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METHOD FOR REGULATING OF THE POSITION OF THE ELECTRODES IN AN ELECTRODE FURNACE AND ARRANGEMENT FOR CARRYING OUT THE METHOD

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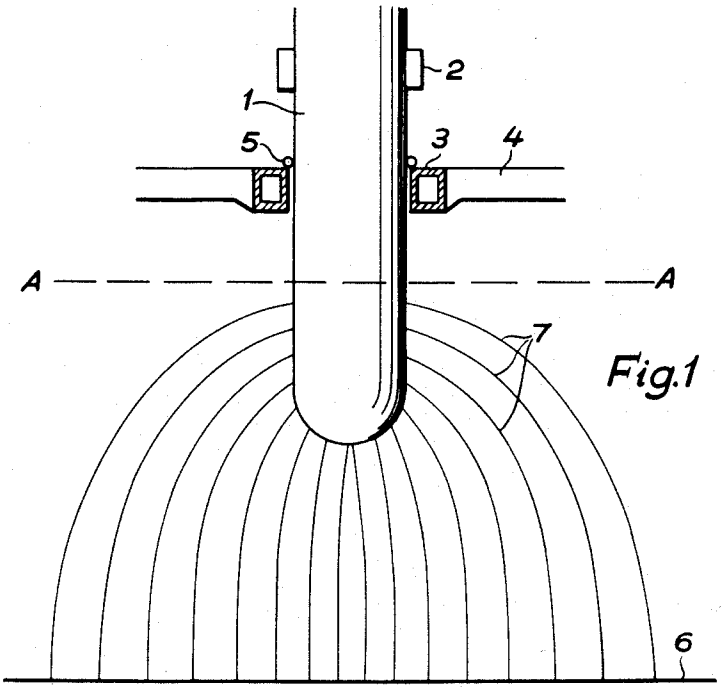

Fig.1

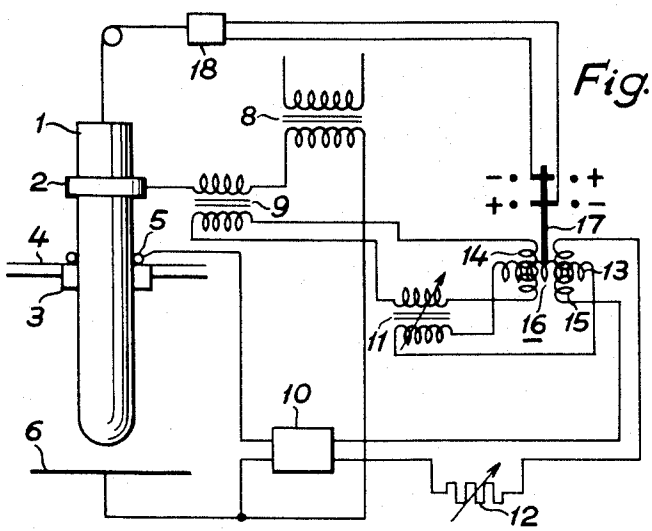

Fig.2

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METHOD FOR REGULATING OF THE POSITION OF THE ELECTRODES IN AN ELECTRODE FURNACE AND ARRANGEMENT FOR CARRYING OUT THE METHOD

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5 Claims. (Cl. 314—74)

The present invention comprises a method for regulating of the position of the electrodes in an electrode furnace, preferably an electrode resistance furnace, and an arrangement for carrying out the method.

In electrode resistance furnaces, where as a rule the most important part of the molten heat is generated in the charge around and under the electrode point, it is important from the metallurgical point of view that the molten zone where the principal part of the heat is generated is situated at a certain height above the melting bath.

With the known regulating systems which are usually used for electrode resistance furnaces, the task of the regulator is to keep constant resistance between electrode and bath by controlling the distance of the electrode from the melt. With constant voltage on the electrodes the power per electrode may then be kept constant, under the assumption that the charge resistance is kept constant. It may now happen, however, that the charge resistance varies dependent upon different charge compositions, etc., and this variation may in many cases make more than 100%. Since the regulator has to keep constant resistance, the electrode—and thereby the melt zone—is lowered when the charge resistance increases and vice versa. There is no possibility to distingush between the change in the resistance which is caused by the charge composition and that caused by the position of the melt zone.

