June 12, 1956 M. LOEWENSTEIN 2,749,583

CONTINUOUS CASTING

Filed April 16, 1952 2 Sheets-Sheet 1

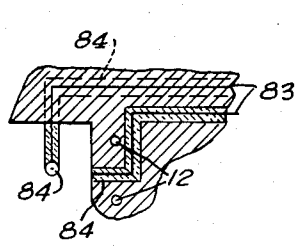


Fig 1A

Fig 1

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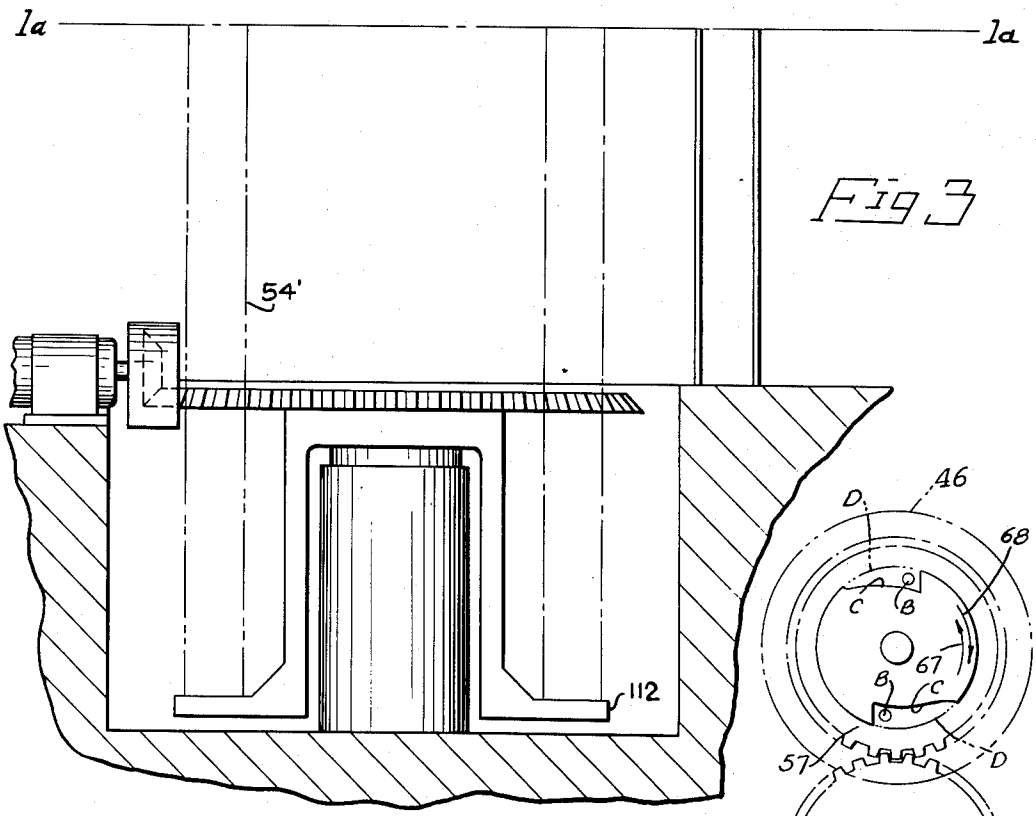


Fig 3

Fig 4

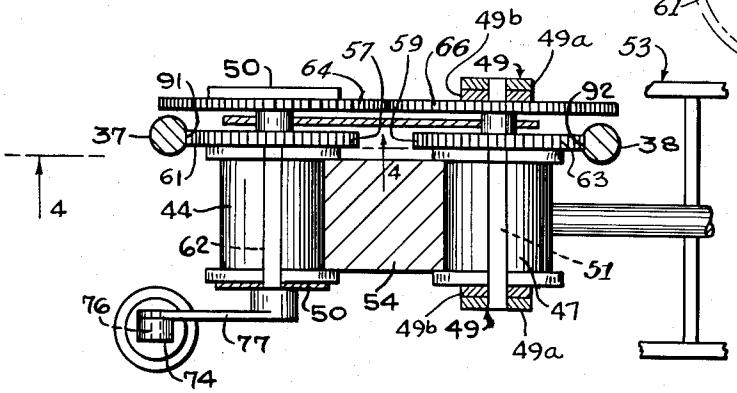


Fig 2

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CONTINUOUS CASTING

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5 Claims. (Cl. 22—57.2)

The invention relates to continuous casting, and relates more particularly to machines and methods of casting continuously in permanent molds.

