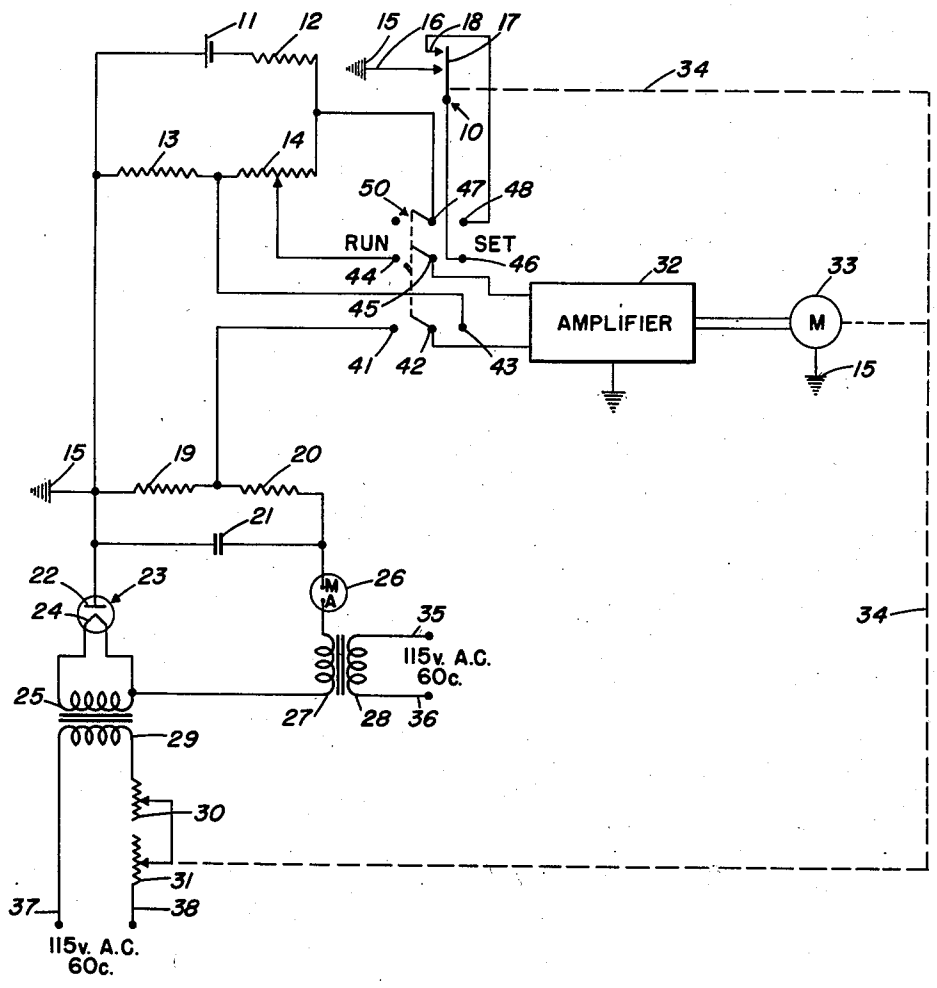
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X-RAY ANODE CURRENT CONTROLLER

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X-RAY ANODE CURRENT CONTROLLER

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This invention relates to current control apparatus for electron discharge tubes, and more particularly to apparatus for automatically regulating the anode current of an X-ray tube.

Prior art devices have been characterized by a number of disadvantages. One such device comprises a saturable core reactor which impresses a constant voltage across the filament of the X-ray tube, thereby tending to maintain the anode current constant. However, during operation the filament of an X-ray tube changes resistance due to warming up, with the result that the anode current changes.

The apparatus described and claimed in the patent to Bischoff, for Roentgen Tube Control, No. 2,147,424, issued February 14, 1939, is concerned with limiting the current to provide overload protection, and employs equipment quite different from that of applicant's device.

The apparatus described and claimed in the patent to Mutscheller for Thermionic Cathode X-ray Stabilizer System, No. 1,953,889, issued April 3, 1934, utilizes grid control of the anode current through the medium of additional triode electron discharge tubes, and is complicated and subject to the usual disadvantages of such devices.

The apparatus described and claimed in the patent to Campbell for Electrical System, No. 1,600,316, issued September 21, 1926, utilizes a manually controlled rheostat in series with the filament transformer primary in conjunction with a register to control the tube current, and lacks all the advantages of an automatic control device.

The apparatus embodying the instant invention overcomes the aforementioned disadvantages and limitations. Variations in anode current are utilized to produce potential differences which are amplified, and applied to a motor for positioning the arm of a balancing potentiometer in series with the primary of the filament transformer, and an arrangement is provided for automatically adjusting the filament current either to increase or decrease the same to maintain the anode current at a predetermined value.

Accordingly, it is an object of the invention to provide new and improved current control apparatus for use with an electron discharge tube.

Another object is to provide new and improved X-ray anode current control apparatus.

Still another object is to provide new and improved anode current control apparatus in which a balancing motor controlled from the anode current is utilized to automatically adjust the filament potential to maintain the anode current at a substantially constant value.

