United States Patent [19]

Whitacre, Jr. et al.

[11] **3,762,680**

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[54] **HOT TOP FOR INGOT MOLDS**

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Related U.S. Application Data

[63] Continuation of Ser. No. 807,858, March 17, 1969, abandoned.

[52] **U.S. Cl.** **249/197**

[51] **Int. Cl.** **B22d 7/10**

[58] **Field of Search** 249/197, 201, 202

[56] **References Cited**

UNITED STATES PATENTS

3,271,000	9/1966	Thiem et al.	249/197
3,352,530	11/1967	Thiem	249/202
3,437,308	4/1969	Thiem et al.	249/202
3,103,046	9/1963	LaBate	249/197
2,952,055	9/1960	Gottschalk	249/201
3,680,827	8/1972	Rausch	249/202

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[57] **ABSTRACT**

A hot top for use in connection with the pouring and forming of metal ingots in molds. The hot top is of the type which would tend to float on molten metal if not secured to the mold and it includes integral means not connected to the mold for preventing floating and for restraining seal leaks of molten metal through the space between the bottom portion of the hot top and the interior mold wall.

9 Claims, 6 Drawing Figures

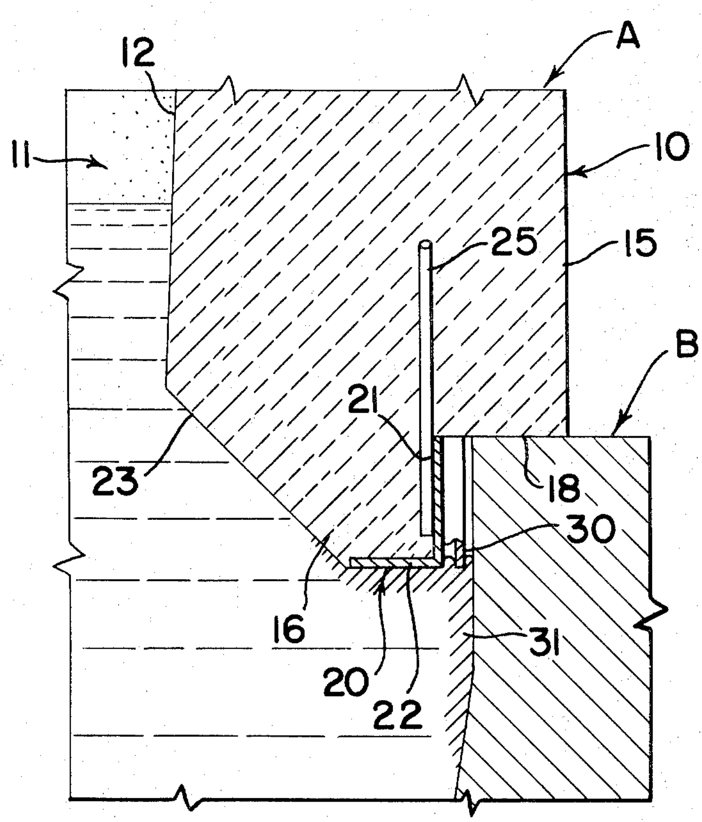
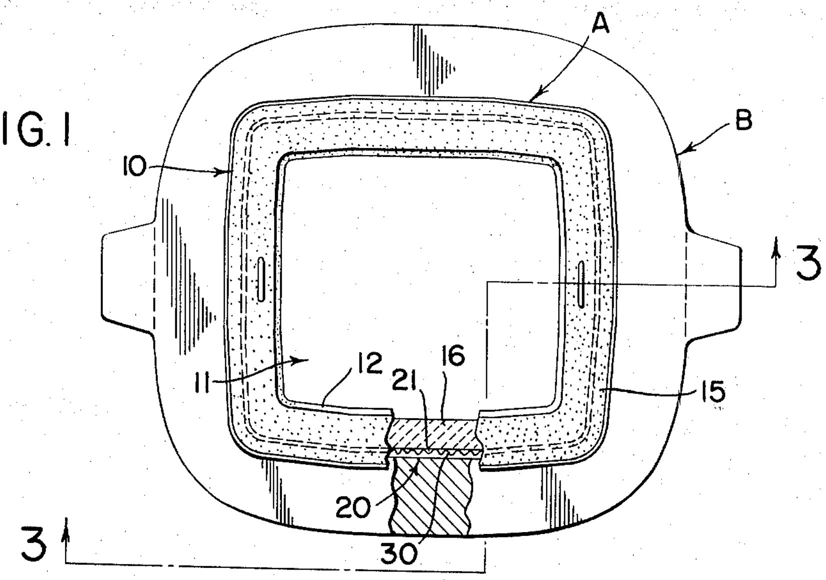


