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A. J. WERTLI
COOLING APPARATUS FOR DIFFERENTIALLY COOLING
A CONTINUOUS CASTING
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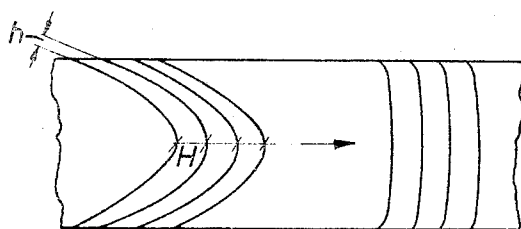


Fig. 1

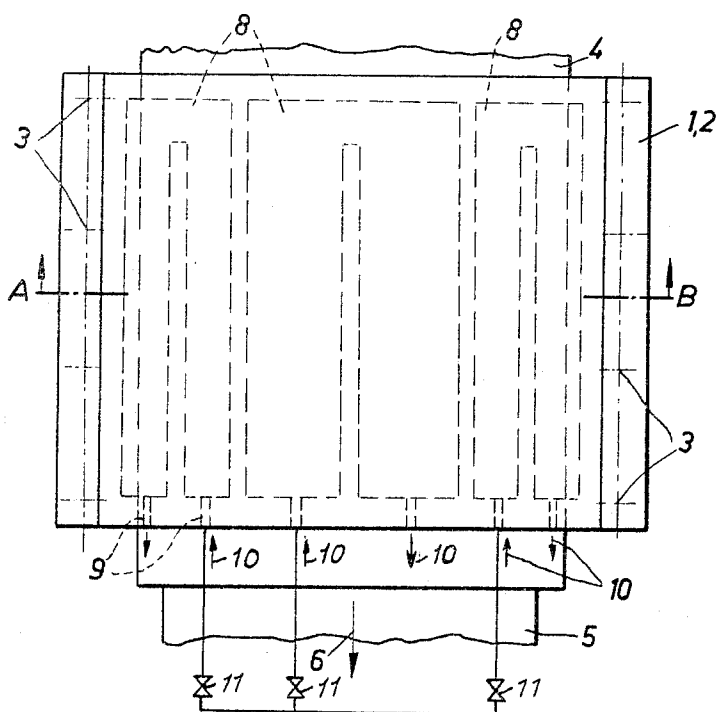


Fig. 2

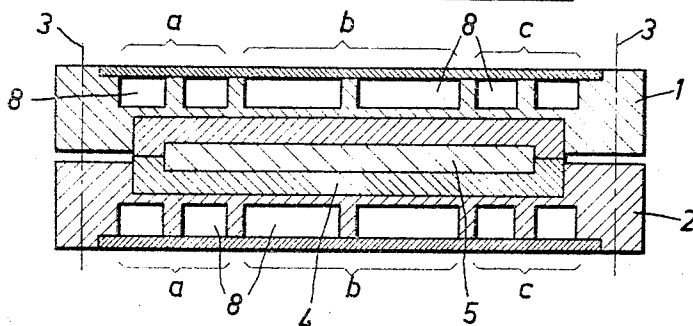


Fig. 3

Inventor:

Alfred J. Wertli

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Alfred J. Werli, Poststr 15, EH-8406 Winterthur, Switzerland

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ABSTRACT OF THE DISCLOSURE

The casting is continuously cooled in a differential manner by passing separate coolant streams through the cooling apparatus in order to obtain different rates of cooling in each coolant passage to effect a homogeneous structure in the casting, the cooling apparatus is formed with U-shaped coolant passages and the temperature or rate of flow of the coolant through each coolant passage is adjustably varied.

This invention relates to an apparatus and method for cooling a continuously cast strip. More particularly, this invention relates to an apparatus and method for cooling a continuously cast metal casting to a strip within the mold forming the same.

Heretofore, the melt of a metal or an alloy has been passed through molds which have been cooled by cooling devices surrounding the molds in order to solidify the melt into a rod. The cooling devices have generally been constructed in two pieces, one piece extending across the upper side of the mold and the other piece extending across the opposite lower side of the mold. Both pieces of the cooling devices have had cooling medium streams passed through chambers therein in a manner wherein each stream has cooled the entire width of the strip.

