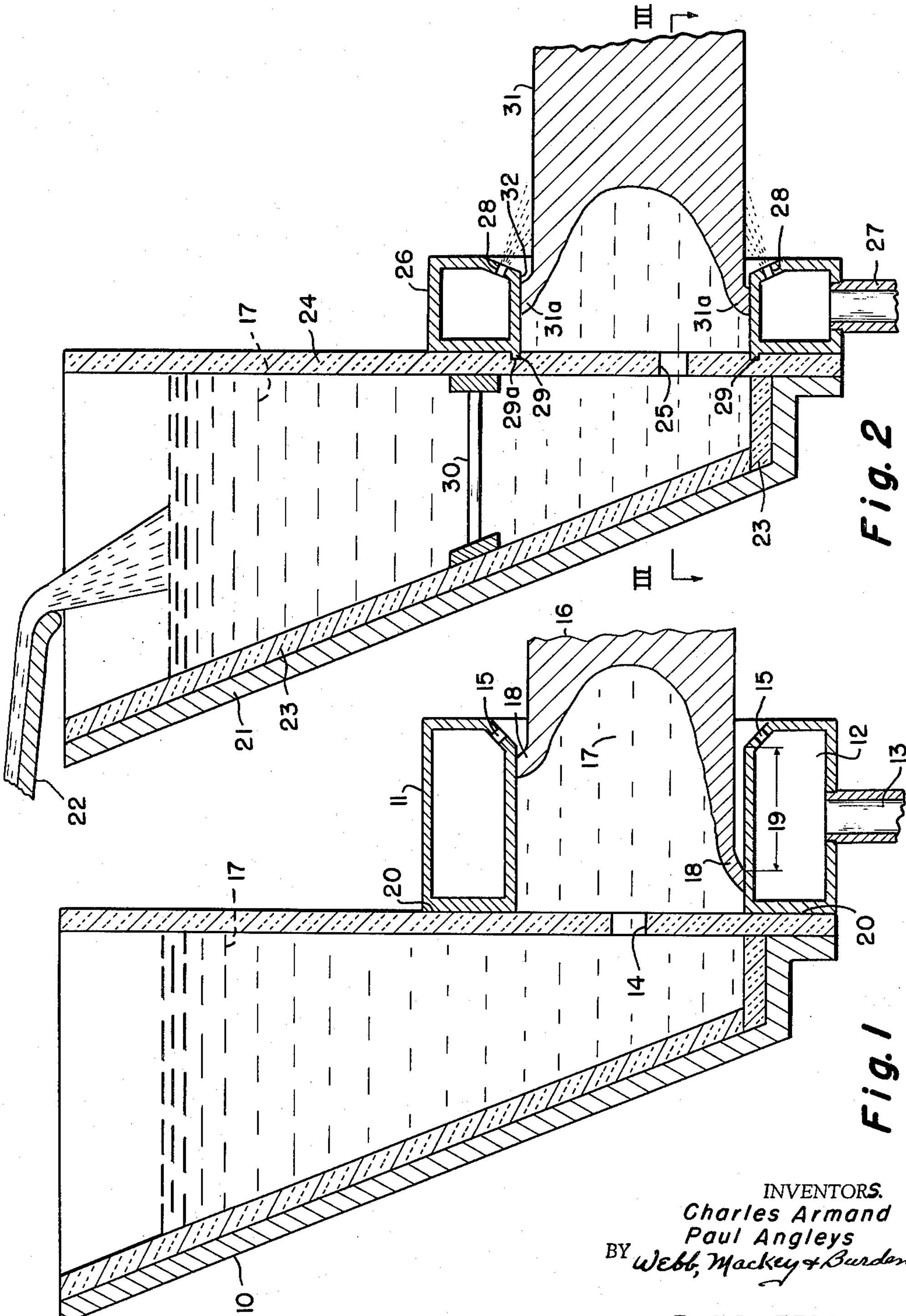
Aug. 22, 1961 C. ARMAND ET AL 2,996,771

METHOD AND APPARATUS FOR HORIZONTAL POURING OF METALS

Filed Nov. 24, 1959 5 Sheets-Sheet 1

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METHOD AND APPARATUS FOR HORIZONTAL POURING OF METALS

Filed Nov. 24, 1959 5 Sheets-Sheet 2

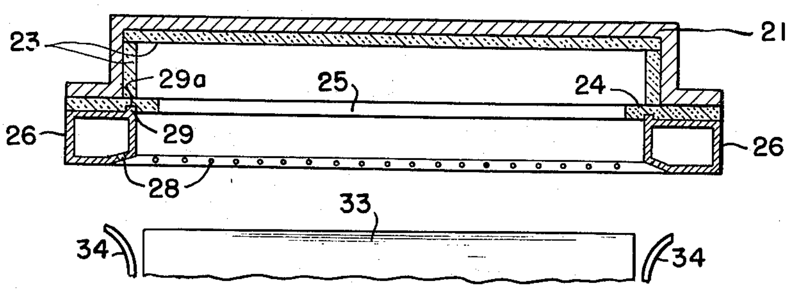


Fig. 3

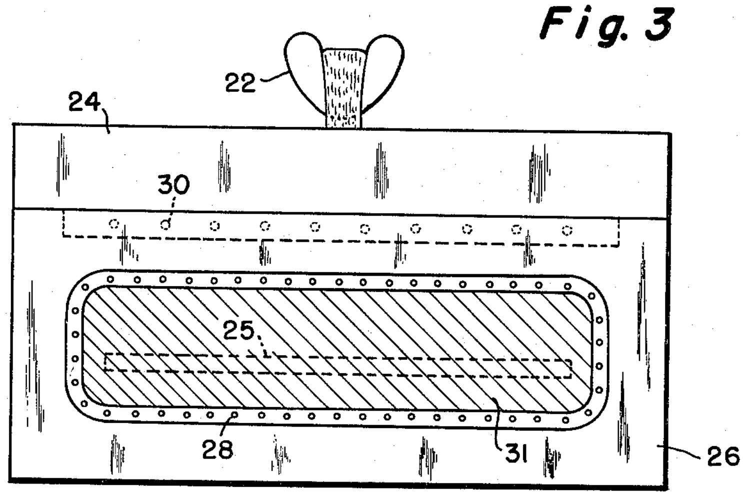


