March 6, 1962 A. O. HORD ET AL 3,023,468

MOLD LINER

Filed Dec. 2, 1959 2 Sheets-Sheet 1

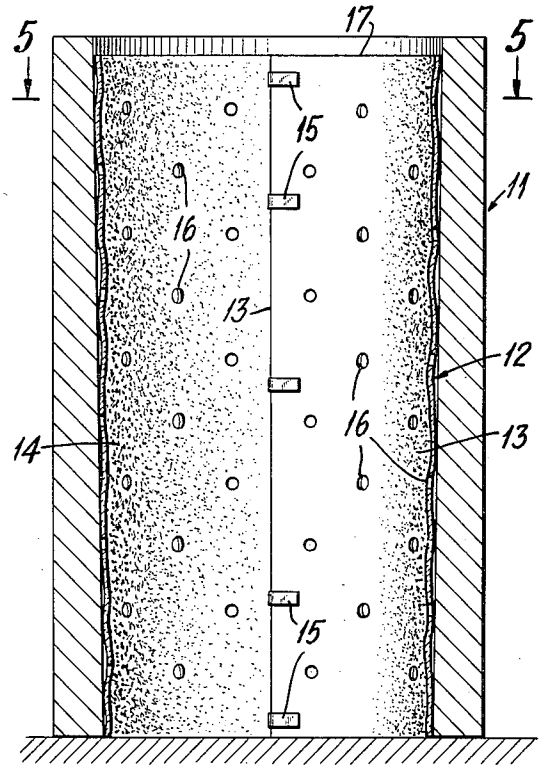


FIG. 1.

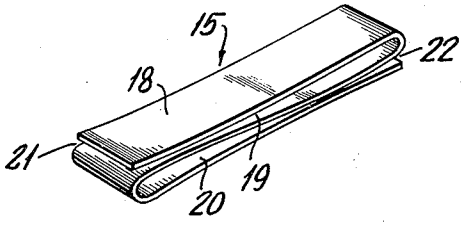


FIG. 2.

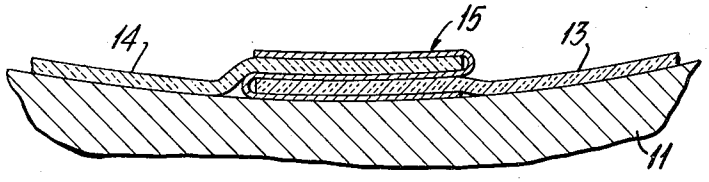


FIG. 3.

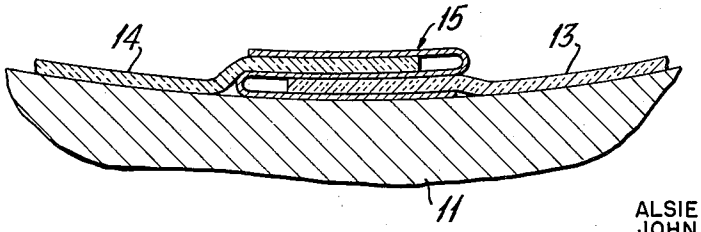


FIG. 4.

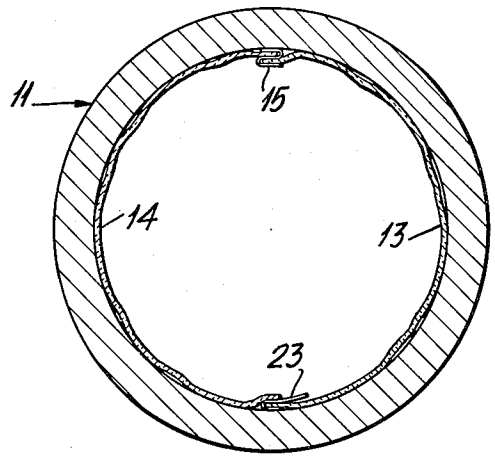
INVENTORS.
ALSIE O. HORD &
JOHN G. ROYAL
BY Thomas J. O'Brien
ATTORNEY.

March 6, 1962 A. O. HORD ET AL 3,023,468

MOLD LINER

Filed Dec. 2, 1959 2 Sheets-Sheet 2

FIG. 5.