Continuous casting methods of the prior art have been characterized by the use of intricate mechanisms. It is therefore among the principal objects of the instant invention to improve the machines and processes of the prior art, and to provide for a simple apparatus and process operable fully automatically.

With the above and other objects of the invention in view, the invention consists in the novel methods, construction, arrangement and combination of various devices, elements and parts, as set forth in the claims hereof, one embodiment of the same being illustrated in the accompanying drawings and described in the specification.

In accordance with the instant invention, the solidified casting, also variously termed as ingot or billet or slab, is withdrawn from a stationary mold at intermittent intervals, while the molten metal is poured into the mold continuously below the surface level of the molten metal therein, and the start of the withdrawal periods is controlled by the level of the molten metal within the mold.

Intermittent casting withdrawal of this type referred to results in a change of the level of the molten metal within the mold, with the following advantages:

It prevents the occurrence of a single restricted wall section of the mold passage at which solidification takes place, and instead distributes the solidification area over a large portion of the mold passage. At the same time, it does not require any complicated mechanism for movement of the mold, instead, the mold is stationary. Furthermore, it permits the cutting of the casting into sections during the intervals of casting standstill, thereby obviating the necessity of a cutter having to travel along with the billet during cutting as found in many instances in the art.

The foregoing and other objects of the invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein—

Fig. 1 is an elevational view, partly in section, of a continuous casting machine in accordance with the invention;

Fig. 1A is an enlarged fragmentary sectional view of a detail shown in Fig. 1;

Fig. 2 is a sectional view, taken on a secant line 2—2 of Fig. 1;

Fig. 3 is a fragmentary sectional view showing the lower portion of the machine illustrated in Fig. 1, below the line 1*a*—1*a* thereof, but embodying a modification; and

Fig. 4 is an elevational view partly in section taken on line 4—4 of Fig. 2.

In carrying the invention into effect, there is provided a chilled mold generally indicated at 11 which has formed in its wall a helical passage 12 for a cooling fluid to chill the mold. The mold 11 is stationary and is secured to

a fixed base 13. The mold 11 has on its interior a substantially vertical casting passage 14 open at the upper end 16 and at the lower end 17.

The exterior surface 19 of the mold provides a tightly sealing guide for a reciprocating reservoir structure, such as a runner box 21. Said runner 21 is arranged coaxially with the mold 11 and is guided thereon in tightly sealed relation and is vertically movable up and down for a certain distance *a*. The runner box 21 forms at its upper part a reservoir 22 which is open on top and which is arranged to receive molten metal and to discharge the same through an orifice 23 that is formed in the bottom of the reservoir 22.

Molten metal may be delivered to the reservoir 22 by any conventional means, for instance by a tiltable trough 24 that discharges molten metal from a furnace 26 into the reservoir 22 through the open top thereof. Means may be provided, though not shown in the drawing, to insulate throughout the path of the molten metal up to and including the reservoir 22, to prevent premature chilling and solidification of the metal.

From the reservoir 22, the molten metal may be discharged through the orifice 23. Metal retaining means are provided, such as a reciprocable stopper 27, which cooperates with the orifice 23, to restrain discharge of molten metal from the reservoir 22 towards the casting passage 14, whenever desired. A mechanism controls the reciprocation of the stopper 27, for instance a hand operated lever 28 that has a handle 31 and which is connected to the stopper 27 by means of a connecting rod 29. Depression of the handle 31 will raise the stopper 27 permitting discharge, and conversely, raising of the handle 31 will cause closing of the orifice 23 by the stopper 27. Instead of manual control by means of the lever 28, there may be substituted remote or automatic control of the stopper 27 in accordance with conventional, suitable means.

The mold passage 14 may have a regular cross-section, such as a circular or polygonal cross-section, or an irregular cross-section, for instance rectangular or the like, depending on the desired shape of products to be cast. The mold passage 14 has the same cross-section throughout its length between the openings 16 at the top and the opening 17 at the bottom, and the passage 14 is straight providing for alignment of said openings 16 and 17.

Through the open top 16 of the casting passage 14 there extends a downward extension of the runner box 21, such as a tube 32 that surrounds an elongated conduit 33 for molten metal. The conduit 33 of the extension 32 intercommunicates interiorly with the reservoir 22, by means of the orifice 23.

