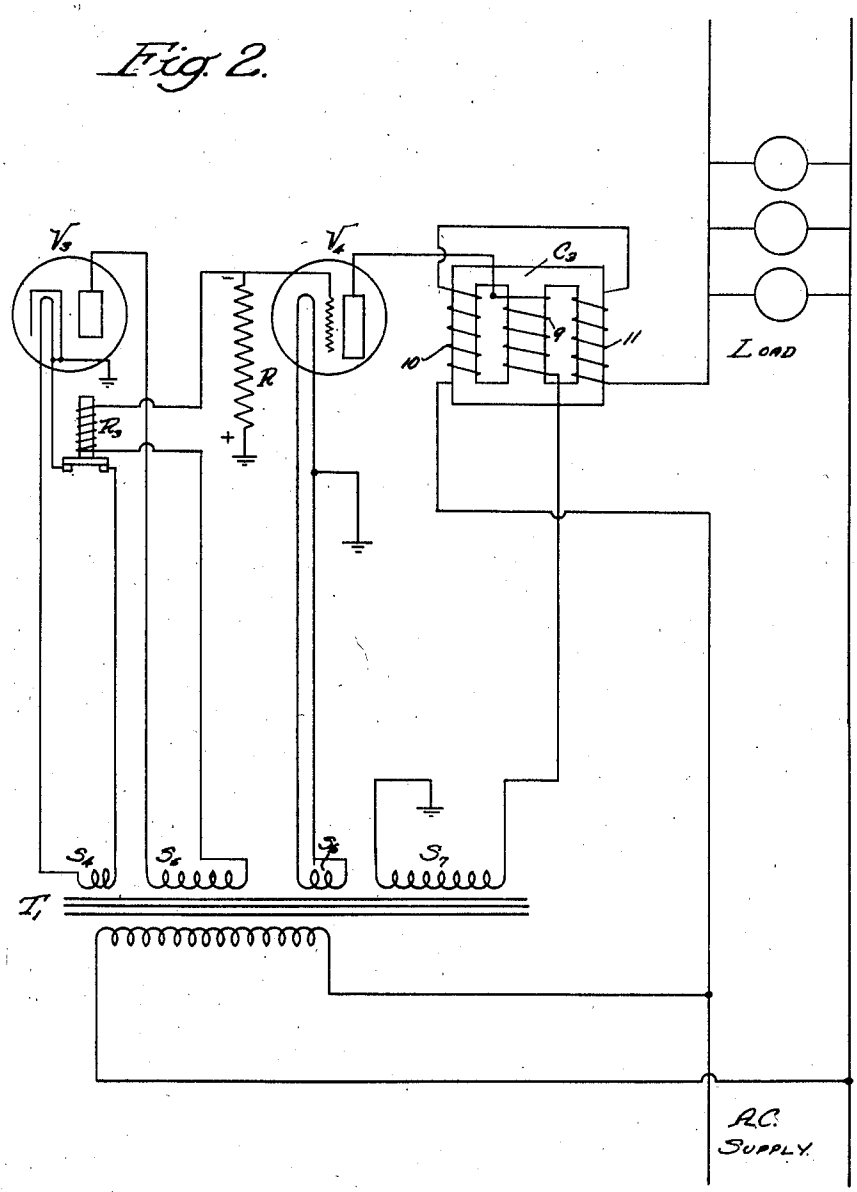
Jan. 9, 1940. R. L. WILCOX 2,186,222

DEVICE FOR VARYING THE CURRENT FLOW IN AN ELECTRIC CIRCUIT

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Fig. 2.



