HORIZONTAL CONTINUOUS CASTING APPARATUS

Filed Aug. 16, 1965 4 Sheets-Sheet 1

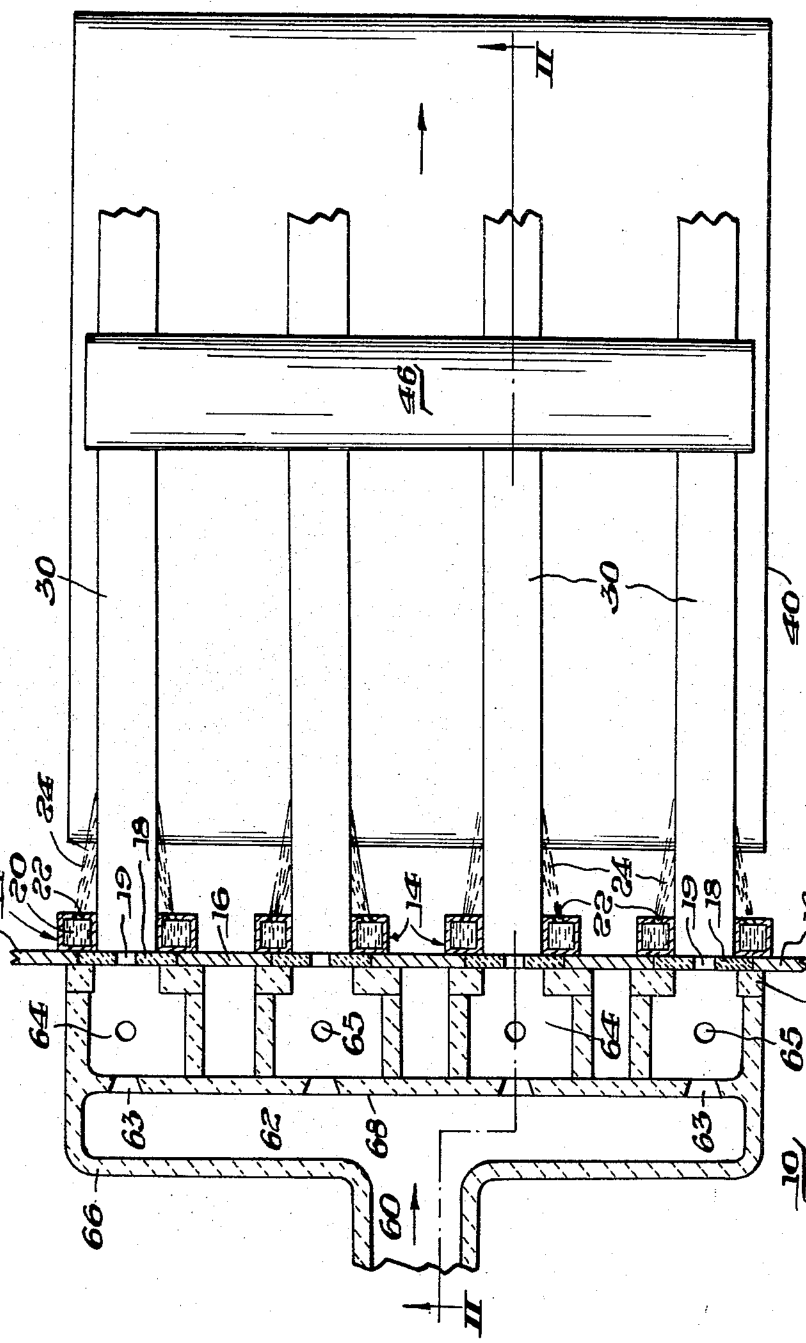

Fig. 1.

