermionic tube is conductive said voltage developing means is rendered inactive.

4. In a protective apparatus for limiting the voltage impressed onto a utilizing means, thermionic means having anode, cathode and at least one control electrode, voltage divider means connected to the input circuit of said thermionic tube for governing the bias between the cathode of said tube and at least one of the control electrodes, switching means responsive to a predetermined current flow in said tube, said switching means being normally engaged when the voltage to be limited is less than a predetermined value, and means responsive to the voltage to be limited and influencing the current flow in said

thermionic tube, said responsive means blocking the current flow in said thermionic tube when the voltage to be limited exceeds a predetermined value whereby said switching means is actuated substantially simultaneously with the blocking of current flow through said thermionic tube, and whereby the resistive value of at least a portion of said voltage divider means is altered when the switching means is actuated.

5. A device according to claim 1, further including means for supplying initial ionization voltage to said glow tube, reset switch means for temporarily short circuiting said ionization voltage supplying means to thereby establish conductivity through said thermionic tube, and switch means controlled by said relay for normally short circuiting said initial voltage supplying means.

6. A device according to claim 5, further including a time delay circuit intermediate said reset switch means and said glow tube to permit said relay to open if a voltage in said voltage developing means persists.

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