

Aug. 6, 1940.

J. H. L. DE BATS

2,210,145

DIRECT ROLLING OF METAL FROM THE LIQUID STATE AND APPARATUS THEREFOR

Filed Aug. 13, 1938

4 Sheets-Sheet 1

Fig. 1.

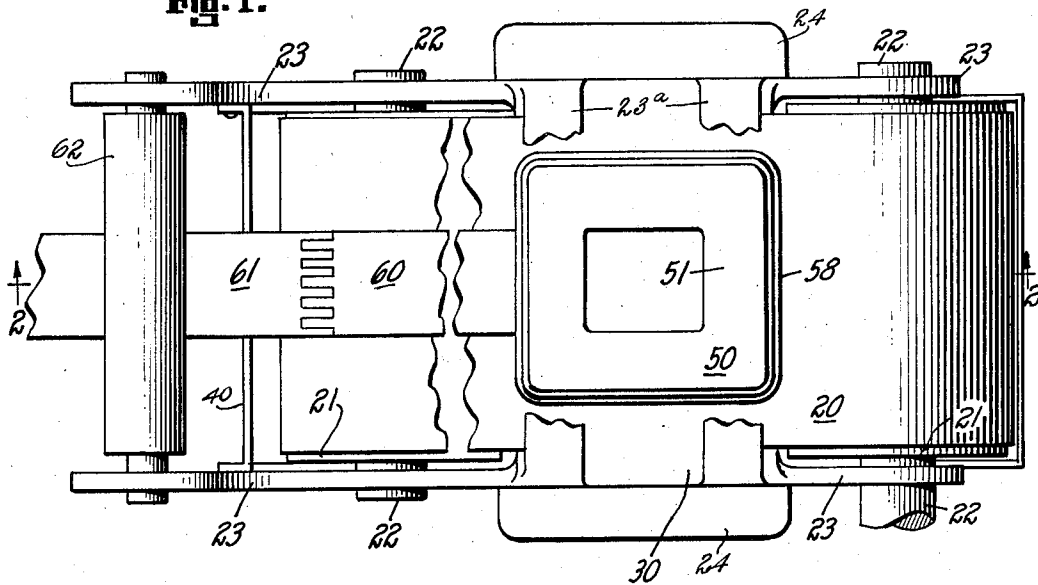
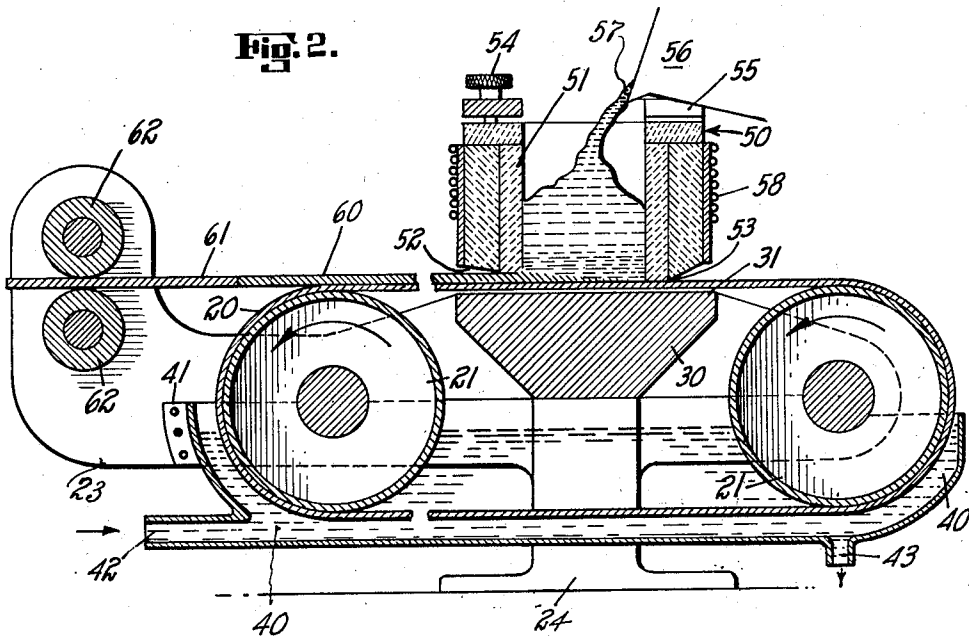


Fig. 2.



