COOLING MEANS FOR CONTINUOUS CASTING APPARATUS

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This invention relates to apparatus for continuously casting metal in the form of rods, bars, tubes or the like and relates more particularly to the means whereby the metal is cooled after it has solidified.

One of the objects of the present invention is to provide a continuous casting apparatus wherein superior means are provided for extracting heat from the previously cast metal.

Another object of the present invention is to provide superior cooling means for continuous casting apparatus wherein intimate thermal engagement with the previously solidified metal is assured despite wear and erosion occurring as an incident to the movement of the said metal with respect to the contacting surfaces of the cooling means.

With the above and other objects in view, as will appear to those skilled in the art from the present disclosure, this invention includes all features in the said disclosure which are novel over the prior art and which are not claimed in the following co-pending applications: Serial No. 157,644, filed August 8, 1937; Serial No. 159,672, filed August 15, 1937; Serial No. 1Y1,188, filed October 27, 1937; and Serial No. 160,795, filed August 25, 1937.

In the accompanying drawings, in which certain modes of carrying out the present invention are shown for illustrative purposes:

Fig. 1 is a broken view mainly in vertical central section of an apparatus for continuously casting metal and embodying the cooling-means of the present invention;

Fig. 2 is a view corresponding to Fig. 1, but showing the downward movement of the heat-transmitting liner as an incident to wear upon its interior passage;

Fig. 3 is a detail sectional view taken on the line 3—3 of Fig. 1;

Fig. 4 is a transverse sectional view taken on the line 4—4 of Fig. 1;

Fig. 5 is a transverse sectional view corresponding to Fig. 4, but taken on the line 5—5 of Fig. 2;

Fig. 6 is a view mainly in side elevation and partly in vertical central section of the two elements of the heat-transmitting liner;

Fig. 7 is a view thereof taken at a right angle to Fig. 6;

Fig. 8 is an under-side view thereof;

Fig. 9 is a perspective view of another form of heat-transmitting liner;

Fig. 10 is a top-end view of still another form of heat-transmitting liner;

Fig. 11 is a view thereof in side elevation;

Fig. 12 is a view of the liner of Figs. 10 and 11, viewed from the lower end thereof; and

Fig. 13 is a transverse sectional view taken on the line 13—13 of Fig. 11.

The particular continuous casting apparatus herein chosen for the purpose of illustrating the present invention in Figs. 1 to 8 inclusive includes a cup-shaped container or crucible generally designated by the reference character 20 and 10 which may be formed of a wide variety of suitable materials, such for instance as clay-graphite materials commonly used in the manufacture of crucibles and the like. The said container or crucible 20 includes a bottom wall 21 and an upward annular side wall 22 and if desired may be enclosed in a housing (not shown) so as to conserve the heat of the molten metal 23 located within the said crucible or container 20 before referred to.

In the particular structure shown, the bottom wall 21 of the container 20 is provided with a central shouldered aperture 24 in which is fitted a shouldered retaining-member 25 formed of refractory material and having an externally threaded tubular shank 26 which projects below the under surface of the bottom wall 21 of the container as is shown particularly well in Figs. 1 and 2.

Threaded onto the downwardly-projecting portion of the externally-threaded shank 26 of the retaining-member 25 is the internally-threaded coupling-sleeve 27 of a primary cooling-chamber generally designated by the reference character 28. The said cooling-chamber is preferably formed of copper or other high heat-conducting material and is provided in its interior with a cooling-compartment 29 into which water or other suitable coolant may flow from a water-head 30 secured to the outer periphery of the said cooling-chamber and in turn supplied with a cooling fluid from a supply-pipe 31. After circulating through the cooling-compartment 29 in contact with the radiating or heat-exchange fins 32 projecting from the inner wall of the said chamber, the coolant passes outwardly through a water-head 33 and thence through an outlet-pipe 34.

Extending axially through both the retaining-member 25 and the cooling-chamber 28 in intimate thermal engagement therewith is a tubular forming-die 35 having an axial forming or casting passage 36 and formed of any suitable material which will withstand the heat of molten copper, brass or other metal, though it has been
found that for this purpose a very fine-grained graphite is preferable.  

