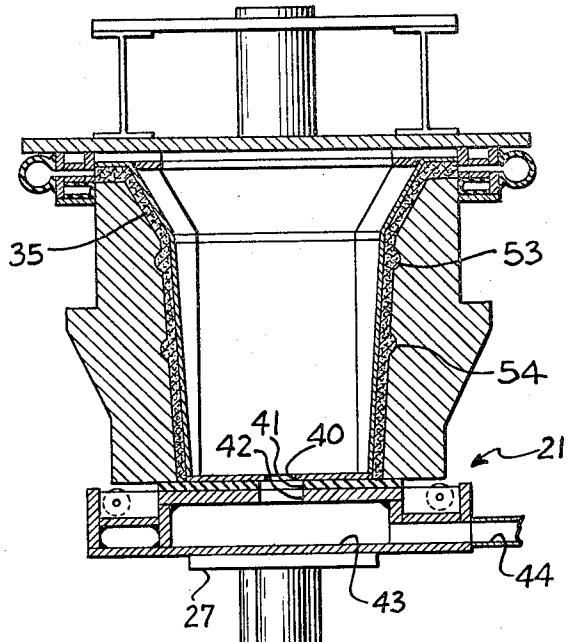
May 21, 1968 F. EASTWOOD 3,384,149

METHOD FOR FORMING HOT TOP LINERS

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Fig. 3



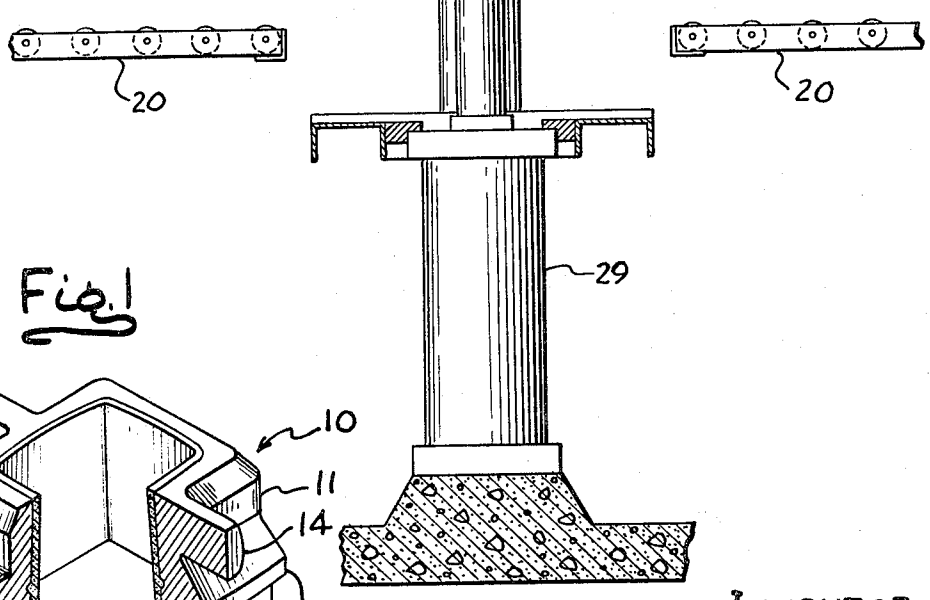
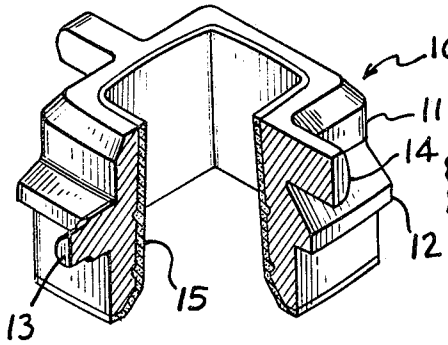