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HORIZONTAL CONTINUOUS CASTING APPARATUS

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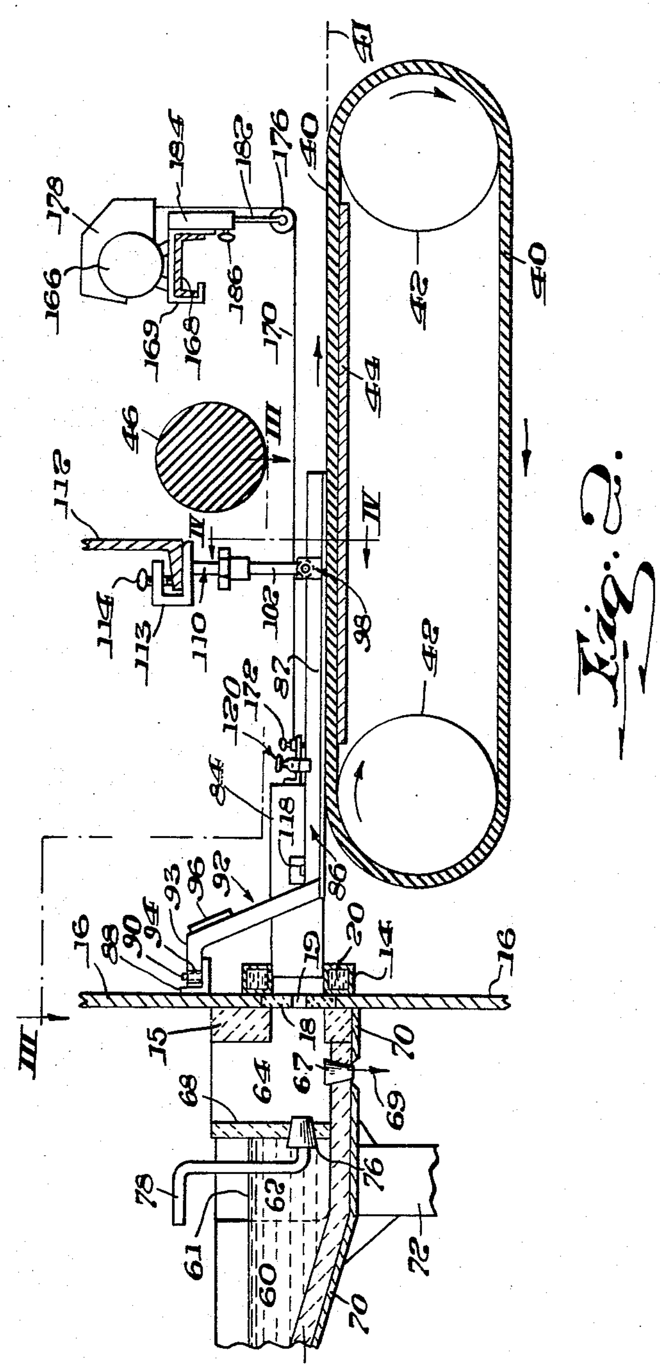

Fig. 2.

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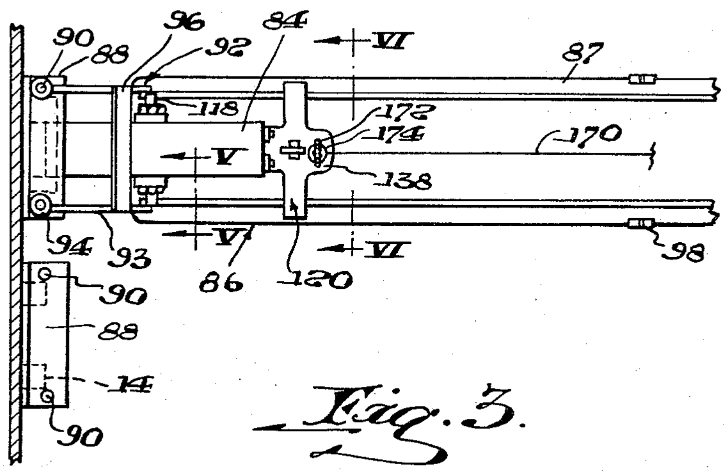

Fig. 3.

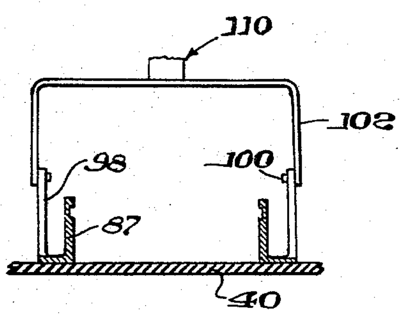

Fig. 4.

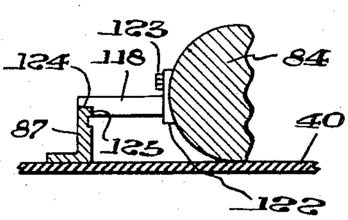

Fig. 5

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Oct. 3, 1967 J. A. BLESSINGER ETAL 3,344,845