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Other objects and advantages will become apparent after a consideration of the following specification taken in connection with the drawing in which the single figure thereof comprises a schematic electrical circuit diagram.

An X-ray tube of any convenient design is shown, generally designated by the reference numeral 23, and having anode 22 and filament 24. The filament is energized from secondary 25 of a well insulated filament transformer having a primary 29, one end of which is connected by way of lead 37 to one side of a suitable A.-C. supply source, not shown. The other end of primary 29 is connected by way of the two rheostats 30 and 31, connected in series as shown, to lead 38 and thence to the A.-C. source. The arm of rheostat 30 is manually adjustable in a manner presently to be described, while the arm of rheostat 31 is connected by mechanical coupling 34 to a reversible balancing motor 33, which is designed to run in two directions selectively in accordance with the polarity of the potential applied thereto, and which is energized from amplifier 32.

One side of the aforementioned filament transformer secondary 25 is connected to one terminal of the secondary 27 of a high voltage transformer having primary 28, which is energized by way of leads 35 and 36 from the aforementioned A.-C. source, not shown. The other terminal of secondary 27 is connected by way of milliammeter 26 and capacitor 21 to anode 22. Anode 22 is further directly connected to ground 15, and by way of the series connected resistors 19 and 20 to meter 26.

The junction between resistors 19 and 20 is connected to terminal 41 of a triple-pole double-throw switch generally designated at 50. Terminal 42 of the switch is connected to one input terminal of the amplifier 32, as shown. Anode 22 is connected by way of resistor 13 and potentiometer 14 to terminal 47 of the aforementioned switch 50. Connected in shunt with the aforementioned elements 13 and 14 is the series connected battery 11 and current limiting resistor 12.

The junction between resistor 13 and potentiometer 14 is connected to switch terminal 43, and the arm of potentiometer 14 is connected to switch terminal 44. Switch terminal 45 is connected to the other amplifier input terminal; switch terminal 46 is connected to the blade 17 of an additional switch generally designated 10, which is operated by a cam, not shown, controlled from motor 33 by coupling 34. One terminal 16 of the

last mentioned switch is connected to ground 15, while the other terminal 18 is connected to switch terminal 48.

The switch 10, which may be of conventional design, is normally closed on contact 18, and is so constructed and arranged that when the aforementioned cam, not shown, and shaft or coupling 34 assume a predetermined position, the switch blade 17 makes simultaneous contact with both contacts 16 and 18.

The aforementioned amplifier 32 may be of conventional design, may have a balanced input to ground, and supply a potential of two polarities to motor 33 selectively in accordance with the polarity of the signal between the input leads to the amplifier.

The operation of the aforedescribed apparatus is substantially as follows: When the triple-pole double-throw switch 50 is closed to the left in its "Run" position, the potential difference across resistor 19 resulting from anode current flow is balanced against the potential drop caused by battery 11 in resistor 13 and that portion of potentiometer 14 between the arm thereof and resistor 13. If these voltages are balanced, they will cancel in the input circuit to the amplifier, and motor 33 will not be energized.

Assume now by way of description that the anode current changes. The voltages are not longer balanced; motor 33 is energized and through coupling 34 adjusts the arm of potentiometer 31 to reduce or increase the filament voltage and thereby restore the anode current to its former value. It will be understood, of course, that the circuit is arranged so that an increase in anode current causes the motor to turn in a direction to move the arm of rheostat 31 to decrease the filament voltage, and vice versa.

In adjusting the equipment for correct operation, the following procedure may conveniently be followed: Switch 50 is closed to the right in "Set" position. The balancing motor then drives the compensating rheostat and cam until the armature of switch 10 is connected to both contacts. When this occurs, the input to the amplifier is effectively shorted, and the motor stops driving. Preferably this condition occurs when the arm of rheostat 31 is substantially in mid position. Rheostat 30 is then adjusted until the anode current has the desired or correct value as indicated on meter 26.

Switch 50 is then thrown to its "Run" position, and the arm of potentiometer 14 adjusted until the amplifier is balanced, and the motor is unenergized. Thereafter the circuit will maintain the anode current substantially constant at the desired value.

Whereas the invention has been described with reference to a particular embodiment thereof in which the anode current of an X-ray tube is regulated, it will be understood that it is applicable to any electron discharge device where the current through any element thereof is proportional to the temperature of a filament or cathode. Filament 24 could, with equal facility, be the heater of a cathode type tube.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

This invention may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In apparatus of the character disclosed for regulating the current through an element of an electron discharge tube having an electron emitter wherein the emission is proportional to the temperature thereof, in combination, means including a balanced resistor circuit connected to said element for obtaining a signal proportional to said current, reversible motor means energized by said signal and rotating in two directions selectively in accordance with increases and decreases of said current about a predetermined value, and means including a variable resistor controlled from said motor means and connected to said emitter for selectively increasing and decreasing the temperature in accordance with the direction of rotation of the motor means thereby to control the emission in accordance with changes in said current.

