

Nov. 11, 1969

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3,477,493

METHOD OF MAKING A REFRACTORY HOT TOP PANEL INSERT

Filed May 4, 1967

2 Sheets-Sheet 1

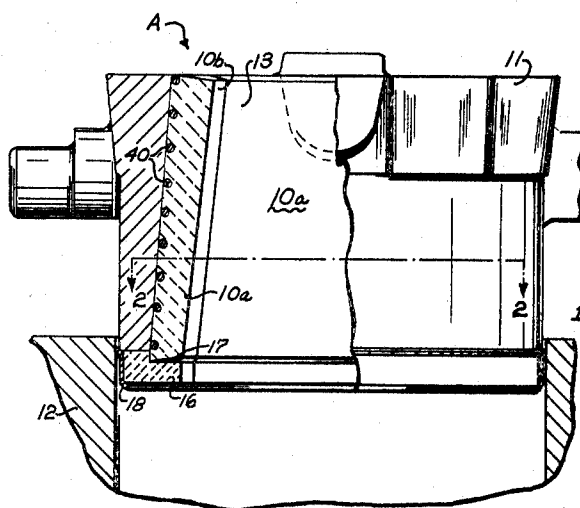


FIG. 1

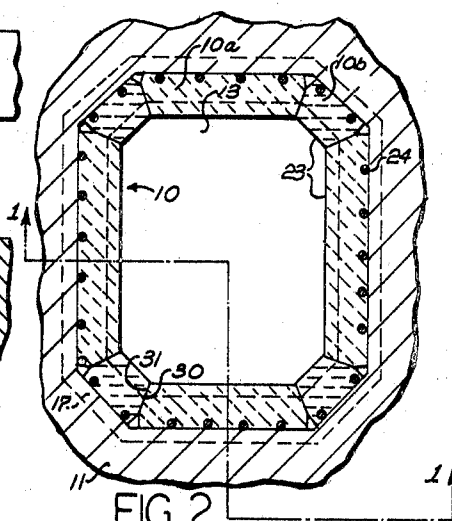


FIG. 2

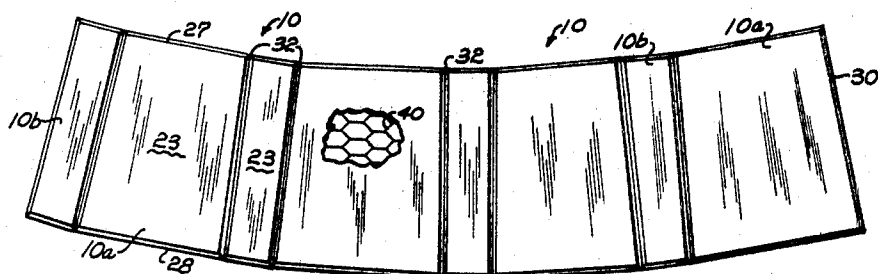


FIG. 3

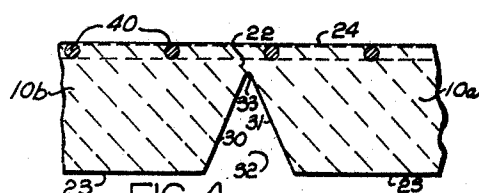


FIG. 4

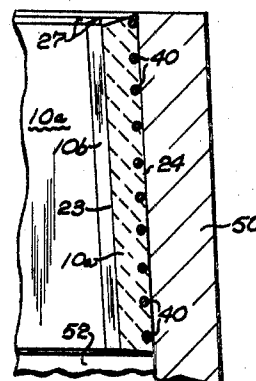


FIG. 5

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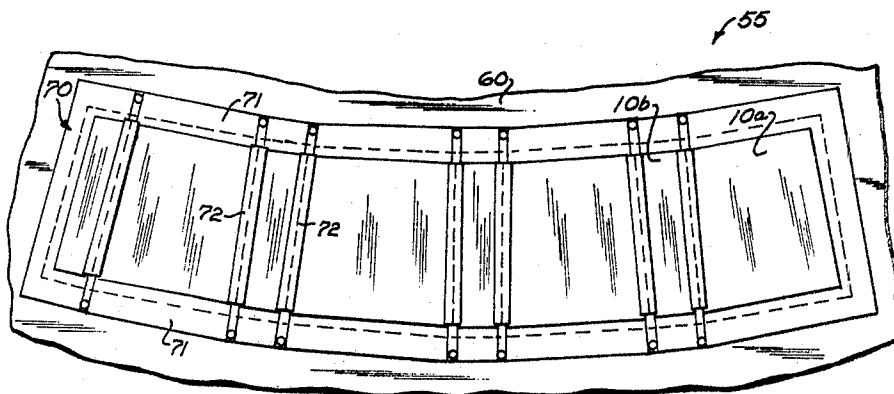


FIG. 6

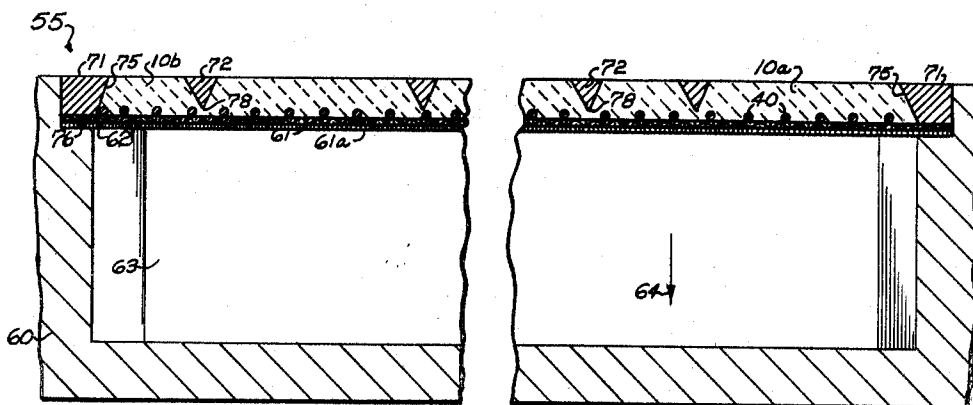


FIG. 7

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METHOD OF MAKING A REFRACTORY HOT TOP PANEL INSERT

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3 Claims

ABSTRACT OF THE DISCLOSURE

A refractory panel insert unit to be surrounded by an ingot mold wall or a hot top casing includes a plurality of highly insulating refractory panels which are integrally connected by frangible refractory connecting portions. A wire mesh netting is embedded at least partially in the back of the panels and provides a hinge interconnection between the panels upon breaking of the frangible connecting portions. The entire insert unit is manufactured by making a slurry of sand, a resin binder, an inorganic fibrous material, and water, and depositing the slurry on a filter screen in a frame over a vacuum box, and embedding the wire netting in the layer of slurry. Applying a vacuum under the filter screen in the vacuum box effects removal of part of the water from the slurry and leaves a wet mat in which is embedded wire netting. The wet mat is then dried to form the highly insulating refractory panel insert unit.