HORIZONTAL CONTINUOUS CASTING APPARATUS

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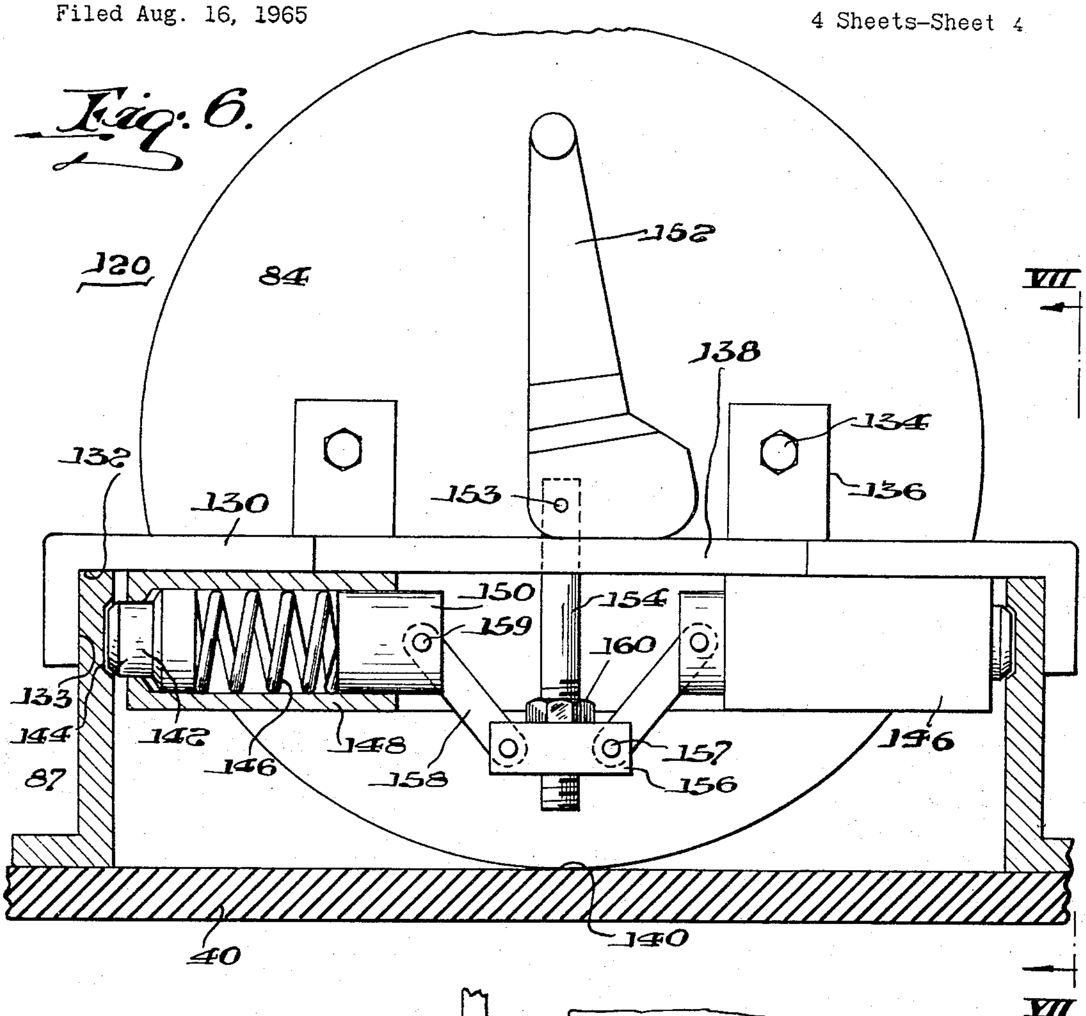
Fig. 6.



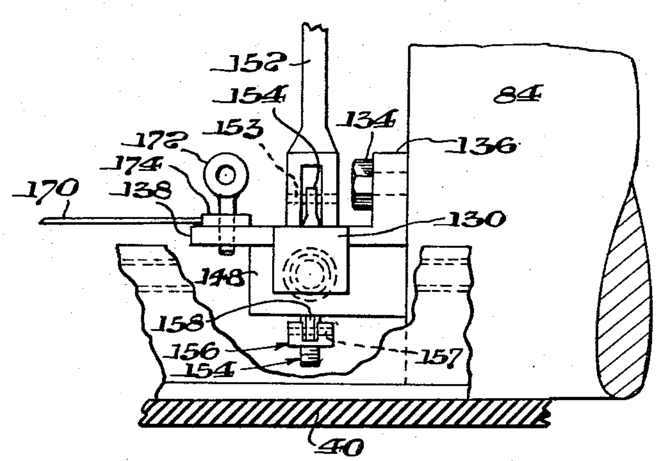


Fig. 7.