Fig. 4

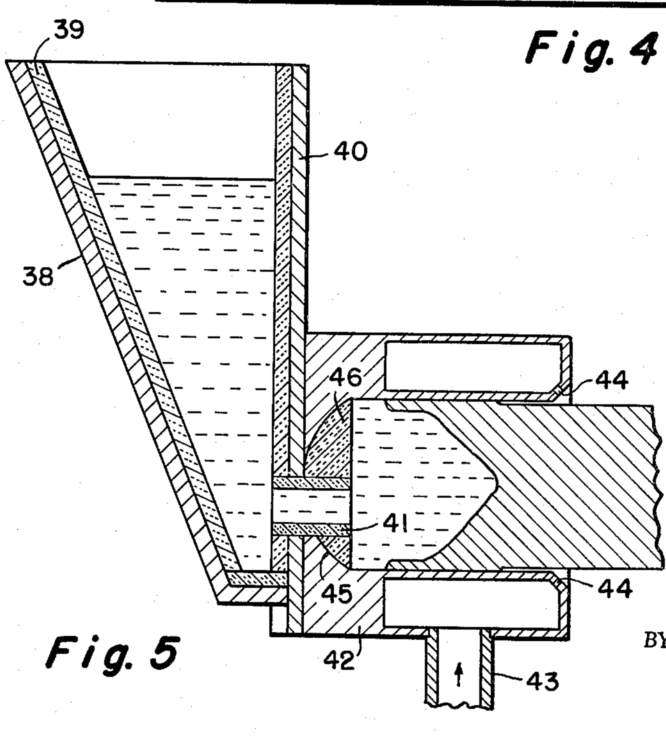


Fig. 5

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METHOD AND APPARATUS FOR HORIZONTAL POURING OF METALS

Filed Nov. 24, 1959 5 Sheets-Sheet 3

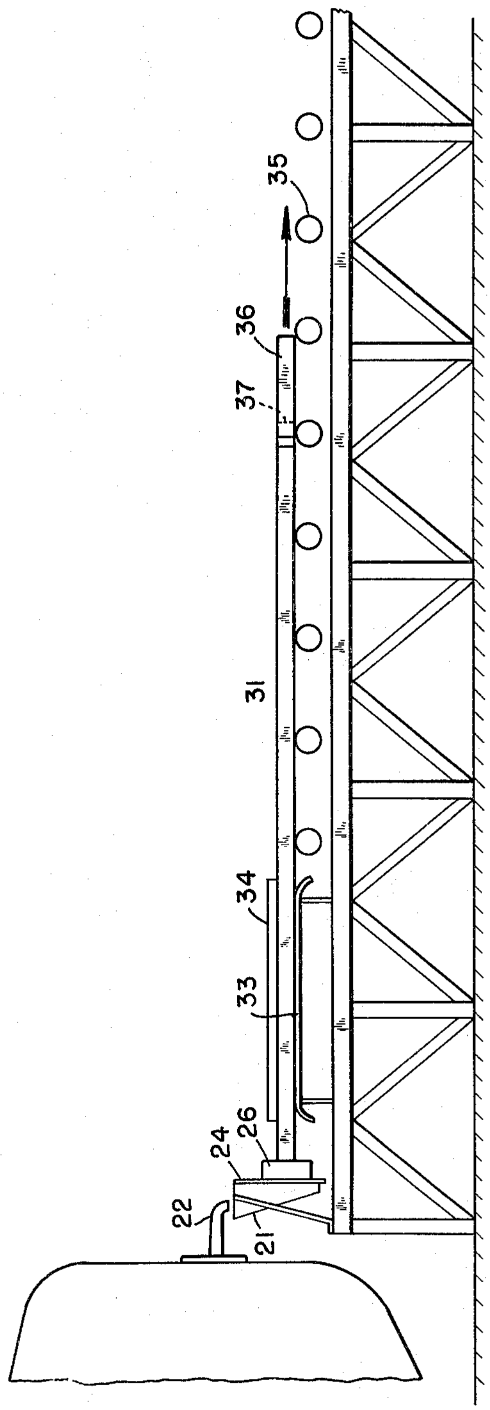


Fig. 6

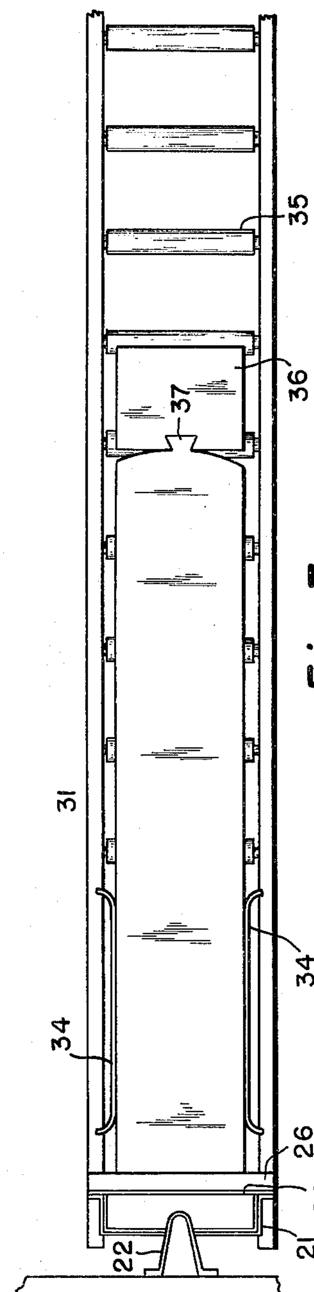


Fig. 7

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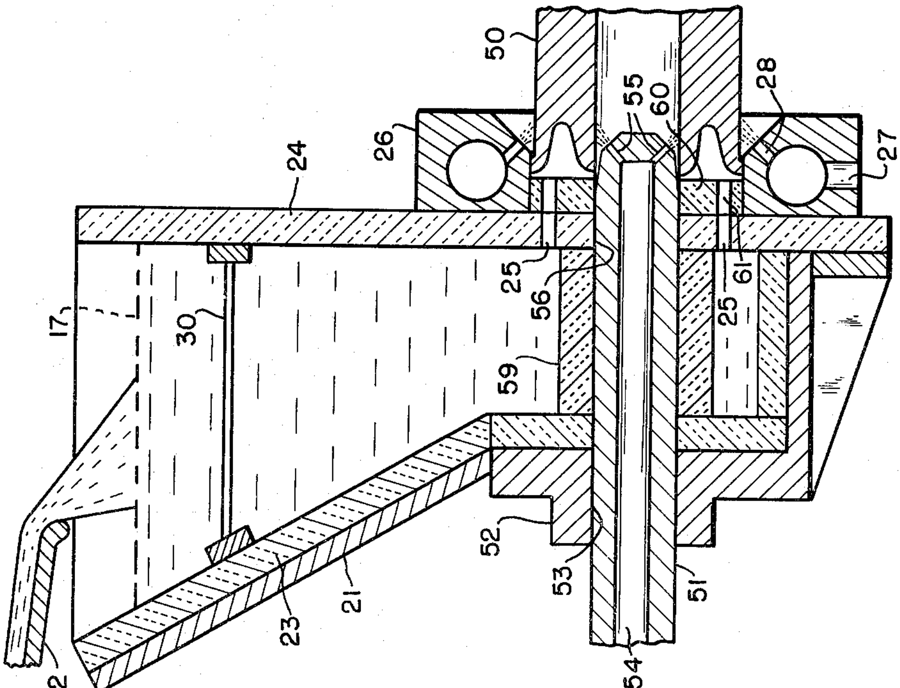