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Fig. 3.

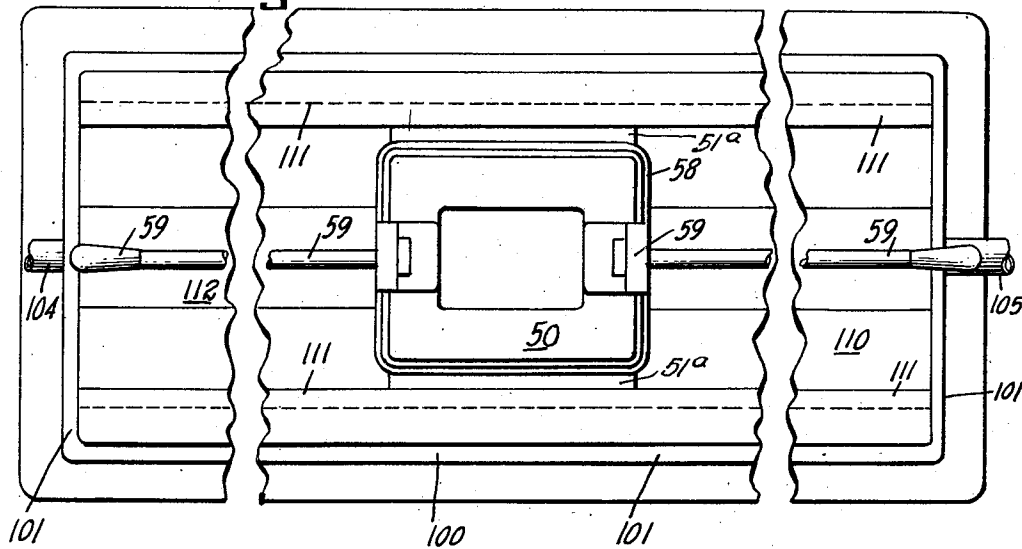


Fig. 4.

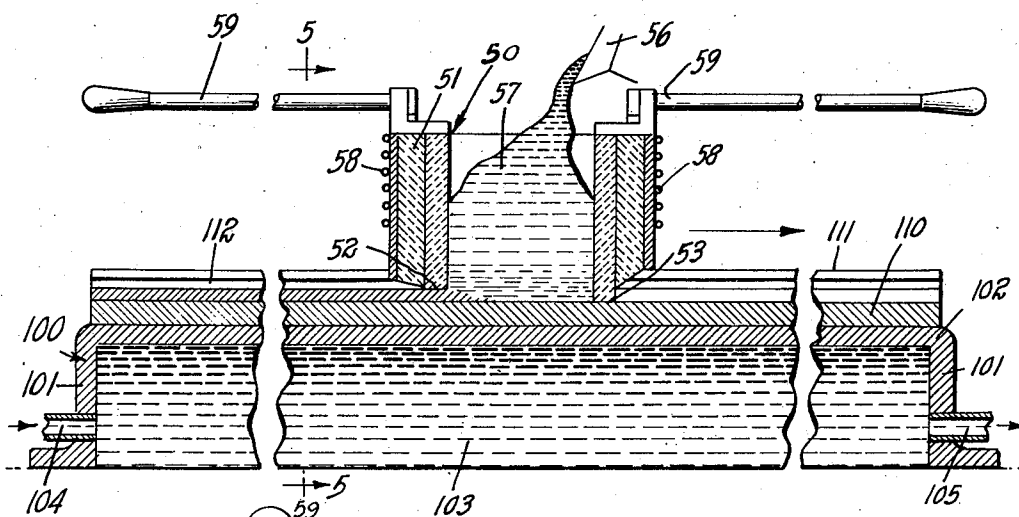
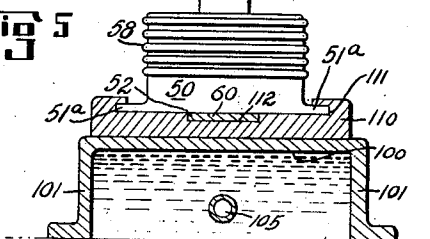


Fig 5



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Fig. 6.

