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APPARATUS FOR AUTOMATICALLY REGULATING SINGLE PHASE ELECTRIC FURNACE ELECTRODES AND THE LIKE

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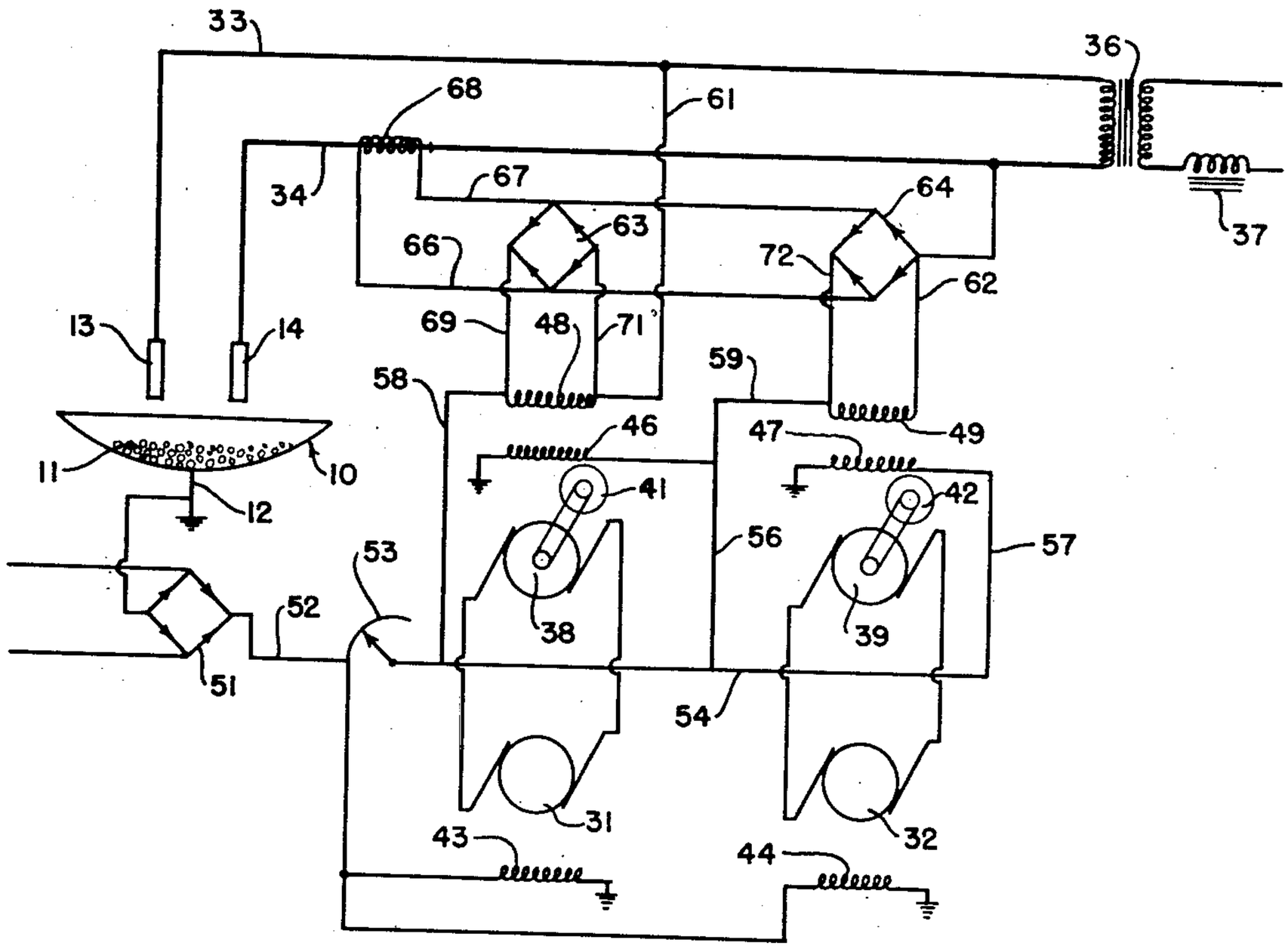

