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METHOD AND APPARATUS FOR CONTINUOUSLY TAPPING
AND DEGASSING MOLTEN METAL INTO INGOT MOLDS
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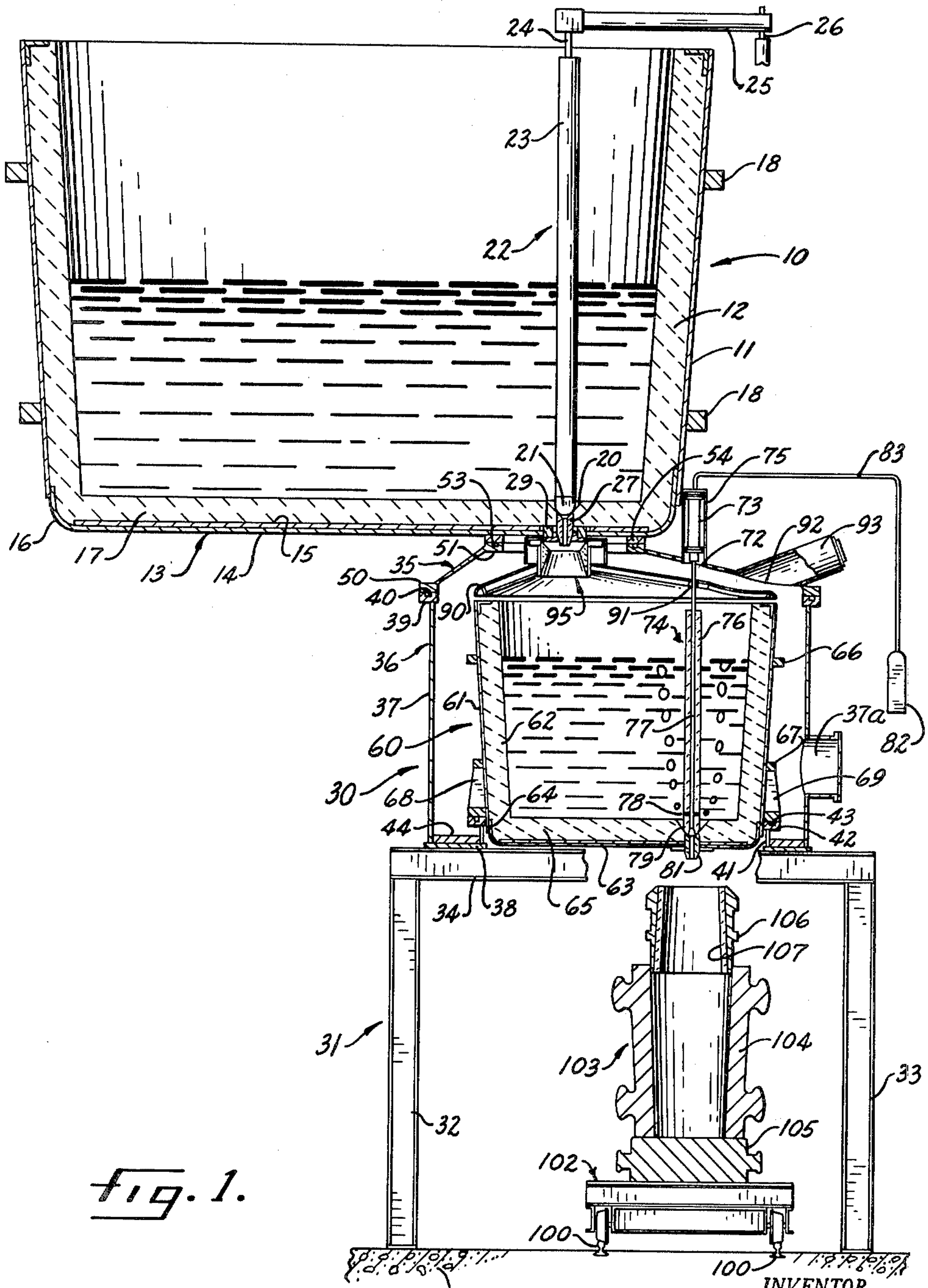

Fig. 1.

