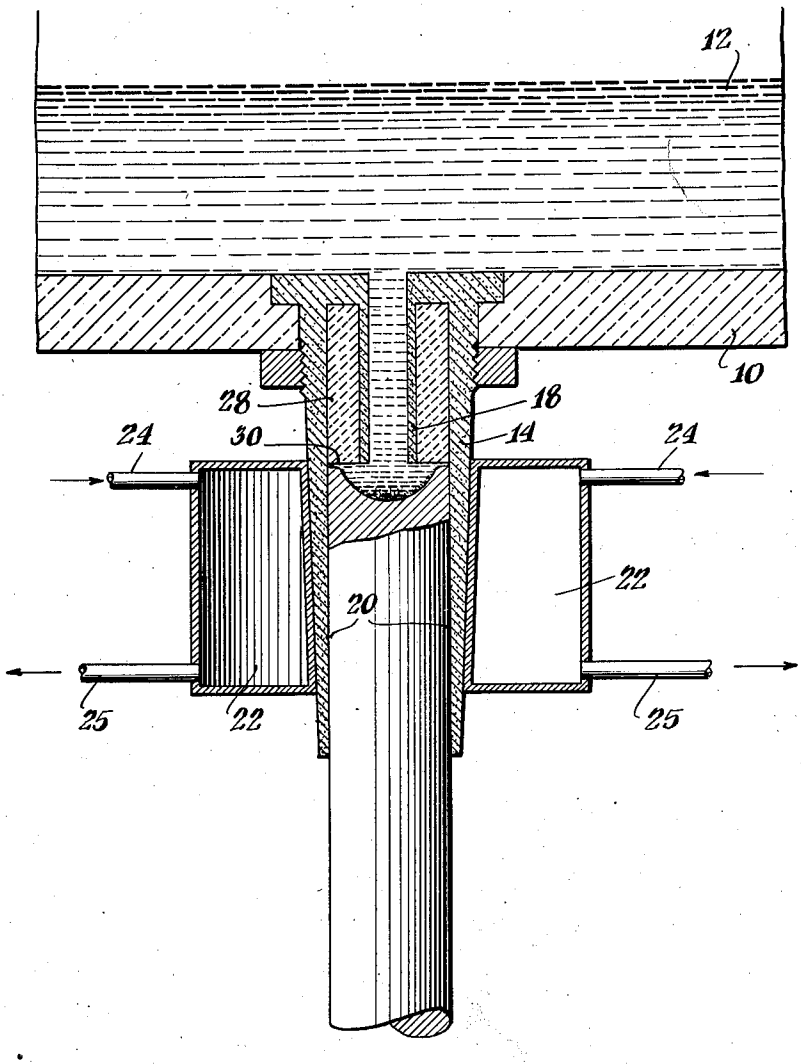
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CONTINUOUS CASTING

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CONTINUOUS CASTING

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This invention relates to the art of continuous casting and more particularly to an improved mold and method for producing continuous cast metal shapes of uniformly high density which are free from objectionable surface cracks and imperfections.

When casting metal, such as copper, brass and the like, wherein the molten metal is introduced into one end of a die or mold having the desired shape and passed downwardly therethrough concurrently as it is chilled to form a solidified cast shape which is continuously withdrawn from the opposite end of the mold, it has been observed that the production of sound castings is dependent, to a large extent, upon the proper location of the point or zone in the mold where initial congealing of the molten metal takes place. Premature congealing of the molten metal above the zone where the maximum rate of heat extraction is being effected results in the formation of pronounced checks or cracks in the outer surface portion of the casting. In extreme cases "freezing" of the apparatus and stoppage of the process ensues.

Where the cross-sectional area of the rod being cast is relatively large the point intermediate the ends of the mold where initial solidification of the liquid metal takes place tends to occur at or near the proper location so that its control is less of a problem. However, when casting relatively small diameter rod, for example, less than three inches, control of the point or zone where initial solidification occurs becomes increasingly more important as the diameter of the cast rod is decreased. With small rods, the ratio of the diameter of the rod to the length of the mold is proportionately less and molten metal is required to be conveyed a proportionately longer distance down the mold before reaching the zone surrounded by the cooling jacket.