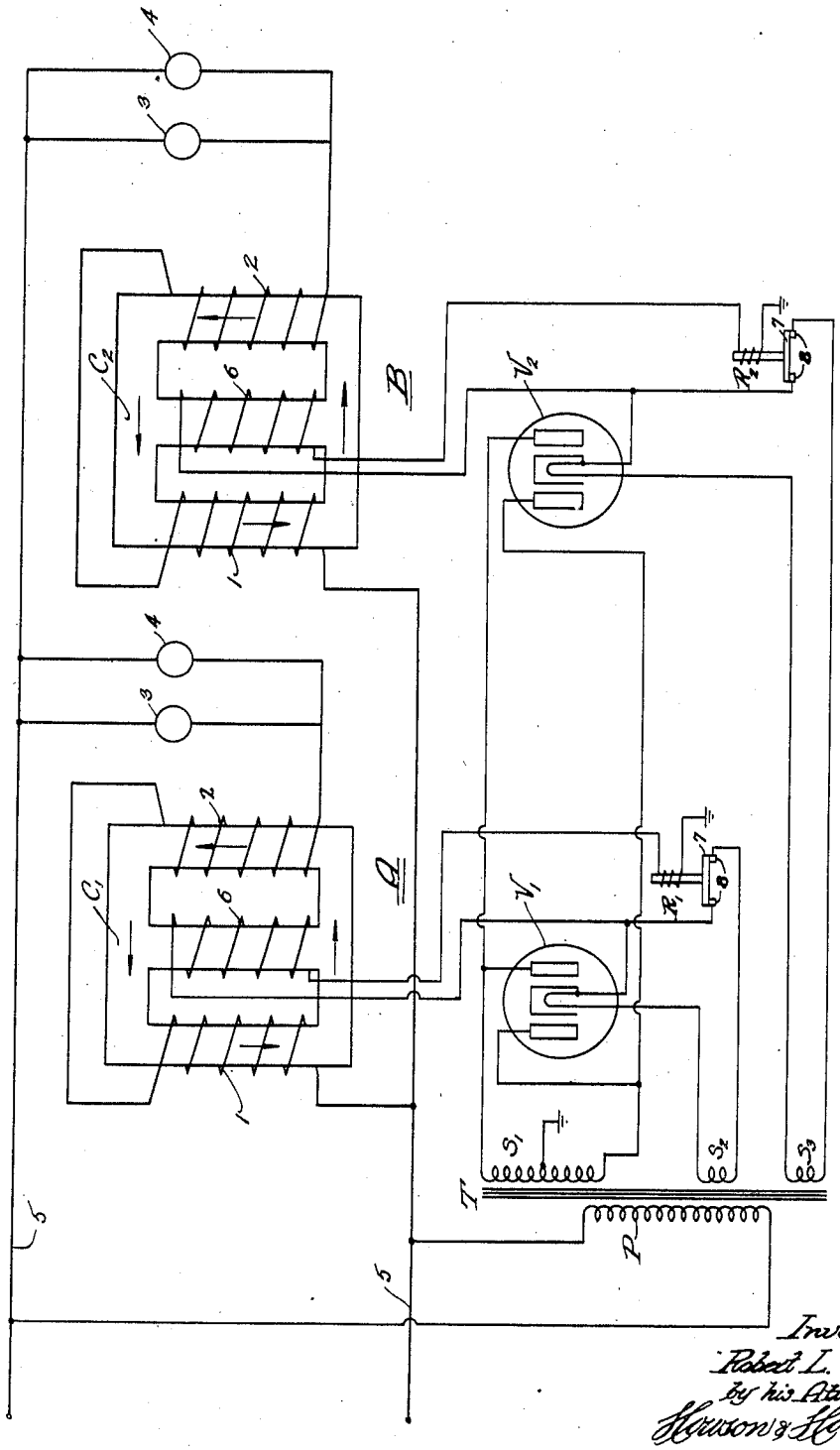
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DEVICE FOR VARYING THE CURRENT FLOW IN AN ELECTRIC CIRCUIT

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Fig. 1.



