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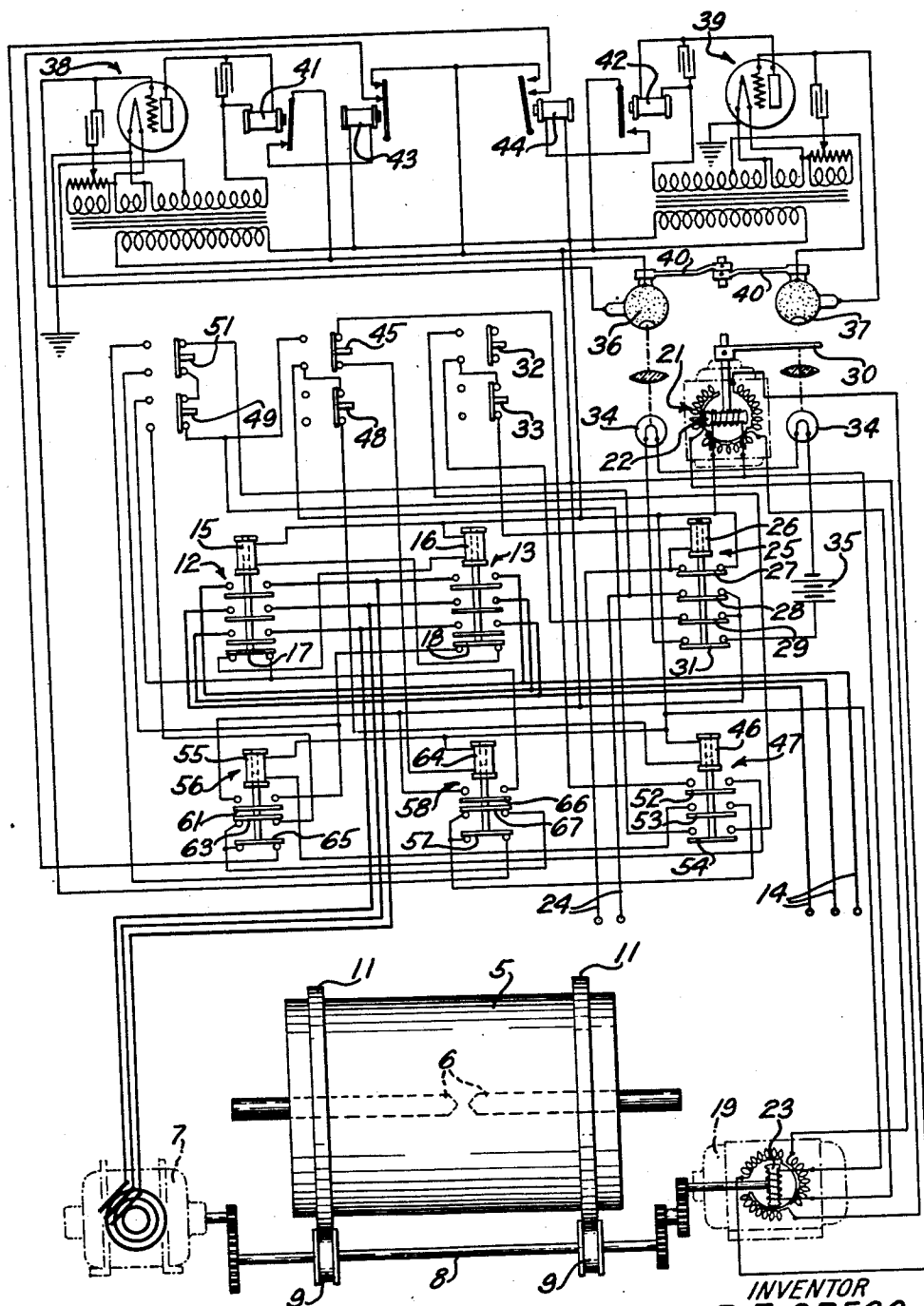
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CONTROL APPARATUS

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8 Claims. (Cl. 172-240)

This invention relates to a control apparatus, and more particularly to a remote control apparatus for a rocking arc furnace.

In a rocking arc type of furnace the electrodes are disposed above the molten metal or the metal to be melted, and in order to prevent one portion of the surface from becoming overheated and to distribute the heat throughout the bath, the furnace is rocked to and fro, producing a washing movement or agitation of the metal. At times there may be a splashing of the molten metal from the furnace, which is hazardous for an operator if he is in close proximity to the furnace.

