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[54] **APPARATUS FOR CASTING METAL SLABS AND BILLETS**
11 Claims, 6 Drawing Figs.

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249/136, 164/344
[51] Int. Cl. B22d 17/00
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130; 164/133, 136, 120, 406-408, 405, 129, 130,
135, 113, 107, 112, 93, 91, 94, 95, 96, 122, 77,
284, 344, 347, 363, 319, 119, 322, 320, 321

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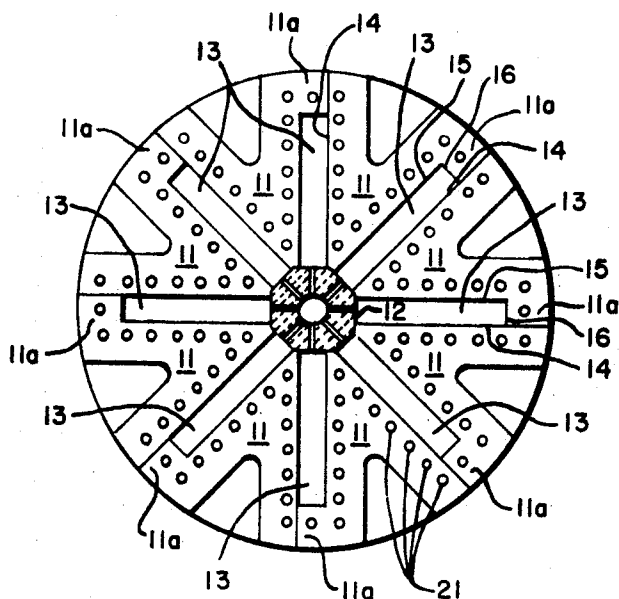
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ABSTRACT: The present invention discloses a mold wherein molten metal is introduced to a riser communicating with the mold so that the level at which the molten metal flows into the mold is progressively raised as the mold cavity fills, and simultaneously pressure is applied to a movable bottom for the mold to slowly lift and compress the solidifying metal so that the solidifying metal is constantly rising against newly introduced molten metal to thereby eliminate or substantially reduce shrinkage defects.



