

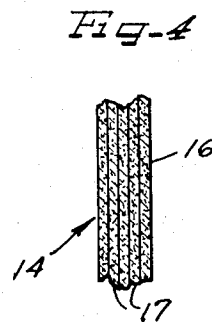
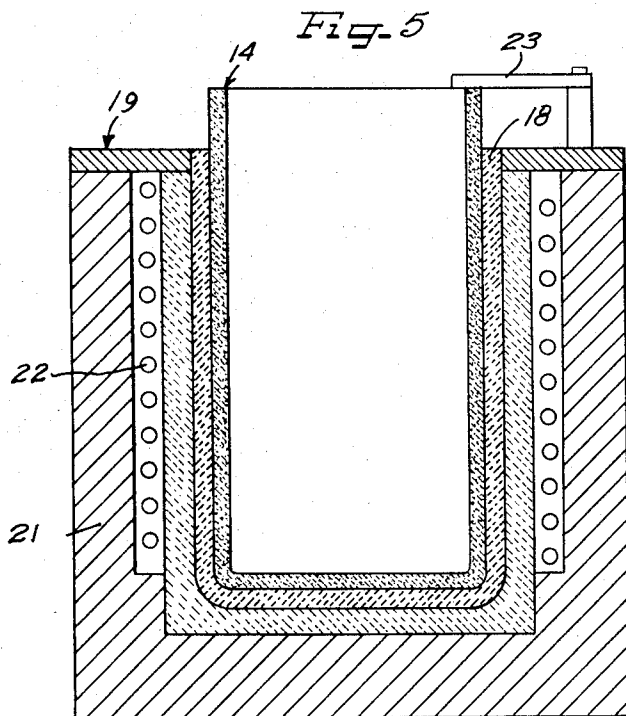
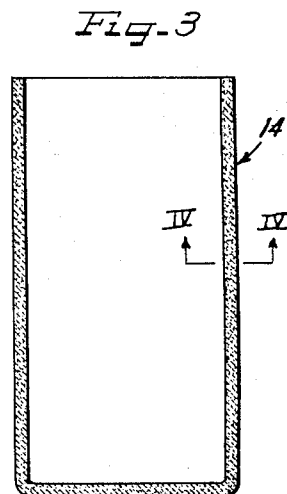
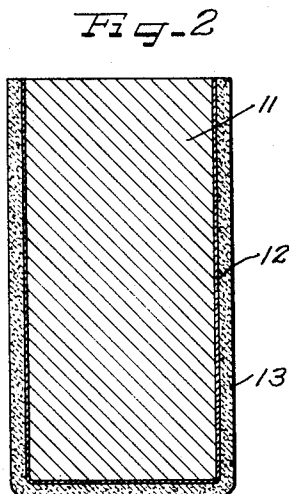
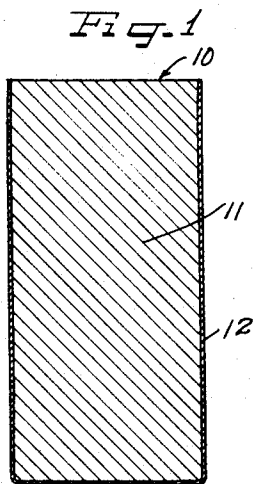
Sept. 10, 1968

B. O. DUNLEVY ET AL

3,401,227

LINER FOR CRUCIBLES

Filed Feb. 9, 1966



INVENTOR.
Barry O. Dunlevy
Leslie E. Harper

BY *Hill, Sherman, Merri, Chas. & Simpson*

ATTORNEYS

1

3,401,227

LINER FOR CRUCIBLES

Barry O. Dunlevy, Minerva, and Leslie E. Harper, Jr.,
North Canton, Ohio, assignors to TRW Inc., Cleveland,
Ohio, a corporation of Ohio

Filed Feb. 9, 1966, Ser. No. 526,290

7 Claims. (Cl. 13—35)

ABSTRACT OF THE DISCLOSURE

A readily insertable and removable liner for an induction-type melting furnace comprising a laminar, self-sustaining ceramic shell composed of layers of finely divided refractory particles bonded together with a binder, the inner surface of the shell being substantially smooth and non-wettable by molten metal, the shell being produced by the well known techniques of shell mold making.

The present invention relates to improvements in the art of induction melting of metals, particularly the melting of iron, nickel, and cobalt based alloys having melting temperatures on the order of 3000° F.

Conventional crucibles used in the induction melting of alloys frequently are composed of alumina or the like. This type of refractory has been found to cause inclusions in the product, presumably because of the molten metal would wet the surface of the alumina, resulting in the spalling or eroding of the crucible material, and necessitating scrapping of the resulting castings.