Where the temperature of the melt is limited to approximately 1250° C., as when casting copper or copper alloys, the loss of superheat in the upper part of the mold is ordinarily enough to cause solidification of the molten metal to begin some distance above the zone where a rapid rate of heat extraction is provided. Results of tests conducted by us indicate that this premature loss of heat by the molten metal above the cooling zone solidifies a fragile skin-like outer portion which shrinks away from the side walls of the mold and is ruptured when subjected to the hdrostatic head pressure and frictional or mechanical stresses incident to the casting process.

Fracture of the newly formed outer skin-like shell also is brought about when this thin shell shrinks away from the mold wall and is reheated sufficiently, by the molten metal in the central portion of the casting, to cause it to expand and again contact the mold wall setting up frictional stresses which the thin shell is unable to withstand. These breaks appear as checks or cracks in the outer surface of the cast shape and the checking cycle is often repeated periodically as the casting process proceeds.

It is the principal object of this invention to overcome these difficulties by devising a mold and method of casting whereby the location of the metal congealing zone can be predetermined and the freezing of the metal controlled to avoid the formation of castings having surface defects.

According to the invention there is provided a mold which during use functions to prevent the molten metal from losing its latent heat until it reaches the zone of high heat extraction capacity. Provision is also made whereby after the molten metal reaches this zone it is allowed to flow laterally from a central source of supply toward the side walls of the mold while being blocked or otherwise prevented from rising above a predetermined point in the mold, such point being below that at which initial solidification of the molten metal would occur under otherwise identical casting conditions. During casting, the mold and associated parts of the casting apparatus are kept filled with the molten metal being cast. Concurrently, as the liquid metal reaches the desired location in the mold where solidification of the metal is to be instituted, it is immediately subjected to a high rate of heat extraction. In this way a thick heavy shell of solidified metal is initially formed around the casting shape which is strong enough to withstand the hydrostatic head pressure of the molten metal and frictional stresses imposed upon it without rupturing as the newly formed shell slides downwardly through the mold.

Although the novel features, which are believed to be characteristic of this invention, will be particularly pointed out in the claims appended hereto, the invention itself and manner in which it may be practiced will be more readily understood by reference to the following description taken in connection with the accompanying drawing. The drawing shows, diagrammatically, a sectional elevation of one form of apparatus in accordance with the invention and which may be employed in practicing the new method thereof; the part of the furnace utilized for retaining molten metal being shown partly broken away.

Referring to the drawing more in detail, the numeral 10 indicates, generally, a reservoir or casting furnace section for holding molten metal to be cast, as shown at 12. Suitably arranged in the floor of the reservoir 10 is a mold 14 into which molten metal from the reservoir is introduced during the casting process.

In continuously casting copper, for example, molten copper is treated in accordance with the usual practice to render it substantially gas-free, and of the desired composition, prior to introducing the metal into the mold. Turbulence of the molten metal is avoided by positioning the mold 14 in the floor of the furnace at a point remote from the charging end. Further, the hydrostatic head of molten metal is kept substantially constant. These factors may be controlled in a manner known to those skilled in the art, in which connection reference may be made to Betterton and Poland Patent No. 2,195,809, granted April 2, 1940.

The mold 14 is made of refractory material which is suitable and durable, such as, dense graphite, metal, or the like. Appropriately the mold may be in accordance with Poland and Lindner Patent No. 2,136,394, granted November 15, 1938. A central tubular member 18 is provided as shown, through which molten metal is conducted from the reservoir 10 down into the mold or forming die portion 20. Where desired, this tube may be provided with valve means, not shown, for regulating the flow of molten metal therethrough, otherwise the column of metal defined by tube 18 and portion 20 of mold 14 will be automatically replenished from the supply 12 in response to the downward movement of the column as the casting is withdrawn from the mold. Surrounding the die portion 20 of the mold there is positioned a water cooling jacket 22 through which water is circulated to provide a cooling or refrigerating zone by which heat is extracted from the column of molten metal to progressively solidify it from its periphery toward its central axis as indicated in the drawing. Cooling water is conducted to and from the jacket 22 from a suitable source of supply, not shown, by means of the conduits 24 and 25 respectively.

