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ELECTRIC RESISTANCE FURNACE

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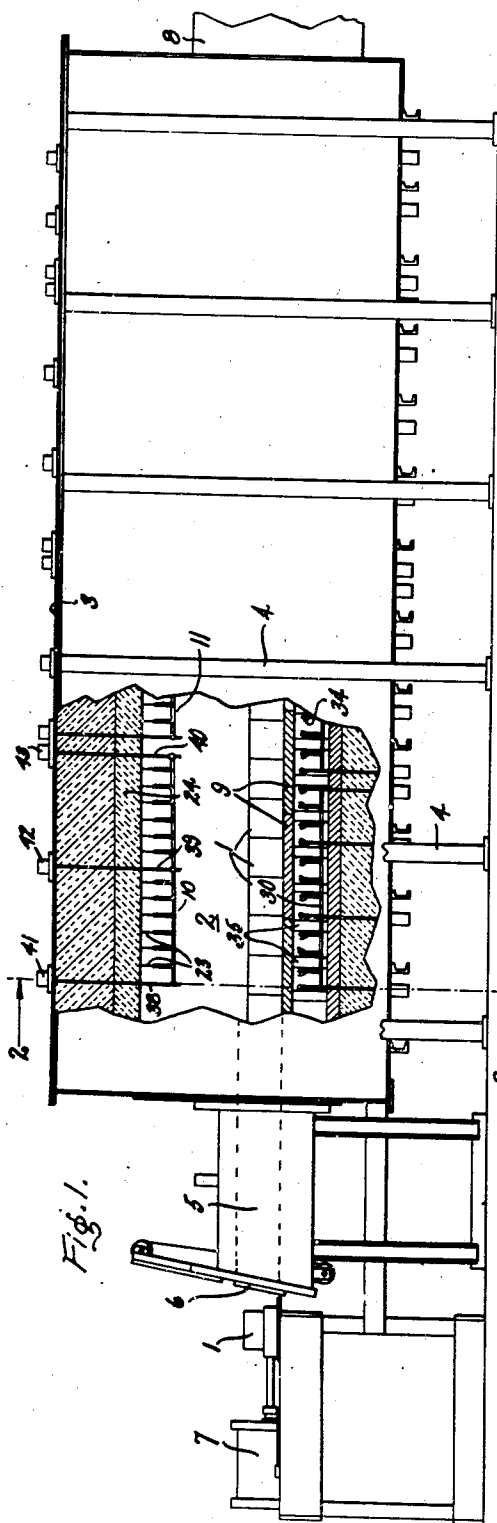


Fig. 1.

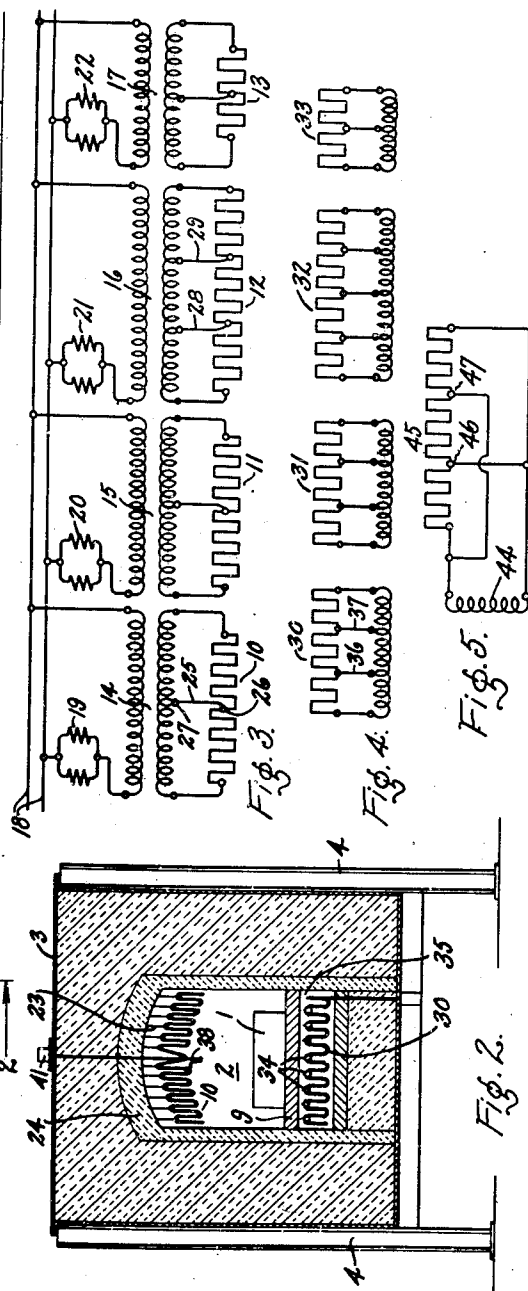


Fig. 3.