Fig. 1



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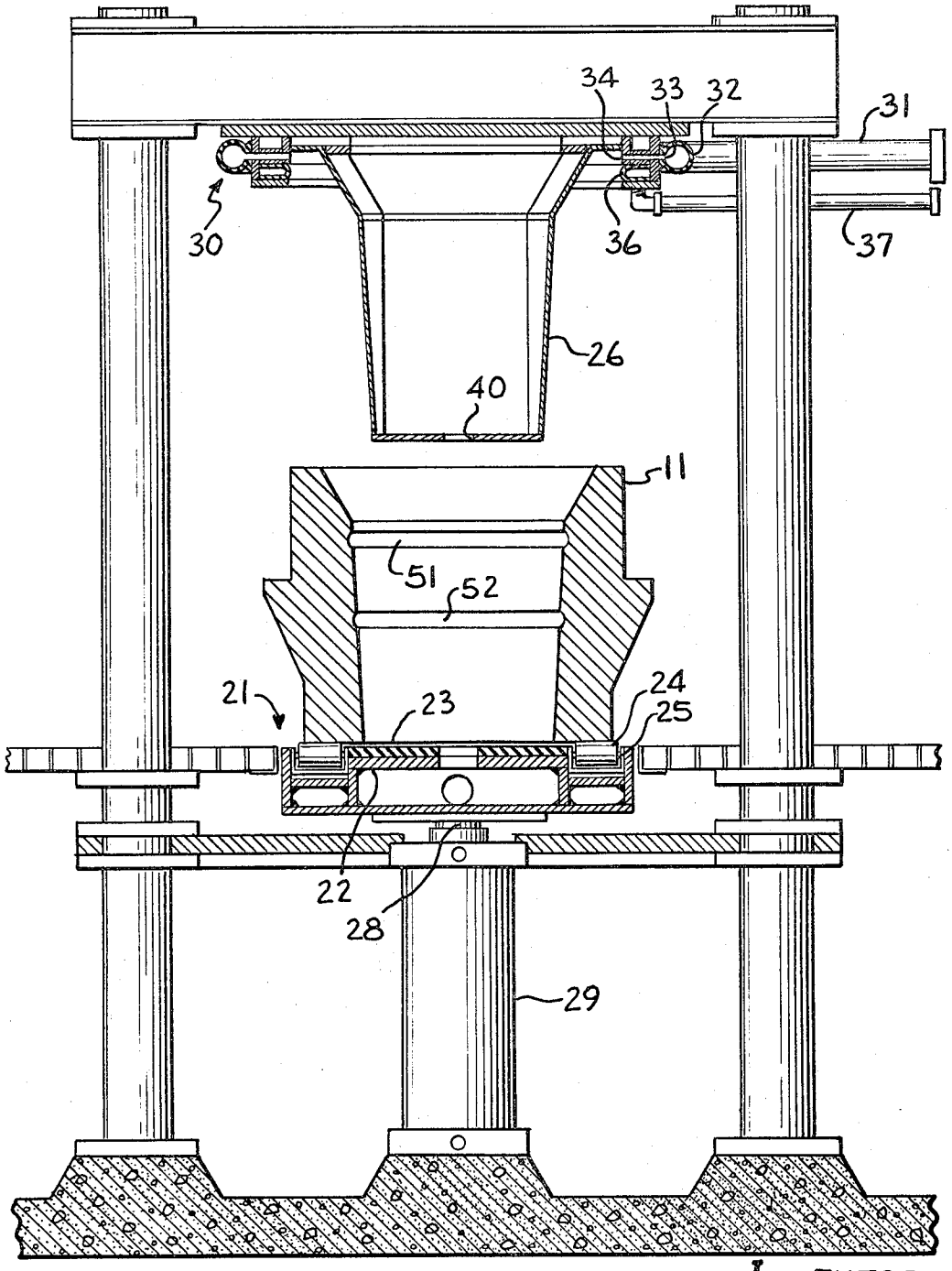


Fig. 2

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3,384,149

METHOD FOR FORMING HOT TOP LINERS

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Filed Dec. 6, 1965, Ser. No. 511,793
8 Claims. (Cl. 164—33)

This invention relates generally to the art of hot topping and, more particularly, to improved method and apparatus for forming heat-insulating liners in a plurality of reusable hot top casings used for casting big-end-up ingots.

In the casting of metal ingots, it is common practice to use a hot top mounted on or at the top of an ingot mold for the purpose of containing "feed" or "head" metal and maintaining it molten while the metal in the ingot mold is solidifying. The metal in the hot top is above and in contact with the metal in the ingot mold so that as the metal in the ingot mold shrinks, the feed metal feeds down into the ingot body and thus prevents the formation of shrinkage cavities in the body of the ingot.

The latest type of hot top in commercial use for the casting of big-end-up ingots today comprises a single metal casing, preferably in the form of a one-piece casting, and a heat-insulating liner on the inner surface of the casing. The casing itself is reusable, but the insulating liner must be replaced after each use, i.e., after the casting of each ingot. The liner is generally made of a relatively low cost composition having good heat-insulating properties, the composition being preformed in self-supporting slabs or sleeves shaped to fit the particular casing in which they are to be used. Then after each use of the hot top, the remnants of the used liner, which usually disintegrates during the casting operation, are removed from the metal casing and replaced by a new preformed liner.

When the heat-insulating liners are preformed in the shape of individual slabs, a typical relining operation consists of driving four slabs down along the four inside walls of the casing with the slabs being wedged against each other in the corners of the casing so as to urge the slabs against the casing walls. This method is described in more detail in copending application Ser. No. 389,656, entitled, "Hot Top for Big-End-Up Ingot Molds," filed Aug. 14, 1964, and assigned to the assignee of this invention. While this method is a vast improvement over prior hot topping methods, it is still a time-consuming operation. The relining operation can be carried out more efficiently when the liner is preformed as a single sleeve which is simply inserted in the casing, rather than a plurality of slabs (also described in the aforementioned copending application) but the adoption of this method on any large scale requires objectionably large storage facilities for the one-piece preformed liners. In addition, the one-piece preformed liners are considerably more costly to ship. It will be appreciated that these increased space requirements for shipping and storing the one-piece liners are due to the large "waste" space inside the liner sleeves. Moreover, since the one-piece liners are generally not tapered to any substantial degree, it is not even possible to telescope the liners to minimize the wasted interior space.