An object of the invention is to provide an effective and efficient control apparatus.

In accordance with one embodiment of the invention, the driving motor of the furnace is controlled through a pair of photoelectric tubes, the light to which is controlled by a vane actuated by a synchronously coupled unit associated with the driving motor whereby the furnace may be controlled from a remote station.

Other features and advantages of the invention will appear as the description proceeds.

A complete understanding of the invention may be had by reference to the following description taken in conjunction with the accompanying drawing, in which the single figure is a diagrammatic view of an apparatus embodying the invention.

Referring now more in detail to the drawing, a rocking electric arc furnace 5 is shown having electrodes 6, across which an arc is formed to melt the charge of materials in the furnace. In order to prevent the material immediately under the arc from becoming overheated and to distribute the heat uniformly throughout the charge, the furnace is rocked to and fro. This is accomplished by means of a reversible three phase motor 7 which drives a shaft 8 carrying flanged rollers 9 on which circumferential rails or rollers 11 of the furnace rest. The furnace is preferably mounted eccentrically within the rails 11 in order to produce an axial oscillation of the furnace in addition to the rotary oscillation caused by the rotation of the motor.

The periodic reversal of motor 7 is affected by a pair of reversing switches 12 and 13, each of which has three contactors arranged so that the closing of switch 12 will connect the motor to a three phase line 14 in such a manner as to cause the motor to rotate in one direction and the closing of switch 13 will connect the motor to the line in such a manner as to cause the

motor to rotate in the opposite direction. Switches 12 and 13 have electromagnets 15 and 16, respectively, for actuating the switches. Each of these switches is also provided with an additional contactor 17 and 18, respectively, the purpose of which will be described hereinafter.

The periodic and alternate actuation of reversing switches 12 and 13 is accomplished through a pair of synchronously coupled dynamo electric machines, the generator 19 of which is mechanically coupled to motor 7 while the motor 21 of the unit may be remotely situated from the generator and is electrically coupled thereto so that the rotor 22 of the motor will always assume the same position as a rotor 23 of the generator, which, as pointed out above, is driven by motor 7. The field windings of these dynamo electric machines are electrically interconnected at similar points and have no other electrical connection; whereas, the rotors of these machines are connected in parallel and to a single phase line 24 through a switch 25. The self-synchronous dynamo electric machines just described are well known in the art and their principle of operation will, therefore, not be further described.

Switch 25 may be actuated by an electromagnet 26 and is provided with contactors 27, 28, 29 and 31. In order to energize electromagnet 26 to close switch 25, a push-button switch 32 is depressed to establish a circuit from one side of line 24, through push-button switch 32, push-button switch 33, through electromagnet 26 to the other side of the line. The closing of this switch establishes a holding circuit for electromagnet 26 from one side of line 24, through contactor 28, contactor 29, push-button switch 33, through the electromagnet to the other side of the line. The closing of switch 25 also energizes the rotors of the synchronous dynamo electric machines from one side of the line through contactor 28, through the rotors in parallel and through contactor 27 to the other side of the line. At the same time the closing of contactor 31 of switch 25 establishes a circuit through a pair of lamps 34 from a source of energy 35.

The light from lamps 34 is directed upon photoelectric cells or tubes 36 and 37 and a vane 30 actuated by rotor 22 of the synchronous device 21 will intercept the light to either photoelectric cell 36 and 37 when the vane passes in front of these cells. The photoelectric cells 36 and 37 are connected to well known types of vacuum tube amplifiers 38 and 39, respectively, which

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are provided with relays 41 and 42, respectively, in their output circuits. The vacuum tube amplifiers and photoelectric cells are so designed that when the light impinges upon either of the photoelectric cells 36 or 37, the contacts of their corresponding relays 41 and 42 will be closed. The closing of the contact of relay 41 will cause the energization and closing of relay 43 from the line 24 through the contacts 27 and 28 of switch 25, and similarly when the contact of relay 42 is closed, it will cause the energization and closing of relay 44.

The photoelectric tubes are carried by arms 40 which are pivotally mounted in axial alignment with the pivot point of vane 30 so that the tubes may be positioned so as to cause the vane to intercept the light thereto at whatever position the tubes may be moved to.

