

April 27, 1954

E. J. STARK
APPARATUS FOR CASTING AND ROLLING
METAL INTO CONTINUOUS STRIPS

2,676,369

Filed April 16, 1952

5 Sheets-Sheet 1

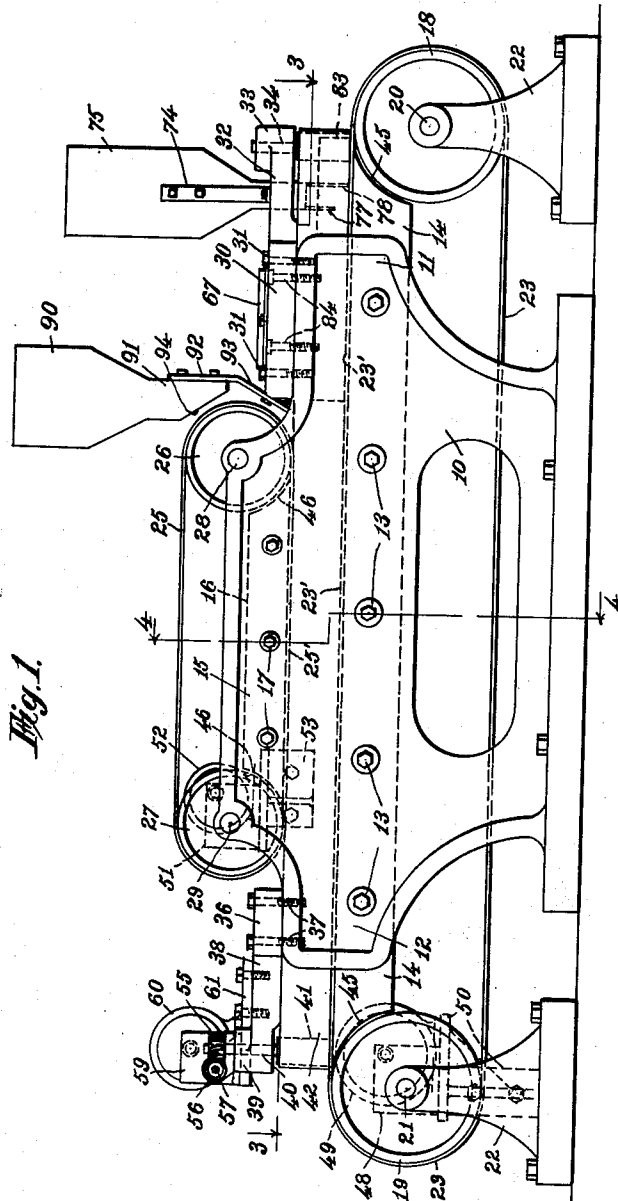


Fig. 1.

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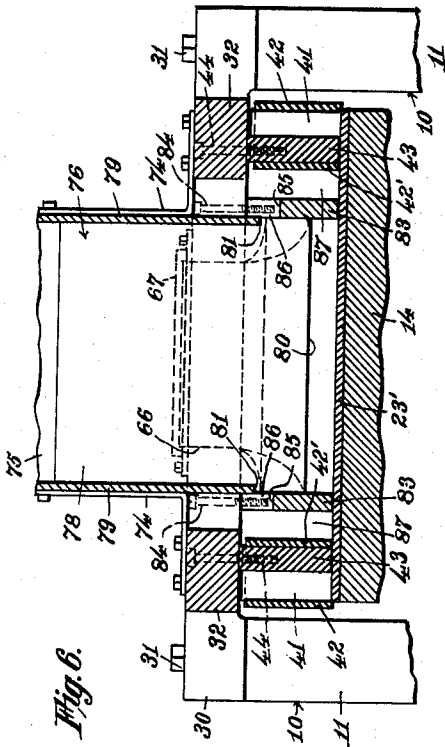


Fig. 6.

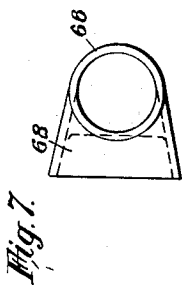


Fig. 7.