FIG. 1



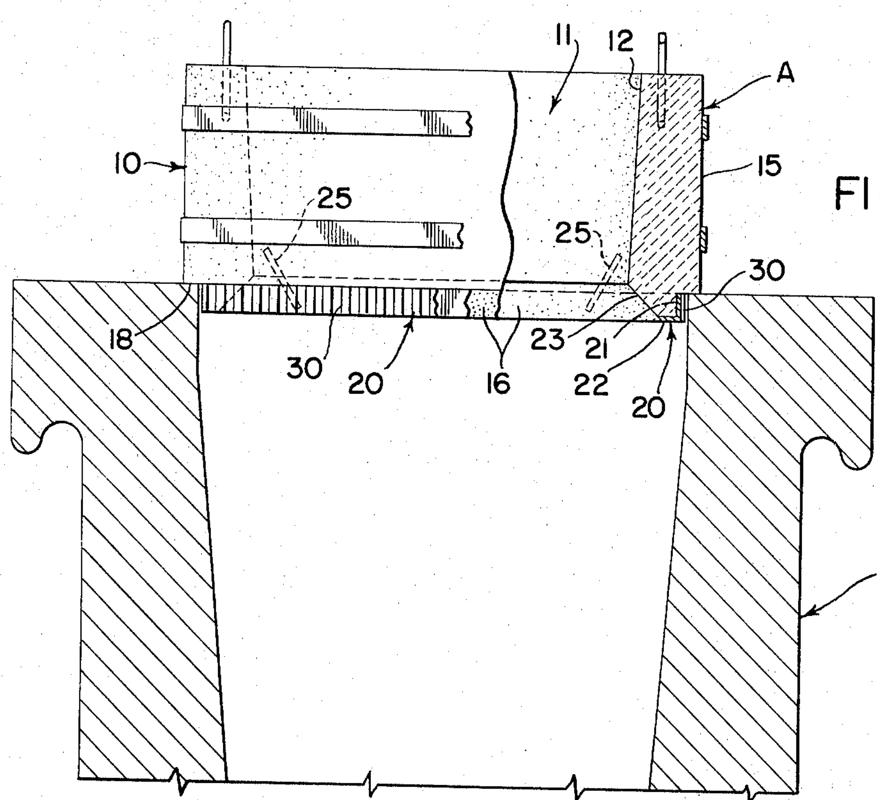


FIG. 3

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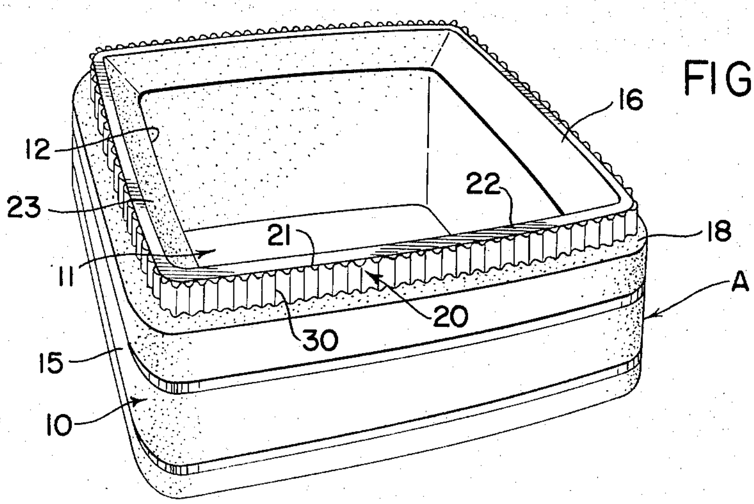


