Nov. 17, 1925. 1,562,204

R. CARLSTEDT

ELECTRIC FURNACE CONTROL

Filed June 24, 1924 2 Sheets-Sheet 1

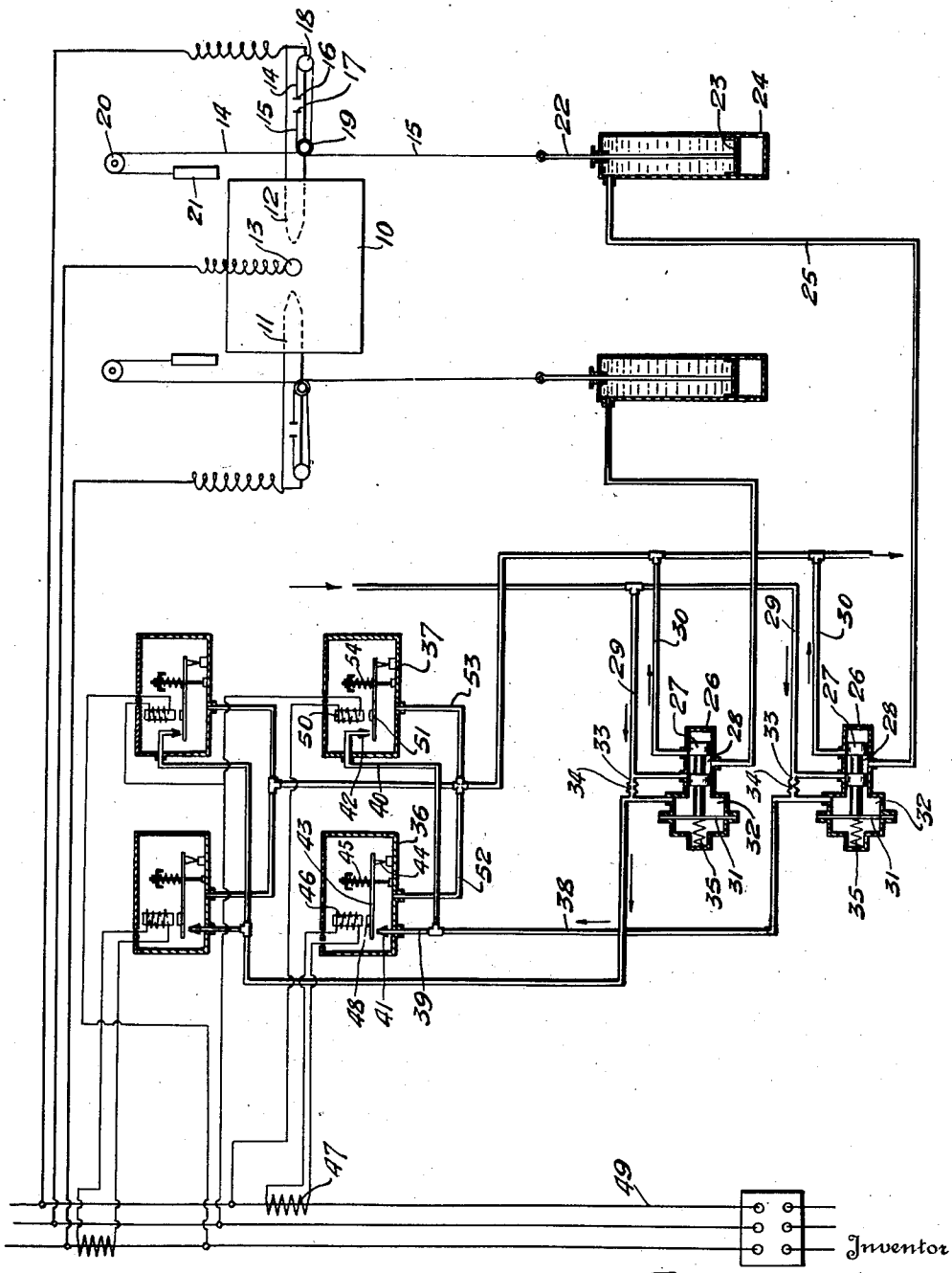


Fig. 1.