The present invention relates to a hot top structure and a method of making the same, and more particularly to a refractory panel insert unit having a plurality of interconnected panel sections which are relatively movable to form a tubular container at the upper end of an ingot mold to permit metal in a molten state to be fed to the solidifying metal in the ingot mold to compensate for shrinkage of the metal during solidification thereof.

The present invention relates to a method of making an insulating panel insert unit comprised of a plurality of flat panels interconnected by flexible hinge means so that the panels may be moved from a flat position to a closed configuration defining a tubular structure.

An object of the present invention is to provide a new and improved method for making a highly insulating unit of the type described in which the hinge means is embedded in frangible portions extending between adjacent panels and folded integrally with the panels.

A still further object of the present invention is to provide a new, and improved method for making a highly insulating panel insert unit of the kind described, and which includes the steps of placing the flexible hinge backing, preferably a flexible wire netting or screen on the filter screen of a vacuum box, placing a contoured molding frame shaped so as to form the refractory panels and panel connecting portions over the flexible wire netting and on the filter screen, pouring a refractory slurry into the contoured molding frame, and partially vacuum de-watering the refractory slurry to form or mold a wet refractory mat, removing the contour molding frame from the wet mat panels, and drying the wetness out of the mat by oven baking or other means to form the highly insulating panel insert unit.