FIG. — 1

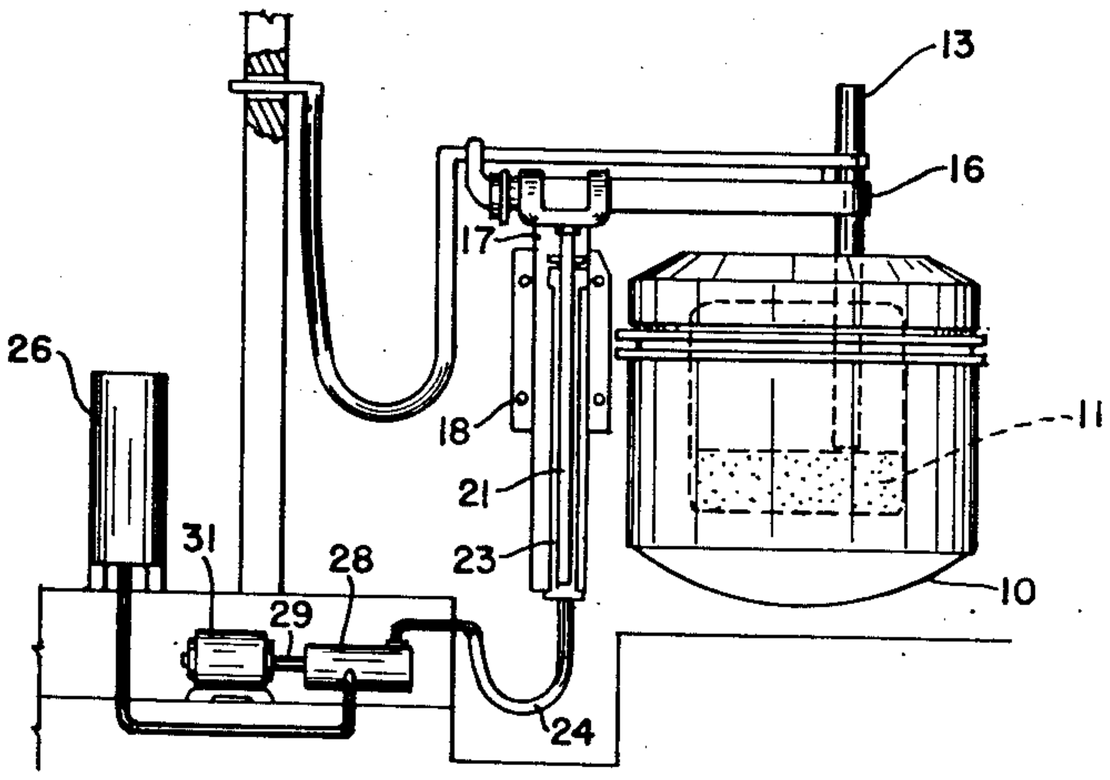

FIG.—2

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APPARATUS FOR AUTOMATICALLY REGULATING SINGLE PHASE ELECTRIC FURNACE ELECTRODES AND THE LIKE

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9 Claims. (Cl. 314—52)

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My invention pertains to means for automatically maintaining a desired and predetermined length of arc between each of two movable electrodes and a body of metal when the electrodes are elements of a single phase electric circuit, as for example in a two electrode single phase direct arc electric furnace.

With the exception of the two electrode single phase direct arc furnace, there are satisfactory systems and devices currently available for automatically regulating and maintaining the position of direct arc furnace electrodes. In the case of two electrode direct arc furnaces, however, the current in one electrode is equal to the current in the other electrode, even though the respective arc lengths may be unequal. As a result, variations of current flow in the electrode or primary circuit can not be utilized successfully for automatically regulating electrode position.

The provision of a satisfactory apparatus for regulating the position of the electrodes in a single phase two electrode direct arc type of electric furnace is one of the principal objects of my invention.

Other objects, which include the provision of means for automatically maintaining a predetermined spacing between each of two electrodes supplied with single phase current and the work, will be disclosed in the course of the following description and in the appended drawings, in which:

Fig. 1 is a diagrammatic illustration of the electrical components of my system and their relationship to each other; and

Fig. 2 is a schematic illustration showing the relationship between the electrical and the mechanical components of my device.