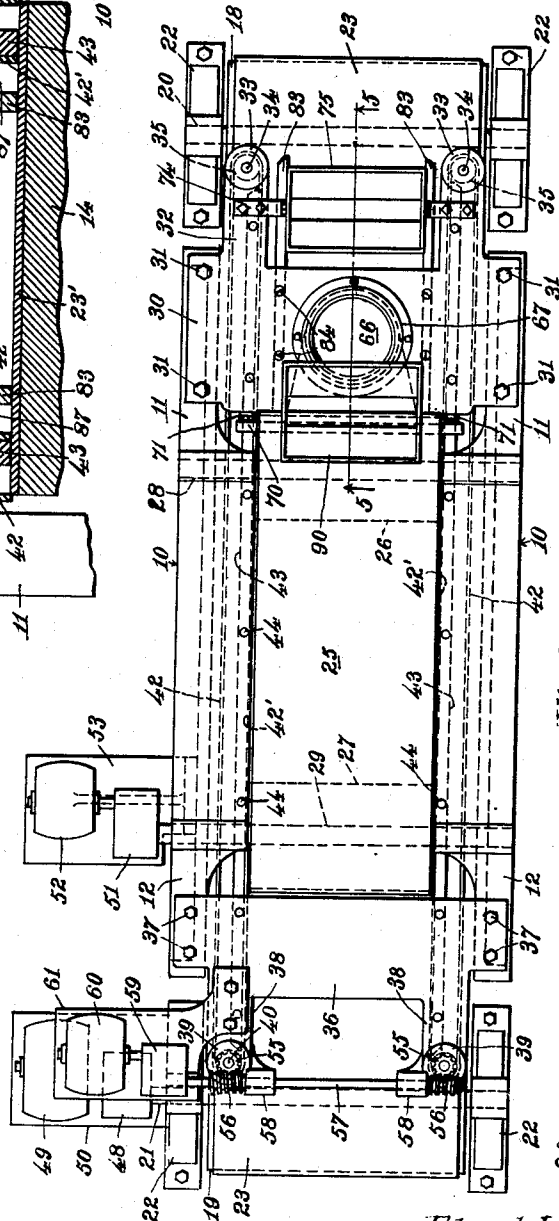


Fig. 8.

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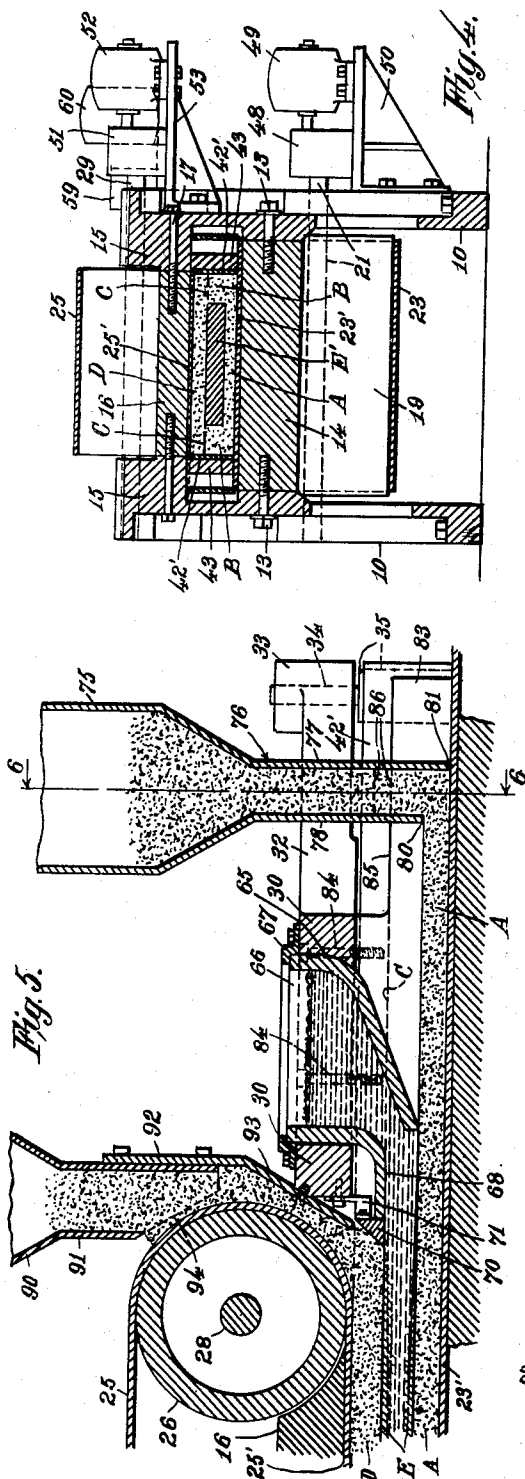
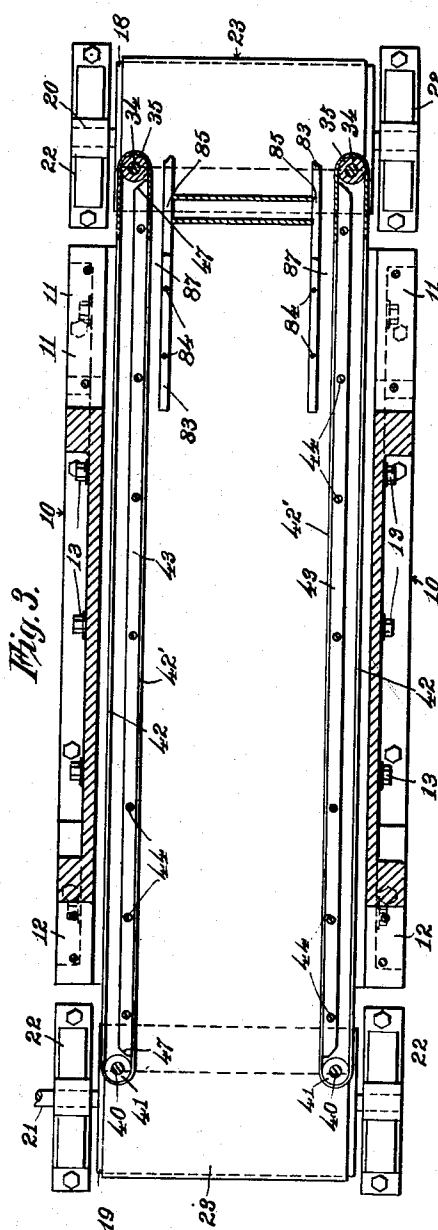


Fig. 3.