Fig. 9

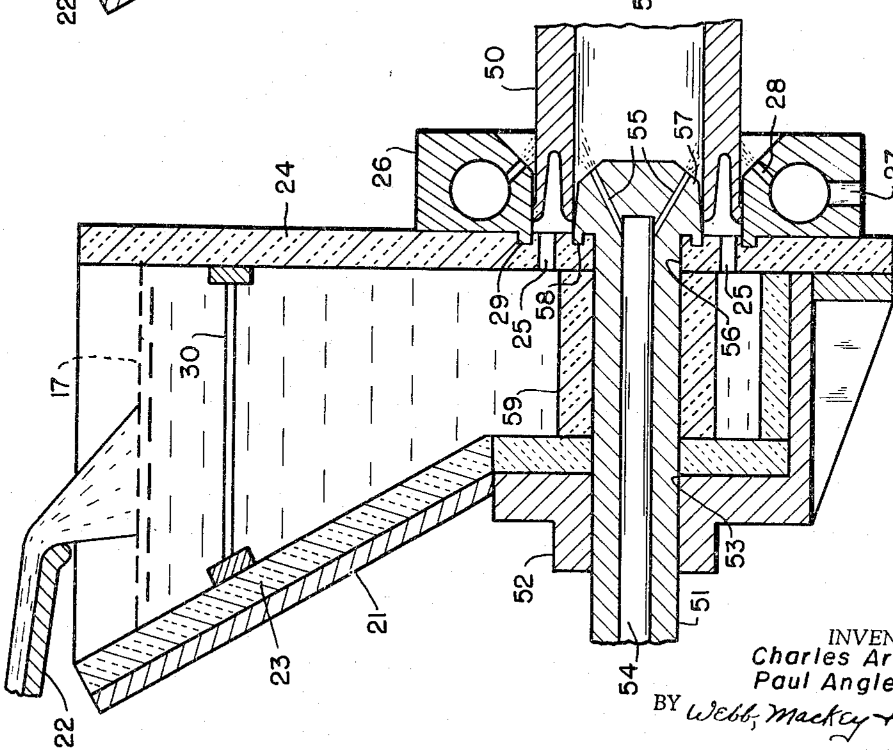


Fig. 8

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METHOD AND APPARATUS FOR HORIZONTAL POURING OF METALS

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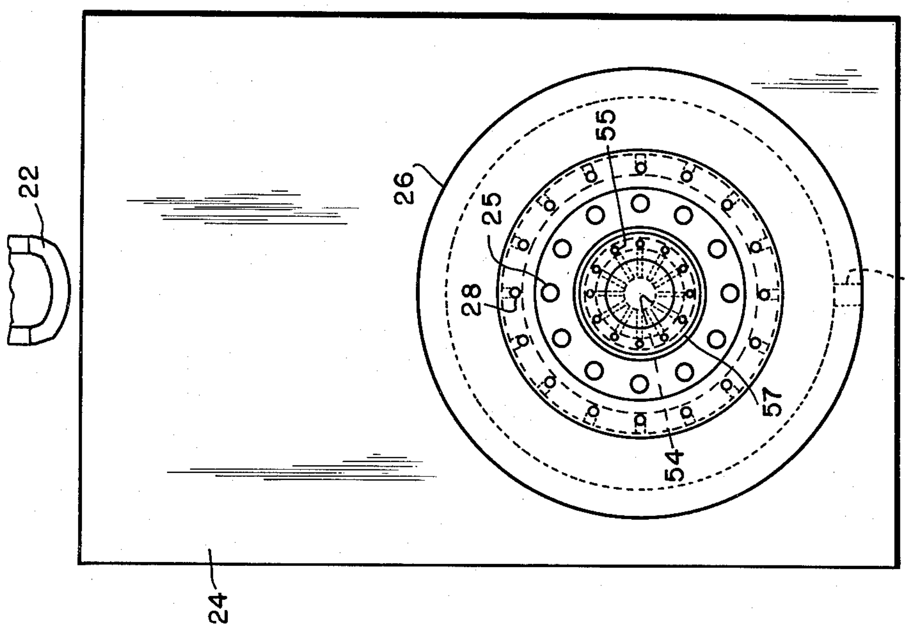


*Fig. 11*

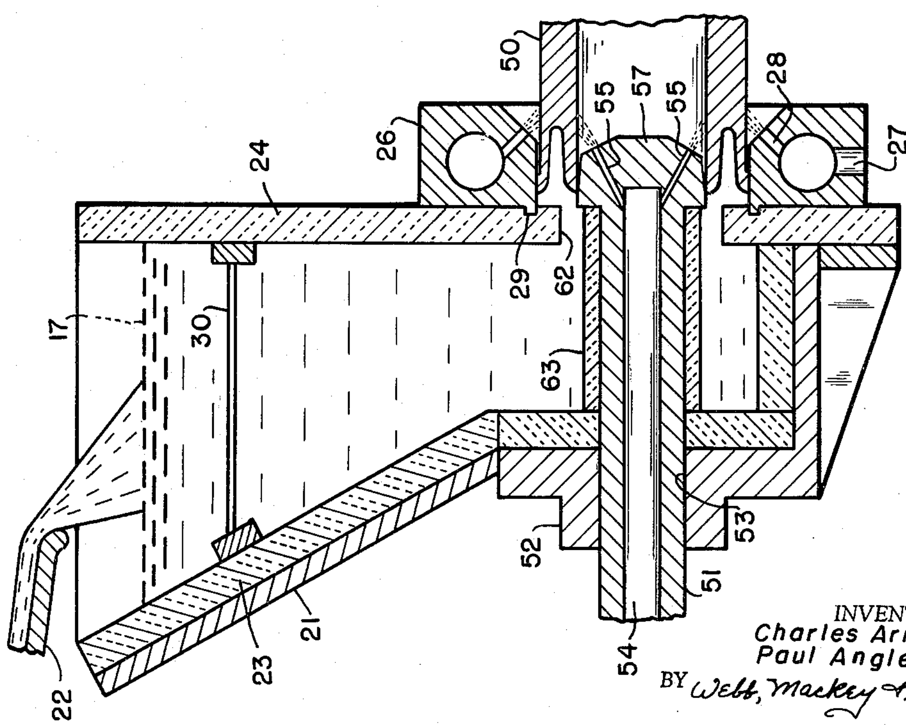


*Fig. 10*

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United States Patent Office

2,996,771

Patented Aug. 22, 1961



2,996,771

# METHOD AND APPARATUS FOR HORIZONTAL POURING OF METALS

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Claims priority, application France Nov. 27, 1958
5 Claims. (Cl. 22—57.2)

This application is a continuation-in-part of application Serial No. 558,317, filed January 10, 1956, now abandoned, and application Serial No. 756,381, filed August 21, 1958, now abandoned.

Our invention relates to a method and apparatus for horizontal pouring of metals. Preferably the method is continuous but it may be performed on a semi-continuous basis. A primary object of this invention is to obtain metal ingots and shapes of great lengths if desired and of high quality. This invention can be used to form ingots and shapes having cross sections of a large variety of dimensions, such as rectangular or round. In particular, bars of small cross section, even cables, can be formed and wound on drums at the take-off side of the apparatus. This invention also achieves high speed pouring of metals without sacrificing the quality of the product. The apparatus is of simple construction and requires only limited maintenance.

The metals to be fabricated with the present method and apparatus include specifically aluminum, aluminum alloys and magnesium; however, the fabrication of other metals are within the scope of this invention. This invention will be described as particularly applicable to aluminum and its alloys although not being so restricted.