Owing to the action of the coolant flowing through the interior of the cooling-chamber 28, in conjunction with the coolant flowing through secondary cooling-means to be later described, the molten metal within the forming-passage 36 will solidify or freeze as soon as sufficient heat has been extracted therefrom, before such molten metal can reach the lower end of the said passage 36 and emerge therefrom. For purposes of illustration, let it be assumed that the speed of withdrawal of the solidified metal in the form of a rod 31 by power-driven withdrawing-rolls 37-37 is such that the cooling-means is effective to cause the freezing or solidification to take place at about the point 38 in the said forming-passage 36.

Coming now to the secondary cooling-means with which the present invention is mainly concerned, it may be stated that the said secondary cooling-means, one embodiment of which is to be presently described in detail, is designed to extract heat from the solidified rod 37 to thus assist the cooling action of the primary cooling-chamber 28 by causing heat to move axially down the solidified rod from the point of solidification 38 in the manner as will hereinafter appear.

The secondary cooling-means above referred to includes a cooling-chamber generally designated by the reference character 39 which is preferably formed of copper or other high heat-conducting material and comprises an outer tubular casing-member 40 having a longitudinal internal rib 41 on its exterior in which is formed a Z-shaped coolant-passage 42 opening into the interior of the casing-member 40 at the upper end thereof and connected at its lower end to an outlet-fitting 43 which latter in turn is connected to an outlet-pipe 44, as shown in Figs. 1 and 2. At a point substantially diametrically opposite the outlet-fitting 43 just referred to the casing-member 40 has opening into its interior a coolant-inlet fitting 45 to which is connected a coolant supply-pipe 46.

Snugly fitting within the outer casing-member 40 is an inner casing-member 47 formed on its exterior with a continuous helical rib 48 to facilitate the transfer of heat from the cooling-chamber 39 to the coolant and resulting in the formation between the convolutions of the said helical rib of what may be aptly termed a helical cooling-compartment 49 which is supplied at one end with a suitable coolant from the pipe 46 and from which such coolant may flow outwardly through the outlet-pipe 44 before referred to. The upper end of the cooling-compartment 49 above referred to is sealed by an end-plate 50 and in a similar manner the lower end of the said cooling-compartment is closed by an end-plate 51, both of which plates 50 and 51 extend between the outer casing-member 40 and the inner casing-member 47 and to which they are secured in a water-tight manner by brazing or other suitable means of attachment.

The inner casing-member 47 is formed with a cooling-chamber which is of special form and has two opposed wall-portions 52-53, each of which is transversely curved and each of which converges toward the other as it approaches the lower end of the said inner casing-member 47. The opposed diametrically-opposite wall-portions of each of these, which are located at a right angle to the aforesaid wall-surfaces 53-53 do not taper toward each other but are in parallelism, as is shown particularly well in Fig. 3.

Installed in the passage 52 in the inner casing-member 47 of the secondary cooling-chamber 39 is a laterally-contractable heat-transmitting liner 55-55 generally designated by the reference character 55-55 and comprising two opposed liner-members 55-55 corresponding to each other and each having a wall-portion 57 which tapers downwardly and inwardly relative to the axis of the heat-transmitting liner as a whole and conforming to the adjacent one of the wall-surfaces 53 in the inner casing-member 47.

The exterior surfaces 58-58 of each of the liner-members 56 lying adjacent its respective opposite longitudinal edges are in substantial parallelism and conform to the wall-surfaces 54-54 of the inner casing-member 47.

It is to be understood that the exterior surface of each of the liner-members 56 throughout their entire perimeter and length conform to the interior surfaces of the passage 52 in the inner casing-member 47 so as to be in intimate heat-conducting contact therewith throughout as large a surface-area as possible.

It will be noted from the accompanying drawings that the cross-sectional form of the liner-members 56-56 are of coneco-convex form and are thicker at their upper ends than they are at their lower ends save at their longitudinal edges where the thickness diminishes so that the wall-thickness along the said longitudinal edges is substantially the same throughout. The interior surface of each of the said liner-members 56 is of semi-circular form in cross-section and is designed to snugly fit the exterior surface of the cast rod 37 though if desired the radius of curvature at the bottoms of the said surfaces 55 may be slightly less than the radius of curvature of the upper end of the said surfaces so as to compensate for the lesser diameter of the rod 37 at its point of emergence from the liner 55 as compared to its diameter at its point of entrance into the said liner, owing to the shrinkage of the said rod due to its lower temperature at its point of emergence.

