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REFRACTORY FOR INDUCTION FURNACES

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The invention relates to refractories and with regard to its more specific features to refractories for use in electric furnaces for melting cuprous metals.

One object of the invention is to provide an improved refractory lining for a Wyatt induction furnace. Another object of the invention is to provide a long life refractory lining for an induction furnace. Another object of the invention is to provide an improved refractory cement. Another object of the invention is to prevent the penetration of copper into a furnace lining in an induction type of furnace.

Another object of the invention is to provide an improved magnesia refractory. Another object of the invention is to provide an improved aluminum oxide refractory. Another object of the invention is to provide an improved method of making a preformed lining.

Another object of the invention is to provide an induction furnace capable of satisfactorily melting pure copper or high copper content alloys. Another object of the invention is to provide an induction furnace lining capable of melting pure copper or high copper content alloys. Another object of the invention is to provide a more efficient Wyatt type of induction furnace. Another object of the invention is to maintain, in an induction furnace, the pinch effect at a more nearly constant figure whereby to maintain desired circulation of the molten metal. Another object of the invention is to avoid undesired decrease of the secondary resistance in a Wyatt type-induction electric furnace.

Another object of the invention is to provide a refractory lining which is reducing in reaction. Another object of the invention is to provide a refractory lining of carbonaceous content. Another object of the invention is to provide a refractory lining containing a reducing material safeguarded against premature burning out. Another object of the invention is to impregnate a preformed lining or a fired refractory with a reducing material. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts, and in the several steps and relation and order of each of said steps to one or more of the others thereof, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

As conducive to a clear understanding of the present invention reference is hereby made to Wyatt Patent No. 1,201,761, which discloses an electric furnace for the melting of metals and in which the heat is generated in the molten metal directly by inducing therein an electric current, the furnace having a primary coil disposed around a channel for the molten metal whereby the channel, which forms a closed circuit through the crucible part, constitutes the secondary of the electric system. Such electric furnaces constructed substantially according to the Wyatt patent of the above number, and with some variations and improvements, have gone into extensive commercial use and are known as Wyatt-induction furnaces. In such a furnace circulation of the molten material is maintained by the so-called "pinch" and motor effects, which are known to those skilled in this art.

In such a furnace the channel for the secondary is formed in a refractory material, and in the past a magnesia refractory has been used. In certain cases and for certain metals an alumina refractory has been used.

When melting high copper content cuprous alloys or pure cooper difficulty has been experienced by reason of an ever increasing deposit of copper in the refractory lining. Such a deposit of copper has the effect of increasing the cross section of the secondary circuit, thus changing its electrical properties detrimentally. This difficulty was most pronounced when attempts were made to melt a substantially pure copper in this type of furnace. Although pure copper has been melted in a furnace of this type with linings prior to my invention, the life of such a furnace when used to melt pure copper or very high cuprous alloys has been relatively short, and to melt copper at all in such a furnace certain precautions and costly procedure have been heretofore used which may be dispensed with in the practice of my invention.

Linings for Wyatt furnaces have been generally of three types; in the greater number of cases the primary coils and core and the outside lining, which might be made of metal as indicated in the patent referred to but in many other cases included an ordinary insulating brick as well as the metal outer casing, were first formed and then the inner refractory lining was formed in situ by the following procedure: Constructing a wooden core, in the desired channel shape, it was held in place around the primary and in the furnace in any suitable manner. A refractory cement was then tamped in place first outside the wooden core and ultimately inside of it to form the refractory lining of the furnace. The wooden

core was then burned out and the refractory cement heated, as by a blow torch or otherwise, to a heat sufficient to dry it out and heat the channel to a temperature close to that of the melting point of the metal to be melted in the furnace. The furnace was then ready to be run, as by the pouring of liquid metal into it and the energization of the primary coil the fusing operation would proceed and in the use of the furnace the refractory lining would gradually become fired.

A second method has been to form and tamp entirely outside of the furnace a refractory mixture with suitable organic temporary binder so that the resulting shape could be handled and then insert such a lining in the furnace and proceed as heretofore stated, the final firing of the lining being due to the use of the furnace as in the first method of procedure.