Aluminum is produced in a plurality of individual electrolyzing furnaces, from each of which the aluminum is drawn off in the liquid state to a mixing furnace in which variations in the compositions of the metal derived from the numerous electrolyzing furnaces are adjusted. From this mixing furnace the aluminum is poured into molds or formed into shapes. The pouring can be effected in various ways depending on the ultimate destination of the metal ingot. If the ingot is to be remelted, a movable chain or ingot molds of cast iron may be passed in front of the pouring orifice of the mixing furnace; each mold is filled with liquid metal; the metal is permitted to solidify and the ingot mold tilted to discharge the ingot of aluminum. The ingot molds are then returned for refilling.

If the aluminum ingots to be formed are intended for treatment directly by a transformer, a chill mold is placed in front of the pouring orifice of the mixing furnace. This chill mold is usually a water-cooled cylinder mounted on a vertical axis. The lower portion of the mold is closed by a plate which can be moved vertically. Molten aluminum is admitted to the chill mold and, as the metal begins to solidify, the plate closing the bottom of the mold is lowered and draws with it the partially solidified metal which completes its cooling on contact with water which is sprayed on it. The speed of pouring is regulated to insure that the level of the molten metal in the chill mold remains constant. Ultimately the downward movement of the ingot must be stopped and the ingot removed so that the pouring may be repeated. In some instances a metal saw cuts off the ingot during its descent without interrupting the pouring. This type of pouring is known as vertical pouring. The high initial cost of this apparatus can only be justified if the installation is very large.

