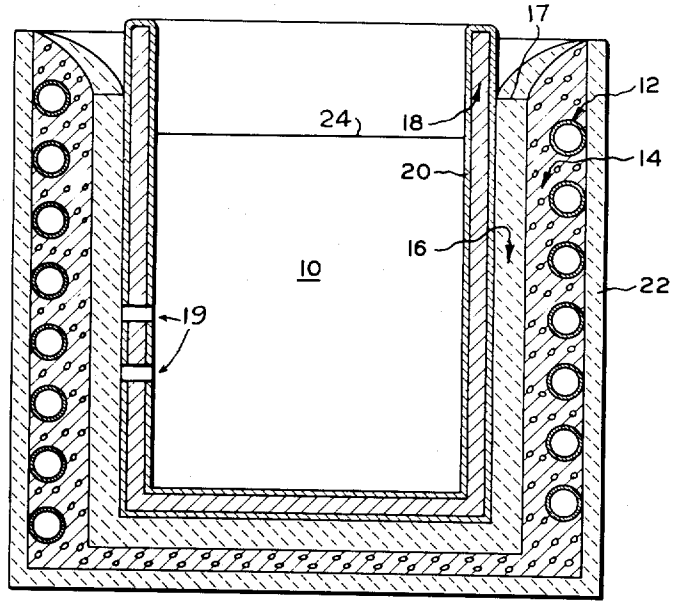
July 31, 1956 P. J. CLOUGH ET AL 2,757,219

PRODUCTION OF METALS

Filed Oct. 14, 1954



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United States Patent Office

2,757,219

Patented July 31, 1956

2,757,219

PRODUCTION OF METALS

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Application October 14, 1954, Serial No. 462,204

7 Claims. (Cl. 13—35)

The present invention relates to melting units used in induction type vacuum furnaces and more particularly to the rammed liner type crucible used for this type of melting unit. The liner is generally of a refractory material such as magnesia and acts to contain the molten metal charge within the crucible and at the same time protect the inducing coils from being attacked by the molten metal.

In order that economy be best served, it is necessary that a simple method of construction be utilized which will produce a liner with added life expectancy and utility. This requires that the constituents, such as magnesia, which go into the liner, be properly bonded together so as to prevent any penetration by the reactants.

Accordingly, it is the principal object of the present invention to provide an improved rammed liner in melting units used in an induction type vacuum furnace.

Still another object is to improve the purity of metals which are melted and cast in an induction type furnace.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the apparatus possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein the single figure is an exaggerated diagrammatic, sectional view of a crucible readied for sintering.

In general, the present invention relates to crucibles used in induction type vacuum furnaces for the melting and casting of high-purity ingots and castings. These crucibles generally comprise a refractory type material to be surrounded by induction coils and are constructed by ramming or packing the refractory material to the desired shape within the induction coil and then sintering the refractory material to form a relatively permanent liner. To insure that the refractory liner be of proper shape, thickness and consistency, a mild steel shell of the desired shape is provided, and the refractory material is rammed in between the metal shell and the induction coils. The refractory material will contain a certain amount of dampness which will, when vaporized and expelled during the sintering, react with the mild steel shell to form iron oxides. These iron oxides will become included in the refractory lining and impair its resistance to penetration by molten metals. Accordingly, to prevent this adverse effect, the present invention proposes that a mild steel shell of the desired shape and size be first thinly coated with a mixture comprising aluminum before it is inserted within the induction coils. In one preferred embodiment, the coated mild steel liner is perforated to better facilitate expelling of the vaporized dampness. The aluminum coating prevents the mild steel shell from subsequently

oxidizing and adversely affecting the rammed refractory liner.

Referring now more particularly to Fig. 1 wherein like numbers refer to like elements, there is shown one preferred form of the invention wherein there is shown a melting unit **10**, the outside of which is a dielectric insulator **22** and which is provided with an induction coil **12**. To the inside of the coil is plastered a lining **14** of cement. The cement lining **14** is then air dried. The drying may be expedited by exposing the lining **14** to heat as, for example, by using a heat lamp. Next refractory material is added in a quantity sufficient to form the bottom of the refractory liner **16**. In the preferred embodiment, the refractory material of liner **16** comprises magnesium oxide, but any material or mixture of materials may be used which will withstand penetration by the molten metal and which will itself have little or no adverse effects upon the material to be melted within the crucible. A mild steel shell **18** is then inserted within the cement lining **14**. The mild steel shell is supported on the bottom by refractory liner **16**, this much of the refractory material having already been added, and serves to shape the interior of the finished crucible by supporting the refractory liner **16** which is rammed around the steel shell. The metal shell **18** may also be perforated as indicated at **19**, to facilitate the removal of vapors during sintering of the rammed lining. The entire steel shell **18** is coated with a thin coating of aluminum **20**. The coating **20** may, however, be restricted to the surface of steel shell **18** adjacent the rammed liner. The thickness of the coating **20** is not critical as long as there has been complete surface coverage. In the preferred embodiment, the coating **20** comprises a major proportion of aluminum and the remainder silicon, but there is room for variation and other metals which will give similar coatings under operating conditions may be used. It is further preferred that the coating **20** be sprayed onto the steel shell **18** in molten alloy form, using a molten metal spray gun.

