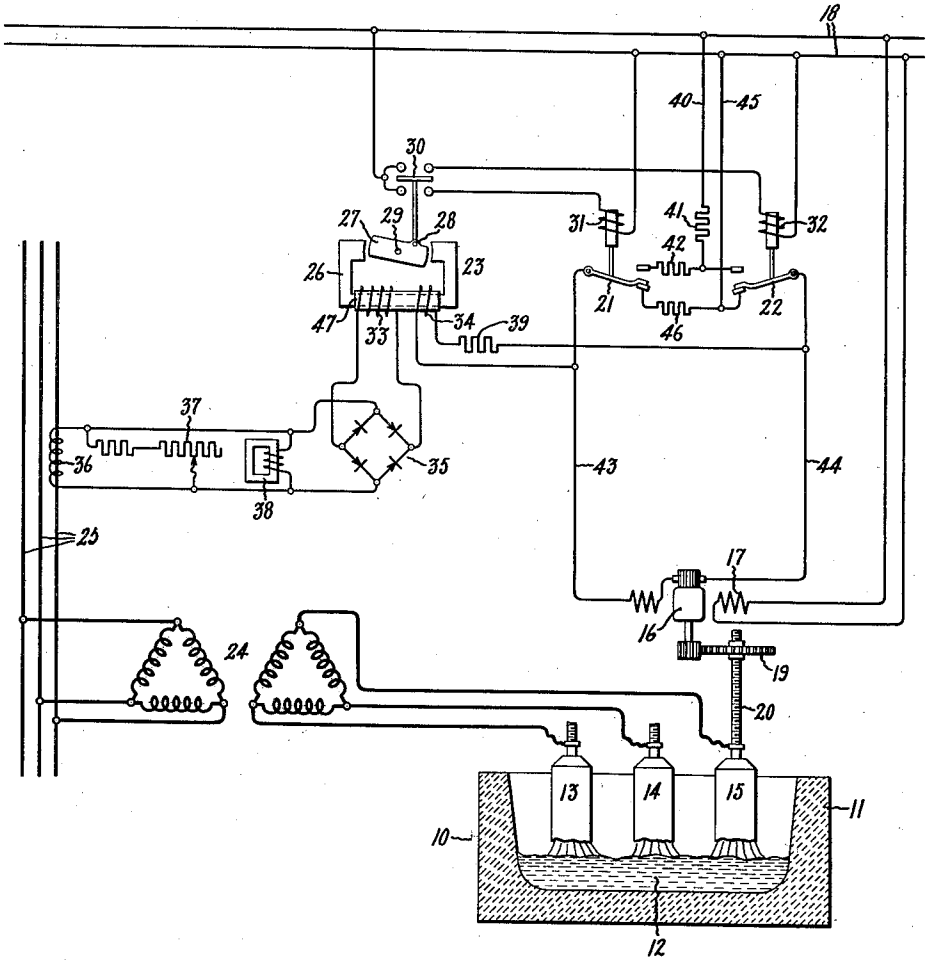
June 21, 1938. L. W. THOMPSON 2,121,644

ELECTRIC FURNACE REGULATOR SYSTEM

Filed April 17, 1937



Inventor:
Louis W. Thompson,
by Harry E. Dunham.
His Attorney.

Patented June 21, 1938 2,121,644

UNITED STATES PATENT OFFICE

2,121,644

ELECTRIC FURNACE REGULATOR SYSTEM

Louis W. Thompson, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application April 17, 1937, Serial No. 137,522

10 Claims. (Cl. 13—13)

My invention relates to electric furnace regulator systems, more particularly to regulator systems for furnaces provided with electrodes, such as arc furnaces, and has for its object simple, reliable and low cost means for adjusting a furnace to maintain a predetermined furnace operating condition.

In carrying out my invention in one form I provide a regulator contact device for controlling an electrode adjusting motor, which regulator device is biased to a position to cause lowering of the electrode and operated in response to a furnace operating condition such as current to raise the electrode. The regulator device comprises a stationary magnet core provided with two poles between which is mounted pivotally an armature connected to operate a contact member. On the stationary magnet core is an actuating coil energized in accordance with the current in the electrode circuit and also an anti-hunting coil connected across the armature of the electrode motor for effecting early deenergization of the motor so as to anticipate the final position of the electrode and prevent overrunning.