It is also known to pour molten metal into chill molds which are mounted on horizontal axes. The horizontal



chill molds normally contain an ingot plug which forms the starting point of the ingot. The mold has an inlet for the molten metal which is normally a horizontal refractory conduit having the same cross section as the mold. The pouring of the metal in the horizontal mold is similar to the vertical pouring except the solidified ingot moves horizontally.

This invention is directed to improvements in the method and apparatus for horizontal pouring of ingots. In particular, this invention is directed to an apparatus for insuring liquid tightness between the metal chill mold and the refractory conduit which feeds liquid metal to the mold. The separation plane between the mold and the refractory conduit is a ring located in a vertical plane into which liquid aluminum tends to infiltrate. This infiltrated aluminum constitutes a solid nucleus which is apt to give rise to scaffolds which may result in an ultimate breaking of the ingot while in formation. In actual practice, no continuous horizontal pouring of high quality aluminum ingots has been achieved with known devices.

This invention is also directed to improvements in the method and apparatus for horizontal pouring of tubular shapes. This apparatus includes a mandrel for forming the inside diameter of the tube. In particular, this invention is directed to an apparatus for insuring liquid tightness between the metal chill mold and the refractory conduit which leads liquid metal to the mold; and between the mandrel and the refractory conduit. The separation plane between the mandrel and the refractory conduit is located in a vertical plane into which liquid metal tends to infiltrate which gives rise to scaffolds possibly resulting in the ultimate breaking of the tube while in formation.

This invention is further directed to locating the inlet for the molten metal into the chill mold such that the ingot is evenly cooled, thereby allowing high speed pouring with a minimum chance of ingot breakage or imperfection formation.

Our invention is more particularly described in the attached drawings wherein:

FIGURE 1 is a longitudinal cross section of the known apparatus;

FIGURE 2 is a longitudinal cross section of the present invention;

FIGURE 3 is a horizontal cross section of the present invention taken on lines III—III of FIGURE 2;

FIGURE 4 is a front view of the present invention;

FIGURE 5 is a longitudinal cross section of a modified form of the present invention;

FIGURE 6 is a side elevation view of the entire pouring apparatus;

FIGURE 7 is a plan view of the apparatus of FIGURE 6;

FIGURE 8 is a cross section taken on a vertical plane passing through the longitudinal axis of a chill mold of the present invention adapted for horizontal pouring of tubular shapes;

FIGURE 9 is a cross section similar to FIGURE 8 but showing a modified form of the present invention;

FIGURE 10 is a cross section similar to FIGURES 8 and 9 but showing a further modification of the present invention; and

FIGURE 11 is a front view of the apparatus shown in FIGURE 8 but with the tubular shape removed for clarity.

The apparatus for horizontal pouring of metals according to the present invention comprises essentially a container, arranged to receive molten metal through its open upper portion, having a front vertical wall which is in liquid tight communication, near the bottom of the container, with a chill mold fabricated from a material which is a good conductor of heat. The chill mold is cooled internally by water and a metal shape or ingot passing out of the chill mold is cooled by a spray of water. Apparatus is also provided for conveying the shape or ingot away from the mold.

A modified form of the present invention is shown in FIGURES 8–11 wherein a container and a chill mold are arranged substantially as described above but including a mandrel which passes through the container and has a front portion positioned within the chill mold. This mandrel shapes the inside of the tube and supplies cooling water to the inside of the tube being formed between the chill mold and the mandrel.

In the device of the present invention, which is intended for continuous pouring of aluminum, the container for the molten metal is a helmet having an internal lining of heat insulating material, for example, asbestos. The helmet has a front vertical wall with an opening in its lower portion entering into a chill mold. The chill mold is preferably made of aluminum and is provided with an externally rear projecting portion which penetrates into the front face of the vertical wall of the helmet. The rear projecting portion has a perimeter identical with the cross section of the outlet of the chill mold. In an alternative form of the device, the chill mold has an internal generally concave form and is applied against the vertical wall of the helmet. A disc of heat insulating material is rigidly fixed in and fitted to the inside shape of the chill mold and a tube of heat insulating material forms the opening in the front wall of the helmet.

Referring specifically to the attached drawings, FIGURE 1 shows the known apparatus for pouring metals. This known apparatus includes a container **10** having vertical walls and a bottom; a chill mold **11** having an internal cooling cavity **12** and inlets and outlets **13** for admission of cooling water to the cooling cavity. The front vertical wall of the container **10** has an opening **14** which admits molten metal into the chill mold. The cooling cavity **12** has openings **15** in the front portion to spray water onto an ingot **16** emerging from the chill mold. Liquid metal **17** is admitted through opening **14** into the chill mold and a bead of solidified metal **18** forms upon chilling in an annular configuration within the chill mold. Opening **14** is located centrally on the horizontal axis of the chill mold. The molten metal contracts upon solidification and becomes detached from the chill mold. The top portion of the bead forms near the outlet of the chill mold as shown in FIGURE 1, however, due to the weight of ingot **16**, the lower portion of the bead **18** forms toward the rear or inlet of the chill mold. The weight of the ingot exerts a downward pressure on the bead, thereby forcing it and the molten metal into closer contact with the lower portion of the chill mold and, consequently, greater and more rapid solidification occurs in this portion. The bead **18** is formed in a plane oblique to the axis of the chill mold shown in FIGURE 1. The bead **18** forms the outside of the ingot while the inside of the ingot is still molten metal. The bottom of the formed ingot is thus retained within the chill mold throughout a distance **19** as shown in FIGURE 1. Since molten metal exists on the inside of the ingot while moving through the distance **19**, the possibility of the bead forming the lower portion of the ingot being remelted by the molten metal **17** and thereby creating a defect in the shape is great. It is desirable to have the bead formed as close to the water sprays issuing through openings **15** as possible. Thereby, the ingot is immediately and rapidly cooled to prevent remelting. One of the prime purposes of the present invention is to achieve such a result.

