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LINING FOR INGOT MOLDS AND METHOD OF PRODUCING INGOTS

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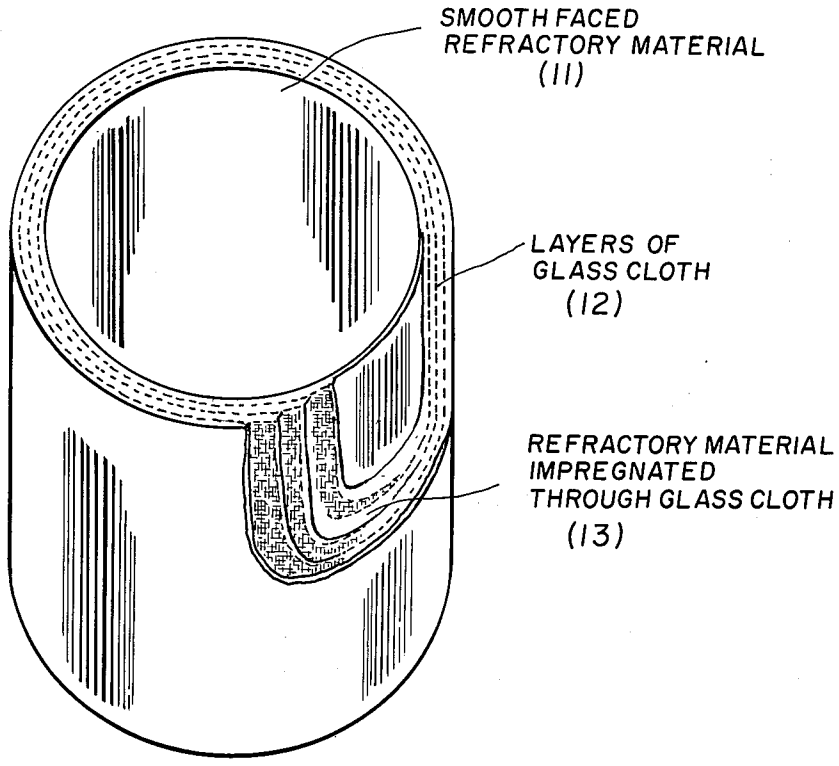

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LINING FOR INGOT MOLDS AND METHOD OF PRODUCING INGOTS

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The present invention relates to molds and mold linings employed in the production of metal castings and to a method for producing metal castings of improved quality.

Those skilled in the art know that ingot practice is a very important step in the production of wrought metal and alloy shapes. Ingots are produced by static casting in a permanent mold which may be of cast iron or other suitable metal. In pouring ingots, the ingot mold generally is placed in an upright position upon a suitable base and pouring is conducted either from the top or from the bottom of the ingot mold. As indicated in Metals Handbook, 1948 edition, pages 335 and 336, the design of the ingot mold and control of the production of ingots are very important considerations in determining the soundness of steel and other metals which are cast into ingots and thereafter worked to provide wrought products. In the production of heat resistant alloys such as nickel-chromium alloys, nickel-chromium-iron alloys, nickel-chromium-cobalt alloys (and including nickel-base, cobalt-base and iron-base alloys which contain additional alloying ingredients such as chromium, aluminum, titanium, molybdenum, tungsten, columbium, zirconium, copper, boron, etc., for the production of superior high temperature properties), the ingot phase of the operation is even more critical than it is in the case of ordinary carbon steel. Thus, it is essential that the metallurgical quality of the ingot be of a high order. That is, the ingot must be sound, free from piping and other mechanical defects. In addition, the ingot surface must be as free as possible of mechanical defects such as might be caused by ingot mold surface defects, splashing of metal against the ingot wall, breaks or imperfections in any ingot mold liner used, etc.

Ingots of heat resistant alloys must be mechanically overhauled before any subsequent hot working can be conducted thereon to remove from the surface thereof any imperfections occurring during the casting operation. This is a very expensive operation involving machine chipping, grinding and so on and the metal removed by such overhauling operations represents an economic loss since it cannot be converted into acceptable mill products.