Another object of the present invention is to provide a new and improved method for making a panel insert unit as defined in the next preceding object, and wherein the grooves which define the joint surfaces of the panels are formed by positioning bars in the molding frame and which are spaced from the vacuum filter screen, and the molding method is carried out by creating a vacuum

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beneath the filter screen to remove most of the liquid from the slurry after the slurry is poured into the mold and flows beneath the bars and around the wire netting to provide the frangible portions integrally interconnecting the adjacent panels.

The present invention further resides in various novel constructions and arrangement of parts, and further objects and advantages of the present invention will be apparent to those skilled in the art to which it relates and from the following detailed description of the illustrated embodiment thereof made with reference to the accompanying drawings forming a part of this specification and in which similar reference numerals are employed to designate corresponding parts throughout the several views, and in which:

FIG. 1 is a fragmentary view, partly in elevation and partly in section, of a hot top embodying the present invention and taken approximately along line 1-1 of FIG. 2 and shown mounted in the open upper end of an ingot mold;

FIG. 2 is a fragmentary sectional view taken approximately along line 2-2 of FIG. 1;

FIG. 3 is a view of a panel insert unit embodying the present invention and illustrates the insert unit in its unfolded condition;

FIG. 4 is an enlarged fragmentary transverse sectional view of the panel insert unit shown in FIG. 3;

FIG. 5 is a fragmentary vertical sectional view showing an insert unit of the present invention positioned in the open upper end of an ingot mold;

FIG. 6 is a fragmentary and somewhat schematic top plan view of an apparatus for use in making the panel insert unit shown in FIG. 3; and

FIG. 7 is an enlarged fragmentary longitudinal cross-sectional view of the apparatus shown in FIG. 6.

The present invention provides a novel panel insert unit and method of making the same, and more particularly provides a novel preformed panel insert unit 10 having a plurality of integrally connected panels or panel sections 10a, 10b which are relatively movable to provide a multisided tubular container at the upper end of an ingot mold to hold a mass of metal in a molten state above the ingot mold to compensate for shrinkage of the metal in the mold during solidification thereof. Although the preformed panel insert unit 10 can be embodied in or is susceptible for use with various types of hot top constructions, it is particularly useful when folded and inserted in a hot top casing, to form a highly insulating hot top A.

The hot top A is adapted to be mounted in the open upper end of an ingot mold 12 and insofar as the metal casing 11 and its manner of use are concerned, is conventional. As best shown in FIG. 1, the metal casing 11 is of a one-piece construction having a central opening 13, although the casing can be made in two pieces and fastened together. The opening or internal cavity 13 is tapered so as to be larger at the bottom than at the top thereof. It will, of course, be understood that the opening 13 could be non-tapered and be of any suitable configuration, such as round or oval, if desired.

The panel insert unit 10 is adapted to be folded to form a multisided tubular container or inner hot top lining having sides shaped complementary to and corresponding in number to the sides defining the opening 13 in the metal casing 11. In the illustrated embodiment, the opening 13 in the metal casing has eight sides and the panel insert unit 10 has eight alternately spaced side and corner panels 10a and 10b so as to form an eight sided hollow figure shaped complementary with the eight sided opening 13. The panel unit 10, when folded to form the inner hot top lining is adapted to be inserted into the

opening 13 of the metal casing 11. The panel insert unit is held against the interior sides of the casing 11 by the taper of the insert against the taper of the casing, and is supported by the bottom ring. Clamps might be used only in multipiece panel inserts for slabs.