In order to start the apparatus, push-button switch 32 is depressed to actuate switch 25 and close a holding circuit therefor, as described above. The switch 25 may be opened by depressing push-button switch 33, which opens the holding circuit. When the switch 25 has been actuated, the apparatus is in condition for either automatic or manual control. If it is desired to oscillate the furnace continuously, a push-button switch 45 is depressed. This causes the energization of an electromagnet 46 of switch 47, the circuit through which may be traced from one side of line 24, through contactor 27 of switch 25, electromagnet 46, push-button switch 48, push-button switch 45, push-button switches 49 and 51, contactor 28 of switch 25, to the other side of the line. The switch 47 is provided with contactors 52, 53 and 54 and upon the closing of push-button switch 45, a holding circuit for electromagnet 46 is established from one side of the line 24 through contactor 27 of switch 25, through electromagnet 46, push-button switch 48, contactor 54 of switch 47, push-button switches 49 and 51, contactor 28 of switch 25, to the other side of the line. If at this time the vane 30 carried by the synchronous motor 21 is in the position shown where it intercepts the light from a lamp 34 to photoelectric cell 37, the photoelectric cell 36 will be illuminated from the other lamp 34 to close the relays 41 and 43. After the closing of switch 47, the release of push-button switch 45 will energize an electromagnet 55 of a switch 56. The circuit through electromagnet 55 may be traced from one side of the line through contactor 27 of switch 25, electromagnet 55, contactor 53 of switch 47, a normally closed contactor 57 of a switch 58, through the armature of relay 43, contactor 28 of switch 25, to the other side of the line. The actuation of switch 55 causes the actuation of reversing switch 12. The circuit through the electromagnet 15 of switch 12 may be traced as follows: from one side of the line 24, through contact 27 of switch 25, electromagnet 15, contactor 18 of switch 13, contactor 61 of switch 56, through contactor 28 of switch 25, to the other side of the line.

The closing of switch 12 applies energy to motor 7 from the three phase line 14, causing the motor to rotate the furnace, as well as the rotor of the self-synchronous generator 19. The rotor of the self-synchronous motor 21 moves the vane 30 until it intercepts the light from a lamp 34 to the photoelectric cell 36. This causes the de-energization of relay 43, opening the circuit of electromagnet 55 of switch 56, whereupon the circuit of electromagnet 15 is de-energized and the motor 7 stopped. At this time relay 44 will have been actuated due to the light falling on photoelectric cell 37 when vane 30 moves away, and the opening of switch 56 closes a contactor 63, establishing a circuit through an electromagnet 64 of switch 58. This circuit may be traced from one side of the line 24, through contactor 27 of switch 25, electromagnet 64, push-button switch 45, contactor 52 of switch 47, contactor 65, through the armature of relay 44, contactor 28, of switch 25, to the other side of the line. The closing of switch 58 energizes the electromagnet 16 of reversing switch 13, the circuit of which may be traced from one side of the line 24, through contactor 27 of switch 25, electromagnet 16, contactor 17 of switch 12, a contactor 66 of switch 58, through contactor 28 of switch 25, to the other side of the line. When the vane 30 again reaches the position shown in the drawing, electromagnet 16 of switch 13 will be deenergized and electromagnet 15 of switch 12 will again be energized and thus the alternate actuation of reversing switches 12 and 13 will continue until the push-button switch 48 is depressed to break the circuit through electromagnet 46 of switch 47. It will be noted that both relays 43 and 44 are closed most of the time since they will be open only when the vane 30 is directly in front of their respective photoelectric cells. However, even though relays 43 and 44 are both closed, switches 56 and 58 cannot be closed simultaneously since each of these switches carries a contactor 65 and 57, respectively, which must be closed before the other switch can be actuated. If one of the photoelectric cells 36 and 37 becomes burned out or becomes otherwise inoperative, the motor 7 will continue to rotate until the vane 30 reaches the other photoelectric cell, after which the motor will be de-energized; or, if both of the cells become inoperative at one time, the motor will stop immediately.

The above description relates to the automatic control of the motor whereby upon the initiation of the operation of the motor it continues to operate indefinitely to oscillate or rock the furnace. The apparatus may also be operated manually. The depression of push-button switch 51 will cause the energization of electromagnet 15 of reversing switch 12. This circuit may be traced from one side of the line to contactor 27 of switch 25, through electromagnet 15, contactor 18 of switch 13, push-button switch 51, a contactor 67 of switch 58, contactor 57, armature of relay 43, contactor 28 of switch 25, to the other side of the line. As long as the push-button switch 51 is depressed, the motor will continue to operate until the vane 30 intercepts the light to photoelectric cell 36, whereupon relay 43 will be de-energized to break the circuit through electromagnet 15, irrespective of whether switch 51 is depressed or not.