It is, therefore, a primary object of the present invention to provide an improved hot topping method and apparatus which is extremely rapid and which does not require any substantial storage space. More particularly, it is a main object of this invention to provide an improved method and apparatus for forming heat-insulating liners in hot top casings for use on big-end-up ingot molds without time-consuming assembling operations and with

only minimal shipping and storage costs. Stated another way, it is an object of this invention to provide an improved method and apparatus for relining reusable hot top casings in a minimum "turn-around" time and without shipping and storing bulky preformed liners.

It is another object of this invention to provide a method and apparatus of the type described above which can be carried out automatically with little or no manual labor. In this connection, a related object of the invention is to provide such a method and apparatus which greatly reduces overall hot topping costs.

A further object of the present invention is to provide an improved method and apparatus for relining reusable hot top casings which permits significant reductions in the cost of the lining composition. A related object is to provide such a hot topping method and apparatus which eliminates the need for the heat-insulating liner composition to be self-supporting, and thus does not require any costly resin or similar expensive binder material. Another related object is to provide such a hot topping method and apparatus in which it is not critical to remove a sufficient quantity of water or other carrier liquid to render the liner self-supporting. As used herein, the term "self-supporting" refers to a liner which is capable of supporting itself and being handled when it is not engaging any supporting structure whatever.

A still further object of the invention is to provide an improved method and apparatus for relining reusable hot top casings which eliminates the need for a substantial resin content to prevent moisture pick-up in the liner. In this connection, a corollary object is to provide such a method and apparatus which do not involve critical temperatures, because temperature critical resins are not required.

Yet another object of the invention is to provide an improved hot topping method and apparatus which eliminates losses due to breakage of preformed liners during shipping, storage and assembling operations.

It is a further object of the present invention to provide an improved hot top relining method and apparatus which permits the elimination of spring clips and other supplementary devices for retaining the liner in the hot top casing. Thus, a related object is to provide such a method and apparatus which obviates clip holes in the hot top casing and, therefore, eliminates the problem of metal clogging in such holes.

It is still another object of this invention to provide an improved hot topping method and apparatus of the foregoing type which permits the relining of hot top casings of different configurations without carrying a separate stock of preformed liners for each different casing configuration.

Other objects and advantages of the invention will become apparent from the following description and upon reference to the accompanying drawings, in which:

FIGURE 1 is a perspective view of a hot top constructed in accordance with this invention, with one corner of the hot top being broken away to show the internal structure.

FIG. 2 is an end view, partially in section, of a mechanism for forming the insulating liner in the hot top of FIGURE 1; and

FIG. 3 is a side elevation, partially in section of the mechanism of FIG. 2.

When the invention is described in connection with certain preferred embodiments, it will be understood that it is not thereby intended to limit the invention to those embodiments. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

Turning now to the drawings, in FIGURE 1 there is shown a hot top **10** adapted to be mounted on the top of a big-end-up ingot mold, such as used in the formation of steel ingots for example. The hot top serves to delay the solidification of the feed metal or head metal contained within it so that molten metal can feed downwardly into the main body portion of the metal ingot to compensate for shrinkage of the ingot during cooling, thereby preventing the formation of shrinkage cavities in the final ingot. In the particular embodiment illustrated, the hot top **10** includes a one-piece outside metal casing **11**, with the lower portion of the outside surface of the casing **11** being complementally formed with respect to the inside walls of an ingot mold so that the lower portion of the hot top can extend down into the upper portion of the mold.

For the purpose of initially mounting the hot top on the lip of a big-end-up mold, an outwardly projecting flange **12** is formed at about the midpoint of the casing so that the hot top can be set on a plurality of wooden blocks spaced around the lip of the mold. The metal casing **11** is also provided with a pair of trunnions **13** located about halfway up the casing for use in inverting the casing, and another pair of trunnions **14** for lifting the hot top.

In order to provide the thermal insulation required to delay solidification of the molten metal in the hot top during the casting of an ingot, the metal casing **11** is lined on the inside with a thin liner **15** having low thermal conductivity. To provide the required thermal insulation, the liner material preferably has a mean heat diffusivity value over the temperature range of 25° C. to 1500° C. of below about 0.015 centimeter-gram-second units. The term "heat diffusivity" is defined as

$$\sqrt{Kc\rho}$$

wherein K is the thermal conductivity of the material, c is the specific heat, and ρ is the density. Suitable highly thermally insulating compositions are those described in the Davidson Patents Nos. 3,072,981 and 3,123,878. The thickness of the liner can vary for different applications, but in general it should be between about 0.5 and about 1.5 inches.

If desired, a refractory bottom ring may be secured to the lower end of the metal casing **11** for the purpose of preventing the creepage of molten metal up behind the insulating liner **15** and to protect the lower end of the casing **11**. In the illustrative embodiment, however, the bottom ring is obviated by use of an insulating liner which wraps around the lower end of the casing, whereby the liner itself serves the purpose of the bottom ring. However, where it is desired to use a bottom ring instead of a wrap around-type liner, a conventional sand ring may be used and held to the casing by means of conventional spring clips. Also, a conventional wiper strip may be fitted over the lower outside corner of the hot top, extending entirely around the hot top with the upper end of the wiper strip bent outwardly to bear against the mold wall to prevent the molten metal from rising in the gap between the hot top and the mold.