It is common practice in order to reduce or eliminate center piping and/or porosity of the ingot to use a hot top on the ingot. A hot top may comprise a collar or annulus of insulating refractory material inserted or fitted into the top of the mold on a supporting ledge or recess in the mold. The purpose of a hot top is to delay freezing of the molten metal near the top of the mold long enough to maintain a reservoir of molten metal available to feed into the center of the ingot as solidification progresses. An exothermic material has also been used in combination with the hot top, i.e., a material that would exothermically react when contacted by molten metal, again for the purpose of providing a pool of molten metal at the top of the ingot available to feed metal to the ingot as solidification proceeds.

In addition to the foregoing, much effort has been expended in seeking means for providing improved linings for the ingot mold surface which contacts the metal poured therein. These efforts usually involved applying to the wall or walls defining the ingot mold cavity or chamber an adherent coating. Such coatings were intended to protect the mold from the erosive action of molten metal during pouring, to prevent the ingot from sticking to the mold, to provide an insulating effect in the mold and thereby to decrease the rate of freezing of the ingot, to prevent cracking or surface burning of the ingot mold and thereby to increase mold life, etc. The practice usually proposed involved applying to the surface of a mold cavity a coating usually comprising a suspension of finely-divided material in a liquid vehicle. Such mold coating materials included a fluid suspension of finely-divided magnesium oxide, diatomaceous silica, graphite, certain types of clays, silicate slags, etc., and generally were applied by spraying, by brushing or by other suitable means.

While the foregoing method of producing a mold coating has been partially successful in overcoming certain casting difficulties, there were certain disadvantages in such methods, particularly when such methods were employed in producing castings of high melting point metals, such as heat resistant alloys containing substantial amounts of alloying ingredients. Generally, it was found that such mold coatings had a tendency to spall and crumble away from the mold wall when the mold was subjected to mechanical and/or thermal shock. For example, the mold coating might spall or crumble during the pouring of hot metal, thus exposing bare metal surface in the mold cavity to the action of the hot molten metal which would either partially fuse to the exposed mold surface or cause partial erosion thereof. In some instances, fragments of the mold coating would be folded into or entrapped in the rapidly chilled surface of the poured metal adjacent the mold surface such that the resulting solidified ingot would have a rough surface containing discontinuities, cold shuts, and other defects, etc., which necessitated considerable overhauling of the ingot in order to prepare it for subsequent mechanical working operations, such as forging, extruding, etc. In fact, it was found from experience that it was more desirable to employ uncoated molds than the coated molds proposed heretofore. In many instances, it was found that cleaner metal was obtained more consistently when an uncoated mold was employed.

It has been deemed desirable in breaking down by extrusion difficulty-forgeable nickel-chromium alloys of high alloy content and other types of nickel-containing and nickel-base alloys to cast the alloys into cylindrical ingots about 7 inches to 13 inches in diameter by about 25 inches to 60 inches long which could be cut into extrusion billets. However, the cylindrical ingot mold is one of the more undesirable molds for ingot castings and it is an extremely difficult problem to produce cylindrical ingots of acceptable metallurgical quality and surface. In addition, ingot mold life is very poor.

Although many attempts were made to overcome the foregoing difficulties and other disadvantages, none, as far as we are aware, was entirely successful when carried into practice commercially on an industrial scale.

It has now been discovered that ingots or castings of improved quality can be produced by employing a novel mold lining which does not have the disadvantages of conventional mold coatings whereby ingots or castings can be produced in accordance with the invention which require minimum overhauling and whereby certain difficulty hot workable heat resistant and other types of alloys can be produced having improved hot workability

or superior metallurgical quality as a result of employing the invention.

It is an object of the present invention to provide as an article of manufacture an improved ingot mold lining for use in producing metal ingots having good metallurgical quality.

Another object of the invention is to provide a mold lining characterized by having improved resistance to thermal and mechanical shock, including improved resistance to spalling, crumbling, breaking, etc., when in contact with hot molten metal during teeming of an ingot.

The invention also contemplates providing an improved mold lining for use in producing metal ingots having greatly minimized piping and center porosity.

It is a further object of the invention to provide a lined mold for producing clean metal ingots of high quality from molten metal.

The invention further contemplates providing an improved method for producing metal ingot castings, said ingot castings being characterized by having improved surface quality and internal soundness and by requiring minimum overhauling as compared to ingot castings produced by conventional casting procedure.

