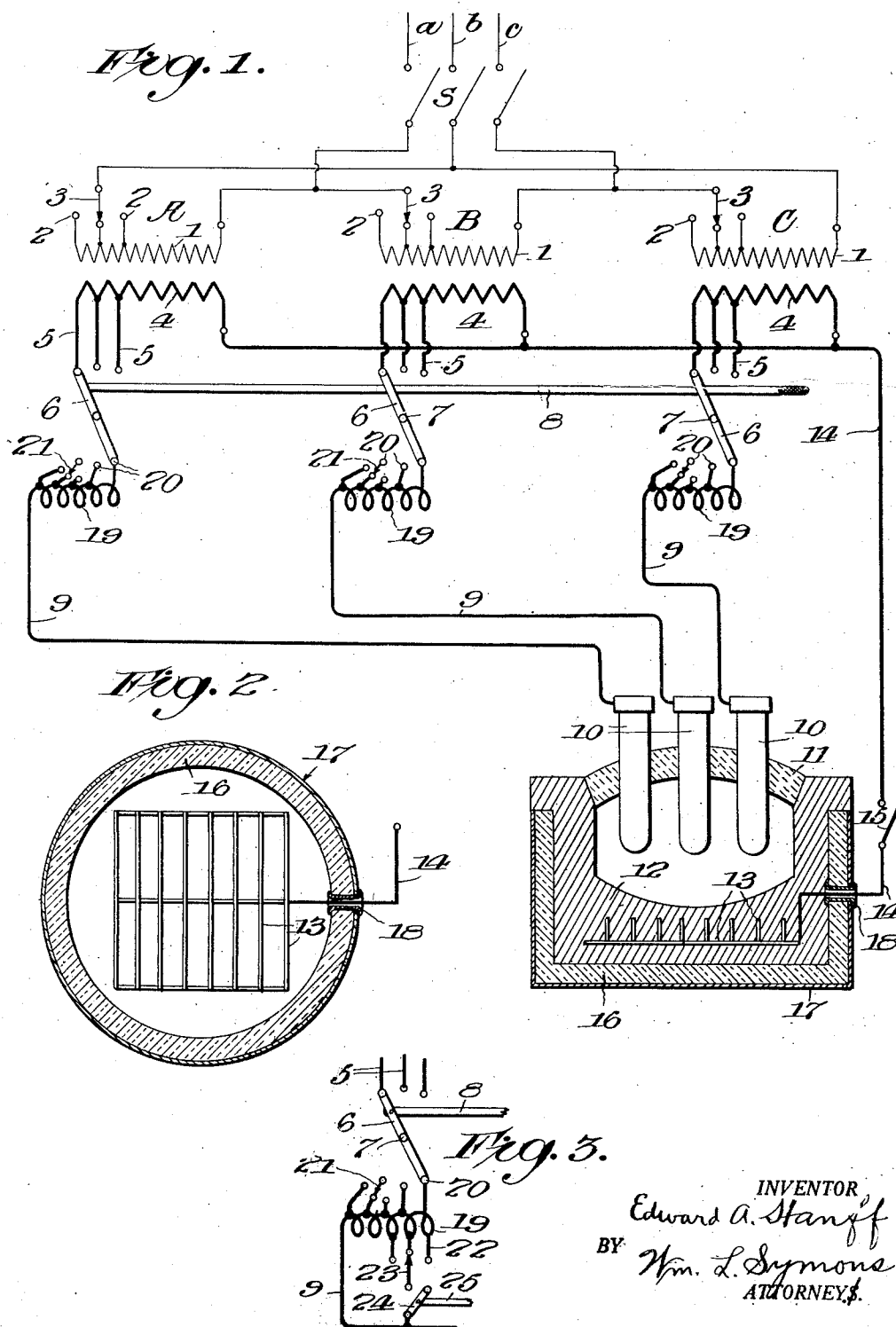


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## UNITED STATES PATENT OFFICE.

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## ELECTRIC FURNACE.

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*To all whom it may concern:*

Be it known that I, EDWARD A. HANFF, a citizen of the United States of America, residing at Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented certain new and useful Improvements in Electric Furnaces, of which the following is a specification.

This invention relates to an improved construction of and arrangement of connections for an electric furnace of the arc type, by means of which the voltage at the arc may be adjusted by the operator to suit the different requirements under different operating conditions, and the power factor controlled as desired.