For a more complete understanding of my invention reference should be had to the accompanying drawing, the single figure of which shows in diagrammatic form an arc furnace regulator system embodying my invention.

Referrring to the drawing, I have shown my invention in one form as applied to an arc furnace **10** comprising a suitable crucible **11** for a metallic charge **12** and suitable carbonaceous electrodes **13**, **14** and **15** extending into the crucible into arcing relation with the charge. While I have shown a three-phase furnace it will be understood that my invention is applicable also to a single-phase furnace or a direct current furnace. The electrodes are each adjustable in a vertical direction to vary the length of the arc in any suitable manner. This adjusting means is shown diagrammatically for the electrode **15** only, but it will be understood that the other two electrodes are each equipped with the same or suitable regulating and electrode adjusting means. As shown, the electrode **15** is adjustable by a suitable direct current reversible electric motor **16** provided with a shunt field winding **17** energized from a suitable direct current supply source **18**. This motor is connected to rotate a fixed gear **19** having its bore threaded to receive a screw rod **20** attached to the electrode **15**.

The armature of the electrode motor **16** is energized from the source of supply **18** through electromagnetic reversing switches **21** and **22** which are in turn controlled by a regulator device **23**. The electrodes **13**, **14** and **15** of the furnace are electrically connected through a suitable transformer **24** to a three-phase source of supply **25**.

The regulator device **23** comprises a stationary magnet core **26** shown as rectangular in shape and provided with spaced pole faces on one side between which is mounted pivotally an armature **27** made of magnet core iron. The armature **27** is pivotally connected at a point **28**, at a suitable distance from the pivot **29** of the armature, to the bridging contact **30** of a two-way relay switch. This switch is arranged when the contact **30** is in its lowermost position, to which it is biased by gravity as shown, to connect the operating coil **31** of the switch **21** across the supply source **18** and, when moved to its uppermost position, to connect the operating coil **32** of the switch **22** to the supply source **18**.

For operation of the regulator **23**, two coils **33** and **34** are provided on the stationary magnet core **26**. The coil **33** is connected to a main of the supply source **25** corresponding with the electrode **15** through a suitable rectifier, shown as a two-way copper oxide rectifier **35**, and a current transformer **36**. Thus the coil **33** is supplied with direct current having a value dependent upon the value of the alternating current being supplied to the electrode **15**. For purposes of adjustment an adjustable resistance **37** is connected across the current transformer **35**.

Also, for the protection of the copper oxide rectifier **35** a saturable iron core reactor **38** is connected in shunt to or parallel with the rectifier. Under normal operating conditions, i. e., normal working current in the electrode circuit, this reactor is nearly but not quite saturated, whereby nearly all of the current in the current transformer circuit is caused to pass through the rectifier. In the event that the elecrode dips into the bath, however, with consequent high currents, the reactor becomes saturated and bypasses a large amount of the current around the copper oxide rectifier.

The anti-hunting or damping coil **34** is connected, as shown, directly across the armature of the motor **16**, a suitable regulating resistance **39** being connected in series with it. The connections of the coil **34** are such that when the motor **16** is energized to raise the electrode, i. e., by movement of the switch **22** to its uppermost position, the coil **34** tends to excite the magnet core **26** in opposition to the coil **33**. This has the effect of weakening the excitation of the magnet core so that the armature **27** moves down in accord-

ance with its bias from the weight of the contact 30 to move the contact 30 to a mid-position somewhat earlier than would otherwise be the case, whereby the motor 16 is deenergized sufficiently early to take into account substantially its tendency to overrun after deenergization due to the inertia of its parts. The electrode 15 is therefore brought to rest closely in the proper position. In the event that the regulator energizes the coil 31 for operation of the motor 16 to lower the electrode, the coil 34 is reversed with reversal of the motor armature, and under these conditions acts in the same direction as the coil 33 whereby the motor 16 is deenergized early to compensate for overrunning.