In order to prevent the molten metal from beginning to freeze or solidify before it reaches the desired point in the cooling zone of the mold, the delivery tube 18 is made to extend down to the point where a high rate of heat extraction can be effected and the annular space between the tube and the inner wall of the mold is filled with heat insulating material 28. Alundum cement, for example, or other suitable refractory material may be used for this purpose. This is either rammed or tamped in place while moist, then dried and fired, or inserted as a preformed shape. Any other suitable method of insulating the tube from the mold wall may be employed. By arranging the mold and associated casting parts in this manner, the point in the mold where it is desired to initiate solidification of the molten metal can be readily predetermined. Thus freezing of the metal to form the cast shape is controlled so that a thick shell of metal can be solidified during the initial stage of forming the casting shape.

In the scheme illustrated, molten metal flowing into the mold 14 is prevented from coming in contact with the mold above the point selected for initial solidification in the refrigerating zone formed by the cooling water jacket 22, by means of the heat insulating filler material 28 and tube 18, the latter serving to constrict the downwardly moving column of molten metal in cross-section to immediately above the selected point while the lower portion of the filler material forms a wall 30 extending from the mouth of the delivery tube 18 to the side walls of the mold, thus mechanically blocking-off the upward flow of liquid metal at the desired location.

Preferably, most of the heat is extracted laterally from the central core of the casting through the walls of the mold adjacent the water cooling jacket, but a minor amount may be extracted upwardly and outwardly through the ceiling wall 30 as the molten metal leaves the end of the tube 18 and flows laterally toward the sides of the mold. The size of the bore forming the tube 18 is such as to provide for delivery of enough molten metal to maintain the mold filled at all times during casting and will vary depending on the casting speed employed and the desired diameter of the rod being cast.

By confining the point or zone of initial freezing at the proper location with respect to the fluid cooled section of the mold, and maintaining the mold filled during casting with avoidance of turbulence, as described, considerably higher casting speed than considered feasible heretofore can be used. Sound copper castings having exceptionally high density, for example having a specific gravity of 8.95+, are readily produced by the process of this invention. Instead of forming a relatively long thin solid metal phase at the interface representing the congelation point of the molten metal, there is produced a relatively short, thick heavy shell of solidified metal. This latter thick shell, unlike the former, possesses sufficient strength to withstand the temperatures and stresses involved during the continuous casting process without remelting, rupturing or deforming as it is moved downwardly through the mold.

While the invention is particularly adapted to the continuous casting of copper or copper alloys, it will be understood that the principles thereof are applicable generally to the casting of other non-ferrous as well as ferrous metals and alloys which present problems similar to those encountered in continuously casting copper or its alloys.

What is claimed is:

1. A process for continuously casting metal which comprises introducing molten metal into one end of a mold, continuously withdrawing solidified metal from the other end, maintaining a cooling zone in one portion of the mold, conducting molten metal downwardly into said mold through a central delivery tube to the point where it is desired that solidification of the molten metal take place to form a cast shape, and abruptly blocking the rise or reverse flow of molten metal contiguous the walls of the mold adjacent said point to force the molten metal to flow laterly from the lower end of said central delivery tube toward the side walls of the mold while concurrently extracting heat from the molten metal at a rate such that a thick shell of solidified metal is initially formed during casting which resists checking or cracking whereby sound cast metal can be continuously withdrawn from the mold.

2. The process for continuously casting metal which comprises introducing molten metal into one end of a mold, continuously withdrawing solidified metal from the other end, predeter-

mining the point or zone in the mold where initial freezing of the molten metal is to take place, conducting the molten metal down to this zone through a central delivery tube while the same is prevented by heat insulating material arranged between the tube and mold side walls from losing heat sufficient to institute solidification, thereafter causing the molten metal to flow laterally from the lower end of the tube toward the side walls of said mold, abruptly obstructing the upward rise of molten metal in the mold at the point where initial freezing of the molten metal is to take place, and simultaneously subjecting the molten metal when reaching said point to a high rate of heat extraction to cause the solidification of a thick shell of metal which forms the outermost part of the casting during the initial stage of the continuous casting process.