It is another object of the invention to provide a method for casting difficulty hot workable heat resistant alloys into lined ingot molds whereby such ingots can be hot worked to produce a high yield of final product having improved metallurgical quality.

Other objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawing which depicts, partially in section, the composite ingot mold lining contemplated in accordance with the invention.

Generally speaking, the present invention contemplates a composite ingot mold lining insert or sleeve comprising a smooth, dense refractory inner facing made of a refractory powder having a particle size not exceeding about 0.01 inch adherently bound to a fibrous reinforcing matrix or backing, said composite lining having substantial rigidity and controlled gas permeability.

The invention also contemplates a method for producing ingots having improved surface and improved metallurgical quality and particularly ingots of nickel-base, iron-base and cobalt-base heat-resisting alloys which comprises preparing a substantially rigid ingot mold lining having a smooth, dense refractory inner facing bound to a fibrous reinforcement and having external dimensions substantially corresponding to the mold cavity of the ingot mold into which it is to be fitted, placing said liner into an ingot mold and casting molten metal into the lined mold thus obtained to produce an ingot having improved metallurgical quality and an improved surface.

Preferably, the refractory used for the inner facing of the mold lining is zircon powder having a fineness to pass a 100-mesh Tyler standard screen (approximately 0.0058 inch particle size). To prepare the lining, the refractory powder is mixed with a binder such as bentonite, sodium silicate or a phenolic resin and with sufficient liquid such as water or alcohol to form a fluid mix or slurry. The slurry is then brushed or sprayed upon a fibrous preform or reinforcing backing of the desired configuration and dimension to form thereon a smooth inner surface. Advantageously, both sides of the fibrous preform may be coated, resulting in impregnation thereof with the refractory mix. The coated preform is then dried to provide a unitary lining which is hard, resilient and substantially rigid and has a smooth, dense inner face having a surface finish not coarser than about 250 micro-inches. Alternatively, the composite mold liner may be built up about a smooth-surfaced former having a surface smoothness not coarser than about 250 micro-inches and having the desired configuration for the ingot to be produced, by applying to the former alternate layers of the refractory mix and the fibrous material to the desired thickness, e.g., about 1/16 inch. The mold liner is then dried and removed from the former, which may or may not have slight draft to facilitate removal of the mold liner. In this manner, the composite liner has, as formed, a smooth, inner refractory metal-contacting face derived from the former and the fibrous backing material is thoroughly impregnated with the finely-divided refractory mix. It is important that the composite mold liner contemplated in accordance with the invention have, after drying, a uniform, controlled porosity so as to be permeable to gas evolved during the freezing of an ingot within the lined mold. Thus, the dry composite ingot mold liner comprising a fibrous backing or matrix impregnated with refractory material should have, by volume, about 15% to about 40% of pores, preferably about 25% to about 30% of pores, uniformly distributed therethrough.

The accompanying drawing illustrates, partially in section and to an exaggerated scale, a composite ingot mold lining contemplated in accordance with the invention. The smooth refractory inner facing of the composite ingot mold liner is shown at 11. The wall of the composite ingot mold liner is made up of layers of glass cloth 12 which has the smooth refractory inner facing 11 bonded thereto. Refractory material is impregnated through the layers of glass cloth 12 as depicted at 13.

The refractory powder advantageously is zircon powder since it is uniform in grade, is thermally stable, and is readily available. Other substantially inert oxygen-containing refractory materials may be used, such as magnesia, alumina, high alumina clays such as kaolin or china clay, and other refractory materials such as sillimanite, topaz, ganister, magnesite, olivine, chromite, zirconia, etc. These materials have a melting or softening point at least about 100° F. higher than the temperature of the metal being cast.

The reinforcing backing or preform advantageously comprises one or more layers of fiber glass cloth or matting but may be of any fibrous, glassy or glass-like, inorganic material such as asbestos or rock wool. A satisfactory fiber glass has a softening point of about 1550° F. and a fluid point of about 2450° F. At 2600° F., this glass has a viscosity of about 60 poises and at 2200° F., a viscosity of 900 poises. Another glass-like fibrous material is one containing about 75% SiO_2, about 0.09% to 17% total of Al_2O_3 and Fe_2O_3, up to about 20% CaO, up to about 9% MgO, up to about 10% Na_2O and up to about 13% B_2O_3. Another glass-like fibrous material comprises about 40% to 80% SiO_2, about 12% to 18% Al_2O_3, up to about 20% Fe_2O_3, up to about 15% CaO, up to about 30% MgO and up to about 12% Na_2O. A type of blast furnace slag which would be suitable as a fibrous material comprises about 30% to 50% SiO_2, about 4% to 15% Al_2O_3, about 0.5% to 5% FeO, about 30% to 50% CaO, and about 0.3% to 20% MgO. Fibrous glass-like materials having a softening point of the order of about 1550° F. and higher have been found satisfactory.