The extension 32 has in its lower portion a nozzle 30 for the discharge of molten metal from the conduit 33 into the casting passage 14. Upon lifting of the stopper 27, therefore, molten metal will pour from the reservoir 22 through the conduit 33 of the extension 32 into the casting passage 14.

The nozzle 30 may be composed of an interchangeable cover for the lower portion of the extension 32, for instance a plate 34 that is exchangeably mounted on the extension 32 and that has a central nozzle opening 35. The interchangeability of the nozzle permits the insertion of different plates 34 having nozzle openings 35 with different apertures area. This enables the selection of a different nozzle for different casts to be made, in order to secure a definite pouring or filling speed so that metal freezes correctly, and also so that the conduit 33 of the extension 32 is always kept filled. It is important to keep the condit 33 filled, so as not to cause an interruption of the continuous coherent liquid metal.

The extension 32 as well as the reciprocating mecha-

nism of the runner box 21 are so arranged that the nozzle 30 of said extension 32 will in all positions of the metal level A within the passage 14 project downwardly below said level A, and preferably project below said level for for a certain distance *b*. This is accomplished by moving the runner box 21 along substantially in synchronism with the movement of the metal level A within the passage 14. For instance, when the metal level A is low, the runner box 21 and the extension 32 will be in its lower position (shown in solid lines in Fig. 1), and conversely, when the metal level A is near the top of the passage 14, the runner box 21 and the extension 32 will be in the upper position (shown in broken lines in Fig. 1).

There is provided a mechanism, generally indicated at 36 which is operable to reciprocate the runner box 21 axially of the mold 11, in such a manner that the tube 32 will always be in axial registry with the passage 14. That reciprocating mechanism 36 comprises a plurality of, for instance two connecting rods 37 and 38, that are connected to the runner box 21 at a flange 39 thereof and which are reciprocably slidable in bearing structures 41 and 42, respectively, that are secured to the base 13.

The lower ends of the connecting rods 37 and 38 are connected to the casting withdrawing mechanism, and the latter will now be described before completing the explanation of the working of the reciprocating mechanism 36 for the runner box 21.

The casting withdrawing mechanism is generally indicated at 43, and is disposed below the bottom opening 17 of the mold 11. Said mechanism 43 comprises a plurality, for instance two pairs, of oppositely arranged flanged rollers commonly known in the trade as pinch rollers.

The rollers of each pair are in superposition, the pair at the left side of the apparatus having a lower roller 44 and an upper roller 46, while the pair on the right side has a lower roller 57 and an upper roller 48. The righthand side pair of rollers 47 and 48 is carried by a double connecting lever 49. Two springs 53 are provided, one acting on each half of the double lever 49, to control the position of the rollers 47 and 48 to follow the change of the contour of the casting. The double connecting lever 49 has a top half portion 49*a* and a bottom half portion 49*b*, and both portions are tiltable about the axis of the shaft 51. The shaft 51 is immovable. As the portions 49*a* and 49*b* of the double connecting lever 49 carry the rollers 48 and 47, respectively, these rollers under the action of the springs 53 will move arcuately about the axis of the shaft 51 following the change of the contour of the casting. The shaft 51 is disposed in a horizontal guide 52.

The left side pair of rollers 44 and 46 is provided with brackets 50. One of the pair of rollers, for instance the right hand pair of rollers 47 and 48, may be adjustable manually, as shown with the spring loaded spindle and crank arrangement 53. The upper rollers 46 and 48 are opposite each other, and likewise the lower rollers 44 and 47 are also in opposite arrangement, to pinch therebetween the casting 54 emerging from the mold passage 14. Each of the rollers carries a gear, the roller 44 having a gear 56, the roller 46 a gear 57, the roller 47 having a gear 58 and the roller 48 a gear 59. Between the gears of each roller pair, there is a pinion, the left hand pair having a pinion 61, which is journalled on the shaft 62 and meshes with the gears 56 and 57, and the right hand pair having a pinion 63 that is journalled on the shaft 51 and meshes with the gears 58 and 59.