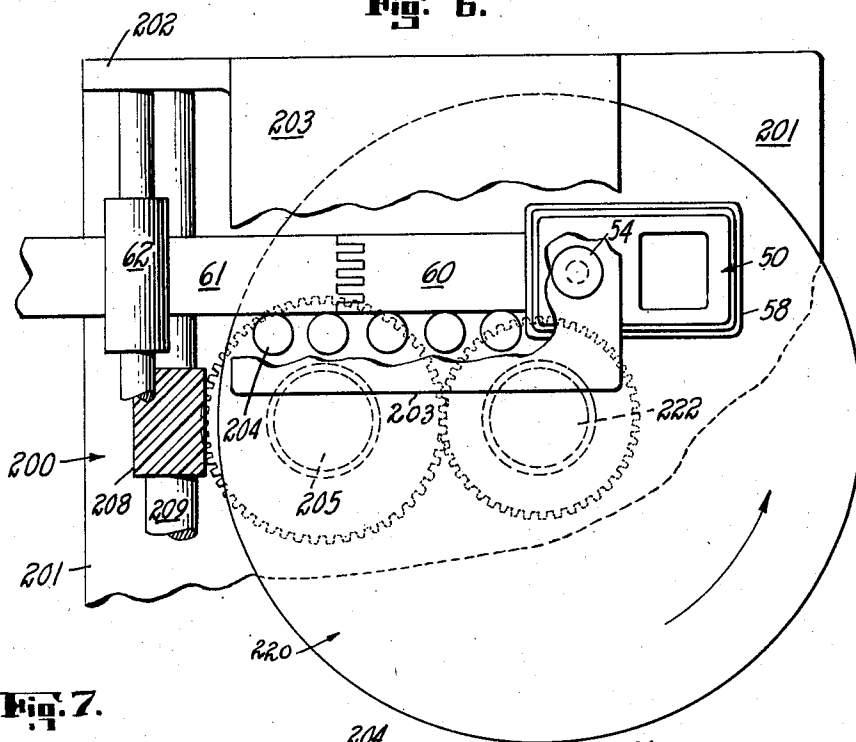
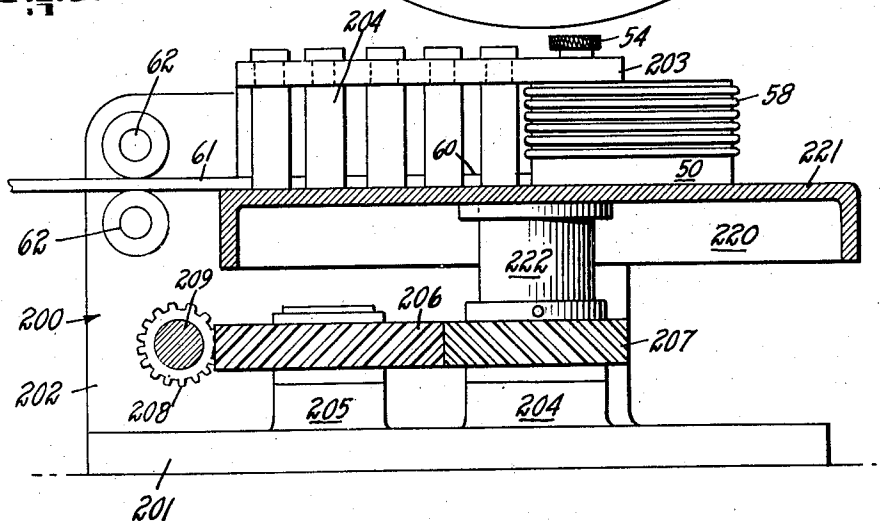


Fig. 7.



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Fig. 8.