However, the strips which have been heretofore cooled have clearly shown parabolic lines in the upper and lower surfaces caused by the solidifying process, particularly when the strips have been advanced intermittently during the casting process. Upon examining the structure of these strips it has been found that a heterogeneous structure exists in front of and in the rear of each of these parabolic lines. Further, because the distances between the parabolic lines at the edge portions have been much smaller than the distances between the lines at the middle of the strip the structure of the edge portions has been heterogeneous throughout.

This heretofore structure is undesirable for subsequent treatments, particularly for cold-forming treatment, since cracks and fissures are likely to appear in the edge portions when the strips are cold-rolled.

Accordingly, it is an object of the invention to provide an apparatus and method of cooling a continuously cast strip to obtain a homogeneous structure over substantially the entire width of the casting.

It is another object of the invention to provide an apparatus and method for differentially cooling a continuously cast strip.

It is another object for this invention to provide an apparatus and method for cooling a continuously cast strip to obtain solidification lines on the surface of the strip substantially perpendicular to the direction of movement of the casting.

It is another object of this invention to provide an apparatus and method for cooling a continuously cast strip which can be subjected to cold working substantially without the occurrence of cracks in the edge portions of the casting.

Generally, this invention provides a cooling apparatus in combination with a mold of an apparatus for continuously casting a strip from the melt of a metallic substance which comprises a means surrounding the mold having a plurality of separate coolant passages therein for the passage of separate coolant streams therethrough to differentially cool different zones of the mold. The coolant passages are arranged longitudinally of the mold parallel to the direction of movement of the metal through the mold in respective cooling zones lying side by side for individually and independently cooling the respective zones.

The method of the invention comprises the step of passing a plurality of separate coolant streams across at least one part of the mold to differentially cool the cooling zones of the mold whereby the edge cooling zones are subjected to a lesser cooling effect than the middle zones. The several coolant streams are conducted through the respective zones either at rates of flow or at temperatures which are differentially adjusted relative to each other. Further, a different coolant may be used in each zone in order to differentiate the heat absorption by the coolant in the individual zones.

These and other objects and advantages of the invention will become more apparent from the following detailed description taken in conjunction with the appended drawings in which:

FIG. 1 illustrates a diagrammatic broken top section of a continuously cast rod; the left-hand portion showing a strip with parabolic lines as heretofore produced and the right-hand portion showing a strip with substantial straight lines as produced by the invention;

FIG. 2 is a diagrammatic top view of a cooling system according to the invention; and

FIG. 3 is a view taken on line A-B of FIG. 2.

Referring to the left-hand side of FIG. 1, the surface of a strip as heretofore produced has a plurality of parabolic solidification lines thereon wherein the distance H between the middle portions of the lines is much greater than the distance h between the end portions of the lines which are on the border of the strip surface. Such a casting has a structure which is heterogeneous substantially throughout the width of the strip.

Referring to the right-hand side of FIG. 1, the surface of a rod formed according to the invention as hereinafter described has a plurality of substantially straight lines normal to the direction of movement of the casting as indicated by the arrow. These substantially straight lines are much shorter than the parabolic lines produced by the heretofore methods as illustrated in the left-hand side of FIG. 1.

Referring to FIGS. 2 and 3, the cooling apparatus of the invention includes a top part 1 and a bottom part 2 which are interconnected, for example, by means of bolts whose locations are indicated by dash-dot lines 3. A mold 4 preferably of graphite, is also made of two parts clamped between the top and bottom parts 1, 2 of the cooling apparatus and surrounds a cavity whose cross section corresponds to the cross section of the cast strip 5. The mold 4 has a part projecting from the cooling apparatus, as shown at the top of FIG. 2 which is pressed against the wall of a furnace, not shown, containing the melt. When casting, the liquid metal flows into the cavity of the mold 4 wherein the metal gradually solidifies to form a strip 5 due to the action of the cooling apparatus. The strip 5 is moved either continuously or intermittently in the direction of the arrow 6.