After the panel insert unit 10 is positioned in the metal casing 11, a refractory bottom ring 16 is placed on the lower end of the hot top, and in a manner and for reasons well known to those skilled in the art. The refractory bottom ring 16 has a recess 17 adjacent its inner periphery to provide an upwardly facing shoulder that engages the lower edge of the panel insert unit 10 to aid in supporting the latter within the metal casing 11 and to prevent molten steel getting behind the panel insert. However, rings 16 of other configurations with or without recess 17 may be used. A wiper strip 18 is positioned on the bottom ring 16 and which is engageable with the sides defining the opening at the upper end of the mold 12 for reasons well known to those skilled in the art. The refractory bottom ring 16 and the wiper strip 18 are adapted to be secured to the casing 11 in any suitable or conventional manner, such as by clips (not shown).

When the hot top A thus equipped is used for a pouring operation, it is positioned a predetermined distance in the upper open end of an ingot mold 12 and initially held in such position by suitable blocks (not shown). After the pouring of the molten metal into the mold 12 and the hot top A, the blocks are knocked out or destroyed and thereafter the hot top rests or "floats" on the solidifying ingot. The hot top contains a molten mass of metal some of which is fed to the ingot in the mold to compensate for shrinkage of the metal during the solidification.

The panels or panel sections 10a, 10b of the panel insert unit 10 are preferably made from a highly insulating refractory material and are disposed in a side-by-side relationship, and with the adjacent panels being integrally connected by refractory portions 22 of reduced thickness as compared to the thickness of the panels 10a, 10b proper. The panels are preferably $\frac{5}{8}$ " to $1\frac{1}{2}$ " in thickness. The panels have substantially planar front and back faces 23, 24 which respectively are adapted to face toward and away from the interior of the hollow inner hot top lining when the unit 10 is folded. The panels 10a, 10b, as viewed in FIG. 3, have planar top and bottom edge surfaces 27, 28 joining and extending transversely of the front and back faces 23, 24 and planar adjacent side edge surfaces 30, 31 joining the front face and extending toward the back face, but terminating at a location spaced from the back face 24. The top and bottom edge surfaces 27, 28 are preferably tapered so as to form with the front face 23 an obtuse included angle therebetween.

The adjacent side edge surfaces 30, 31 of adjacent panels 10a, 10b are spaced from and face one another and are tapered so as to form with the front faces 23 an obtuse included angle therebetween. The adjacent side edge surfaces 30, 31 are planar and tapered toward each other so as to join one another at a location intermediate the front and back faces 23, 24 of the panels so as to define grooves 32 whose bottoms 33 are spaced from the back face 24 of the panels preferably approximately $\frac{3}{16}$ " from the back face of the panels. The grooves 32 are V-shaped and the adjacent side edge surfaces 30, 31 define an included angle therebetween. The angle of the groove will vary depending upon the number of panels in the insert unit and the angular distance through which the panels must move to conform to the opening in which they are to be inserted. For example, if four panels are in the insert unit and the unit is to form a complete lining, the angle of the groove would be approximately 90 degrees. In the illustrated embodiment, the angle is approximately 45 degrees.

The refractory portions 22 integrally connecting the

adjacent panels 10a, 10b extend between the bottoms 33 of the grooves 32 and the back face 24 of the panels. These portions 22 are frangible and break substantially along the bottom 33 of the V-shaped grooves 32 when the panels 10a, 10b are relatively moved to form the hollow lining, as will be hereinafter more fully apparent.

The panels 10a, 10b of the preformed insert unit 10 are also hingedly connected together by a flexible backing or hinge means 40 secured thereto and preferably substantially embedded therein. The hinge means 40 could be of any suitable construction and formed from any suitable material which has sufficient strength to support the respective panels when the frangible portions 22 are broken. Preferably, the hinge means is a flexible wire netting or screen. The flexible wire netting or screen is preferably completely embedded within the material at a location spaced rearwardly from the bottom 33 of the grooves 32, and intermediate the bottom 33 of the grooves 32 and the back face 24 of the panels 10a, 10b. The thickness of the wires forming the wire screen is somewhat exaggerated in the drawings for illustrative purposes.