In brief, my invention contemplates the provision of a substantially constant source of direct current, which is passed in independent circuits through each of the electrodes and the charge. Thus, if for any reason the length of the arc changes, the resistance in these circuits will be increased or decreased accordingly, thus producing a variation in current flow, which may be utilized for control purposes. Apparatus responsive to such variations is therefore provided for raising or lowering the electrodes individually as the control current rises or falls, thus returning the electrode to such position as to strike an arc of the desired length and returning the direct current valve to normal.

More specifically my device includes a furnace hearth 10 shaped in conventional manner to receive and contain a charge of solid or molten

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metal 11, which constitutes the work. The refractory which lines the hearth includes conductive members which establish a ground connection 12 with the work 11. A first electrode 13 and a second electrode 14 are movably supported above the work 11 as by arms 16, shown diagrammatically in Fig. 2. The arms 16 are generally horizontal and may be secured to upright members 17 slidably supported for vertical movement by members 18. The upright members 17 may be connected to piston rams 21, each of which is in turn slidably sealed in hydraulic cylinders 23. A hydraulic line 24 connects the lower portion of each cylinder 23 with a suitable reversible hydraulic pump 28, which preferably also includes a reservoir 26 and a driving shaft 29.

It will be understood that the precise apparatus for raising and lowering the electrodes 13 and 14 does not constitute a part of my invention and may assume substantially any form desired, provided the form selected is capable of actuation upwardly and downwardly by suitable reversible electric motors 31 and 32.

As shown in Fig. 1, the motor 31 controls movement of the electrode 13 and the motor 32 controls movement of the electrode 14 either upwardly or downwardly, depending upon the direction of rotation of the corresponding motor. Single phase alternating current is supplied to the electrodes 13 and 14 by leads 33 and 34, which are in turn connected to the secondary of a suitable furnace transformer 36. A reactor 37, usually, although not necessarily, disposed in the primary circuit of the transformer 36, is employed to limit the maximum flow of current between the electrodes 13 and 14. Preferably the action of the reactor 37 is such that the maximum current flowing between the electrodes 13 and 14 will not exceed twice the normal arc current for which the furnace is designed.

The motors 31 and 32 receive their driving current from generators 38 and 39, respectively, each of the generators being driven throughout the operation of my device at a substantially constant speed by suitable alternating current motors 41 and 42, respectively. Motors 31 and 32 are in addition provided with field windings 43 and 44, respectively. The generator 38 is provided with a winding 46 adapted when energized to create a current driving the motor 31 in a direction tending to lower the electrode 13. A similar winding 47 is provided for the generator 39. The winding 46 for the generator 38 is opposed by a winding 48, which when energized,

generates a current tending to drive the motor 31 in a direction which raises the electrode 13. A similar winding 49 is provided for the generator 39. It is, of course, necessary that the windings 46, 47, 48, and 49 be energized by direct current. I therefore provide a rectifier 51 or the like adapted for supplying, as from an alternating current source, the necessary direct control current for the field windings 43 and 44 of the motors 31 and 32 and for the field windings 46, 47, 48, and 49 of the generators 38 and 39.

The rectifier 51 is grounded, as at 12, and is connected, as by wire 52, to supply a substantially constant direct current to the motor field coils 43 and 44 and to a variable resistance 53. A wire 54 is connected to the variable resistance 53 and to wires 56 and 57, which are in turn connected to the windings 46 and 47, as indicated, the opposite ends of the windings 46 and 47 being grounded. A wire 58 connects wire 54 with winding 48, and a wire 59 connects the winding 49 with the wire 56 and the wire 54. The opposite end of the winding 48 is connected by a wire 61 to lead 33, which is in turn connected to the electrode 13, wire 62 being employed to connect the opposite end of coil 49 with the lead 34, which communicates with the other electrode 14.

From the foregoing it may be seen that current flowing through the windings 46 and 47, which act to lower the electrodes 13 and 14, will be of substantially constant value, the actual value depending upon the setting of the variable resistance 53. A similar current from the same source is supplied to the windings 48 and 49, which oppose the windings 46 and 47, respectively; but since the circuit through the windings 48 and 49 is completed through the arcs which normally exist between the electrodes and the work 11, it is obvious that the value of this current will be ordinarily somewhat less than the value of the current in the windings 46 and 47 due to the resistance of the arcs. The current flowing through the windings 48 and 49 must therefore be supplemented by additional current to equal the value of the current flowing in the windings 46 and 47 when the electrodes 13 and 14 are in the desired position.