The upper part 1 and the lower part 2 of the cooling apparatus are each divided into three zones a , b and c , the zones a and c being placed above and below the edge portions of the strip and the zone b being located above and below the middle of the strip. Each zone comprises

a U-shaped cooling chamber 8 extending in the longitudinal direction of the strip, the legs of the U extending from the base of the U in the direction of movement of the strip through the mold. The cooling chambers 8 are provided with apertures 9 at the ends of the legs of the U for admitting coolant to the chamber and releasing the coolant from the chamber as shown by arrows 10. In addition, suitable conventional means such as hand operated valves 11 which are disposed in flow lines are provided for adjusting the rate of flow of the coolants through the chambers 8. In this way the cooling effect throughout the width of the strip 5 can be varied and controlled as desired.

Whereas the heretofore used methods have not provided division of the cooling effect, with the method according to the invention the individual cooling streams can be so adjusted that less cooling is effected in the zones *a* and *c* than in the zone *b*, for example, by reducing the rate of flow of coolant through the zones *a* and *c* relative to the rate of flow of coolant through the zone *b*. This causes a more uniform heat release across the width of the strip resulting in a more uniform structure of the strip material. Strips made by the method according to the invention and with the described cooling system do not show parabolic solidification lines but substantially straight lines extending perpendicular to the direction of movement of the strip in the casting apparatus, as shown in the right side of FIG. 1. Further, castings made according to the invention have good metallurgical qualities, particularly for cold-working.

Instead of differentially adjusting the rate of flow of coolant through the individual zones, the different cooling effects may be obtained in another manner, for example, by differentially adjusting the temperature of the coolant entering the different zones *a*, *b*, *c*.

It is also possible to supply the border zones with a coolant that has cooling properties different from those of the coolant supplied to the middle zones. Coolants having different cooling properties are, for example, water and oil.

Any two of the described three methods of obtaining different cooling effects may be combined or all three described methods may be used at the same time.

When producing strips having a greater ratio of the sides than shown in FIG. 3, the central portion of the upper and of the lower part of the cooling apparatus may be divided into two or more zones, each zone being provided with a separate coolant stream.

Further, without departing from the scope of the invention, a one-piece cooling apparatus which has a separate upper and lower portion may be used in lieu of the apparatus shown. In this case a separate cooling zone having its own coolant stream may be arranged at the side of each edge of the strip or the cooling zones placed above and below the edges of the strip may be connected to form a common cooling zone. It is also possible to replace the joint connecting the upper and the lower part of the cooling apparatus shown in FIG. 3 by a joint which extends at a right angle to the joint shown in FIG. 3 and to arrange cooling zones adjacent to the edges of the metal strip as described.

Instead of providing a single U shaped cavity 8 in each

zone, several such cavities may be arranged in each zone.

It has been found that by cooling the edge portions of the strip differently from the cooling of the middle of the strip, solidification of the melt is more uniform and the structure of the casting is more homogeneous thereby resulting in strips of good metallurgical quality. The strips show substantially straight lines normal to the direction of movement of the strips which lines are much shorter than the parabolic lines characterizing strips made in the heretofore known manner. Further, the method according to the invention can be used when making strips the width of which is six times its thickness thereby considerably broadening strip manufacturing possibilities. For example, the method can be utilized to produce strips the long side of whose rectangular cross section is up to seventy times the short side.

Having thus described the invention it is not intended that it be so limited as changes may be readily made therein without departing from the scope of the invention. Accordingly, it is intended that the foregoing description and appended drawings be interpreted as illustrative only and not in a limiting sense.

What is claimed is:

1. In combination with a mold of an apparatus for continuously casting a strip from a melt of a metallic substance, a cooling apparatus comprising two parts, each of said parts being disposed on opposite sides of said mold in contact therewith, each of said parts having a plurality of U-shaped cooling chambers disposed longitudinally of said part and parallel to said mold and means connected to each of said cooling chambers for circulating separate flows of coolant through each of said cooling chambers to effect different rates of cooling across said mold.

2. The combination as set forth in claim 1 wherein said means includes means for adjusting the rate of flow of coolant through each of said cooling chambers to effect different rates of flow through said cooling chambers.

3. In the combination as set forth in claim 1 wherein a plurality of said passages are placed adjacent to a central zone of the mold, and others of said passages are placed adjacent the lateral zones of the mold.

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J. SPENCER OVERHOLSER, *Primary Examiner*.

R. S. ANNEAR, *Assistant Examiner*.