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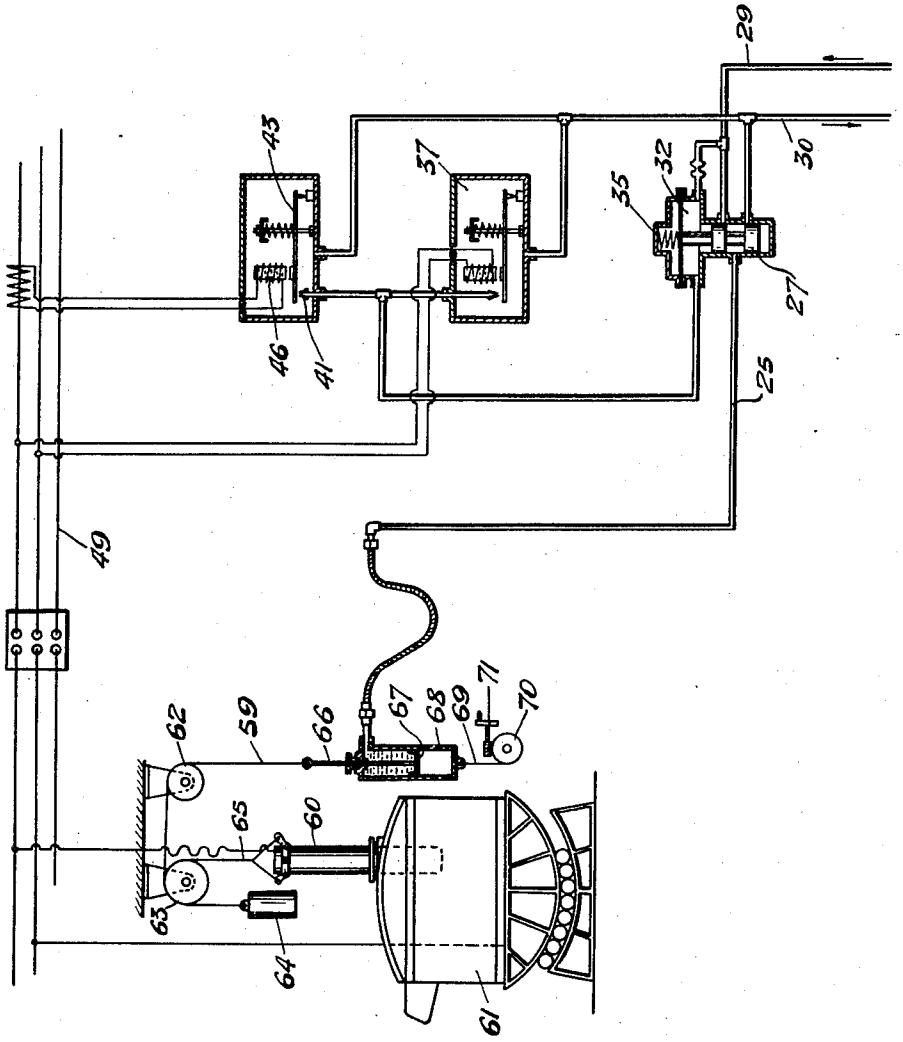


Fig. 2.

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Patented Nov. 17, 1925. 1,562,204

UNITED STATES PATENT OFFICE.

RAGNAR CARLSTEDT, OF STOCKHOLM, SWEDEN, ASSIGNOR TO ARCA REGULATORS INCORPORATED, A CORPORATION OF VIRGINIA.

ELECTRIC-FURNACE CONTROL.

Application filed June 24, 1924. Serial No. 722,046.

To all whom it may concern:

Be it known that I, RAGNAR CARLSTEDT, a subject of the King of Sweden, and resident of Stockholm, Sweden, have invented certain new and useful Improvements in Electric-Furnace Controls (for which I filed applications in Sweden May 27, 1920; Germany, July 10, 1922; England, Apr. 5, 1923; Canada, June 7, 1922; and Japan, July 13, 1922), of which the following is a specification.

My invention relates to an automatic regulating mechanism for the electrodes of an electric furnace and has for its object to provide an automatic regulation which is extremely sensitive and yet not delicate; to regulate the electrodes so that a constant temperature is maintained in the furnace and to regulate the electrodes both by amperage and voltage so that under normal conditions the amperage is the controlling factor, moving the electrodes closer together for lower values of amperage, while at low values of voltage the electrodes are prevented from contacting.

Further objects will be evident as the description proceeds.

This application is a continuation in part of my copending application Serial No. 563,458, filed May 24, 1922.

The accompanying drawings illustrate my invention diagrammatically in a manner which, taken in connection with the text herewith, will enable one skilled in the art to build and operate the same, and in these drawings Fig. 1 shows the invention applied to an electric furnace of the Rennerfelt type and Fig. 2 shows the same applied to the Gronwall type of furnace.