Fig. 4.

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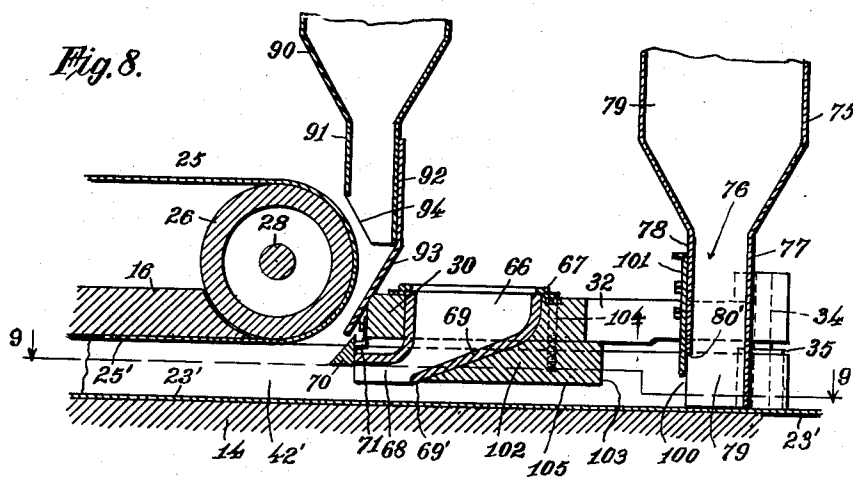
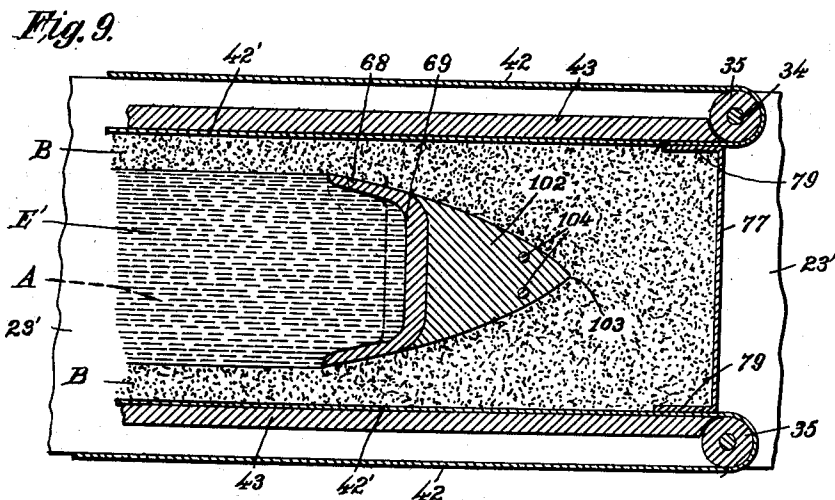
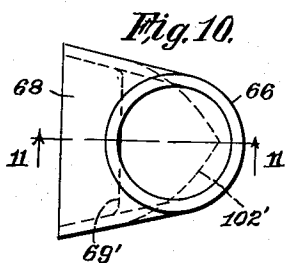
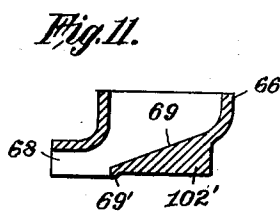
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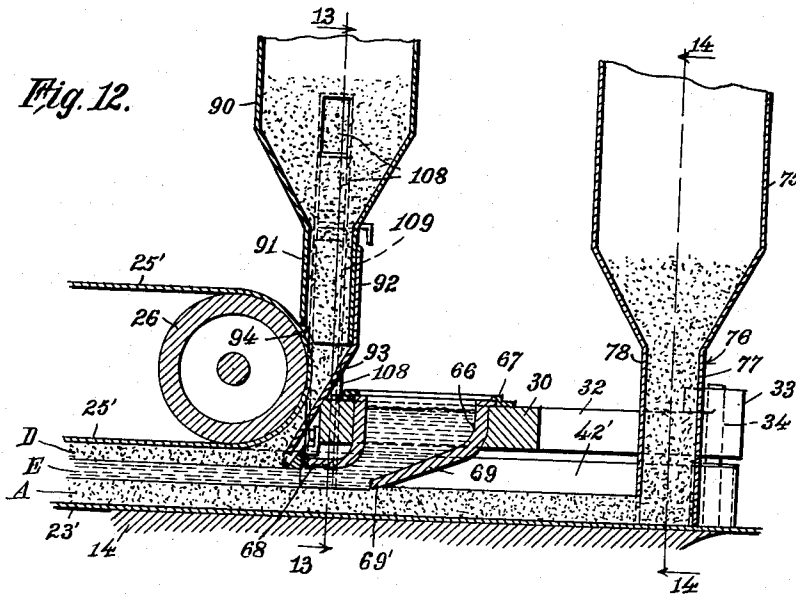


Fig. 13.