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HORIZONTAL CONTINUOUS CASTING APPARATUS

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2 Claims. (Cl. 164—274)

ABSTRACT OF THE DISCLOSURE

Horizontal continuous casting of multiple metal ingots may pe effected wherein a plurality of molds are supplied by a single molten metal source and where the ingots are withdrawn by a common withdrawal and support means. Casting may be terminated at a selected mold by the insertion of a plug into an orifice across a branch trough at the mold entrance. Thereafter, casting may be restarted using a separate starting plug which is guided, preferably by a pair of rails, to maintain alignment with the mold. Independent drive means withdraw the starting plug at a rate independent of the common withdrawal means and starting plug response to the common withdrawal means is restricted. Support and withdrawal of the starting plug and the ingot connected thereto are transferred to the common withdrawal and support means after the separate starting plug has achieved the same withdrawal rate. The separate starting plug, alignment or guiding means therefor together with the independent withdrawal means are all positionable at any mold site.

This invention relates to a method and apparatus for continuous casting in horizontally disposed molds, wherein a plurality of molds share a common molten metal supply. Especially concerned is the casting of the light metals, aluminnm, magnesium and their alloys.

In the continuous casting under consideration here a plurality of horizontally disposed molds are mounted on a common mold mounting plate to maintain their rigid position with respect to each other and the other equipment. Molten metal is supplied to a header trough and thence through branch troughs to each mold. The drastically chilled molds are generally separated from the molten metal by a partial barrier or closure made of a refractory or heat insulating material to prevent chilling of the molten metal before it reaches the mold walls. These partial closures, hereinafter designated the header plates, have openings to permit the passage of molten metal into the mold wherein its progressive solidification begins so as to continuously form an ingot emerging horizontally.

Some means is situated after the mold outlets to support the solidified ingots and to withdraw them from the molds. As the molds are aligned in a single horizontal plane and are in a general parallel relationship in this plane, the most practical method of supporting and withdrawing the ingots is by the provision of a series of rollers, or preferably a continuous belt, of sufficient width to support all the ingots.

While the mold is described as open ended, obviously the flow of molten metal out of the mold is closed. Once casting is underway such is accomplished by the solidified ingot. At the start of a casting run this is effected by a starting plug. In most cases there are a number of individual plugs, one per mold, mounted on a common frame. A casting run is initiated by positioning the starting plug assembly such that each mold is closed by a starting plug, introducing molten metal to each mold and

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withdrawing the starting plug assembly while drastically chilling each mold to progressively soldify an ingot emerging from each mold. After sufficient ingot length is developed the starting plug assembly is removed.

This type of casting has proven highly successful in producing large quantities of ingot generally ranging from 4 to 9 inches in diameter which may provide stock for extrusion operations and the like. However, such a system has one serious hindrance. If one ingot starts to develop imperfections, such as excessive lap defects, surface tearing, liquation and the like, such generally cannot be alleviated without affecting the entire operation in that for repairing or replacing merely a single mold, or for instituting other corrective action for the affected mold, the entire casting line is generally shut down. This downtime creates additional problems in the molten metal feed and hold furnace systems as will be recognized by those skilled in the art. Another factor is the inevitable waste of metal and lost production associated with such interruptions. These factors and others make such shutdowns extremely costly. Thus the need arises for a system which permits the interruption of a defective casting operation at a single mold, repairing or adjusting the conditions causing the defect and thereafter restarting casting at this mold position, all without any interruption in the casting at the other mold positions.

Accordingly it is a primary object of this invention to provide for the continuous casting of a plurality of ingots in horizontally disposed open ended molds, whereby casting can be interrupted at any selected mold and thereafter re-instituted without any interruption to casting at any other mold.

Another object is to do so where the casting line includes a common molten metal supply and a common ingot support and withdrawal system.

Other objects will, in part, be obvious and will, in part, appear hereinafter in this description, including the claims appended hereto and the drawings in which:

FIGURE 1 is a plan, partly in cross-section, showing a multiple horizontal continuous casting apparatus in accordance with the invention;

FIGURE 2 is an elevation, partly in cross-section, of the FIGURE 1 casting apparatus taken along line II—II in FIGURE 1, but including apparatus in accordance with invention;

FIGURE 3 is a fragmentary plan view, partly in cross-section, of a portion of the FIGURE 1 apparatus, taken at a higher elevation along line III—III in FIGURE 2 and showing additional features of the invention;

FIGURE 4 is an elevation, partly in cross-section, taken along line IV—IV in FIGURE 2;

FIGURE 5 is an elevation, partly in cross-section, taken along line V—V in FIGURE 3;

FIGURE 6 is an elevation, partly in cross-section, taken along line VI—VI in FIGURE 3;

FIGURE 7 is an elevation, partly in cross-section, taken along line VII—VII in FIGURE 6.