The shaft 62 carries also a gear 64 keyed thereon for tied rotation with the pinion 61, and the shaft 51 carries similarly a gear 66 that rotates with the pinion 63. The gears 64 and 66 are in mesh, so that the rotation of the pinion 61 is thus transmitted to the pinion 63 by way of the shafts 62 and 51 thereof and of the gears 64 and 66. When the left pinion 61 is rotated in the direction

of an arrow 67 (counterclockwise), the gears 56 and 57 will rotate clockwise (arrows 68), thereby rotating the rollers 44 and 46 in that direction 68. At the same time, the gear 64 will be rotated in direction 67 by the pinion 61 and will turn the gear 66 in direction 68, thereby turning in that clockwise direction the pinion 63. The pinion 63 will turn the gears 58 and 59 counterclockwise (direction 67), thereby rotating the right hand rollers 48 and 49 in opposite directions as compared to the left hand rollers 44 and 46, in order to pull downwardly the casting 54 therebetween.

The rollers 44, 46, 47 and 48 all have the same diameter. Furthermore, the pinion 61 has the same diameter as the pinion 63. The gears 56, 57, 58 and 59 have all the same diameter; and the gear 64 has the same diameter as the gear 66. Thus, all the rollers 44, 46, 47 and 48 will have the same circumferential speed, at use.

It will be understood that the terms "left" and "right" and "clockwise" and "counterclockwise" are used only for clarification, and simplification of the description, but that no limitation is thereby intended.

There is provided an actuator 69, designed to rotate in opposite directions the pinion 61. The actuator 69 comprises a hydraulic cylinder 71 that is pivotally mounted at 72 and has a piston 73 to which there is attached a connecting rod 74, of adjustable length, which carries a pivot 76. A lever 77 connects the said shaft 62 with the pivot 76, to carry out the rotation of the shaft 62 and thereby of the pinion 61.

Lowering of the piston 73 in the cylinder 71 will turn the lever 77 for a certain angle, causing rotation of all the rollers for moving the billet 54 downwardly for a predetermined distance *c*. The circumference of the rollers and the length of stroke of the piston 73 are so dimensioned that one downward stroke of the piston 73 will cause withdrawal of the billet 54 for a distance which corresponds to the distance *c* between the uppermost position 78 of the molten metal level A and the lowermost position 79 thereof.

Following the downward stroke of the piston 73, there occurs a slow upward return stroke thereof, commencing immediately following the downward stroke, after which there will follow the next downward stroke for withdrawal of the casting 54.

There is provided a suitable unidirectional "free wheeling device" of conventional design (to control the power transmission), for instance an overrunning roller clutch, between the pinion 61 and the rollers 44 and 46 of its gears 56 and 57, and a similar device to control the power transmission between the pinion 63 and the rollers 47 and 48 of its gears 58 and 59, so that the rollers will only be rotated during the downward stroke of the piston 73, and will remain at standstill during the upward stroke thereof. A "free wheeling device" of the type referred to is illustrated in Fig. 4 operating between the gear 57 and the roller 46 thereof. Balls B are disposed in wedge shaped chambers formed between surfaces C and D of the gear 57 and the roller 46, respectively. Thus, when the gear 57 is turned by the gear 61 in the direction 68, the balls B will be in wedging engagement with the gears 57 and the roller 46, and the gear 57 will turn the roller 46 in the same direction 68; when the gear 57 is turned in the opposite direction 67, however, the balls B will be in the inactive position shown in Fig. 4, wherein no wedging takes place, and the roller 46 will not partake in the rotation in the direction 67.

As the piston 73 moves down and up, the billet 54 will be withdrawn intermittently, in a step-by-step motion, so that periods of withdrawal alternate with intervals of standstill.

During these standstill intervals, the molten metal owing to its continued discharge from the tube 32, will refill the passage 14 until the metal level A has reached

the upper position 78. Near that position of the level, there will be actuated an actuating means to operate the cylinder 71 to retract the piston 72 downwardly.

That actuating means is shown schematically in Fig. 1 and designated 81. It comprises an electric circuit which is interconnected to an electric source, as schematically illustrated by an electric plug 82. The circuit includes two terminals 83 that are spaced from each other and disposed on the interior of the passage 14 and insulated at 84 from the metal of the mold 11. The terminals 83 are preferably made of a material that is conductive and at the same time has a melting point sufficiently high above the temperature of the molten metal, so that when the molten metal level A rises to the terminals 83 it will bridge the same electrically but without melting them. The terminals 83 are interconnected to a relay and switch mechanism 86, which in turn actuates a valve operator 87 to control the flow of hydraulic fluid in the cylinder 71, and also actuates a signalling device such as a signal lamp 88 to indicate to the operator that the molten metal level A has reached the upper position 78. Following the completion of the electric circuit by the bridging of the terminals 83, the actuator 69 will cause withdrawal of the billet 54 substantially for a distance corresponding to the distance *c* between the upper level position 78 and the lower level position 79. Thereafter, while the billet 54 is at a standsitll, the molten metal will again fill up to the upper level 78 for subsequently starting another withdrawal operation.