The third heretofore used method of procedure has been to form and fire entirely outside of the furnace the lining. In both cases where the lining is preformed outside of the furnace, whether it is prefired or not, it is only the lining for the channel that is preformed, the upper or crucible part being a refractory cement tamped into place.

The present invention may be embodied in a cement to be tamped into place, or it may be embodied in a preformed lining, either prefired or not, but the method of procedure will be different in cases of a preformed prefired lining as will hereinafter appear.

I provide magnesia grain. I prefer to use a mixture of various mesh sizes in order to produce a dense refractory. For example I may use one-third of grain of the mesh size from 14–24, one-third of grain of the mesh size from 30–90, and one-third of grain of the mesh size 100 and finer.

Of such a mixture of magnesia grain I take for example 90 parts. To this I add for example 4 parts of bentonite. Bentonite is considered to be the result of devitrification and chemical alteration of the glassy particles of volcanic ash or tuft. It is an aluminum silicate of high adsorptive, distensive and colloidal properties which materially promotes workability of a mixture. It is its property of adsorbing a large amount of water and becoming a jelly-like mass which promotes workability. In this embodiment of the invention the bentonite also constitutes the major portion of the bond. So far as many features of the invention are concerned I might use any other ceramic or clay of high refractory properties for a bond.

I further add in the neighborhood of one part of a suitable flux. Magnesia is highly refractory, and in order to bond it into an integral mass a flux is desirable. For my flux I prefer to use boric acid. I may, however, use other suitable fluxes such as sodium silicate.

The mixture so far specified constitutes 95 parts. I add a suitable reducing agent to the extent of the remaining 5 parts of the 100%. This reducing agent is one which is such with respect to molten copper. Many such reducing agents might be used but I prefer to use a carbonaceous substance. Any carbonaceous reducing agent containing a high carbon content is satisfactory, for example lamp black, powdered coke, powdered coal either anthracite or bituminous, and graphite. In the preferred form of the invention I use flake graphite because it is a little less reactive than some other forms of carbon and I desire that the reaction shall not be too violent. However, I may use substances other than those including primarily any allotropic form of the element carbon, for example I may use silicon carbide, boron carbide or other carbides.

When using graphite I prefer to use 5 parts in 100 as stated, but a greater or lesser amount may be used with satisfactory results. For example, some of the advantages of the invention may be obtained using as low as 1% of graphite and I may use as much as 10% thereof.

The bond, which might be bentonite or some other clay, might be greatly varied in quantity, for example anywhere between 1% and 10%, and how much flux is used or whether any is used at all is a matter of selection. I wish it to be understood that my invention is not limited to the amount of bond or material used to promote workability.

The invention is applicable also to aluminum oxide refractory materials, but magnesia is preferred because it does not react with copper oxide. When using aluminum oxide I may use the same mesh size grain and the same proportions of other substances mentioned.

Having thus provided a refractory mixture, I add thereto a suitable temporary binder. While I may use any temporary binder whatsoever, for example an organic binder such as dextrine, Goulac or molasses, I prefer to use the inorganic binder sodium silicate because of its protective qualities on the mixture during the burning out operation and subsequent use.

The refractory mixture and the temporary binder may be mixed together in any suitable manner, for example on the floor with a shovel, or in a mixing machine. When using sodium silicate I use a commercial solution to the extent of about 1% or 2% thereof as sodium silicate is a flux and I do not desire too high a fluxing action. The sodium silicate may constitute both the flux and the temporary binder, in which case the boric acid or the like may be omitted.

When placing my novel refractory in position in the furnace by the tamping method, I proceed according to prior practice, the tamping being done as usual, for example with an air hammer or the like. Then the wooden core, if such were used, is burned out in the usual manner, and this burning out serves to dry the refractory material. Any method of burning out, either by means of a blow torch or by means of secondary wiring imbedded in the wood, may be used.

Prior to heating the newly formed lining for the introduction of the molten metal I prefer to line the channel and also the crucible with a suitable glazing agent such as sodium silicate and silica. Such a glaze might be 75% silica, the remainder sodium silicate solution. This glaze serves to protect the graphite or other reducing substance in the refractory mixture from burning out during the heating stage just prior to the introduction of the molten copper or other alloy. If sodium silicate is used as a temporary binder this also has some effect in protecting the reducing agent from burning out but I prefer also to apply the glaze for further protection.

