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CURRENT REGULATOR

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10 Claims. (Cl. 175—363)

This invention relates to current regulators, and more particularly to means whereby the current through a circuit may be maintained constant irrespective of changes in the load.

This application covers an improvement upon the invention disclosed in my copending application filed June 20, 1932 as Serial No. 618,369, and entitled "Current controlling apparatus".

One feature of this invention is that it holds the current in the load circuit at any desired constant level; another feature of this invention is that it achieves control through the use of electronic tubes, without any resistance or heat losses; still another feature of this invention is that it is capable of complete control of the output of the tubes, and is capable of continuous variation from maximum to zero. Other features and advantages of this invention will be apparent from the following specification and the drawing.

In the particular embodiment of this invention illustrated herewith the A. C. supply line is indicated by reference numerals 10 and 11. The transformer 12 has its primary 13 connected across this supply, and its secondary 14 attached at one end to the anode 15 of the tube 16, and its other end attached to the anode 17 of the tube 18. The cathodes 19 and 20 of these tubes are connected together, and a lead 21 runs from them through a solenoid 22 to one end of the load 23. This load 23 may comprise any electrical system through which it is desired to maintain a constant D. C. current, as for example, a series street lighting system, a battery charging line, or an electrolytic chemical process in which the resistance may vary from maximum value to a minimum value which approaches short circuit value. From the other side of the load 23 a lead 24 completes the load circuit to the mid-point 25 of the secondary 14.

The tubes 16 and 18 are of the controlled arc rectifying type, and in this particular embodiment include grids 26 and 27. These grids are connected respectively to opposite ends of the secondary 28 of the grid transformer 29. A grid return circuit is completed from the mid-point 30 of the secondary 28 to the cathode through the lead 31. The primary 32 of the transformer 29 is in the common return of a phase splitting circuit which also derives its energy from the A. C. lines 10 and 11 through the transformer 33, which has its primary 34 connected across said lines.

The phase splitting circuit is energized by the secondary 35 of the transformer 33, which secondary has across it a voltage dividing resistor 36 having its ends connected to the ends of the

transformer secondary 35 by the leads 37 and 38. The center point 39 of this resistor 36 is connected to one end of grid transformer primary 32 by a lead 41. The phase splitting circuit also includes an inductance 42 connected to one side of the voltage supply, namely, the transformer secondary 35, and a resistance 43 making its return to the other side of said secondary 35 through the contact arm 44, the voltage dividing resistor 36, and the lead 37. A common circuit or return for both the inductance and the resistance branch is provided by the lead 45, the primary 32 of the grid transformer, and the lead 41 to the center tap of the resistor 36.

The slider arm 44 of the voltage dividing resistor is pivoted at the point 46, and is attached by linkage 47 to the movable core 48 in the solenoid 22. The other end of this core 48 has connected thereto a spring 49 which has one end attached to some fixed point 50 by adjustable connecting means shown here as a wingnut 51.

In operation, A. C. current is supplied to the anodes 15 and 17 by the transformer secondary 14. The cathodes 19 and 20 are adapted to receive current from whichever one of either cooperating anodes is positive at any given instant, and then to pass the pulsating D. C. current through the lead 21, the solenoid 22, the load 23, and the lead 24 back to the center point of the secondary 14. The tubes will not, however, break into operation the moment their anodes become positive, but will remain inactive until the voltage on the respective grids becomes more positive than the critical voltage of the tube at a given instantaneous positive anode voltage. Control of the quantity of current passed through these rectifying tubes 16 and 18 may thus be achieved by changing the phase of the voltage on the grids with respect to that applied to the anodes. This is accomplished by the action of the phase splitting circuit, wherein the voltage drop across the inductance 42 and the resistance 43 combines to give the resultant voltage drop across the primary 32 of the grid transformer 29. Change in the relationship of these voltage drops affects the resultant, and this change is achieved automatically through movements of the core 48 which is attached to the resistor switching arm 44. Should the resistance in the load 23 drop for any reason an increased current will tend to flow. This change in current will cause the solenoid to exert a stronger pull on its core 48 and will thus overcome the tension of the spring 49 and pull the core 48 further into the solenoid. This motion of the core will be transmitted through the link-

age 47 to the resistor switching arm 44, which will thus be moved closer to the neutral point 39. The voltage drop across the resistance 43 will thus be reduced, changing the relationship between it and the inductance 42, and causing the voltage in the primary 32 of the grid transformer 29 to swing further out of phase with the voltage supplied to the anodes 15 and 17. The tubes will thus break into operation later in each cycle, and therefore a smaller average current will be passed by them, thus restoring the current through the load 23 to the desired constant level.

Manual changes of the level at which it is desired to hold the current constant, may be achieved through manipulation of the wingnut 51, thus effecting the tension of the spring 49, or by manual change in the ohmic value of the inductance 42 or the resistance 43. Once the level has thus been set at a desired value, the action of the solenoid will maintain the current through the load 23 at that desired value.

While I have shown and described the embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims in which it is my intention to claim all novelty inherent in my invention as broadly as permissible, in view of the prior art.