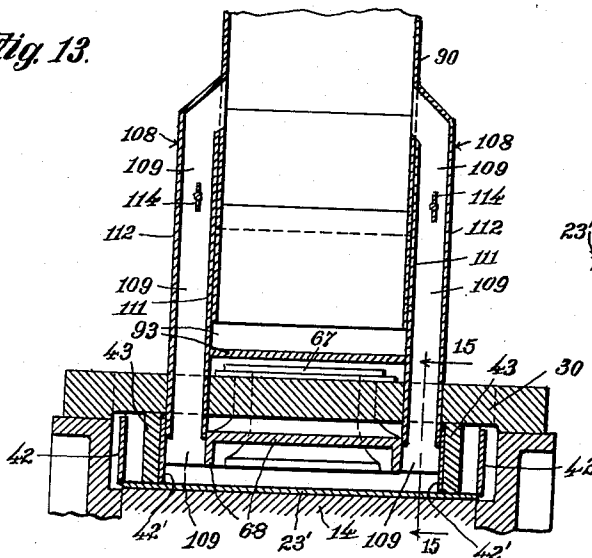


Fig. 15.

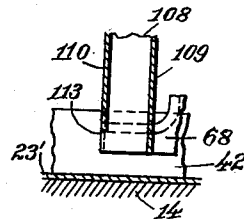
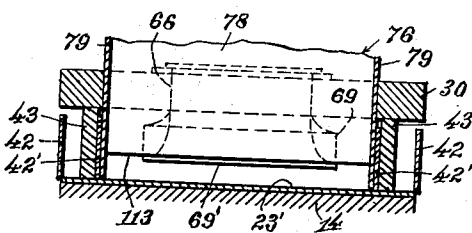


Fig. 14.



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APPARATUS FOR CASTING AND ROLLING METAL INTO CONTINUOUS STRIPS

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Application April 16, 1952, Serial No. 282,551

10 Claims. (Cl. 22—57.4)

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This invention relates to improved apparatus providing novel means for casting and rolling metal, particularly steel, into continuous strips of any desired cross-sectional shape or dimensions, and of any preferred length; and is a continuation-in-part of application Ser. No. 56,878, filed October 27, 1948, now abandoned.

It is the usual custom in the production of steel plates or strips, to cast the molten metal, as prepared in the open hearth, into ingots; and subsequently reheating the ingots for reducing in a blooming mill and repeated passes through the rolling mill to reduce the bloom to the desired dimensions for further operations. This requires heavy, expensive machinery which occupies considerable space, and consumes much time and labor.

The object of the present invention is to provide improved apparatus whereby the steel may be cast and rolled directly from the molten state as received from the open hearth, into semi-finished sheets or billets of the desired sizes ready for fabrication into the desired objects or products, thereby dispensing with the heavy blooming and rolling mills and the intermediate step of casting the metal into ingots.

A further object of the invention is to provide apparatus for casting and rolling steel billets which will protect the strips or billets from oxidation while being formed, and which will provide for the escape of gases from the hot metal.

The novel apparatus of the present invention consists generally of means for continuously forming the bottom and sides of a moving trough-like mold of granular heat-resistant material, means for pouring a constant stream of molten metal therein, means for providing a top layer of said granular material over said metal, and means for subjecting the whole to pressure while the metal freezes.

The bottom and sides of the continuous trough-like mold is formed by depositing the granular material upon an endless moving belt, from a hopper or other suitable source, and between synchronously moving side belts. The combination of the lower belt and said side belts will hereinafter be designated collectively as an endless belt structure. The metal is teemed through a suitable nozzle into the trough-like mold formed on said lower belt structure, and a top layer of granular material is deposited on the metal and on the top edges of the sides of the mold.

Various means may be employed for forming the bottom and sides of the trough-like mold, and several such means are illustrated in the draw-

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ings and hereinafter described in detail. In carrying out this feature of the invention, granular material may be deposited on the belt structure from a feeding device, a portion of the material being fed rearwardly to form the bottom of the mold, and other portions thereof being fed laterally from the same feeding device to form the side portions of the mold. If preferred, sufficient material may be fed directly rearwardly from the feeding element to form both the bottom and sides of the mold, and a wedge shaped element provided forwardly of the metal teeming nozzle, and above the desired level of the bottom, to divide the material above said level and direct the same laterally between the nozzle and the side belts to form the sides of the mold. A further modification of the means for forming the mold may be by spreading a layer on the lower belt extending the full width thereof between the side belts and of substantially the desired thickness for the bottom, and then depositing granular material on the upper face of the lateral portions of said layer at points each side of the metal teeming nozzle, to form the sides of the mold. Each of the above forms are illustrated and described herein, and it is obvious that various modifications of each may be made without departing from the scope of the present invention.

The strip of metal thus formed and completely surrounded by the granular material, is then subjected to pressure by passing, together with the lower belt structure and an upper belt, between pressure members engaging and backing the inner laps of the several belts.