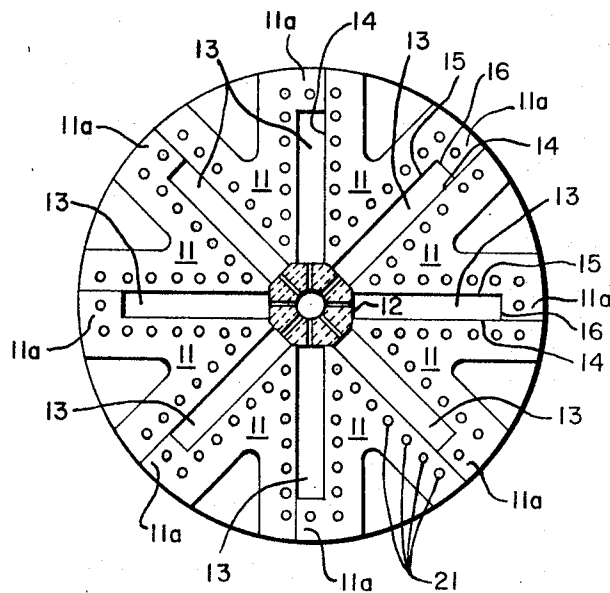


FIG. 2

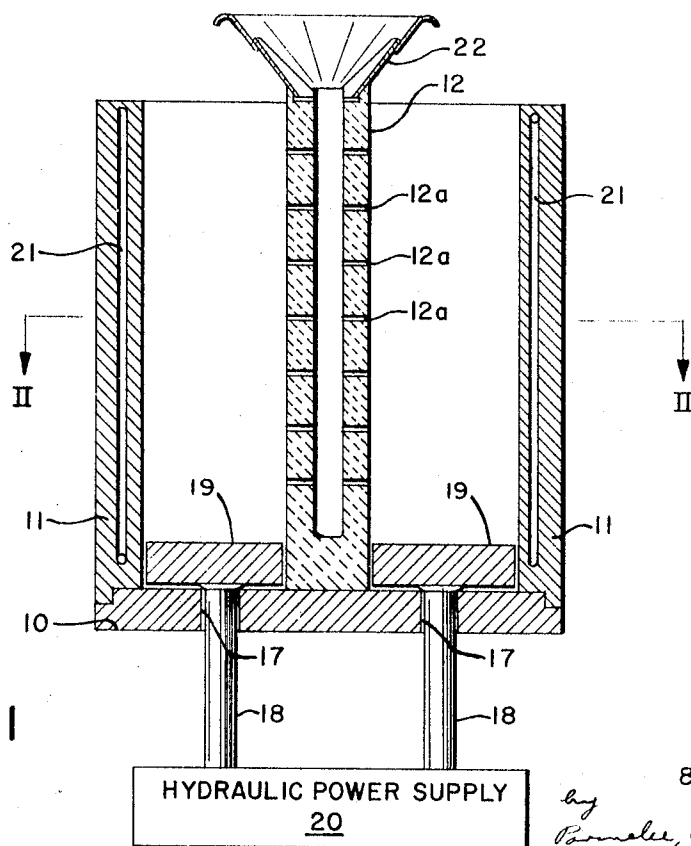


FIG. 1

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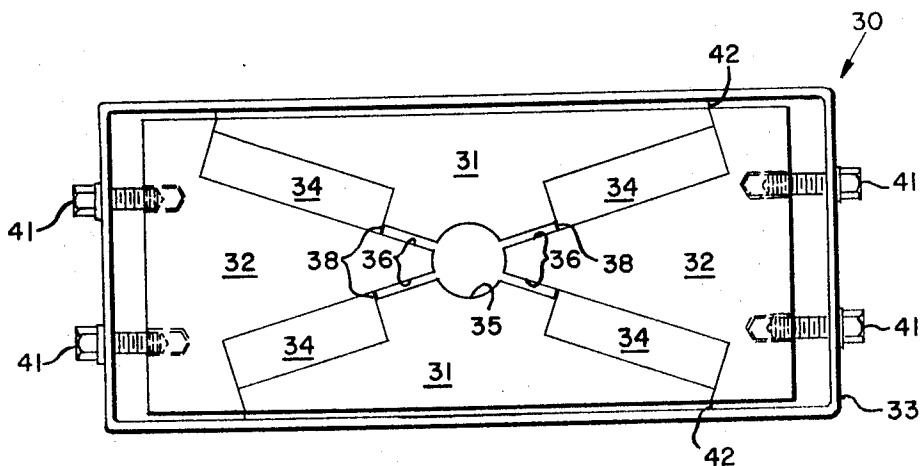


