July 30, 1946. H. D. GARRETSON 2,404,905

ELECTRICAL CIRCUIT ARRANGEMENT

Filed Jan. 31, 1944

FIG. 1.

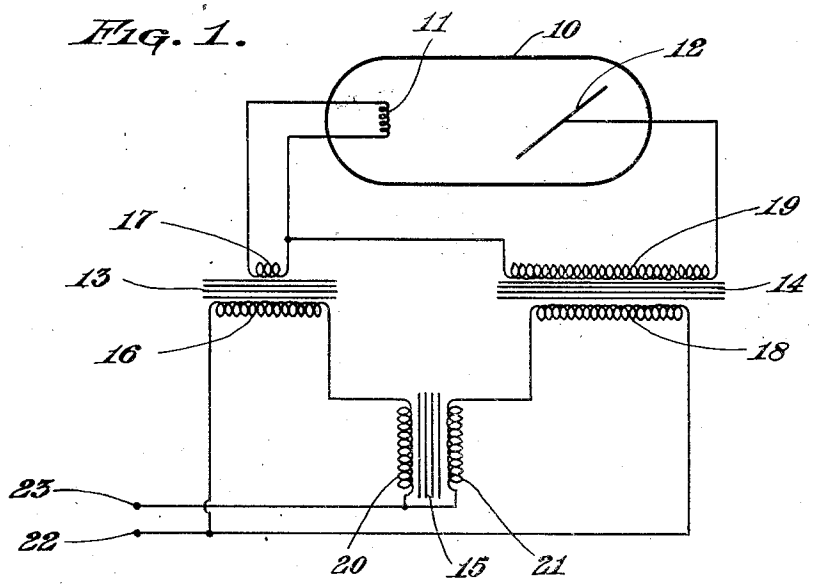
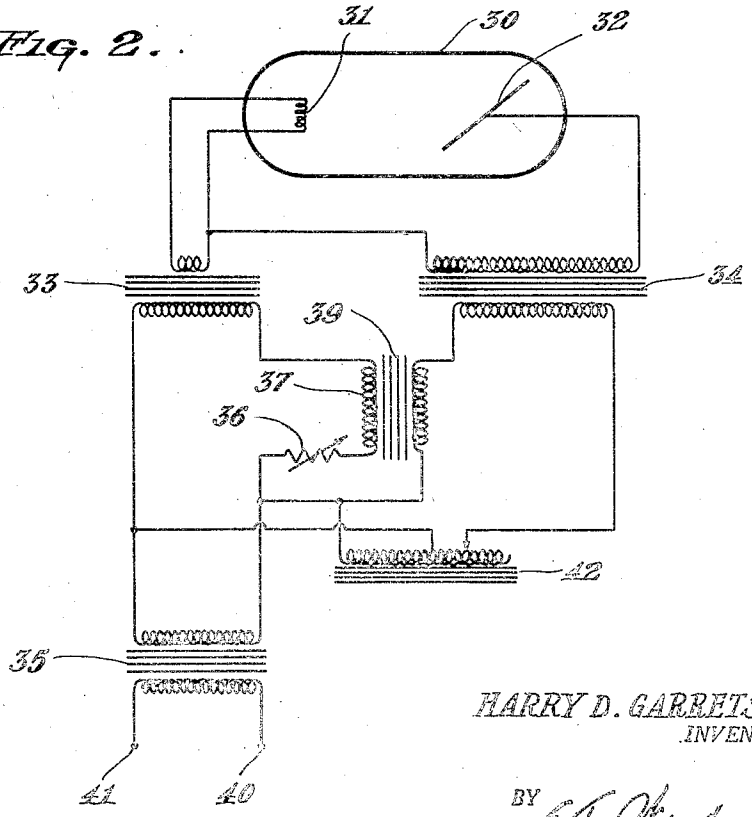


FIG. 2.



HARRY D. GARRETSON
INVENTOR.

BY R. F. Hunteroth

ATTORNEY.