In the operation of the system the regulator 23 is adjusted by regulation of the resistance 37 so as to be energized sufficiently by the actuating coil 33 in response to the current supplied to the electrode 15 to maintain its switch contact 30 in the intermediate open circuit position shown in the drawing. When the electrode current decreases, for example because of the burning away of the electrode and the lengthening of the arc, the contact 30 tends to move to its lowermost position until, upon the occurrence of a predetermined low current, the contact 30 closes a circuit with its lowermost contacts for the coil 31. The switch 21 is thrown by the coil 31 to its uppermost position thus closing a circuit for the armature of the motor 16 in a direction to cause the motor to lower the electrode. This circuit may be traced from the source 18 through the conductor 40, the resistances 41 and 42, switch 21, conductor 43, the armature of the motor, conductor 44, switch 22 and conductor 45 back to the supply source. Just before the establishment of the predetermined current condition, by reason of the accumulative effect of the coil 34 as previously described, the contact 30 is returned to its intermediate position whereby the switch 21 drops to its lowermost position disconnecting the motor from the supply source 18 and connecting a dynamic braking resistance 46 across the motor armature.

In the event the current in the electrode circuit becomes greater for any reason than the predetermined normal, the regulator 23 raises the contact 30 to its uppermost position whereby a circuit is established from the supply source 18 to the coil 32 which throws the switch 22 to its uppermost position. This establishes a circuit for the armature of the motor 16 in the opposite direction for reverse rotation for raising of the electrode. The circuit may be traced from the supply source through the conductor 40, resistance 41, switch 22, conductor 44, armature of the motor, conductor 43, switch 21, braking resistance 46 and conductor 45 back to the supply source. The motor operates until just prior to the establishment of the normal current condition, the contact 30 is moved to its intermediate position whereby the motor is disconnected from the source 18 and the resistor 46 connected across its armature for dynamic braking.

Resistors 41 and 42 are provided for motor speed regulating purposes. It will be noted that both resistances are in the motor circuit in series with each other when the switch 21 is moved to its uppermost position to lower the electrode, whereas the resistor 41 only is included in the motor circuit when the switch 22 is moved to its uppermost position for the raising operation. This provides greater torque for the raising operation, the adjustments of the resistance being made to give about the same motor speed in each case.

For the purpose of damping out the effect of small transitory changes in the furnace current a suitable damping means is preferably used with the regulator 23. As shown, a copper damping sleeve 47 is provided around the lower arm of the magnet core 26 under the coils 33 and 34. This prevents operation of the regulator to start the motor in response to transitory currents which tend to correct themselves, although a persistent current of too low or too high value produces operation of the regulator.

While I have shown a particular embodiment of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made, and I therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. In a regulator system for an alternating current furnace, a direct current motor for adjusting an electrode, control means for starting said motor to adjust said electrode comprising a pivotally mounted armature, a magnet core for said armature, an actuating coil on said core, current supply means responsive to an electrical condition of the electrode circuit for producing a current varying with said electrical condition, electrical connections between said current supply means and said actuating coil including a current rectifying device, and an anti-hunting coil on said magnet core connected to said motor.

2. The combination with an electric furnace provided with a member movable to adjust the rate of heat generation in said furnace, a motor for moving said member, switching means for starting and stopping said motor for each direction of rotation to move said member, said switching means being biased to a position to increase the rate of heat generation of said furnace, operating means for said switching means comprising a magnet core provided with pole faces, an armature mounted for pivotal movement between said pole faces, an operating connection between said armature and said switching means, an actuating coil on said core, means responsive to an operating condition of said furnace for supplying a current to said actuating coil varying with said operating condition, and an anti-hunting coil on said magnet core connected to said motor so as to be reversed upon reversal of said motor and thereby oppose said actuating coil when said switching means is operated against its bias and to assist said actuating coil when said switching means is operated in accordance with its bias.

3. In an electric furnace regulator system, a motor for adjusting an electrode, control means for starting said motor to adjust said electrode comprising a pivotally mounted armature, a stationary magnet core for said armature, an actuating coil on said core, current supply means responsive to an electrical condition of the electrode circuit for producing a current varying with said electrical condition, electrical connections between said current supply means and said actuating coil, and an anti-hunting coil on said magnet core connected to said motor so as to be reversed upon reversal of said motor and thereby oppose said actuating coil when said motor is operating to raise the electrode and to assist said actuating coil when said motor is operating to lower the electrode.