FIG. 2

FIG. 4

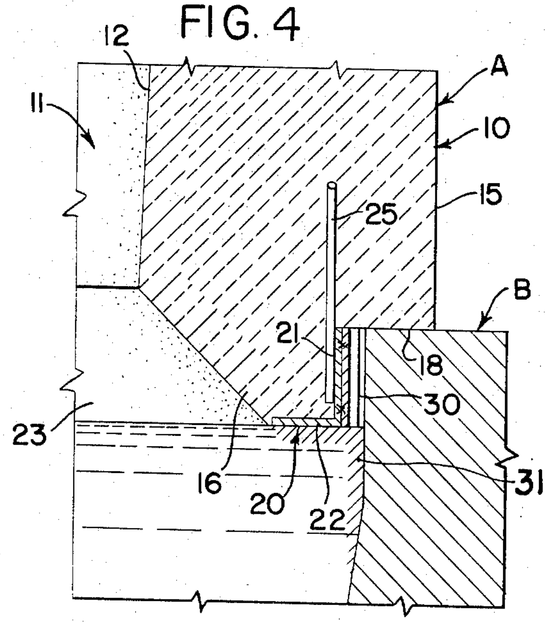
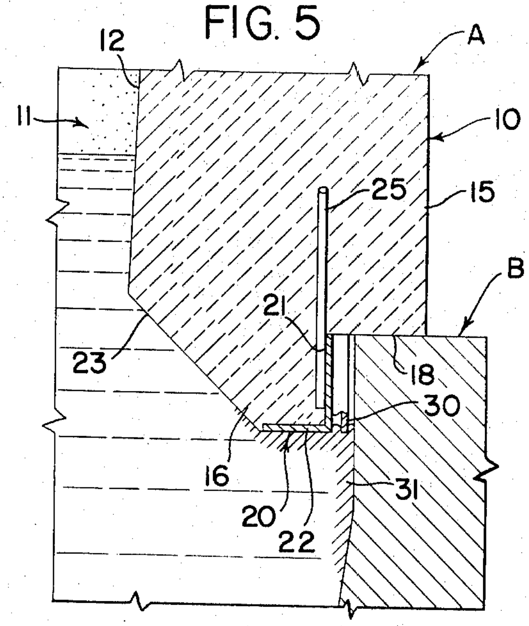


FIG. 5



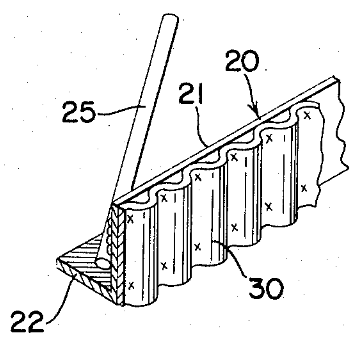


FIG. 6

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HOT TOP FOR INGOT MOLDS

This application is a continuation of Ser. No. 807,858 filed Mar. 17, 1969, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to the forming of metal ingots from molten metal and especially the forming of steel ingots. More particularly, the invention relates to hot tops for ingot molds such as are used to form a reservoir of molten metal above the top of the mold, from where the molten metal sinks or drains down into the central part of the ingot as the metal cools and shrinks to prevent the formation of voids or in other words, the condition known in the art as "piping." It is desirable to keep the metal in the hot top in a molten state as long as possible to continually fill in the vacated spaces as the metal chills.

Hot tops conventionally take the form of perimetric sleeves which have a lower portion adapted to fit in the open end of the ingot mold, and an upper portion with extending supports adapted to rest on top of the mold. Such hot tops form a funnel through which molten metal may be poured. As the molten metal may in some instances "float" the hot top, due to the buoyant force of the liquid, means are sometimes necessary for fastening the hot top to the mold or to provide sufficient weight in the hot top to overcome the buoyant force.