The invention proposes a regulating method in which the current line picture illustrating the distribution of the electrode current in the charge, is kept mainly constant by adjusting the inductance, which refers to said current line picture, to a constant value. According to the method of the invention a magnitude is derived for at least one electrode, which magnitude is dependent on the inductance referring to the corresponding electrode current path running inside the furnace, and mainly independent of current and resistance in said current path, and said magnitude is kept mainly constant by raising or lowering of said electrode.

The invention also comprises an arrangement for carrying out the above-mentioned method, which arrangement comprises an organ for expressing said magnitude, e.g. a reactance relay, the organ being arranged to control an operating device intended for electrode movement, e.g. an electric motor with associated mechanical power transfer links.

The invention is described in the following with reference to accompanying schematical drawings, where FIGURE 1 shows one of the electrodes in an electrode resistance furnace and the distribution of the electrode current in the charge, and FIGURE 2 shows a scheme for an arrangement according to the invention.

In FIGURE 1, **1** indicates an electrode, the current supply of which is made via electrode clamps **2**. The electrode is led into the furnace by means of the arch ring **3** which is mounted in the furnace arch **4**, and supplied with contact rollers **5**, which make contact with the electrode. The line A—A indicates the height of the charge above the melt. It is apparent from the figure that the electrode **1** is relatively deeply immersed in the charge,

which is usual with electrode resistance furnaces. The furnace power is developed in a zone which coincides with the current path between electrode **1** and the surface **6** of the melt, which current path is illustrated by means of current lines **7** in the figure. If one assumes that the furnace is kept full each time, the current line picture for the electrode current path between arch ring and melt must change with varying distance between electrode point and melt, so that each electrode position gives a characteristic value for average cross section of said current path. As known per se a current path with small cross section has greater inductance than an equally long current path with large cross section. Accordingly one obtains for each electrode position a characteristic value for the inductance referring to said current path.

The mentioned magnitude dependent upon the inductance and independent of current and resistance may be derived in different ways. For instance, the vector current and voltage values of said current path may be measured and the reactance derived by means of a vector construction or with help of a monographic chart. A comparison of vector values for indicating constant inductance may according to the invention also be made by supplying said current and voltage vectors to an electrodynamic system, e.g. a reactance relay, in such a way that equilibrium between magnetic powers is maintained only with a certain value on reactance of said current path. The desired value is adjusted by means of variable relay constants.

According to one embodiment of the invention the deriving of said magnitude may be carried out by means of a high frequency voltage, which is superimposed on said current path by connecting it to a high frequency measuring equipment. The measuring frequency is chosen so high that the high frequency measuring system is not affected by the low frequency furnace voltage. The high frequency measuring may be carried out in many different ways. For instance, an oscillating circuit in the measuring arrangement is tuned for resonance at desired value for said inductance. Said current path may also be connected into a conventional measuring bridge for inductance measurements.

FIGURE 2 shows schematically an arrangement for effecting automatic regulation according to the invention. In the figure, **1** indicates the electrode which is supplied with current from the furnace transformer **8** via the contact ring **2**. The circuit is closed via the molten bath **6**. **16** indicates the electrodynamic system in a reactance relay, which system consists of two fixed coils and a movable coil **13**. The one fixed coil **14** is connected to the secondary side of a current transformer **9**, the primary side of which is series connected to the secondary side of the furnace transformer. The other fixed coil **15** of the system is connected via a regulating resistance **12** to a phase shifting device **10** belonging to the complete reactance relay, which device is intended for 90° phase shifting of the voltage between the contact rollers **5** placed on the arch ring **3** and the molten bath **6**. The movable coil **13** of the relay receives voltage from a current transformer **11** with variable transformation ratio and with the primary side connected in series with the fixed coil **14**. The movable coil **13** which is free to make an angular movement within a certain range is suspended in the resulting field of the coils **13** and **14**, which fields counteract each other. With a certain relation between the current of the measured circuit and the reactive voltage component of the same circuit, for example, with a certain value of the reactance of the current path between the contact rollers **5** and the molten part of the charge **6**, said resulting field will be zero and no force then acts on the moving coil. The contact arm **17**, which is attached to the movable coil, will then have the position shown in FIG. 2.

The desired reactance value of the measured circuit corresponds to this position and can be adjusted by means of the variable resistance 12. As soon as a decrease or increase of the reactance of the measured circuit occurs, a corresponding torque will start to act on the coil 13 in one direction or the other; respectively. The value of this torque can be adjusted by varying the ratio of the current transformer 11. Thus the arm 17 which is furnished with partial contacts, will be moved to a left or a right contact position respectively and make contact with one or another of the sets of plus and minus terminals shown in the figure, whereby a servo-motor 18 will be driven in one or the other direction giving a lifting or a lowering of the corresponding electrode.