Some attempts have been made to provide replaceable liners for crucibles used in induction melting furnaces, but with limited success. In some cases, such liners had insufficient strength to resist the pressure of the molten metal, and such liners invariably were quite expensive. The present invention provides an improved liner for a crucible which overcomes these disadvantages. The liner of the present invention is sufficiently strong when properly inserted into the crucible to withstand the pressure of molten metal. The liner is sufficiently inexpensive so that it can be disposed of after a single use. Furthermore, the liner may be changed in less than one minute time, whereas the replacement of a conventional crucible takes up to about three hours. The major advantage, however, of the new liner is the fact that it has an inner surface which is substantially smooth and is substantially non-wettable by the molten metal so that the liner is not attacked, and spalling and erosion are substantially eliminated.

One of the objects of the present invention is to provide an improved liner for an induction type melting furnace which can be quickly inserted into the crucible assembly, and quickly removed.

Another object of the invention is to provide an improved liner for induction type melting furnace which presents a smooth surface to the molten metal and which is substantially non-wettable by the molten metal.

Another object of the invention is to provide a laminar type liner for an induction melting furnace which has remarkable strength properties in use.

Another object of the invention is to provide a method for melting a metallic charge in an induction furnace which utilizes the improved liner of the present invention.

We have now found that a ceramic shell of the type heretofore used in foundry practice for a casting mold makes an excellent replaceable liner for an induction type melting furnace. The laminar structure characteristic of such a shell mold provides a degree of strength, when the liner is slidably inserted into the crucible, which resists buckling and is still free to expand during heating. This results in a reduction of spalling tendencies and produces a cleaner melt far superior to that obtained in normal cru-

2

cibles which employ liners which are rigidly supported within the crucible body. The excellent surface finish which is obtainable by using the shell molding technique provides a non-wettable surface for the molten metal, thereby improving the quality of the melt.

In the manufacture of the liner of the present invention, the replaceable liner is built up on a pattern through a sequence of steps involving application of finely divided refractory particles and suitable binders. After elimination of the pattern material, the shell is then fired at somewhat elevated temperatures, and is then ready for use. When inserted into the crucible in sliding relation, the liner is fairly snugly supported by the body of the crucible, but still has a capacity to expand during heating.

One of the surprising discoveries made in conjunction with this development was that a liner fabricated by shell mold making methods can withstand temperatures of molten metal far in excess of those which were thought to represent the upper limit for casting purposes. For example, we have used ceramic shell type liners at temperatures of about 3050° F., which is about 500° in excess of the typical casting temperatures for alloys poured into ceramic type shell molds. We believe this remarkable strength is attributable to the fact that as the metal is progressively heated to its melting point, the crucible liner sinters to achieve very high strength, enabling it to withstand the weight of the molten metal charge. This is borne out by the fact that if the same molten alloy is poured at 3050° F. directly into an unsupported crucible, without the progressive sinter, the crucible bulges and fails.

A further description of the present invention will be made in conjunction with the attached sheet of drawings which illustrates a preferred embodiment.

In the drawings:

FIGURE 1 is a cross-sectional view illustrating the construction of a pattern useful for forming the improved liner of the present invention;

FIGURE 2 is a view of the pattern after it has been sequentially coated with a number of layers of refractory particles in the shell mold making process;

FIGURE 3 is a cross-sectional view of the green shell after removal of the pattern material;

FIGURE 4 is a greatly enlarged cross-sectional view taken substantially along the line IV—IV of FIGURE 3 illustrating the laminar construction of the liner; and

FIGURE 5 is a cross-sectional view of the liner inserted in the crucible of an induction melting furnace.

As shown in the drawings:

In FIGURE 1, reference numeral 10 identifies generally a pattern structure for producing the liner of the present invention, and including a plug 11 composed of aluminum or the like, coated with a wax coating 12. The pattern structure 10 is dipped into ceramic slurries of controlled particle size. We have found that the best results are obtained by using ceramic particles of a particle size such that at least 99% pass through a 140 mesh screen. A typical screen analysis of the material used for the present invention is given in the following table:

	Percent
+100 mesh -----	0.52
—100 mesh +140 mesh -----	0.02
—140 mesh -----	99.46

The pattern is dipped into ceramic slurries, with intermediate drying steps, until the desired thickness of the shell identified at reference numeral 13 is built up. Typically, the shell thickness is on the order of ¼ inch.