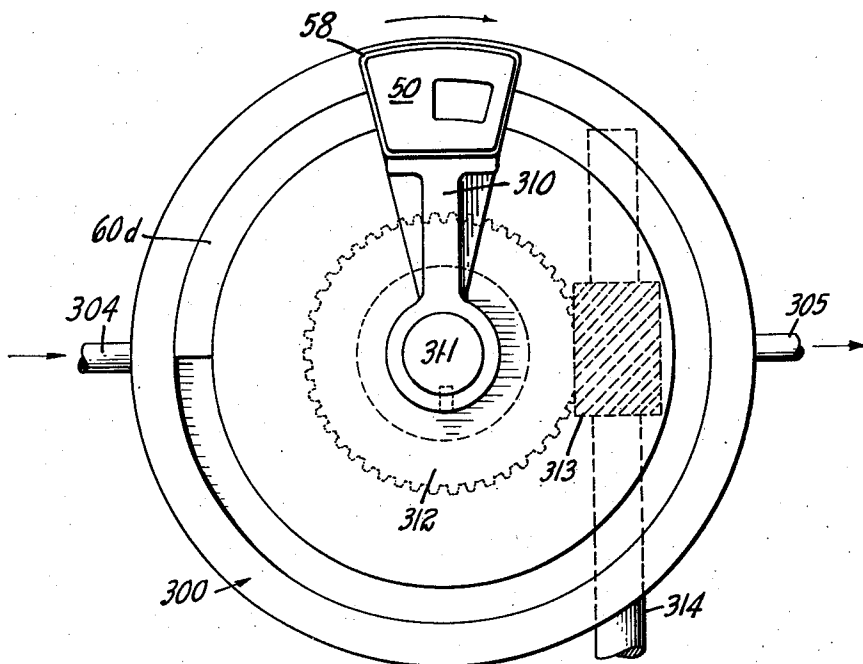
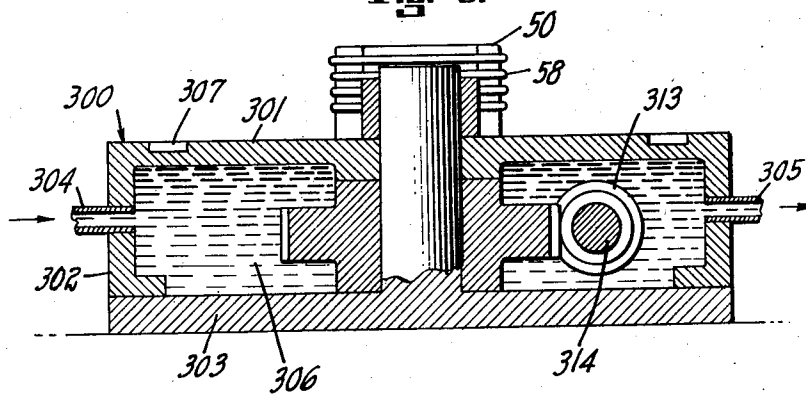


Fig. 9.



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UNITED STATES PATENT OFFICE

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DIRECT ROLLING OF METAL FROM THE LIQUID STATE AND APPARATUS THEREFOR

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Application August 13, 1938, Serial No. 224,658

11 Claims. (Cl. 29—33)

This invention relates to the direct casting and rolling of metals in continuous lengths, and in a variety of shapes, as well as to the apparatus used, and the products thereof.

Direct casting or rolling of metals is much to be desired, as it will afford opportunity for discarding soaking heats and other treatments, at present required to impart some degree of uniformity of crystallization in cast ingots, blooms and cast metal masses generally which are to be subjected to further forming treatments, including rolling to shape.

The novel features of the present invention comprehend the direct formation of structural metal shapes of rolled metal proceeding directly from the cast metal and without the intermediate formation of ingots or blooms. The invention also comprehends the continuous formation of metal shapes in novel forms of apparatus, and, in which the molten metal is initially frozen from one side of a to-be-formed shape, and thereafter is rolled and otherwise manipulated in a continuous and direct treatment to the finished shape. The several features of novelty include special apparatus and devices for use with the same, as well as special methods of procedure.

The above recited, and other desirable features and advantages of the present invention will be described in the specification and illustrated in the drawings, certain preferred forms of apparatus being shown, by way of example only, for, since the underlying principles may be incorporated in other specific apparatus and devices, it is not intended to be limited to the ones here shown, except as such limitations are clearly imposed by the appended claims.

In the drawings, like numerals refer to similar parts throughout the several views, of which

Fig. 1 is a broken top view of a continuous drawing apparatus;

Fig. 2 is a vertical longitudinal section of the apparatus of Fig. 1;

Fig. 3 is a view similar to Fig. 1, showing an apparatus for making special shapes, and having a traveling furnace;

Fig. 4 is a longitudinal vertical section of the apparatus of Fig. 3;

Fig. 5 is a transverse vertical section taken on line 5—5 of Fig. 4;

Fig. 6 is a plan view, partly in section, of an apparatus having a moving circular table;

Fig. 7 is a vertical section through the apparatus of Fig. 6, and

Figs. 8 and 9 are views similar to Figs. 6 and 7, respectively, showing an apparatus having a traveling furnace and stationary casting plate.