Referring now to FIGURES 1 and 2, therein is shown a continuous casting apparatus **10** having four horizontally disposed molds **14**, each rigidly mounted, by fastening means not shown, on a common mold mounting plate **16** so as to assure a fixed position with respect to the other molds and the other equipment. Each mold **14** is provided with some mold chilling means such as water channel **20** disposed around each mold and provided with a series of holes **22** to spray water **24** for chilling the ingot **30**. In this manner both the mold and emerging ingot are chilled by water supplied to the mold by pipe feed means, or the like, not shown. Generally some means, not shown, is provided for lubricating the mold surface to ease passage of the ingot therethrough. The molds are disposed in a single horizontal plane and are situated in parallel relationship to one another so that the ingots emerging therefrom are likewise in common plane parallel relationship.

Suitable means such as continuous belt **40** is provided to support and withdraw the solidified ingots emerging from the mold. A single continuous belt **40** of sufficient width to support all the ingots works quite dependably here and provides a single support and withdrawal means common to all the ingots. For purposes of this description this continuous belt is designated the prime mover, or prime ingot support and withdrawal means, and includes belt drums **42** and belt support plate **44** which, respectively, move and position the belt. The belt is aligned with the bottom surface of the mold to describe a prime mover pass line **41**. The prime ingot support and withdrawal means is provided with some power means, not shown, such as a reversible variable speed electric drive. A suitable scheme for shearing or cutting the ingots to prescribed lengths can be situated at some location after the belt **40**. Obviously some other prime ingot support and withdrawal means, such as rollers or the like may be employed, although the continuous belt has been found quite satisfactory. To complement the belt serving as the prime mover, one or more hold down rollers **46** are preferably disposed to bear against the upper surface of the emerging ingot, providing more positive traction or gripping between the belt and roller.

Another aspect of the hold down roller is that it serves to keep the ingots in axial alignment with the molds by preventing any ingot movement across the belt. The use of hold down rollers can be viewed as establishing a discrete zone of maximum influence for the prime ingot support and withdrawal means, i.e. the zone where the ingot is gripped between the belt and the hold down roller. Considering an ingot which has not yet reached this zone, some degree of movement by slipping along or across the belt may be encountered. However, once the ingot reaches this zone, such uncontrolled movement is substantially eliminated. When reference is made to prime ingot support and withdrawal means such is intended to include both combination and separate means although the former is preferred from the standpoint of simplicity.

On the molten metal side of the mold **14** is a main feed trough **60** flowing into a distribution header **62** and thence through branch troughs **64** into each mold. The liquid level **61** is maintained at a higher elevation than the ingot. The main feed distribution header and feed troughs all are lined with a refractory or heat insulating material **66** to prevent molten metal heat loss. The troughs, of course, are supported and reinforced by structural members such as backup plate **70** and posts **72**, although such structural details are not fully developed herein in order to conserve space and more directly emphasize the inventive features of the development described herein.

At the entrance of each branch trough is situated a plate **68** adapted to be closed to the flow of molten metal as by a plug **76**. In the embodiment shown, the tapered plug **76** is of graphite having a mean diameter of about 2½ inches and provided with a handle **78**. The branch trough entrance plate **68** is provided with a tapered hole **63**, of substantially matching size so as to be closed by the insertion of plug **76**. In normal operation the plug **76**, of course, is removed to permit passage of molten metal into the mold branch trough. At the entrance of each mold there is situated a header plate **18** having a hole **19** therethrough for the passage of molten metal from branch trough **64** into the mold. The header plate is made of a refractory or insulating material to avoid chilling the molten metal before it reaches the chilled mold. In the embodiment shown the header plate **18** is fitted into a matching opening in the mold mounting plate **16** and held in position between the mold **14** and branch trough end member **15**.

Each branch trough is provided with a drain hole **65** closed by a branch drain hole plug **67** which can be fashioned from a refractory paste material. Closing the branch entrance plate opening with plug **76** and removing the branch trough drain plug **67**, as by driving it out the bottom, in the direction indicated by arrow **69**, as with a hammer and a spike, permits stopping the flow of molten metal to the branch trough and draining of residual molten metal through the drain opening **65**. This serves to effectively interrupt the casting at any individual selected mold without substantial danger to operating personnel and, further, without interrupting the casting at any of the other molds. The ingot is removed from the mold by the prime mover.