One prior art hot top for example, is formed of cast iron and accordingly is extremely heavy — 1,600 lbs. in a typical instance. This type is costly to manufacture and is used over and over again with the provision of a new refractory lining each time it is used. For this reason it is commonly called a permanent hot top. The weight prevents floating of the hot top as the ingot is poured but the hot top must initially be positioned on and removed from the mold by an overhead crane and after the ingot is formed, it must often be cleaned of metal splashing etc. with torches. Also, removal of the hot top from the ingot and mold is difficult and sometimes delays the charging of a stripped ingot into the soaking pit for more than the allotted time between pouring or teeming, with the result that the ingot must be scrapped.

Such heavy cast iron hot tops often use a metal wiper strip which contacts the molten metal as it rises in the mold and which hopefully prevents the metal from leaking out. It is common practice, however, for the cross-sectional dimensions of the mouth of the mold to vary as much as plus or minus one quarter inch from mold to mold and since the hot tops are generally all a standard size for a given series of molds, there may be a substantial space between the sides of the downwardly extending lower portion of the hot top and the adjacent interior wall of the mold.

In some instances, the metal does not freeze or solidify between the hot top and the mold and thus leaks out due to the ferrostatic pressure (or liquid head) as the molten metal is poured to a relatively high level inside the hot top. Even after pouring is completed the metal may continue to leak out between the mold and the hot top and overflow the top edge. As more and more metal overflows the top of the mold due to the ferrostatic pressure, the overflow may become severe enough to cause the ingot to "hang" on the solidified part and the resulting "hanger cracks" often ruin the ingot which must then be scrapped and remelted.

The permanent hot tops are so inherently plagued with the leakage problem that common practice in the art is to first pour the ingot up to the point where the molten steel first contacts the bottom of the hot top. Then pouring is stopped for about 15 to 20 seconds to permit more solidification of the metal, after which additional molten metal is poured to fill up the hot top. This practice has limitations from a metalurgical point of view, however, and results in a diminished metalurgical quality of the ingot.

More recent prior art practices have incorporated so-called "consumable" hot tops. These hot tops are formed of a refractory material such as sand, or dolomite molded with a resin binder into the desired form. The heat of the molten metal eventually burns away the resin during and after teeming and the sand or dolomite can easily be knocked off the neck or crop of the ingot once the metal solidifies.

Another technique which is used in connection with hot tops to improve the quality of the ingot is the provision of an exothermic lining within the hot top which burns during and after teeming and thus maintains the metal in a molten state for a longer period of time to facilitate the sinking of the molten metal into the spaces in the central core zone of the ingot as the metal shrinks upon solidification.

Since the above described "consumable" hot tops are much lighter than those formed of steel, means must be provided to secure them to the mold to prevent floating which will ruin the ingot. Many techniques have been proposed to secure the hot top such as that disclosed in U. S. Pat. No. 3,212,750 to La Bate wherein external hold down ties are shown and described for this purpose. Other lightweight consumable hot tops have used wiper strips secured to the bottom of the hot top, which are resilient and which grip the wall of the mold. See e.g. U. S. Pat. No. 3,110,942 to Thiem et al. These, however, are not always effective and in most cases are quickly melted by the rising metal so that generally external hold down or tie down means have been required.

The unique hot top construction of the present invention, however, resolves many of the difficulties indicated above and affords other features and advantages heretofore not obtainable.

SUMMARY OF THE INVENTION

It is among the objects of the invention to prevent "floating" of a lightweight consumable hot top during the pouring of molten metal into an ingot mold.

Another object is to restrain leakage of molten metal from an ingot mold through the space between the lower portion of a hot top and the adjacent interior wall at the mouth of the ingot mold.

Still another object is to provide a lightweight consumable hot top for an ingot mold which is of minimum vertical height and which is capable of forming a neck at the upper end of an ingot with a maximum transverse cross section.