In Fig. 1, 10 designates the electric furnace which is provided with three electrodes 11, 12 and 13. Two of these electrodes, 11 and 12, are regulated by means of similar mechanisms so that only one need be described to give a full and clear understanding of the invention.

Electrode 12 is shown as operated by means of a flexible member in two parts 14 and 15, as, for example, a chain. Part 14 is fastened to the electrode as indicated at 16 and passes first around pulley block 18, then around pulley block 19, thence around pulley block 20 and is connected to counterweight 21. Part 15 is connected to the movable electrode as indicated at 17, passes around pulley block 19, and is connected to piston rod 22 attached to piston 23 in cylinder 24. Cylinder 24, piston 23, piston rod 22, flexible members 14, 15, the counterweight 21 and the pulleys constitute what I term a servo-motor. This is the primary actuating agent for the electrode. The servo-motor is liquid pressure operated, liquid under pressure being admitted thereto or rejected therefrom through conduit 25.

Conduit 25 connects with a secondary agent 26 for actuation of the electrodes. This secondary agent I term an actuating means. The actuating means comprises a pilot valve 27 which is recessed as indicated at 28, and operates upon movement to connect conduit 25 either with a supply conduit 29 for liquid under pressure or a discharge conduit 30 which carries liquid to waste. Attached to the pilot valve is a diaphragm 31 forming a part of the boundary of diaphragm chamber 32. Diaphragm chamber 32 is connected with supply conduit 29 by means of conduit 33 which has a restriction 34 therein. For purposes of description I have shown this conduit 33 as outside the main housing for the pilot valve but it is evident that this conduit with its restricted portion may be within the said housing. It is sufficient that there is some restricted means of supplying liquid to diaphragm chamber 32. It is not necessary that both the servo-motor and actuating means be supplied from the same source. Spring 35 acts on the pilot valve in opposition to the pressure in diaphragm chamber 32.

The diaphragm chamber 32 communicates with two relays 36 and 37, tertiary agents of actuation, through conduit 38 and branch conduits 39 and 40. The branch pipe 39 terminates in a nozzle 41 through which a continuously flowing stream of liquid passes, and branch pipe 40 terminates in a nozzle 42. Nozzle 41 is controlled by lever 43 pivoted at 44. An adjustable spring 45 acts on the lever tending to force it against the nozzle whereby to diminish the flow of liquid therethrough. An electro-magnet 46 consisting of a core surrounded by a coil which is connected to current transformer 47 also acts on lever 43 by its attractive effect on armature 48. By this means the lever 43 is moved in response to changes of current in the electric circuit 49 which supplies electric energy to the electrodes.

Relay 37 is similar to relay 36 except that the nozzle 42 is situated on the opposite side of the lever and the magnet coil 50 is connected across the wires of circuit 49 so that it is responsive to voltage. At normal voltage magnet 50 holds lever 51 against nozzle 42 so that little or no liquid discharges therethrough.

The relays drain through conduits 52 and 53.

The mode of operation of the arrangement is as follows: Spring 45 is adjusted to the correct value of amperage for the proper arc across the electrodes. If the resistance between the electrodes increases, due to consumption of the carbon of electrode 12, the strength of the current in circuit 49 decreases. This decreases the induced current in current transformer 47 and consequently in magnet 46 and the force of the magnet being decreased correspondingly, lever 43 moves closer to nozzle 41 under the preponderating action of spring 45. The suppression of the jet flow through the nozzle increases the pressure in conduits 39, 38 and consequently in diaphragm chamber 32. Increase of pressure in chamber 32 causes a movement of the pilot valve 27 to the left as shown in the drawing, thereby connecting conduit 25 with supply conduit 29 so that liquid under pressure is admitted to the servo-motor. Piston 23 is then moved downwardly causing electrode 12 to move inwardly toward electrode 13, by means of the flexible members and pulleys, whereby the resistance is decreased and the current in circuit 49 increased, thus returning the device to a state of balance.

If the current exceeds the normal value due, for example to decreased resistance between the electrodes, magnet 46 increases in strength of magnetic field and attracts the armature 48 so that the flow through nozzle 41 in increased which, in turn, decreases the pressure in conduits 39, 38 and diaphragm chamber 32. Decrease of pressure in chamber 32 causes movement of the pilot valve 27 to the right as shown in Fig. 1 whereby conduit 25 is connected with discharge conduit 30. The counterweight 21 then overcomes the liquid pressure in cylinder 24 and moves the electrode outwardly, thus increasing the resistance between the electrodes and causing a return to equilibrium.