FIG. 3

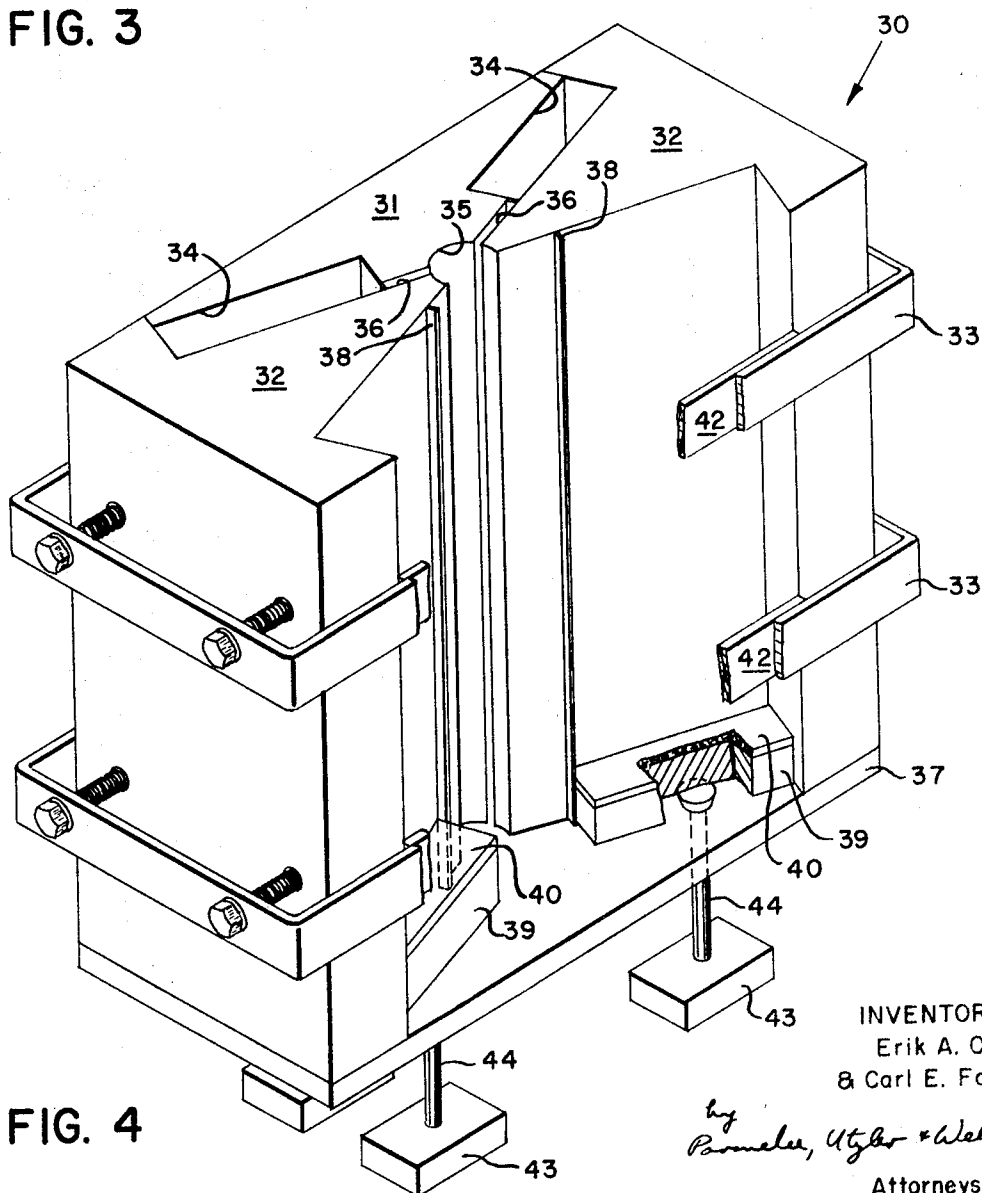


FIG. 4

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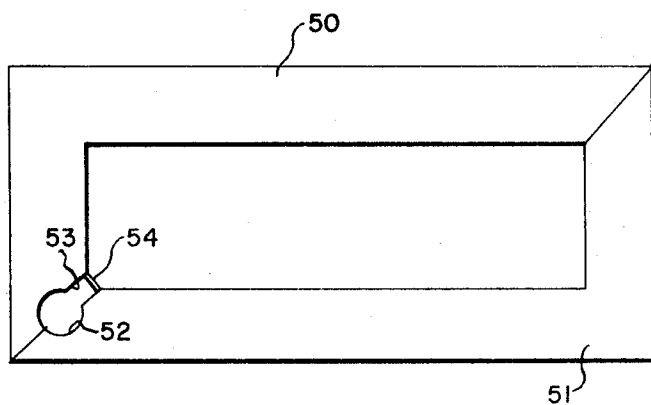