Patented July 30, 1946

2,404,905

UNITED STATES PATENT OFFICE

2,404,905

ELECTRICAL CIRCUIT ARRANGEMENT

Harry Douglas Garretson, Whitestone, N. Y., assignor to North American Philips Company, Inc., Dobbs Ferry, N. Y.

Application January 31, 1944, Serial No. 520,524

3 Claims. (Cl. 250—103)

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My invention relates to electrical circuit arrangements for stabilizing the operating conditions of electron discharge tubes. An important use of the invention is for stabilizing the anode current of X-ray tubes and the invention will be described in this connection.

There are several factors influencing the stability of the anode current of X-ray tubes. Among these are variations of the supply voltage of the tube and variations of the internal electrical properties of the tube. The latter variations are brought about chiefly by changes in the emission of the filamentary cathode of the tube by reason of the change in resistance thereof due to normal evaporation of the filament metal and/or changes in the emission coefficient due to localized heating of the filament by random ionic bombardment and the like. While variations of the supply voltage may be corrected by means of a suitable constant-voltage device interposed between the voltage mains and the tube, a similar simple expedient has not been available for compensating the changes in the electrical characteristics of the tube.

It is the object of my invention to provide a circuit arrangement for correcting variations of the operating conditions of electron-discharge devices.

A more specific object of my invention is to provide a novel circuit arrangement for counterbalancing variations in the characteristics of X-ray tubes and stabilizing the anode current thereof.

These and further objects of my invention will appear as the specification progresses.

In accordance with the invention, the anode current of an X-ray tube is stabilized by the compensating action provided by two mutually dependent impedances one of which regulates the filament voltage of the X-ray tube and the other of which regulates the anode voltage. More specifically, the anode current of an X-ray tube is stabilized by means of two mutually coupled reactors one of which is connected in series with the filament voltage supply and the other of which is connected in series with the anode voltage supply. The two reactors are magnetically coupled in such a sense that an increase in anode-current produces a compensating decrease in the filament voltage and hence filament emission and conversely a decrease in anode current due to a decrease in filament current produces a compensating increase in anode voltage whereby the counterbalancing action so effected maintains the anode current at a substantially constant value.

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My invention will be described in greater detail with reference to the appended drawing forming part of the specification and in which,

Figure 1 illustrates a circuit arrangement in accordance with the invention;

Figure 2 illustrates a modification of the circuit of Fig. 1 which permits independent adjustment of the filament and anode voltages of an X-ray tube at desired operating values.

The circuit arrangement shown in Fig. 1 comprises an X-ray tube 10 having a filamentary cathode 11 and an anode 12, a filament supply transformer 13 having primary and secondary windings 16 and 17, respectively, an anode supply transformer 14 having primary and secondary windings 18 and 19, respectively, and a stabilizing compensator 15 comprising two mutually coupled windings 20 and 21. The supply mains for operating the X-ray tube are indicated at 22 and 23.

The secondary winding 17 energizes the cathode 11 and secondary winding 19 energizes the anode 12 whereby one end of winding 19 is connected to the anode and the other end connected to the cathode 11. One end of each of the primary windings 16 and 18 of the transformers 13 and 14 respectively, is connected to the supply main 22. The other end of winding 16 is connected to the supply main 23 through the winding 20 of the stabilizing compensator 15 and similarly, the other end of winding 18 is connected to the terminal 23 through the winding 21 of the stabilizing compensator.

The stabilizing compensator serves to maintain the anode current of the X-ray tube at a substantially constant value by reason of the mutual influences of the windings 20 and 21. For example, assuming for the moment that an increase in the resistance of the filament has taken place which change would normally decrease the anode current because of the decreased heating and consequently the decreased emission of the filament. Such a change in filament resistance causes a decrease in filament current and consequently a decrease in the current flowing through the primary winding 16 of the transformer 13. Since the filament supply current also passes through the winding 20, the decreased current produces a decrease in the impedance of winding 21 of the compensator 15 allowing a greater voltage to be impressed on the winding 18 of the transformer 14 and hence impressing a greater voltage on the anode 12.