The resistance across the electrodes is a function of the temperature in the furnace so that changes in temperature react on the regulator in such a manner that an exact evenness of heat is obtained.

Spring 54 in relay 37 is set to keep nozzle 42 closed until a certain minimum voltage exists, for example, one half the normal voltage, and as long as the voltage is high the electromagnet 50 attracts lever 51 with a force greater than the opposing force of spring 54 so that little or no liquid issues from nozzle 42, the pressure in diaphragm chamber 32 then depending only on the action of relay 36. If, however, the voltage in circuit 49 decreases to a low value, relay 37 will be brought into operation and the force of spring 54 will preponderate over the attractive force of magnet 50, causing lever 51 to increase the flow through conduit 40. This decreases the pressure in chamber 32, thus causing connection between the servo-motor and discharge conduit 30 whereby the electrodes are moved apart.

Suppose, for example, the power in circuit 49 should suddenly cease. The consequent drop in amperage would cause the electrodes to move together and, if nothing prevented it, they would hit, causing injury to the electrodes. However the low voltage is responded to by relay 37 which operates, as above explained, to move the electrodes apart. This relay thus prevents short circuiting when the current is cut in.

In similar manner electrode 11 is controlled by a normally operating relay and a safety low voltage relay which operate on an actuating means, in turn controlling a servo-motor.

In starting the furnace it is merely necessary to throw in the main switch and there will be a sufficent voltage drop across the terminals of electro-magnet 50 to attract lever 51 and prevent outflow through nozzle 42. Since the amperage is then zero or very low, there is little or no outflow of liquid through nozzle 41, and thus the electrodes are brought together until the desired current in the arc is obtained.

My invention has been applied in practice with unusual results. The current is kept so constant that a movement of the pointer of the ameter is barely susceptible. In one installation the production has been increased thirty per cent and the work of two men on one furnace eliminated.

In Figure 2 I have shown diagrammatically my invention applied to the control of one of the electrodes 60 of a Gronwall furnace 61 with a modified arrangement of connecting up the servo-motor to provide a relatively smaller cylinder for these larger furnaces.

The electrode is moved into and out of the furnace by means of a chain or the like 65 passing around pulley 63 connected with counterweight 64 which is heavier than the electrode. A second chain or similar flexible member passes over pulleys 62 and 63 and is also connected to counterweight 64. This member 59 is connected at the opposite end to piston rod 66 which is attached to piston 67 movable in cylinder 68 due to the pressure of liquid in the cylinder.

The whole cylinder 68 is movable by

means of a chain or the like 69 wound around a drum 70, which drum is adapted to be rotated by means of a worm-wheel, worm and handwheel indicated at 71. Thus as the electrode is burnt and it recedes into the furnace the hand adjustment 71 may be used to take care of the greater movement of the chain 59 while the servo-motor cylinder takes care of the momentary fluctuations. This provides a simple flexible arrangement and avoids large heavy and cumbersome apparatus.

The cylinder 68 is connected up to a secondary and tertiary agent of force impulse transmission in a manner similar to that of Fig. 1. A part of conduit 25 is flexible.

In operation: Suppose the hand adjustment 71 is set so that the piston 67 is approximately in the middle of cylinder 68. Suppose now the resistance across the furnace arc increases. The decreased current in circuit 49 causes a movement of lever 43 toward nozzle 41 due to the decreased magnetic field in magnet 46. This increases the pressure in chamber 32 which causes a movement of the pilot valve 27 to connect cylinder 68 with supply conduit 29, thereby increasing the pressure in cylinder 68. This causes a movement of the electrode 60 into the furnace against the action of counterweight 64, thus decreasing the arc resistance and returning the parts to a state of equilibrium.

The reverse operation and the function of low voltage relay 37 will be readily understood from an examination of the drawing taken in connection with the description and showing of Fig. 1.

It is to be noted that in each form of the invention the parts are so arranged that should anything happen to cause a failure of the liquid pressure as, for example, a break in connecting conduit 25, the movable electrodes will be withdrawn from the furnace and contact between them is prevented. It is evident that in Fig. 2 cylinder 68 might be inserted in that part of flexible member 73 which is just above electrode 60. Many similar changes in the construction and arrangement of parts may obviously be made without departing from the spirit or scope of the invention. In certain cases the secondary agency which I have termed an actuating means may be omitted.