3. A process for continuously casting metal comprising introducing molten metal into one end of a mold, continuously withdrawing solidified metal from the other end, providing a cooling zone along a portion of said mold, delivering the molten metal to the cooling zone of the mold through a restricted opening while preventing the metal from losing sufficient heat to cause initial congelation until it has passed through said opening, maintaining said mold and associate parts filled with molten metal to avoid turbulence during casting, and abruptly blocking reverse flow of the molten metal thus delivered in the mold at said cooling zone where initial freezing of the molten metal is to take place while subjecting the molten metal flowing into said cooling zone portion of the mold to a high rate of heat extraction to bring about the solidification of a thick outer shell of metal during formation of the cast shape as the same is continuously being withdrawn from said mold.

4. In continuous casting mechanism, a reservoir for holding molten metal, a mold for receiving molten metal from said reservoir which is in communication therewith, cooling means surrounding a portion of said mold for congealing metal introduced therein, said mold having an inwardly extending annular abutment forming a molten metal tight juncture with the side walls of said mold and arranged adjacent said cooling means for limiting the upward flow of molten metal contiguous with the side walls of said mold during casting to bring about rapid solidification of said molten metal adjacent and immediately below the junction of said abutment and mold side walls whereby there is formed a thick walled casting which can be withdrawn from the outer end of said mold as a continuous cast shape without rupturing.

5. A mold for casting metal by continuously supplying molten metal to one end thereof and continuously withdrawing solidified metal from the other end thereof characterized in that the interior bore of said mold is provided with an annular abutment which extends inwardly from the side walls of said mold for limiting the rise of molten metal above a predetermined point where initial freezing of the molten metal is to take place, and means comprising a fluid cooling jacket arranged around said mold adjacent said point for providing a rapid rate of cooling to solidify a thick wall of metal around the casting during the initial formation of the cast shape.

6. In continuous casting of copper rod of less than three inches in diameter wherein molten metal is conducted from a supply thereof into one end of an open end mold having the desired shape and passed downwardly therethrough concurrently as the metal is chilled to form a solidified cast shape which is continuously withdrawn from the opposite end of the mold, the improvement consisting in providing the inner wall of the mold with an annular abutment which extends inwardly therefrom towards the central cavity of the mold, thereby defining the upper limit of contact of the molten metal with the mold side wall arranging a cooling water jacket around the outside of said mold adjacent the annular abutment section of the mold, circulating water therethrough to extract the heat rapidly from the molten metal immediately upon its flowing in contact with the side walls of the mold contiguous with said annular abutment causing the initial freezing of a thick outer shell of solidified metal during formation of the cast shape, and insulating said molten metal against loss of heat sufficient to bring about solidification while it is being conducted from the receptacle into said mold and in contact with the side walls of the mold adjacent said abutment.

7. In apparatus for continuously casting metals, the combination with a reservoir for molten metal, an open-ended, vertically-disposed mold for receiving molten metal from said reservoir into its upper end and discharging the casting from its lower end, and cooling means for solidifying metal in the mold, of means contiguous with the inner mold wall denying molten metal access to said inner wall above a predetermined point, said point being below that at which initial solidification of the molten metal would occur under otherwise identical conditions of casting, and insulating means precluding all solidification of metal in the mold above said predetermined point.

8. In continuously casting metals by confining molten metal as a downwardly moving column, directing the column through a cooling zone whereby heat is extracted to form the casting by progressively solidifying the metal from the periphery of the column toward its central axis, and replenishing the column with molten metal from a supply thereof in response to the downward movement of the column, the method of initially solidifying the molten metal at the periphery of the column as a relatively thick shell which comprises selecting a point in the upper region of the cooling zone as the point of initial solidification, said point being below that at which initial solidification would occur under otherwise identical casting conditions, and constricting the molten column in cross section immediately above the selected point and insulating the portion of the column thus constricted to preclude all solidification of metal above the selected point, whereby the molten metal at and adjacent the periphery of the full column immediately below the selected point is initially solidified as a relatively thick shell constituting the outer portion of the cast shape.

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