As the cast rod 37 is drawn downwardly by the withdrawing-rolls 37-37 it will, owing to its frictional engagement with the inner surfaces 55 of the heat-transmitting liner 55, tend to draw the said liner downwardly. This downward draft upon the liner as just referred to will in turn tend to more intimately engage its outer surfaces with the interior surfaces of the passage 52 in the inner casing-member 47 and also tend to move the inner surfaces 59 of the said liner-members into more intimate contact with the external surfaces of the rod 37. This action being due to the tapered character of the passage 52 and the caused surfaces of the liner-members 56.

As wear takes place, the heat-transmitting liner 55 may ultimately shift downwardly from the position in which it is shown in Fig. 1 into the position in which it is shown in Fig. 2, during all of which time, however, it will have maintained intimate thermal contact with both the rod 37 and the wall-surfaces of the passage 52 of the secondary cooling-chamber 39. It will be noted by comparing Figs. 1 and 4 respectively with Figs. 2 and 5 that as the wear above referred to takes place, the longitudinal edges of the liner-members 56 will approach more closely to the similar edges of the complementary liner-member. This approach of the longitudinal edges of the liner members will, of course, be gradual throughout the entire longitudinal movement thereof and in
effect constitutes a gradual contraction of the heat-transmitting liner viewed as a whole. Various materials may be employed for use in the heat-transmitting liner 55 as well as in other heat-transmitting liners to be later described, though graphite is preferred to employ a very fine-grained graphite since such material will withstand very high temperatures and will provide a minimum of frictional coefficient between its interior surfaces and the exterior surface of the rod 37 or other rod-like objects being cast.

In Fig. 9 is shown another form which a laterally-contraction heat-transmitting liner may assume in accordance with the present invention. The heat-transmitting liner of Fig. 9 is generally designated by the reference character 66 and includes two corresponding opposed liner-members 61—61 together providing a figure in cross-section which is substantially rectangular. Each liner-member 61 is provided with two opposite flat walls 62—62 which are parallel with each other and with a third external wall 63 extending between the two said walls 62 and tapering downwardly and inwardly toward the axis 25 of the heat-transmitting liner 60 considered as a whole. Each of the opposed liner-members 61—61 above referred to is formed in its interior with a longitudinal groove 64 which is of substantially semicircular form in cross-section to snugly fit the exterior surface of a cast rod such as 37 before described. The liner-members 61 may be considered as being of plano-concave form in cross-section in contradistinction to the liner-members 56 before described which are of concavo-convex form in cross-section.

It will, of course, be understood that the heat-transmitting liner 60 of Fig. 9 will be fitted within a correspondingly-shaped passage in a suitable cooling-chamber such as 39 before described.

In Figs. 10 to 13 inclusive is shown still another form of heat-transmitting liner which is generally designated by the reference character 68 and which has its exterior surface of conical form and which is of ring-shaped form in cross-section. The said heat-transmitting liner 65, instead of being parted into physically-distinct members or elements to permit lateral contraction, is formed with two series of longitudinal slots 66 and 67 which are parallel to each other and maintain the surfaces of the cylindrically-contoured longitudinal passage 68 extending therethrough in snug engagement with the exterior surface of a cast rod such for instance as 37 before described. The series of longitudinal slots 66 intersect the upper end of the heat-transmitting liner 65 and extend in close proximity to the lower end thereof. On the other hand, the longitudinal slots 67 which are located intermediate the slots 66 above described intersect the lower edge of the heat-transmitting liner 65 and extend into close proximity to the upper edge thereof, which edges however, the said slots 66 do not intersect. In this way, the heat-transmitting liner 65 is constructed to comprise a plurality of laterally-contractionable members 68 extending longitudinally between the slots 66 and 67.

The heat-transmitting liner 65 just above described will, like the other form of liners described, transversely contract as wear takes place in its passage 68 to maintain intimate thermal contact with a rod being cast and also with the surface of a conically-contoured passage in a suitable cooling-chamber of the general character of the passage 52 before described.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalence range of the appended claims are intended to be embraced therein.

We claim:

1. A laterally-contraction heat-transmitting liner for use in the cooling-chambers of continuous casting apparatus, comprising a plurality of liner-members exteriorly-divided laterally-contractionable longitudinal passage in the said cooling-chambers and shaped interiorly to form a laterally-contractionable longitudinal passage between them of substantially-uniform cross-sectional form throughout their length for the reception of rod-like cast-metal, the said liner-members being constructed to be arranged in contractible-engagement with the walls of said tapered passages with laterally-spaced longitudinal edge-portions providing longitudinal clearance-gaps therebetween to permit the traverse contraction of the said liner-members during the endwise movement of the heat-transmitting liner toward the contracted end of the said tapered passages.