As can be seen in the cross sections formed by the break away in FIGURE 1, the lower inside corner of both the casing **11** and the liner **15** is tapered so as to form a tapered top shoulder on the ingot. This tapered shoulder reduces "overrolling" during processing of the final ingot, and thus increases the yield from each ingot.

In a typical steel mill, ingots are cast in large batches, or "heats." Thus, every time the ingots in a given heat are stripped from the molds in which they are cast, an equal number of hot top casings must be relined before they can be reused in the casting of another heat of ingots. Of course, one of the necessary steps in the relining operation is removal of the residue from the previous liner; the liners usually disintegrate during the casting operation, but sometimes there is still a residue of the used liner which clings to the hot top casing and must be removed therefrom before a new liner can be applied. This cleaning step is not a novel feature in the method of this invention and can be accomplished by any of the conventional cleaning means used for this purpose.

The magnitude of the problem posed by the necessity of relining the hot top casings after each use will be readily appreciated when it is recognized that hundreds or even thousands of ingots are cast every day in a modern steel mill. As mentioned previously, the use of one-piece preformed liner sleeves provides an efficient means of relining the hot top casings between uses, but the space required to ship and store these preformed liner sleeves has mitigated against any widespread acceptance of such a relining method in commercial casting of big-end-up ingots, especially in the larger mills where hundreds or thousands of hot tops must be relined daily.

In accordance with this invention, the hot top casings to be relined are continually transferred to a fixed lining station where a perforated forming tool is telescoped into each casing so as to form an annular cavity between the inside walls of the casing and the outside walls of the forming tool. A slurry comprising finely divided refractory material, a fibrous material, and a liquid carrrier is then fed into the annular cavity, the liquid carrier is withdrawn through the perforated forming tool to build up a composite layer of the fibrous and refractory materials in the annular cavity, and finally the forming tool is telescoped out of the casing and the layer of fibrous and refractory materials so that the layer forms a liner on the inside walls of the casing. To complete the relining operation, the casing is then transferred from the lining station to a drying station where the "green" liner formed by the forming tool is dried sufficiently to permit the casting of molten metal in the relined casing.

The relining method of this invention represents a significant breakthrough in the hot topping art, permitting for the first time complete automation without any preforming operations whatever. Since the liner is completely formed in situ, the method not only can be carried out rapidly without any manual labor, but also does not require any shipping, storage, or handling of preformed liners. In effect, the liner is both formed and stored in the casing. Furthermore, since the liner is always in supporting engagement with the casing walls on which it is formed, there is no need for the liner to be self-supporting. Consequently, the costly resins or other similarly expensive binders which are used to make the preformed liners self-supporting are no longer required, thereby substantially reducing the raw material costs and providing a significant economic advantage over other relining methods. The method of this invention also permits elimination of all supplemental retaining means, such as retaining rings and the like, to hold the liner in place because the in situ forming of the liner enables the use of self-retaining liner configurations.

Turning now to FIGURES 2 and 3 for a more detailed description of a preferred embodiment of the invention, a plurality of one-piece hot top casings **11**, from which the residue of the previously used liner has already been removed, are transported in seriatim by means of a roller conveyor **20** to a fixed lining station including a casing table indicated generally at **21**. The casings **11** are inverted before they arrive at the lining station so that the wider end of the hot top opening is at the top of the casing as it enters the lining station. The casing table **21** includes a central support plate **22** which is covered with a sealing gasket **23**, and both the plate **22** and the gasket **23** are large enough in diameter to overlap the edges of the casing opening. As a casing **11** enters the lining station, it rides over a plurality of rollers **24** which are mounted in vertically movable brackets **25** in a channel formed in the table adjacent the main supporting plate **22**. After the casing **11** has reached a center position on the table **21**, the rollers **24** are lowered by lowering the

brackets 25 so that the casing comes to rest on the sealing gasket 23 on top of the central support plate 22.

After the casing 11 has come to rest on the sealing gasket 23 by lowering of the rollers 24, the entire casing table 21 is raised into telescoped relation with a liner forming tool 26 which is mounted directly above the table 21 in axial alignment therewith. Raising of the table 21 is accomplished by means of a plate 27 mounted on the top end of a vertical piston rod 28 which extends downwardly into a cylinder 29 connected to a suitable source of pressurized hydraulic fluid. The forming tool 26 is complementally formed with respect to the interior of the hot top casing 11 so that after the casing 11 and the tool 26 have been moved into telescoped relationship with each other, an annular cavity is formed between the perforated outside walls of the tool 26 and the solid inside walls of the metal casing 11. Since the tool 26 and the casing 11 are complementally formed with respect to each other, this annular cavity will be of substantially uniform width around the entire circumference of the tool.