The arrangement shown on the drawing is only one of many feasible embodiments in the scope of the invention. Thus the contact arm shown in FIGURE 2 may be replaced by a sensing organ which supplies a servo-system with a magnitude mainly proportional to the deviation of the movable coil from the balance position.

Another arrangement for carrying out a method according to the invention based on the use of high frequency measuring circuit, is achieved by applying a voltage dependent upon the inductance of said current path to the input side of an amplifier which together with the operating device intended for the electrode movement forms part of a servo-system. The applied voltage may for example be the voltage of that branch of the measuring bridge where the current is zero at equilibrium.

I claim:

1. In the operation of an electrode resistance furnace having a furnace bottom containing the molten part of the charge and a non-molten part of the charge above the molten part, a roof having at least one opening therein, an electrode mounted for vertical movement through said opening and extending into the non-molten part of the charge, and means forming a circuit path between said electrode and the molten part of the charge; the steps of deriving a magnitude which is dependent on the reactance of said circuit path and independent of the resistance and current of said path, and varying the vertical position of said electrode in accordance with variations in such magnitude to maintain the reactance of said circuit path substantially constant.

2. In the operation of an electrode resistance furnace having a furnace bottom containing the molten part of the charge and a non-molten part of the charge above the molten part, a roof having at least one opening therein, an electrode extending through said opening and mounted for vertical movement therein and extending into the non-molten part of the charge, fixed means above said roof having a sliding contact with said electrode, means forming a circuit path between said sliding contact means and said molten part of the charge, and circuit means supplying current to said electrode; the steps of measuring the vector of the working current supplied to the electrode and the voltage drop between said sliding contact means and said molten part of the charge to derive a magnitude which is dependent on the reactance of said circuit path and independent of the current and the resistance of said circuit path, and moving said electrode vertically in accordance with variations in such magnitude to maintain said reactance substantially constant.

3. In an electrode resistance furnace having a bottom part for containing the molten part of the charge and in which the charge includes a non-molten part above the molten part, and a roof having an opening therein, an

electrode extending through said opening, and means connected to said electrode for raising and lowering it, fixed means above said roof making a sliding contact with said electrode, circuit means connected to such bottom part and to the electrode for supplying current thereto, the lower end of the electrode entering the non-molten part of the charge, means forming a circuit path between said sliding contact means and the bottom part of the charge, and means in said circuit path operatively connected to said raising and lowering means and responsive to variations in the reactance of said circuit path and independent of the resistance and current thereof for operating said raising and lowering means to maintain the reactance of the said circuit path substantially constant.

4. In an electrode resistance furnace having a bottom part for containing the molten part of the charge and in which the charge includes a non-molten part above the molten part, and a roof having an opening therein, an electrode extending through said opening, and means connected to said electrode for raising and lowering it, fixed means above said roof for making a sliding contact with said electrode, circuit means connected to such bottom part and to the electrode for supplying current thereto, the lower end of the electrode entering the non-molten part of the charge, means forming a circuit path between said sliding contact means and the bottom part of the charge, and reactance relay means in said circuit path operatively connected to said raising and lowering means and responsive to variations in the reactance of said circuit path and independent of the resistance and current thereof for operating said raising and lowering means to maintain the reactance of the said circuit path substantially constant.

5. In an electrode resistance furnace having a bottom part for containing the molten part of the charge and in which the charge includes a non-molten part above the molten part, and a roof having an opening therein, an electrode extending through said opening, and means connected to said electrode for raising and lowering it, fixed means above said roof for making a sliding contact with said electrode, circuit means connected to such bottom part and to the electrode for supplying current thereto, the lower end of the electrode entering the non-molten part of the charge, means forming a circuit path between said sliding contact means and the bottom part of the charge, relay means in said circuit path operatively connected to said raising and lowering means and including a contact member movable in a path between two extreme positions, said relay means in said two extreme positions causing operation of said lifting and lowering means in opposite directions, said relay means being responsive to variations in the reactance of said circuit path and independent of the resistance and current thereof moving said contact member, when such inductance deviates from a predetermined value, to operate said raising and lowering means in a direction to maintain the reactance of the said circuit path susbtantially constant.

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