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(54) AN APPARATUS FOR THE CONTINUOUS CASTING OF METAL BARS, PIPES AND SHEETS.

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Description

The present invention relates to an apparatus for the continuous casting of metal bars, pipes and sheets, comprising a chill mold for receiving the molten metal, a cooling member fitted around the rear part of the chill mold as seen in the withdrawing direction, a refractory lining protecting at least the cooling member, and members for the continuous withdrawing of the bar, pipe or sheet which has solidified in the chill mold from the chill mold.

From DE—C—876573 as the nearest prior art document it is known to make use of a coolant which is in contact with the chill mold. This coolant may be zinc, it is not completely in a molten state during casting, but is maintained in a molten state near the chill mold and in a solid state opposite the chill mold. The heat-flow is therefore not uniform as the coolant is in different states which have different coefficients of heat-conductivity.

The object of the present invention is to promote the transfer of the heat from the material being cast and thereby to increase the casting rate and obtain a more advantageous crystal structure in the casting, at least when copper or copper alloys are being cast.

Previously known there are devices for the continuous casting of metal bars, pipes or sheets, having a chill mold made of a refractory material for receiving the molten metal, and around the chill mold there has been fitted a cooler with water or molten metal flowing in its ducts. The chill mold may be made of graphite, and during casting the heat transferred from the solidifying molten metal and the solidified metal is directed further to a cooling medium circulating in the cooler. It is very important that this transfer of heat is effective, for it decides the rate at which the continuous casting can be carried out.

A metal bar, pipe or sheet contracts when solidifying and cooling, and thereby a gap forms between the piece being cast and the chill mold; the gap is known to complicate the transfer of heat from the piece being cast to the chill mold. This gap cannot be completely eliminated because, if it is, then there is the risk that the casting adheres to the chill mold if the mold converges in the withdrawing direction. Owing to the low heat conductivity of air and gases, even a very narrow gap caused by contraction constitutes a considerable obstacle to the transfer of heat. Therefore, among experts the idea has prevailed that this gap due to contraction between the chill mold and the casting is the reason why the transfer of heat in the existing casting apparatus is considerably less advantageous than it ought to be if only the transfer of heat in the chill mold, the transfer of heat in the cooling material and the heat transfer coefficient in the cooling ducts of the cooler are taken into account.

It has now been shown surprisingly that the above-mentioned general conception has been correct only in part. Measurements and calculations which have been performed have shown that in the casting apparatus used there appears considerable heat resistance also in the interface between the chill mold and the cooler. This heat resistance is particularly significant in the continuous casting of metal sheets. The probable reason for this is that, owing to the thermal expansion movements of the material, gaps form between the chill mold and the cooler, and it has been impossible to prevent the formation of such gaps even by means of bolt joints. Studies have now shown that if the reducing effect of these gaps on the transfer of heat could be eliminated, it would be possible to improve the efficiency of the casting apparatus substantially even if nothing were done with respect to the air gap between the casting and the chill mold.

The formation of gaps between the chill mold and the cooler could theoretically be eliminated by means of tight bolt joints or by a suitable design of the surfaces of these two members, but in practice this has not produced the desired results. For this reason, an attempt has now been made to find other solutions to this problem.

The object of the present invention is therefore to provide an apparatus for the continuous casting of metal bars, pipes or sheets, an apparatus in which the transfer of heat from the solidifying melt and the cooling metal piece is more effective than previously so that the casting rate can be increased and simultaneously a product with improved crystal structure can possibly be obtained.

This object is solved by the characteristics given in accompanying Claim 1.

In the apparatus according to the present invention, the gap or gaps between the chill mold and the cooler are filled with a medium having a high thermal conductivity, such as molten metal or molten salt, in which case this gap is advantageously connected to an outside expansion vessel. In practice it is easy to find usable materials with a high thermal conductivity in the professional literature of the field, so that listing such materials in this context has been considered unnecessary. It can, however, be mentioned that a metal melt containing at least 50% by weight of tin has proven to be one such thermally conductive material.

Filling a gas space between two solid surfaces with molten metal in order to improve the transfer of heat is in principle known *per se*. see for instance US—A—3874438 where a casting is immediately cooled by e.g. a metal melt. This procedure has even been proposed for use in casting apparatus in order to improve the transfer of heat between the chill mold and the casting during the continuous casting of metal bars, pipes and sheets. The procedure has not, however, produced the desired results but has involved obvious and very great practical difficulties in the form of, for example, leakages. For this reason this procedure has not gained any practical significance. During the development of the present invention it was surprising to observe that most of the thermal resistance appeared between the chill mold and the cooler and not mainly between the chill mold and the casting, as had been assumed previously.

Furthermore, it was surprising that the procedure which had previously been applied to the improvement of the transfer of heat between the chill mold and the casting had been found difficult to use for that purpose proved to be highly applicable to the improving of the transfer of heat between the chill mold and the cooler.