After the casing 11 and the forming tool 26 have been moved into telescoped relationship, a slurry containing finely divided refractory material, fibrous material, and a liquid carrier is fed into the annular cavity by means of a manifold assembly 30 extending around the top of the forming tool 26. The slurry is fed into the manifold assembly through a feed pipe 31 which conducts the slurry into an annular manifold tube 32 having a plurality of inside ports 33 opening into corresponding registering passageways 34 communicating with the annular cavity 35 between the casing 11 and the forming tool 26. In order to prevent any leakage of the slurry down along the outside walls of the casing 11, an air filled sealing gasket 36 is mounted directly below the slurry passageways 34 for engaging the outer surface of the hot top casing 11 as it is moved into telescoped relationship with the forming tool 26. Air is supplied to the sealing gasket 36 through a pipe 37 connected to a suitable source of pressurized air.

As the slurry enters the cavity 35 from the manifold assembly 30, the slurry flows downwardly into the cavity 35, which is closed at the bottom by means of the sealing gasket 23 bearing against the bottom of the forming tool, with the carrier liquid being extracted through the perforated walls of the hollow forming tool 26 so as to build up a composite layer of the solid fibrous and refractory material on the outer surface of the tool. The liquid extraction through the perforated walls of the tool 26 is effected by a pressure differential which may be achieved by several different means. For example, the slurry supplied from the inlet manifold 30 is ordinarily under a certain feed pressure, and this pressure itself is sufficient in certain cases to force the carrier liquid from the cavity 35 through the perforated walls into the interior of the tool 26. In addition, a vacuum may be drawn on the inside of the tool 26 so as to increase the pressure differential across the perforated walls and thereby enhance the extraction of carrier liquid therethrough.

In accordance with one aspect of this invention, the liquid extraction process is facilitated by preheating the walls of the casing 11, before it enters the lining station, to a temperature above the boiling point of the carrier liquid so that the liquid is vaporized as it contacts the inner walls of the casing. The resulting increase in pressure within the cavity 35, due to vaporization of the carrier liquid, tends to force the carrier liquid inwardly through the perforated walls into the interior of the forming tool. It will be appreciated that this preheating of the hot top casings will not usually require a separate heating step in a commercial operation, since the casings to be relined are already at an elevated temperature due to the heat absorbed from the molten metal during the previous casting operation. Thus, in a typical commercial operation, the casings reach a relatively high temperature during the casting operation, but by the time a complete heat of ingots has been stripped from the molds and the hot top casings have been cleaned of the used liner residue, the casings have usually cooled to a somewhat lower temperature. This lower temperature is usually more than adequate to vaporize water, which is probably the most common slurry carrier liquid used in this type of operation. The upper limit on the temperature of the casings entering the lining station depends mainly on the charring or burning temperature of the other slurry ingredients. For example, when paper pulp is used as a fibrous ingredient in the slurry, the casing temperature should not be above about 400° F. since temperatures above that level tend to char or burn the paper pulp.

It should be recognized that even though the residual heat in the hot top casings is normally adequate to provide the desired temperature in the casings entering the lining station, it is still necessary to provide a casing preheater in order to heat new casings or casings which have cooled to room temperature during a shutdown. Of course, the process can also be carried out without any casing preheating, but the drying times tend to be excessive in such an operation.

As the carrier liquid is extracted through the perforated walls of the forming tool 26, the extracted liquid is collected inside the forming tool and discharged by gravity through a discharge port formed by an aperture 40 in the bottom of the forming tool 26 and registering apertures 41 and 42 formed in the sealing gasket 23 and the central support plate 22. The discharged liquid then enters an effluent chamber 43 formed in the bottom of the table 21 and then on out through a waste line 44. While the carrier liquid is being extracted through the perforated walls of the forming tool 26, the solid fibrous and refractory material in the slurry are directed against the outer surface of the forming tool, with the fibrous material quickly building up a random mat which acts as a filter to retain the finely divided refractory material within the liner cavity 35 while permitting the carrier liquid to pass through into the interior of the tool. Consequently, a composite layer of fibrous and finely divided refractory material builds up around the outer surface of the forming tool 26 until it completely fills the annular cavity 35, thereby forming a "green" liner on the inner surface of the hot top casing 11.

One of the significant advantages of the present invention is that the insulating liner is formed in situ on the walls of the hot top casing, so that there is no necessity for the liner to be self-supporting as in the case of preformed liners for example. Consequently, the relatively costly resins which are normally used to make the preformed liners self-supporting can be omitted from the slurry composition used in the method of this invention. Moreover, since the lined casings are normally used within a matter of hours after the liner has been formed, there is no problem of moisture pick-up in the casing, and thus again there is no need for the costly resin which is used to minimize such moisture pick-up in preformed liners. The only essential ingredients of the slurry composition, other than the carrier liquid, are a finely divided refractory material and a fibrous material to form the filtering media on the perforated walls of the forming tool and to hold the composite layer together. The fibrous material may be either organic, such as paper pulp, or inorganic, such as asbestos fibers, or a mixture of both organic and inorganic materials. A suitable refractory material is silica flour, although many other finely divided refractory materials known in the art may be used in the place of, or in mixture with, the silica flour. It is generally desirable to include at least a small portion of binder in the slurry composition, but the method of this invention permits the use of inexpensive binders such as wheat flour and the like rather than the costly resins used heretofore. Also, it will be recognized that many other materials may be added to the slurry composition for the purpose of providing the final liner with various properties which may be desirable in different

applications. For example, certain exothermic materials may be included in the slurry to form an exothermic layer. Many other additives are well known to those skilled in the art and may be added as desired for different types of casting operations.