The metal pouring nozzle may have a discharge end of any selected shape or dimensions according to the desired cross-sectional shape or dimensions of the strip to be formed. As, or after the strip emerges from the discharge end of the device said strip may be sheared into the desired lengths; but as this forms no part of the present invention, such step is not illustrated, described or claimed in the present application.

The invention will be more readily understood by reference to the accompanying drawings forming a part of this specification and in which:

Figure 1 is a side elevation of the apparatus embodying my invention;

Figure 2 is a top plan view of the same;

Figure 3 is a horizontal section taken on substantially the line 3—3 of Figure 1;

Figure 4 is a transverse section on the line 4—4 of Figure 1;

Figure 5 is a detail longitudinal section taken

on substantially the line 5—5 of Figure 2, and illustrated upon an enlarged scale;

Figure 6 is a detail cross section on the line 6—6 of Figure 5;

Figure 7 is a detail plan view of a nozzle;

Figure 8 is a detail longitudinal section similar to Figure 5, illustrating a modified form of the invention, the metal and the granular material being omitted;

Figure 9 is a horizontal section on the line 9—9 of Figure 8, the granular material and metal being included;

Figure 10 is a detail plan view of a modified form of teeming nozzle;

Figure 11 is a section on the line 11—11 of Figure 10;

Figure 12 is a detail vertical longitudinal section similar to Figures 5 and 9, but illustrating a further modification of the invention;

Figure 13 is a vertical transverse section on the line 13—13 of Figure 12, the granular material and molten metal being omitted;

Figure 14 is a similar detail section on the line 14—14 of Figure 12; and

Figure 15 is a detail section of a further modification taken on substantially the line 15—15 of Figure 13.

Referring to Figures 1 to 7 inclusive of the drawings, 10—10 indicate the side frame members of the device, each having a front and a rear extended portion 11 and 12 respectively. Between the side frame members 10, and secured thereto as by bolts 13, is a supporting plate 14, the ends of which project beyond the extended portions 11 and 12 of the frame. Between the upper portions 15 of the side frames is a pressure plate 16 secured thereto as by bolts 17.

Mounted adjacent the front and rear ends respectively of the frame are rotary drums 18 and 19, the shafts 20 and 21 of which have bearings in suitable supports 22. An endless belt 23 is mounted on said drums, and the upper lap 23' thereof travels upon the upper face of the supporting plate 14 and constitutes a travelling base upon which the mold is formed, as will be fully described hereinafter.

Arranged in spaced relation above the belt 23 is an endless upper belt 25 carried on rotary drums 26 and 27, the shafts 28 and 29 thereof having bearings in the upper portion 15 of the side frames 10. The lower lap 25' of belt 25 travels against the under face of the pressure plate 16.

A transverse plate 30 is secured to the frame extensions 11, as by bolts 31 and is provided with forwardly extending arms 32 terminating in bearing sleeves 33 for the spindles 34 of vertically disposed rollers 35. A similar transverse plate 36 is secured to the rear extensions 12 as by bolts 37, and is provided with rearwardly extending arms 38 terminating in bearing sleeves 39 for spindles 40 of rollers 41.

Carried by the rollers 35 and 41 on each side of the machine are parallel endless belts 42, the inner laps 42' of which are positioned inwardly from the edges of the lower belt 23 and engage the upper surface thereof. See Figure 6. Gauge plates 43 are arranged behind the inner laps 42' of the belts 42 and are secured in position by bolts 44. The edges of the lower lap 25' rest upon the upper edges of the inner laps 42' of the side belts, so that the inner laps of the several belts form an elongated longitudinal space between them, which is rectangular in cross-section; and it is through this space that the formed

mold and the metal therein is compressed and frozen, as hereinafter described.

The ends 45 of the supporting plate 14 are curved concentrically with the drums 18 and 19 and lie close to the peripheries thereof in order to fully support the upper lap 23' of the belt 23 throughout its length; and the ends 46 of the plate 16 are similarly curved concentrically with the drums 26 and 27 to back the lap 25' of the belt 25 throughout the length thereof. In order to similarly back the inner laps 42' of the belts 42, the gauge plates 43 are formed with beveled ends 47.

It should be understood that the several belts 23, 25 and 42 are each formed of a flat flexible sheet of heat-resisting material which will not warp; and not being subject to contact with the molten metal at any time in the operation of the device, will not be burned, become warped or misshapen, or deteriorated by continuous use, thereby minimizing, not only the cost of manufacture, but also the cost of repairs and the loss of time incident to repairs and replacements.

Any suitable means may be employed to drive the several belts at a uniform speed. As illustrated in the drawings the shaft 21 of drum 19 is connected through gearing in housing 48, with a motor 49, said housing and motor being supported on a bracket 50. Shaft 29 of drum 27 is similarly connected through gearing in a housing 51 with a motor 52; 53 indicating a bracket support for the same.

The spindles 40 of the rollers 41 extend upwardly above the bearing sleeves 39 and are each provided with a worm gear 55 meshing with worms 56 on a transverse shaft 57 having bearings 58 on the arms 38. The shaft 57 is connected through gearing in a housing 59 to a motor 60 supported on a bracket 61. The above described motors and gearings are synchronized to drive the several belts at uniform speed.