Thus, in the apparatus according to the present invention, a liquid with a high thermal conductivity, such as a molten metal, is used for filling the gap between the chill mold and the cooler. In this apparatus the heat-transferring medium does not come into contact with the metal being cast and, owing to the drop of temperature between the walls of the chill mold, the boiling point of the heat-transferring medium need not necessarily be higher than the solidification point of the metal being cast. Also, there is no fear of leakage problems in this case.

In order to achieve the advantages of the invention it is by no means necessary that the molten metal or salt is in a flowing motion, but it can just as well be completely stationary. The effectiveness of the heat-transferring medium is based on its thermal conductivity, which is far superior to that of gas, a decisive factor in this connection.

It is important that the heat-transferring material fills as completely as possible the gaps between the chill mold and the cooler so that no gas pockets appear in these spaces. Therefore, it is advantageous to connect the gap or gaps to an expansion vessel for the heat-transferring medium so that heat-transferring medium can flow into the gap or gaps between the chill mold and the cooler and back as the volume of the gaps varies according to the thermal expansion movement of the surrounding walls.

The invention is described below in greater detail with reference to the accompanying drawing, in which

Figures 1 and 2 depict cross sectional side elevations of two preferred embodiments of the invention.

In the drawing, the melt to be cast is indicated by reference numeral 1. The melt to be cast can be in a melt container the wall of which in general is indicated by 2 and to which a chill mold 4 made of graphite is attached to receive the melt. Outside the container wall 2 there is, fitted around the chill mold 4, a cooler 3, in which ducts for the cooling medium have been made in a known manner. The melt 1 flowing into the chill mold 4 yields heat to the walls of the chill mold 4 and forms, at a certain distance from the inlet of the chill mold 4, a solidification front, which is indicated by a dotted line in the drawing. The solidified metal is withdrawn in the form of a bar 7 from the chill mold 4 by means of withdrawal members 9. While solidifying and cooling, the metal contracts somewhat so that a gap 5 forms between the bar 7 and the chill mold 4. In addition there is between the chill mold 4 and the cooler 3, or there has been separately made, a gap 6, which in accordance with the invention is filled with a medium which transfers heat well. Thus the transfer of heat from the chill mold 4 to the cooler 3 is more effective than normally.

In the case represented by Figure 2, the gap 6 between the chill mold 4 and the cooler 3 is connected by means of a pipe 8 to an expansion vessel 10, which is partly filled with a medium which transfers heat well. The expansion vessel 10 is at a higher level than the gap 6, in which there thus prevails a metallostatic pressure when molten metal is used as the cooling medium. The metal in the expansion vessel can be maintained in a molten state by, for example, fitting a heating resistor around the vessel.

It is evident that the present invention can be applied to continuous casting in any direction. If the present invention is applied to an upward continuous casting and if the solidification front is formed above the surface of the melt, reference numeral 2 in Figure 1 indicates a refractory lining which prevents the melt from coming into direct contact with the cooler 3, which in this case must be lowered at least partly to a level below the melt surface.

Claims

1. An apparatus for the continuous casting of metal bars, pipes or sheets, comprising a chill mold (4) for receiving the molten metal (1), a cooling member (3) fitted around the rear part of the chill mold (4) as seen in the withdrawing direction, a refractory lining (2) which protects at least the cooling member (3), and members (9) for the continuous withdrawing of the bar (7), pipe or sheet which has solidified in the chill mold (4) from the chill mold (4), characterized by a highly thermally conductive medium which fills the gap (6) between the chill mold (4) and the cooling member (3), and which is in a molten state at least during the casting.

2. An apparatus according to Claim 1, characterized in that the gap (6) between the chill mold (4) and the cooling member (3) is connected (8) to an outside expansion vessel (10).

3. An apparatus according to claim 1 or claim 2, characterized in that the highly thermally conductive medium is a metal melt which contains at least 50% by weight of tin.

Revendications

1. Appareil pour le coulage continu de barres, tubes ou feuilles métalliques, comprenant une lingotière (4) pour recevoir la fonte métallique (1), un organe de refroidissement (3) attaché autour de la partie arrière de la lingotière (4), regardé dans la direction du tirage, une garniture intérieure réfractaire (2) protégeant au moins l'organe de refroidissement (3), et des dispositifs

(9) pour le tirage continu de la barre (7), du tube ou de la feuille solidifiés dans la lingotière (4) en dehors de cellui-ci, caractérisé par un milieu hautement thermoconducteur qui remplit l'espace (6) entre la lingotière (4) et l'organe de refroidissement (3) et qui se trouve à l'état fondu au moins au cours de coulage.

2. Appareil selon la revendication 1, caractérisé en ce que l'espace (6) entre la lingotière (4) et l'organe de refroidissement (3) est relié (8) à un vase extérieur d'expansion (10).

3. Appareil selon la revendication 1 ou 2, caractérisé en ce que le milieu hautement thermoconducteur est un métal fondu contenant au moins 50% en poids d'étain.