After the liner cavity **35** has been filled the composite layer of fibrous and refractory material, and sufficient carrier liquid has been extracted therefrom to enable the green liner to maintain its integrity on the casing walls, the forming tool and the lined casing are moved relatively away from each other, and the casing is transferred to a drying station to dry the green liner before it is used in the casting of another ingot. In order to break the green liner loose from the outer surface of the forming tool before the tool and the casing are telescoped away from each other, compressed air is admitted into the interior of the forming tool **26** just before the casing table **21** is retracted away from the forming tool **26**. This compressed air applies a brief burst of pressure against the inner surface of the green liner, through the perforated walls of the tool, so as to break the green liner away from the forming tool. Alternatively, other suitable means, such as a collapsible forming tool for example, could be used to break the liner away from the forming tool before the tool and the casing are moved relatively away from each other.

In order to transfer the lined casing away from the lining station after the table assembly **21** has been lowered to its fully retracted position, the transport rollers **24** are raised into engagement with the lower end of the hot top casing so as to raise the casing slightly off the sealing gasket **23**. The casing is then transferred onto a continuation of the roller conveyor **20** which transports the casing and the green liner therein to a drying station where the green liner is dried sufficiently to permit the casting of molten metal in the lined casing. The drying station may take the form of a conventional drying oven or any other suitable drying means. It should be pointed out here that the length of the drying period is considerably shortened by preheating the hot top casings upstream of the lining station, which of course, includes the use of residual heat in the casings to provide the desired preheating effect. It should also be pointed out that the degree of drying required in the liners formed by the method of this invention is not as great as the degree of drying required in preformed liners because there is no necessity for the liners of this invention to be self-supporting since they are formed in situ.

In accordance with a further aspect of this invention, the inside walls of the hot top casing are provided with a recess so that the liner formed in situ thereon projects into the recess to form a self-retaining liner. More particularly, the combination of the casing recess and the complementally formed liner projection serve to prevent the final liner, which often shrinks somewhat during the final drying step, from falling out of the casing when the casing is inverted prior to being mounted on the ingot mold. Thus, the illustrative hot top casing **11** is provided with a pair of peripheral recesses or grooves **51** and **52** extending completely around the inner surface thereof. Consequently, when the insulating liner is formed in situ as shown in FIGURE 3, the recesses **51** and **52** form a part of the annular cavity **35** and thus the composite layer of refractory and fibrous material which fills the cavity projects into these recesses **51, 52**. In other words, the insulating liner is always complementally formed with respect to the inner surface of the hot top casing **11**, and thus any recesses formed in the inner surface of the casing will be occupied by complementally formed projections on the liner which is formed in situ. In the particular configuration illustrated, the two grooves **51, 52** are occupied by complementally formed ribs **53, 54** which serve to prevent axial movement of the liner within the casing. Of course, axial movement of the insulating liner within the casing is not a problem as long as the casing remains in the inverted position shown in FIGURES 2 and 3, but the casing naturally must be inverted at some subsequent point before it is mounted on top of an ingot mold, and it is then that the retaining ribs **53, 54** serve to retain the liner within the inverted casing. It will be recognized that the recesses formed in the inner surface of the hot top casings could be provided with many other configurations, and these recesses will always result in the formation of a complementally formed projection on the insulating liner so as to retain the liner in place within the casing. For example, one alternative configuration would be the provision of a single groove in the upper inside corner of the casing (the lower inside corner in the inverted position shown in FIGURES 2 and 3) so that a complementally shaped flange would be formed on the resultant liner to prevent the liner from dropping out of the casing when it is subsequently inverted. These self-retaining liner configurations have the advantage of eliminating the need for spring clips, or other supplementary devices which are normally used to secure the liner within the casing, thereby eliminating the holes which must be formed in the hot top casing to receive the spring clips and which tend to become clogged with metal.

An alternative embodiment of the present invention comprises forming the green liner on the outer surface of the forming tool before the casing and the tool are moved into telescoped relationship with each other. In this embodiment, the insulating liner is preliminarily formed on the perforated tool by the method described in Ednell Patent 3,066,069, or by any other suitable method. Then when the hot top casing **11** is moved into position at the lining station and raised into telescoped relationship with the forming tool, the green liner has already been formed and it is simply a matter of pressing the casing against the green liner to complete the forming, and then blowing the green liner off the forming tool onto the casing. The casing is then lowered away from the forming tool in the same manner described above and transferred onto the drying station. This method has the advantage of permitting the use of several forming tools at a single lining station so that a green liner can be formed on one tool while the liner previously formed on another tool is being transferred to a casing. Then for the next casing, the roles of the two forming tools would be reversed. In practicing this embodiment of the present invention, the casing is raised until it presses firmly against the green liner on the forming form so as to conform the liner to the exact shape of the casing while the liner is still in a moldable condition. The casing is then lowered away from the green liner until it leaves a gap of approximately one inch or less to facilitate the dislodging of the green liner from the forming tool by a "puff" of compressed air as described above. It has been found that the green liner can withstand the slight impact as it is transferred from the forming tool to the casing, even though no binder resin is included in the liner composition.