In an electric furnace of the arc type, when charged with cold metal, I find it is desirable to use as high a voltage on the arcs as possible. This higher arc voltage permits more rapid input of power, thereby decreasing the time of melt-down. I also find this to be advantageous in the case of loosely piled light or sandy scrap, the resistance of which is comparatively high while cold. The use of the higher voltage permits the current to flow more readily through the mass, and start arcing promptly. Experience also shows that when melting cold scrap, it is desirable to melt with a long arc, which, dilating around the electrode, melts a large cavity through the bed of scrap and thus prevents pieces from falling in and short-circuiting the electrode.

At other times during the operation of the electric furnace, it is desirable to employ a voltage lower than that used in melting down the charge. For example, after the charge is in a molten state, a lower voltage may be used to supply the necessary heat to the metal for the purpose of mixing and refining. The higher voltage is objectionable at that time, owing to the action of the intense radiant heat of the long arc, reflected by the white finishing slag, upon the roof and linings of the furnace.

During the use of the higher voltage, as mentioned, for melt-down, or at other times, it frequently happens that violent current surges occur, owing to pieces of metal fall-

ing between the electrodes and short-circuiting them. Where the capacity of the power supply is not considerably in excess of the power requirements of the furnace, these surges are apt to cause objectionable variations in voltage on the power system. Such current surges also cause excessive wear and tear on the electrical equipment, as well as delays from frequent operation of the overload protective devices. To reduce these surges, it is customary to provide reactances in the power circuit, which may be either embodied in the transformed design or may be connected in series with either high tension or low tension leads of the transformer.

After the charge has been melted down, the current fluctuations are much less severe and it is desirable to eliminate as much reactance in the circuit as possible, since excessive reactance causes loss of power and unnecessarily reduces the power factor of the load.

One object of this invention is to provide means for obtaining the higher voltage required for melting down the charge rapidly and, where conditions require the same, inserting the proper reactance in the circuit to obtain a stabilized power input. A further object is to provide means for changing the voltage to a lower value at some stage of the heat to suit the requirements, and at the same time, where desired, for reducing the amount of reactance in the circuit, to a corresponding value.

In order that the invention may be readily understood, reference is had to the accompanying drawings, forming part of this specification, and in which—

Fig. 1 is a diagram illustrating my improved electrical connections and also showing the furnace in vertical section;

Fig. 2 is a sectional plan view of the furnace, the material of the bottom being omitted for the sake of clearness; and

Fig. 3 is a fragmentary diagrammatic view similar to Fig. 1 showing an amplification or modification of the invention.

The furnace obtains power through a bank of transformers, A, B, and C, the preferred connection being 3-phase, having high ten-

sion coils 1 connected in delta, and the low tension coils 4 connected in star.

*a*, *b*, and *c* represent incoming lines, which may be of any desired voltage. Switch S connects these lines to the primary side of the transformers A, B and C. The primary coil 1 of each transformer is provided with a number of taps, 2, the point of connection to which may be selected by means of an adjustable contact 3 to give small variations in the voltage delivered to the furnace, to correspond to the charge being melted, or to the thickness and composition of the slag carried on the metal, or to accommodate small variations in the voltage of the power supply.

The secondary coils 4 of the transformers are connected in star, and each is provided with a plurality of taps 5 for supplying different voltages. Three of such taps are shown, the left hand tap representing high or full voltage and the others, lower or fractional voltage.

It is desirable to provide means by which the furnace electrodes may be connected at will to any desired tap on the transformers to obtain the voltage best suited to the stage of the heat. For this purpose, I provide multipoint switches 6, pivoted at 7, which may be placed in engagement with any of the taps 5 of the transformer secondaries. These switches may be simultaneously operated by means of a handle 8, and control the flow of current from the transformers over conductors 9, to the electrodes 10 of the furnace.

The electrodes 10 project down through the roof 11 and the furnace is provided with a refractory bottom 12, which, when heated, is susceptible of conducting electricity. Embedded in this conducting bottom is a metallic grid 13, which is preferably substantially coextensive with the melting chamber and the material of which is distributed throughout the area of the bottom. This grid 13 is connected by a conductor 14 to the neutral point of the star-connected secondaries 4, a switch 15 being interposed in such connection.

The conductive bottom 12 and grid 13 are insulated from the metallic shell or casing 17 of the furnace by means of a layer of insulating material 16, such as kieselguhr, silica, or the like. An insulating bushing 18 is provided where the conductor 14 passes through the wall of the furnace.

Reactance coils 19 are provided, each of which has a plurality of terminals 20, adapted to be selectively engaged by the corresponding switch 6. One or more of these terminals may be adjustable, as indicated at 21, to give varying amounts of reactance.