Extending through an aperture 65 in plate 30 is a pouring or teeming nozzle 66 which is removably held in position by a flanged ring 67. The nozzle 66 is provided with a discharge spout 68, the end of which terminates substantially under the forward end of the belt 25 and substantially midway between the belts 23 and 25. The bottom wall 69 of the teeming nozzle inclines rearwardly and downwardly, and terminates in a rear edge 69' in the plane of the bottom of the discharge spout 68. The discharge end of the spout 68 is shaped to substantially the desired cross-section of the strip to be cast and rolled. In order that strips of various cross-sections may be formed, interchangeable nozzles are provided, each having a spout of a desired form.

A control gauge is provided at the discharge end of the spout. This comprises a transverse bar 70 supported by brackets 71 adjustably secured to the rear edge of the plate 30.

Forwardly of the nozzle 66, and supported upon the arms 32 of the plate 30 by brackets 74, is a hopper 75 for the granular material from which the molds are formed. The hopper 75 is formed with a down spout 76, which is rectangular in horizontal cross-section and consists of a front wall 77, a rear wall 78 and side walls 79. The front wall 77 extends downwardly to the upper lap 23' of the belt 23, and the rear wall 78 terminates with its lower edge 80 spaced from the belt approximately the same distance as is the lower edge of the nozzle spout 68, although it may be spaced above the level of said spout for a purpose hereinafter described. This distance, to-

gether with the lower rear edge 69' of the nozzle, determines the thickness of the bottom of the mold, as will appear hereinafter. The side walls 79 are spaced apart a distance substantially equal to the width of the spout 68 and terminates with their lower edges 81 on a level below that of the upper edges of the side belts 42.

Extending parallel with the belts 42 are retaining plates 83 which fit close against the side edges of the front and rear walls of the down spout 76. These plates 83 extend from adjacent the forward ends of the belts 42 to substantially the discharge end of the pouring nozzle spout 68; and are held in place, as by bolts 84, with the lower edges of the plates engaging the belt 23. The upper edges 85 of the plates 83, adjacent the hopper spout 76, is below the level of the edges 81 of the side walls 79, leaving an aperture 86 through which the granular material may flow into the spaces 87 between the plates 83 and the inner laps 42' of the side belts to form the side walls of the mold.

Immediately in front of the forward end of the belt 25 is a second hopper 90 having a down spout 91 to which is attached a supporting plate comprising a vertical upper portion 92 secured to the spout and a forwardly inclined lower portion 93 bolted or otherwise secured to the rear edge of the plate 30. See Figure 5. The lower end of the spout 91 is tapered as at 94 to feed the granular material against the belt 23 as it passes downwardly around the drum 26; and the inclined portion 93 of the hopper supporting plate distributes the material evenly under the belt to form the top of the mold, as will be more fully described hereinafter.

As hereinbefore stated, the several belts above described are formed of a heat-resistant material; and the granular material used is a silica bearing substance such as is provided to the market under the trade name of "Frit" or "Melt," and consists principally of a ground glass base. However, it is to be understood that the invention is not limited to the use of any specific product so long as it is a granular, silica bearing substance.

The operation of the form of the invention above described is as follows: The granular material is fed from the hopper 75, under the edge 80 of the front wall 78 forming a layer A of uniform thickness upon the upper lap 23' of the belt 23 between the retaining plates 83. The layer A constitutes the bottom of the mold. At the same time, material flows laterally through the apertures 86 under the lower edges 81 of the side walls of the hopper and over the top of the retaining plates 83 into the spaces 87 between the plates 83 and the side belts 42, forming the sides B of the mold to the level of the top of the plates 83, and as indicated by the dotted lines C in Figures 4 and 5. As the trough-like mold thus formed passes forwardly under the nozzle 66, the material forming the bottom A is leveled and smoothed by the lower portion of the inclined bottom wall 69, and the fluid metal which has been supplied to the nozzle in any preferred manner, flows into the mold, as illustrated in Figure 5, to substantially the level of the sides B thereof the depth being controlled by the adjustable gauge bar 70. As the trough-like portion of the mold, with the fluid metal therein, passes beyond the bar 70, the granular material from the hopper 90 forms a layer D upon the molten metal and the upper edges of the side portions B of the molds. The metal in the mold, as it passes through the machine, grad-

ually cools and solidifies inwardly from the surfaces, as indicated at E in Figure 5, forming a continuous bar or billet E' of steel, as shown in cross-section in Figure 4. The gases from the metal can escape through the granular material of the mold. A portion of the granular material fuses and forms a thin coating on the surfaces of the metal which prevents oxidation of the same. As the metal cools, the coating spalls off, leaving the billets or strips with clean, unoxidized surfaces. The material which spalls off may be reclaimed, ground, and reused by mixing with the material to be fed to the hoppers.

A modification of the invention, particularly as to the means for forming the trough shaped portion of the mold, is illustrated in Figures 8 and 9. In this form of the device, the side retaining plates 83 are omitted and the side walls 79 of the hopper 75 and down spout 76 extend downwardly to the lap 23' of the lower belt 23. Preferably the hopper 75 and down spout 76 are widened so that the side walls 79 thereof are substantially in engagement with the inner laps 42' of the side belts 42, as illustrated in Figure 9. The rear wall 78 terminates in an edge 80' positioned above the belt 23 a sufficient distance to form a discharge opening 100 of ample size to permit the flow of the maximum amount of granular material required to form both the bottom A and the side walls B of the mold trough. A vertically adjustable gate 101 is provided whereby the quantity of material released may be nicely regulated to provide just the proper amount of mold forming material for the bottom and side walls.