The particles employed in accordance with the present invention can be any of the typical refractory particles used for the manufacture of ceramic shell molds, including materials such as zirconia, quartz, silicon carbide, zir-

conium silicate, aluminum silicate, and high silicon oxide glasses.

Colloidal silica serves as an effective high and low temperature binder, and is usually used in the form of a colloidal aqueous solution resulting from the decomposition of sodium silicate solutions by acids.

A typical ceramic slurry used for dipping the pattern material contains about 3000 grams of refractory particles per liter of colloidal silica. A small amount of a thickener such as methyl cellulose can also be added to the slurry.

In a typical sequence of operation, the pattern is first dipped into the aqueous slurry and then adiabatically dried so that the temperature of the pattern remains substantially constant. After each successive dip, the drying is repeated, preferably at lower humidity conditions in succeeding stages. For example, the first coating may be conveniently dried using air at a wet bulb temperature of 75° F., followed by a drying of the second coat by air having a relative humidity of 45 to 55%. The third and fourth coats can be dried with a relative humidity of 35 to 45%, the fifth and sixth coats with a relative humidity of 25 to 30%, and the final coat or coats at a relative humidity of 15 to 25%.

After the mold is built up to the required thickness, the wax is then melted out, and the aluminum plug 11 is removed. The liner which results is then fired at a temperature of about 1800° F. for about one hour and is ready for use.

The laminar structure of the liner 14 produced according to the present invention is best illustrated in the enlarged showing of FIGURE 4. The liner 14 has a relatively smooth, non-wettable inner face 16 backed up by a plurality of layers 17 resulting from the successive dips in the ceramic slurry compositions.

As illustrated in FIGURE 5, the outer dimension of the liner 14 is sufficient so that the liner is readily received in sliding engagement within a crucible 18 forming part of an induction melting furnace 19. The furnace 19 also includes a frame 21 in which there is supported an induction coil 22 energized through a suitable alternating current source (not shown). A clamp 23 is pivotally supported on the frame 21 so that it may be swung out over the liner 14 to prevent the liner sliding out of the crucible 18 when the molten metal is poured.

In the operation of the furnace, a charge of the metal is placed within the liner 14, and the induction coil is energized. As the furnace comes up to temperature, the particles in the liner 14 are further sintered, producing a strong shell structure which can withstand the weight of the metal. Temperatures in excess of 3000° F. have been used with liners of this type without producing inclusions in the resulting melt.

The liners of the present invention are inexpensive to manufacture, as compared with conventional crucible assemblies. The liner is easily removed, so that there is no physical removal problem. A liner produced according

to the present invention may be changed in less than one minute whereas three hours or so are required for relining conventional crucibles. The use of the liner of the present invention results in a lower cost per pound of metal poured, and increased production.

It should be evident that various modifications can be made to the described embodiments without departing from the scope of the present invention.

We claim as our invention:

1. An induction type melting furnace comprising a furnace frame, an induction coil supported in said frame, a refractory crucible disposed within said frame and surrounded by said coil, and a liner received within said crucible, said liner comprising a laminar, self-sustaining ceramic shell composed of layers of finely divided refractory particles bonded together with a binder, the inner surface of said shell being substantially smooth and being substantially non-wettable by molten metal.

2. The furnace of claim 1 in which said refractory particles have a particle size such that at least 99% pass through a 140 mesh screen.

3. The furnace of claim 1 in which said liner is received in slidable relation with respect to the interior of said crucible.

4. The method of melting a metallic charge which comprises placing the charge in a lined crucible of an induction furnace, the liner in said crucible comprising a laminar, self-sustaining ceramic shell composed of layers of finely divided refractory particles bonded together with a binder, and inductively heating the charge to a melting temperature, said melting temperature being in excess of the sintering temperature of said shell, whereby said shell is substantially strengthened by sintering before said metallic charge reaches its melting temperature.

5. The method of claim 4 in which the surface of said liner which contacts the metallic charge is substantially smooth and substantially non-wettable by the molten metal.

6. The method of claim 4 in which said finely divided particles have a size such that at least 99% pass through a 140 mesh screen.

7. The method of claim 4 in which the melting temperature of the metallic charge is on the order of 3000° F.

References Cited

UNITED STATES PATENTS

2,757,219	7/1956	Clough et al.	13—35
2,947,641	8/1960	Bleuenstein	164—361
3,154,624	10/1964	Dolph et. al.	13—35
3,249,676	5/1966	Rydinger et al.	13—30
3,328,017	6/1967	Conner	266—43

RICHARD M. WOOD, *Primary Examiner.*

L. H. BENDER, *Assistant Examiner.*