

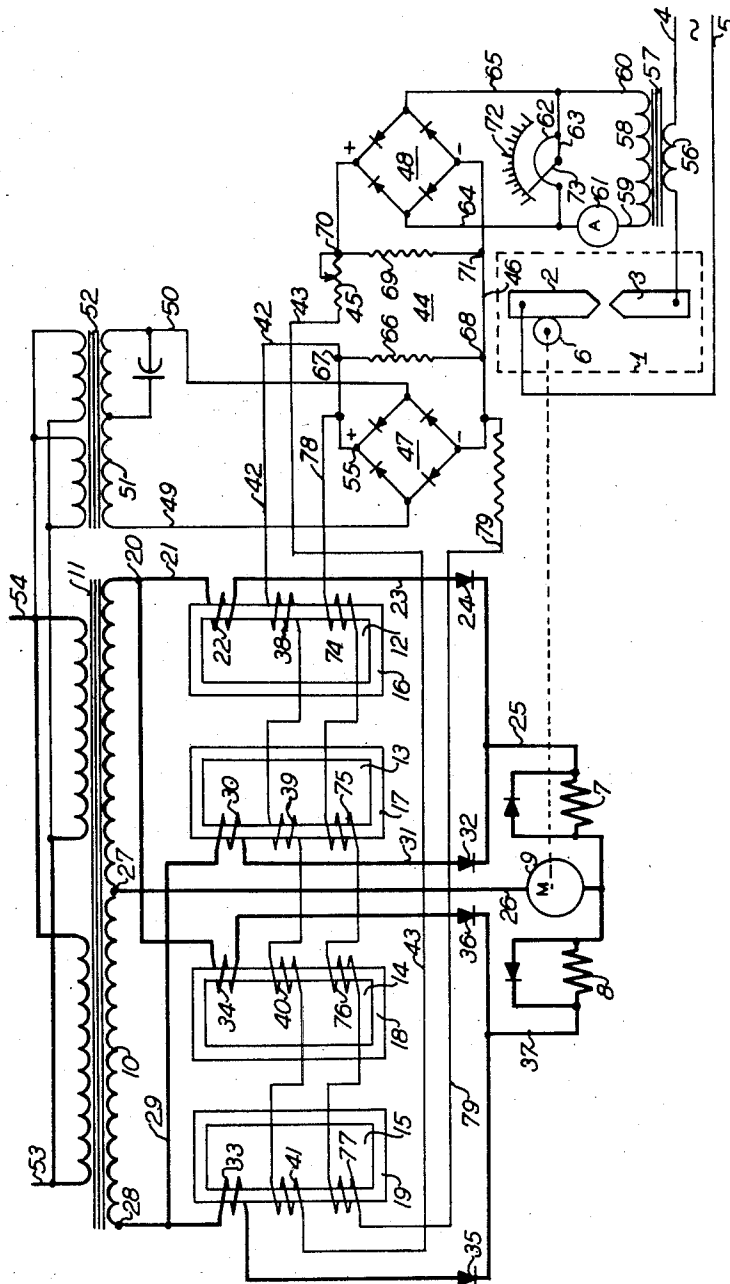
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CONSTANT CONDITION REGULATING SYSTEM

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CONSTANT CONDITION REGULATING SYSTEM

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This invention relates to electric control systems, that are operative automatically to maintain substantially constant a magnitude or condition that tends to vary above or below a normal value.

The invention is applicable to a variety of uses, but to render this disclosure concrete it has been chosen to illustrate and describe it as applied to the regulation of an electric current to a constant magnitude; and more particularly the alternating current of an electric arc between the electrodes of an arc heated furnace.

The actual invention is that set forth in the appended claims.

As distinguishing from many controls of furnace temperature, the control of this invention has no means such as a thermostat, thermocouple, or the like, responding to changes of the furnace temperature and activating a control to maintain the temperature constant; but responds solely to variations of the arc current itself to restore it to a preselected or normal magnitude upon its tending to rise above or fall below the normal.

The invention comprises in general an electric motor, normally at rest when the arc current is at the preselected value, and mechanically connected to the arc electrodes to move them closer together or farther apart when the current varies due to any cause, particularly due to consumption of the electrodes.

The motor is actuated to run in one direction or the other for this purpose by the outputs of two full wave rectifying saturable reactor devices having D.C. saturating control windings and therefore being of the type sometimes called a transductor. The transductors also have biasing windings, that normally cause the outputs to be very small.

The control windings for both transductors are energized from a network normally in a null or balanced condition, and put out of balance in either of two senses by arc current variations, and then the network energizes the saturating windings in one of two senses to activate the transductors to have outputs of different values to drive the motor in a corresponding one of its two directions.