In order to rotate the motor in the reverse direction at this time, the switch 49 may be depressed, which energizes the electromagnet 16 of reversing switch 13, the circuit through which may be traced from one side of the line through contactor 27, through electromagnet 16, contactor 17 of switch 12, push-button switch 49, contactor 63 of switch 56, contactor 65, the armature of relay 44, contactor 28 of switch 25, to the other side of the line. It will be seen that unless the vane 30 is in front of one of the photoelectric cells, the motor 150

7 may be manually started to rotate in either direction and as long as one of the switches 49 or 51 is depressed. When the vane is in front of photoelectric cell 37, only the switch 12 may be

5 actuated by the depression of push-button switch 51 and conversely when the vane 30 is in front of photoelectric cell 36, only the switch 13 may be actuated by the depression of push-button switch 49.

10 The control apparatus permits the rotation of the furnace to be controlled either automatically or manually from a remote location. The photoelectric cells and the motor 21 of the synchronous dynamo electric machines are preferably also

15 located at the remote control station, although this is not essential, and the vane 30 may be located at the furnace if suitable means are provided for protecting the photoelectric cells and associated apparatus. Also the photoelectric

20 cells and amplifier circuits may be omitted and the armatures of relays 41 and 42 may be actuated directly by the driving means for the self-synchronous generator 19.

25 It will thus be understood that the nature and embodiment of the invention herein described and illustrated is merely a convenient and useful form of the invention and that many changes and modifications may be made therein without departing from the spirit and scope of the

30 invention.

What is claimed is:

1. In a control apparatus, a driven element to be controlled having a forward and backward movement, a pair of photoelectric cells,

35 a vane actuated by the driven element cooperating with said cells for controlling the light thereto, means cooperating with said cells controlling the driven element, and means for adjusting the distance between said cells for controlling the

40 amount of movement of the driven element.

2. In a control apparatus, a driven element to be controlled having a to and fro movement, a pair of photoelectric cells, a vane cooperating with said cells for controlling the light thereto,

45 a synchronously coupled unit associated with the driven element for actuating the vane, means cooperating with the cells for controlling the driven element, and means for adjusting the position of the cells to determine the extent of

50 movement of the driven element.

3. In a control apparatus, a driven element to be controlled, a pair of photoelectric cells, means responsive to said cells for reversing the direction of movement of the driven element, means

55 associated with the driven element for control-

ling the operation of the cells, and means for stopping the driven element at the end of its travel away from a cell when said cell becomes inoperative.

4. In a control apparatus, a motor, a pair of reversing switches for reversing the direction of rotation of the motor, a pair of control switches for controlling the operation of said reversing switches and preventing their simultaneous closure, and a pair of relays responsive to the position of said motor for governing the operation of said control switches.

5. In a control apparatus, a motor, a pair of synchronously coupled dynamo-electric machines, one of which is mechanically coupled to said motor, a pair of relays responsive to the position of the other of said dynamo-electric machines, a pair of reversing switches for reversing the direction of rotation of said motor, and a pair of control switches responsive to said relays for controlling the operation of the reversing switches.

6. In a control apparatus, a motor, a pair of synchronously coupled dynamo-electric machines, one of which is mechanically coupled to said motor, a vane actuated by the other of said dynamo-electric machines, a pair of photoelectric cells in the path of said vane, a pair of relays responsive to said photoelectric cells, reversing switches for reversing the direction of rotation of said motor, and control switches responsive to said relays for controlling said reversing switches to continuously cause a to and fro movement of the motor.

7. In a control apparatus, a motor, a pair of photoelectric cells spaced apart a predetermined distance, a vane movable from one of said cells to the other to control the light thereto, means for moving said vane a distance proportional to the amount of movement of said motor, and

115 means associated with said photoelectric cells for driving said motor in one direction a distance proportional to the spacing of said cells and then reversing the motor.

8. In a control apparatus, a motor, a pair of photoelectric cells spaced apart a predetermined distance, a vane movable to control the light impinging on said cells, synchronously coupled dynamo-electric machines, one of which is actuated by said motor and the other of which

125 actuates said vane, and means associated with said photoelectric cells for driving the motor a distance proportional to the spacing of said cells and then reversing the motor.

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