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DEVICE FOR VARYING THE CURRENT FLOW IN AN ELECTRIC CIRCUIT

Filed June 17, 1938 3 Sheets-Sheet 3

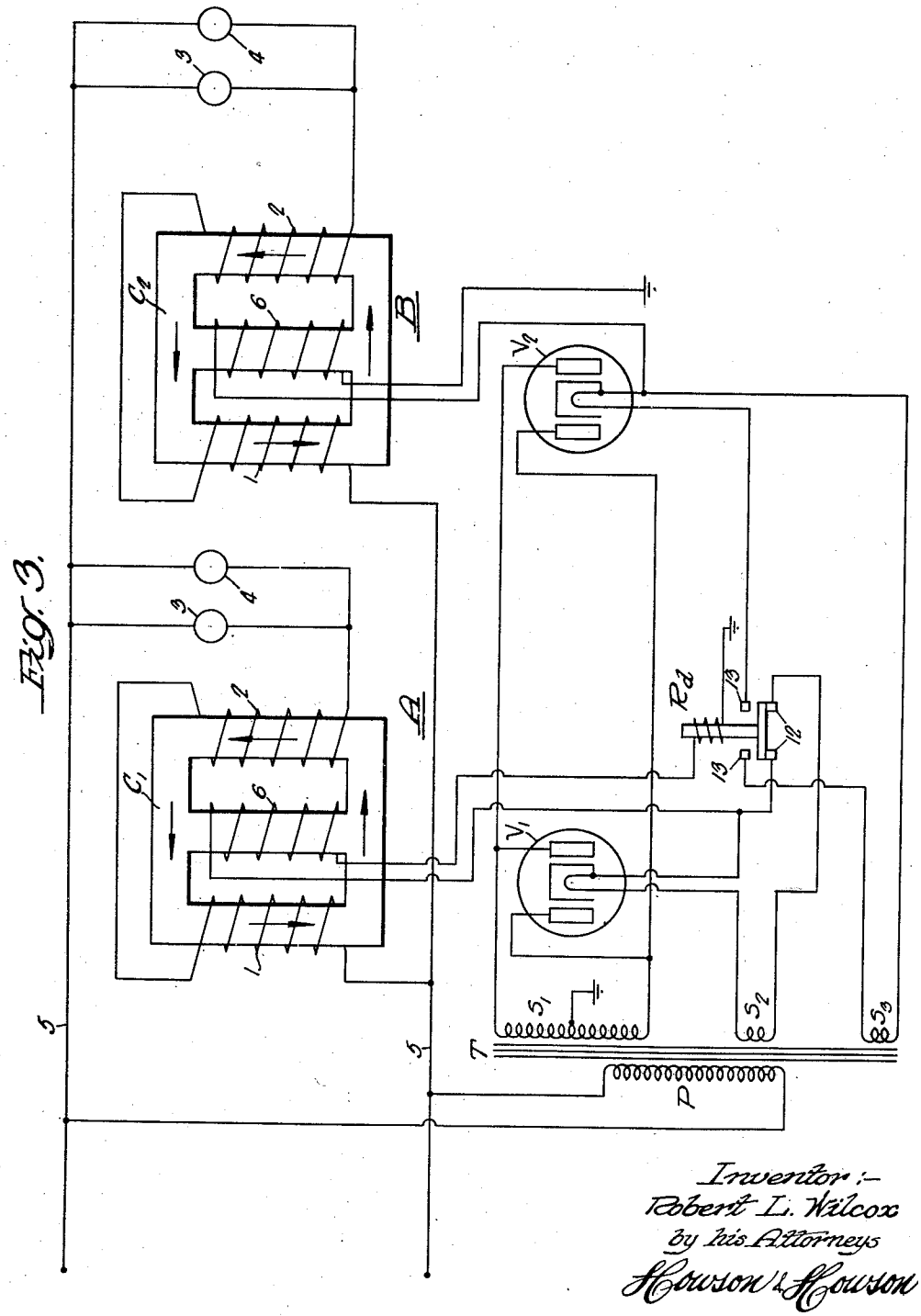


Fig. 3.

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UNITED STATES PATENT OFFICE

2,186,222

DEVICE FOR VARYING THE CURRENT FLOW IN AN ELECTRIC CIRCUIT

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Application June 17, 1938, Serial No. 214,368

3 Claims. (Cl. 171—242)

This invention relates to a novel device for varying the current flow in an electrical circuit and, more particularly, to a novel device for causing the current in said circuit to vary at a sensible rate from a predetermined low value to a predetermined maximum value and vice versa and to repeat this operation cyclically and automatically.

The principal object of the invention is to provide a novel device of this character which is simple in construction, economic to manufacture and operate, and highly efficient in operation.

Another object of the invention is to provide a device comprising one or more units, each of which controls one or more electrical circuits, and each of which comprises a current-regulating device controlled by a space discharge device whose operation is cyclically varied by alternate energization and deenergization of such device.

A further object of the invention is to provide a device of this character employing a reactor comprising a saturable magnetic core for regulating the current flow in the circuit being controlled, the said core having associated therewith a winding controlled by the space current of the space discharge device, whereby the saturation of the magnetic core is controlled by the space discharge device.