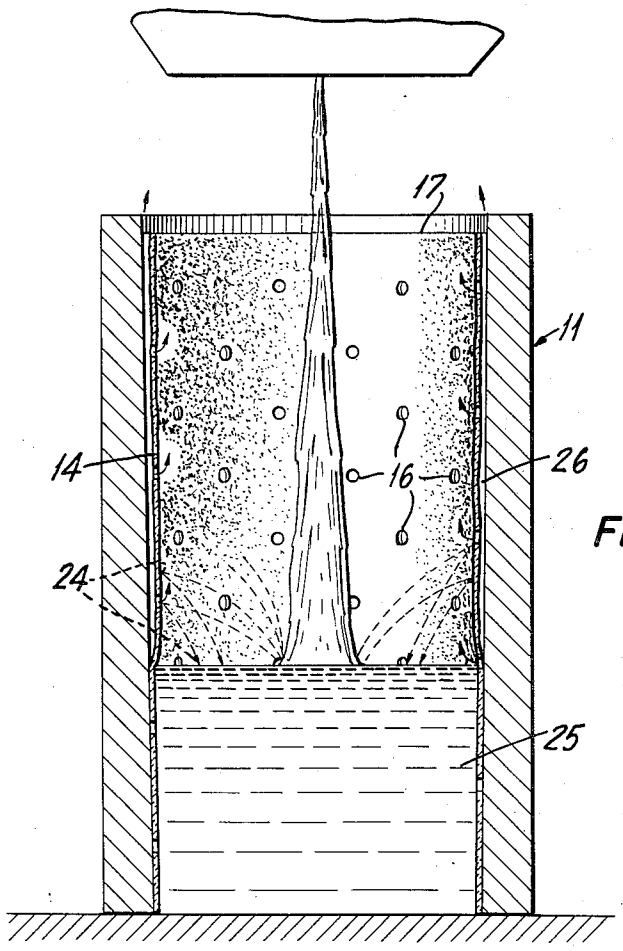


FIG. 6.

INVENTORS.
ALSIE O. HORD &
JOHN G. ROYAL
BY
Thomas L. O'Brien
ATTORNEY.

United States Patent Office

3,023,468
Patented Mar. 6, 1962

3,023,468

MOLD LINER

Alsie O. Hord, Greentown, and John G. Royal, Kokomo, Ind., assignors to Union Carbide Corporation, a corporation of New York

Filed Dec. 2, 1959, Ser. No. 856,819
7 Claims. (Cl. 22—116)

This invention relates to mold liners used in the production of ingots and to a method for producing ingots of an improved quality.

The casting of metals into forms and, in particular, ingots is often only the first step in the fabrication of other more complex shapes. It is, therefore, often essential that these ingots be of a high degree of quality. In particular, the surface of the ingot must be free of those surface imperfections which interfere with forging, rolling, drawing or other forming operations.

In practice ingots are produced having surface defects such as scabs, pits, blowholes, inclusions, etc., which must be removed by grinding, machining, scarfing, etc., before a surface satisfactory for forming operations is presented. These expensive finishing operations, which also decrease the yield of useful metals obtained from an ingot, are necessary lest the surface defects be carried over into the fabricated article.

To prevent the formation of these surface defects in castings and ingots and thereby do away with the expensive finishing operations, various mold liners and coatings have been used. For example, metallic and non-metallic materials have been used as liners or curtains to prevent the splashing and surging of molten metal on the ingot mold wall.

The use of consumable non-metallic materials as coatings or linings as taught by the prior art has several inherent disadvantages. For example, the material may either melt or flake off into the cast molten metal and become embedded therein as a non-metallic inclusion or the heat of the molten metal may decompose the coating or lining material and thereby introduce harmful products of decomposition into the molten metal.

Molds have been lined in the past with non-consumable, non-metallic materials but the results were not satisfactory. Previous attempts to use heat-resistant materials and, in particular, asbestos sheet, as mold liners were not successful. When an asbestos liner is loosely fitted into a mold, it buckles and folds, entrapping metal within the folds. When an asbestos liner is rigidly fixed to the mold walls, it tears under the pressure of the surging molten metal, leaving unprotected areas and introducing asbestos into the metal.