In the preferred method of assembling the melting unit, the aluminum-coated steel shell **18** is centered within the cement lining **14** to insure that the refractory lining **16** will be of proper and uniform thickness throughout. The metal shell **18** is then shored up from its inner side to prevent it from collapsing or deforming during the ramming of the refractory material. Any convenient type of shoring may be used, although it has been found most convenient to use a wooden insert which is fitted to the interior of the metal shell **18**. The refractory material which is to form liner **16** is then rammed into position between the metal shell **18** and the cement lining **14**. In the preferred embodiment, the refractory material comprises magnesium oxide and is rammed in to form the sides of the liner **16** up to a point **17** well above where the melt line **24** will occur during the actual melting operations.

The remainder of the sides of liner **16** up to the top comprises a mixture of magnesium oxide and sodium silicate, which can be air dried. Any refractory material which will facilitate high temperature melting and casting may be used for the refractory liner **16**. It is preferred, too, that the refractory material be rammed into position under sufficient pressure to insure a liner **16** of uniform thickness throughout, the particles of which are intimately integrated to offer the greatest resistance to penetration by the molten charge as well as resistance to flaking and dusting off due to any erosive action by the charge. After the ramming of the refractory material has been completed, any forms used to shore up the metal shell **18** should be removed and the liner **16** air dried and then sintered.

Air drying and sintering are combined in one preferred method. A charge of metal reactants is placed in the

melting unit 10 (within the steel liner 18) and heated in an open vacuum furnace to red heat, on the order of about 1200° F., or to where the charge shows the first signs of melting. Heating at this temperature is continued until all the dampness contained within the refractory material has been expelled. It has been found that this operation requires on the order of about four hours. The melting unit 10 is then subjected to vacuum and a regular melting and casting run is performed, with the aluminum-coated steel shell 18 being melted and becoming part of the charge. As a result of this procedure, the rammed liner crucible 16 is properly dried and sintered.

Since certain changes may be made in the above process and apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description, or shown in the accompanying drawing, shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An improvement in the process of ramming refractory liners in melting units used in vacuum induction furnaces, the improvement comprising ramming refractory material behind a temporary steel shell, said shell being coated with a metal alloy comprising aluminum, and drying and sintering said refractory material.

2. An improvement in the process for ramming refractory liners in melting units used in vacuum induction furnaces, the improvement comprising ramming refractory material behind a mild steel shell, said shell being coated with a substantially continuous film of an aluminum and silicon alloy, and drying and sintering said refractory material.

3. An improvement in the process for ramming refractory liners in melting units used in vacuum induction furnaces which comprises packing a cement lining over the induction coils, drying said cement lining, inserting a metal shell within said cement lining, said metal shell comprising the metal to be processed in said crucible and being coated on its outer side with an aluminum-silicon mixture, said aluminum comprising the major proportion of said mixture, ramming between said cement lining and the metal shell a lining of refractory material, and drying and sintering said refractory material.

4. An improvement in the process for ramming refractory liners in melting units used in induction vacuum furnaces which comprises providing a cement lining to cover the inside of the induction coils, air drying said cement lining, inserting a mild steel shell within said cement lining, said mild steel shell being thinly coated with aluminum and silicon, ramming between the cement lining and the mild steel shell a liner of refractory material, said refractory material comprising magnesium oxide below a point approximately a melt line and magnesium oxide plus sodium silicate above said melt line, and drying and sintering the refractory material.

5. An improvement in the process for ramming refractory liners in melting units used in induction vacuum furnaces which comprises providing a cement lining on the inner side of induction coils, air drying said cement lining, packing the bottom of the crucible with refractory material, inserting within said cement lining and on top of said bottom layer of refractory material a mild steel shell, said shell being coated with a finely divided mixture of aluminum and silicon and comprising a major part of aluminum, ramming refractory material between the cement lining and the mild steel shell, and drying and sintering said refractory material to form said rammed refractory liner.

6. An improvement in the process for ramming refractory liners used in induction vacuum furnaces which comprises packing a cement lining over the induction coils, drying said cement lining, inserting within said cement lining and on top of said bottom layer of refractory material a mild steel shell, said shell being coated with a continuous coating of aluminum and silicon and comprising a major portion by weight of aluminum, ramming refractory material between the cement lining and the mild steel shell to a height above a contemplated melt line, said refractory material comprising magnesium oxide, ramming the remaining space to the top of the crucible between said cement lining and said mild steel shell with an air-drying refractory material comprising magnesium oxide and sodium silicate, partially drying said refractory material in air, and then sintering said refractory material under vacuum at a temperature sufficiently high to melt the mild steel shell.

7. A process according to claim 6 wherein the coated mild steel shell is perforated.

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