When switch 6 is operated to the left, making connection to the left hand or full

voltage tap on the transformer, connection is also made to the extreme right hand terminal on reactance 19, thus having the maximum amount of reactance in circuit. When switch 6 is operated to engage the intermediate or low voltage taps 5, the reactance 19 is connected at the corresponding intermediate terminals, thus reducing the amount of reactance, or cutting it out entirely, if desired.

In the arrangement above disclosed, both the arc voltage and the reactance in series may be adjusted to give the best possible conditions for any period of the heat.

With the transformer secondary coils connected in star, and with switch 15 closed, either of electrodes 10 may arc through the furnace charge to the bottom independently of the other two, as when the first electrode contacts in starting up, and with all three electrodes operating, any unbalancing, due to a lower resistance path from either electrode, will be taken care of by current flowing through the grid 13, back to the neutral point of the transformer. Where grid 13 is not insulated from the shell of the furnace 17, the difference in potential between the shell and the electrodes may be dangerous or cause annoyance to the operators, in case tools or other devices are pushed against the electrodes and allowed to contact with metal parts of the furnace shell. Insulation 16 prevents danger of shock or annoyance, and permits the shell of the furnace to be effectively grounded.

The passage of the current through the furnace charge and bottom to grid 13, effectively stirs up the metal, owing to convection currents set up in the furnace bath, thus insuring uniform temperature in all parts of the metal. At certain stages in the process, it is desirable to limit the stirring effect, and by opening switch 15, the current is prevented from flowing through the metal to the bottom, thus reducing the stirring or agitating effect, as desired.

In the foregoing, it has been stated that the purpose of the reactance is to limit the current surges during melt-down periods, when desired. It is sometimes desirable to make use of the higher voltage during the last stages of the refining period, so as to superheat the metal to a high temperature to render the metal more fluid. At this time, it is not desirable to limit the current by means of reactances, as the violent surges, due to short-circuits, will not occur and to superheat the metal the maximum possible power input may be desired for a short period of time. In order to accomplish this, I have provided the arrangement shown in Fig. 3, which arrangement may be employed in addition to the switch 6 and terminals 20. Referring to Fig. 3, it will be seen that I

have provided an auxiliary switch 24, operated by a handle 25 and adapted to short-circuit the reactance coil 19. In order to short-circuit either the entire coil, or only portions of it, as desired, I preferably provide a series of taps 22, with which an adjustable contact arm 23 cooperates. By setting the arm 23 to engage the desired one of the taps 22, more or less reactance may be cut out by closing the switch 24, as will be obvious. It will, of course, be understood that a switch 24 as shown in Fig. 3 is provided for each of the reactance coils and that all of the switches are simultaneously operated by the handle 25.

I am aware that heretofore electric furnaces have been arranged with transformers having primary coils so constructed as to permit them to be thrown in series or multiple formation, thus varying the secondary voltage. One difficulty with this arrangement is that the reactance of the transformer is doubled on a low secondary voltage, which, being used at a time when the metal is hot and being refined, occurs at a period when there is less need for reactance to stabilize the current.

Another difficulty is that only two voltages are available, whereas I find it quite desirable to have one high voltage when melting down, a lower voltage when refining under acid conditions, and a still lower voltage when refining under basic slag.

I am also aware that reactance has been used in series with the furnace arc to stabilize the current, this reactance sometimes having been made inherent to the transformer construction and at other times a separate reactor has been placed in the primary lead. In still other arrangements, the reactor has been placed in the secondary lead, but such reactance was constant. When the low voltage tap is used for refining, much less power is required, owing to the lower voltage. However, the current, being constant, the inherent reactance of the transformer and of the secondary leads is correspondingly increased, which gives an undesirably and unnecessarily low power factor at that stage of the operation, whereas, when beginning the melt-down, when the charge is all cold and the arc voltage high, so that the reactance inherent to the transformer windings in the secondary circuit is of a comparatively low percentage, it is then especially desirable to insert such reactance as may be necessary to stabilize the current in the arc, the power in the arc becoming substantially constant, when operating with sufficient reactance to give a power factor of 71%.

In my improved arrangement I, therefore, provide an outside reactor, which is accompanied with a switch, so arranged that when

changing from high-melt-down voltage on the secondary, to a lower refining voltage on the secondary, the external reactance is reduced or cut out, so that the power factor on the lower voltage remains substantially the same as on the higher voltage.