The network has two opposing D.C. potentials impressed upon it, one being a permanently fixed potential, and the other being a variable potential.

The potentials are produced by current flowing in resistors, and are hereinafter referred to as resistor potentials to simplify description.

Variations of the variable potential causes it to predominate over, or be predominated over by, the fixed potential, to effect the said unbalance of the network in one of said two senses.

The current producing the variable resistor potential is proportional to the arc current, and varies therewith; and variations of arc current from normal thus puts the network out of balance, and the motor then operates to restore the arc current to normal and thereby rebalance the network.

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The variable potential is derived from the arc current, through the agency of a potentiometer; and for each adjustment of the potentiometer the effectiveness of the variable potential is changed, and thus the constant or regulated value of the arc current can be predetermined, by selective adjustment of the potentiometer without disturbing the ohmic value of either of the said resistors of the network.

The potentiometer may be calibrated in units of arc current and preset and fixed for the desired value of the current.

The motor acts to control or regulate the arc current to the selected value.

The control therefore distinguishes from prior controls in which the effective ohmic value of a resistor of the network must be changed to rebalance the network, and in which systems it is changed by a follow-up movement of a resistance-changing element, communicated to it by a motor.

The network of the invention is unbalanced upon a variation of arc current by a corresponding variation of the current in a network resistor causing a change in the resistor potential; and the potentiometer adjustably changes the current in the network resistor to adjust its potential; and also adjusts the arc current; and neither the ohmic value of the potentiometer resistance nor of the network resistor are changed in the operation of the control to maintain constant arc current or to rebalance the network.

The main objects of the invention are:

To provide a control system having the principles of operation described above;

To provide a control system comprising apparatus and electrical connections operative to perform the control features described above.

Other objects will appear hereinafter to those skilled in the art upon a reading of the following description.

The invention is fully disclosed in the following description taken in connection with the accompanying drawing in which the single figure is a diagrammatic representation of a preferred embodiment of the invention.

Referring to the drawing there is indicated at 1 an electric furnace having electrodes 2—3 connected to A.C. supply lines 4—5 for supplying A.C. to an arc between the electrodes to thereby supply furnace heat; and at 6 is a rotary device rotated in alternate directions by a reversible motor M, for moving the electrode 2 closer to or farther from the electrode 3 to regulate the current in the arc, to correspondingly regulate the heat in the furnace.

The motor M is of the differential field type having two series fields 7—8; which if they were energized equally would cause the motor armature 9 to remain at rest and if one predominated over the other would cause the armature to run in a corresponding direction; and such a motor is used in the control hereof, but is caused to remain at rest by energization of its fields at such small values that it will remain at rest whether they are exactly equal or not.

The motor armature and fields are supplied with D.C. from the secondary 10 of a transformer 11 whose primary is energized by A.C. mains 53—54, through a pair of full wave rectifying saturable reactors or amplifiers; a pair 12 and 13 for the armature 9 and field 7, and a pair 14—15, for the armature 9 and field 8.

The amplifiers 12 and 13 comprise cores 16—17 respectively, and the amplifiers 14—15 comprise cores 18—19 respectively; the cores having windings thereon and circuits therefor as follows.

As to the amplifiers 12 and 13, a half wave of A.C.

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current in the secondary 10 flowing toward the secondary end point 20, flows by wire 21 through a main winding 22 on the core 16, thence by wire 23 through a dry plate rectifier 24, wire 25, field 7, armature 9, and by wire 26 to a mid point 27 of the secondary.

A half wave in the other direction flows from the opposite secondary end point 28, by wire 29, through a main winding 30 on the core 17, and by wire 31, rectifier 32, and wire 25 to the field 7, armature 9, and the secondary mid point 27 by wire 26; thus energizing the armature and the field 7 with full wave rectified current.

As to the amplifiers 15 and 14, the field 8 and armature 9 are similarly energized with full wave rectified secondary current through main windings 33 and 34 on the cores 19 and 18, rectifiers 35—36, and wire 37.

The flux in the cores 16—17—18—19 is always in one direction, say downwardly as viewed; and in the absence of other windings, the flux and the reactance thereof would cause currents of some intermediate value to flow in the fields 7 and 8. However, biasing windings 74, 75, 76, 77 are provided on the respective cores 16, 17, 18, 19 constantly energized by D.C. They are all connected in series as shown in a circuit comprising wires 78 and 79 connected across a rectifier 47 and poled to oppose the main windings; and they therefore increase the reactance of the main windings and by suitable predetermined energization cause the said currents flowing in the fields 7—8 to be of very small value.