Fig. 4.

Fig. 5.

Fig. 2.

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ELECTRIC RESISTANCE FURNACE

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My invention relates to electric furnaces, more particularly to high temperature resistor heated furnaces utilizing a resistor having a high temperature coefficient of resistivity in good heat dissipating relation with the charge and in which a portion only of the resistor is cooled upon the insertion of a cold charge or movement of the charge along the heating chamber, and has for its object simple and reliable electric power supply connections for maintaining a predetermined voltage on each portion of the resistor irrespective of changes in its temperature and resistance whereby the furnace is self-regulating to increase the heat generation in the cooled portion for rapid reheating and to prevent destructive overheating of one or more uncooled portions of the resistor.

In the operation of continuous resistor heated furnaces at high temperatures, i. e., at a temperature of substantially 2100 degrees F. or higher, obtained by means of a resistor made of molybdenum and with the conventional connection of the resistor across a supply source, I have found that the portion of the resistor most remote from the incoming charge deteriorates rapidly from overheating with resulting failure of the resistor even though the remaining portion of the resistor shows no evidence of overheating. As a consequence, the operation of such a furnace is accompanied by frequent failure of the heating resistor or resistors with shut-down of the furnace for repairs.

This failure of the resistor in such high temperature furnaces is caused, I have found, by voltage unbalance, i. e., unequal voltages applied to the various portions, which voltage unbalance is in turn caused by the cooling of a portion only of the resistor by the incoming charge, whereby the resistance of that portion is greatly decreased. As a result, the total resistance of the heater is decreased and the current flow in the resistor increased, whereby an increased voltage is applied to the hot portion and a decreased voltage to the cooled portion. The hot portion thus heats to a still higher temperature at which deterioration occurs. An indication of the magnitude of this effect is given by the effect of temperature on the resistance of molybdenum which, at an operating temperature of 2400 degrees F. may be ten or more times its value at an ambient temperature of 70 degrees F.

In carrying out my invention I provide power supply connections for maintaining predetermined voltages which connections I connect to the resistor in conformity with the decrease in resistance along its length resulting from cooling

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by the incoming charge in such a manner that the portion, or portions, subject to substantial change in resistance are each supplied at all times with a predetermined voltage. This results in an increased current in the portion whose resistance is decreased but this has the desirable effect of rapidly increasing the temperature of that portion. The portion of the resistor whose resistance is not substantially decreased continues to operate at the operating temperature without increase in temperature so that no overheating occurs.

In one form of my invention I supply current to the resistor by means of a transformer having its secondary terminals connected to the terminals of the resistor and provided with one or more intermediate voltage taps which are connected to corresponding voltage points of the resistor.

In accordance with a modified form of my invention I use a low voltage high current transformer secondary winding to which are connected the various portions of the resistor in parallel with each other.

For a more complete understanding of my invention reference should be had to the accompanying drawing, Fig. 1 of which is a side elevation view partly in section of a continuous resistor furnace embodying my invention; Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1 looking in the direction of the arrows; Fig. 3 is a diagram of connections of a plurality of heating resistors mounted on the roof of the heating chamber; Fig. 4 is a diagram of connections for the plurality of resistors mounted at the bottom of the heating chamber; while Fig. 5 shows a modified form of my invention.