Once the casting is interrupted for a given mold, the mold may be replaced or repaired or other measures taken to alleviate the defective ingot production at that site. The next step is re-instituting or restarting the casting operation at the repaired mold, likewise without any casting interruption at the remaining molds. This is accomplished by use of a separate starting plug together with means for guiding and supporting such and for withdrawing such independently of the prime mover until the starting plug speed and ingot speed matches that of the prime mover, and placing the ingot on stream with the others to include the separate casting restart.

Referring to FIGURES 2 and 3 the separate starting plug **84** is positioned at the outlet of the mold **14** and rests upon guide rail assembly **86**. As will be appreciated, the starting plug features some means, not shown, for connecting to the solidified ingot, steel wires, key arrangements, and the like, being known in the art for this purpose. The starting plug generally matches the mold opening in size and cross-section so that it can be inserted into the mold outlet to close such to the flow of molten metal at the start of a casting run and so as to fit between the prime mover belt and the hold down rollers.

The guide rail assembly **86** comprises a pair of guide rails **87** and some means of fixing the rails in rigid position with respect to the mold and the prime mover. It is noteworthy that the alignment here is highly critical to a successful casting start-up operation in that any misalignment can create ingot deflection problems, tearing, and the like, as will be appreciated by those skilled in the art. In the embodiment shown, the mold ends of the guide rails are rigidly connected to the mold mounting plate **16** by means of mounting ledges or abutments **88** having connecting pins **90** affixed thereto. The front (mold) end of the rails is affixed to the rail mounting frame assembly **92** comprising brackets **93** adapted by sleeve **94** affixed thereto to mount on the connecting pins **90**, and cross brace **96** to rigidly fix the brackets **93**, and hence the guide rails **87**, all with respect to one another. The rail assembly is thus movable from one mold position to another by placing the mounting sleeves **94** upon the connecting pins **90** situated at each mold site. The pins and the sleeves are advantageously constructed for a fairly snug fit to prevent any significant motion of the guide rails. Thus positioning the guide rail assembly mounting frame upon the connecting pins **90** assures a relatively fixed and stable rail configuration which is in proper alignment with the mold and the prime mover pass line **41**. Proceeding to the rearward portion of the guide rail assembly and referring to FIGS. 2, 3 and 4, there is shown hold down lugs **98**, one affixed to each rail, connected by pin **100** to hold down yoke **102**. A screw type jack **110** is connected to a rigid member such as beam **112** which may be a portion of the support frame, not shown, for hold down roller **46**. The jack, of course, is movably mounted to beam **112**, as by means of a channel member **113** and set screw **114**, such that it may be moved from one mold position to another. It is advantageous to provide some means, such as index markings, set screw indentations, or the like, to assure correct alignment of the jack with the mold axis. The jack is used to urge the rail hold down lugs **98**, and hence the guide rails **87**, against the prime mover belt **40** under a slight pressure to prevent any upward movement of the rails which might cause a slight vertical mis-alignment between the rails and belt.

The size and spacing for the rails **87** is something of a matter of choice in accommodating a specific range of ingot sizes. For instance a rail height and spacing of two and seven inches, respectively, accommodates an ingot size range of about 4 to 6½ inches diameter. The length of the rails is preferably such that the starting lug, and hence the ingot connected thereto, are guided and supported until the plug reaches the hold down roller. At this point, since the starting plug size substantially matches that of the ingot, it will be gripped between the prime withdrawal means, belt **40**, and the hold down roller **46** which are spaced to grip the ingot. The starting plug **84** will then be under the sole influence of the prime withdrawal and support means and hence, further support by the rails is not necessary. It can thus be seen that ingot support and withdrawal can thus be conveniently transferred to the prime ingot support and withdrawal means.

Returning to the starting plug **84**, it includes a pair of front guide lugs **118** and a rear guide lug assembly **120**. Referring to FIGURES 2, 3 and 5 the front lugs include means for fastening to the starting plug **84**, such as flange **122** and bolts **123**. Each lug also features abutments **124** and **125** which bear against the top and inside surface of guide rail **87** to provide, respectively, vertical and horizontal support for the starting plug.

Referring to FIGURES 2, 3, 6 and 7, the starting plug rear guide assembly **120** includes a pair of guide lugs **130** having bearing surfaces **132** and **133** to bear against, respectively, the upper and outside surfaces of guide rail **87** to provide vertical and horizontal support for the rear portion of starting plug **84**. The guide assembly **120** is affixed to the starting plug **84** by means of bolts **134** and mounting lugs **136** affixed to the guide lugs **130**. Also included is a tab **138** affixed to the guide lugs **130** to facilitate connection to the independent starting plug withdrawal means described hereinafter. In the embodiment shown both alignment lugs **130**, the withdrawal tab **138** and the mounting lugs **136** are formed as an integral structure as best shown in FIGURES 3 and 6.