Furthermore, a plane **20** in which the chill mold contacts the front face of the container **10** is susceptible to infiltration by the molten metal **17**, thereby increasing the possibility of breakage of the formed shape. The



apparatus of the present invention completely obviates the possibility of infiltration of the molten metal into the plane **20**.

The present invention is shown in FIGURES 2, 3 and 4. Referring specifically to these drawings, the apparatus comprises a helmet or container **21**, the top opening of which is situated below a pouring nose **22** of the mixing furnace. The rear side and bottom wall of the helmet **21** are lined with asbestos or similar deformable insulating material **23** and the front wall is preferably made from asbestos or similar deformable insulating material **24**. The interior of the helmet communicates through an opening **25** in the front wall **24** with a chill mold **26**. The chill mold is preferably fabricated from aluminum and is internally cooled by a flow of water introduced through pipe **27**. The chill mold has a plurality of spraying orifices **28** in its outermost wall.

A liquid tightness of the joint between the chill mold and the wall **24** is effected by projection **29** on the chill mold which penetrates into the front face of the wall **24**. The chill mold is pressed tightly against the outside face of wall **24** until a groove **29*a*** is formed therein due to the deformability of wall **24**. This liquid tightness is enhanced by supporting grid **30** maintained in position between the vertical walls of the helmet in any well known manner.

The solidified shape or ingot **31** passes out of the chill mold at opening **32** in the chill mold and along a flat surface **33** and between two walls **34**. This gives the ingot sufficient time to cool and assume a form of a straight bar or rod before it is taken off on a conveyor track having rollers **35**. In this manner, crinkling and curving of the lower surface of the shape is prevented and in some situations its fracture is prevented.

The ingot or shape is carried away by a tractor-plug **36** having the same cross section as the ingot and having a hollow form at its central portion shaped like a dovetail **37**. This plug is initially located at the opening **32** in the chill mold and receives the molten metal which passes into the dovetail **37** in which it solidifies. The plug is then drawn over the surface **33** and the rollers **35**, in any well known manner, thus drawing along the ingot as it is formed.

The opening **25** is located below the horizontal axis of the chill mold **26**. As explained above with reference to FIGURE 1, the bead is normally formed in a plane which is oblique to the axis of the chill mold. This oblique formation of the bead occurs when the opening from the container into the chill mold is located at or above the axis of the chill mold. To form the bead in a plane vertical to the axis of the chill mold, it is necessary that the opening **25** be below the central horizontally extending axis of the chill mold. In this manner, the hot metal is introduced into the lower portion of the cavity of the chill mold. Thus even though the weight of the ingot induces a more rapid cooling of the lower portion of the bead, the introduction of the hot metal below the axis of the chill mold retards this uneven bead formation. Thus, by proper location of opening **25** below the axis of the chill mold, bead **31*a*** is formed in a vertical plane substantially perpendicular to the axis of the chill mold and as close to the outlet of the chill mold as possible under the operating conditions.

There are may factors that enter into the exact location of the opening **25** relative to the axis of the chill mold. The type of metal being cast is one factor to be considered in that denser metals exert a greater pressure on the lower portion of the bead due to their inherent weights per unit volume and, therefore, require that the opening **25** be positioned closer to the lower portion of the bead and at a greater distance from the axis of the chill mold. The temperature of the molten metal must also be considered in that as the temperature increases the necessity for lowering the opening **25** decreases and small vertical changes in the location of opening **25** effect large changes in the location of the plane of bead formation. The particular shape of the opening 25 is a factor to be considered in that as the opening increases in size the necessity of moving the opening 25 downward and away from the axis of the chill mold decreases. The size of the ingot or shape to be produced must be considered for the reasons stated above with respect to the density of the metal being cast in that the pressure exerted on the lower portion of the bead increases as the size of the ingot or shape increases and thus the opening 25 must be moved downward from the horizontal axis of the chill mold as the size of the ingot or shape increases. The rate of extrusion must also be considered but it will of course vary and have the same effect as the size of opening 25 discussed above.

As pointed out above with reference to FIGURE 1, the ingot is retained within the chill mold a distance 19 in the known apparatus, however, in the apparatus of this invention, as shown in FIGURE 2, the bead is formed in a substantially vertical plane perpendicular to the axis of the chill mold and thereby permits a reduction in the length of the chill mold. The formed ingot or shape is not retained within the chill mold any appreciable distance, and the water being emitted through spraying orifices 28 floods the ingot with cooling water as soon as possible after formation of the ingot thereby preventing a remelting of the outside of the ingot and avoiding the formation of defects in the ingot. Since the length of the chill mold can be reduced in the present invention and thereby reduce the time period between the formation of the bead and the spraying of the hot ingot with water, the rate of extrusion per unit time is increased greatly. The production of each chill mold is therefore increased.

Furthermore, the bead of metal which forms the outer surface of the shape or ingot is fragile when it becomes detached from the wall of the chill mold and the possibility of breakage due to shock is very great.