It is the primary object of this invention therefore to provide a process for casting ingots having a surface which is substantially free from imperfections.

It is also an object of this invention to provide an improved mold lining consisting of sheets of an asbestos material for use in producing ingots having a surface free of imperfections.

It is another object of this invention to provide a process for casting ingots substantially free from surface defects and internal defects.

It is also an object of this invention to provide a process for casting ingots which give a greater yield and quality of fabricated product after forging, rolling or drawing of the ingot.

It is a further object of this invention to provide a mold liner which protects the inner surface of the ingot mold, and makes easier the removal of the ingot from the mold and also extends the life of the mold.

Other aims and advantages of this invention will be apparent from the following description and the appended claims.

In accordance with the present invention a method for casting metals is provided comprising lining the mold with at least one sheet of heat-resistant material, said sheet having sufficient rigidity to support itself vertically when positioned snugly within the mold as a liner having substantially the same configuration as the configuration of the mold, the longitudinal edges of said sheet overlapping one another, means for preventing buckling of the liner during pouring of the molten metal, said means permitting movement of the overlapped edges of said sheets relative to each other to permit expansion of said liner during pouring, pouring molten metal into the solined mold, whereby the pressure of the molten metal causes the lining to arrange itself against the walls of the mold, and then solidifying the molten metal in the mold.

In the drawings:

FIG. 1 is an elevational sectional view of an ingot mold lined in accordance with the invention;

FIG. 2 is an isometric view of the S-shaped retaining clip;

FIG. 3 is a fragmentary detail of FIG. 1 before pouring molten metal into the lined mold and;

FIG. 4 is a fragmentary detail of FIG. 1 after pouring molten metal into the lined mold;

FIG. 5 is a section taken along the line 5—5 of FIG. 1;

FIG. 6 is the elevational sectional view of FIG. 1 while metal is being poured.

In FIGURE 1 an upright ingot mold **11** is shown containing an assembled liner **12** composed of two asbestos sheets **13** and **14** fitted snugly in the mold. The longitudinal edges of the sheets are overlapped and held together by the S-shaped clips **15**. Vents **16** for the escape of air and gases are also shown. The upper end **17** of the liner is shown extending to a point about one inch short of the top of the upright mold.

FIGURE 2 shows the S-shaped clip which holds the longitudinal edges of the sheets in an overlapped relationship and allows the asbestos sheet to support itself when positioned in the mold and which simultaneously allows the liner to expand with the pressure of the molten metal during pouring. The S-shaped clip can be formed from a strip of resilient material by bending the strip 180° twice, i.e., by bending the strip back on itself twice. The clip thus formed has three legs **18**, **19**, and **20** forming two oppositely disposed openings, **21** and **22**, into which the longitudinal edges of the asbestos sheet are inserted. The clip should be sufficiently resilient to slidably grip the edges of the sheets. The width of these openings is determined by the thickness of the asbestos sheet material being used. The width is regulated to permit the asbestos sheet to slide out of the clip when pulled. The length of the clip opening should be sufficient to prevent buckling of the sheet when formed into an upright standing envelope. The number of clips required is similarly related to the size of the envelope and should be sufficient to allow the envelope to stand upright in the empty mold without buckling.

In FIG. 6 a pouring of metal into the asbestos lined ingot mold is shown. The asbestos liner is shown fitted in the mold somewhat loosely for the purposes of explanation but it is actually fitted snugly in the mold. As the mold fills with molten metal 25 the pressure of the metal forces the asbestos liner to expand outward, arranging itself against the walls of the ingot mold. Before pouring of the metal as shown in FIG. 3, each S-shaped clip 15 holds the edges of the asbestos sheets 13 and 14 in an overlapping relationship. During pouring the circumference of the liner lengthens as the liner is pushed outward to the mold walls. The increase in liner circumference is made up by the movement of the ends of the sheet sliding out of the S-shaped clips. After pouring the clips still hold the edges of the asbestos liner in an overlapping relationship but, as seen in FIG. 4, the edges have moved relative to each other to provide an increased liner circumference.