A further object is to provide a consumable hot top for a big-end-up type ingot mold which will enable the ingot to be poured "straight up" or in other words without a break before filling the hot top.

A still further object is to reduce the "sinking" or "dishing" of the molten metal in a lightweight consumable hot top so that the neck formed by the hot top has a relatively greater height in the center thereof.

These and other objects are accomplished by an improvement in a hot top for an ingot mold, which hot top is disposed prior to pouring of an ingot, with its lower end disposed in the upper end or mouth of the ingot mold and which defines an interior funnel for pouring molten metal into the mold, the composition of the hot top being such that it would tend to float as the level of the molten metal rises in the mold during pouring. The improvement resides in a metallic means secured to the bottom of the hot top, the metallic means having a sufficient mass and sufficient heat capacity to resist being melted upon contact with the rising surface of the molten metal, and being adapted to weld to the molten metal and freeze a layer thereof which becomes bonded thereto. By inducing freezing of the molten metal of the ingot, the hot top is thus anchored to the initial skin of solidified metal adjacent the wall of the mold so as to prevent floating of the hot top relative to the mold as the metal is poured to a maximum level within the hot top.

According to one aspect of the invention, a second metallic member is secured to the bottom portion of the hot top between the side of the bottom portion and the wall of the mold to define a space of reduced and broken cross-section there-between and thus to restrain the formation of seal leaks caused by molten metal rising between the lower portion of the hot top and the mold, and escaping from the top of the mold.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a hot top embodying the invention and positioned in the opening of a big-end-up type ingot mold, parts being broken away and shown in section;

FIG. 2 is a bottom perspective view of the hot top of FIG. 1;

FIG. 3 is a side elevation of the hot top of FIG. 1 on a larger scale and with parts broken away and shown in section as indicated by the line 3—3 of FIG. 1;

FIG. 4 is a fragmentary sectional view drawn to a still larger scale and showing the hot top and mold of FIG. 1 with molten metal poured approximately to the level of the bottom of the hot top;

FIG. 5 is a fragmentary sectional view drawn to an enlarged scale, and similar to FIG. 4 showing the molten metal poured to a relatively high level within the hot top;

FIG. 6 is a fragmentary perspective view on an enlarged scale showing in particular the construction and attachment of the seal leak restrainer member forming a part of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

While the invention is applicable to many different types of hot tops and to many variations in construction thereof, for the purpose of illustration the invention will be described with respect to the consumable type generally formed for the most part of a particulate refractory material bonded with a resin and having a lining portion formed of an exothermic material which burns as the ingot solidifies. The exothermic lining maintains that portion of the molten metal within the hot top itself in a molten state for a sufficient period of time to enable molten metal to flow downward into the mold as the metal solidifies and shrinks.

Referring more particularly to FIG. 1 there is shown a hot top A positioned in the open end of a big-end-up type ingot mold B for making steel ingots. The ingot mold B is of conventional form and has a rectangular transverse cross-section which tapers from a larger dimension at the top to a smaller dimension at the bottom to facilitate stripping of a metal ingot from the mold B once the molten metal solidifies.

The hot top A which is shown positioned in the open upper end of the mold B generally comprises a main body portion in the form of a perimetric wall broadly indicated by the numeral **10**, which defines a central opening or funnel **11** through which molten metal may be poured into the mold B. The wall **10** has an interior lining portion **12** formed of an exothermic material adapted to ignite and burn during the initial pouring and solidification of the molten metal to help maintain the metal in the hot top in a molten state for as long as possible to avoid "piping." The perimetric wall **10** and lining **12** are molded and bonded together with a resin into the desired form. The perimetric wall **10** may be formed for example of dolomite bonded together with a phenolic resin and the exothermic lining **12** may be formed for example of the components listed below in tabular form:

Fired Kyanite (Al_2O_3) - (SiO_2)
Aluminum Dross (Al-Al_2O_3)
Ferro Silicon ($FeSi$)
Aluminum Powder (Al)
Manganese Dioxide (MnO_2 - MnO_3)
Iron Oxide (Fe_2O_3) (Fe_3O_4)
Flux [e.g. Sodium Fluoride (NaF_2) Potassium Fluoride (KF_2) Calcium Fluoride (CaF_2)]
Resin binder (e.g. a phenolic resin or a urea based resin)

Other suitable formulations and typical proportions of the various constituents are listed in the following patents for example:

U. S. Patent No. 2,490,327 Soffel; 2,591,105 Strauss et al.; 3,006,046 Shephard et al.; 3,025,153 Cross; 3,060,533 Marburg; 3,082,104 Belz.