The materials and the compositions from which the panels are made may vary within certain limits, but where the highly insulating insert unit is to be used against a cast iron casing or in an ingot mold, as shown in the drawings, the insert unit is preferably made of a material which includes a granular refractory filler, such as silica flour of such particle size as to substantially all be through 200 mesh U.S. sieve, a heat-destructible binder, and an inorganic fibrous material. The inorganic fibrous material is an asbestos material. A material of this type is disclosed in application Ser. No. 401,944, filed Oct. 6, 1964 and assigned to the same assignee as the present invention. The fine pore structure created in the manufacture of the panels make the panels highly insulating. The high insulating property of the panels can be expressed by the thermal conductivity or K factor of the material. The K factor is, as is well known in the art, the amount of heat in B.t.u.'s which will flow through a 1" thick 1-sq. ft. area in one hour per degree F. difference between the hot and cold sides or faces of the panel. The K factor varies with the average or mean temperature between the hot and cold faces of the material. The present panels are highly insulating since they have a K factor of less than 1.5 determined for an average or mean temperature range of 1000 degrees F. to 1750 degrees F. This, of course, means that less than 1.5 B.t.u.'s are lost by conduction through 1 sq. ft. of a 1" thick panel in one hour for each degree F. difference between the hot and cold faces of the panel. The relatively low K factor indicates that the panels are highly insulating and particularly adapted for use in a hot top casing without a ceramic lining or directly in an ingot mold.

The panel unit 10 is preferably formed by a vacuum or pressure wet molding operation during which the flexible wire netting is immersed in the aqueous slurry therein and in which the panels 10a, 10b are formed in a side-by-side open, unfolded position, as shown in FIG. 3, and in a manner to be hereinafter more fully described.

The panel insert unit is adapted to be folded from its unfolded position shown in FIG. 3 to a position in which the adjacent side and corner panels 10a, 10b are angularly related to form a tubular container for insertion into the opening 13 of the metal casing 11 by grasping the adjacent panels 10a, 10b and bending and stretching the flexible netting 40 at and along the frangible portions 22 between the panels to an angle necessary to bring the adjacent side edge surfaces 30, 31 of the panels into engagement with one another. During the folding movement of the adjacent panels 10a, 10b, the frangible portion 22 therebetween will break to allow the flexible screen 40 to bend so that the adjacent side edge surfaces 30, 31 of the panels 10a, 10b properly mate to form the tubular container. The flexible netting holds the panels together

after the frangible portions 22 are broken. The preformed insert unit 10, when folded to form the inner hot top lining, then is inserted into the opening 13 in the top of the metal casing. The bottom ring 16 and the wiper strip 18 are then secured in place and the hot top A is positioned in the opening at the upper end of the mold. The molten metal to form the ingot is then poured through the hollow opening 13 in the hot top A and the hot top is filled to the level desired. The panel insert unit 10 makes a highly insulating container and provides that some of the molten metal in the hot top A will feed by gravity to the ingot in the mold to compensate for shrinkage of the metal during solidification.

It has been found that by providing the frangible portions 22 for integrally connecting the adjacent panels 10a, 10b, a strong flat construction is achieved which may be readily shipped without significant breakage, and yet when the adjacent panels are folded they form a tubular container backed up by a hot top casing or mold wall. By embedding the flexible wire netting 40 in the insert unit 10 closely adjacent the bottom of the grooves, but between the bottom of the grooves and the back faces 24 of the panels, the adjacent panels can be folded such that their adjacent joint surfaces mate along their entire length. By providing reasonably tight joints between the adjacent panels, metal leakage through the joints and behind the panels is minimized. Additionally, it has been found by substantially embedding the flexible wire netting between the back faces of the panel and the bottoms of the grooves that the panels, being reinforced by wire netting, can withstand rough handling, and the inserts will hold together and be usable even if the panels are cracked during shipment, storage, and handling.

It should be noted that since the central opening 13 of casing 11 is tapered, the panel insert unit 10, is designed so that when folded, it forms a generally trapezoidal tubular container. The insert unit 10, when in its flat unfolded condition as illustrated in FIG. 3, is segmented and somewhat curved, and with the panels 10a being of a trapezoidal shape and panels 10b being rectangularly shaped. If the central opening of the casing is not tapered but is formed by parallel sides, then the insert unit in its flat condition would be in the form of a rectangle and, when folded, would form a generally cylindrical tubular container.