In practicing the invention it is preferred that the starting plug be restrained from any responsiveness to the prime ingot withdrawal means, especially during the critical initial stages of the independent start-up operation. For instance, the rearward-most portion of the starting plug **84** is generally disposed to rest upon the prime moving belt **40** such as at point **140** in FIGURE 6 and possibly might otherwise be urged to move along with the belt **40**. This restraint is conveniently accomplished by including in the starting plug rear guide assembly a pair of spring-opposed brake plugs **142** disposed to bear against the inner surface of the guide rail **87**. In the embodiment shown the guide rail features a recess **144** for the brake plugs to ride in. One or more springs **146** can be disposed between the brake plugs to urge them outwardly against the guide rails with sufficient force to prevent any movement of the starting plug in response to the prime mover. A significant advantage of the embodiment shown in FIGURE 6 is that the rear guide lugs **130** and brake plugs **142** cooperate to maintain proper spacing of the guide rails **87**. Another advantage here is that the interlocking of the brake plugs and the recess **144** provides additional vertical restraint especially as to any upward movement of the starting plug. This further assures close vertical alignment between the starting plug and the uninterrupted ingots.

Some provision is preferably made for compressing the springs **146** to relieve the force against the brake plugs **142** when placing the starting plug and rear guide assembly on the guide rails **87**. This may be accomplished in the manner shown in FIGURE 6 wherein the brake plugs **142** are partially enclosed and retained by spring housings **148** which also partially enclose spring compressor plugs **150**, a separate housing and spring being provided for each brake plug. As can best be seen in FIG. 6, rotating cam lever **152** ninety degrees in the clockwise direction causes an upward movement in the tie rod **154** connected to cam lever **152** by pin **153**. The tie rod **154** connects at its bottom end to connecting lug **156** which in turn is pivotably mounted by pins **157** to spring compressor connecting rods **158** which have their other ends pivotably mounted by pins **159** to the spring compressor plugs **150**. Upward movement of the tie rod **154**, in response to cam lever **152** thus causes compression of the springs. Nut **160** on the tie rod **154** provides accurate adjustment of a spring force in the compressed position. The amount of braking force needed here is not very high in that the principal force to be overcome is that generated by friction between the starting plug and the prime ingot withdrawal belt **40**. However, once the starting plug reaches the hold down roller **46** and is gripped between the belt and the roller the full prime moving force is exerted on the starting plug which should already have reached the prime withdrawal line speed. Thus the separately started ingot can be considered as returning to the casting line when it passes under the hold down roller.

The starting plug **84** is withdrawn from the mold **14** by means operating independently of the prime mover. Referring to FIGURES 2 and 7 variable speed electric motor **166** is mounted upon a rigid structural member **168** in a fashion which permits its movement across the ingots to be aligned at any ingot or mold position as by bracket member **169**. As with structural member **112**, beam **168** may be a portion of the support frame, not shown, for hold down roller **46**. A flexible connecting cable, chain, or the like, **170** connects the variable speed motor **166** to the starting plug **84** by means of a pin **172** inserted through a loop or ring **174** at one end of the flexible connection and through the withdrawal tab **138** on the starting plug rear guide assembly. The configuration designated **178** represents a storage facility for the chain or cable **170** together with means coupling motor **166** thereto. Pulley or sprocket **176** is provided beneath the variable speed electric motor **166** to permit a bend of approximately 90° in cable or chain **170** so that it can maintain a constant alignment with both the independent withdrawal means and the starting plug.

Of course, the independent drive means is of sufficient power to overcome the motion restraining effect of brake plugs **142**. Other variable power means may be used in lieu of the electric power means shown. For instance, a hydraulic drive means has been used successfully and those skilled in the art will undoubtedly derive other drive schemes.

One way of viewing the independent drive means illustrated is to consider such a variable speed power means connected by a flexible tension coupler, e.g. chain or cable **170**, to the starting plug. The starting plug, in turn, includes brake means to keep the tension coupler rigid and prevent motion of the starting plug in response to the prime ingot support and withdrawal means, but permit motion in response to the independent withdrawal means.