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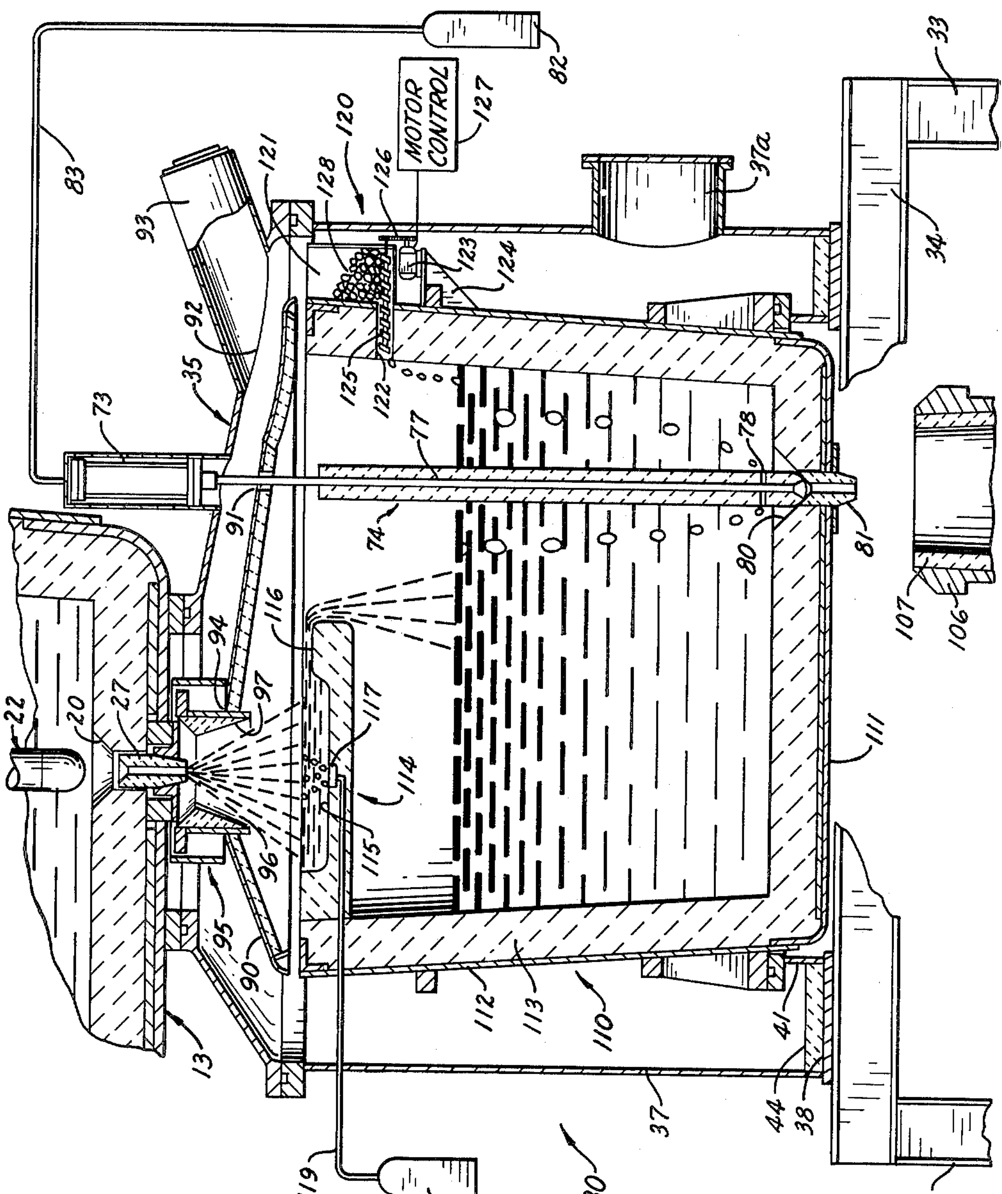

Fig. 2.

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3,145,095
METHOD AND APPARATUS FOR CONTINUOUSLY TAPPING AND DEGASSING MOLTEN METAL INTO INGOT MOLDS

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This invention relates generally to teeming molten metal from a large reservoir such as a holding or tapping ladle into receptacles such as ingot molds, and particularly to a method and apparatus for degassing molten metal as it is continuously teemed into ingot molds.

There has long been a need in the steelmaking industry for a production method of continuously degassing molten metal as it teemed into ingot molds. Several methods and apparatus have been proposed, but they fall short of being commercially feasible in that they require additional expensive equipment, or so prolong the time the metal is in transit from the tapping ladle to the mold that temperature loss is a serious factor. For example, in one process a tundish or pouring ladle is completely immersed in a vacuum tank, the molten metal is degassed, and then the ingot molds are poured from the tundish. Such an arrangement requires additional equipment for handling the tundish, and the additional time consumed in inserting and removing the ladle from the vacuum tank permits the metal to cool so far that the metal must be tapped from the open hearth or electric furnace in a superheated condition.

Another method is to insert the ingot molds into a vacuum chamber and pour directly into the molds. This system requires a specially designed ingot mold vacuum chamber and again, handling problems are involved because only a limited number of molds may be teemed at one time. As a result, the tapping ladle must remain idle while the metal in one or a series of ingot molds in the ingot mold vacuum chamber are treated, or a plurality of vacuum chambers must be constructed so that several batches of molds may be continuously treated. In this event, considerable additional equipment is needed but in either case the equipment-manipulating time considerably lengthens the pouring cycle.

In this latter system a revolving table or, as it is known in the trade, a lazy susan holding six or more molds is rotated into alignment with the discharge nozzle of the tundish or pouring ladle. The pouring capacity of the molds may add up to as much as 250 tons, which is the size of a large heat, but it is practically impossible to construct a ladle large enough to effectively degas 250 tons of molten metal at one time. As soon as the size of the ladle is cut down, the large capacity of the ingot molds is lost because the metal in the pouring ladle must be treated before the molds are teemed.

Accordingly, a primary object of this invention is to provide a method of continuously teeming very large heats of molten metal into ingot molds and simultaneously degassing the metal as it is teemed.

Another object is to provide a method of continuously degassing very large heats of molten metal by subjecting the flowing metal to a vacuum between the holding or tapping ladle and the ingot molds.

Another object is to provide a method of continuously degassing very large heats of molten metal by simultaneously subjecting the flowing metal to a vacuum as it passes from the tapping ladle to a tundish and purging through a stopper rod in the tundish.

Yet a further object is to provide a method of continuously degassing very large heats of molten metal by simultaneously stream-degassing the molten metal as it falls

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from a holding ladle to a tundish, and purging in the tundish.

Yet another object is to provide a method of continuously degassing large heats of molten metal by simultaneously stream-degassing the molten metal as it falls from a holding ladle into a tundish, and degassing the metal in the tundish by purging through a combination purging-stopper rod.

A further object is to accomplish the aforementioned objects using standard equipment which requires little or no modification.

Yet another object is to accomplish the foregoing methods by using equipment which is small and neat.

Yet another object is to provide a system for continuously degassing large heats of molten metal which may be continuously operated, even while the tundishes are down for maintenance.

Another object is to provide a system for continuously degassing molten metal which is capable of handling a wide range of sizes of heats.

Yet a further object is to provide a system for continuously degassing large heats or baths of molten metal and continuously teeming the molten metal into a plurality of ingot molds simultaneously.

Another object is to provide a system for continuously degassing molten metal comprising multiple vacuum tanks connected to a manifold communicating with a single ejector system whereby a plurality of teeming operations from one or a plurality of holding ladles can be run from only one vacuum pumping system.

Other objects and advantages will become apparent upon a reading of the following description of the invention.

The invention is illustrated more or less diagrammatically in the accompanying drawings, wherein:

FIGURE 1 is a partly diagrammatic, partly sectional view with parts broken away of one embodiment of the invention, and

FIGURE 2 is a partial, sectional view to an enlarged scale of another embodiment of the invention.

Like reference numerals will be used to refer to like parts throughout the drawings.

A large reservoir of molten metal is indicated generally at 10. The reservoir may be a holding or tapping ladle, or even a furnace, but in any event it is of a size considerably larger than the ingot molds into which the metal is eventually teemed. In the steelmaking industry, for example, tapping ladles of 100 to 150 ton capacity are fairly widely used, although the ladles may range in size from as small as 50 tons, or even somewhat less, up to around 300 tons. In this instance the reservoir is a tapping ladle having an outer steel shell 11 and an inner refractory lining 12. The bottom 13 of the ladle is shown in this instance as comprising a pair of plates 14 and 15, with lower plate 14 being bent upwardly as at 16 and secured to the lower inner edge of steel shell 11. Suitable refractory 17 protects the bottom 15, and a plurality of stiffening ribs 18 extend about the periphery of the ladle. Since the exact details of construction of the ladle are not essential to an understanding of the invention, the ladle is not further described.

The bottom layer of refractory 17 is recessed as at 20 to form a seat for the blackhead 21 of a stopper rod indicated generally at 22. The rod includes a conventional ceramic or refractory shank 23 protecting a core 24, the core being welded at its upper end to a positioning arm 25. Arm 25 in turn is elevated and lowered and swung about pivot arm 26 by any suitable mechanism, not shown.

A discharge nozzle 27 is received in discharge opening 28 in the bottom of the ladle. Any suitable securing and hold-down structure 29 may be employed to hold the nozzle in place directly aligned with the stopper rod 22.

A vacuum tank is indicated generally at **30**. The tank rests on a framework **31** which comprises a plurality of upright stanchions **32**, **33** and supporting crossbeams **34**. The tank consists of an upper removable portion **35** and a substantially larger lower stationary portion **36**. Lower portion **36** is composed of a metal shell **37** resting on an annular plate **38** bolted or otherwise suitably secured to the crossbeams **34**. The upper end of wall **37** terminates in a sealing ring **39** whose smooth upper surface is apertured to receive any suitable sealing means, such as an O-ring seal **40**. A short ladle support ring **41** extends upwardly from annular plate **38** and terminates in another sealing ring **42** formed with an aperture in its smooth upper surface which mates with bearng ring **43** welded to the outside of the ladle. An annular refractory lining **44** resting on annular ring **38** protects the bottom of the tank from splash and excessive heat.

The upper portion or top half **35** of the vacuum tank is formed roughly in the shape of a lopsided frustum of a cone, the lower edge of the top half terminating in a sealing ring **40** which mates with sealing ring **39**. The upper edge of top half **35** terminates in a sealing ring **51**. The lower surface of sealing ring **50** is highly machined, as is the upper surface of seal ring **39**, so that when in engagement, and with O-ring seal **40** in place, a vacuum-tight joint is formed between the mating surfaces. Likewise, the upper surface of sealing ring **51**, which is apertured to receive O-ring seal **53**, is highly machined to form an airtight seal with the seal ring **54** secured to the bottom plate **14** surrounding the discharge nozzle **27**.

An intermediate metal receptacle or tundish is indicated generally at **60**. The tundish or pouring ladle is similar in construction to the tapping ladle and consists of an outer steel shell **61** and an inner refractory lining **62** secured thereto. A double walled bottom **63** is welded to the lower inner peripheral surface of shell **61** as at **64**, and a layer of refractory **65** protects the bottom **63** from splash and the heat of the molten metal in the ladle. A plurality of horizontal reinforcing ribs **66**, **67** extend about the periphery of the ladle, and a plurality of vertical struts or braces **68**, **69** are welded at their upper ends to ribs **67** and at their lower ends to bearing ring **43**. The combined weight of the metal in the ladle and the ladle on the O-ring seal **70** between sealing ring **42** and bearing ring **43** forms an airtight joint between the ladle and the bottom of the vacuum tank.

A suitable vacuum connection **37*a*** opens into the tank wall **37** near its lower edge. The top wall of the tank is apertured as at **72** to receive actuating mechanism **73** for a combination purging-stopper rod **74**. The actuating mechanism **73** is encased within a closed pipe **75** welded to opening **72** about its lower periphery.

The combination purging-stopper rod consists of an outer refractory shell **76** surrounding a gas conduit **77**. The conduit terminates, at its lower end, in means for emitting gas outwardly from the conduit into the melt within the tundish. In this instance the gas-emitting means has been illustrated as a porous ceramic purging disc **78** similar to that shown in copending application, Serial No. 805,927, now U.S. Patent No. 3,083,422, issued April 2, 1963, which is assigned to the assignee of the instant application. It will be understood, however, that within the scope of the invention the gas-emitting means may also take the form of a porous section of the rod, said section being sufficiently porous to permit outward flow of gas under pressure while restricting inward flow of molten metal by capillary action. The lower end of the rod terminates in a blackhead **79** which seats in discharge aperture **80** in the bottom of the ladle. The blackhead engages discharge nozzle **81** which projects through the bottom of the ladle and is directly aligned with ingot molds therebelow.

The combination purging-stopper rod **74** is connected to a source of gas under pressure **82** by a line **83** leading, in this instance, to the gas conduit **77** through the actuating mechanism **73**. Any suitable gas inert to the metal undergoing treatment may be utilized. Argon, helium, nitrogen and, in some instances, even dry air may be utilized.

A radiation shield **90** overlies the open upper end of ladle **60**. It is closely spaced thereto to prevent radiation heat losses, as more fully described in copending application Serial No. 855,442, assigned to the assignee of this application. The radiation shield is apertured as at **91** to receive the gas conduit, also at **92**, to provide an unobstructed line of sight into the boiling melt through window glass **93**.

The radiation shield is also apertured as at **94** to receive a pouring sleeve assembly **95** having a passage **96** through which molten metal from the holding ladle falls. The sleeve assembly contains an inner refractory liner **97** which is so formed that the cross-sectional area of the passage **96** decreases in cross-sectional area upwardly for a substantial distance from the bottom of the sleeve assembly. Further details of the pouring sleeve assembly may be gained from copending application Serial No. 855,442, and accordingly the assembly is not described in detail here. Suffice to say, as fully set forth in said copending application, the downwardly outward divergence of the sleeve **97** results in a substantial outward divergence of the downwardly passing molten metal. This radial divergence of the metal in turn promotes maximum contact between the undegassed metal and the vacuum, allowing maximum opportunity for oxygen removal prior to a time at which it may be bound up with oxide forming materials, such as aluminum, in the tundish, and thereby eventually appear as oxide inclusions.

A set of tracks **100** is embedded in the foundry floor **101** upon which the supporting framework **31** rests. A plurality of flatcars **102** rolling on track **100** carry a plurality of ingot molds **103**. Each ingot mold in this instance is shown as composed of a metal jacket **104** resting on a mold stool **105**. A hot top, consisting of an outer metallic ring **106** and an inner refractory lining **107**, is positioned within the top of the mold shell **104**.

Another embodiment of the invention is illustrated in FIGURE 2. In this construction, the fall of the metal from the holding ladle into the tundish is broken by a purging and diffusing platform to thereby increase the stream degassing time.

A tundish is indicated generally at **110**. It consists of a bottom shell **111** welded to the lower inner periphery of side shell **112**. A layer of refractory **113** protects the bottom and sides.

A purging and diffusing platform is indicated generally at **114**. The platform, which is essentially merely a shallow metal receptacle, is illustrated in this instance as a refractory tray which forms a shallow basin **115**. An overflow channel **116** in one edge of the platform discharges into the approximate center of tundish **110**. Any suitable means may be utilized to secure the platform to the upper inner edge of the tundish. The bottom of the platform is recessed to receive a purging disc **117** which in turn is connected to a source of purging gas **118** under pressure by line **119**. The disc has a porosity sufficient to permit outward escape of the gas while preventing inward penetration of metal by capillary action.

The platform may be round or square or any convenient configuration, but in any event it is convenient to provide a surface complementary to the inside surface of the refractory lining **113**. Likewise, although a single overflow channel **116** has been illustrated, a plurality of channels could be utilized, or the channels could be entirely eliminated. With this latter construction, the metal would merely spill over all edges uniformly assuming that the edges remain in the same horizontal plane. Alternately, a single large channel on the order of a foot or more in width could be utilized.

An alloy feeder for ladle or tundish additions is indicated generally at **120**. The feeder comprises a reservoir which may merely be a V-shaped tray 121 whose bottom is aligned with an opening 122 in the side of the dish near its upper edge. A motor 123 mounted on platform 124 drives worm 125 through chain 126. Motor 126 is controlled by motor control 127 so as to drive worm 125 at a constant speed. Although only a single alloy feeder has been illustrated, it will be understood that a plurality could be used, each driven by its individual motor, or all could be run from a single motor.

The use and operation of the invention are as follows:

Molten metal from an open hearth or other melting pot is fed into the holding or tapping ladle 10. The size of the ladle, and correspondingly the large quantity of molten metal it will hold, maintains the metal fluid for a substantial period of time.

To continuously teem from the tapping ladle 10 into the ingot mold 103, holding ladle stopper rod 22 is lifted which causes metal to cascade downwardly through tapping ladle discharge nozzle 27 and into tundish 60. As the metal passes through pouring opening 96 in pouring sleeve assembly 95 it is stream-degassed. Although the value of the vacuum will vary during the process, it is highly desirable to maintain the vacuum at a relatively low value, on the order of one millimeter of mercury or less. This relatively low vacuum and the illustrated contour of the pouring sleeve assembly causes the stream of molten metal to literally explode into a fine spray of discrete droplets so that a maximum surface area of metal is exposed to the vacuum. The included deleterious gases, such as hydrogen, nitrogen and oxygen, thereby migrate to the surface and are discharged through the vacuum connection 37*a*.

After the level of the metal in tundish 60 rises at least to a level of 54½ inches, or, more preferably, six feet, purging gas from source 82 is admitted by suitable valving, not shown, to the melt through conduit 77. The aforementioned minimum metal depth of 54.5 inches must be attained before blackhead 79 is unseated or atmospheric pressure will force air upwardly into the tundish through discharge aperture 80. As the purging gas passes into the melt, and rises upwardly, it induces the included gasses to migrate into the bubbles so that they are eventually discharged from the system when the bubbles reach the surface. The bubbles also set up a circulation of metal which brings virgin, undegassed metal from the bottom of the ladle to the top where it may be exposed to the vacuum acting over the surface of the melt. The vacuum chamber 30 must be back filled with an inert, dry gas when the tundish is emptied. For a more complete description of the purging action, reference is made to copending applications, Serial Nos. 777,664 and 805,927, both assigned to the assignee of this application.

When the metal is sufficiently degassed for teeming, actuating mechanism 73 raises purging-stopper rod 74 and metal cascades downwardly into ingot molds 103 through tundish discharge nozzle 81. When the metal finally reaches the ingot mold, it is substantially degassed.

The tundish must have a capacity sufficient to allow metal to be teemed into the mold without losing the ferrostatic head which ensures a proper seal as explained heretofore. A ten foot to twelve foot tundish is quite adequate.

In FIGURE 2, the stream degassing time is considerably lengthened by cascading the metal from the holding ladle into the tundish. Shallow receptacle 114 intercepts the fine spray of droplets which fan outwardly from the holding ladle nozzle and collects them in basin 115. When the basin overflows through the channel 116, it is again streamed degassed as it drops down into the tundish. The actual time a droplet of metal is in transit between the holding ladle and the tundish is considerably longer than the system shown in FIGURE 1 because the average velocity of the droplet is considerably lower.

The transit time can easily be determined by reference to the standard gravity acceleration formula, $S=\frac{1}{2}at^2$

where S equals the distance in feet between the bottom of the tapping ladle discharge nozzle 27 and the metal level in tundish 60, *a* equals the acceleration of gravity, approximately 32 feet per second, per second, and *t* equals the vertical transit time in seconds. By applying the formula to the instantaneous condition in which the distance from the tapping ladle nozzle to the interceptor platform equals the distance from the platform to the metal level in tundish 60, it can readily be seen that transit time is increased 41 percent. Actually the transit time may be considerably higher since the metal is not subjected to any ferrostatic head when it leaves the interceptor platform as it is when it leaves the tapping ladle. The effect of the ferrostatic head is increased by the fact it acts against a vacuum. This transit time does not include lateral movement time of the metal in the interceptor platform, during which time it is of course subjected to a surface vacuum. When lateral movement time is taken into consideration, the total transit time is very substantially increased.

The pool of metal in basin 115 may be further treated by bubbling a purging gas upwardly through it through the porous purging disc 117.

The basic function of the interceptor platform is to expose more surface area of steel to vacuum and is especially useful in installations in which headroom is a problem. In plants in which the metal is permitted to fall 15 feet or so from the holding ladle into the tundish, the metal is adequately dispersed and subjected to vacuum long enough to be completely degassed. The purging platform in effect replaces a long uninterrupted fall.

The metal in the tundish may be alloyed by means of the alloy feeder indicated at 120. Rotation of worm 122 at a constant speed adds alloy material 128 to the pool of metal in the tundish. It is convenient to add the alloys on a pound per minute basis so that the total addition may be easily corollated to the size of the melt.

Usually the alloys are added after stream degassing stince many standard alloying elements, such as silicon and aluminum, are highly deoxidizing and inhibit loss of gases from the steel. If the alloys were added before stream degassing, it would be quite difficult to thoroughly degass the melt. Likewise, although the point of entry of the alloying material to the melt may be at any convenient location, it is desirable to pass the material into the melt in the area in which the melt is most thoroughly degassed. In this instance, the alloying material is added adjacent the stopper rod because the metal has a lower included gas content in this vicinity as it is more fully explained in the aforementioned applications.

It will be apparent to one skilled in the art that other modifications are well within the spirit of the invention. For example, it is entirely feasible to utilize a pair of vacuum tanks, each tank having a pouring opening aligned with a discharge nozzle in the tapping ladle. The output of such a system is substantially twice that of the illustrated system, and in addition, should repair of a vacuum tank become necessary, the unit can be kept in operation with the other tank.

Whether a double or single nozzle arrangement in the tapping ladle is utilized, however, the system can be kept in continuous operation by bodily removing a tundish that needs maintenance work and inserting another in its place. The removed tundish can then be rechecked and refurbished at leisure and the system kept in operation.

Likewise, although a tundish having only a single tapping nozzle is utilized, because such ladles are most commonly used today, it is entirely within the scope of the invention to form a second or more discharge openings in the bottom of the tundish so that two or more ingot molds can be poured simultaneously from the same tundish.

In addition, although a porous ceramic disc 78 has been illustrated for emitting the gas from the rod, other equivalent structures may be used. It is really only essential that one or a plurality of gas openings, be they fabricated holes or porous material, be provided.

It will be understood that the structure shown in the figures has been chosen for purposes of illustration because all of the parts, except the vacuum tank, are standard equipment in the industry today and can be immediately utilized to practice the method of the instant invention without modification.

The above description is intended to be exemplary only and not definitive. Accordingly, the scope of the invention should not be limited except by the scope of the following appended claims.

I claim:

1. A continuous degassing-teeming process in which degassed molten metal is continuously teemed into a plurality of molten metal receptacles, said process including the steps of,

placing a quantity of undegassed molten metal which is greater than the quantity of molten metal to be received in any final receptacle into which the degassed molten metal is to be teemed above an intermediate receptacle,

passing molten metal downwardly from the reservoir into the intermediate receptacle,

removing at least a portion of the included deleterious gases from the downwardly passing molten metal by subjecting said downwardly passing molten metal to a vacuum sufficiently low to effectively degas it,

forming a pool of molten metal in the intermediate receptacle as long as undegassed molten metal remains in the reservoir by regulating the rate of admission of the molten metal from the reservoir to the intermediate receptacle, and the teeming rate of the molten metal from the intermediate receptacle to the teeming receptacles,

the minimum depth of the pool in the intermediate receptacle being the depth corresponding to the pressure differential between atmospheric pressure and the absolute pressure to which the pool is subjected,

the pool having a depth of from 54.5 inches to 6 feet,

subjecting the pool of molten metal in the intermediate receptacle to a vacuum sufficiently low to effectively degas it, and,

teeming the degassed molten metal into a plurality of final receptacles each of which is of a smaller capacity than the reservoir.

2. The continuous degassing-teeming process of claim 1 further including the steps of

back filling the intermediate receptacle with a non-explosive gas atmosphere after the reservoir is exhausted, and

teeming the last receptacle under the non-explosive gas atmosphere.

3. The continuous degassing-teeming process of claim 1 further including the steps of

imparting a substantial radial outward divergence to the molten metal passing downwardly from the reservoir.

4. The continuous degassing-teeming process of claim 1 further including the step of

additionally degassing the molten metal in the intermediate receptacle by bubbling a purging gas upwardly through the pool formed in the intermediate receptacle.

5. A method of continuously teeming molten metal from a large reservoir into a plurality of relatively smaller receptacles such as ingot molds, said method including the steps of providing a large reservoir of molten metal, passing the molten metal downwardly into an intermediate receptacle in the presence of a vacuum sufficiently low to degas the molten metal, increasing the time the molten metal is in transit between the large reservoir and the intermediate receptacle by directing the downwardly passing molten metal against a flow interrupting member, passing the molten metal from the flow interrupting member downwardly into the intermediate receptacle, degassing the molten metal in the intermediate receptacle after a greater than atmospheric head of metal is built up in the intermediate receptacle by subjecting the surface of the molten metal in the intermediate receptacle to a vacuum sufficiently low to degas the molten metal, and thereafter teeming degassed molten metal in the intermediate receptacle into said relatively smaller receptacles.