FIG. 5

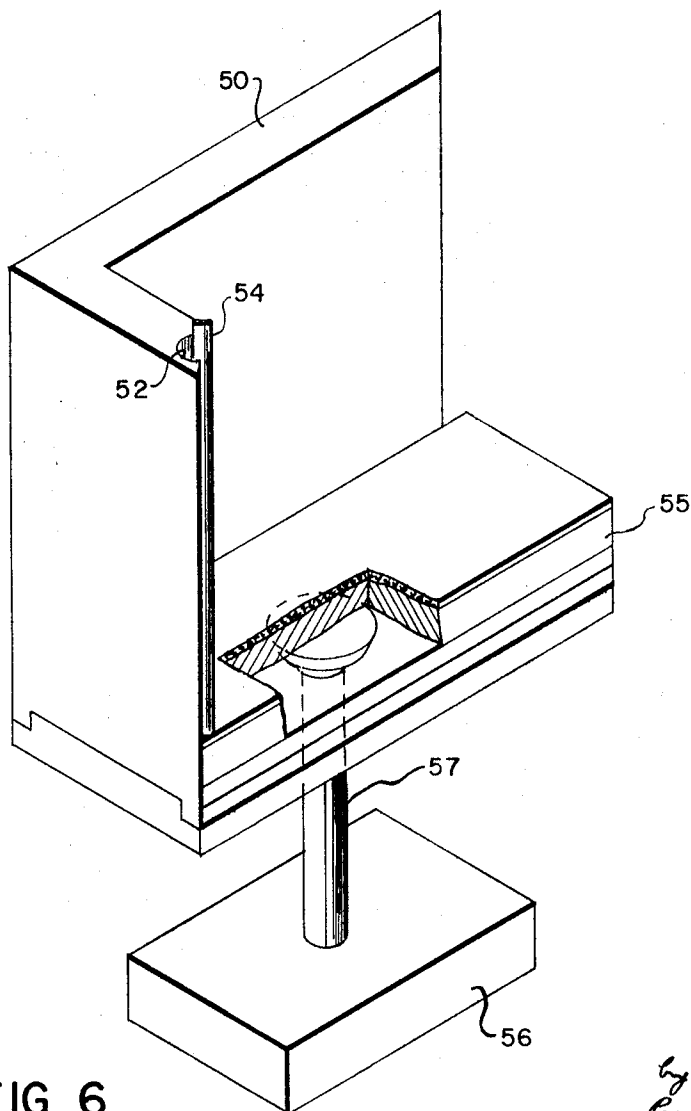


FIG. 6

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APPARATUS FOR CASTING METAL SLABS AND BILLETS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to apparatus for the casting of metal slabs and billets.

2. Description of the Prior Art

The prior art is exemplified by U.S. Pat. No. 1,757,549 to Smith, et al. issued May 6, 1930. This patent discloses a method and apparatus for the bottom pouring of a plurality of ingots simultaneously. Beyond that, this patent has no direct relevance to the present invention.

In the usual procedure of casting molten steel into fixed cavity molds, such as ingot molds, solidification occurs from the bottom toward the top, and from the sidewalls toward the center. The cooling of the metal in this manner with the attendant shrinkage results in a cavity or "pipe" in the top center of the ingot and shrinkage stresses that may result in cracks or fissures in the cast metal.

Summary of the Invention

According to the present invention there is provided apparatus whereby molten metal is poured into a mold cavity from a riser or the like positioned adjacent the mold and in communication therewith so that metal flows from the riser into the mold from progressively higher locations as the mold fills. The mold is provided with a bottom wall and sidewalls movable relatively to each other to effect a progressive reduction in size of the mold cavity whereby compressive forces are exerted on the metal during pouring and solidification to thereby relieve tensile stresses and reduce the formation of skin defects in the metal. The invention may be used advantageously with a single mold or with a plurality of molds which are filled simultaneously from a common pouring riser communicating with each of the molds. Preferably the bottom wall of the mold is moved upwardly relative to the sidewalls at a rate which will exert a pressure on the metal which is equal to or greater than the ferrostatic pressure.