A still further object of the invention is to provide a device of this character wherein the alternate energization and deenergization of the said space discharge device is effected by means of a relay controlled by the space current of the discharge device.

Other objects and features of the invention will appear hereinafter.

In the accompanying drawings:

Fig. 1 is a diagrammatic illustration of a two-unit or two-stage device constructed according to the invention;

Fig. 2 is a similar illustration of a modification; and

Fig. 3 illustrates a further modification.

Referring to Fig. 1, there are provided two similar control devices or units designated respectively A and B adapted to control different working circuits or load circuits. In any instance, the complete apparatus may be composed of any desired number of these units. The apparatus illustrated employing two units has been chosen arbitrarily to disclose the invention.

Each of the control devices or units comprises a current regulator in the form of a saturable magnetic core C_1 or C_2 which, together with its associated windings, comprises a variable reactor serving to control the current flow in the associated load circuit. Each device or unit comprises further a space discharge device V_1 or V_2 and a relay R_1 or R_2 novelly arranged to control the associated current regulating device, as described hereinafter.

Each of the current-regulating reactors preferably comprises a magnetic core having two outer legs and an inner leg as illustrated, the core being formed of any magnetic material, such as iron or steel, suitable for the purpose in view. On the respective outer legs of the core, there are provided windings 1 and 2 which are serially connected with one another and are included in the working or load circuit to be controlled. In the specific illustration, the windings 1 and 2 are included in circuit with parallel connected load devices 3 and 4 which may take the form of lamps. Each of the load circuits controlled by the devices or units A and B is energized by supply conductors 5 which may be connected to the usual 110 volt A. C. source.

On the inner leg of each saturable core, there is provided a winding 6 which is supplied with variable current in the manner described hereinafter, to vary the flux density in the core and thus vary the reactance of the current-regulating device which, in turn, varies the current supplied to the load devices 3 and 4. The windings 1 and 2 are arranged so that during any given half cycle of the energizing current, the current flowing in these windings sets up magnetic lines of force in opposite directions in the two outer legs, with the result that the magnetic flux, due to the current in windings 1 and 2 traverses a loop, as indicated by the arrows, without entering the inner leg. Obviously, the components of the flux oppose one another insofar as the inner leg is concerned, as is well understood in the art.

A transformer T has its primary winding P connected to the A. C. source and is provided with a plurality of secondary windings for supplying the necessary voltages to the tubes V_1 and V_2. Preferably, each of these tubes comprises a double-diode rectifier, thus providing full-wave rectification of the current supplied to the transformer T from the supply source. The secondary winding S has its extremities connected to the anodes of the tubes as illustrated, while its center tap is grounded. The secondary windings S_2 and S_3 serve to suppy current to the energizing circuits for the filaments or heaters of the tubes. Each of the relays R_1 and R_2 comprises contacts 7 and 8 which are included in the energizing circuit for the filament of the associated tube. The

winding of each relay has one extremity grounded, while its other extremity is connected to one end of the winding 6 of the associated current regulator. The other end of the winding 6 is connected to the cathode of the associated tube.

Since the operation of each of the devices or units A and B is the same, it is only necessary to describe the operation of one of these units. Considering the unit A, for example, and assuming that the tube V_1 is in the cold condition, the relay contacts 7 and 8 are closed so that when the transformer T is energized, the filament of tube V commences to heat. At this time, the current supplied to the load devices 3 and 4 is at its minimum value and is limited by the reactance of the windings 1 and 2 and the associated core, there being no current flow through winding 6. As the cathode of tube V_1 becomes heated, it emits electrons and its electron emission gradually increases, thereby establishing an increasing space current flow through the tube and through the space current circuit including winding 6 and the winding of relay R_1. During one-half cycle of the supply current, a unidirectional current flows through one of the diodes of tube V_1 and through a portion of the secondary winding S_1 to ground, thence through the winding of relay R_1 and the winding 6 back to the cathode. During the next half cycle of the supply current, a unidirectional current flows through the other diode of tube V_1 and through the other portion of secondary winding S_1 to ground and thence through the winding of R_1 and winding 6 to the cathode. The increasing current flow through the winding 6 increases the flux density of core C_1 substantially to the saturation point and thus decreases the reactance of the current regulator until the current supplied to the load devices 3 and 4 is increased to a predetermined high value. At that time, the magnitude of the current flowing through the relay winding is sufficient to operate the relay, thereby opening the energizing circuit for the filament or heater of tube V_1. Consequently, the cathode of the tube commences to cool, thereby effecting a gradual reduction of the space current flow through the relay winding and through winding 6. Hence the flux density of core C_1 is gradually reduced, thereby gradually increasing the reactance of the current regulator and effecting gradual decreasing of the current supplied to the load devices 3 and 4. Since much less current is required to maintain the relay R_1 energized than is required to energize it, the relay holds the energizing circuit for the filament of V_1 open for a substantial period of time. When the space current flow through the winding of R_1 has decreased to a low value, the relay is deenergized permitting contacts 7 and 8 to close and thereby reenergizing the filament circuit of tube V_1. The cycle then repeats itself.