Referring to the drawing, I have shown my invention in one form as applied to an elongated intermittent type continuous furnace in which the charge or articles to be heated are placed in suitable rectangular containers or boxes 1, which are introduced at predetermined intervals into the charging end whereby the whole series of boxes are moved through the furnace and the leading one ejected from the furnace. The furnace comprises suitable top, bottom and side walls of heat refractory material as shown in Fig. 1 forming an elongated heating chamber 2, the walls being enclosed in a suitable metal casing 3 and supported on I-beam posts 4. At the left-hand, or charging, end of the furnace is a relatively short preheating chamber 5 closed by a door 6 which may be moved upward to open the furnace and permit a hydraulic pusher device 7 to push a box 1 containing cold articles into the preheating chamber 5. When charge box 1 is pushed into

the chamber the whole series of boxes extending through the heating chamber are pushed along, the foremost one being pushed out at the right hand discharge end of the furnace. On the right-hand end is a cooling chamber 8, not shown in detail. The enclosing metal casing for the heating chamber and the preheating and cooling chambers is gas-tight and suitable reducing gas, such as hydrogen, is maintained in these chambers to prevent oxidation of the charge and heating resistance.

The furnace is heated by means of a plurality of heating resistors made of molybdenum suspended from the roof of the heating chamber and mounted below the heat refractory hearth plates 9 on which the boxes 1 rest. A series of four heating resistors 10, 11, 12 and 13 are hung from the roof, these resistors being disposed in the order mentioned along the length of the heating chamber in closely spaced relation. These resistors are supplied with power from separate transformers 14, 15, 16 and 17 connected to a suitable alternating source of supply 18. They are separately controlled independently of each other by means of saturable core reactors 19, 20, 21 and 22 provided with direct current saturating coils, not shown, and control mechanism such as described and claimed in United States Patent No. 2,266,569, dated December 16, 1941 to Elbert D. Schneider and August R. Ryan.

As shown in Figs. 1 and 2, the resistor 10 comprises a plurality of series connected spaced parallel lengths extending back and forth crosswise of the heating chamber, each length consisting of a plurality of vertically extending loops which are mounted on heat refractory metal pin supports 23, the upper ends of which are secured in the roof wall 24 of the heating chamber. The remaining roof heating resistors 11, 12 and 13 are similar in construction to the resistor 10 but may have different resistances and rates of heat generation in conformity with the heat requirements along the length of the heating chamber.

In accordance with my invention I provide one or more intermediate electric connections between each heating resistor and the transformer secondary supplying power to it whereby predetermined voltages are supplied to the various portions of each resistor. The resistor 10, for example, is provided with an electric conductor 25 extending from a midpoint 26 on the resistor to a midpoint 27 on the secondary winding of the transformer 14 to the relatively high voltage terminals of which winding the two end terminals of the resistor 10 are connected. This assures that, regardless of the resistance at any particular time of the two half portions of the resistor 10 on opposite sides of the point 26, predetermined voltages are applied to these portions.

I have found that each time a cold charge box is introduced into the furnace, the relatively cold box and charge moved underneath the lefthand portion of the resistor 10 very substantially cools that portion of the resistor whereby its resistance is reduced substantially. In a typical furnace I found that the resistance of the lefthand resistor portion nearer the cold charge may be reduced as much as fifty per cent by reason of the cooling of that portion by the cold charge whereby the total resistance of the resistor would be reduced twenty-five percent. Assuming that the intermediate connection 25 is not provided, the current through the entire resistor would in such case increase thirty-three and one-third percent with 33.4 per cent of the total voltage across the left-

hand half and 66.6 per cent across the righthand half of the resistor. This increased current in the hot righthand portion of the resistor would result in an increased power generation in that portion of 77 per cent whereby this portion would be heated to a still higher temperature, at which rapid deterioration takes place. On the other hand, the heat generated in the lefthand cooled portion would be reduced somewhat because of the great reduction in its resistance.

By means of the intermediate connection 25, however, I maintain a predetermined voltage across the two portions of the resistor even though the resistance of the lefthand portion is reduced fifty per cent as assumed above. As a result, the current in the lefthand portion whose resistance was reduced fifty per cent would be doubled and its power input doubled. However, this does not result in overheating of the resistor because it is at a reduced temperature, but has the desirable effect of bringing the resistor portion more quickly up to its normal operating temperature with increase in resistance and reduction of power input to the normal value. Under the conditions assumed, i. e., with the middle or intermediate connection on the resistor, the righthand portion operates substantially as before the introduction of the cold charge.

It will be understood that the conditions assumed above are somewhat arbitrary in view of the fact that actually the cooling of the resistor 10 would be graduated along its length with the greatest cooling obviously at the end adjacent the cold charge and with comparatively little cooling at the opposite end. The length of the resistor, i. e. lengthwise region of the heating chamber over which the resistor extends, is therefore selected in conformity with the corresponding dimension of the cold charge or box 1 in such manner that the lefthand portion of the resistor extends over the region of pronounced cooling effect from the cold charge. It will be observed, for example, that the resistor 10 extends over a lengthwise region of the heating chamber substantially coextensive with the six charge boxes 1 just below it.