As can be seen from the foregoing detailed description, the present invention provides an improved hot topping method and apparatus which permits reusable hot top casings to be quickly relined without the necessity for shipping, packing, storing, and assembling preformed liners. This, of course, results in a number of attendant economic advantages, such as elimination of shipping, packing, and storage costs, elimination of breakage problems, and the possibility of complete automation with no manual labor whatever. This invention also permits significant reductions in the cost of the lining composition by virtue of the fact that the liner does not need to be self-supporting and, therefore, does not require any costly resin to bond the liner ingredients together and/or inhibit moisture pick-up. This facilitates formation of the liner because temperature critical resins are no longer required. Furthermore, this invention permits the elimination of retainer rings because the liner can be formed in situ with a configuration which renders the liner self-

retaining, simply by providing appropriate recesses in the inner surface of the casing being lined. Also, wiper strips can be embedded in the liner before it has been completely dried thereby permitting elimination of the spring clips or other supplementary devices which are used for retaining purposes. The inventive method also makes the dimensions of the hot top casing less critical because the liners which are formed in situ naturally assume the same dimensions as the casing even though these dimensions may vary somewhat from casing to casing.

I claim as my invention:

1. The method of forming heat-insulating liners in hot top casings for use on big-end-up ingot molds, which method comprises the steps of continually advancing a plurality of the hot top casings in seriatim to a fixed lining station, inserting a perforated forming tool into each casing arriving at the fixed lining station so as to form an annular cavity between the inner surface of the casing and the outer surface of the forming tool, feeding a slurry comprising a finely divided refractory material, a fibrous material, and a liquid carrier into said cavity and withdrawing the liquid carrier through the interior of the perforated forming tool so as to build up a layer of the fibrous and refractory materials in said cavity, withdrawing the forming tool from the casing and the layer of fibrous and refractory materials so that said layer forms a liner on the inner surface of the casing, continually advancing each casing away from the lining station and drying the liner therein sufficiently to permit the casting of molten metal in the lined casing, and mounting each casing with its dry liner on a big-end-up ingot mold for the next casting operation.

2. A method of forming heat-insulating liners in a plurality of hot top casings used on big-end-up ingot molds, which method comprises the steps of cooling each casing, after it is removed from a mold and ingot, to a temperature below the burning temperature of the liner to be applied thereto and above the boiling point of the liquid carrier used in forming the liner, continually advancing a plurality of the hot top casings in seriatim to a fixed lining station, inserting a perforated forming tool into each casing arriving at the fixed lining station so as to form an annular cavity between the inner surface of the casing and the outer surface of the forming tool, feeding a slurry comprising a finely divided refractory material, a fibrous material, and a liquid carrier into said cavity and withdrawing the liquid carrier through the interior of the perforated forming tool so as to build up a layer of the fibrous and refractory materials in said cavity, withdrawing the forming tool from the casing and the layer of fibrous and refractory materials so that said layer forms a liner on the inner surface of the casing, and continually advancing each casing away from the lining station and drying the liner therein sufficiently to permit the casting of molten metal in the lined casing.

3. A method of cyclically forming heat-insulating liners in a plurality of hot top casings used for casting big-end-up ingots, which method comprises the steps of removing the used liner from each casing, after it is removed from the mold and ingot after each casting operation, continually advancing a plurality of the hot top casings from which the used liners have been removed to a fixed lining station, inserting a perforated forming tool into each casing arriving at the fixed lining station so as to form an annular cavity between the inner surface of the casing and the outer surface of the forming tool, feeding a slurry comprising a finely divided refractory material, a fibrous material, and a liquid carrier into said cavity and withdrawing the liquid carrier through the interior of the perforated forming tool so as to build up a layer of the fibrous and refractory materials in said cavity, withdrawing the forming tool from the casing and the layer of fibrous and refractory materials so that said layer forms a liner on the inner surface of the casing, continually advancing each casing away from the lining station and drying the liner therein sufficiently to permit the casting of molten metal in the lined casing, and returning each lined hot top casing to the casting area for mounting on a big-end-up ingot mold for another casting operation and subsequent cyclic repetition of the foregoing steps.

4. The method of forming heat-insulating liners in reusable hot top casings for use on big-end-up ingot molds, which method comprises the steps of continually transferring a plurality of the hot top casings in seriatim to a fixed lining station, moving each casing transferred to the lining station into telescoped relationship with a hollow perforated forming tool which is complementally formed with respect to the interior of the hot top casing so as to form an annular cavity between the inner surface of the casing and the outer surface of the forming tool, feeding a slurry comprising a finely divided refractory material, a fibrous material, and a liquid carrier into said cavity and withdrawing the liquid carrier through the interior of the perforated forming tool so as to build up a composite layer of the fibrous and refractory material on the outer surface of said tool until said annular cavity is filled with the composite layer, the inner surface of said casing being provided with a recess whereby the composite layer projects into said recess to retain the composite layer against axial movement within the casing, moving the casing and the composite layer out of telescoped relationship with said forming tool so that the composite layer forms a liner on the inner surface of the casing, and continually transferring each casing so lined away from the lining station and drying the liner therein sufficiently to permit the casting of molten metal in the lined casing.