Whereas loosely fitted or rigidly fitted sheets are not able to resist the forces of the surging molten metal, a liner fitted and arranged according to the method of this invention is able to accommodate itself to the forces and pressures exerted by the molten metal. By inserting the liner in the mold snugly, i.e, tightly yet free to yield when strained, and arranging it with the longitudinal edges overlapped but free to move, the liner is free to position itself against the walls of the mold when the metal is poured.

Any means for preventing the liner from buckling while permitting the overlapped longitudinal edges to move is suitable. The preferred means is a fastener holding the longitudinal edges together while permitting them to move, but other means for accomplishing the same result are included within the scope of this invention.

One example of the preferred means is the S-shaped clip described above. Any other type fastener which will hold the longitudinal edges in an overlapped relationship while permitting the edges to withdraw from the restraint of the fastener when stressed, thereby allowing expansion of the liner, is suitable.

In an example of the practice of the invention an open-ended ingot mold having a tapered mold cavity is lined using two sheets of asbestos material by first positioning the mold on its side as in FIG. 5 and inserting therein a sheet 13 of asbestos material. The sheet should be at least equal in length to the depth of the mold and should be slightly wider than one-half the circumference of the mold so as to provide an overlapping area when a second, similarly-sized sheet 14 is inserted in the mold.

The first sheet is smoothed in place against the walls of the mold to make a snug fit. A number of S-shaped clips 15 are inserted over one longitudinal edge of the sheet 13 ready to receive the edges of the second sheet 14 when it is inserted in the mold. The other longitudinal edge of the first sheet 13 is fitted with a number of unformed clips 23 having a hook-like configuration. When the second sheet is inserted in the mold, one edge is inserted into the clips 15 and the sheet is smoothed against the walls of the mold opposite the first sheet with an overlap on the first sheet of about 2 inches. The other edge of the second sheet overlaps the first sheet and is secured in position by bending the free end of the unformed clip 23 over it. When the liner is thus fashioned, the operator may then pull the ends of the liner through the opening at the small end of the tapered mold to fit the liner snugly into place. This movement of the liner should leave a bare ring at the top of the mold 17.

The practice of bending the unformed clip into its S-shape within the mold, rather than before the sheets are inserted in the mold, has been found to give a more secure fit. However, both sets of clips may be bent to the prescribed S-shape before the liner is assembled.

The S-shaped clips may be formed from blanks of a resilient material, such as steel, having a length of about 5 inches and a width of about one-half inch, although other sizes may be used. A mold about 40 inches in depth would require from about 4 to about 8 clips evenly spaced along each longitudinal edge.

Molds of any cross-sectional configuration may be fitted with the asbestos lining described above. The asbestos sheets are merely formed or bent into a lining having a configuration similar to that of the mold with the overlapping ends held by the S-shaped clips described above. In this way circular, oval, square, hexagonal and any other type mold may be provided with the asbestos liner of this invention. Any number of sheets may be used to form the liners. One sheet may be used with its edges overlapping or two or more sheets may be connected edge to edge with the S-shaped clips depending on the size and configuration of the mold.

Furthermore, pigs or semi-finished articles may be cast in molds lined with asbestos sheets in the manner of this invention. The only requirement is that the mold be of a simple shape allowing the use of the asbestos sheet material which is held free to arrange itself against the walls of the mold when stressed by the pressure of the molten metal.

The lining material may be made of asbestos paper sheet or asbestos textiled fabric within the range of from about 1/64-inch thick to about 3/8-inch thick. Good results have been obtained using a 1/16-inch thick asbestos paper sheet having the chemical analysis shown in Table 1.

TABLE 1

Chemical Analysis of Asbestos Paper Sheet

	Percent
MgO	40.05
SiO_2	34.40
Fe_2O_3	5.25
CaO	0.36
Al_2O_3 (plus ZrO_2)	0.25
Other materials lost on ignition at 1000° C., 1 hr.	Balance

The balance or 19.69 percent of the material is made up of consumable materials such as starch or other binders and water. The water content was found to be 14.95 percent at 800° C.

When molten metal is poured into the lined mold, its heat causes the vaporization of the water and starch contained in the asbestos and the water in the ingot mold walls. The resulting steam causes undesirable agitation of the metal and can cause explosive rupture of the liner. The asbestos-lined mold should preferably be preheated to drive off this water. However, the venting system described below will allow for the escape of any such water if preheating of the mold is not practiced or is incomplete.