FIG. 5 shows another way in which the panel insert unit 10 can be employed to form a hot top. The panel insert unit 10 is there shown as being inserted down into and attached directly to the open upper end of an ingot mold 50. The ingot mold 50, as shown in FIG. 5, is of the conventionally known, big-end-down type of ingot mold having a downwardly tapered central opening 52. A big-end-down type of ingot mold is one in which the central opening 52 is tapered so as to be larger at the bottom than at the top thereof. It will, of course, be understood that the provisions of the present invention are also applicable to the big-end-up type of mold and to molds having different contours.

The panel insert unit 10, when folded to form a tubular container or form whose sides are complementary to the sides of the opening 52, is adapted to be inserted into the opening of the mold 50 and attached to or held against the interior sides defining the opening 52 by any suitable or conventional means to form a hot top. After the insert unit 10 is in place, molten metal to form the ingot can then be poured through the tubular container to the level desired to provide that some of the molten metal at the upper end of the ingot in the mold will feed downward to compensate for shrinkage of the metal in the solidifying ingot.

The present invention provides a novel and economical method for making the panel insert unit 10. The method, in general, includes a one-step molding operation in which the panels 10a, 10b and the frangible sections 22 are shaped as an integral unit and the flexible wire screen is

embedded within the refractory material. The various steps in carrying out the method of the present invention will be described with reference to the description of an apparatus 55, schematically shown in FIGS. 6 and 7, for carrying out the method.

The apparatus 55 for carrying out the method of the present invention comprises a vacuum box 60 which is an open top box of the desired shape and which has a horizontally disposed vacuum screen 61 backed up by a strong grid 61a extending thereacross at its upper end. The box 60 is provided with an upwardly facing peripherally extending supporting ledge 62 on which the vacuum screen 61 and grid 61a is supported. The vacuum screen 61 defines with the sides and bottom of the box 60 a vacuum chamber 63 located beneath the vacuum screen 61. The vacuum chamber 63 is adapted to be connected with a suitable vacuum source to provide or create a vacuum in the chamber 63 and the presence of the vacuum in the chamber 63 is designated generally by the arrow 64.

The contoured molding frame 70 comprises an outer frame part 71 shaped so as to provide the outer peripheral configuration of the panel insert unit 10 when in its flat position, as shown in FIG. 3. A plurality of spaced bar members 72 are suitably secured to and extend transversely between the upper and lower generally longitudinal extending portions of the outer frame part 71, as viewed in FIG. 7. The bars 72 are employed to form the grooves 32 in the panel unit 10 and are spaced and disposed relative to each other and the outer frame 71 so as to define with the outer frame 71 the configuration of the respective panels 10a, 10b to be molded.

As best shown in FIG. 7, the bars are V-shaped to form the V-shaped grooves 32 in the panel unit 10 and the inner vertically extending sides 75 of the outer frame part 71 are suitably contoured or tapered to provide the free side edge surfaces 30 and 31 of the two endmost panels. The top and bottom end surfaces at each panel have tapered surfaces formed by corresponding surfaces of frame 71. The outer frame part 71 has a planar bottom surface 76 which is placed directly onto the vacuum screen 61 and the bars 72 have their lowermost portions 78 located or spaced above the plane of the bottom surface 76 of the outer frame part 71, and thus located above the vacuum screen 61, and for reasons to be hereinafter more fully described.

In carrying out the steps of the method, the flexible wire netting 40 is placed directly on the vacuum screen 61 and then a contoured molding frame 70 movable relative to the box 60 is placed or positioned on top of the vacuum screen 61.

After the contoured molding frame 70 has been placed onto the vacuum screen 61 to form a mold, this mold is filled with slurry of a suitable composition, such as the composition disclosed in the aforementioned patent application, Ser. No. 401,944. The slurry covers the vacuum screen 61 and surrounds and flows underneath the bar members 72 to provide the frangible portions 22 and surrounds the wire netting to substantially embed the latter within the slurry. With the creation of the vacuum 64 the slurry is partially dewatered to leave a wet mat and then the contoured molding frame 70 is moved upwardly relative to the vacuum box 60 to remove the same from the wet mat which will subsequently become the panel insert unit 10.