One or both of the rods 37 and 38, may be provided on the lower end with a rack 91 and 92 respectively, that is engaged in mesh with the pinions 61 and 63 adjacent thereto. Consequently, when the piston 73 is lowered, the pinion 61 which is turned thereby will rotate in a direction 67, and the pinion 63 will turn in the opposite direction 68; the pinions 61 and 63 thereby will lower the rods 37 and 38 owing to the engagement with the rack 91 and 92 on the outside of the pinions 61 and 63, respectively. As a result, lowering of the casting 54 will take place in synchronism with the lowering of the runner box 21. During the upward return stroke of the piston 73, the pinions 61 and 63 will be reversed while, due to the free wheeling connection between the pinions 61 and 63 on the one hand and the rollers 44, 46, 47 and 48 on the other hand, the rollers will remain at a standstill; during the said reverse rotation of the pinions 61 and 63, the engagement thereof with the racks 91 and 92 will cause an upward movement of the rods 37 and 38 and consequently of the runner box 21. Thus, while the billet 54 is at a standstill, the runner box 21 will be lifted into the upper position 78.

This lifting of the runner box 21 is so arranged, by means of adjustment of the movement of the piston 73 that the speed of lifting of the runner box 21 will substantially be in synchronism with the raising of the level A in the passage 14, as the filling of the mold 11 proceeds during the period of standstill of the casting 54.

This lifting movement of the runner box 21 is brought to an end by the termination of the upward stroke of the piston 73. The piston 73 will again be lowered after it is actuated when the molten metal has filled up the mold until the level A thereof bridges the terminals 83.

The linking of the pinions 61 and 63 with the rollers 44, 46, 47 and 48 on the one hand, and with the racks 91 and 92 on the other, causes a simultaneous downward movement of the billet and of the rubber box, at the same speed and to the same extent. The distance A between the extreme positions of the runner box 21, accordingly is equal to the distance *c* between the extreme positions of the metal level A, which also corresponds to the billet withdrawal length during one cycle.

As best shown in Fig. 1, the distance between the bottom of the mold 11 and the upper rollers 46 and 48 is small, so that only a short "dummy" ingot is needed to close the bottom of the mold at the start of the operation, and this dummy ingot can be readily moved upwardly between the feed rollers. For this purpose, the free wheeling device referred to in the foregoing may be made releasable, so that the piston 73 during its upward stroke may move the dummy ingot into position.

With this intermittent withdrawal method, billets may be cast of a length limited only by the space available below the apparatus and by the capacity of the furnace 26. However, in most instances, it will be desired to cut the billet into sizes of predetermined length, for easier handling and transportation. The cutting may best be carried out during the standstill intervals of the billet. For this purpose, there is provided a cutting arrangement generally indicated at 93 which comprises a cutter 94, a power motor 96 to rotate the cutter, and hydraulic means to feed the cutter transverse of the billet for severing the same. The motor may run continuously or periodically during the cutting operation. Leads 99 connect the motor 96 to the actuating means 81 for the interconnection to an electric source. A hydraulic cylinder 95 and piston are provided to advance the cutter 94 in an operation direction 97 and the piston movement is synchronized with the casting standstill periods. During movement in the direction 97, the cutter 94 will cut the castings 54.

The entire cycle of movement, first in the operating directions 97, and then in the idling direction 98, must be completed during the standstill period of the casting 54.

Means are provided to lubricate the surface of the casting passage 14 in the mold 11. For instance, a conduit 90 is provided in the runner box 21 that has spray outlets 95 at a point slightly above the point immersion of the extension 32 below the metal level A. As the extension 32 is substantially synchronized in its movement with the movement of said level A, the spray outlets 95 will at all times remain above the level A and can cover that part of the passage 14 that is free of molten metal with a fine film for lubricating the inner wall of the mold 11.

In accordance with the invention, an elastic fluid agent such as an inert gas, can be introduced under pressure into that space of the passage 14 formed above the metal level A, in order to prevent oxydation. The gas may be introduced for instance through a sealable channel 101, that is formed in the runner box 21.