This may be accomplished by providing rectifiers 63 and 64 connected in parallel by wires 66 and 67 to a suitable current transformer or induction coil 68, the primary of which is lead 34. The output of the rectifier 63 is passed through the winding 48 by wires 69 and 71 in a direction supplementing the current flow through the winding from the wire 58. Similarly, the output of the rectifier 64 is passed through wires 72 and 62 through the winding 49 in a direction supplementing the current flowing through the winding from the wire 59. The values of the various components influencing the flow of current through the winding 48 and 49 are selected in such manner that when the apparatus is in operation and the electrodes 13 and 14 are in proper position the total flow of current through the coils 48 and 49 will be sufficient to neutralize the effect of the current flow through the windings 46 and 47, thus making the output of the generators 38 and 39 zero.

In operation, the work 11 is placed in the hearth 10 with the electrodes 13 and 14 located well above the work 11. The motors 41 and 42 are energized from a suitable source of alternating current, placing generators 38 and 39 in

operation. The variable resistance 53 is adjusted to the desired position and the current is supplied to the furnace transformer 36 and the rectifier 51.

Since the electrodes 13 and 14 have not established electrical contact with work 11 at this moment, current will not flow through the secondary of the furnace transformer 36. The rectifier 51, however, energizes the motor field windings 43 and 44 and also energizes the windings 46 and 47. The windings 48 and 49 are not at this moment energized due to lack of electrical contact between the electrodes 13 and 14 and the work 11. The entire output of the generators 38 and 39 is therefore effective to drive both electrodes downwardly until they come into contact with the charge 11. Assuming for the purpose of explanation that the electrode 13 makes contact with the charge before the electrode 14, it will be observed at the moment of contact a circuit through winding 48 is completed. The current flowing through the winding at this moment will be large, since there will be no arc resistance between electrode 13 and the work 11 to reduce its value. The winding 48 therefore neutralizes the winding 46 and the motor 31 is brought to a stop. The winding 49, however, is not energized until the electrode 14 makes contact with the work 11. Therefore, the electrode 14 will continue downwardly until such contact is established.

Once both electrodes are in contact with the charge 11, current will flow through the leads 33 and 34, thereby energizing the current transformer 68 and the rectifiers 63 and 64. The rectifiers 63 and 64 act to supplement the current already flowing through the windings 46 and 49, thus increasing the effectiveness of the windings 48 and 49 with respect to the windings 46 and 47 and causing the motors 31 and 32 to drive electrodes 13 and 14 upwardly. As the electrodes are moved upwardly by the motors 31 and 32, arcs are drawn between the electrodes and the work, which as they increase in length, reduce by increased resistance the value of the current flowing in the leads 33 and 34, which in turn reduces the output of the rectifiers 63 and 64. At the same time, the current flowing from the wires 58 and 59 through the windings 48 and 49 is reduced correspondingly because of the increased resistance of the arcs. Thus, it may be seen that the electrodes 13 and 14 will move upwardly until the increasing resistance of the arcs limits the current flowing through the windings 48 and 49 to a value neutralizing the effect of the windings 46 and 47, thus bringing the electrodes 13 and 14 to a stop. As the electrodes gradually burn, the length of the arc is increased, which in turn decreases the current to the windings 48 and 49, thus permitting the windings 46 and 47 to become predominate, and thereby drive the electrodes downwardly until a balance is again established.

The arc length to be maintained by each electrode is determined by the setting of the variable resistance 53, which controls the value of the control current flowing through the windings 46 and 47, and which markedly influences the effectiveness of the windings 48 and 49. The position selected should be such that the desired current load from the transformer 36 is obtained.