Considering the apparatus shown in Figs. 1 and 2, it will be noted that a continuous belt or casting plate of heat conductive metal, such

as copper or aluminum, is mounted for travel over a supporting plate or table and passes through a trough in the bottom of the apparatus, which trough is provided with a suitable coolant, such as water or brine. Mounted over the table is a furnace having an open bottom in contact with the moving belt or apron and having an orifice or gate for defining and controlling the issuance and flow of metal at the edge forming the front of the device. The metal at the bottom of the furnace is chilled and frozen by its contact with the cooled belt or apron, and is carried forward through the gate as a newly formed strip of red hot metal. This strip of metal is chilled on one side only, due to the unilateral contact with the chilled forming surface. A leading strip or tongs carries the plastic metal strip through feed rolls to rolling apparatus, not shown, where the strip is worked down to size and proper crystalline structure. Due to the method of operation the rolled strip is formed and worked simultaneously with the development of crystal growth or formation in the mass. As the crystals are in statu nascendi they are worked before they have any opportunity to grow, and the resulting structure is physically homogeneous, as to its crystallizing structure, which condition is impossible of attainment in metal masses, such as ingots, where coarse and differential crystallization has taken place, and in which no amount of heat treating, soaking, and mechanical workings will compensate for or remove the in-crystallized differences. In addition, no porosity or pipe formation occurs in the products of the present invention, due to the withdrawal of a continuous layer of bottom, sound metal, from the furnace and the unilateral chilling of such metal.

The application of the initial chill from a single surface only, increases the structural efficiency of the products, and particularly of various steels and irons which may be used. This is believed to be due to the fact that with a single chilled surface, there are not formed a number of freezing surfaces, each tending to condense metal in itself at the expense of the center or core of the formed mass, as occurs in ingots cast according to present practices.

The apparatus, whose function has been described in general terms immediately above, and, as shown in Figs. 1 and 2, comprises a copper belt or apron of suitable thickness, of the order of $\frac{1}{8}$ to $\frac{1}{2}$ an inch in thickness, and of any desired width. This belt 20 is mounted for unidirectional travel on spaced rolls or pulleys 21 which, in turn, are rotatably mounted on shafts 22, journaled in the side frame members 23. Spaced pedestals 24 support the side frames and are secured thereto. A support or table 30 is mounted on and across the pedestals, and the belt

20 is adapted to pass thereover and be supported thereby. A coating of solid lubricant 31, desirably of graphite, is provided for the top of the table, and provides a frictionless bearing for the belt. The table 30 may be made of insulating material, such as chromite, fused magnesia, and equivalent materials, care being taken to provide sufficient bulk of material to support the load of the pouring or casting apparatus, including the furnace. The trough 40, for the coolant, is secured to and between the side frame members 23 as by means of bolts or rivets or welds, all indicated generally at 41. The trough is provided with an inlet 42 and an outlet 43, for the coolant. The trough is so constituted and arranged as to receive the lower or bottom segments of the rolls 21 and the belt 20, in its return travel, and cool the several parts of the apparatus which are exposed to the heat of the liquid metal. The amount and temperature of the coolant, and its rate of flow, will be carefully determined to assure the desired amount of heat withdrawal from the newly formed strip of hot metal 60. The furnace, or casting pot, 50, as shown, comprises an open-bottomed pot 51 of heat-resisting material, such as chromite, brucite, and the like. The furnace is supported between framing members 23a of the structure. The front edge of the bottom of the crucible forms a throat or gate 52 for the issuing metal. The remaining bottom edges 53 are in sliding contact with the moving belt 20, which forms a continuous, heat-removing traveling bottom for the assembly, as well as a carrying apron for the newly-formed metal strip 60. A regulating device 54 serves to determine and maintain the desired aperture opening of gate 52. A support 55 serves to brace a crucible 56 during the pouring of molten metal 57 into the casting chamber 50. A source of controlled heat, such as high frequency coil 58, serves to maintain the metal 57 in a desired state of liquidity. It will be observed that the coil is spaced up from the belt 20. This is to prevent any induced electrical effects in the belt, and also to permit the cooling of the bottom metal in contact with the moving belt, while, at the same time, maintaining the supply of metal in the upper part of the chamber sufficiently liquid to prevent formation of pipe or any crystallization whatsoever. As noted above, the unilateral freezing and cooling afforded by the belt 20 insures that no structural physical or crystalline differences will be engendered in the newly solidified metal before it is subjected to the manipulative action of the working and forming rolls. The continuous strip casting apparatus described immediately above, may be supplemented by other apparatus, in which the furnace 60 travels, usually to-and-fro, in a fixed path over a stationary chill plate. Referring more particularly to Figs. 3 and 4, the modified apparatus comprises a stationary, hollow base 100, having sides 101 and a top or table portion 102. A coolant fluid 103 is introduced into member 100 through inlet 104 and is exhausted or withdrawn through outlet 105. A separate heat-conductive plate 110 is mounted on and secured to the top 102 of the base. The plate 110 is provided with parallel edge grooves 111, adapted to receive flanges 51a of the casting chamber 50 and by means of which the furnace is caused to maintain a desired to-and-fro travel over plate 110. Handles 59 may be secured to the casting chamber to permit its