Where billets are being cut to a desired length by means of the cutting arrangement 93, the cutting as explained in the foregoing will take place during billet standstill intervals. However, the cut off length does not have to be the same as the length of drop of the billet during each withdrawal thereof but instead may be a multiple of that drop length. In order to accomplish this automatically, the actuating means 81 may be provided with a timing or counting device of well-known conventional design to actuate the cylinder 95 only after a predetermined number of withdrawal cycles.

Billet sections which have been cut by the cutter 94 may be discharged into a vessel, such as a basket 102 that is movable to and from a vertical receiving position in registry with the billet casting position and shown in solid lines in Fig. 1. The basket 102 may be tilted into a position away from the said receiving position into a discharge position shown in broken lines at 102', so that the billet section 54' may be discharged therefrom onto rollers 103.

In order to carry out the tilting of the basket 102, there is provided a tilting mechanism generally indicated at 104 which comprises a hydraulic cylinder 106 that operates a piston 107 which is linked by links 108 to the basket 102. The basket furthermore carries on one side a rack 109 that engages a freely turnable pinion 111 for positioning the basket 102 in tilted position 102'.

When the cutter 94 is not used, and the billet 54 is cast in full length, it may be discharged onto a rotor, such

as a rotating table **112** shown in Fig. 3. By a rotation of the table **112**, the billet **54** may be moved into a position **54'** away from the casting position, so that it can be picked up by an overhead hoist. Receiving baskets (not shown) may be mounted on the table **112** to receive billets **54** discharged from the mold **11**, and while one billet is being hoisted from the position **54'**, another billet meanwhile may be cast and discharged onto the table **112**.

It will be apparent to those skilled in the art that the novel principles of the invention disclosed herein in connection with specific exemplifications thereof will suggest various other modifications and applications of the same. It is accordingly desired that in constructing the breadth of the appended claims, they shall not be limited to the specific exemplifications of the invention described herein.

Having thus described the invention, what I claim as new and desire to be secured by Letters Patent, is as follows:

1. In a casting machine having a stationary mold forming a substantially vertical casting passage open on top and bottom and arranged to receive molten metal of varying level and means for intermittently actuating withdrawal of casting from the bottom opening, in combination, means for delivering molten metal through said top opening into said passage, comprising a reservoir structure reciprocably disposed above said passage and arranged to hold and to discharge molten metal, a tubular extension projecting downwardly from said structure and intercommunicating interiorly with said reservoir and extending into said passage for discharging from said reservoir molten metal into said passage, and means connected to said actuating means and to said reservoir structure forcibly lowering the latter during, and in synchronism with, the casting withdrawal and, respectively, raising the same during casting standstill.

2. In a billet casting machine, as claimed in claim 1, further characterized in that, the movement of said reservoir structure being substantially in synchronism with the movement of the metal level in the mold.

3. In a casting machine having a stationary mold forming a substantially vertical casting passage open on top and bottom, and a mechanism for intermittent casting withdrawal, in combination with, means for delivering molten metal into said passage through said open top and comprising a reservoir structure vertically reciprocably disposed above said passage for receiving and for discharging molten metal, a nozzle movable with said reservoir and intercommunicating therewith and extending into said passage below the metal level therein for discharging molten metal thereinto from said reservoir, and means connected to said withdrawal mechanism and to said nozzle and operable to move said nozzle in synchronism with said casting during withdrawal for maintaining said nozzle during withdrawal below said level.

4. Delivery means for molten metal, for use in connection with a casting machine having a stationary mold forming a substantially vertical casting passage and means for withdrawing casting in solidified form intermittently from the bottom thereof, said delivery means comprising a tube interconnected to a source of molten metal and extending into said passage for delivering molten metal to the interior thereof and being reciprocably movable in registry with said passage, the lower end of said tube projecting into the molten metal disposed in said passage below the upper level thereof throughout the changes in vertical position thereof, and means connected to said withdrawing means and to said tube and operable for maintaining said lower end substantially spaced for the same distance below said upper metal level in said passage throughout the withdrawal periods of said metal.

5. Delivery means, as claimed in claim 4, together with, said last named means including means for synchronizing the movement of said tube with the movement of said metal level comprising a mechanism between said delivering means and said casting withdrawing means and actuated by the latter and operable to control the reciprocable movement of said tube.

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