The resistors 11 and 12 are likewise each cooled substantially at their lefthand ends as the charge boxes are advanced in the furnace, and the righthand end of the resistor 13 may be cooled substantially by its proximity with the end wall of the furnace. Consequently, I preferably provide one or more intermediate electric connections on these resistors. As shown in Fig. 3, the resistors 11 and 13 have one central connection, while the resistor 12 is provided with two intermediate connections with its secondary winding 28 and 29. These connections 28 and 29 are preferably made at equally spaced points along the resistor so as to divide the resistor into three sections having equal resistances when they are at the same temperature. The connections 28 and 29 lead to points on the secondary winding, dividing it into three equal voltages.

It will be understood that the resistor intermediate connections are made at points suitably dividing the resistor into sections for the application of predetermined corresponding voltages from the transformer. In other words, the sections may have different resistances in which case proportionate transformer voltages are applied, these voltages being the voltages applied to the resistor sections under uniform or other predetermined temperature conditions in the resistor.

A series of heating resistances are also pro-

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vided in the bottom of the heating chamber below the hearth plates 9, four such bottom heating resistances 30, 31, 32 and 33 (Fig. 4) being arranged lengthwise of the furnace from left to right in the order mentioned, and each being connected to a separate transformer secondary as shown. The resistor 30 and, likewise, resistors 31, 32 and 33, are similar in construction to the resistor 10 in that they are provided with a plurality of lengths extending back and forth across the heating chamber, each length consisting of a plurality of vertical loops. Instead of being supported on pins, however, the loops of these resistors are supported on heat refractory hooks or pegs 34 projecting from opposite sides of heat refractory walls 35 on which the hearth plates 9 are supported. The bottom resistors, however, are in more intimate thermal relation with the charge boxes than the top resistors and, consequently, are cooled to a greater extent upon the advance of each charge box. Consequently, as shown the resistor 30 is shorter than the resistor 10, extending over somewhat more than five charge boxes, and it is provided with two equally spaced intermediate power supply connections 36 and 37. Likewise, the resistor 31 is provided with two intermediate connections, while the resistor 32 is provided with three intermediate connections and the shorter end resistor 33 provided with only one.

In a typical furnace embodying my invention the heating resistor was made from a molybdenum round wire one-fourth inch in diameter. Terminal conductors are provided for each resistor, which conductors extend through the wall of the furnace and through packing boxes to seal the furnace, the terminals for the roof heating resistors extending upward through the roof of the furnace, while the terminals for the bottom heating resistors extend downward through the bottom wall of the furnace. The resistor 10 as shown has three terminal conductors 38, 39 and 40 which extend upward through the roof wall of the furnace and out through the packing boxes 41, 42 and 43. It will be understood that the terminals for the other heating resistors extend out through adjacent packing boxes which are indicated on Fig. 1 of the drawing.

My invention has application generally in continuous type furnaces including those utilizing a conveyor for moving a series of charges through the heating chamber which may be circular in form. It is also useful in continuous furnaces in which a series of charges on a conveyor are moved continuously through the heating chamber or a length of material such as strip steel is moved continuously through the heating chamber. It will be understood that when the charges are thus passed continuously through the heating chamber a portion of the heating resistor is cooled continuously and, therefore, operates at some lower temperature with increased power input resulting from its decreased resistance. Moreover, the cooling of a portion of the resistor may be caused by its location transversely of the heating chamber. For example, top and bottom heating resistors may be connected in series with each other with an intermediate tap connection to maintain uniform voltages by reason of the greater cooling of one resistor, such as the bottom resistor, by the charge.

My invention is useful generally in furnaces using a heating resistor having a high temperature coefficient of resistivity and in which a portion of the resistor, which would otherwise operate at

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a uniform temperature, is cooled by the dissipation of heat to the charge or to the furnace wall irrespective of whether the furnace is of a continuous type. For example, in furnaces for forging or hardening purposes, such as disclosed in U. S. Patent No. 1,696,728 to Otis et al., dated December 25, 1928, wherein a plurality of openings are provided through each of which the charge is inserted and removed at different times, the insertion of a cold charge through one opening may substantially cool the adjacent resistor portion so as to cause an unbalanced voltage condition.