What I regard as new, and desire to secure by Letters Patent, is:

1. In a constant current system, an alternating current supply line, a load circuit the resistance of which may vary between a predetermined maximum value and a minimum value which approximates short circuit value, an electron tube having working electrodes connected to said line and to said circuit, said tube having means for controlling the conductivity thereof, a control circuit for said means, said control circuit comprising means for supplying a controlling alternating potential synchronous with the potential supplied by said line to the electrodes of said tube, said last named means comprising an inductive branch, a resistance branch, a potential dividing resistor having a control contact for regulating the potential applied to said branches in series, and a common return from said branches to a point on said resistor intermediate its ends, said return having a transformer winding therein, movement of said contact controlling the phase shift of said controlling potential relative to the potential impressed upon said working electrodes, and a current sensitive member in series relation to said load circuit for controlling the shifting of said contact to keep the current substantially constant for all variations in resistance between said maximum and minimum.

2. Means for supplying alternating current of controlled phase with respect to an alternating current supplied thereto comprising an alternating current supply circuit, a resistor bridged across the supply circuit, a resistor branch and a reactor branch connected to a common return, said common return being connected to the midpoint of said bridged resistor, one of said branches being connected to one side of the supply circuit, and a contactor connected to said other branch and adapted to make contact at any selected point along the bridged resistor whereby the phase of current in said common return circuit is varied.

3. Apparatus of the character described, including, an alternating current supply circuit, a

controlled arc rectifying tube energized by said circuit, control means in said tube, a load circuit requiring a current of substantially constant value supplied by said tube, a solenoid in said load circuit having a movable core therein, a phase splitting circuit for energizing said control means and including a voltage dividing resistor connected to said supply circuit having a contact arm capable of varying the potential applied to said phase splitting circuit, and means operatively connecting said core and said contact arm whereby variations in the current through said solenoid effect movement of said contact arm in such manner as to shift the phase of the potential applied to said control means for restoring the current flow to said substantially constant value.

4. Apparatus of the character described, including, an alternating current supply circuit, a controlled arc rectifying tube energized by said circuit, control means in said tube, a load circuit requiring a current of substantially constant value supplied by said tube, a phase splitting circuit whereby the phase of the voltage applied to said control means may be shifted with respect to the anode of said tube, said phase splitting circuit including a voltage dividing resistor having a contact arm, and means whereby changes in the current in said load circuit from said substantially constant value alter the position of said contact arm to restore said load current to said substantially constant value.

5. Apparatus of the character described, including, an alternating current supply circuit, a controlled arc rectifying tube energized by said circuit, control means in said tube, a load circuit supplied by said tube having a solenoid therein; a phase splitting circuit comprising an inductance branch, a resistance branch, a common return and a voltage dividing resistor connected to said supply circuit and variably connected to said phase splitting circuit, means for adjusting said voltage dividing resistor as a function of the current flowing through said solenoid, and means whereby the voltage developed in said return is impressed on said control means.

6. Apparatus of the character described, including, an alternating current supply circuit, a controlled arc rectifying tube energized by said circuit, control means in said tube, a load circuit requiring a current of substantially constant value supplied by said tube, a solenoid in said load circuit having a movable core therein; a phase splitting circuit comprising a transformer secondary, a voltage dividing resistor connected across said secondary, an inductance branch connected to one end of said voltage dividing resistor, a resistance branch connected to the contact arm of said voltage dividing resistor, and a common return for said branches; means whereby the voltage developed in said return is impressed on said control means, and means operatively connecting said core and said contact arm whereby variations in current through said load circuit effect movement of said contact arm to restore the load current to said substantially constant value.

7. In a constant current system, an alternating current supply line, an anode transformer, a pair of grid controlled rectifiers, a direct current circuit for supplying current to a load device, means for supplying excitation to the grids of said rectifiers comprising an excitation transformer, a phase shifting current supply circuit for supplying excitation to the grids of the tubes, said circuit including a branch including mainly re-

sistance and a branch including mainly reactance, and a common return from said branches the phase of current through which is applied to said grids, a resistance bridged across said phase
5 shifting current supply circuit, said common return being connected to substantially the midpoint of said resistance, a shiftable contactor engaging said resistance, said contactor being connected to one of said branches, the other of said
10 branches being connected to one side of the phase shifting current supply circuit, and a device responsive to the current in the load circuit for shifting said contactor.

8. In an electrical control system, in combination, a pair of impedance devices of different phase angle disposed to be connected in series circuit relation across the terminals of a source of alternating current, circuit means interconnecting the common connection between said impedance devices and a point substantially electrically midway between said terminals, and means for varying the voltage impressed across said impedance devices from said source whereby the phase relation of the voltage applied to said
25 circuit means is varied relative to the voltage of said source.

9. In an electrical control system, in combination, a transformer having a primary winding for connection to a single phase source of alternating

current and a secondary winding, means for providing a connection substantially midway between the terminals of said secondary winding, a pair of impedance devices of different phase angle connected in series circuit relation, one terminal of said series connected devices being connected to one terminal of said secondary winding, circuit means interconnected between the common connection between said impedance devices and said mid-connection, and means for connecting the other terminal of said series connected devices to said secondary winding for variably energizing them, thereby altering the phase relation of the voltage applied across said circuit means relative to the voltage of said source.
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10. In an electrical control system, in combination, a transformer having a primary winding for connection to a single phase source of alternating current and a secondary winding, a voltage divider connected across said secondary winding having a mid-tap and a variable tap, a pair of impedance devices of different phase angle interconnected between one terminal of said secondary winding and said variable tap, and a load circuit
20 interconnected between said mid-tap and the common connection between said impedance devices.
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