

Feb. 29, 1944.

J. D. RYDER ET AL
ELECTRICAL SYSTEM
Filed March 3, 1941

2,343,116

2 Sheets-Sheet 1

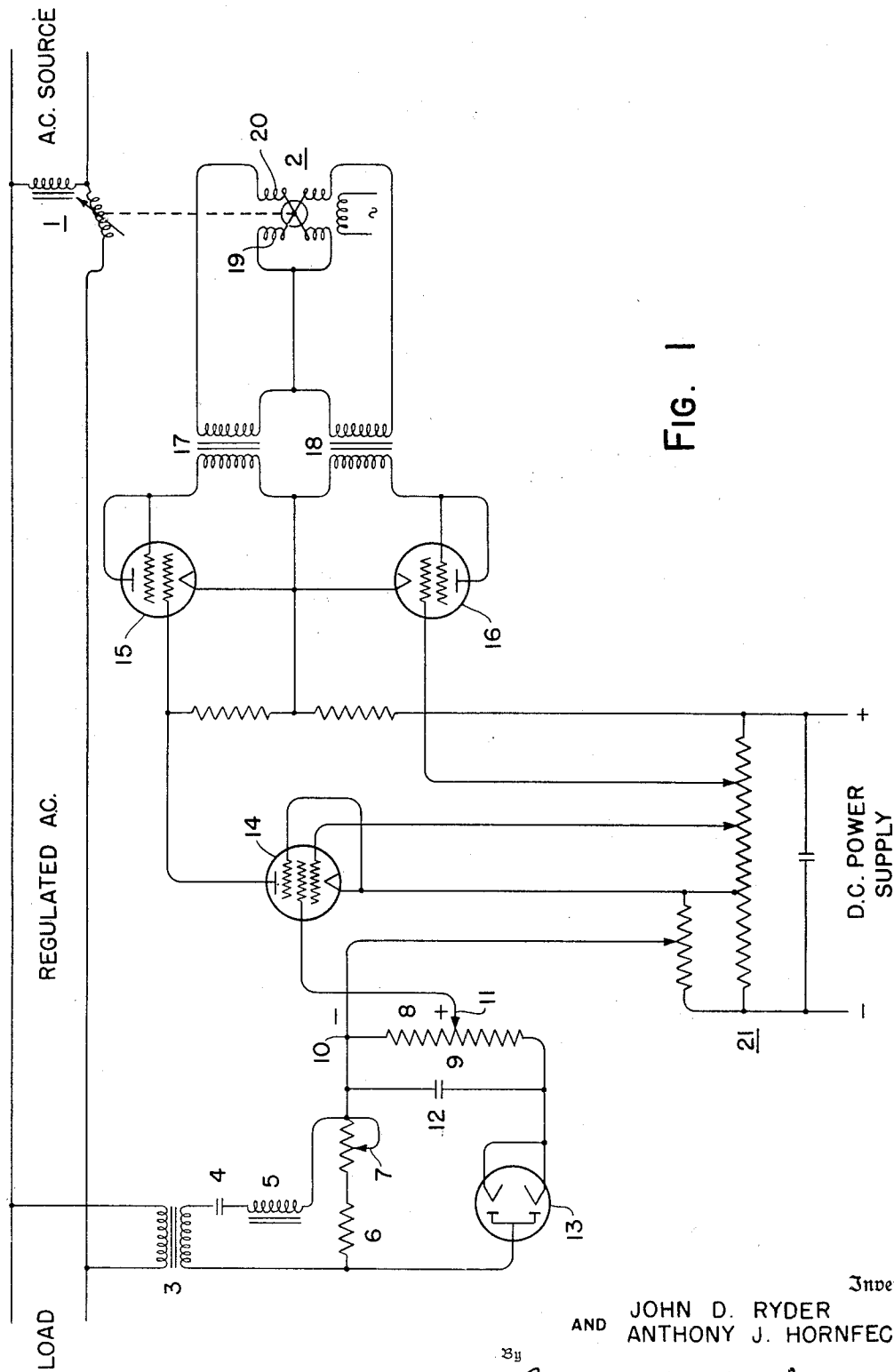


FIG. 1

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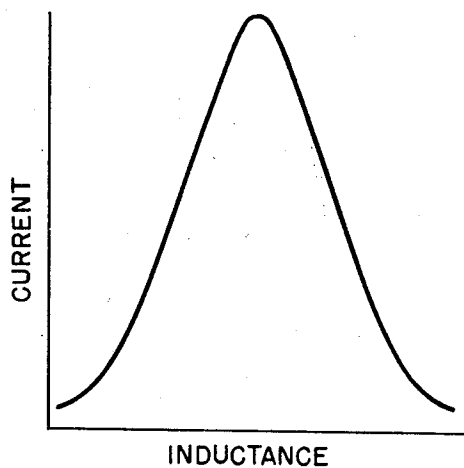


FIG. 2

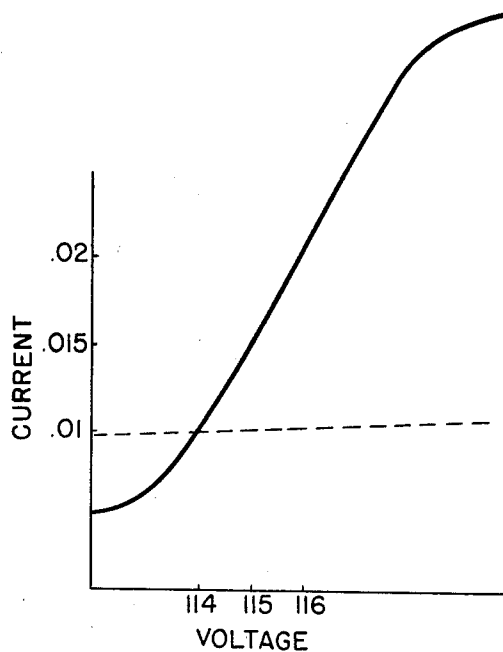


FIG. 3

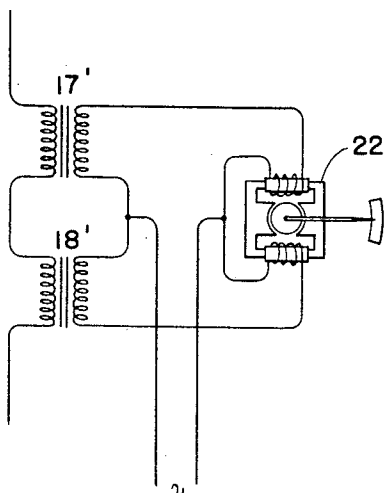


FIG. 5

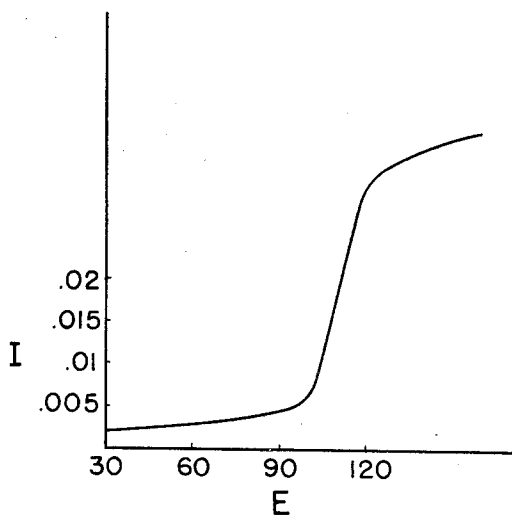


FIG. 4

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2,343,116

ELECTRICAL SYSTEM

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Application March 3, 1941, Serial No. 381,534

3 Claims. (Cl. 172-239)

This invention relates to an electrical system and apparatus, and particularly to a system for voltage regulation of an alternating current supply to apparatus requiring substantially constant voltage.

In general, it relates to means sensitive to a departure of a variable from desired value and to the automatic return of the value of the variable to the optimum value.

A principal object of our invention is to provide a voltage regulator for maintaining substantially uniform the voltage of an alternating current supply, which voltage might otherwise vary with fluctuations in line voltage.

In the drawings:

Fig. 1 is a diagrammatic representation of a preferred embodiment of our invention.

Figs. 2, 3 and 4 are graphs showing relationship of values in an electrical system.

Fig. 5 illustrates a modification of Fig. 1.

In the drawings the alternating current source is connected to the regulated alternating current supply through an induction voltage regulator 1 having its secondary winding mechanically movable relative to the primary winding. The induction regulator 1 is of a known type and for the purpose of explanation will be spoken of as a 10% buck or boost regulator. That is, if the alternating current source voltage is supported to be constant at 115 volts across the primary of the regulator 1, then the secondary has a range of approximately plus or minus 11 volts which may be added to or subtracted from the actual voltage of the alternating current source to maintain the regulated alternating current supply uniform at a value of 115 volts within the limits of the system.

In general, the arrangement is such that deviations in the voltage of the regulated alternating current supply from optimum value, as caused either by the load connected to the supply or by variations in voltage of the alternating current source, are immediately magnified and become effective to energize a motor 2 which is adapted to mechanically move the secondary winding of the regulator 1 in proper direction and amount to return the regulated voltage to optimum value. The necessary mechanical connections and gear reduction are provided between the motor 2 and the secondary winding of regulator 1 and inasmuch as these are ordinary expedients it is not necessary to go into detail in this specification. It is, of course, to be understood that the motor 2 when energized has a high speed of rotation in selected direction and that the movable secondary

of the regulator 1 is to have a relatively slow speed of movement and that the proper gear ratios therebetween may vary from one installation to another, but of course may be readily calculated or arrived at experimentally.

Connected to the regulated alternating current supply we show a transformer 3 of approximately 1 to 1 ratio merely to serve the purpose of insulating the control circuit from the regulated alternating current supply.

The secondary of the insulating transformer 3 is connected in a loop circuit including in series a negative reactance or capacitance (capacitor) such as the condenser 4, and a positive reactance such as an impedance or iron core reactor 5, as well as a fixed resistance 6 and an adjustable resistance 7, the latter comprising a sensitivity adjustment. The whole comprises a voltage sensitive non-linear resonant circuit receiving substantially full line voltage through the insulating transformer 3. The reactances of the elements 4 and 5 are opposite and are equal at some design value of current. When the voltage in the loop (from the transformer 3) changes, then the current flow changes very rapidly with respect to the voltage change.

Referring now to Fig. 2 it will be observed that in such a non-linear resonant circuit the current rises very rapidly relative to inductance. The circuit is, however, voltage sensitive because the iron core inductance depends upon the voltage and as seen in the plot of Fig. 2 when voltage changes, the current flow through the loop changes very rapidly with respect to the inductance change. The relation between current and voltage in the resonant circuit is shown in Fig. 3 wherein the dotted line represents the Ohm's law relation between voltage and current and represents a linear circuit. The present non-linear resonant circuit relationship between current and voltage is shown by the solid line and it will be observed therefrom that if the voltage in the secondary of insulating transformer 3 varies from 115 say to 116 volts (less than 1% variation) the current flowing through the resonant non-linear circuit may well vary from .015 to .02, namely, a variation of 30%. Such values are representative only of the relationship between voltage and current in the resonant circuit may be made larger or smaller than the specific values as desired by proper selection of the elements of the circuit. If the circuit followed Ohm's law the current change would be the same percentage change as the voltage change. Fig. 4 is a more complete plot of the relationship between current

and voltage, and of which Fig. 3 is a portion drawn to different scale.

We now use the greatly magnified current variation (representative of voltage variation) to produce a large voltage drop across the resistance 6, which in turn produces across the resistance 8 a direct current voltage of a value in volts equal to the peak value of the alternating current voltage across 6. We have designated at 8 that portion of a resistance 9 between the negative terminal 10 and the adjustable positive terminal 11, which latter comprises the standard adjustment for the circuit. A condenser 12 is connected in parallel with the resistance 9, while an electron discharge device 13 is connected in series with the elements 6, 7 and 9. The device 13 is a diode rectifier producing across the terminals 10, 11 normally pulsating direct current, but through the inclusion in the circuit of the condenser 12 there is applied to the terminals 10, 11 a continuous direct current voltage whose magnitude is at least one hundred times the change in alternating current voltage which has occurred in the regulated alternating current supply.

The direct current voltage at the terminals 10, 11 representative of change or departure of alternating current voltage from optimum value is applied to an amplifying tube or electronic voltmeter 14. The voltmeter tube 14 acts as a relay to control a pair of motor control tubes 15, 16 whose output circuits include the transformers 17, 18 respectively. The reversible induction motor 2 is provided with opposed wound shading poles 19, 20. The winding 19 is connected in circuit with the primary of the transformer 17, the secondary of which is connected in the output circuit of the electron discharge device 15. The winding 20 is similarly connected in circuit with the primary of the transformer 18, the secondary of which is connected in the output circuit of the electron discharge device 16.

When the electron discharge devices 15 and 16 are non-conducting, the impedance of the primaries of the transformers 17, 18 is sufficient that the windings 19, 20 are substantially open circuited and the motor 2 is not urged to rotation. With the electron discharge device 15 rendered conducting, the impedance of the primary of the transformer 17 is reduced sufficiently so that the winding 19 is substantially short circuited and the motor 2 rotates to move the movable portion of the induction regulator 1 in desired direction. Conversely when the electron discharge device 16 is conducting, the winding 20 is substantially short circuited, moving the induction regulator in opposite direction. Certain features of the motor control circuit are disclosed and claimed in the patent to John D. Ryder No. 2,215,254.

The tap points and values of the resistances 21 are determined by design and experimentation, whereafter they are preferably not altered. As previously mentioned, the adjustable resistance 7 provides a sensitivity adjustment, while the adjustable arm 11 (varying the resistance length 8) provides a standard adjustment.

In general, it will be observed that deviations in alternating current voltage from optimum value are applied in proper direction and greatly magnified to the vacuum tube voltmeter 14 which, through the agency of amplifying tubes 15, 16 and transformers 17, 18, controls the rotation of motor 2 in desired direction and

amount for positioning the movable portion of the induction regulator 1 whereby the voltage of the regulated alternating current supply is returned to optimum value and the system balanced. In balanced condition the equal opposed shading poles 19, 20 do not urge the motor 2 to rotation.

In Fig. 5 we illustrate a modification wherein the opposed wound shading pole type motor 2 is replaced by an opposed field reversing motor 22. The circuit including the primaries of transformers 17' and 18' as well as the field windings 19 and 20 is energized from a suitable source of alternating current. In this arrangement the transformers 17' and 18' will be of somewhat different value than transformers 17 and 18 of Fig. 1 due to the difference in voltage of the alternating current applied to the primaries.

With the arrangement of Fig. 5 the opposed windings of motor 22 may normally be energized or normally deenergized, it being understood that with one winding energized and the other winding deenergized the motor will rotate in desired direction. It is quite probable that other types of motor may be used with only slight changes in the circuit including the primaries of transformers 17 and 18, and we include as our disclosure any type of reversing motor having opposed windings and controllable as to rotation and direction of rotation through the agency of transformers 17 and 18 in the manner explained.

Certain features of the electronic voltmeter circuit, disclosed but not claimed herein, are disclosed and claimed in the copending application Serial No. 381,535 of John D. Ryder copending herewith.

While we have disclosed and described certain preferred embodiments of our invention, it is to be understood that we are not to be limited to the exact arrangements shown.

What we claim as new, and desire to secure by Letters Patent of the United States, is:

1. A motor control system operative in response to small voltage variations from an optimum value in an alternating current circuit comprising in combination, a non-linear, resonant circuit, means energizing said last mentioned circuit from the first circuit, a resistor, means energizing said resistor with a direct current component of the voltage drop in an element of said resonant circuit, an electronic voltage sensitive device having a control element energized from said resistor, a pair of electron discharge devices connected to be selectively controlled by the output of said voltage sensitive device, a reversing induction motor having opposed wound coils, energizing of one of said coils producing rotation in one direction and energizing of the other of said coils producing rotation in the reverse direction, means for energizing said coils comprising a pair of transformers with the primary of each connected in circuit with one of said coils, the secondary of each transformer, being connected in the output circuit of one of said electron discharge devices.

2. A motor control system operative in response to small voltage variations from an optimum value in an alternating current circuit comprising in combination, a non-linear, resonant circuit having different impedance elements in series, means continuously energizing said last mentioned circuit from the first circuit, a resistor, means energizing said resistor continuously with a direct current component of the voltage drop in an element of said resonant circuit, an

electronic voltage sensitive device having a control element connected to said resistor, a pair of electron discharge devices connected to be selectively controlled by the output of said voltage sensitive device, a reversing induction motor having opposed wound shading coils, short circuiting of one of said coils producing rotation in one direction and short circuiting the other of said coils producing rotation in the reverse direction, means for short circuiting said coils comprising a pair of transformers with the primary of each connected in circuit with one of said coils, the secondary of each transformer being connected in the output circuit of one of said electron discharge devices.

3. A motor control system operative in response to small voltage variations from an optimum value in an alternating current circuit comprising in combination, a non-linear, resonant loop circuit including a capacitance, a reactance and a resistance in series, means energizing said

loop circuit from the first circuit, a resistor, means including a rectifier for energizing said resistor with direct current representative of the voltage drop in the resistance of said loop circuit, an electronic tube having an input circuit at least partially energized from said resistor, a pair of electron discharge devices connected to be selectively controlled by the output of said voltage sensitive device, a reversing induction motor having opposed wound shading coils, short circuiting of one of said coils producing rotation in one direction and short circuiting the other of said coils producing rotation in the reverse direction, means for short circuiting said coils comprising a pair of transformers with the primary of each connected in circuit with one of said coils, the secondary of each transformer being connected in the output circuit of one of said electron discharge devices.

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