Located between the discharge opening 100 and the spout 68 is a horizontally disposed wedge shaped member or plow 102 with the apex 103 thereof extending forwardly toward the discharge opening 100 of the down spout. The plow 102 preferably extends forwardly from the nozzle 68 and may be secured in position in any desired manner. As illustrated, the plow 102 is attached to the transverse plate 30 as by bolts 104, and the rear end thereof may abut the inclined bottom wall 69 of the spout 68, although this is not necessary.

Preferably, the lower face 105 of the plow lies in a plane slightly above that of the lower edge of the spout 68, although it may be in the same plane therewith without departing from the scope of the invention. As the material released from the down spout 76 advances toward the spout 68 of the pouring nozzle 66, the portion of the material above the plane of the face 105 of the plow, is divided laterally upon opposite sides of the spout and forms the side walls B of the mold, as illustrated in Figure 9.

The central portion of said layer A, for substantially the width of the strip to be cast, passes under the bottom wall 69 of the discharge spout 68, which wall is inclined downwardly and rearwardly in the direction of movement of the belts; and the lower edge of said wall 69 will level the surface of the granular material thereby forming a smooth level surface to receive the molten metal. When the bottom face 105 of the plow 102 is in a plane above the level of the bottom edge of the spout wall 69, the slight excess material passing under the plow will be pressed downwardly by the inclined wall 69 at it passed thereunder, thereby compacting the material to form a firmer face to receive the metal. This may also be accomplished in the form illustrated in Figures 1 to 8 of the drawings by having the edge 80

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of the downspout wall in a plane slightly above the plane of the lower edge of the spout, as hereinbefore stated. This forms a smooth, firm and level surface for the bottom wall A of the mold.

In Figures 10 and 11 the plow 102' is illustrated as formed integrally with the nozzle 66 instead of constituting a separate detachable element as above described; and it is evident that the plow, either as a separate element, or as integral with the nozzle, may be varied in size and contour to serve the specific requirements of the design of the device with which it is to be used.

In Figures 12 to 14 inclusive a further modification of the means for forming the mold is illustrated. As shown therein, the portion of the granular material to be used in forming the side walls B of the mold, is fed from the hopper 90 instead of from the hopper 75. To this end, a pair of laterally disposed ducts 108 extend downwardly from the hopper 90 and discharge at their lower ends into the spaces between the spout 68 and the inner laps 42' of the side belts 42. Each duct includes a front wall 109, a rear wall 110 and inner and outer side walls 111 and 112 respectively. The lower ends of said ducts 108 terminate between the spout 68 and the inner laps 42' of the side belts 42 without undue friction on the latter; and the front wall 109 may extend downwardly to approximately the level of the upper face of the bottom A of the mold, although this is not necessary. The rear wall 110 terminates in a lower edge 113 which is spaced above the belt portion 23' a distance equal to the desired height of the side walls B. The modification shown in Figure 15 is similar to that illustrated in Figures 12 to 14, except that the sides 111 and 112 extend downwardly and terminate on a level with the lower edge of the front wall 109. A damper 114 may be provided in each duct 108 for regulating the quantity of granular material delivered to form the side walls B of the mold. The top layer D is formed in the same manner as hereinbefore described.

With the structures illustrated in Figures 8 to 15, inclusive, the cross-sectional dimensions of the billet may be readily varied, either in width or thickness, or both, by replacing the teeming nozzle 66 with one having a spout of the required dimensions. This will require adjustment of the means for feeding the granular material to form a proper mold. In the form illustrated in Figures 8 to 11 inclusive, this adjustment of the feed may be accomplished by means of the adjustable gate 101, it being understood that in some instances the plow 102 may also need to be replaced by one of suitable size. When using a nozzle provided with an integral plow, this adjustment is taken care of with the change of nozzle. With the form illustrated in Figures 12 to 14, the inception of the mold cavity is produced by the lower end of the nozzle, and the balance of material required for the sides B is controlled by the dampers 114.

While the invention is particularly designed for the treatment of steel, and has been so described, it is to be understood that it is applicable to the treatment of other metals without departing from the scope of the invention as described and claimed.

I claim:

1. In a device of the class described an endless belt structure forming a trough having a bottom and side walls, an upper endless belt cooperating with said belt structure, said belt structure extending forwardly beyond the forward end of

the upper belt, a hopper above the forward end of said belt structure and having a down spout for depositing granular mold forming material thereon, said spout comprising front, rear and side walls, the front wall extending downwardly to the bottom wall of said belt structure, and the rear wall terminating above said bottom wall to gauge the depth of the material deposited thereon to form the bottom of a mold, means for forming side walls of granular material for said mold, a spout for depositing molten metal on said mold bottom between said side walls, a second hopper for depositing a layer of granular material on said metal and top edges of said side walls, and means synchronously for driving said belts.