5. The method of forming heat-insulating liners in reusable hot top casings for use on big-end-up ingot molds, which method comprises the steps of continually transferring a plurality of the hot top casings in seriatim to a fixed lining station, moving each casing which arrives at the lining station into telescoped relation with a hollow perforated forming tool which is complementally formed with respect to the interior of the hot top casing so as to form an annular cavity between the inner surface of the casing and the outer surface of the forming tool, feeding a slurry comprising a finely divided refractory material, a fibrous material, and a liquid carrier into said annular cavity and withdrawing the liquid carrier through the interior of the hollow perforated forming tool so as to build up a layer of the fibrous and refractory materials on the outer surface of said tool until the composite layer completely fills said annular cavity, supplying compressed air into the interior of said forming tool so as to break said composite layer away from the outer surface of said tool and then moving the casing and the composite layer thereon out of telescoped relationship with said forming tool so that said layer forms a liner on the inner surface of the casing, and continually transferring each casing so lined away from the lining station and drying the liner wherein sufficiently to permit the casting of molten metal in the lined casing.

6. The method of forming heat-insulating liners in reusable hot top casings for use on big-end-up ingot molds, which method comprises the steps of continually transferring a plurality of the hot top casings in seriatim to a fixed lining station, providing a hollow perforated forming tool at the fixed lining station, said forming tool being complementally formed with respect to the interior of the hot top casings, contacting the outer surface of said forming tool with a slurry comprising a finely divided refractory material, a fibrous material, and a liquid carrier and withdrawing the liquid carrier through the interior of the perforated forming tool so as to build up a composite layer of the fibrous and refractory materials on the outer surface of said tool, moving said tool with said composite layer thereon and the casing to be lined into telescoped relationship with each other so as to transfer said composite layer from the outer surface of said tool to the

inner surface of said casing, moving said casing with said composite layer thereon and said tool out of telescoped relationship with each other and transferring the resultant lined casing to a drying station, and drying the lined casing at said drying station sufficiently to permit the casting of molten metal therein.

7. The method of forming heat-insulating liners in reusable hot top casings for use on big-end-up ingot molds, which method comprises the steps of continually transferring a plurality of the hot top casings in seriatim to a fixed lining station, providing a hollow perforated forming tool at the fixed lining station, said forming tool being complementally formed with respect to the interior of the hot top casings, contacting the outer surface of said forming tool with a slurry comprising a finely divided refractory material, a fibrous material, and a liquid carrier and withdrawing the liquid carrier through the interior of the perforated forming tool so as to build up a composite layer of the fibrous and refractory materials on the outer surface of said tool, relatively moving said tool with said composite layer thereon and the casing to be lined into telescoped relationship with each other, pressing the casing and the composite layer on the tool into firm engagement with each other to conform said layer to the interior configuration of said casing, relatively moving the casing and the conformed composite layer slightly away from each other, and admitting compressed air into the interior of said tool so as to transfer the composite layer from the tool to the casing.

8. The method of forming heat-insulating liners in reusable hot top casings for use on big-end-up ingot molds, which method comprises the steps of continually transferring a plurality of the hot top casings in seriatim to a fixed lining station, providing a hollow perforated forming tool at the fixed lining station, each of said casings having a tapered shoulder on the lower inside corner thereof and each casing being inverted so that the tapered

shoulder is at the top of the casing as it arrives at the lining station, said forming tool being complementally formed with respect to the inner surface of the hot top casings, said inner surface of each casing including said tapered shoulder and the adjacent end of said casing, contacting the outer surface of said forming tool with a slurry comprising a finely divided refractory material, a fibrous material, and a liquid carrier and withdrawing the liquid carrier through the interior of the perforated forming tool so as to build up a composite layer of the fibrous and refractory materials on the outer surface of said tool, moving said tool with said composite layer thereon and the casing to be lined into telescoped relationship with each other so as to transfer said composite layer from the outer surface of said tool to the inner surface of said casing, moving said casing with said composite layer thereon and said tool out of telescope relationship with each other and transferring the resultant lined casing to a drying station, and drying the lined casing at said drying station sufficiently to permit the casting of molten metal therein.

References Cited

UNITED STATES PATENTS

1,637,532	8/1927	Oliver et al.	162—220
2,366,212	1/1945	Perry	162—397
2,881,680	4/1959	Spengler et al.	92—58
2,896,266	7/1959	Anthony	264—269
2,942,319	6/1960	Anthony	164—33 X
3,066,069	11/1962	Ednell	162—227
3,072,981	1/1963	Davidson	249—201 X
3,120,684	2/1964	Gathmann	164—33 X
3,216,069	11/1965	Anthony	164—33 X

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