The perimetric wall **10** is formed with an upper portion **15** which extends entirely above the top of the mold and a lower portion **16** which is formed with smaller longitudinal and lateral outer dimensions and which extends into the open end of the mold entirely below the top surface thereof. Between the upper portion and lower portions **15** and **16** respectively is a shoulder **18** which rests against the top of the mold.

In accordance with the invention, the hot top has a metallic bar **20** of "L-shaped" cross-section, which is formed of hot rolled steel or wrought iron of a thickness for example of about 3/32 inch. The bar **20** serves as an anti-float means in a manner to be described below and has the vertical leg **21** of its "L-shaped" cross-section disposed adjacent the outer surface of the lower portion **16** of the perimetric wall **10** and its lower horizontal leg **22** extending the full width of the bottom of the wall. The lower portion **16** of the perimetric wall **10** has its inner surface **23** flared outwardly and downwardly as best illustrated in FIGS. **4** and **5**.

The anti-float bar **20** is secured to the perimetric wall **10** by means of upwardly and diagonally extending integral anchoring arms **25** welded to the vertical leg **21**, and embedded in the body of the perimetric wall **10** at spaced locations all away around the circumference of the bar **20**.

A seal leak restraining member **30** in the form of a perimetric band of corrugated metal of relatively thin form is positioned around the lower portion **16** of the perimetric wall adjacent the vertical leg **21** of the anti-float bar **20** as best shown in FIGS. **2** and **6**. The seal leak restrainer **30** is secured to the anti-float bar **20** and hence to the hot top body by means of spot welds at spaced locations all around the lower portion **16**. Other securing means may be used, however, as desired.

OPERATION

FIGS. **4** and **5** best illustrate the operation of the anti-float bar **20** and seal leak restrainer **30** in accordance with the invention. FIG. **4** shows molten metal being poured into the ingot mold with its surface being at about the level of the bottom of the horizontal leg **22** of the anti-float bar **20**. As soon as the hot molten metal contacts the relatively cool bar **20**, it loses heat to the bar and thus chills and solidifies while at the same time forming a weld therewith. This occurs simultaneously with the forming of a solidified outer skin **31** immediately adjacent the relatively cool walls of the mold. The solidified portions of the ingot adjacent the anti-float bar **20** and the mold wall are contiguous with one another and therefore form a bond and prevent floatation which would otherwise be caused by the buoyant force of the metal as it rises in the central opening portion of the hot top. FIG. **5** best illustrates this condition and it will be seen that the solidified material is truly locked to the hot top to prevent it from rising.

In the event the space between the bar **20** and the wall of the mold is too great to form a continuous solidified portion bridging the gap between them it is possible that molten metal may rise up between the space between the vertical leg **21** of the anti-float bar **20** and the mold where the seal leak restrainer **30** is located. The seal leak restrainer is so thin that the lower portion thereof will probably be melted by the rising metal. However, as the metal rises it gives up heat to the seal leak restrainer and to the wall of the mold as well as to the adjacent vertical leg of the anti-float bar **20** so that solidification occurs before the rising molten metal can reach the top of the mold and leak out.