What I claim is:

1. The combination with an electric furnace having a bottom susceptible of conducting electricity and an arcing electrode, of a transformer having a secondary winding provided with taps, a connection between one end of said winding and said furnace bottom, a switch for selectively connecting said electrode to any desired one of said taps, and an adjustable reactance in circuit with said electrode.

2. The combination with an electric furnace having a plurality of arcing electrodes, of a transformer system having a plurality of secondary windings, each winding being provided with a series of taps, a switch for selectively connecting each electrode with a tap on one of said windings, and means for simultaneously operating said switches so as to connect the electrodes with corresponding taps of each series.

3. The combination with an electric furnace having a plurality of arcing electrodes, and a bottom susceptible of conducting electricity, of a three-phase transformer having star-connected secondary windings, each provided with a series of taps, the neutral point of said windings being connected to said bottom, and means for selectively connecting said electrodes to any desired one of each series of taps, so as to vary the voltage supplied to the electrodes.

4. The combination with an electric furnace having arcing electrodes, of a three-phase transformer having primary windings connected in delta and secondary windings connected in star, both of said windings having a series of taps whereby voltage supplied to the electrodes may be varied.

5. The combination with an electric furnace, of means for supplying alternating current thereto at varying voltages, a reactance in the supply circuit, and means for varying such reactance as the voltage is varied.

6. The combination with an electric furnace, of a transformer for supplying current thereto, said transformer having high and low voltage taps, a reactance in the supply circuit independent of said transformer, means for changing the circuit connections from the high to the low voltage tap, and means for simultaneously reducing the value of said reactance.

7. The combination with an electric furnace having an electrode, of a transformer having taps for supplying current at variable voltages to said electrode, a reactance

in such supply circuit, and means for changing the value of said reactance in accordance with the variation in voltage.

8. The combination with an electric furnace having an electrode, of a transformer having taps, a switch for connecting the electrode to any desired tap, a reactance coil, and means operated by said switch for either connecting it in the circuit between the transformer and the electrode, or cutting it out of such circuit, as desired.

9. The combination with an electric furnace having an electrode, of a transformer having full and fractional voltage taps, a reactance coil, means for selectively connecting the said electrode to either tap, as desired, and means for including said reactance coil in such connection only when the full voltage tap is selected.

10. The combination with an electric furnace having an electrode, of a transformer having high and low voltage taps, a reactance coil, means for connecting said electrode through the reactance coil to the high voltage tap, means for shifting the connection to the low voltage tap and simultaneously cutting the reactance coil out of circuit, and additional means, operable at will, for cutting part or all of said reactance coil out of circuit, when connected with the said high voltage tap.

11. The combination with an electric furnace, of means for supplying relatively high or low voltage thereto, a reactance coil normally included in the circuit when high voltage is being supplied, means for automatically cutting out such coil when low voltage is being supplied, and auxiliary means for cutting out part or all of said coil when high voltage is being supplied, if desired.

12. An electric furnace having a bottom susceptible of conducting electricity, an arcing electrode, a metallic member embedded in said bottom and distributed throughout the same, a metallic shell or casing entirely insulated from said bottom and metallic member, means for connecting one terminal of a source of current to said electrode, and

means insulated from said shell for connecting the other terminal to said metallic member.

13. The combination with an electric furnace having a plurality of arcing electrodes and a bottom susceptible of conducting electricity, of a three-phase transformer having star-connected secondary windings connected with said electrodes, a metallic shell encasing the furnace, and a metallic grid embedded in said furnace bottom, said grid being insulated from the said shell, and connected to the neutral point of said secondary windings.

14. The combination with an electric furnace, of means for supplying alternating current thereto, means for varying the voltage of the current so supplied, and means connected to and actuated simultaneously with the voltage varying means for maintaining the power factor substantially constant at all voltages.

15. The combination with an electric furnace, of a transformer having taps, means for selectively connecting the furnace electrode to any desired tap, and means for maintaining substantially the same power factor with all of the taps.

16. The herein described method of operating an electric furnace having an arcing electrode which consists in supplying current to said electrode at one voltage during a given stage of the operation, and then simultaneously changing both the voltage and the reactance of the supply circuit during another stage of the operation as the metallurgical conditions in the furnace may require.

17. The herein described method of operating an electric furnace having an arcing electrode, which consists in supplying current to said electrode at a relatively high voltage during the melting stage, and reducing such voltage and at the same time reducing the reactance of the supply circuit during the refining stage.

In testimony whereof I affix my signature.

EDWARD A. HANFF.