4. An electric furnace regulator system comprising a motor for adjusting an electrode, switching means for starting and stopping said motor for each direction of rotation to adjust said electrode, said switching means being biased to a position to raise the electrode, an actuating coil for said switching means, connections for supplying an alternating voltage to said electrode, current supply means responsive to an electrical condition of the electrode circuit for producing an alternating current varying with said electrical condition, electrical connections between said current supply means and said actuating winding including a current rectifying device, a saturable reactor connected in parallel with said rectifying device, and an anti-hunting coil cooperating with said actuating coil connected across the armature of said motor so as to be reversed upon reversal of said motor and thereby oppose said actuating coil when said switching means is operating to raise the electrode and to assist said actuating coil when said switching means is operating to lower the electrode.

5. The combination in an electric furnace system, of a member movable to adjust the rate of heat generation in the furnace, a motor for adjusting said member, switching means for starting and stopping said motor for each direction of rotation to adjust said member, said switching means being biased to a position to increase the rate of heat generation in the furnace, operating means for said switching means comprising a magnet core provided with pole faces, an operating connection between said armature and said switching means, an actuating coil on said core, connections for supplying an alternating current to the furnace, current supply means responsive to an electrical operating condition of the furnace for producing an alternating current varying with said operating condition, electrical connections between said current supply means and said actuating coil including a current rectifying device, and a saturable reactor connected in parallel with said rectifying device.

6. The combination with an electric furnace provided with a member movable to adjust the rate of heat generation in said furnace, a motor for adjusting said member, switching means for starting and stopping said motor for each direction of rotation to adjust said member, said switching means being biased to a position to increase the rate of heat generation of said furnace, operating means for said switching means comprising a magnet core provided with pole faces, an armature mounted for pivotal movement between said pole faces, an operating connection between said armature and said switching means, an actuating coil on said core, connections for supplying an alternating current to said furnace, current supply means responsive to an electrical operating condition of said furnace for producing an alternating current varying with said operating condition, electrical connections between said current supply means and said actuating coil, including a current rectifying device, and an anti-hunting coil on said magnet core connected to said motor so as to be reversed upon reversal of said motor and thereby oppose said actuating coil when said switching means is operated against its bias and assist said actuating coil when said switching means is operated in accordance with its bias.

7. The combination in an electric furnace regulator system of a motor for adjusting an electrode, control means for starting and stopping said motor for each direction of rotation to adjust the electrode, said control means being biased to a position to lower the electrode, operating means for said control means comprising a magnet core provided with pole faces, an armature mounted for pivotal movement between said pole faces, an operating connection between said armature and said control means, an actuating coil on said core, connections for supplying an alternating current to said electrode, current supply means responsive to an electrical operating condition of said electrode for producing a current varying with said operating condition, electrical connections between said current supply means and said actuating coil including a current rectifying device, a saturable reactor connected in parallel with said rectifying device, and an anti-hunting coil on said magnet core connected to the armature of said motor so as to be reversed upon reversal of said motor and thereby oppose said actuating coil when said switching means is operated against its bias and assist said actuating coil when said switching means is operated in accordance with its bias.

8. In a regulator system for an alternating current electrode furnace, a motor for adjusting an electrode, control means for starting said motor to adjust said electrode comprising an armature, an actuating coil for said armature, current supply means responsive to an electrical condition of the electrode circuit for producing a current varying with said electrical condition, electrical connections between said current supply means and said actuating coil including a current rectifying device, and means connected in parallel with said rectifying device for bypassing current around said rectifying device in the event of predetermined abnormal electrical conditions in said electrode circuit.

9. In a regulator system for an alternating current electrode furnace, a motor for adjusting an electrode, control means for starting said motor to adjust said electrode comprising an armature, an actuating coil for said armature, current supply means for producing a current varying with the current in the electrode circuit, electrical connections between said current supply means and said actuating coil including a copper oxide current rectifying device, and a saturable reactor connected in parallel with said rectifying device for bypassing current to protect said rectifying device in the event of excessively high currents in the electrode circuit.

10. In a regulator system for an alternating current electrode furnace, a direct motor for adjusting an electrode, control means for starting said motor to adjust said electrode comprising an armature, an actuating coil for said armature, current supply means for producing a current varying with the current in the electrode circuit, electrical connections between said current supply means and said actuating coil including a copper oxide current rectifying device, a saturable reactor connected in parallel with said rectifying device for bypassing current to protect said rectifying device in the event of excessively high currents in the electrode circuit, and an anti-hunting coil associated with said armature connected to said motor so as to be reversed upon the reversal of said motor.

LOUIS W. THOMPSON.