As a result of the phenomenon of calefaction and formation of a sheath of vapor, the cooling water which is flooded on the ingot through the orifices 15 of the known apparatus normally does not provide sufficient cooling of the extremely hot ingot. It is thus necessary to apply the cooling water in a form of sprays at a sufficiently high pressure to break through this sheath of vapor. The water issuing from the orifices 28 of the present invention is at a high pressure.

A dross, which is essentially composed of alumina, forms on the surface of the liquid aluminum contained in the helmet. This dross must be prevented from stagnation in the helmet since there is a risk of it being forced in surges through the opening 25 and thus sporadically to pollute the ingot. This is prevented by skimming-off the dross or by filtering the metal in accordance with a known method.

In the alternative form of the present invention shown in FIGURE 5, the helmet 38 is provided with an interior lining 39 of asbestos or similar deformable insulating material and has its front vertical wall 40 traversed by a tube 41 of asbestos or the like. The chill mold 42 is cooled by a flow of water admitted through pipe 43 and is provided with spraying orifices 44. The chill mold is applied tightly against the front wall 40 of helmet 38 in any known manner. The rear of the chill mold 42 has a concave surface 45 in which is fixed a disc 46 of asbestos or similar material. The tube 41 passes through the asbestos lining in the helmet, the wall 40, and an opening in the rear of chill mold 42 and asbestos disc 46. This device functions in the same manner as that shown in FIGURES 2, 3 and 4. The apparatus shown in FIGURE 5 merely illustrates an alternative manner in which a liquid type connection between the chill mold and the helmet may be achieved. The tube 41 is located below the horizontal axis of the chill mold for the reasons and in the same manner as explained above with reference to FIGURES 2, 3 and 4.

FIGURES 8, 9 and 10 show modifications of the present invention which are particularly adapted for continuous horizontal pouring of tubular shapes. Many of the parts are similar to those described above and retain the same numerical designations.

Referring specifically to FIGURE 8, the pouring spout 22 delivers molten metal 17 to the helmet or container 21. The helmet or container 21 is of a construction similar to that previously described, except that it contains a reinforced portion 52 at its lower end which has an opening 53 therethrough. The inside of the helmet is lined with insulating material as has been previously described. A supporting grill 30 is positioned within the helmet to provide rigidity to the front wall 24. The chill mold 26 is positioned on the exterior surface of the front wall 24 and has a continuous lip 29 projecting rearwardly from its rear face into a groove formed in the front wall 24 by pushing the chill mold against the front wall until a liquid-tight connection is achieved. A plurality of openings 25 are pierced in the front wall in a position between a mandrel 51 and the chill mold 26. One or more of such openings 25 may be provided in the front wall to provide an even flow of the liquid metal 17 into the area between the mandrel and chill mold. The openings 25 are located a greater distance from the mandrel than they are from the inside wall of the chill mold. The purpose of this location is to overcome some of the disadvantages stated above with respect to pouring continuous solid ingots, i.e., to obtain a vertical bead thereby facilitating quicker cooling of the tube by the water sprays.

The mandrel 51 has an axial channel 54 which is connected to a supply of cooling water (not shown) and leads to spray orifices 55 in the head of the mandrel. The mandrel 51 passes through the container 21 and through an opening 56 in the front wall 24 and has an enlarged head 57 which extends beyond the front face of the wall 24, and is enclosed within the chill mold. This enlarged head has a slight conicity (or a truncated cone) for reasons to be explained hereinafter. A portion of the enlarged head 57 is flat around its periphery and has the same periphery as the internal cross section of the tube being poured.

The rear face of the enlarged head 57 has a continuous lip 58 extending rearwardly therefrom which extends into a groove formed in the external surface of the front wall 24 by pushing the mandrel against the wall 24 thereby achieving a liquid-tight seal between the rear face of the mandrel and the front wall 24.

A plurality of the spray orifices 55 are angularly disposed within the head of the mandrel to spray cooling water on the inside of the tube being poured in the same manner as the spraying orifices 28 spray water on the outside of the tube from the chill mold 26.

The portion of the mandrel passing through the container 21 is insulated with insulating material 59.

The molten metal 17 passes from the container 21 through the openings 25 and begins to solidify when it contacts the inside wall of the chill mold 26 and the mandrel head 57 and forms a tube 50. As soon as the solidification starts there is a shrinkage of the metal as described previously and the outside perimeter of the tube contracts away from the inside wall of the chill mold 26. To reduce the danger of rupture of the tube at this point because of the fragility of the metal which is not sufficiently solidified, the mold 26 is as short as possible so that the spraying orifices 28 can spray cooling water on the outside of the tube and reduce to a minimum the size of the liquid metal volume within the inside of the tube. Likewise, the inside perimeter of the tube contracts on the enlarged head 57 of the mandrel. To avoid the possibility that this contraction will result in rupture of the tube against the mandrel head, the head 57 has a slight conicity which compensates for the contraction of the inside perimeter of the tube. It is also desirable to have the inside surface of the tube sprayed with cooling water from the orifices **55** as soon as possible after initial solidification.

The further modification shown in FIGURE 9 is similar to the apparatus shown in FIGURE 8 in that the mandrel **51** extends through an opening **53** in the reinforced portion **52** of the container and through an opening **56** in the front wall **24**. However, the mandrel of FIGURE 9 does not have an enlarged head but rather the head is the same size as the remainder of the mandrel and the opening **56** in the wall **24**. An axial channel **54** extends through the mandrel **51** and spray orifices **55** deliver cooling water to the inside of the tube **50** being poured.