Moreover, in furnaces of the type in which the entire charge for the furnace is inserted at one time, the charge may have a non-uniform shape and size so that the portion of the charge adjacent one portion of the heating resistor has much greater mass than the portion of the charge adjacent another portion of the resistor with the result that the first resistor portion is cooled very substantially with resulting voltage unbalance.

In Fig. 5 of the drawing I have shown a modified form of my invention utilizing a single transformer secondary winding 44 which is connected to supply current to the portions of the resistor 45, the portions being connected in parallel relation with each other. As shown, the resistor is provided with two intermediate tap connections 46 and 47 whereby the resistor is divided into three portions preferably of equal resistance, although the resistances of the portions may be unequal. As shown, the upper terminal of the secondary winding 44 is connected to the left hand terminal of the resistor 45 and to the intermediate point 47, while the lower terminal of the secondary winding is connected to the right hand terminal of the resistor and to the intermediate point 46. This arrangement requires a transformer secondary winding of lower voltage and higher current carrying capacity than the arrangement of Figs. 1 to 4 in which a higher voltage secondary winding is provided with one or more intermediate taps.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A self-regulating high temperature electric furnace comprising walls forming a heating chamber, a heating resistor in said chamber provided with end terminals and having a length substantially greater than the length of a charge of material to be heated, supporting means mounting said resistor in said chamber in good heat dissipating relation with the charge in said chamber, means for introducing a relatively cold charge into said chamber adjacent an end portion of said resistor between one end terminal of said resistor and an intermediate point of said resistor whereby said end portion is cooled substantially by the cold charge, said resistor being made of a material having a high positive temperature coefficient of resistivity so that when said end resistor portion is cooled by a cold charge its resistance decreases substantially, a transformer provided with relatively high voltage terminal connections, electric connections connecting said terminals of said transformer to said end terminals of said resistor for supplying current to said resistor whereby a predetermined low voltage is applied to said end portion, and an electric connection between said intermediate point of said resistor and an intermediate point of said transformer for maintaining said predetermined low voltage on said end portion of said resistor

thereby to supply an increased current to said end portion when its resistance is decreased by cooling by a cold charge and effect an increased generation of heat in said end portion without substantial increase in the current in the remaining portion of said resistor.

2. A self-regulating high temperature electric furnace comprising walls forming a heating chamber, means for conveying charges of material to be heated through said chamber, a heating resistor in said chamber provided with end terminals and extending along said chamber in the direction of movement of the charges and having a length in said direction substantially greater than the length of a single charge, supporting means mounting said resistor in said chamber in good heat dissipating relation with the charges in said chamber, means for introducing a relatively cold charge into one end of said chamber adjacent an end portion of said resistor between one end terminal of said resistor and an intermediate point of said resistor whereby said end portion is cooled substantially by the cold charge, said resistor being made of a metal having a high positive temperature coefficient of resistivity so that when said end resistor portion is cooled by a cold charge its resistance decreases substantially, a transformer provided with relatively high voltage terminal connections, electric connections connecting said terminals of said transformer to said end terminals of said resistor for supplying current to said resistor whereby a predetermined low voltage is applied to said end portion when the temperature of said resistor is substantially uniform throughout its length, an

intermediate tap connection on said transformer having a voltage substantially the same as the voltage of said intermediate point of said resistor under predetermined temperature conditions in said resistor, an electric connection between said intermediate point of said resistor and said tap connection for maintaining said predetermined low voltage on said end portion of said resistor thereby to supply an increased current to said end portion when its resistance is decreased by cooling by a cold charge and effect an increased generation of heat in said end portion without substantial increase in the current in the remaining portion of said resistor.

ROBERT D. VAN NORDSTRAND.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,147,165	Hampton	July 20, 1915
1,162,178	Lohr et al.	Nov. 30, 1915
1,252,635	Ward	Jan. 8, 1918
1,515,511	Milner	Nov. 11, 1924
1,638,857	Keene	Aug. 16, 1927
1,732,916	Summey	Oct. 22, 1929
2,404,059	Hall	July 16, 1946

OTHER REFERENCES

Marks: Mechanical Engineer's Handbook (4th edition, McGraw-Hill Book Company), page 2042. Figure 86.