In preparing the refractory slurry for production of the improved hard and resilient composite mold liner contemplated in accordance with the invention, the slurry should contain about 50% to about 90% by weight of the refractory powder suspended in a liquid. When bentonite is used as the binder, about 2% to about 5% of bentonite is used with about 5% to about 20% of water to produce a plastic slurry. When a phenolic resin is employed as the binder, the slurry should comprise about 50% to about 90% by weight of refractory powder with the remainder phenolic resin solution in alcohol containing about 1% to about 6% by weight of resin. When sodium silicate is used as the binder, the slurry should contain about 75% to about 90% refractory powder, about 1% to about 5% sodium silicate and about 5% to about 20% water by weight.

The composite mold lining contemplated in accordance with the invention may be of any desired thickness although in practice it need be no thicker than required to give handling strength to the lining. Thus, a lining about

1/32 to about 1/16 inch thick is satisfactory for use in a cylindrical mold about 9 inches in diameter. It is to be understood that an additional insulating wrapping, e.g., one or more layers of fiber glass cloth or matting, may be provided about the outer surface of the liner, if desired, to provide an additional insulating effect. Of course, when such additional outer wrappings are employed, the dimensions of the composite liner must be adjusted to compensate for the thickness of the outer wrapping. Alternatively, the composite mold liner itself may be produced in a greater thickness up to about 1/8 inch or even about 1/4 inch to provide an enhanced insulating effect.

For the purpose of giving those skilled in the art a better appreciation of the advantages of the invention, the following illustrative example is given:

Example

A mold liner having an outside diameter of about 9 inches was made on a smooth cylindrical preform by applying thereto a slurry of zircon refractory cement powder having a particle size such as to pass a 100-mesh Tyler screen, said powder being mixed with about 4% of bentonite and about 8% water to form a slurry. A fiber glass cloth of coarse weave (about 100 meshes to the square inch) was then aplied to the slurry coating and was wrapped about the preform with continuous application of the refractory slurry to produce a composite mold liner containing three layers of glass cloth impregnated with the refractory slurry and coated on both sides therewith. The liner was then dried and was removed from the form. It was about 1/16 inch thick, was sufficiently strong to stand by itself, had a pore content of about 30% by volume, and had a smooth, dense inner surface with a surface finish smoother than about 100 micro-inches. The dried liner was inserted into a cylindrical cast iron ingot mold having an inside diameter of about 9 inches. The cast iron mold was provided with a recess at the top thereof into which an exothermic hot top collar was placed. A molten nickel-chromium alloy containing about 20% chromium, about 2.4% titanium, about 1.2% aluminum, about 0.9% iron and about 0.6% manganese, with the balance substantially all nickel (such as is sold under the trademark NIMONIC "80") was teemed into the ingot mold from the top using a tundish or pouring crucible having a nozzle about 1½ inches in diameter. The pouring dish was then removed and the metal was allowed to freeze in the mold. After removal from the mold, it was found that the ingot had a smooth surface substantially reproducing the surface finish of the liner. The ingot was cut into billets about 24 inches long and was prepared for extrusion by pickling, and grinding, shot blasting or any combination of these. A stock removal of only about one to five pounds was sufficient to prepare the billets for extrusion. The billets were radiused and then extruded to bars about 3 inches by 3 inches in section and were thereafter hot rolled to rods about ¾ inch in diameter. A recovery in excess of 80% of the initial cast ingot weight was obtained in the hot rolled rods as compared to a recovery of only about 65% of the initial ingot cast weight at this stage of fabrication which had been obtained using unlined molds by the best previous practice.