The child mold **26** in FIGURE 9 is substantially similar with that shown in FIGURE 8 with the exception that the mold does not have projections **29** extending rearwardly from its rear face. Rather the chill mold is tightly pressed against the exterior surface of the front wall **24** and a refractory disc **60** is tightly wedged between the mandrel head and the chill mold **26**. The disc **60** is continuous throughout the whole area between the mandrel **51** and the mold **26** thereby providing a liquid-tight seal between the disc and the mandrel and between the disc and the mold. The disc **60** has openings **61** therethrough in alignment with the openings **25** in the front wall **24** to permit entrance of the molten metal from the container **21**.

The operation of the apparatus shown in FIGURE 9 is substantially similar to that described above with respect to FIGURE 8.

A further modification is shown in FIGURE 10 and is substantially similar to that previously described with respect to FIGURES 8 and 9. The mandrel **51** passes through the opening **53** in the reinforced portion **52** of the container **21** and through the container and wall **24**. The mandrel has an enlarged head **57** similar to the mandrel in FIGURE 8 with the exception that the mandrel does not have a rearwardly projecting lip **58**. An annular passage **54** supplies water to spray orifices **55** in the head of the mandrel. The mandrel passes through an enlarged opening **62** in the front wall **24** and is enclosed in insulating material **63** which extends from the rear wall of the container into abutting relationship to the enlarged head **57** of the mandrel. A liquid-tight seal is formed between the insulating material **63**, which completely encloses the mandrel within the container **21**, and the rear face of the enlarged head **57**. The tube **50** is formed between the chill mold **26** and the enlarged head of the mandrel **57** in the same manner as described in FIGURE 8. The chill mold **26** has a continuous rearwardly projecting lip **29** as described above.

The tube **50** which is formed in the modified apparatus can have any desirable cross section, such as rectangular or round.

The mandrel **51** and the chill mold **26** may be fabricated from metal or graphite.

The front wall **24** of the container and any other insulating material described herein, preferably is a refractory material having a low heat conductivity and is easily deformed under pressure, such as asbestos.

*Example*

A horizontal metal pouring apparatus such as shown in FIGURES 2, 3 and 4 was used. The outside dimensions of the chill mold were: 600 mm. wide by 270 mm. high by 48 mm. in depth. The inside dimensions of the chill mold were: 506 mm. wide by 62 mm. high by 41 mm. in depth. The spray openings **28** were 2.5 mm. in diameter and emitted water at an angle of 20° to the axis of the chill mold. The water entering the chill mold was at a pressure of 350 grams per sq. cm. The opening **25** was a horizontal slot 466 mm. long and 5 mm. in height. The top of the opening **25** is located 6 mm. below the horizontal axis of the chill mold.

A molten metal containing 99.65% aluminum was introduced into the chill mold through opening **25** at a temperature of 680° C. An ingot was produced 500 mm. in width and 60 mm. in height at the rate of 55 cm. per minute. The ingot was of excellent quality devoid of scratches and defects.

While we have described a present preferred embodiment of our invention, it may be otherwise embodied within the scope of the following claims.

We claim:

1. A device for the continuous horizontal pouring of metal shapes comprising a container for liquid metal, a side wall on the container fabricated from asbestos, an opening in said side wall for discharge of the liquid metal; a horizontal chill mold having an inside bottom wall, and an outlet conforming in cross section to approximately that of the metal shape, said chill mold having a rearwardly extending continuous lip which is pressed into the asbestos side wall to form a liquid-tight connection between said container wall and the chill mold, said chill mold being adapted to chill the liquid metal to form a solid annular bead of metal within the chill mold which becomes detached to form the outer surface of said metal shape, said opening being below the central horizontally extending axis of the chill mold and above said inside bottom wall, and in such location that the annular bead forms in a plane substantially perpendicular to said axis of the chill mold, said chill mold having walls forming an internal cooling cavity, and means for supplying fluid to said cavity.

2. A device for the continuous horizontal pouring of metal shapes comprising a container having an opening for the introduction of liquid metal and having a base and upwardly extending walls including a front vertical wall, said front wall being fabricated from deformable asbestos and provided with an orifice for the exit of liquid metal from the container, a chill mold surrounding said orifice and having a rear surface applied against the exterior of said front wall and having an outlet substantially conforming in cross section to that of the desired shape, said chill mold being adapted to chill the liquid metal and form said shape therefrom, a substantially continuous metal lip projecting rearwardly from said rear surface of the chill mold and tightly fitted in a groove formed in the exterior surface of said vertical wall, such that a liquid-tight seal exists between the front vertical wall and the chill mold.

3. A device according to claim 2 wherein the periphery of said lip is identical to that of the outlet of the chill mold.

4. A device according to claim 2 including a second orifice in the front wall of the container, a mandrel positioned within said second orifice and chill mold such that the liquid metal from the container will pass between the mandrel and the chill mold to form a tubular shape, a portion of the mandrel within the chill mold being enlarged, the rear surface of the enlarged portion having a continuous rearwardly projecting lip press fitted in liquid-tight engagement with said front wall.

5. A device for the continuous horizontal pouring of metals to form tubular articles including a container for liquid metal, a front wall on the container fabricated from deformable asbestos, at least one opening in said front wall through which the liquid metal can pass from the container, a chill mold in liquid-tight contact with the exterior of said deformable front wall and surrounding said opening, a hollow mandrel positioned in and passing through one of said openings in said container, one end of the mandrel being located within the chill mold and having a plurality of spray orifices, means to supply cooling liquid to the inside of the mandrel such that the liquid can pass out of the spray orifices, said chill mold having walls forming a cooling chamber and having spray orifices to spray a cooling liquid on said tubular articles, means to supply cooling liquid to said chill mold, said mandrel being spaced from the chill mold by a disk of heat resistant deformable material, said

disk having openings in alignment with the opening in said front wall such that the liquid metal passes from the container through said openings and into the space between the mandrel and the chill mold to form tubular articles by chilling the metal.


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