The present invention improves casting techniques particularly in the casting of slabs which may be 30 feet or more long, i.e. a mold height of 30 feet or more. To cast such a slab using conventional techniques is extremely difficult owing to the splashing of metal and "blowouts" or ruptures of the metal skin. As the metal solidifies to form a skin it pulls away from the mold walls and the ferrostatic pressure in the liquid center of the slab causes a rupture of the skin and an escape of the metal into the space between the skin and mold wall forming defects in the slab. The application of a progressive, compressive force helps to prevent such ruptures.

An object of the invention is to provide an improved method and apparatus for the casting of metal.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical section of a plural mold arrangement according to the invention;

FIG. 2 is a plan view taken along the line II-II of FIG. 1;

FIG. 3 is a plan view of another embodiment of a plural mold arrangement according to the invention;

FIG. 4 is a perspective view of FIG. 3 with parts broken away;

FIG. 5 is a plan view of a single mold embodiment according to the invention; and

FIG. 6 is a perspective view of the embodiment of FIG. 5 with parts removed and parts broken away.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings 10 is a support member or stool on which are mounted a plurality of identical cast iron mold segments 11 and a centrally disposed fountain or riser 12. Each mold segment 11 is generally V-shaped as viewed in plan

with each leg of the V forming one sidewall of adjacent mold cavities 13. A portion of one leg of the V extends at right angles to the leg to form another sidewall of a mold. For convenience in describing the segments, 14 will be referred to as the backface of the segment, 15 to the front face, and 16 to the face formed by the portion 11a extending at right angles to the face 15. When the segments are arranged in circular succession as shown in FIG. 1, with the backface 14 of one segment confronting the front face 15 of an adjacent segment with the portion 11a abutting the outer portion of back face 15, there is formed a circular series of angularly spaced mold cavities 13, three sides of each cavity being formed by the sidewalls or faces 14, 15 and 16. Coolant pipes or passages 21 are provided in each of the mold segments 11 to cool the mold faces by flowing water or other suitable coolant through the pipes from a suitable source (not shown).

The fourth sidewall of each cavity 13, opposite the side 16 is formed by the outer face of the central tubular riser 12. The riser 12 comprises an upright polygonal cylinder made from a frangible refractory material having a solid bottom portion resting on the stool 10, a hollow interior and, an open top through which metal may be poured into the interior. The outer polygonal surface of the riser constitutes the fourth sidewall of each cavity 13. In the illustrated embodiment there are eight mold cavities 13 so the riser is octagonal. Preferably the vertex edge of each V-shaped segment 11 is provided with a notch extending the full height of the segment of receiving therein, in abutting relation, the vertex edge defined by each pair of adjacent planes forming the outer surface of the riser. The mold segments and the riser being dimensioned so as to snugly interfit.

The riser 12 is provided with sets of vertically spaced lateral openings 12a therein communicating with the hollow interior of the riser and each of the mold cavities 13. Each opening 12a extends horizontally on a radius from the center of the riser outwardly to each mold cavity, and each opening lies in a horizontal plane with corresponding openings into each of the mold cavities at a given level along the height of the riser. The bottommost openings are spaced above the bottom of the hollow interior of the riser and the topmost openings are spaced from the tops of the mold cavities. At the top of the riser there is a funnel 22 to aid in pouring metal into the riser.

In the stool 10 there are a plurality of openings 17 through which extend a plurality of rods 18 each having a block 19 at one end thereof disposed in a mold cavity 13. Each block 19 is shaped to conform to the interior of the mold cavities and forms the bottom walls of the molds. The opposite ends of the rods 18 are operatively connected to a suitable driving means such as a source of hydraulic power indicated diagrammatically at 20, whereby the rods 18 and therefore the bottom walls 19 of each mold are vertically movable in the manner of a piston in a cylinder. They will ordinarily be operated in unison but if desired each rod may be separately operated.

In operation the bottom walls 19 are initially bottomed on the stool 10 and metal is poured into the riser. When the metal level reaches the lowermost openings 12a metal flows from the riser into the mold cavities where it quickly cools and solidifies to form an outer crust or shell on the forming slab or billet. Metal also solidifies in the openings 12a at the height corresponding to the height of the forming slab. Metal flows from the riser into the molds through successively higher sets of openings until the molds are all filled to the desired height.