It is quite important, in accordance with the present invention, that the composite mold liner not only have a smooth inner facing of refractory powder bound to the backing of glassy material but that the glassy material also be impregnated with the bound refractory powder. The foregoing liner wall structure is quite rigid and is relatively incompressible. It is an advantage that the liner wall structure not compress in contact with hot molten metal during teeming of the ingot since compression of the liner structure due to the weight of the molten metal can cause cracking of the liner wall with resulting penetration of the molten metal into the cracks. Such penetration of the liner wall causes undesirable fins on the ingot and may permit contact of molten metal against the inner face of the ingot mold with resulting accelerated deterioration thereof.

It is also important that the liner fit snugly into the ingot mold cavity so that the liner will not deform and/or crack during teeming of the ingot and so that the liner will frictionally engage the face of the mold cavity and will not float in contact with the hot molten metal. Generally, the maximum clearance between the liner and mold should not be over 1/64 inch on the mold cavity diameter. When the liner is made using a matrix of woven glass cloth or of glass matting, the outer surface of the liner wall has myriads of slight projections in the circumferential direction and it is these slight projections which contact the ingot mold cavity to give a point-to-point contact. The slight valleys between projections provide additional routes whereby escape of gases from the freezing metal is facilitated. The mold liner wall itself has controlled permeability to gases due to the controlled porosity thereof as disclosed hereinbefore.

Since the matrix material, e.g., fiber glass cloth, does not contact molten metal when ingot molds provided with the composite ingot mold liner produced in accordance with the invention are employed in teeming metal ingots from high melting point metal, there is little or no fusion of the matrix material during the teeming operation. Furthermore, the inner facing of refractory material does not adhere to the metal. When the composite mold liner has a fiber glass matrix, the remnants of the liner after casting an ingot are quite brittle, apparently as a result of the prolonged high heating to which the composite mold liner is subjected in use.

The composite mold liner has substantial elasticity and will deflect under pressure applied in a diametric direction, as by squeezing between the hands. Upon release of such pressure, the composite liner will spring back to its original shape and size. This feature is important in fitting the composite liner into the ingot mold cavity since the liner must fit snugly but should not be broken or cracked while it is being fitted into the mold.

As in all ingot casting, it is very important to maintain a steady feed of metal to the ingot mold during casting in accordance with the present invention. In this way, splashing of metal is minimized and other defects which attend an uneven pouring rate are avoided. It is desirable in top pouring the ingots to use a pouring dish or tundish having a nozzle of such a diameter that a pool of metal can be maintained in the pouring dish at a substantially constant level during the teeming of the ingot so as to assure a constant rate of pouring.

The composite refractory mold liner contemplated in accordance with the invention not only produces ingots having superior surface finish and improved metallurgical quality but also provides greater mold life. Thus, the average mold life obtained through using the composite refractory mold lining is about 200 casts whereas the prior practice using unlined molds provided an average mold life of only about 40 casts. Practice with the improved ingot mold liner contemplated in accordance with the present invention practically eliminates the casting operation itself as a factor in ingot mold life. The limiting factor in the life of cast iron ingot molds becomes that of mechanical damage due to handling of the heavy molds, as, for example, during the stripping operation.

Another advantage of the invention flowing from the improved surface quality of the ingots is the fact that mechanical overhauling of the ingot is greatly minimized. In fact, the improved practice involving the use of the improved hard and resilient composite refractory mold lining provided in accordance with the invention has substantially eliminated the necessity for lathe turning the ingots produced. It has now been found that pickling, vapor blasting, shot blasting or grinding overhaul of the ingots produced in accordance with the practice

described herein provides sufficient overhauling thereof before billets cut from the ingots are extruded. The smooth refractory facing of the composite liner apparently prevents adherence thereto of any metal splash occurring during the teeming operation and, in any event, an improved ingot surface is obtained as compared to prior practice in producing ingots of heat-resisting alloys.

The sleeve-like mold lining may be produced in various transverse cross-sectional shapes depending upon the transverse cross-sectional shape of the ingot or casting to be produced. For example, the sleeve-like mold lining may have a transverse cross section whose peripheral outline corresponds to a circle, an ellipse, a triangle, a square, a rectangle, or other shapes, depending upon the shape of the ingot to be cast.