2. In a device of the class described, a lower endless belt, a pair of side endless belts, and an upper endless belt, the inner laps of said belts forming an elongated passageway, rectangular in cross-section, the lower belt and side belts extending forwardly beyond the forward end of said upper belt, a hopper above the forward end of said lower belt and having a down spout for depositing granular mold forming material on said belt, said spout comprising front, rear and side walls, the front wall extending downwardly to said lower belt, and the rear wall terminating above said belt to gauge the depth of the material deposited thereon to form the bottom of a mold, means for forming side walls of granular material for said mold, a spout for depositing molten metal on said mold bottom between said side walls, a second hopper for depositing a layer of granular material on said metal and top edges of said side walls, and means for synchronously driving said belts.

3. In a device of the class described, a lower endless belt, a pair of side belts and an upper belt, said lower and side belts extending forwardly beyond the forward end of the upper belt, a hopper above the forward end of said lower belt and having a down spout for depositing granular mold forming material on said belt, said spout comprising front, rear and side walls, the front wall extending downwardly substantially to said belt, and the rear wall terminating above said belt to gauge the depth of the material deposited thereon to form the bottom of a mold, parallel retaining plates having the inner faces thereof in alignment with the sides of said spout and extending forwardly and rearwardly therefrom and forming longitudinal passageways between the same and the inner laps of the side belts, the side walls of said spout terminating above the upper edges of said plates to permit granular material to flow over the same into said passageways to form the side walls of said mold, means for pouring molten metal onto said granular material between said side walls, means for depositing a layer of granular material over said molten metal and side walls, and means for continuously and synchronously driving said belts.

4. In a device of the class described, a lower endless belt, a pair of endless side belts, and an upper belt, said lower and side belts extending forwardly beyond the forward end of the upper belt, a hopper above the forward end of said lower belt and having a down spout for depositing granular material on said belt, said spout comprising front, rear and side walls, the front wall extending downwardly substantially to said belt and the rear wall terminating above said belt to gauge the depth of the material deposited thereon to form the bottom of the mold, parallel retain-

ing plates in substantial alignment with the sides of said spout and extending forwardly therefrom to form passageways between the same and the inner laps of said side belts, the side walls of said spout terminating in spaced relation above the level of the upper edges of said plates to permit granular material to flow over the same into said passageways to form the side walls of said mold, a pouring nozzle for molten metal supported rearwardly of said hopper and having a downwardly and rearwardly extending nozzle, the bottom of which is spaced from said lower belt substantially the same distance as is the lower edge of the rear wall of said hopper down spout, and a second hopper for granulated material arranged rearwardly of said nozzle for depositing a layer of granular material over the molten metal as it issues from said nozzle and over the top of the side walls of the mold.

5. A device as set forth in claim 4, further characterized by a transverse gauge bar adjustably mounted at the discharge end of said pouring nozzle spout.

6. In a device of the class described, a lower endless belt, a pair of side belts and an upper belt, said lower and side belts extending forwardly beyond the forward end of said upper belt, a hopper above the forward end of said lower belt and having a down spout for depositing granular material on said belt, said spout comprising front, rear and side walls, said front wall extending downwardly to said belt and the rear wall terminating above said lower belt to gauge the depth of the material deposited thereon to form the bottom of a mold, a fixed transverse member arranged rearwardly of said hopper and having an aperture to receive a pouring nozzle, a nozzle removably secured therein and having a downwardly and rearwardly extending spout of substantially the width of the hopper down spout, parallel retaining plates extending from the sides of said down spout to the sides of said nozzle spout forming passageways between said plates and the inner laps of the side belts, the side walls of said down spout terminating in spaced relation above the upper edges of said plates to permit granular material to flow over said plates to form the side walls of said mold, and a second hopper for granular material arranged rearwardly of said nozzle for depositing a layer of granular material over the molten metal as discharged from said spout, and over the side wall of the mold.

7. A device as set forth in claim 6 in which the last said hopper is arranged above the forward end of said upper belt, and a supporting plate for said hopper adapted to hold the downwardly moving granular material against the end of said upper belt and deliver said material onto the molten metal as it issues from the spout.

8. In a device of the class described, an endless belt structure comprising a lower belt and a pair of side belts, an upper belt cooperating with said belt structure, said belt structure extending forwardly beyond the forward end of the upper belt, a hopper above the forward end of said belt structure and having a down spout for depositing granular mold forming material thereon, said spout comprising front, rear and side walls, the front wall extending downwardly to said lower belt, and the rear wall having a discharge opening of ample size to permit passage of material to form both the bottom and side walls of a continuous trough-like mold, a spout for teeming molten metal into said mold, deflecting means located between said discharge opening and said spout for moving a portion of the material laterally to form the side walls of said mold, means rearwardly of said spout for depositing a layer of granular material over the metal in said mold and means for synchronously driving said belts.

9. A device as set forth in claim 8 in which the teeming nozzle is removable and replaceable with a different size nozzle, in combination with means for adjusting the size of the discharge opening in the down spout.

10. A device as set forth in claim 8 in which the deflecting means for the granular material is integral with the teeming spout.

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