When, for example, an increase in filament emission occurs, for example, because of ionic bombardment of the filament producing addi-

tional heating, it is found that a similar stabilizing effect is produced. More particularly, the instantaneously increased anode current causes a larger than normal current to flow through winding 18 and through winding 21. The increased current through winding 21 increases the effective impedance of winding 20 thereby lowering the voltage across winding 16 and consequently decreasing the filament voltage.

The arrangement shown in Fig. 2 comprises an X-ray tube 30 having a filamentary cathode 31 and an anode 32. For energizing the cathode 31 there is provided a filament transformer 33 having its secondary winding connected to the filament. The anode 32 is energized by a transformer 34 having one leg of its secondary winding connected to the anode and the other end of the winding connected to the cathode 31. The primary winding of transformer 33 is energized from the power mains 40—41 from a constant-voltage transformer 35 being connected thereto through a filament-voltage regulating resistor 36 and winding 37 of a stabilizing compensator 39 in series. Transformer 34 is energized from the transformer 35 through the intermediary of an adjustable autotransformer 42 the movable tap of which is connected to one end of the primary winding of transformer 34. The other end of the winding of transformer 34 is returned to the common terminal of the transformer 42 through the winding 38 of the compensator 39.

By means of the arrangement shown in Fig. 2, absolute stability of the operating characteristics of the X-ray tube is achieved and at the same time a high degree of flexibility permitting selection of the anode current and anode voltage at preselected values is realized. Thus the filament temperature may be adjusted to any desired operating value by means of the resistor 36. The anode voltage is similarly adjustable by means of the autotransformer 42. By means of the constant voltage transformer 35 the anode current is stabilized against changes in the voltage of the supply mains and by means of the stabilizing compensator 39 the anode current is made independent of changes in the characteristics of the X-ray tube.

While I have described my invention by means of specific examples and in specific embodiments, I do not wish to be limited thereto for obvious modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

What I claim is:

1. An electrical circuit arrangement comprising an electron-discharge device including an electrically heated cathode having an electron emissive coefficient responsive to the temperature thereof and an anode, circuit means to supply a current for heating said cathode, circuit means to supply a current for said anode, and means to maintain the anode current of said discharge tube at a substantially constant value comprising, an impedance in series with the cathode supply circuit and an impedance in said anode supply circuit, said impedances being mutually coupled and being mutually dependent in value and being adapted to vary the temperature of the cathode and the anode voltage in an inverse manner proportional to changes in the anode current.

2. An electrical circuit arrangement comprising an X-ray tube including a filamentary cathode and an anode, a transformer having one winding connected to said filamentary cathode, a transformer having one winding connected to said anode and the cathode, said transformers each having an additional winding connected to voltage supply mains, and a stabilizing compensator having a winding connected in series with the mains and the winding of the filament supply transformer and having a second winding connected in series with the mains and the winding of the anode supply transformer, said windings being mutually coupled in such a sense that variations in anode current produce inverse variations of the filament current, and the anode current of the X-ray tube is thereby maintained at a substantially constant value.

3. An electrical circuit arrangement comprising an X-ray tube having a filamentary cathode and an anode, a transformer having one winding connected to said filamentary cathode, a transformer having one winding connected to said anode and the cathode, a constant-voltage transformer interconnecting said filament transformer and said anode transformer to voltage supply mains, means to adjust the voltage applied to said filament to a predetermined selected value means to adjust the voltage supplied to said anode to a predetermined selected value, and a stabilizing compensator having a winding connected in series with the constant voltage transformer and the winding of the filament supply transformer and having a second winding connected in series with the constant voltage transformer and the winding of the anode supply transformer, said windings being mutually coupled in such a sense that variations in anode current produce inverse variations of the filament current, and the anode current of the X-ray tube is thereby maintained at a substantially constant value.

HARRY DOUGLAS GARRETSON.