Patentansprüche

1. Vorrichtung zum kontinuierlichen Guss von metallischen Stangen, Rohren oder Blechen, mit einer Kühlkokille (4) zum Eingiessen der Metallschmelze (1), einer Kühleinrichtung (3), die den hinteren Bereich der Kühlkokille (4) umgibt, in Abzugsrichtung gesehen, eine feuerfeste Auskleidung (2), die mindestens die Kühleinrichtung (3) schützt, und Einrichtungen (9) für den kontinuierlichen Abzug der Stange (7), des Rohres oder des Bleches aus der Kühlkokille (4), worin sie sich verfestigt haben, gekennzeichnet durch ein stark wärmeleitendes Medium, das den Zwischenraum (6) zwischen der Kühlkokille (4) und der Kühleinrichtung (3) ausfüllt und sich zumindest während des Giessvorganges in flüssigem Zustand befindet.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, dass der Zwischenraum (6) zwischen der Kühlkokille (4) und der Kühleinrichtung (3) mit einem äusseren Ausdehnungsgefäss (10) verbunden ist (8).

3. Vorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass das stark wärmeleitende Medium ein Metall ist, das mindestens 50 Gew.-% Zinn enthält.

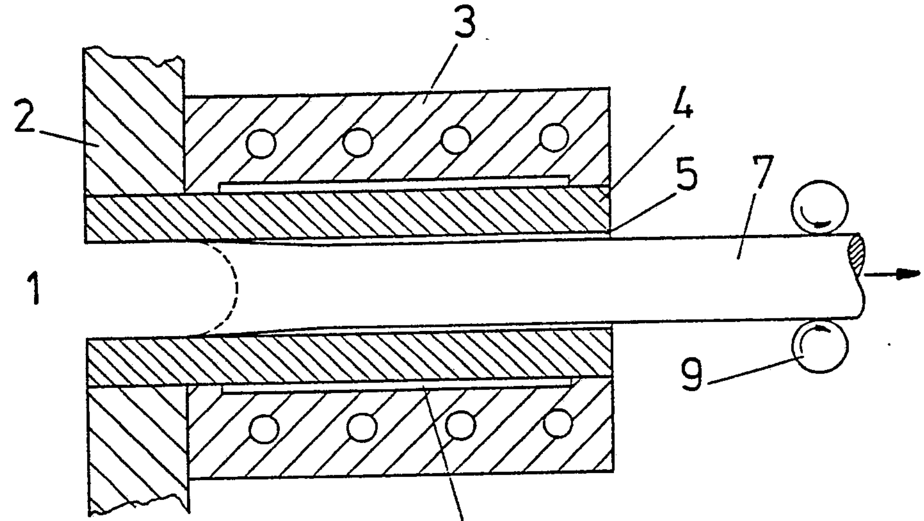

Fig. 1

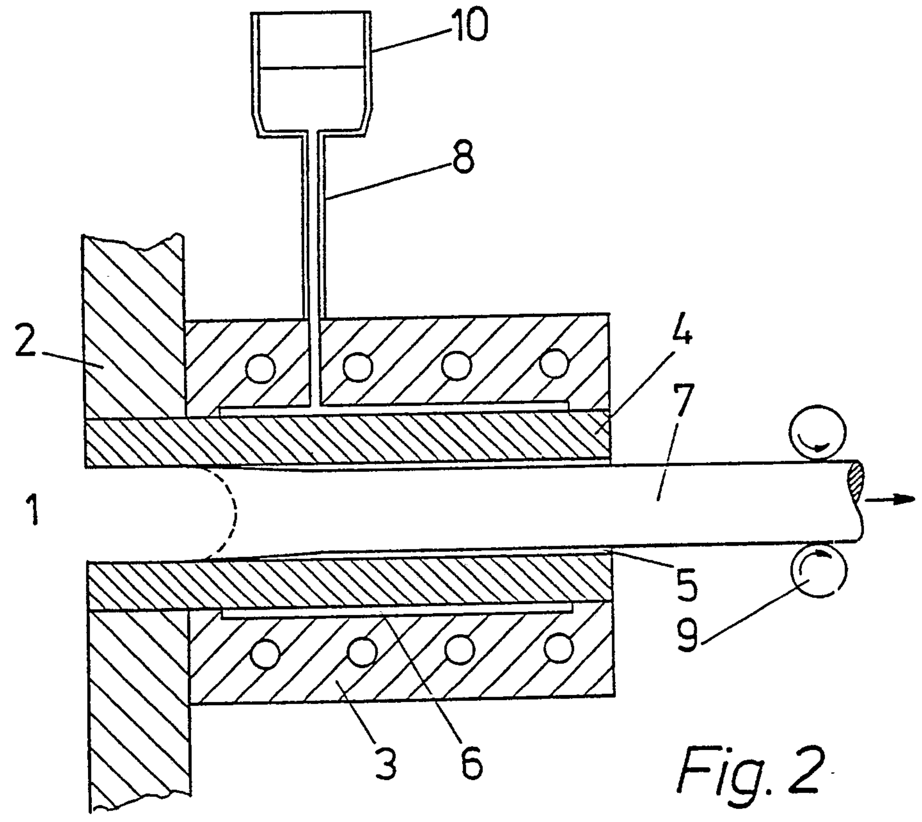

Fig. 2