In accordance with the invention casting is restarted by positioning starting plug guide rail assembly **86** upon the prime mover and the connecting pins **90**, attaching hold down yoke **102** to the guide rail hold down lugs **98** and compressing jack **110** so as to slightly urge the guide rails against the prime mover. The starting plug **84** is placed upon the guide rails **87** and inserted a short distance into the mold **14**. As the rearward portion rests upon the prime mover the brake provisions of the starting plug rear guide assembly are actuated by rotating cam lever **152**, in FIGURE 6, ninety degrees clockwise. At this point the independent drive chain or cable **170** is connected to the withdrawal tab **138** on the starting plug rear guide assembly **120**, as shown in FIGURE 7, by means of pin **172** and the cable or chain slack is relieved by the action of the independent drive means **166** but without imparting any significant motion to the starting plug **84**. Casting is restarted by withdrawing plug **76** from the opening **63** in the branch trough entrance plate **68**. Of course, branch trough drain plug **67** is replaced previous to the restarting operation. As the molten metal passes from distribution header **62** into the branch trough **64**, thereby filling the mold **14** with molten metal, the mold is chilled by means of causing water to flow through channel **20**. The starting plug is immediately withdrawn at a gradually increasing withdrawal rate until it reaches the production speed of the other ingots, i.e. the withdrawal rate of the prime ingot support and withdrawal means. It is extremely important here that the initial starting plug movement be slow and controlled so as to avoid any spilling of unsolidified metal out of the mold outlet. By following the teaching of this invention the ingot withdrawal can be gradually brought up to production speed without such an occurrence. Once the ingot is up to production speed the withdrawal rate is held constant by independent withdrawal means **166** until the starting plug **84** has passed under hold down roller **46**. At this point the starting plug and the ingot connected thereto are under the full influence of the prime ingot support and withdrawal means and the independent withdrawal means can therefore be stopped causing the chain or cable **170** to flex somewhat which facilitates convenient removal of pin **172** to free the starting plug **84** from the independent withdrawal means. The cable or chain **170** is then removed to its storage provision **178** on the independent withdrawal means. The sprocket or pulley **176** is elevated to allow clearance for the ingot by suitable means such as a telescoping arrangement whereby the bottom portion **182** of the sprocket support post telescopes into the upper portion **184** and is held in position there by set screw **186**. The entire independent withdrawal means can then be slid out of position along structural member **168** if desired. The starting plug **84** is then freed from the ingot connected thereto and set aside as is the rail assembly **86**, and the casting operation is resumed as before the interruption.

The invention has been described with particular reference to a preferred embodiment. However, many modifications to this preferred embodiment will suggest themselves to those skilled in the art and it is intended that the claims appended hereto include such other embodiments and practices as fall within the true spirit of the invention.

What is claimed is:

1. In continuous casting apparatus comprising a plurality of horizontally disposed open ended chilled molds sharing a common molten metal supply and common prime ingot support and withdrawal means, the improvement comprising

means for closing the flow of molten metal to a selected mold without interrupting flow to the remaining molds and

means for restarting casting at the selected mold comprising

a separate starting plug constructed to close the mold outlet to the flow of molten metal,

means for supporting the starting plug so as to maintain said starting plug in axial alignment with said selected mold,

means for withdrawing the starting plug and the ingot connected thereto at a rate independent of the prime ingot withdrawal means,

means to prevent starting plug response to said prime ingot withdrawal means, and

means for transferring support and withdrawal of the starting plug and the ingot connected thereto to the prime ingot withdrawal and support means.

2. In continuous casting apparatus comprising a plurality of horizontally disposed open ended molds sharing a common molten metal supply system having a distribution trough and branch troughs connecting such to each mold, and a common prime ingot withdrawal and support means, the improvement comprising

means for closing the flow of molten metal to selected mold without interrupting flow to the remaining molds, said means comprising a partial barrier situated at the entrance of the branch trough, said partial barrier having a hole adapted to be closed by a plug and a plug for closing said hole, and

means for restarting casting at the selected mold comprising

a separate starting plug constructed to close the mold outlet to the flow of molten metal,

means, positionable at any mold position, comprising a plurality of rails constructed and arranged to support the starting plug so as to maintain such in axial alignment with said selected mold,

means affixed to said starting plug arranged to cooperate with said rails in guiding said starting plug,

independent drive means comprising a variable speed power means and a tension coupler connecting said power means to said starting plug,

means to restrict starting plug motion outwardly from said selected mold, said means being so constructed and arranged as to prevent starting plug response to the prime ingot support and withdrawal means but permitting response to said independent drive means, and

means for transferring support and withdrawal of the starting plug and the ingot connected thereto to the prime ingot withdrawal and support means, said transfer means being arranged to take effect after the starting plug and the ingot connected thereto have achieved the same withdrawal rate as the prime ingot withdrawal means.

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