Although there are several intermediate agencies of control, my apparatus is extremely sensitive and yet it can be made without delicate parts subject to wear and liability to become disadjusted. The sensitiveness is due primarily to the use of a liquid and the manner of utilizing the liquid in a continuously flowing stream and the combination of the continuous stream with the other parts herein set forth in a manner such that minute changes of the actuating impulse cause exact, definite and instantaneous changes in a series of progressively increased liquid forces which are multiplied to give an enormous primary actuating force for that which is to be controlled.

Having thus described my invention, what I claim and desire to secure by Letters Patent of the United States is:

1. Electric furnace apparatus comprising, in combination, an electrode, an electric circuit for said electrode, a liquid pressure operated servo-motor to control said electrode, a nozzle through which a stream of liquid flows continuously, a lever controlling flow through said nozzle, means whereby changes of pressure in said stream of liquid caused by movement of said lever cause operation of said servo-motor, and means responsive to amperage in said circuit to control movement of said lever.

2. Electric furnace apparatus comprising, in combination, an electrode, an electric circuit for said electrode, a liquid pressure operated servo-motor to control said electrode, a nozzle through which a stream of liquid flows continuously, a lever controlling flow through said nozzle, means whereby changes of pressure in said stream of liquid caused by movement of said lever cause operation of said servo-motor, an armature on said lever, and a solenoid responsive to amperage in said circuit to change the position of said armature.

3. Electric furnace apparatus comprising, in combination, an electrode an electric circuit for said electrode, a liquid pressure operated servo-motor to control said electrode, a nozzle through which a stream of liquid flows continuously, a lever controlling flow through said nozzle, means whereby changes of pressure in said stream of liquid caused by movement of said lever cause operation of said servo-motor, means responsive to amperage in said circuit to control movement of said lever, a second nozzle through which a stream of liquid flows continuously, a second lever controlling flow through the second nozzle, means whereby changes of pressure in the last mentioned stream of liquid cause operation of said servo-motor and means responsive to voltage in said circuit to control movement of the second lever.

4. In combination, an electric furnace, an electrode for said furnace, an electric circuit to which said electrode is connected, liquid pressure operated means to control movement of said electrode, and means responsive to amperage and voltage in said circuit to control said liquid pressure operated means, said means operating to move said electrodes together upon decrease of amperage in normal operation, and to move said electrodes apart when the voltage is extremely low.

5. In combination, an electric furnace, an electrode for said furnace, a liquid pressure

operated servo-motor to control said electrode, an electric circuit for said electrode, a continually flowing stream of liquid to indirectly control said liquid pressure operated servo-motor and means responsive to conditions in said electric circuit to control said continuously flowing stream of liquid.

6. In combination, an electric furnace, an electrode for said furnace, a liquid pressure operated servo-motor to control said electrode, an electric circuit for said electrode, a continually flowing stream of liquid to indirectly control said liquid pressure operated servo-motor and means responsive to amperage and voltage in said electric circuit to control said continuously flowing stream of liquid.

7. In combination, an electric furnace, electrodes for said furnace, automatic means to move said electrodes together upon decrease of amperage and to move said electrodes apart when the voltage is zero.

8. In combination, an electric furnace, an electrode for said furnace, liquid pressure operated means to control said electrode, means responsive to amperage to control said liquid pressure operated means under normal conditions of operation and means responsive to voltage to control said electrode under extreme conditions.

9. In combination, an electric furnace, an electrode for said furnace, a liquid pressure operated servo-motor to control said electrode, liquid pressure operated actuating means to control said servo-motor, a relay comprising a continuously flowing stream of liquid to control said actuating means, an electric circuit for said electrode and means responsive to electric impulses in said circuit to control said relay.

10. In combination, an electric furnace, an electrode for said furnace, a liquid pressure operated servo-motor to control said electrode, liquid pressure operated actuating means to control said servo-motor, a relay comprising a continuously flowing stream of liquid to control said actuating means, an electric circuit for said electrode, means responsive to amperage in said circuit to control said relay and means responsive to voltage in said circuit to control said continuously flowing stream of liquid under low voltage conditions regardless of control in response to amperage.

11. Electric furnace apparatus comprising an electrode, a circuit for said electrode, a liquid pressure operated servo-motor to move said electrode comprising a cylinder and a piston movable in said cylinder, a relay including a continuously flowing stream of liquid, changes of pressure in which are adapted to operate the servo-motor, means to control said stream of liquid in response to conditions in said circuit, and means to move said cylinder by hand.

In testimony whereof I hereunto affix my signature.

RAGNAR CARLSTEDT.