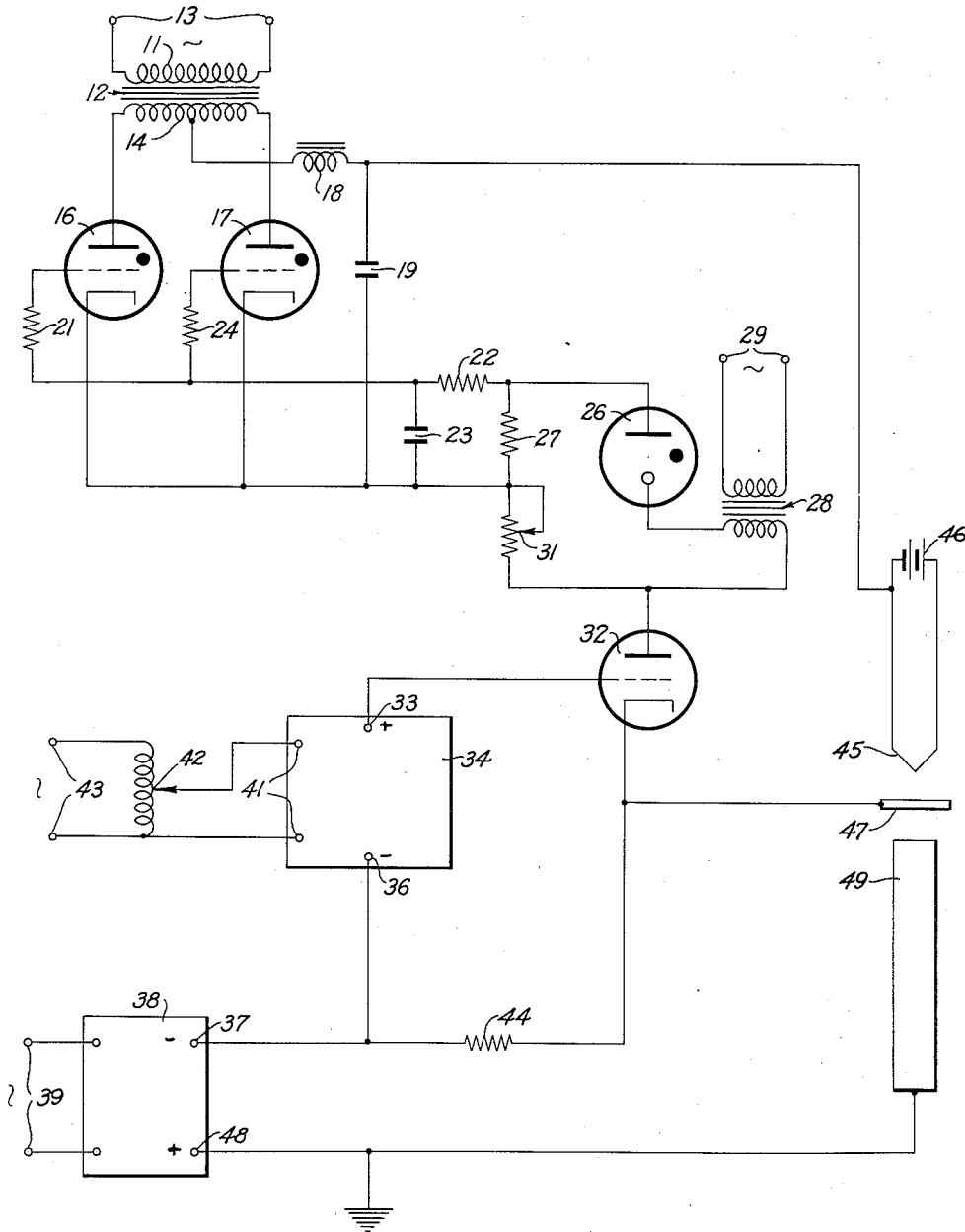


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INVENTORS
ERNEST O. LAWRENCE
FRED H. SCHMIDT
VICTOR B. WAITHMAN

By Roland A. Anderson
ATTORNEY

UNITED STATES PATENT OFFICE

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ELECTRONIC REGULATOR

Ernest O. Lawrence and Victor B. Waithman,
Berkeley, Calif., and Fred H. Schmidt, Seattle,
Wash., assignors to the United States of America
as represented by the United States Atomic
Energy Commission

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1

This invention relates to an electronic circuit and more particularly to a regulator and protector circuit.