As the metal solidifies in the molds it begins to contract and pull away from the mold walls, which process, if left uncontrolled, would cause cracks to form in the slabs. To counteract this, the bottom walls 19 are slowly moved upwardly as the slab is forming to relieve the tensile stresses of contraction in the solidifying skin of the slab and preferably to place the forming slab under some compression.

When the slabs are all solidified in the molds they are removed and the refractory riser broken away. There will be small projections on that side of the slab adjacent the riser caused by the solidified metal from the openings 12a, these

being attached to a solid body of metal that solidifies in the tube. These projections can readily be removed by a cutting torch or the like. The bottom walls 19 are lowered again and a riser installed for the next cycle of operation.

Referring to FIGS. 3 and 4 there is shown another embodiment of a plural mold arrangement indicated generally as 30. In this embodiment there are two pairs of mold segments 31 and 32 held together by straps 33. Each of the segments 31 and 32 are shaped so that when joined together as shown they define four mold cavities 34 each with four sidewalls, a central riser 35 and passageways 36 communicating with the riser 35 and mold cavities 34. The whole assembly is mounted on a suitable stool 37.

Each passageway 36 comprises a continuous vertical slot coextensive with the mold cavity and the riser. Strips 38 are disposed in each of the passageways 36 at the start of pouring. These strips may be cardboard, aluminum or other suitable materials which will burn away or melt as metal is poured into the riser. The strips help control the flow of metal into the molds to cause the metal to flow from the riser to the molds from progressively higher locations as the molds fill.

Each mold is provided with a hydraulically actuated movable bottom wall 39 in essentially the same manner as before described by means of a hydraulic power supply 43 and piston rod 44. Preferably each bottom wall is provided with a covering member 40 made of asbestos or other suitable heat-resistant, flexible material to help seal the bottom wall with the mold sidewalls.

The straps 33 are continuous rectangular straps around the mold segments secured in place by suitable fastening means such as the bolts 41 which are received in openings in the end segments 32. When the straps are secured, wedges 42 of wood, metal or other suitable material are forced between the straps and the side segments 31.

Referring to FIGS. 5 and 6 another embodiment of the invention is illustrated using a single mold. Two mold segments 50 and 51 are joined together to form a mold cavity and a riser 52 located at one corner of the mold. The riser communicates with the mold cavity through a continuous vertical passageway 53 as in the embodiment of FIGS. 3 and 4. A flow-control strip 54 is inserted between the passageway and the mold cavity in the same manner as before described in connection with FIGS. 3 and 4. An asbestos-covered, hydraulically actuated, movable bottom wall 55 is provided also as previously described operated by a hydraulic power supply 56 and rod 57. Straps or other suitable means may be employed to hold the mold segments 50 and 51 together. As in the embodiment of FIGS. 1 and 2, the embodiments shown in FIGS. 3 to 6 would normally employ a pouring funnel such as funnel 22.

With the invention as described, slabs up to 30 or more feet may be cast with few surface defects and almost no "pipe" so as to achieve almost 100 percent yield except for the metal which ultimately solidifies in the riser.

The diameter of the riser cavity is preferably on the order of 2 and 4 inches depending on the number and size of mold cavities it supplies.

The amount of pressure applied to the bottom walls, the rate of movement and total distance moved depend on the size of slab and the metal being cast. A heat-resistant flexible cover may be used on the bottom wall of the embodiment shown in FIG. 1 as well as with the other described embodiments.

In some cases it may be desirable to move the sidewalls relative to the bottom wall, either in a downward direction or laterally, or to move both the bottom wall and the sidewalls, or to move one sidewall laterally, in all cases to reduce the size of the cavity and exert a compressive force on the metal.

While we have described several embodiments of our invention, it will be understood by those skilled in the art that variations thereof are possible within the scope and spirit of the invention.