2. Cooling-means for continuous casting apparatus having a molten metal container from which molten metal emerges in hot solidified rod-like form, comprising: a cooling-chamber having a compartment for the flow of a coolant therethrough and also having a tapered passage for the reception of a heat-transmitting liner; and a longitudinally-contractionable heat-transmitting liner composed of a plurality of independently-movable liner-elements located in the tapered passage in the said cooling-chamber and exteriorly tapered to snugly fit the tapered surface of the said tapered passage, the said liner-elements of the heat-transmitting liner being spaced from each other to provide a passage between them for the reception of the rod-like metal from the said container and the said liner-elements being movable longitudinally to the smaller portion of the tapered passage in the said cooling-chamber and movable laterally toward each other as such longitudinal movement takes place to maintain contact with the surface of the rod-like metal.

3. Cooling-means for continuous casting apparatus having a molten metal container from which molten metal emerges in hot solidified rod-like form, comprising: a cooling-chamber having a compartment for the flow of a coolant therethrough and also having a tapered passage having a greater diametrical extent in one direction as compared to its diametrical dimension at a right angle to the said diametrical dimension, said tapered passage being adapted to receive a heat-transmitting liner; and a heat-transmitting liner comprising two opposed members of U-shaped form in cross-section and providing between them a passage for snugly receiving the rod-like cast metal coming from the said container, the said opposed members of the heat-transmitting liner snugly fitting the tapered passage in the said cooling-chamber and being movable longitudinally toward the contracted portion of the said tapered passage and laterally movable toward each other as such longitudinal movement.
ment takes place to maintain contact with the surface of the rod-like metal.

4. Cooling-means for continuous casting apparatus having a molten metal container from which molten metal emerges in hot solidified rod-like form, comprising a cooling-chamber having a compartment for the flow of a coolant therethrough and also having a passage for the reception of a heat-transmitting liner, the said passage having two opposite wall-portions which are longitudinally tapered toward each other and two other wall-portions which are substantially parallel; and a heat-transmitting liner comprising two opposed members providing between them a passage for snugly receiving the rod-like cast metal coming from the said container and each of the said members having oppositely-located wall-portions which are substantially parallel and also having a third wall-portion which is tapered to conform to the taper of one of the tapered wall-portions of the passage in the said cooling-chamber, the heat-transmitting members of the said heat-transmitting liner being movable longitudinally toward the contracted portion of the tapered passage in the said cooling-chamber and laterally movable toward each other as such longitudinal movement takes place to maintain contact with the surface of the rod-like metal.

5. A laterally-contractable heat-transmitting liner for use in the cooling-chambers of continuous casting apparatus, having an exteriorly-tapered surface designed to snugly fit the tapered surface of a cooling-chamber, and having an interior passage of substantially-uniform cross-sectional form throughout its length for the reception of rod-like cast metal, the said heat-transmitting liner also being formed with a plurality of independently movable liner-elements shaped interiorly to form a laterally-contractable longitudinal passage between them of substantially-uniform cross-sectional form throughout its length for the reception of rod-like cast metal, the said heat-transmitting liner having opposed exterior surfaces tapering toward each other, and also having opposed exterior surfaces at a right angle to the said tapered surfaces and extending substantially parallel with each other.

6. A laterally-contractable heat-transmitting liner for use in the cooling-chambers of continuous casting apparatus, comprising a pair of independently movable liner-elements, each of U-shaped form in cross-section and arranged to provide an interior passage of substantially-uniform cross-sectional form throughout their length for the reception of rod-like cast metal, each of the said liner-elements having longitudinal edge-portions on the opposite sides of the passage therethrough, which edge-portions are in substantial parallelism, the longitudinal exterior surface of the liner-elements intermediate the aforesaid edges being tapered.

7. A laterally-contractable heat-transmitting liner for use in the cooling-chambers of continuous casting apparatus, having an exteriorly-tapered surface designed to snugly fit the tapered surface of a cooling-chamber and having an interior passage of substantially-uniform cross-sectional form throughout its length for the reception of rod-like cast metal, the said heat-transmitting liner also being formed with two sets of longitudinal slots intersecting the lower end of the liner and extending into a position adjacent but not intersecting the upper end of the liner.

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