From the foregoing description, it will be apparent that my apparatus functions in such manner as to maintain electrical operating conditions in the electrode or primary circuit sub-

stantially constant and also to equalize by movement of the appropriate electrode the resistance of each of the arcs. Operation of the furnace and of the electrode control mechanism is not affected by variation in the rate of electrode consumption or other variables which may tend to change the resistance of the arc struck between either of the electrodes and the conductive charge. This contrasts sharply with the operation of a control device for use in such a system which is dependent for control of electrode position upon the total resistance in the arc or electrode circuit, as indicated by variation in current flow in such circuit.

The foregoing description has been confined to the application of my invention to direct arc double electrode single phase electric furnaces, since it is well adapted to such use, but it will be understood that it may be applied to other devices within the scope of the appended claims.

I claim:

1. In an electric arc furnace of the type having a hearth adapted for containing a conductive charge and means for grounding the charge, a pair of spaced electrodes above the charge, reversible electrode motors for driving the electrodes towards and away from the charge and conductors for supplying single phase alternating current to the electrodes, an improved electrode control apparatus which comprises a generator for driving each of the electrode motors, each of said generators having a grounded first winding for generating current for driving the corresponding electrode motor in an electrode-lowering direction and each having a second winding opposing the first winding for driving the corresponding electrode motor in an electrode-raising direction, a grounded source of substantially constant direct current, wires connecting said source to the first and second windings, wires connecting each of said second windings to its corresponding electrode, and means for supplementing the flow of current through each of the second windings, said means being variable directly with the current flowing between the electrodes.

2. In a structure having a pair of movable electrodes constituting elements of a single phase alternating electric circuit wherein said circuit is completed by arcs formed between each electrode and a conductive work body, the improvement in control apparatus for automatically maintaining each electrode in such position that the length of each arc is substantially equal, which includes a pair of reversible electric motors, means for coupling one of said motors to each electrode, individual generators for each of the motors, means for driving the generators at a substantially constant speed, each of said generators having opposed first and second windings, the second winding being connected to the corresponding electrode, a substantially constant source of direct current to all of said windings, a variable direct current source for each of the second windings connected to supplement the flow of current in such windings from the said constant direct current source, and means for varying the output of each of said variable direct current sources directly with the flow of current in the electrode circuit.

3. In a structure having a pair of movable electrodes constituting elements of a single phase alternating electric circuit wherein said circuit is completed by arcs formed between each electrode and a conductive work body, the improvement in control apparatus for automatically maintaining each electrode in such position that the length of each arc is substantially equal, which includes a pair of reversible electric motors, means for coupling one of said motors to each electrode, individual generators for each of the motors, means for driving the generators at a substantially constant speed, each of said generators having a grounded first winding for generating current for driving the corresponding electrode motor in an electrode-lowering direction and each having a second winding opposing the first winding for driving the corresponding electrode motor in an electrode-raising direction, a grounded source of substantially constant direct current, wires connecting said source to the first and second windings, wires connecting each of said second windings to its corresponding electrode, and means for supplementing the flow of current through each of the second windings, said means being variable directly with the current flowing between the electrodes, a variable direct current source for energizing the variable direct current sources.

4. In a structure having a pair of movable electrodes constituting elements of a single phase alternating electric circuit wherein said circuit is completed by arcs formed between each electrode and a conductive work body, the improvement in control apparatus for automatically maintaining each electrode in such position that the length of each arc is substantially equal, which includes a pair of reversible electric motors each coupled to an electrode for driving the electrodes towards and away from the work body, a generator for supplying current to each motor, means for continuously driving the generators at substantially constant and equal speed, each of said generators having opposed first and second windings, a first substantially constant direct current connected to each of said first windings, means for also passing said first direct current through each of said second windings and a corresponding electrode to the work body, a second direct current source for each of said second windings for supplementing the flow of said first direct current therethrough, and a transformer in the electrode circuit for energizing the said second direct current source proportionately to the flow of current in the electrode circuit.

5. In a structure having a pair of movable electrodes constituting elements of a single phase alternating electric circuit wherein said circuit is completed by arcs formed between each electrode and a conductive work body, the improvement in control apparatus for automatically maintaining each electrode in such position that the length of each arc is substantially equal, which includes a pair of reversible electric motors each coupled to an electrode for driving the electrodes towards and away from the work body, a generator for supplying current to each motor, means for continuously driving the generators at substantially constant and equal speed, each of said generators having opposed first and second windings, a first substantially constant source of direct current, conductors for completing the circuit from the first direct current source through each of said first windings, conductors for completing a circuit from said first direct current source through each of the second windings, the corresponding electrode, and work body, a second direct current source for each of the second windings, conductors for connecting each of said second direct current sources to the corresponding winding for supplementing the flow of current therethrough, and transformer means in the electrode circuit for energizing the said second direct current sources proportionately to the flow of current in the electrode circuit.