2. In apparatus of the character disclosed for regulating the anode current of an X-ray tube having a filament, in combination, means connected to said anode for obtaining a first voltage proportional to said current, manually adjustable means for obtaining a second voltage, an amplifier, said first and second voltages being applied in opposition to said amplifier, a reversible motor energized by the output of said amplifier and rotating in two directions selectively in accordance with variations in the amplitude of said first voltage above and below the amplitude of said second voltage, and a variable resistor controlled from said motor and connected to said filament for controlling the temperature and emission thereof in accordance with changes in said current.

3. In apparatus of the character disclosed for regulating the anode current of an X-ray tube having a filament, in combination, resistor means connected in the anode-cathode circuit of said tube for obtaining a first voltage proportional to said current, capacitor means connected in parallel with said resistor means, manually adjustable means including a potentiometer and a source of potential applied thereacross for obtaining a second voltage, an amplifier, said first and second voltages being applied in opposition to said amplifier, a reversible motor energized by the output of said amplifier and rotating in two directions selectively in accordance with variations in the amplitude of said first voltage above and below the amplitude of said second voltage, and a variable resistor having the resistance thereof controlled from said motor and connected to said filament for controlling the temperature and emission thereof in accordance with changes in said current.

4. In apparatus of the character disclosed for regulating the anode current of an X-ray tube having a filament, in combination, resistor means connected in the anode-cathode circuit of said tube for obtaining a first voltage proportional to said current, a capacitor connected in shunt with said resistor means, manually adjustable means including a potentiometer and a source of potential applied thereacross for obtaining a second voltage, switching means including a switch having first and second settings, an amplifier, means for applying said first and second voltages in opposition to said amplifier while the switch is in the first setting, a reversible motor energized by the output of said amplifier

and rotating in two directions selectively in accordance with variations in the amplitude of said first voltage above and below the amplitude of said second voltage, and a variable resistor having the resistance thereof controlled from said motor and connected to said filament for controlling the temperature and emission thereof in accordance with changes in said current, said switching means including means whereby while the switch is in the second setting the motor adjusts the variable resistor to a predetermined value.

5. In apparatus of the character disclosed for regulating the anode current of an X-ray tube having a filament, in combination: voltage divider resistor means connected in the anode-cathode circuit of said tube for obtaining a first voltage proportional to said current, said anode being maintained at ground potential, said first voltage being a small fraction of the total anode voltage of said tube; capacitor means connected in shunt with said voltage divider resistor means; means for obtaining a second voltage of adjustable value, said last named means including a source of potential and first, second, and third resistors all connected in series in the order named, said second resistor comprising a potentiometer having a movable arm; the junction between said source and first resistor being at ground potential; switching means including a switch having first and second settings; an amplifier; means for applying said first and second voltages in opposition to said amplifier while the switch is in the first setting; a reversible motor energized by the output of said amplifier and rotating in two directions selectively in accordance with variations in the amplitude of said first voltage above and below the amplitude of said second voltage; and a variable resistor having the resistance thereof controlled from said motor and connected to said filament for controlling the temperature and emission thereof in accordance with changes in said current; said switching means including means whereby while the switch is in the second setting the motor adjusts the variable resistor to a predetermined value.

6. In apparatus of the character disclosed for regulating the anode current of an X-ray tube having a filament, in combination: voltage divider resistor means comprising a pair of series connected resistors connected in the anode cathode circuit of said tube for obtaining a first voltage proportional to said current, said anode being maintained at ground potential, said first voltage being a small fraction of the total anode voltage of said tube; capacitor means connected in shunt with said voltage divider resistor; means for obtaining a second voltage of adjustable

value, said last named means including a source of potential and first, second, and third resistors all connected in series in the order named, said second resistor comprising a potentiometer having a movable arm, the junction between said source and said first resistor being connected to ground; a triple pole, double throw switch having first, second, and third contacts on one side thereof, first, second, and third arms, and fourth, fifth, and sixth contacts on the other side thereof opposite said first, second, and third contacts respectively; the junction between said pair of resistors being connected to said third contact; the junction between said first and second resistors being connected to said sixth contact; the arm of said potentiometer being connected to said second contact; an amplifier having a balanced input to ground; said second and third arms being connected to the input terminals of said amplifier; said first arm being connected to the junction between said second and third resistors; an additional switch having a fourth arm and having seventh and eighth contacts adapted to be closed or opened simultaneously; said seventh contact being connected to said fourth contact; said eighth contact being connected to ground; said fourth arm being connected to said fifth contact; said triple pole switch applying said first and second voltages in opposition to said amplifier while the triple pole switch is in a first setting; a reversible motor energized by the output of said amplifier and rotating in two directions selectively in accordance with variations in the amplitude of said first voltage above and below the amplitude of said second voltage; and a variable resistor having the resistance thereof controlled from said motor and connected to said filament for controlling the temperature and emission thereof in accordance with changes in said current; said motor being also operatively connected to said fourth arm for moving the same, said triple pole switch when in the second setting energizing said amplifier and motor to move said fourth arm to close the contacts associated therewith and short the input to said amplifier when the variable resistor assumes a predetermined value.

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