The composite refractory-faced mold lining contemplated in accordance with the present invention provides important advantages by way of improved ingot surface and improved ingot quality not obtained in using unlined ingot molds or in using previously-proposed ingot mold linings. For example, applicants have found that a mold lining comprising core sand which had a particle size of about 0.2 mm. made to fit a cast iron ingot mold and containing about 2 or 3% of core oil or bentonite as a binder and a mold lining comprising vitreous tile both resulted in ingots having gross segregation or deep primary piping. Furthermore, such mold linings produced an inferior rough and flawed ingot surface presumably as a result of adherence of metal splash to the comparatively rough mold lining. The special composite mold lining avoids the foregoing defects and produces ingot castings of superior quality.

Generally, the present invention is widely applicable to the casting of metals and alloys, particularly those having a melting point above about 1600° F. For example, the invention is applicable to the casting of alloys comprising at least about 40% total of the group manganese, iron, cobalt, nickel and copper. Such alloys may contain up to about 50% manganese, up to about 98% iron, up to about 60% cobalt, up to about 98% nickel and up to about 98% copper. Important alloying elements which may be present in the alloy include up to about 45% chromium, up to about 40% molybdenum and up to about 40% tungsten. Other alloying or incidental elements which may also be present in the alloy to which the invention is applicable include up to about 15% aluminum, up to about 15% titanium, up to about 1% zirconium, up to about 10% vanadium, up to about 10% columbium, up to about 10% tantalum, up to about 10% silicon, up to about 10% beryllium, up to about 40% zinc, up to about 20% tin, up to about 5% magnesium, up to about 1% cerium, up to about 1% calcium, up to about 2% carbon, up to about 1% boron, etc. Included among the metals that can be cast in accordance with the invention are nickel, iron and copper.

The invention is particularly applicable to the casting of heat resistant chromium-containing alloys, including, for example, nickel-chromium alloys, nickel-chromium-iron alloys (such as nickel-base alloys and stainless steels), nickel-chromium-cobalt alloys, nickel-chromium-iron-cobalt alloys, iron-chromium alloys, etc. Such heat resistant alloys can be cast into ingots, slugs or the like for subsequent conversion into wrought products by hot extrusion methods; although when the cast metal is subjected to other hot working operations, the benefits of the present invention are also realized.

The present application is a continuation-in-part of our copending U.S. application Serial No. 461,868, filed October 12, 1954, now U.S. Patent No. 2,882,568, granted April 21, 1959.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

We claim:

1. A composite refractory ingot mold lining comprising a smooth, dense refractory inner facing and a fibrous backing of glassy material, said refractory inner facing being of refractory powder having a particle size less than about 0.01 inch bonded together and to said fibrous backing and said lining containing about 15% to about 40% voids, by volume, to provide a controlled permeability to gas.

2. A composite ingot mold lining comprising a fibrous backing made of glassy material impregnated and coated on both inner and outer faces with a gas-permeable refractory mixture of powder having a particle size less than about 100 mesh bonded together and to said backing, said refractory coating having a smooth, dense inner face with a surface finish not coarser than about 250 micro-inches and containing, by volume, about 15% to about 40% voids to provide a controlled gas permeability.

3. A composite ingot mold lining comprising a fiber glass matrix impregnated and coated on both inner and outer faces with a gas-permeable refractory mixture of powder having a particle size less than about 100 mesh bonded together and to said backing, said refractory coating having a smooth, dense inner face with a surface finish not coarser than about 250 micro-inches and containing, by volume, about 25% to 30% voids to provide a controlled gas permeability.

4. A metal ingot casting mold consisting essentially of a chamber adapted to receive molten metal and a sleevel-like mold lining in said chamber and conforming substantially to the surface configuration of said mold chamber, said composite mold lining comprising a smooth, dense refractory inner facing and a fibrous backing of glassy material, said refractory inner facing being of refractory powder having a particle size less than about 0.01 inch bonded together and to said fibrous backing and containing about 15% to about 40% voids, by volume, to provide a controlled permeability to gas.

5. A metal ingot casting mold consisting essentially of a chaber adapted to receive molten metal and a sleeve-like mold lining in said chamber and conforming substantially to the surface configuration of said mold chamber, said composite mold lining comprising a fibrous backing made of glassy material impregnated and coated on both inner and outer faces with a gas-permeable refractory mixture of powder having a particle size less than about 100 mesh bonded together and to said backing, said refractory coating having a smooth, dense inner face with a surface finish not coarser than about 250 micro-inches and containing, by volume, about 15% to about 40% voids to provide a controlled gas permeability.