Thus, the current supplied to the load devices 3 and 4 gradually decreases and increases cyclically between two predetermined values. Obviously, the frequency of the cyclic operation will depend upon the design of the apparatus and, more particularly, upon the heating and cooling rate of the filament and cathode of tube V_1 and also upon the design of relay R_1. Obviously, the frequency may be varied not only by varying the design of the apparatus but also by the employment of well-known expedients, for example by the use of a variable resistor in the filament circuit of the tube to vary the current flow therein or by the use of time delay circuits of known character. If desired, the relay may have a time delay characteristic to retard its switch closing operation.

While the apparatus is applicable for any use, it is particularly adapted to provide various lighting effects. By providing a plurality of units, such as the units A and B, and assigning different colors to the lamps controlled thereby, and by causing the devices to operate at different frequencies, it will be apparent that various color lighting effects may be obtained. Thus, in Fig. 1 the frequencies of the two units may be made different by employing tubes having different heating and cooling characteristics or by employing any other well-known expedient such as above mentioned. Where it is desired to have a fixed color sequence, the frequencies may be adjusted accordingly. The possibilities of such a system are substantially unlimited, particularly in the cyclic blending or changing of color combinations. It will be understood that the invention contemplates the employment of one unit alone or the employment of any desired number of units for controlling any number of circuits regardless of the specific character of the load devices included in such circuits.

Obviously the relay R_1 or R_2 may be connected for voltage operation instead of for current operation. For example, the relay winding could be connected in shunt with winding 6 instead of in series therewith.

It will be apparent also that a single double acting relay could be used to control both units of Fig. 1, such relay having front and back contacts and a single armature so that the tubes V_1 and V_2 would be energized alternately. Such a modification of the apparatus is shown in Fig. 3 wherein the double-acting relay R_4 controls the filament energizing circuits of both of the tubes V_1 and V_2. The contacts 12 control the filament circuit of tube V_1 while the contacts 13 control the filament circuit of tube V_2. It will be apparent that in this instance the filaments are energized alternately and cyclically, and the space currents of the tubes are varied cyclically and differentially, thus effecting corresponding variation of the current in the work circuits.

Further, the tube of either or both units may be alternately energized and deenergized by any suitable means other than a relay.

In Fig. 2, there is illustrated a modified form of the invention which may be used to advantage under certain conditions, for example when substantial amounts of power are involved. In this instance, the load-controlling reactor is directly controlled by the grid-controlled vacuum tube V_4 which, in turn, is controlled by the diode rectifier tube V_3, as will be explained in detail presently. The heater element of tube V_3 is energized from the secondary winding S_4 of the transformer T_1 and the energization of this tube is controlled by the relay R_3. The anode of tube V_3 is connected through the secondary winding S_5 and through the winding of relay R_3 to the grounded resistor R and to the control grid of tube V_4. It will be seen that the space-current circuit of tube V_3 extends from the anode through winding S_5 and resistor R to ground and thence to the cathode of the tube.

The grounded filamentary cathode of tube V_4 is energized from the secondary winding S_6. The anode of this tube is connected through the control winding 9 on the saturable magnetic core C_3 and through the secondary winding S_7 to ground.

The load circuit being controlled includes the

series-connected windings 10 and 11 on the core C_3 so that the magnitude of the current in the load circuit is variable by means of the control winding 9, as will be understood from the above description.

