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ELECTRICAL CONNECTION IN SINGLE-PHASE ELECTRODE FURNACES

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FIG. 1

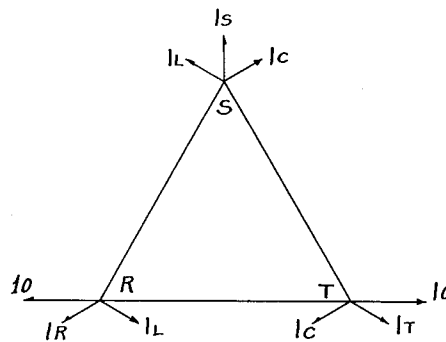
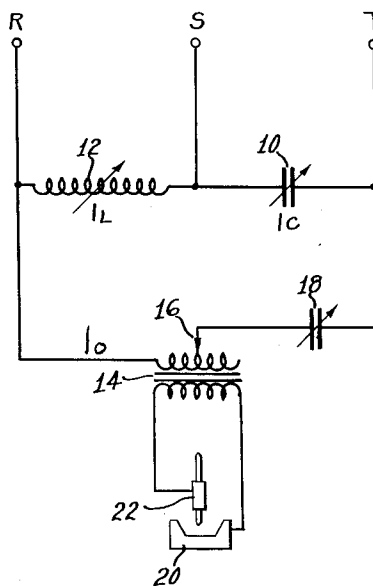


FIG. 2



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ELECTRICAL CONNECTION IN SINGLE-PHASE ELECTRODE FURNACES

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3 Claims. (Cl. 13—12)

When a single phase electric smelting furnace is connected to a three-phase system it results in an unsymmetric load being placed on the system. As a rule the generators will permit a certain amount of unsymmetric load but the load of commercial single phase smelting furnaces is so great that the unsymmetric load on the power system will exceed the limit permitted by the power generators and this will cause great inconvenience and danger for the generators in the power plant. Single phase smelting furnaces ordinarily have so low a power factor that the conditions of unsymmetric load will be additionally aggravated.

To overcome this difficulty various compensation devices have been designed where, by means of induction coils and condensers, it has been tried to obtain symmetric loads on three phase systems to which is connected a single phase system. Many of these devices have proved satisfactory for the relatively symmetric loads which are created by furnaces such as true resistance furnaces and induction furnaces. In electrode furnaces, however, the load will vary over wide limits due to the movement of the charge in the furnace and the formation of electric arcs and the like. Experience has shown that these phenomena and the change in loads resulting from connecting and disconnecting the furnace cause overloads on the compensation devices and this in turn causes injurious overloads and flashing in the high voltage system of the furnace and the other electric devices connected on the high voltage side.

According to the present invention the above mentioned drawbacks of over tension and flashing can be avoided by a system in which the single phase furnace is connected between two of the phases of the three phase system and a condenser system is connected in series with the single phase furnace. Such condenser system preferably is arranged in series with the primary of the furnace transformer. In some cases a somewhat equivalent result can be had by arrangement of the condensers in parallel with the furnace transformer but this arrangement is not generally suitable for electrode furnaces as it would require that the capacity of the condensers be adjusted according to the furnace current. The condenser system in series with the furnace transformer should have sufficient capacity to take care of the inductivity of both the furnace transformer and of the furnace itself and a circuit should thereby be obtained where $\cos$ is approximately 1.

Appropriate condensers and an induction coil are arranged in the other phases as will be more fully described hereafter.

The invention can best be understood by reference to the accompanying drawing in which:

Fig. 1 is a vector diagram of a three-phase system explanatory of the invention.

Fig. 2 is a diagrammatic view of a furnace connected to a three phase system in accordance with the present invention.

In Fig. 1 the letters R, S and T indicate terminals of

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a three-phase system represented by the vectors R—S, S—T, and R—T. When a furnace is to be energized from one phase of such voltage, say the phase R—T, a symmetric and purely ohmic load may be obtained when the furnace current I_O is in phase with the voltage R—T and when, in accordance with the invention, a reactive load comprising capacitors, is connected to be energized by the phase S—T with a current I_C numerically equal to a current I_L through a purely inductive reactance connected in the phase R—S. Complete symmetry is obtained at a certain load on the furnace when the furnace

current I_O is equal to $\sqrt{3} I_C$ and also equal to $\sqrt{3} I_L$. To insure that the current through the furnace is in phase with the voltage R—T, condensers are connected in the phase R—T in series with the furnace transformer and of a reactance at the frequency of the supply voltage, that is equal to the inductive reactance of the furnace transformer, together with its load. Under these conditions, as can be seen from the diagram of Fig. 1, the total current I_T from terminal T, which is the resultant of the currents I_C and I_O , is equal to the total current I_R from terminal R, which is the resultant of the currents I_O and I_L , and is also equal to the total current I_S from terminal S, the resultant of the currents I_L and I_C .

In Fig. 2 the terminals of the three phase system, as before, are indicated by the letters R, S and T. A condenser system 10 is located between T and S and an inductance 12 is located between R and S. The furnace transformer 14 is arranged between R and T and is provided with an adjustable tap 16 on the primary side of the transformer. A condenser system, indicated at 18, is in series with the primary of transformer 14. The secondary of the transformer is connected to the furnace pot 20 and electrode 22.

As illustrative of the invention let us presume that the frequency of the source is 50 cycles per second, and that there is an average voltage drop of 75 volts in the furnace and a current of 50,000 amperes. In such case the condenser system 10 and the inductance 12 should preferably be so chosen that the reacting power of each is of the order of 1900 kilovolt amperes. To obtain a power factor of 1, that is, to insure that the current through the furnace will be in phase with the phase R—T, the condenser system 18 must be so chosen that the reactance thereof is equal to the reactive load of the furnace including the transformer 14. This value will depend on the design of the furnace, but by good furnace design a value of 1500–1800 kilovolt amperes for the reactive load may be assumed for a furnace load of 3300–3400 kilowatts. The condenser system must accordingly have a capacity within the range stated. As indicated in Fig. 2, the condenser systems 10 and 18 and the induction coil 12 are preferably adjustable to allow for change in furnace load.

Obviously if more than one single phase furnace is involved such furnaces will be connected between different phases of the system.

The invention has now been described with reference to a single embodiment thereof. Numerical values of the capacitive and inductive reactances have been suggested for presumed values of furnace current, voltage and frequency. Obviously such numerical values are illustrative only and not to be considered as limiting the scope of the invention.

I claim:

1. A circuit for energizing a single phase electrode furnace from a three phase voltage source which comprises a furnace transformer having its secondary winding coupled to the furnace and its primary connected in series with a condenser system across the first phase of the source, the capacitive reactance of said condenser sys-

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tem being substantially equal to the inductive impedance of the transformer and its load at the frequency of the source, a capacitative reactance connected across a second phase of the source and an inductive reactance connected across the third phase of said source.

2. The circuit according to claim 1 wherein the said two last mentioned reactances are substantially equal.

3. The circuit according to claim 1 wherein said transformer, said condenser system and said two last mentioned reactances are all adjustable to maintain a symmetrical load on the source with change in furnace load.

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