Accordingly, the unique hot top construction of the invention performs two related functions, namely that of welding to the metal and simultaneously chilling the metal adjacent the anti-float bar so as to make a continuous mass of solidified metal from the chilled skin along the mold wall to the anti-float bar. This accordingly locks the bar to the solidified portion of the ingot and prevent floating. The second function is to prevent the formation of seal leaks even though the hot top may be locked in place, the seal leaks arising from the escape of metal from an excessive space between the lower portion **16** of the hot top and the interior mold wall. This possibility is obviated by means of the seal leak restrainer **30** which is positioned in the space to break the space into a number of smaller passages and also to rob heat from the metal so that before it reaches the top of the passage it solidifies to plug the space and prevent leakage. The reduction in the incidence of "hanger cracks" due to the seal leak restrainer **30** is particularly significant and increases the overall yield from a pour by reducing the number of ingots which must be scrapped.

A most significant advantage is that the hot top A permits ingots to be poured "straight up" or in other words without a 20 second pause in the pouring as the level of molten metal reaches the junction of the mold and the hot top, as has been universally required in the prior art practices to prevent seal leaks. The "straight up" pour both reduces pouring time per heat and also improves the metallurgical quality of the ingot. This advantage is particularly important where a defective ladle stopper makes it necessary to pour continuously with no pause in the pouring as the ladle moves between molds. This condition is often called a "full runner" in the steel making art.

As compared with permanent type hot tops, the hot top A reduces the time required in each heat to remove the hot tops from the molds and ingots (e.g. no crane is required) and to strip the ingots from the molds. Accordingly, there is less delay in getting ingots into the soaking pits.

Also, the invention reduces labor costs in the ingot pouring phase of steel making by eliminating the need for lining permanent hot tops with refractory material, for repairing and maintaining permanent hot tops — particularly after running stoppers, and for removing or stripping the permanent hot tops with an overhead crane after pouring.

It will be understood that the advantages mentioned can also be derived with other constructions of hot tops or the like, even those hot tops which are formed of cast iron so that the weight alone of the hot top prevents floating. In the cast iron hot top, the invention may be used to prevent seal leaks and also to reduce the weight of metal needed to prevent floating and thus reduce cost.

While the invention has been shown and described with respect to specific embodiments thereof, this is intended for the purpose of illustration rather than limitation and other variations and modifications will be apparent to those skilled in the art upon a reading of the specification and claims. Accordingly, the patent is not to be limited in any way that is inconsistent with the extent to which the progress in the art has been advanced by the invention.

What is claimed is:

1. A hot top for an ingot mold with a bottom part adapted to fit into the upper end of the mold with a perimetric gap between said part and the inside surface of said mold, said bottom part comprising externally exposed, perimetrically disposed, rigid, metallic, angle-shape, integral freezing means extending all around said part and integrated therewith and comprising the lower and outer exterior portions of said part with its interior surfaces within said part and having an exterior annular vertical surface spaced from and facing said inside surface of the mold across said gap and having an annular downwardly facing surface on the bottom of said part exposed to direct contact with the rising teeming molten ingot adjacent said gap and having thickness, rigidity, mass and heat capacity per unit of exposed surface area sufficiently greater than prior flexible wiper strips to induce quick-freezing of solid skin on the top of the molten ingot to said bottom surface upon contact therewith and promote progressive freezing of said skin beyond said means toward the adjacent inside surface of the mold tending to bridge said gap while the frozen shell of the ingot, which freezes progressively by losing heat to the mold, grows toward said progressively freezing skin at said gap, said skin and said shell tending to merge and bridge all the perimetric length of said gap before the head of molten metal rising in said hot top can induce harmful leakage through said gap, said bottom part other than said freezing means being consumable and said metallic freezing means comprising an L-shaped bar with said annular vertical surface of said bar comprising the outer side of said part exposed to molten metal in said gap; no part of said bar bridging said gap, said bar influencing molten metal in said gap thermally rather than mechanically.

2. The hot top of claim 1 wherein said means has sufficient mass and specific heat to close said gap while said mold and hot top are filled in one uninterrupted, continuous pour.

3. The hot top of claim 1 in which said means becomes welded and bonded to said skin.

4. The hot top of claim 1 in which said metallic means comprises an angled bar about 3/32 inch thick comprising the lower outer edge and corner of said bottom part with a vertical leg exposed to said gap.