We claim:

1. Apparatus for the casting of metal slabs and billets, comprising,

a. a vertically disposed mold having sidewalls and at least one bottom wall forming at least one coreless mold cavity,

b. vertically disposed pouring riser means adjacent the mold and having opening means therein communicating with each of the mold cavities and formed such that metal flows into the mold cavities from progressively higher locations as the mold cavities fill, and

c. means for effecting the relative vertical movement between the entire mold bottom wall and the sidewalls to reduce the size of the cavities during the pouring and solidification of the metal, whereby as molten metal is poured into the riser and flows into the mold cavities through the opening means there is exerted a force on the metal as it progressively solidifies in the mold thereby relieving tensile stresses on the metal as it shrinks during solidification.

2. Apparatus as defined in claim 1 including means for cooling the mold sidewalls.

3. Apparatus as defined in claim 1 including coolant passageways formed in the mold sidewalls, and means for effecting the flow of coolant through the passageways.

4. Apparatus for the casting of molten steel into slabs and billets comprising:

a. a plurality of molds each having sidewalls and a vertically movable bottom wall together forming a coreless mold cavity,

b. a pouring riser having an open top, sidewalls and a bottom wall and a vertical succession of horizontal openings in the riser sidewalls communicating with each of the mold cavities whereby as metal flows into the riser it flows through successively higher openings into the mold cavities to fill them simultaneously,

c. means for effecting simultaneous vertical upward movement of the entire mold bottom walls relative to the sidewalls of the molds during filling of the mold cavities.

5. Apparatus as defined in claim 4 including a pouring funnel at the top of the riser.

6. Apparatus as defined in claim 4 wherein the riser sidewalls form one sidewall of each of the molds.

7. Apparatus for the simultaneous casting of a plurality of metal slabs or billets, comprising,

a. a series of mold segments each having a front face and a backface, the segments being arranged in circular succession with the front face of each segment confronting the backface of an adjacent segment to form a circular succession of angularly spaced mold cavities, each pair of adjacent segments forming three vertical sidewalls of a four-walled mold,

b. an upright refractory fountain centrally located with respect to the circular succession of mold segments and forming the fourth sidewall of each mold, the fountain having a bottom, an open top, a hollow interior, and a series of lateral openings therein forming passageways for the flow of metal from the hollow interior into each of the mold cavities, there being a like series of vertically spaced openings communicating with each of the mold cavities,

c. a bottom wall for each of the molds, and

d. means for moving the bottom walls vertically upward with respect to the mold sidewalls.

8. Apparatus for the casting of metal slabs and billets comprising:

a. a plurality of vertically disposed molds each having sidewalls and a bottom wall forming a coreless cavity,

b. vertically disposed pouring riser means adjacent the molds and having opening means therein communicating with each mold cavity and formed such that metal flows into the mold cavities from progressively higher locations as the mold cavities fill, and

c. means for effecting relative vertical movement between each entire mold bottom wall and the sidewalls to reduce the size of the cavity during pouring and solidification of the metal, whereby as molten metal is poured into the

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riser and flows into each mold cavity through the openings there is exerted a force on the metal as it progressively solidifies in each mold thereby relieving tensile stresses on the metal as it shrinks during solidification.

9. Apparatus for the casting of metal slabs and billets, comprising,

a. a pair of mold segments joined together to form the sidewalls of a mold cavity,

b. a bottom wall,

c. means for effecting relative vertical movement between the mold sidewalls and the bottom wall during the pouring and solidification of the metal to progressively reduce the size of the mold cavity,

d. said mold segments defining vertical pouring riser means

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including an elongated passageway extending substantially over the entire vertical height of the mold cavity and communicating with the riser and the mold cavity, whereby metal poured into the riser may flow to the cavity, and

e. cover means disposed in the passageway made of a material which is readily destructible upon contact with molten metal for controlling the flow of metal into the cavity such that the metal flows from the passageway at progressively higher locations as the mold fills.

10. Apparatus as defined in claim 9 wherein the bottom wall is lined with a heat-resistant flexible cover.

11. Apparatus as defined in claim 9 wherein the cover is asbestos.

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