manual movement along and over the plate 110. This plate may be formed with casting channels of rectangular cross-section, as indicated by 112 in Figs. 3, 4 and 5, the front edge of the furnace being flush with the top of the casting channel or mold section, as distinguished from the detail of Figs. 1 and 2, in which the casting channel is formed in the front edge of the furnace. However, it may be the same as that of Figs. 1 and 2 if a flat table without the channel 112 is used.

These strips can be made at a minimum of cost and labor, but with a greatly improved physical condition, due to the fact that the initial unilateral chilling of the cast metal and the immediate working of the so-formed strip, permits the formation and securing of a uniform, fine crystalline structure, and in statu nascendi, without ever being exposed to conditions favoring the formation of coarsely crystalline particles in various parts of the metal bodies or masses and shapes produced.

Referring now to the structures delineated in Figs. 6 and 7, there is shown an apparatus comprising the usual furnace 50, and draw-off rolls 62, mounted on a framework 200. The framework includes a base 201, sides 202, and a top, bridging member 203. The bridging member is provided with a plurality of aligned, vertical guiding rolls 204, in substantial alignment with one edge of the outlet or gate of the casting chamber. The casting chamber is held in place on member 203 and is in sliding contact with the upper surface 221 of revolving table 220. The table is mounted for rotation on shaft 222 journaled in boss 204 on the bottom of the framework 200. A second boss 205 is journaled to receive gear 206, which is in mesh with gear 207, the latter being secured to shaft 222 as a driving member therefor. A spiral gear 208, mounted on driving shaft 209, is in mesh with gear 206, and serves to furnish the necessary motive power for the rotation of table 220. Shaft 209 is journaled in the framing members 202, and is connected to a source of motive power, not shown. The casting table is made of copper, aluminum, or other heat-conductive material, and the surface may be coated with graphite. As the table is rotated, fresh chilling surfaces are constantly presented to the metal issuing from the casting chamber 50. The issuing strip 60 is guided along the aligning rolls 204, and is drawn through the take-off rolls 62 by the starting strip 61. The bulk of the metal in the casting table is such as to insure a chill effect on all molten metal contacted therewith. To prevent excess absorption or soaking up of heat in the table, the latter may be exposed to the action of coolant fluids, either liquid or gaseous.

The apparatus delineated in Figs. 8 and 9, comprises a stationary casting table, suitably cooled, and provided with an annular casting channel, together with a rotary arm carrying the furnace and adapted to discharge the liquid metal into the chill mold annulus, upon rotation of the arm. Considering the drawings more in detail, a table 300 is formed with a top surface 301, a continuous cylindrical wall 302, and a base 303, forming a liquid-tight joint with the wall 302. An inlet pipe 304 and an outlet pipe 305 provide means for the introduction and withdrawal of coolant fluid 306 from the interior of the table. A casting channel 307, of annular shape and rectangular cross-section, is formed in the table surface. The usual casting cham-

ber 50 is mounted on an arm 310, which arm is rotatably carried and rotated by vertical shaft 311 journaled in the top and bottom members of the table 300. A ring gear 312 is secured to the shaft, and is driven by a spiral gear 313, mounted on shaft 314, which is journaled in the wall 302, and is driven by suitable driving mechanism, not shown. The outlet or gate of the casting chamber will be in register with the casting channel. True annular shapes may be formed in this apparatus, or the initially chilled strip 60d may be continuously removed as the furnace lays it down.