The glazing mixture may be simply applied in any convenient manner, as by spraying or the like. In the case of sodium silicate, penetration of air is prevented even before any firing thereof. In the cases of preforming the refractory, whether prefired or not, I also apply the glazing mixture, only in such cases I prefer to apply it outside as well as inside.

For the formation of a preformed but "green" lining I make up the refractory mixture and temporary binder as aforesaid. For the formation of a preformed and prefired refractory lining I proceed differently. I make up the mixture including the temporary binder without the reducing agent. I then fire the mixture in a kiln in the usual manner. I then place the fired article in a bath of any suitable liquid containing, in suspension or otherwise, the reducing material. For example, I may use water having graphite in suspension. For example, I may use what is known under the trade name as "Aquadag", or I might use what is known as "Oildag". On the other hand, I may use any organic liquid, for example artificial resinous varnish ("Bakelite"), or molasses or the like. I then introduce the article in the bath into a vacuum box and remove the air, for example to a vacuum of around 28", that is to say a positive air pressure of around 2" of mercury. Having exhausted all the air, the entrained air in the article has bubbled out through the liquid, and I then open up the box. As the air pressure increases the liquid containing the reducing agent is driven into the pores of the refractory article. In the case of organic substances such as molasses, artificial resin etc. I then proceed to carbonize the reducing agent as by heating to a suitable temperature.

In operation the reducing agent effectively prolongs the life of the furnace and to a substantial extent prevents the growth of the secondary circuit, either by deposit of copper or by entrance of molten copper into the pores of the refractory. I believe that the reason why there was copper penetration in prior refractories was partly due to the hydrostatic head of the molten metal and partly to the wetting of the refractory substance by copper oxide or oxides in the liquid state. Copper is a readily oxidizable substance, particularly in the molten state, and molten coppers have copper oxide in solution. Whereas copper itself does not wet a refractory, so far as I am aware, the oxides do, or at least the copper oxide found in molten copper appears to wet the refractory. In this manner copper was carried into the refractory very rapidly and increased the effective cross sectional area of the secondary either as a molten copper or, in case of temperature changes and excessive penetration, as solid copper. In any case in which the liquid is frozen the copper comes out as metallic copper because copper and copper oxide do not coexist in solid solution. In many cases the penetration of the copper with the copper oxide was extreme and extended even to the outside of the refractory lining or even therebeyond.

By the use of a reducing agent according to the invention, however, there is no substantial penetration by the copper in a liquid state or otherwise. I believe the beneficial result to be due to the reduction of whatever copper oxide comes in contact with the refractory thus preventing the penetration as copper and also highly cuprous alloys appear not to wet a refractory substance of the nature herein described.

It will thus be seen that there has been provided by this invention a method, a composition of matter, an article of manufacture, and an apparatus in which the various objects herein above set forth together with many thoroughly practical advantages are successfully achieved. As various possible embodiments might be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. The method of making a furnace lining for cuprous induction furnaces which comprises mixing refractory oxide grain with a bond and a temporary binder, pressing the mixture into the shape desired, firing to vitrify the bond, placing the fired lining in a receptacle, filling the receptacle above the level of the lining with a liquid including a reducing agent which is such as to molten copper, placing the receptacle in a vacuum box, reducing the pressure, and removing the lining from the vacuum box thereafter.

2. A composition for use in the manufacture of linings for Wyatt cuprous induction furnaces which comprises in the neighborhood of 90 parts of granular basic refractory oxide a substantial part of which is in grain sizes between 14 mesh size and 100 mesh size, between 1% and 10% of a bond comprising plastic clay having temporary binder properties, and from 2% to 10% of a reducing agent of the group consisting of carbon, graphite, silicon carbide, and boron carbide, thoroughly mixed together, thereby to form a lining which shall resist penetration of metals and metal oxides into the lining.

3. A Wyatt type of induction furnace having a refractory lining of refractory oxide grain and bond and comprising in the neighborhood of 90 parts of granular basic refractory oxide with between 1% and 10% of a bond comprising plastic clay having temporary binder properties, and from 2% to 10% of a reducing agent of the group consisting of carbon, graphite, silicon carbide, and boron carbide, thereby constituting a lining which resists penetration of metals and metal oxides thereinto.

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