Other materials than asbestos may be used for the liner provided they are heat-resistant, i.e., are not consumable by the heat of the molten metal.

One of the most important benefits obtained from the use of a heat-resistant liner such as an asbestos liner in an ingot mold is the control of the metal droplets as they are splashed upward during the pouring operation as shown in FIG. 6. The metal droplets 24 strike the asbestos sheet 14 and fall back and are incorporated into the liquid metal 25. The insulating effect of the asbestos sheet prevents the sudden chilling and freezing of the droplets. This, of course, prevents the formation of those defects commonly found on the surface of as-cast ingots as a result of the freezing of metal splashings. If no liner is used, or if a metal liner is used, these droplets freeze on the walls of the mold or metal liner and cause the above-described defects on the surface of the ingot. Similarly, if a lining formed of a glass-like coating on the walls of the mold is used, the hot metal droplets either fuse to the lining and freeze or they melt the lining causing the droplet and glass coating to fall back into the melt. These glass fragments can cause undesirable inclusions in the ingot. However, the ingots cast

in an asbestos-lined mold are free of these and other defects, e.g., scabs, cold shuts, blowholes, inclusions, pits and generally rough surface.

The asbestos liner also serves to insulate the ingot from the mold walls thereby providing for a less rapid cooling and solidification of the ingot.

The use of an asbestos liner also results in easier removal of the ingot from the mold. The walls of the mold are less subject to attack from the hot metal and therefore give a longer useful life.

In FIG. 6 the escape path of accumulated gas or air is shown. These gases form when the molten metal vaporizes the water contained in the asbestos liner and mold walls. Any gas or air entrapped between the molten metal and the liner is forced through the vents **16** into the space **26** between the liner and the mold walls. As the level of the molten metal rises, it forces any air or gas entrapped in the space between the mold walls and the liner to flow upward and out through the vents into the mold cavity (as shown by the arrows). The liner should preferably not extend all the way to the top of the mold but rather should fall short of 17 by about one inch. This arrangement has been found to allow easy escape of the gases.

The vents described above may be perforations ranging from about 1/64-inch to about 3/4-inch or over in diameter and the number of perforations may vary from about one per square foot to over 20 per square foot depending on the amount of moisture which may be vaporized. An optimum arrangement consists of about sixteen 1/8-inch diameter perforations per square foot.

These perforations may be made with a sharp tool by merely pushing a hole through the asbestos and pushing the flap up to leave a hole or more preferably by punching out a portion of the asbestos to make the perforations. The vents need not be actual perforations, moreover, but may be the natural openings found in woven materials such as an asbestos woven fabric. Therefore, a woven asbestos fabric may be used without vents provided the weave is coarse enough to permit venting of the gases.

The use of the asbestos mold liner of this invention results in substantial economic savings through the elimination of the need for extensive surface grinding operations. Furthermore, there is an increased yield of usable product—on the average of a 5 percent increase. Asbestos liners fashioned in the manner described in the example and having a composition such as that given in Table 1 have been used successfully to cast ingots of cobalt-base, nickel-base, and iron-base alloys. These ingots were substantially free of surface defects.

The description of this invention has been in terms of its specific embodiments. Modifications and equivalents will be apparent to those skilled in the art and this disclosure is intended to be illustrative of, but not necessarily to constitute a limitation upon the scope of the invention.

It is to be understood that the language in the foregoing claims pertaining to ingot molds not only includes molds having a circular cross-section, as shown in the accompanying figures, but also includes molds having other geometrical configurations such as square, hexagonal, rectangular, octagonal, oval, and slab molds.

What is claimed is:

1. A composite mold for the casting of metals comprising, in combination, a mold having a cavity to receive molten metal, and an asbestos liner snugly fitted along the walls of said cavity, said liner consisting of at least one sheet of an asbestos material, the longitudinal edges of said sheets overlapping one another, movement permitting means holding said edges overlapped for preventing buckling of the liner during pouring of the metal, said means maintaining the longitudinal edges of said sheets in an overlapped relationship and permitting movement of the overlapped edges of said sheets relative to each other to permit expansion of the liner during pouring of molten metal into the so-lined mold.