In devices having a filamentary cathode and a bombardment heated cathode, an arc may inadvertently occur between the two cathodes resulting in damage and possible disintegration of the filamentary cathode. It is proposed by this invention to automatically extinguish an arc formed between the two cathodes and simultaneously regulate the arc current between the bombardment heated cathode and an arc block. The automatic extinguishing of an arc formed between the two cathodes is accomplished by utilizing the increase in current between the two cathodes to charge a condenser which activates an electronic switching arrangement to stop the flow of current for a short period of time, thereby breaking the arc. The arc regulating action of the circuit is accomplished by utilizing the current flowing between the arc block and the bombardment heated cathode to control the grid voltage of a regulator tube, which in turn regulates the emission of the bombardment heated cathode.

It is therefore an object of this invention to provide an electronic regulator and protector circuit for a device having a filamentary cathode and a bombardment heated cathode.

Another object of this invention is to provide an arrangement for automatically extinguishing an arc between a filamentary cathode and a bombardment heated cathode.

A further object of this invention is to provide an arc regulating device.

Other objects and advantages of this invention will be apparent in the following description and claims considered together with the accompanying drawing, in which:

Figure 1 is a schematic wiring diagram embodying the invention and is the sole drawing thereof.

Referring to Fig. 1 in detail, the primary winding 11 of a transformer 12 is shown connected to a suitable source 13 of alternating current. One end of the secondary winding 14 of this transformer is connected to the anode of a gas triode tube 16, while the other end is connected to the anode of a gas triode tube 17. The secondary winding is center tapped, and this center tap is connected to an inductance 18 which is an element of a filter network. The remaining portion of the filter network is a condenser 19 which is connected from the inductance 18 to the cathode of the tubes 16 and 17. The control grid of the tube 16 is connected to a bias resistor 21 which is in turn connected to a common connection be-

2

tween a resistor 22 and a condenser 23. The control grid of the tube 17 is connected to a bias resistor 24 which is connected to the junction between the resistor 22 and the condenser 23. This resistor 22 is connected to the anode of a voltage regulator tube 26 and to a resistor 27. The resistor 27 is further connected to the condenser 23 and to the cathode of the tubes 16 and 17. The cathode of the tube 26 is serially connected with the secondary winding of a transformer 28. The primary winding of this transformer 28 is connected to a suitable source of alternating current 29. The secondary winding of the transformer 28 is further connected to a potentiometer 31 which is in turn connected to the junction of the resistor 27 and the condenser 23. The variable portion of this potentiometer 31 is so arranged that any desired portion can be shorted, thereby allowing manual control of the resistance in this portion of the circuit. A connection is made from the lead common to the secondary winding of the transformer 28 and the potentiometer 31 to the anode of a triode tube 32. The control grid of the tube 32 is connected to the positive output terminal 33 of a conventional power supply 34. The negative output terminal 35 of the power supply 34 is connected to the negative terminal 37 of a high voltage power supply 38 which is connected to a suitable source of A. C. 39. The input terminals 41 of the power supply 34 are connected to a variac control 42 which is in turn connected to a suitable source of alternating current 43. The negative terminals 36 and 37 of the power supplies 34 and 38 are connected to a resistor 44 which is connected to the cathode of the tube 32. The common connection of the inductance 18 and condenser 19 is connected to a filamentary cathode 45 which is heated by a suitable battery supply 46. A connection is made from the cathode of the tube 32 to a bombardment cathode 47. The positive terminal 48 of the power supply 38 is connected to an arc block 49 and is held at zero potential by a connection to ground.