5. The hot top of claim 4 wherein said metallic means comprises a corrugated metal band associated with said vertical leg in said gap.

6. A hot top for an ingot mold with a bottom part adapted to fit into the upper end of the mold with a perimetric gap between said part and the inside surface of said mold, said bottom part comprising externally exposed, perimetrically disposed rigid metallic freezing means extending all around said part and having an annular surface on the bottom of said part exposed to contact with the teeming molten ingot adjacent said gap and having thickness, mass and specific heat sufficient to induce quick freezing of solid skin on the top surface of the molten ingot under said bottom part upon contact with said means and to promote progressive freezing of said skin beyond said bottom part toward the adjacent inside surface of the mold in said gap while the shell of the ingot, which freezes progressively by losing heat to the mold, grows toward said progressively freezing skin in said gap, said skin and said shell bridging and closing all of said gap before the head of molten metal rising in said hot top induces leakage through said gap, said hot top having a corrugated metal band with vertically extending undulations associated with said means and disposed in said gap.

7. In a consumable hot top for an ingot mold which tends to float on molten metal being cast in the mold and is adapted to rest on the top of the mold with its bottom end entering and fitting with a perimetric gap within the open upper end of the mold, the improvement comprising rigid, metallic, perimetric freezing means spaced from the interior of the mold across said gap and compatible with the metal being cast to weld and bond therewith by contact with molten metal rising in the mold and freezing a skin thereon bonded to said means, said means being closely attached interiorly to the bottom end of the hot top and exposing only an exterior weldable surface area to said molten metal at the bottom end of said hot top throughout the whole perimeter thereof adjacent said gap for making a perimetric welded bond between said means and said skin, said mold chilling the teeming ingot metal adjacent the inside surface thereof and forming a progressively thickening frozen shell containing the liquid metal of the ingot, and said freezing means promoting the freezing of said skin across said gap toward the inside surface of the mold to join said shell to overcome the tendency of the hot top to float as it is filled with molten metal, said means having sufficient mass and specific heat per unit of exposed area to freeze said skin, preserve the attachment of said means to the hot top and promote the freezing of said skin into juncture with said shell, said means having its mass and heat capacity concentrated at the lower, outer perimetric edge of the bottom end of said hot top, said means being angled and comprising the exposed lower, outer corner of said bottom end of said hot top with one leg covering substantially the whole bottom surface of said end and one leg covering the adjacent perimetric side of said end.

8. The improvement of claim 7 wherein said frozen skin is also chilled by said side leg and tends to join and become coextensive with said shell in said gap.

9. In a consumable hot top for an ingot mold which tends to float on molten metal being cast in the mold and is adapted to rest on the top of the mold with its botton end entering and fitting with a perimetric gap within the open upper end of the mold, the improvement comprising rigid, metallic, perimetric freezing means spaced from the interior of the mold across said gap and compatible with the metal being cast to weld and bond therewith by contact with molten metal rising in the mold and freezing a skin thereon bonded to said means, said means being closely attached interiorly to the bottom end of the hot top and exposing only an exterior weldable surface area to said molten metal at the bottom end of said hot top throughout the whole perimeter thereof adjacent said gap for making a perimetric welded bond between said means and said skin, said mold chilling the teeming ingot metal adjacent the inside surface thereof and forming a progressively thickening frozen shell containing the liquid metal of the ingot, and said freezing means promoting the freezing of said skin across said gap toward the inside surface of the mold to join said shell to overcome the tendency of the hot top to float as it is filled with molten metal, said means having sufficient mass and specific heat per unit of exposed area to freeze said skin, preserve the attachment of said means to the hot top and promote the freezing of said skin into juncture with said shell, said means having its mass and heat capacity concentrated at the lower, outer perimetric edge of the bottom end of said hot top, and a corrugated band of compatible metal associated with said means in said gap between the said bottom end of the hot top and the inside of the mold and with the flutes and crests of the corrugations extending vertically whereby to aid in freezing said skin and bridging frozen skin and shell between the said bottom end of the hot top and the said inside surface of said mold.

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