6. A metal ingot casing mold consisting essentially of a chamber adapted to receive molten metal and a sleeve-like mold lining in said chamber and conforming substantially to the surface configuration of said mold chamber, said composite mold lining comprising a fiber glass backing impregnated and coated on both inner and outer faces with a gas-permeable refractory mixture of powder having a particle size less than about 100 mesh bonded together and to said backing, said refractory inner facing having a surface finish not coarser than about 250 micro-inches and said lining containing, by volume, about 25% to about 30% voids to provide a controlled gas permeability.

7. The method for producing ingots of heat-resisting metal having an improved surface and improved metallurgical quality which comprises preparing an ingot mold

liner by forming a sleeve of fiber glass cloth; impregnating said sleeve and smoothly coating the inner face thereof with a plastic refractory mix comprising a refractory powder having a particle size not greater than about 100 mesh; drying the impregnated and coated sleeve to produce a relatively hard and resilient ingot mold liner having a smooth, dense, refractory inner surface with a surface finish finer than about 250 micro-inches and containing, by volume, about 15% to about 40% voids to provide controlled gas permeability; inserting said mold liner into the cavity of a metal ingot mold such that said mold liner frictionally engages the face of said cavity; pouring molten heat-resisting metal into the resulting lined ingot mold; and freezing said metal in said lined ingot mold to provide an ingot having a surface which substantially reproduces the surface fiuish of said mold liner and which is characterized by improved metallurgical quality.

8. The method for producing ingots of heat-resisting metal having an improved surface and an improved metallurgical quality which comprises preparing an ingot mold liner by forming a sleeve of fiber glass cloth; impregnating said sleeve and smoothly coating the inner face thereof with a plastic refractory mix comprising a refractory powder having a particle size not greater than about 100 mesh; drying the impregnated and coated sleeve to produce a relatively hard and resilient ingot mold liner having a smooth, dense, refractory inner surface with a surface finish finer than about 250 micro-inches and containing, by volume, about, 25% to about 30% voids to provide controlled gas permeability; inserting said mold liner into the cavity of a metal ingot mold such that said mold liner frictionally engages the face of said cavity; pouring molten heat-resisting metal into the resulting lined ingot mold; and freezing said metal in said lined ingot mold to provide an ingot having a surface which substantially reproduces the surface finish of said mold liner and which is characterized by improved metallurgical quality.

9. The method for producing ingots of heat-resisting alloy having an improved surface and improved metallurgical quality which comprises lining a metal ingot mold with a substantially rigid composite mold lining having a fibrous backing of glassy material and a smooth, dense inner facing of a refractory powder mixture bonded together and to said backing, said bonded refractory powder mixture being made of refractory powder having a particle size not greater than about 0.01 inch and containing about 15% to 40% voids, by volume, to provide controlled gas permeability; pouring into the resulting lined ingot mold molten heat-resisting alloy; and freezing said metal in said lined ingot mold to provide an ingot having an improved surface and improved metallurgical quality.

10. The method for producing ingots of heat-resisting alloy having an improved surface and improved metallurgical quality which comprises preparing an ingot mold liner by impregnating and coating a sleeve-like backing made of fibrous glassy material with a plastic refractory mix of a refractory powder having a particle size not greater than about 100 mesh to produce a substantially rigid ingot mold liner having a smooth, dense, refractory inner surface with a surface finish finer than about 250 micro-inches and containing about 15% to about 40% voids, by volume, to provide controlled gas permeability; inserting said mold liner into a metal ingot mold; pouring molten heat-resisting alloy into the resulting lined ingot mold; and freezing said metal in said lined ingot mold to provide an ingot having a surface which substantially reproduces the surface finish of said mold liner and which has improved metallurgical quality.

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UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 2,973,563 March 7, 1961

Ernest Frederick Leaberry et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 25, for "aplied" read -- applied --;
column 8, line 36, for "sleevel-like" read -- sleeve-like --;
column 9, line 17, for "fiuish" read -- finish --.

Signed and sealed this 22nd day of August 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents