Nov. 24, 1942. G. R. ROEMER 2,303,139

METHOD OF AND APPARATUS FOR CENTRIFUGALLY DEGASIFYING MOLTEN METAL

Filed Oct. 23, 1941 2 Sheets-Sheet 1

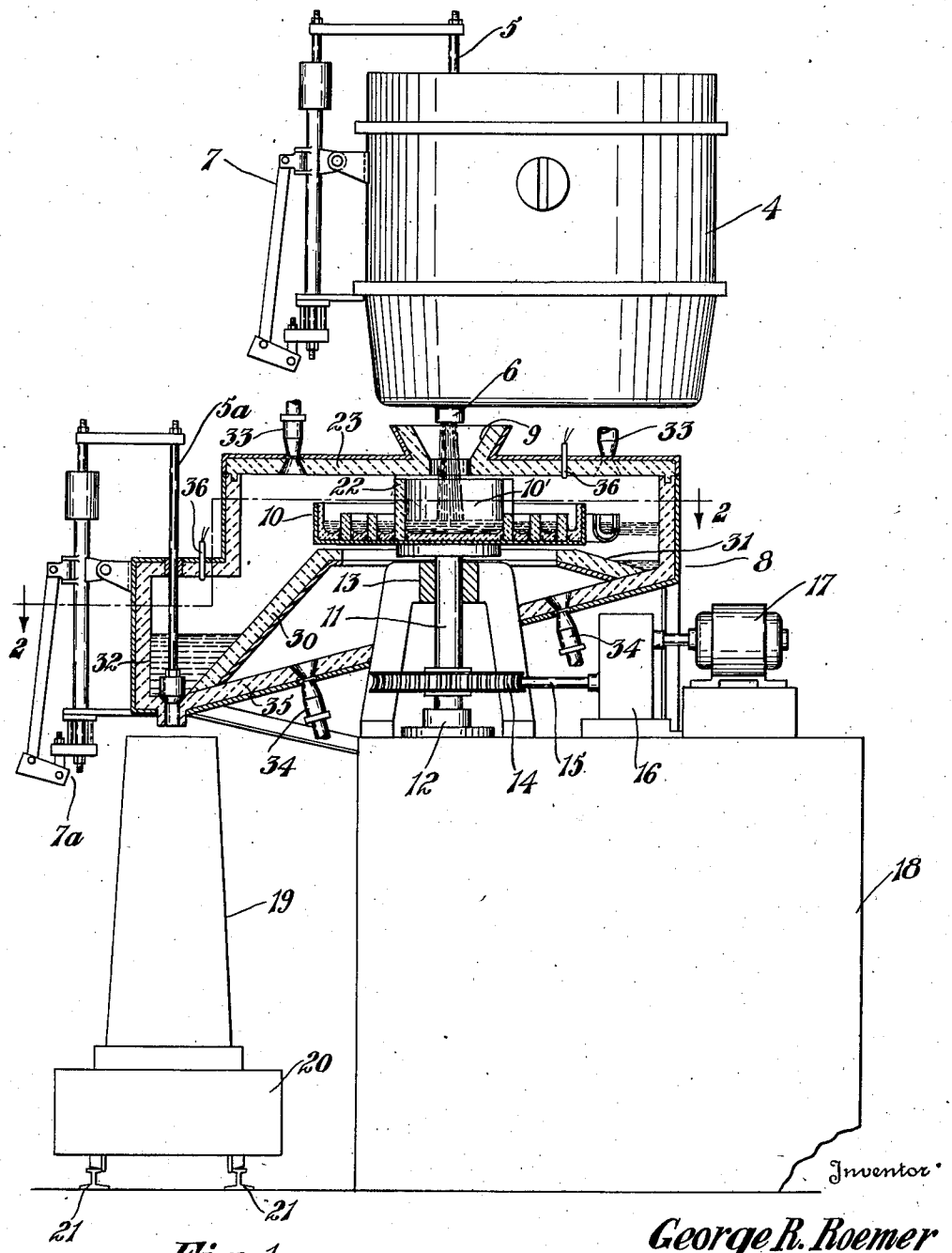


Fig. 1

Inventor:
George R. Roemer
By Frease and Bishop
Attorneys

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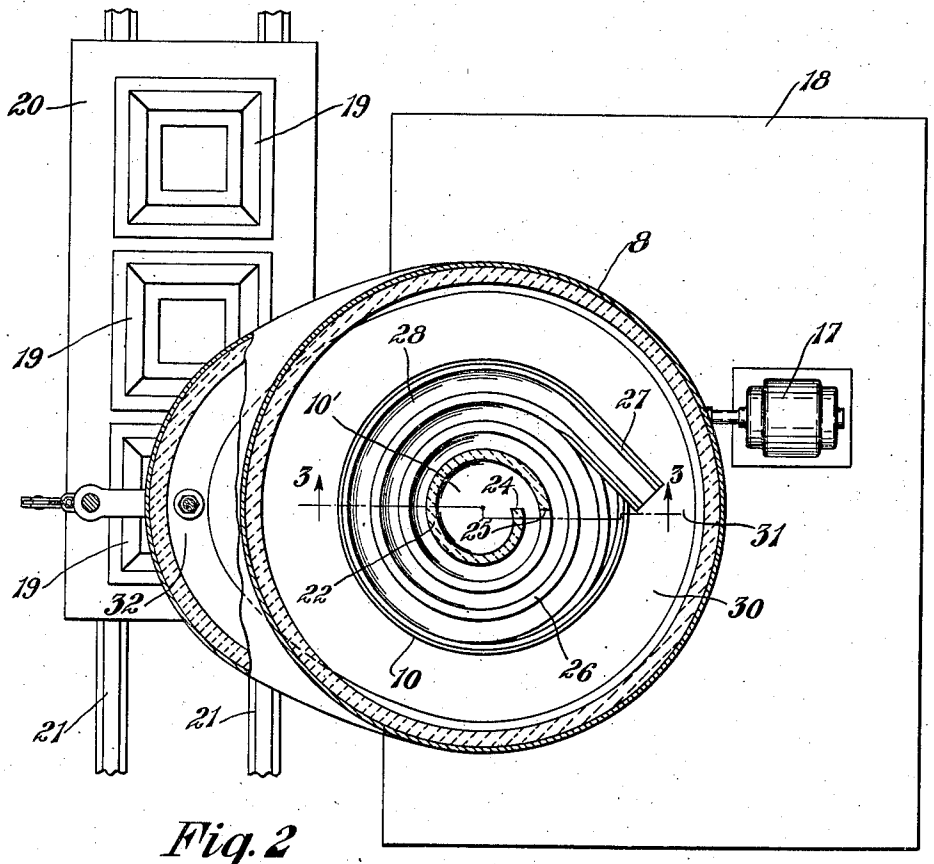


Fig. 2

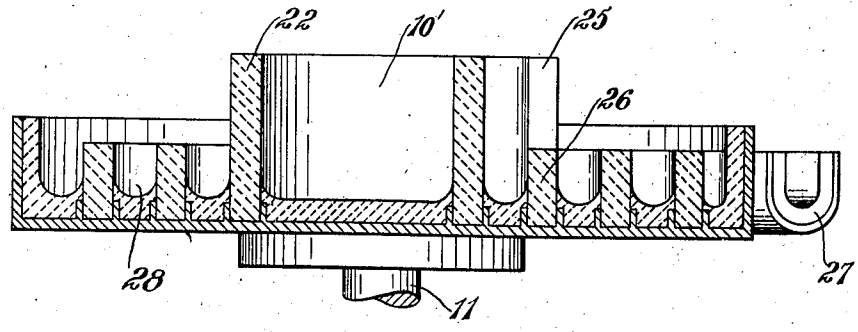


Fig. 3

Inventor
George R. Roemer

By Frease and Bishop
Attorneys

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2,303,139

METHOD OF AND APPARATUS FOR CENTRIFUGALLY DEGASIFYING MOLTEN METAL

George R. Roemer, Mount Lebanon, Pa.

Application October 23, 1941, Serial No. 416,233

12 Claims. (Cl. 22—79)

The invention relates generally to a novel method of and apparatus for pouring ingots, rolls or other castings to improve the quality of the metal by reducing the defects, and to increase the yield.

More particularly, the invention relates to a method of centrifugally working the molten metal after it leaves the ladle and before it enters the mold, in such a way as to throw out entrapped gases, promote homogeneity and generally improve the character of the casting.

Common practice in pouring and casting metal, for example in the making of open hearth steel, is to tap a heat of steel out of the open hearth furnace at about 2900° to 3000° F. down a runner into a large ladle of say 150 tons capacity, then move the ladle over a row of vertical ingot molds into which the molten metal is poured rapidly at about 2800° to 2900° F. from the bottom of the ladle.

The steel must be poured rapidly to prevent the formation of a large scull of solidified metal in the ladle, and because of the extremely high static pressure of the mass of molten metal in the ladle, the impact against the bottom of the mold may be from 250 pounds to 700 pounds per square inch, depending upon the capacity of the ladle. This impact, in combination with the high pouring temperature, causes the mold and stool to be cut and the metal to surge and splash violently in the mold, producing scabs, blisters and minute gas pockets on the surface of the ingot.

Moreover, with common practice, great difficulty is experienced in the formation of gas pockets or blow holes throughout the ingot, and also in the lack of homogeneity in the ingot due to the presence of non-metallic inclusions and segregation as the ingot solidifies. Entrapped gases are particularly troublesome in semi-deoxidized and rimming or open steels, and when the molten metal is poured rapidly in the mold at high temperature it solidifies before these gases escape or are oxidized to any substantial extent, resulting in the formation of gas pockets. It is therefore desirable to pour at as low a temperature as possible to prevent the molten metal from rising too much in the mold and forming an excessive amount of blow holes.

Some particles of non-metallic or slaggy materials, particularly in semi-deoxidized and rimming steels where these materials are more plentiful, are entrapped with the gases in the ladle, because there is not time for all the non-metallic particles to rise to the top of the molten metal in the ladle. These entrapped particles are carried into the mold and tend to form undesirable non-metallic inclusions in the ingot.

Segregation is caused by the fact that certain ingredients in the molten metal, primarily carbon, phosphorus and sulphur, have lower melting points than iron and therefore solidify at low temperatures. These ingredients, and also certain alloying elements present in alloy steels, segregate in the mold usually at the center of the ingot, which is the last to solidify.

Segregation can never be entirely eliminated but it can be somewhat reduced by lowering the pouring temperature (which tends to increase the amount of ladle scull) to increase the rate of solidification, and by striving to keep the metal in substantial equilibrium in the mold. However, this equilibrium can only be approached when the entrapped gases have been substantially removed previously, as in fully-deoxidized steel, but cannot be approached in semi-deoxidized or rimming steels.

Accordingly, in making steel according to common practice, and especially semi-deoxidized or rimming steel, it is recognized that a certain amount of defects will be unavoidable in the ingot, and an effort is made to partially eliminate the entrapped gases before casting and to locate substantially all of the defects such as blow holes and segregation in the upper part of the ingot.

For example, with fully-deoxidized and semi-deoxidized steel deoxidizers such as silico aluminum may be added in both the furnace and the ladle to partially oxidize the gases and thus reduce the number of blow holes in the ingot, and the use of sinkhead casings or "hot tops" is very common to keep the top of the ingot molten longest and cause the segregation to locate in or near the end which is then cropped off during rolling.

While these expedients result in fewer defects and generally improve the quality of the ingot, the operator must choose a happy medium in lowering the pouring temperature to reduce segregation, without too greatly increasing the amount of scull formed in the ladle, and there is still a large loss in yield due to ladle sculls, cropped ends and the like. Also, a substantial percentage of ingots have to be surface chipped or scarfed or even scrapped because of defects of one kind or another.

It is therefore a general object of the present invention to provide a novel method of centrifugally degasifying the molten metal before it is cast, so as to improve the homogeneity and the quality of the ingot, and substantially overcome

the difficulties encountered in the common practice of casting ingots.

More specifically, it is an object of the present invention to provide a novel method of and apparatus for centrifugally degasifying molten metal so as to substantially eliminate the formation of scabs, blisters and minute gas pockets on the surface of the ingot.

Another object is to substantially eliminate blow holes in the ingot by a novel method of treating the molten metal before it is cast.

A further object is to provide a novel method of treating the molten metal which enables the control of the temperature at which the metal is poured into the ingot mold.

Another object is to provide a novel method of treating the molten metal which reduces the formation of non-metallic inclusions and segregation in the ingot.

A further object is to provide a novel method of degasifying the molten metal which increases the yield by reducing the percentage of sculls, cropped ends and the like.

A still further object is to provide a novel method of treating the molten metal so as to materially reduce the amount of reconditioning of the ingots and blooms rolled therefrom, such as chipping, scarfing and the like.

These and other objects are accomplished by the improvements comprising the present invention which may be stated in general terms as including pouring the molten metal from a ladle into the center of a horizontally rotatable spiral trough discharging tangentially at its outer periphery, rotating the trough as the metal passes spirally therethrough and discharges into a catch basin enclosing the trough and maintained at a predetermined temperature, and then pouring from the catch basin into ingot molds.

Referring to the drawings, in which improved apparatus for carrying out the invention is shown somewhat diagrammatically by way of example,

Figure 1 is a side elevation, with parts in section, of a preferred embodiment of apparatus for carrying out the invention;

Fig. 2 is a plan sectional view as on line 2—2, Fig. 1, and

Fig. 3 is an enlarged vertical sectional view of the spiral trough, as on line 3—3, Fig. 2.

Similar numerals refer to similar parts throughout the drawings.

A conventional open hearth ladle is indicated at 4, and may have a capacity of 100 to 150 tons, and is adapted for receiving molten metal tapped at about 2900° to 3000° F. from a heat in an open hearth or other melting furnace. The ladle 4 is provided with a usual stopper 5 which regulates the pouring of molten metal from the pouring spout 6 at the bottom of the ladle, the usual mechanism for manually raising and lowering the stopper 5 being indicated generally at 7. The ladle 4 may be positioned as shown in Fig. 1 by means of a crane (not shown) over the improved catch basin 8, with its pouring spout 6 directly over the funnel shaped receiving opening 9 of the catch basin.

A horizontal spiral receiving trough indicated generally at 10 is mounted for axial rotation within the catch basin 8 coaxial with the receiving opening 9. The spiral trough is mounted on the top of a vertical shaft 11 which is journaled at its lower end in a bearing indicated at 12 and adjacent its upper end in a bearing bracket 13. The shaft 11 is coaxial with the inlet opening 9 of the catch basin, and is rotated by means of a worm gear 14 secured on the shaft and meshing with a suitable worm (not shown) on the driving shaft 15, the driving shaft 15 being operatively connected through a gear reducer 16 with a preferably variable speed driving motor 17.

As shown, the shaft 11 and the driving mechanism therefor, together with the catch basin 8, are all supported on a suitable elevated support indicated diagrammatically at 18 for locating the catch basin above ingot molds 19 carried on a flat car 20 rollably supported on rails 21. Obviously, the support 18 can be made movable on suitable rails if desired.

The spiral trough 10, as best indicated in Figs. 2 and 3 has preferably an enlarged area or well 10' at its inner end or central portion formed by the spiral wall 22 which extends upwardly closely adjacent to the top wall or cover 23 of the catch basin. The spiral wall 22 has its inner end at 24 and spirals outwardly from that point to its outer end 25.

From the outer end 25 of the wall 22 a spiral wall 26 of reduced height continues the spiral wall 22 outwardly and terminates in a discharge spout 27 which preferably is disposed tangentially of the trough at its outer periphery. The spiral walls 22 and 26 thus form a continuous spiral trough 28 from the central well 10' to the discharge spout 27. The convolutions of the walls 22 and 26 are spaced radially so that the trough 28 has a substantially uniform cross sectional area from the end 25 of wall 22 to and through the spout 27, said area being preferably slightly greater than the cross sectional area of the stream of metal flowing out of the pouring spout 6.

The walls of the spiral trough 28 are preferably refractory material as shown, and the increased height of wall 22 provides the substantially circular well 10' in which to receive the molten metal from the ladle 4 and prevent the metal from splashing out of the trough as it is poured.

The catch basin 8 completely encloses the spiral trough and its walls and cover are preferably lined with refractory material as shown. Within the chamber of the catch basin and immediately below the spiral trough 10, a preferably substantially frusto-conical bottom wall or collecting hearth 30 is provided. The collecting hearth slopes from a high point 31 at one side substantially circumferentially downwardly to a low point or well 32 provided at the opposite side of the catch basin. Means for pouring molten metal from the well 32 of the catch basin and for regulating the pouring speed preferably includes a stopper 5a adapted to be manually controlled by suitable mechanism indicated at 7a.

As shown cover 23 of the catch basin is separable from the side walls thereof, and burners 33 shown diagrammatically are for supplying heat through the cover 23 into the catch basin chamber for maintaining the temperature therein at a predetermined degree. Similarly, burners 34 are provided in the outside bottom wall 35 of the catch basin for helping maintain the desired temperature in the catch basin and for preheating the conical hearth 30 prior to the start of pouring a ladle into the spiral trough 10. Suitable pyrometers indicated diagrammatically at 36 may be provided through the walls of the catch basin for indicating the temperature therein so as to enable close temperature control.

In carrying out the novel method in the preferred embodiment of apparatus illustrated herein, after the ladle 4 full of molten metal from the melting furnace is positioned as shown

in Fig. 1, the stopper mechanism 7 is manipulated to pour the metal rapidly out of the pouring spout 6 through the inlet opening 9. However, the scope of the invention as defined in the appended claims includes pouring directly from the melting furnace into the inlet opening 9. Because of the fact that the metal is not being poured directly into an ingot mold such as 19, it can be poured rapidly at the high ladle temperature without danger of forming excessive scabs and other defects resulting from the combination of high temperature and rapid pouring in common practice; and accordingly the metal can be poured faster, making possible the use of a thinner slag blanket on top of the ladle, without increasing the size of the scull which remains in the ladle after poring.

In other words, in common practice a slag blanket of say six inches is necessary on top of the molten metal in the ladle to keep the metal molten throughout the operation of pouring into ingot molds at the reduced speed which is required to prevent the formation of scabs, gas pockets and the like in the mold. With the present invention, wherein the molten metal is poured from the ladle into the well at the center of the spiral trough, increased pouring speed is possible so that a thinner slag blanket can be used on the molten metal in the ladle without increasing the amount of scull formed therein.

As the metal is poured into the well 10' in the spiral trough within the spiral wall 22, the trough is axially rotated on shaft 11 and the metal immediately and continuously flows out through the spiral channel or trough 28 and is discharged tangentially thereof through the pouring spout 27. The centrifugal force imparted by the rotating trough tends to throw the metal outwardly against the spiral walls and this action causes the release of gas bubbles entrapped in the molten metal. By providing a spiral trough having a cross section slightly greater than the cross section of the stream being poured from the ladle, a relatively long stream of molten metal having a relatively small cross section is acted upon over a substantial period of time by the centrifugal force generated by rotating the spiral trough, providing for release of a maximum amount of entrapped gases from the molten metal.

The speed of rotation of the trough 10 may be regulated by the variable speed motor 17, and the temperature within the catch basin regulated by means of the burners 33 and 34, in accordance with the type and kind of steel being treated.

As the molten metal is discharged from the discharging spout 27, it is thrown outwardly into the catch basin and falls on the frusto-conical hearth 30 to collect in the well portion 32 thereof. For steel of a certain analysis, the burners 33 and 34 can be regulated so as to maintain the temperature within the catch basin at say 2700° F., which is 200 to 300° less than the temperature of the metal being poured from the ladle. Therefore, the molten metal can be poured into the ingot molds at this substantially lower temperature, and the speed of the pouring can be reduced and closely regulated by manipulation of the stopper 5a, so that a minimum amount of gas pockets, segregation and other defects normally resulting from the combination of high pouring speed and high temperature are present in the ingot.

Also, by regulating the depth of molten metal in the well 32 of the catch basin, the static pressure of the molten metal may be kept to a minimum, with the result that scabs and blisters formed by the splashing of the molten metal in the mold are consequently materially reduced.

Due to the fact that the entrapped gases are considerably reduced as the molten metal flows through the spiral trough and the metal is kept molten for a considerable time between the ladle and the ingot mold, the non-metallic or slaggy particles distributed in the molten metal will have more time to rise to the top of the molten metal in the catch basin, so that a material amount of these particles will be separated out within the catch basin. For removing these non-metallic or slaggy materials, the cover 23 of the catch basin can be lifted off after a heat has been run through, and these materials cleaned out, or a slag notch can be provided at a suitable level in the catch basin.

The release of entrapped gases in the spiral trough and catch basin materially reduces the need for adding deoxidizers in the ladle and ingot mold, and this is particularly advantageous in the manufacture of semi-deoxidized and rimming steels where little or no deoxidizers are used.

The treatment or working of the molten metal in passing through the rotating spiral trough and being collected in the catch basin not only has the effect of releasing a substantial amount of entrapped gases from the molten metal, but when the molten metal is poured from the catch basin at a predetermined reduced temperature and at slower pouring speed, the molten metal in the ingot mold more nearly approaches substantial equilibrium so as to increase the rate of solidification, which results in reducing the amount of segregation.

The present invention enables a substantial increase in yield in the casting of ingots, by reducing the percentage of sculls, cropped ends and the like; materially reduces the amount of reconditioning of ingots and blooms required, by reducing the number of scabs, gas pockets and other defects; and generally improves the quality of the ingots by providing more homogeneity and less segregation therein.

I claim:

1. The method of degasifying molten metal before casting which includes pouring molten metal from a ladle into a horizontal spiral trough, centrifugally working the metal as it passes through the trough, discharging the metal from the outer end of the trough tangentially of the spiral, collecting said discharged metal, controlling the temperature of said metal to keep it molten while in said spiral trough and while being collected, and pouring said discharged molten metal into casting molds.

2. The method of degasifying molten metal before casting which includes pouring molten metal from a ladle into the inner end of a horizontal spiral trough, centrifugally working the metal as it passes through the trough, discharging the metal from the outer end of the trough tangentially of the spiral, collecting said discharged metal and controlling the temperature thereof, and then pouring said molten metal into casting molds.

3. The method of degasifying molten metal before casting which includes pouring molten metal into the inner end of a horizontal spiral trough, centrifugally working the metal as it passes through the trough and discharges out-

wardly therefrom, collecting said discharged metal and controlling the temperature thereof, and then pouring said molten metal into casting molds.

4. The method of degasifying molten metal before casting which includes pouring molten metal from a ladle into the inner end of a horizontal spiral trough, whirling the trough axially as the metal flows therethrough and discharges from the outer end thereof, collecting said discharged metal, controlling the temperature of said metal to keep it molten while in said spiral trough and while being collected, and pouring said discharged molten metal into casting molds.

5. The method of degasifying molten metal before casting which includes the steps of pouring the molten metal into the inner end of a horizontal spiral trough, axially rotating the trough as the metal flows therethrough, and discharging the metal from the outer end of said trough tangentially of the spiral.

6. Apparatus for degasifying molten metal before casting, including a catch basin, a horizontal spiral trough axially rotatably mounted in said catch basin and adapted for receiving molten metal at its inner end, means for rotating said trough, a discharge spout at the outer end of said trough disposed tangentially thereof, said catch basin enclosing said trough and adapted for collecting molten metal discharged therefrom, means for controlling the temperature in said catch basin to keep the metal in the trough and basin molten, and means for pouring the collected metal from said catch basin into casting molds.

7. Apparatus for degasifying molten metal before casting, including a horizontal spiral trough for receiving molten metal at its central portion and for discharging it peripherally, means for horizontally axially rotating said trough, a catch basin enclosing said trough and adapted to collect molten metal discharged therefrom, means for controlling the temperature in said catch basin, and means for pouring the collected metal from said catch basin.

8. Apparatus for degasifying molten metal before casting, including a horizontal spiral trough mounted for axial rotation and adapted for receiving molten metal at its inner end, means for rotating said trough, a discharge spout at the outer end of said trough disposed tangentially thereof, a catch basin for collecting metal discharged from said trough, and means for maintaining said metal at a predetermined temperature while it is being rotated, discharged and collected.

9. Apparatus for degasifying molten metal before casting, including a horizontal spiral trough for receiving molten metal at its central portion and for discharging it peripherally, means for horizontally axially rotating said trough, means for collecting metal discharged from said trough, and means for maintaining the metal at a predetermined temperature while it is being rotated, discharged and collected.

10. Apparatus for degasifying molten metal before casting, including a spiral trough for receiving molten metal at one end and discharging it at its other end, means for axially rotating the spiral trough, means for collecting metal discharged from said trough, and means for maintaining the metal at a predetermined temperature while it is being spirally rotated, discharged and collected.

11. The method of degasifying molten metal before casting which includes pouring molten metal into one end of a spiral trough, whirling the trough axially as the metal flows therethrough, discharging the metal from the other end of said spiral trough, maintaining the metal at a predetermined temperature as it flows through and discharges from said spiral trough, and then pouring said discharged molten metal into casting molds.

12. Apparatus for degasifying molten metal before casing, including a catch basin, a horizontal trough axially rotatably mounted in said catch basin and adapted for receiving molten metal at its inner portion and discharging it at its outer peripheral portion, said catch basin enclosing said trough and adapted to collect molten metal discharged therefrom, means for maintaining the metal in the trough and catch basin in molten condition, and means for pouring the collected metal from said catch basin into casting molds.

GEORGE R. ROEMER.