Consider now the normal operation of the circuit with the alternating current sources 13, 29, 39, and 43 energized. The tubes 16 and 17 then operate as a full wave rectifier, the output of which is smoothed by the filter network comprising the inductance 18 and the condenser 19. The negative side of this filtered voltage is impressed on the filamentary cathode, while the positive side is impressed on the bombardment heated cathode through the potentiometer 31 and the tube 32. Thus a voltage difference exists between the filamentary cathode 45 and the bom-

3

bombardment heated cathode 47 sufficient to attract electrons thermally emitted from the filamentary cathode 45 to the bombardment heated cathode 47. The tube 32 is maintained in a normally conducting state by means of the positive bias supplied to its control grid by the power supply 34, which is adjustable through the variac 42. A voltage difference is established sufficiently large that an arc exists between the bombardment heated cathode 47 and the arc block 49 by the power supply 38, the negative terminal 37 of which is connected to the bombardment heated cathode 47 through the resistor 44 and the positive terminal of which is directly connected to the arc block 49.

From the foregoing, it is seen that under stable conditions electrons emitted by the filamentary cathode 45 are utilized to heat the bombardment heated cathode 47 and thereby establish an arc between the bombardment heated cathode 47 and the arc block 49. However, stable conditions do not always exist, as an arc may inadvertently occur between the filamentary cathode 45 and the bombardment heated cathode 47. In order to extinguish this arc before the filamentary cathode is damaged, the circuit comprising the resistor 22, the condenser 23, the resistor 27, the voltage regulator tube 26, and the transformer 28 has been connected between the control grids and cathodes of the tubes 16 and 17. Thus should an arc occur between the two cathodes 45 and 47, the accompanying increase in current through the rectifying tubes 16 and 17 results in a proportional increase in voltage across the potentiometer 31. The resistance of the potentiometer 31 has been set at a predetermined value, so that the increased voltage across the potentiometer due to the arc plus the voltage across the secondary of the transformer 28 during the half-cycles at which the cathode of the voltage regulator tube 26 is negative, is sufficient to cause this voltage regulator tube to conduct and charge the condenser 23. The plate of the condenser 23 which is connected to the control grid of the tubes 16 and 17 is therefore charged negatively with respect to the plate of the condenser connected to the cathode of the tubes and the resulting negative bias on the control grid in addition to the positive bias on the cathode is sufficient to prevent the tubes from conducting. Therefore, during the time necessary for the condenser 23 to discharge through the resistors 22 and 27, the tubes 16 and 17 are held in a non-conductive state. The values of the condenser 23 and the resistors 22 and 27 are predetermined to allow sufficient time for the arc to be extinguished between the filamentary cathode 45 and the bombardment heated cathode 47. After the condenser 23 has discharged, the tubes 16 and 17 again conduct and the voltage between the two cathodes 45 and 47 is restored.

Another type of unstable condition may occur wherein the arc current between the bombardment heated cathode 47 and the arc block 49 fluctuates. Regulation of the arc current is accomplished by the interconnection between power supply 38 and the control grid circuit of the tube 32. Thus an increase in the arc current between the bombardment heated cathode 47 and the arc block 49 increases the voltage drop across the resistor 44 and thereby decreases the voltage impressed on the control grid of the tube 32 through the power supply 34. This decrease in voltage at the control grid of the tube 32 re-

4

sults in an increased internal resistance of the tube, thereby allowing less current to flow and decreasing the potential difference between the filamentary cathode 45 and the bombardment heated cathode 47, which in turn reduces the emission of the bombardment heated cathode 47 and regulates the arc current. The arc current is thus reduced until it conforms with the predetermined value as established by manual control of the variac 42. A decrease in the arc current has the opposite effect in that the bias of the control grid of the tube 32 increases, thereby raising the emission of the bombardment heated cathode 47 to increase the arc current to the predetermined value.

While the salient features of the invention have been described in detail with respect to one embodiment, it will, of course, be apparent that numerous modifications may be made within the spirit and scope of this invention, and I do not therefore desire to limit the invention to the exact details as shown, except insofar as they may be defined in the following claims.