2. A composite mold for the casting of metals comprising, in combination, a mold having a cavity to receive molten metal, an asbestos liner snugly fitted along the walls of said cavity, said liner consisting of at least one sheet of an asbestos material, said asbestos material having vents to permit the passage of gases therethrough, the longitudinal edges of said sheets overlapping one another, slidable fastening means interconnecting said overlapped edges, said means maintaining the longitudinal edges in overlapped relationship and permitting the movement of the overlapped edges relative to each other to permit expansion of the liner during pouring of molten metal into the so-lined mold.

3. A composite mold for casting of metals comprising, in combination, a mold having a cavity to receive molten metal, an asbestos liner snugly fitted along the walls of said cavity, said liner consisting of at least one sheet of an asbestos material, said sheets having perforations to permit the passage of gases therethrough, the longitudinal edges of said sheets overlapping one another, a plurality of generally S-shaped clips inserted over said longitudinal overlapped edges to maintain said edges in an overlapped relationship and to permit expansion of said liner during pouring of the molten metal into the so-lined mold.

4. A mold liner for use in a mold in the casting of metals comprising, in combination, at least one sheet of an asbestos material arranged into an open-ended body having substantially the same configuration as the configuration of a mold, the longitudinal edges of said sheets overlapping one another sufficiently to prevent parting of said sheets and exposure of a mold wall to molten metal when poured, a plurality of generally S-shaped clips having two oppositely disposed openings, the overlapping edges of said sheets inserted in the openings in the clips.

5. In the method of casting metal in an ingot mold, the improvement comprising arranging at least one sheet of heat-resistant material snugly within the mold with the longitudinal edges overlapping one another but free to move relative to each other, preventing buckling of the liner during pouring of the molten metal by attaching means for maintaining the edges of said sheets overlapped but free to move relative to each other to permit expansion of said liner during pouring, pouring molten metal into the so-lined mold, whereby the pressure of the molten metal causes the liner to arrange itself against the walls of the mold, and then solidifying the molten metal in the mold.

6. In the method of casting metal in an ingot mold, the improvement comprising arranging at least one sheet of an asbestos material snugly within the mold with longitudinal edges of said sheets overlapping one another but free to move relative to each other, said asbestos material having perforations to permit the passage therethrough of gases, said sheets having sufficient rigidity to support themselves vertically when positioned snugly within the mold as a liner having substantially the same configuration as the configuration of the mold, preventing buckling of the liner during pouring of the molten metal by attaching means for maintaining the edges of said sheets in an overlapped relationship but free to move relative to each other to permit expansion of the liner during pouring, said edges overlapping sufficiently to prevent parting of the edges and exposure of the mold walls to the molten metal when poured, pouring molten metal into the so-lined mold, whereby the pressure of the molten metal causes the liner to arrange itself against the walls of the mold, and then solidifying the molten metal in the mold.

7. In the method of casting metal in an ingot mold, the improvement comprising arranging at least one sheet of an asbestos material snugly within the mold with the longitudinal edges of said sheet overlapping one another but free to move relative to each other, said asbestos material having perforations to permit the passage therethrough of

gases, preventing buckling of the liner during pouring by attaching a plurality of generally S-shaped clips over the overlapped edges of said sheet at substantially even-spaced intervals for maintaining the edges of said sheets in an overlapped relationship but free to slide relative to each other to permit expansion of the liner during pouring, said edges overlapping sufficiently to prevent parting of the edges and exposure of the mold walls to the molten metal when poured, pouring metal in the so-lined mold, whereby the pressure of the molten metal causes the liner to arrange itself against the walls of the mold and then solidifying the molten metal in the mold.

References Cited in the file of this patent

UNITED STATES PATENTS

723,454	Foster	Mar. 24, 1903
1,124,093	Woodruff	Jan. 5, 1915
1,859,355	Crowther	May 24, 1932
2,273,543	Terrill	Feb. 17, 1942
2,494,405	Olsen	Jan. 10, 1950
2,518,055	Olsen	Aug. 8, 1950
2,763,043	Grant	Sept. 18, 1956