Saturating control windings 38—39—40—41 are provided on the respective cores 16—17—18—19, energized in a manner to be described, by D.C. They are all connected in series as shown in a circuit comprising wires 42 and 43, the current in which is reversible.

When the current in the wires 42—43 is in one direction the main windings 38—39 are poled to assist the windings 22—30, increasing the flux in the cores 16—17, which in a well known manner, causes an increase of current in the windings 22—23, thereby raising the energization of the field 7 above said very small value; and the windings 40 and 41 oppose the windings 34—33 and in a similar manner reduce the small current in the field winding 8 to a still smaller and negligibly small value; causing the motor M to run in a corresponding direction. The current in the field winding 8 being thus made so small as to be negligible, the effect is that of causing the motor to run by the field 7 alone.

When the current in the circuit 42—43 is in the other direction, the polarity of the saturating control windings 38—39—40—41 is reversed, the windings 40—41 assisting, and the windings 38—39 opposing, and as will now be understood the energization of field winding 8 is increased and that of field winding 7 is rendered negligible, causing the motor to run in the other direction and in effect, due to the field 8 alone.

A greater magnitude of the current in the circuit 42—43 will cause the field 7 or 8 to have greater effect and accordingly drive the motor faster as is believed to be clear.

Absence of current in the circuit 42—43 will cause the fields 7—8 to have such small energizing currents as to cause the motor to remain at rest whether the currents are exactly equal or not, which likewise will now be clear.

The circuit 42—43 is energized with current in one direction or the other or deenergized, as described, by the following means.

A normally balanced network indicated generally at 44, is provided, comprising an upper line 45 and a lower line 46, connected at their ends to the output terminals or full wave rectifiers 47 and 48; the network thus being illustrated as a rectangle for convenient reference.

The said circuit 42—43 is in and a part of the upper line 45 as will be seen.

A rectifier 47 has its D.C. output terminals connected to the network lines 45—46, delivering thereto a unidirectional potential of fixed value, by having its A.C. input

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terminals connected by wires 49—50 to the secondary 51 of a transformer 52 whose primary is energized from the said A.C. mains 53—54 as shown.

For illustrative purposes, the output terminal 55 of the rectifier 47 connected to the network line 45 may be considered as positive.

A rectifier 48 also has its D.C. output terminals connected to the network lines 45 and 46 and delivers variable D.C. potential thereto, poled to be in opposition to the potential of the rectifier 47, and having variable A.C. applied to its input terminals as follows.

The A.C. flowing in the above described furnace arc circuit, comprising the A.C. lines 4 and 5, flows through the primary 56 of a current transformer 57 having a secondary 58. Alternating secondary current flows by wires 59—60 through a meter 61; and then through the resistor 62 of a potentiometer 63 bridging the wires 59—60. The potential drop through the potentiometer resistance is applied to the input terminals of the rectifier 48 by wires 64—65.

The D.C. output potential of the rectifier 48 is thus made proportional to the arc current magnitude.

As described, current is intended to flow in one direction or the other in the circuit 42—43 which is part of the line 45 of the network. In the absence of other provisions such current could not flow, being blocked at both ends of the network line 45 by the rectifying elements of the rectifiers 47—48.

Accordingly the network lines 45—46 are bridged, by a resistor 47 connected to the lines at points 67—68 adjacent to the rectifier 47, and by a resistor 69 connected to the lines 45—46 at points 70—71 adjacent to the rectifier 48.

The rectifiers 47—48 thus supply current through the resistors 66—69; respectively; and the network proper comprises the top line 45 between the points 67—70, and the bottom line 46 between the points 68—71, with the resistors 66—69 at the ends of the lines, each providing a potential drop or resistor potential therebetween.

The potential between the points 67—68 is constant, being derived from the aforesaid constant output potential of the rectifier 47. The potential between the points 70—71 is variable, being derived from the variable output potential of the rectifier 48 as described.

If the potentials of the two resistors 66—69 are equal, the network is balanced and no current will flow in the circuit, 42—43. If the potential of the resistor 69 is greater or less than that of the resistor 66, current will flow in the circuit 42—43, in a corresponding direction and of magnitude proportional to the difference of the two potentials.

It will be noted that the value (ohmic) of the resistor 69 or of the resistor 66 is not adjustable to balance the network.

The potentiometer may have a scale 72 indicating positions of its movable arm or contact 73, and the scale may be calibrated in units of arc current or units of temperature.

The operation of the control to effect its said intended purposes is as follows.

The potentiometer arm 73 may be set to the constant value of arc current wanted, as indicated on the scale 72.

It is assumed that the electrodes 2—3 are separated so that no arc is drawn between them and no current flows in the secondary 56.

The rectifier 48 delivers no current to the resistor 69, and its potential is at zero value.

If the A.C. lines 53—54 are now connected to an A.C. source (by the usual switch not shown) the rectifier 47 will energize the resistor 66, and its potential will cause current to flow in the circuit wire 42 through the saturating control windings 38—39—40—41, causing the motor M to run as described, and the motor will operate the device 6 and move the electrode 2 into contact with the electrode 3.

Current of great magnitude will then flow in the transformer primary 56 and induce flow of large current through the potentiometer 63, and large drop of potential therein, which will be applied to the input terminals of the rectifier 48 and cause it to deliver a large current through the resistor 69 and produce therein a large potential, preponderating over the opposing fixed potential of the resistor 66 and reversing the control current in the circuit 42—43 and in the saturating windings 38 to 41.

This reversal of control current will reverse the motor M as described and it will operate to raise the electrode 2 and draw an arc at the electrodes.

As the arc is thus increased in length, the current in the primary 56 decreases, and, as will now be understood, the potential of the resistor 69 will decrease and approach that of the resistor 66 and predominate less over the potential of resistor 66, and the current in the circuit 42—43 will decrease; and as described this will cause the motor M to slow down.

This action goes on until the potential of resistor 69 equals that of the resistor 66 whereupon the network will be balanced or be in null condition, and current in the circuit 42—43 will be at zero and the motor M will stop, leaving the electrode 2 in a regulated position at which the arc current and furnace heat are at the desired regulated value.

Thereafter any deviation of the arc current from the regulated value, say a decrease, will cause a decrease in the potential of resistor 69 and unbalance the network, and the potential of resistor 66 will predominate and cause current to flow in the circuit 42—43 in the direction to effect rotation of the motor in the direction to move the electrode 2 in the direction to restore the arc current to the regulated magnitude.

The aforesaid biasing windings 74, 75, 76, 77 perform in general the well known function of modifying the output current flowing in the main windings 22, 30, 34, 33. Here, where the current in the main windings is made unidirectional by rectification, and the biasing windings are energized constantly at a predetermined value with D.C. and are poled to be in opposition to the main windings, they perform the particular function of reducing the unidirectional current in the main windings to a very small value.

We claim:

1. An electric control operative automatically to regulate to a substantially constant value the amperage magnitude of a main electric current that tends to deviate, in either of two senses, from a normal value; comprising: an electrical network including a D.C. control circuit and two resistors in series therewith; means causing D.C. to flow through one resistor at a constant value to produce thereby a first D.C. resistor potential of fixed value; circuit means deriving current from the main current and causing it to flow through an impedance to produce an impedance potential, proportional to and varying with the amperage magnitude of the main current; circuit means communicating the impedance potential to the second resistor to cause D.C. to flow therein and produce a second resistor potential opposing the fixed resistor potential and equal thereto when the main current is at the normal value, and then balancing the network and deenergizing the control circuit; and unequal thereto upon deviations of the main current and then unbalancing the network and causing D.C. current to flow in the control circuit in one of two directions; and apparatus activated by the control current effective to restore the amperage of the main current to its normal value from its deviation in either sense in accordance with the direction of current in the control circuit, to rebalance the network.

2. The control described in claim 1 and in which the impedance is selectively adjustable to adjust the impedance potential to effect changes in the normal value of the main current and thereby preselect the normal value.

3. An electric regulating control operative automati-

cally to regulate to a substantially constant value the amperage magnitude of an alternating main current that tends to deviate in either of two senses from a normal value; comprising: an electrical network including a control circuit and two resistors in series therewith; means causing D.C. to flow through one resistor at a constant value to produce thereby a first D.C. resistor potential of fixed value; a transformer having a primary energized by the main current and having a secondary circuit including an impedance, to produce an alternating impedance potential; proportional to and varying with the amperage magnitude of the main current; a full wave rectifier having input from the impedance potential and output to the second resistor to cause D.C. to flow therein and produce a second resistor potential opposing the first resistor potential and equal thereto when the main current is at the normal value and then balancing the network and deenergizing the control circuit; and unequal thereto upon deviations of the main current and then unbalancing the network and causing D.C. current to flow in the control circuit in one of two directions; and an apparatus activated by the control current effective to restore the main current amperage to its normal value from its deviation in either sense in accordance with the direction of current in the control circuit, to rebalance the network.