Considering the operation of this device, when the contacts of relay R_3 are closed as illustrated, the tube V_3 is energized, causing an increasing space-current flow through the space-current circuit of the tube, including the relay winding and the resistor R. Consequently, an increasing negative bias voltage is built up across the resistor R and, since this voltage is applied between the grid and cathode of tube V_4, it serves to decrease the plate current of the tube flowing through the control winding 9. As a result, the flux density in the magnetic core C_3 is decreased, thereby increasing the reactance of the reactor which, in turn, decreases the magnitude of the current flowing in the load circuit.

When the space current of tube V_3 is of sufficient magnitude to energize relay R_3, the tube V_3 is deenergized and the space current of the tube diminishes. Consequently, the negative bias across resistor R decreases, causing the plate current of tube V_4 to decrease. The increasing current flow through winding 9 increases the flux density of the core C_3, thereby decreasing the reactance of the reactor which, in turn, causes the current in the load circuit to increase in magnitude.

Thus, it will be seen that the magnitude of the current in the load circuit is caused to vary cyclically between predetermined low and high values. It will be noted that the space current of tube V_3 controls the relay R_3 to thus control the energization of tube V_3 and also controls the bias across resistor R to thus control the plate current of tube V_4 which, in turn, controls the reactance of the reactor.

While a single unit has been shown in Fig. 2, it will be understood that any desired number of such devices may be employed to control different load circuits and varying effects or results may be obtained, as mentioned above in connection with Fig. 1.

Although certain embodiments of the invention have been illustrated and described for the purpose of disclosure, it will be understood that various other embodiments and modifications are possible without departing from the scope of the invention.

I claim:

1. In combination with an electric power supply and a work circuit, an impedance having a control winding, the terminal voltage of said impedance varying in response to changes in the magnitude of current in said control winding, a circuit connecting said power supply to said work circuit through said impedance, an electrical discharge tube having a filament which has an appreciable thermal lag whereby the current therethrough is dependent upon said lag, a space current circuit for said tube, an energizing circuit for said filament, a relay having a winding in said space current circuit and contacts controlled by the relay winding and arranged in said energizing circuit to control the same, whereby the space current of said tube is caused to vary cyclically, and means for varying the magnitude of current in said impedance winding in correspondence to the cyclic variation of said space current, whereby the terminal voltage of said impedance is caused to vary cyclically to thereby vary the current in said work circuit accordingly.

2. In combination with an electric power supply and a work circuit, an impedance having a control winding, the terminal voltage of said impedance varying in response to changes in the magnitude of current in said control winding, a circuit connecting said power supply to said work circuit through said impedance, an electrical discharge tube having a filament which has an appreciable thermal lag whereby the current therethrough is dependent upon said lag, a space current circuit for said tube, an energizing circuit for said filament, means for controlling said energizing circuit so as to cause heating or cooling of said filament, means associated with said space current circuit for operating said controlling means so as to effect cooling of said filament when the space current reaches a predetermined amplitude and to effect heating of said filament when the space current decreases to a predetermined low amplitude, whereby the space current of said tube is caused to vary cyclically between said amplitudes, and means for varying the magnitude of current in said winding in correspondence to the cyclic variation of said space current, whereby the terminal voltage of said impedance is caused to vary cyclically to thereby vary the current in said work circuit accordingly.

3. In combination with an electric power supply and a pair of work circuits, a pair of impedances each having a control winding associated respectively with said work circuits, the terminal voltage of each said impedance varying in response to changes in the magnitude of current in said control winding, circuits connecting said power supply to said work circuits through said impedances, a pair of electrical discharge tubes associated respectively with said impedances, each said tube having a filament which has an appreciable thermal lag whereby the current therethrough is dependent upon said lag, a space current circuit for each tube, an energizing circuit for each filament, a double-acting relay having a winding in one of said space current circuits and having contacts in one filament energizing circuit and other contacts in the other filament energizing circuit, whereby said filaments are energized alternately and cyclically and the space currents of said tubes are varied cyclically and differentially, and means for varying the magnitude of current in each said impedance winding in correspondence to the cyclic variation of the space current in the associated tube, whereby the terminal voltages of said impedances are caused to vary cyclically and differentially to thereby vary the current in said work circuits accordingly.

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