What is claimed is:

1. In a protective system for an electrical device having at least two elements supplied from a rectifier circuit, said circuit comprising a pair of gas triode tubes having anodes and cathodes interconnected as a full-wave rectifier across a first source of alternating current, the combination comprising means for connecting the anodes of said gas tubes to one element of said device, a condenser connected between the control grids and cathodes of said gas tubes, a pair of series connected resistors connected in parallel with said condenser, a diode gas tube having its anode connected to the junction between said pair of resistors, a transformer having a primary winding connected across a second source of alternating current and one terminal of a secondary winding connected to the cathode of said diode tube, a variable resistor connected between the cathodes of said gas triodes and the other terminal of said secondary winding, and means connected between the junction of said variable resistor and the secondary winding of said transformer and a second element of said device.

2. In an electrical control system for a device having a first cathode, a second cathode, and an anode, the combination comprising means connected between said second cathode and said anode for establishing an arc discharge therebetween, a source of voltage having a pair of gas discharge triode tubes interconnected as a full-wave rectifier between said first and second cathodes for establishing electron bombardment of said second cathode, and a circuit network connected in series between said second cathode and one side of said source, said circuit network comprising a gas discharge diode tube, a transformer having a primary winding connected across a source of alternating current and one side of a secondary winding connected to the cathode of said diode tube, a variable resistor connected between the other side of said secondary winding and the cathodes of said rectifier tubes, the junction between said variable resistor and said secondary winding being connected to said second cathode, a pair of series connected resistors connected between the control grids and cathodes of said rectifier tubes, the anode of said diode being connected to the junction between said pair of resistors, and a condenser connected in shunt across said pair of resistors, whereby said condenser is charged to place a negative bias on

5

the control grids of said rectifier tubes each time said diode tube fires in response to an increase in a predetermined voltage across said variable resistor.

3. In an electrical control system for a device having a first cathode, a second cathode, and an anode, the combination comprising a first source of voltage connected between said second cathode and said anode for establishing an arc discharge therebetween, a second source of voltage having a pair of gas discharge triode tubes interconnected as a full-wave rectifier between said first and second cathodes for establishing electron bombardment of said second cathode, and a circuit net work connected in series between said second cathode and one side of said second source, said circuit network comprising a triode tube having its cathode connected to said second cathode, its control grid connected to a regulating means for controlling the resistance of said triode tube in response to the voltage between said cathode and said anode; a transformer having a primary winding connected across a source of alternating current and one side of a secondary winding connected to the anode of said triode tube; a diode gas discharge tube having its cathode connected to the other side of said secondary winding; a pair of series-connected resistors having the junction therebetween connected to the anode of said diode tube, one end connected to the cathodes of said rectifier tubes, and the other end connected to the control grids of said rectifier tubes; a variable resistor connected between the anode of said triode tube and the cathodes of said rectifier tubes for predetermining the firing voltage of said diode tube; and a condenser connected between the ends of said series connected resistors for storing energy when said diode tube conducts and applying a cut-off bias to the control grids of said rectifier tubes.

6

4. In a protective system for an electrical device having at least two elements supplied from a rectifier circuit, said circuit comprising a pair of gas triode tubes having anodes and cathodes interconnected as a full-wave rectifier across a first source of alternating current, the combination comprising a filter network connected across the output of said gas triode tubes, the negative side of said filter network being connected to one element of said device, a condenser connected between the control grids and cathodes of said gas tubes, a resistor connected in parallel with said condenser, a diode gas tube having its anode connected to the junction between said resistor and condenser, means connected to the cathode of said diode tube for impressing an alternating current, a variable resistor connected between the cathodes of said gas triode tubes and said alternating current means, and means for connecting the junction between said variable resistor and alternating current means to the second element of said device.

ERNEST O. LAWRENCE.
VICTOR B. WAITHMAN.
FRED H. SCHMIDT.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,065,280	Koros et al.	Dec. 22, 1936
2,081,995	Gulliksen	June 1, 1937
2,149,080	Wolff	Feb. 28, 1939
2,315,445	Milarta	Mar. 30, 1943
2,383,492	Klemperer	Aug. 28, 1945