By using the bar members 72 whose bottommost portions are spaced upwardly from the vacuum screen 61 so that the slurry flows beneath the bar members, accurate spacing between the adjacent joint surfaces 30, 31 of the adjacent panels is achieved, which, in turn, enables mitered joints to be effected when the panel insert unit is folded to form a tubular container and a workable fit of the insert into the hot top casing, or ingot mold. Moreover, it has been found that the employment of this molding method enables the units to be more rapidly

produced due to the minimizing of air leakage through the slurry around the bottom and sides of the bar members and, thus, helps to prevent loss of vacuum around the panel perimeters and enables the units 10 to be produced at relatively low cost. Additionally, by substantially embedding the flexible screen within the refractory panel insert, loosening of the panels from the screen and breakage of the panels is minimized or eliminated.

From the foregoing, it should be apparent that the objects hereinbefore enumerated and others have been accomplished and that a new and improved hot top structure and method of making the same have been provided. Although the novel hot top structure and method of making the same of the present invention have been illustrated and described herein to a detailed extent, it will, of course, be understood that the invention is not to be regarded as being limited correspondingly in scope and that other changes and modifications can be made therein without departing from the spirit of the present invention.

Having described our invention, we claim:

1. A method of making a hot top structure which comprises a refractory panel insert unit having front and back faces and a plurality of spaced grooves extending thereacross whose bottoms are spaced from the back face of the panel insert unit to define a plurality of integrally connected refractory panels disposed in a side-by-side relationship and flexible hinge means imbedded within said refractory insert unit between the bottom of the grooves and the back face of the insert unit to hingedly interconnect the adjacent panels, and which comprises the steps of placing the flexible hinge means on a generally horizontally disposed porous base, placing a contoured mold of a shape to provide the desired outer configuration of said one-piece refractory insert unit and which has a plurality of spaced bars whose bottommost portions are spaced upwardly from the plane of the bottommost surfaces of the remainder of the contoured mold onto said porous base to form a mold with the bottommost portions of said bars being spaced upwardly from said porous base, pouring a refractory slurry into said mold with the slurry flowing around said flexible hinge means and underneath said bars, dewatering said slurry, by applying a pressure differential to the top and bottom of the slurry, removing said contoured mold after said slurry has been substantially dewatered to form said one-piece refractory insert unit having a flexible means imbedded therein, and completing the drying of the material composition of said refractory insert unit in an oven means.

2. A method of forming a highly refractory insulating unit comprised of a plurality of panels interconnected by flexible material for relative angular movement from an open flat position to a closed position defining a closed tubular structure comprising the steps of simultaneously molding the adjacent panels in a mold cavity and forming integral portions interconnecting adjacent panels adjacent one side of the unit with the flexible material for hingedly connecting the same imbedded in the inter-connecting portions and the panels by flowing slurry of refractory material into a mold cavity having laterally spaced bars extending inwardly from one side thereof to separate one part of the mold cavity into mold spaces corresponding to the panels with the slurry being of greater depth than the height of the bars to provide at one side of said panels a slurry receiving space, filling the space so that the slurry extends through said spaces coextensively with the unit by flowing slurry into said spaces and around said flexible material disposed in said spaces to provide said interconnecting portions in which said flexible material is imbedded, dewatering the slurry to deposit the refractory material in the slurry in the mold by applying a pressure differential to the top and bottom of the slurry, the flexible material being surrounded by slurry during dewatering so that it does not project outwardly of the deposited slurry when dewatering is completed, and removing the unit from the mold cavity and drying the same at an elevated temperature.

3. A method as defined in claim 2 wherein the dewatering is accomplished by drawing water through holes in the bottom of the mold by using a pressure below atmospheric and maintaining said co-extensive portion during the dewatering operation to provide an air seal for preventing the drawing of air along the sides of said bars.

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U.S. Cl. X.R.

164—15; 264—87, 234