6. In a structure having a pair of movable electrodes constituting elements of a single phase alternating electric circuit wherein said circuit is completed by arcs formed between each electrode and a conductive work body, the improvement in control apparatus for automatically maintaining each electrode in such position that the length of each arc is substantially equal which includes a pair of reversible electric motors each coupled to an electrode for driving the electrodes towards and away from the work body, a generator for supplying current to each motor, means for continuously driving the generators at substantially constant and equal speed, each of said generators having opposed first and second windings, a first substantially constant source of direct current, conductors for completing the circuit from said first direct current source through each of said first windings, conductors for completing a circuit from said first direct current source through each of the second windings, the corresponding electrode, and work body, a variable resistance connected in series between the first direct current and each of the windings, a second direct current source for each of the second windings, conductors for connecting each of said second direct current sources to the corresponding winding for supplementing the flow of current therethrough, and transformer means in the electrode circuit for energizing the said second direct current sources proportionately to the flow of current in the electrode circuit.

7. In a structure having a pair of movable electrodes constituting elements of a single phase alternating electric circuit wherein said circuit is completed by arcs formed between each electrode and a conductive work body, the improvement in control apparatus for automatically maintaining each electrode in such position that the length of each arc is substantially equal, which includes a pair of reversible electric motors each coupled to an electrode for driving the electrodes towards and away from the work body, each of said motors having a field winding, a generator for supplying current to each motor, means for continuously driving the generators at substantially constant and equal speed, each of said generators having opposed first and second windings, a first substantially constant source of direct current, conductors for completing the circuit from the first direct current source through each of said first windings, conductors for completing a circuit from said first direct current source through each of the second windings, the corresponding electrode, and work body, conductors completing a circuit from the first direct current source through each of said motor field windings, a variable resistance connected in series between the first direct current and each of the windings, a second direct current source for each of the second windings, conductors for connecting each of said second direct current sources to the corresponding winding and supplementing the flow of current therethrough, and transformer means in the electrode circuit for energizing the said second direct current sources proportionately to the flow of the current in the electrode circuit.

8. Apparatus for regulating the position of a pair of vertically movable electric furnace electrodes constituting elements of a single phase electrode circuit with respect to a conductive grounded work body disposed below the electrodes comprising a pair of reversible electric motors each connected to an electrode, a field winding for each motor, a generator for each motor, means for driving each generator at a substantially constant speed, each of said generators having opposed first and second windings, a first substantially constant source of direct current, conductors for passing direct current from said first source through the motor windings, through each of the said first generator windings, and through each of the said second generator windings to the corresponding electrode and then to the work body, means for varying the resistance disposed between said first direct current source and said first and second generator windings, and means for supplementing the flow of current through the second generator windings including a pair of rectifiers each connected to one of the second windings, and a transformer for energizing the rectifiers, the primary winding of said transformer being connected in the electrode circuit and energized only when current flows between the electrodes.

9. Apparatus for regulating the position of a pair of vertically movable electric furnace electrodes constituting elements of a single phase electrode circuit with respect to a conductive grounded work body disposed below the electrodes comprising a pair of reversible electric motors each connected to an electrode, a field winding for each motor, a generator for each motor, means for driving each generator at a substantially constant speed, each of said generators having opposed first and second windings, a first substantially constant source of direct current including a first rectifier connected to a substantially constant alternating source of alternating current, conductors for passing direct current from said first rectifier through the motor windings, through each of the said first generator windings, and through each of the second generator windings to the corresponding electrode and then to the work body, resistance means for varying the output of first said rectifier, second and third rectifiers each connected to one of said second windings for supplementing the flow of current therethrough, and a current transformer for supplying current to the second and third rectifiers, the primary of said current transformer being in the electrode circuit and energized only when current flows through said electrode circuit.

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