6. A method of continuously teeming molten metal from a large reservoir into a plurality of relatively smaller receptacles such as ingot molds, said method including the steps of providing a large reservoir of molten metal, passing the molten metal downwardly into an intermediate receptacle in the presence of a vacuum sufficiently low to degas the molten metal, increasing the time the molten metal is in transit between the large reservoir and the intermediate receptacle by directing the downwardly passing molten metal against a flow interrupting member, forming a shallow pool of molten metal in the flow interrupting member to thereby expose a large surface area of molten metal to the vacuum, passing the molten metal from the flow interrupting member downwardly into the intermediate receptacle, degassing the molten metal in the intermediate receptacle after a greater than atmospheric head of metal is built up in the intermediate receptacle by subjecting the surface of the molten metal in the intermediate receptacle to a vacuum sufficiently low to degas the molten metal, and thereafter teeming degassed molten metal in the intermediate receptacle into said relatively smaller receptacles.

7. The continuous teeming method of claim 6 further characterized by and including the step of degassing the molten metal in the shallow pool by passing an inert gas upwardly through the pool.

8. A system for continuously degassing molten metal as it is teemed into ingot molds from a large reservoir, said system including, in combination, a large reservoir of molten metal, said reservoir having a discharge aperture in its bottom, means for opening and closing said discharge aperture to discharge molten metal into a vacuum tank positioned at level below the reservoir, said vacuum tank having a pouring opening in its lower portion and a pouring port in its upper portion, said pouring port communicating with the discharge aperture in the reservoir, first sealing means between the vacuum tank and the reservoir, a tundish in the vacuum tank, said tundish communicating with the reservoir through the vacuum tank pouring port and having a discharge opening in its bottom, said tundish discharge opening communicating with the pouring opening in the vacuum tank, second sealing means between the tundish and the vacuum tank, a molten metal receiving receptacle disposed generally below and communicating with the discharge opening in the tundish, means for degassing molten metal in the tundish, and means for selectively opening and closing the tundish discharge opening to thereby teem degassed metal into said teeming receptacle.

9. The system for continuously degassing molten metal of claim 8 further including means for making additions to the tundish under vacuum.

10. The continuous teeming system of claim 8 further characterized in that the means for alternately opening and closing the discharge opening in the tundish and the degassing means are a combination purging stopper rod, said rod having a purging gas conduit extending substantially its entire length, said conduit communicating at its upper end with a source of purging gas under pressure and at its lower end with means for emitting purging gas outwardly into the melt closely adjacent the bottom of the tundish.

11. The continuous teeming system of claim 8 further characterized by and including means for stream degassing the molten metal as it passes from the reservoir into the vacuum tank, said stream degassing means including

a pouring sleeve assembly having a pouring passage through which the stream of molten metal passes, said pouring passage increasing in cross sectional area downwardly for a substantial distance above its bottom to thereby disperse a stream of molten metal into a spray of fine droplets whereby maximum surface area of the metal to the vacuum is exposed.

12. The continuous teeming system of claim 8 further characterized by and including means for purging the molten metal in the tundish with a gas inert to the metal undergoing treatment, said means for purging including means for admitting purging gas from a source of supply under pressure into the tundish adjacent its bottom.

13. A system for continuously degassing molten metal as it is teemed into ingot molds from a large reservoir, said system including, in combination, a large reservoir of molten metal, said reservoir having a discharge aperture in its bottom, means for opening and closing said discharge aperture to discharge molten metal into a vacuum tank positioned at level below the reservoir, said vacuum tank having a pouring opening in its lower portion and a pouring port in its upper portion, said pouring port communicating with the discharge aperture in the reservoir, first sealing means between the vacuum tank and the reservoir, a tundish in the vacuum tank, said tundish having a discharge opening communicating with the pouring opening in the vacuum tank, a shallow receptacle in the vacuum tank generally vertically aligned with the pouring port and discharge into the tundish, second sealing means between the tundish and the vacuum tank, an ingot mold disposed generally below and communicating with the discharge opening in the tundish, means for degassing molten metal in the tundish, and means for selectively opening and closing the tundish discharge opening to thereby teem degassed metal into said teeming receptacle.

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