4. The control described in claim 3 and in which the impedance is selectively adjustable to adjust the impedance potential to effect changes in the normal value of the main current and thereby preselect the normal value.

5. In a control system energized by alternating current; an alternating current main circuit to be regulated to a substantially constant normal current amperage magnitude; a D.C. electric motor drivable in alternate directions and communicating mechanical power to a device operable thereby to restore the main current to its normal value upon deviations therefrom, above or below normal; a rectifying inductor apparatus energized from A.C. mains and having saturating control windings, and supplying two rectified output currents to the motor to drive it in alternate directions or bring it to rest in correspondence with the direction of current in the saturating control windings, or the absence of current therein; a network comprising a control winding circuit and two resistors in series therewith; a full wave rectifier having an A.C. input and supplying constant output D.C. through a first one of the resistors producing a first unidirectional resistor potential, of fixed value; a transformer comprising a primary in the alternating main circuit and comprising a secondary having a secondary circuit through an impedance device to produce an impedance potential variable with variations of main circuit current amperage; a full wave rectifier having an input energized by the variable impedance potential and supplying variable D.C. through a second one of the resistors producing a second unidirectional resistor potential, varying in value with variations of the main alternating current amperage, and equal to and opposing the fixed resistor potential and balancing the network and deenergizing the control circuit when the main current is at the normal value; and variations of the main current above or below normal value causing the second resistor potential to be higher than or lower than the fixed potential and unbalancing the network and causing current to flow in the control circuit in one direction or the other.

6. The control system described in claim 5 and in which the impedance of the impedance device is adjustable selectively to adjust the impedance potential to adjust the value of the main current at which the two resistor potentials are equal and the network is balanced, to thereby preselect the normal regulated value of the main current.

7. In a control system, a main circuit the current amperage in which is to be regulated to a substantially constant normal value; an electric motor having a pair of

field windings energizable to develop opposite motor torques for driving the motor in alternate directions, and the motor communicating mechanical power to a controller means to operate it alternately to cause it to restore the main current amperage to its normal value upon deviations therefrom, above or below normal; a pair of inductor devices comprising core means, main winding means, biasing winding means, and control winding means, on the core means; the main winding means of the pair of devices connected to be energized from an A.C. supply through rectifiers and respectively supplying unidirectional output current to the respective motor fields to energize them; the biasing winding means energized from a D.C. source at constant value, and poled to oppose the main winding means of both devices and causing the said field currents to be of low value; the control winding means connected to be energized by current in a control circuit; means to cause D.C. to flow in the control circuit in alternate directions upon deviation of the main current amperage above and below the normal value; the control winding means of one device poled the same as the biasing winding means thereof; and the control winding means of the other device poled oppositely to the biasing winding means thereof; whereby the output current from one device to one field is caused to decrease below said low value, and that from the other device to the other field is caused to increase above said low value, when the control current flows in one direction and the motor is caused to run in one direction; and whereby in like manner the motor is caused to run in the other direction when the control current flows in the other direction and means to cause the control current to be at zero value and the motor to be at rest when the main current being regulated is at its normal regulated value, and to cause the control current to be always proportional to the amount of deviation of the main current above or below its regulated value.

8. In a control system for regulating to a constant normal value an electrical quantity of an electric circuit; an electric motor having a pair of field windings energizable to develop opposite motor torques for driving the motor in alternate directions, and the motor communicating mechanical power to a controller means to operate it

alternately to cause it to restore the electrical quantity to its normal value upon deviations therefrom above or below normal; a pair of inductor devices comprising core means, main winding means, biasing winding means, and control winding means, on the core means; the main winding means of the pair of devices connected to be energized from an A.C. supply through rectifiers and respectively supplying unidirectional output currents to the respective motor fields to energize them; the biasing winding means energized from a D.C. source at constant value and poled to oppose the main winding means of both devices and causing the said field currents to be of low value; the control winding means connected to be energized by current in a control circuit; means to cause D.C. to flow in the control circuit in alternate directions upon deviation of the electrical quantity above and below its normal value; the control winding means of one device poled the same as the biasing winding means thereof; and the control winding means of the other device poled oppositely to the biasing winding means thereof, whereby, the output current from one device to one field is caused to decrease below said low value, and that from the other device to the other field is caused to increase above said low value, when the control current flows in one direction and the motor is caused to run in one direction; and whereby in like manner the motor is caused to run in the other direction when the control current flows in the other direction and means to cause the control current to be at zero value and the motor to be at rest when the main current being regulated is at its normal regulated value, and to cause the control current to be always proportional to the amount of deviation of the main current above or below its regulated value.

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