The several casting plates or members, as noted, are desirably made of metal, although, for some purposes, asbestos, and other mineral, heat-resisting materials may be used.

It will now be appreciated that there have been shown and described a number of forms of casting apparatus suitable for the direct casting of liquid metals, such as steels and irons, into various forms and the immediate working of such materials, in a state of incipient crystallization, to prevent the formation of coarse crystalline structure and insure the formation of a uniform, solidified condition in the mass.

What is claimed is:

1. The method of forming metal strip directly from liquid metal which comprises, depositing the liquid metal on a cooling surface and freezing the metal by cooling it only from the single surface which is in contact with the cooling surface, while inhibiting heat loss from other surfaces whereby to cause solidification from one surface only and to inhibit crystal growth from all other surfaces.

2. The method of forming metal strip directly from liquid metal which comprises, depositing the liquid metal on a cooling surface from a vessel which maintains a body of liquid metal while causing relative movement between the vessel and the cooling surface, and freezing the metal by cooling it only from the single surface which is in contact with the cooling surface, while inhibiting heat loss from other surfaces whereby to cause solidification from one surface only and to inhibit crystal growth from all other surfaces.

3. The method of forming metal strip directly from liquid metal which comprises, heating a body of metal in a furnace to keep it molten, maintaining an extended bottom opening of the furnace over a flat cooling surface with all sides of the opening touching the surface except an orifice on one side from which the strip of solidified metal issues, and causing relative movement between the furnace and the cooling surface to progressively deposit molten metal on the cooling surface at a rate to freeze it solely from the cooling surface to a thickness to substantially fill the orifice with solid metal as the strip issues therefrom, whereby to cause solidification from the bottom surface only of the strip and to inhibit solidification from all other surfaces.

4. The method as set forth in claim 3 which further comprises in combination, filling the orifice at the beginning of a pour with a starting member which holds the liquid metal in the furnace until freezing begins and which moves out of the orifice as soon as the relative travel between the furnace and cooling surface begins

and the solidified strip begins to emerge from the orifice.

5. The method as set forth in claim 3 which further comprises in combination, filling the orifice with a starting strip having a furcated end, and moving the starting strip out of the orifice to draw the formed strip of solidified metal with it.

6. The method of forming metal strip directly from liquid metal which comprises, holding the bottom edges of an open bottom melting furnace in engagement with a plane cooling surface, maintaining the body of metal in the furnace in molten condition but freezing the metal at the bottom of the furnace in a strip the width of the open bottom, and drawing the strip out through an orifice on one side edge of the bottom the width of the bottom opening by causing relative surface movement between the furnace and cooling surface.

7. Apparatus for forming metal strip directly from liquid metal, comprising in combination, a metal melting furnace, a chill surface, said furnace having an extensive bottom opening above the three bottom side edges engaging said chill surface, said furnace also having a lateral orifice in the bottom edge of the fourth side the width of the bottom opening, and means for causing relative surface movement between said furnace and said chill surface.

8. Apparatus for forming metal strip directly from liquid metal, comprising in combination, a metal melting furnace, a chill surface, said furnace having an extensive bottom opening above and three bottom edges engaging said chill surface, said furnace also having a lateral orifice in the bottom edge of the fourth side the width of the bottom opening, a starting strip adapted to fit in and fill said orifice, and means for causing relative surface movement between said furnace and said chill surface.

9. Apparatus for forming metal strip directly from molten metal, comprising in combination, a plane rotary cooling table, a molten metal container having a bottom opening and the edges thereof in engagement with the surface of said table, one side having an orifice in the bottom the width of said bottom opening, means to rotate said table beneath said container, and stop guide means for one edge of the solidified strip as it leaves said table to prevent it from being carried around with the table.

10. The method of forming elongated metal bodies directly from liquid metal which comprises, depositing the liquid metal on a cooling surface, facilitating cooling and solidification from one surface while simultaneously maintaining a body of molten metal in contact with the opposite side and inhibiting cooling from that side until the elongated body has substantially solidified.

11. The method of forming elongated metal bodies directly from liquid metal which comprises, depositing the liquid metal on a cooling surface progressively along its length, actively cooling and causing solidification from one surface while simultaneously maintaining a bath of molten metal in contact with the opposite side, and actively heating the molten metal on that side until the elongated body has substantially solidified where it separates from the bath.

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