

[54]	APPARATUS FOR SUPPORTING AND GUIDING SLAB IN THE SECONDARY COOLING ZONE OF CONTINUOUS CASTING MACHINE	3,589,611	6/1971	Jones, Jr.	239/550
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[30] **Foreign Application Priority Data**

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 Nov. 12, 1973 Japan..... 48-126342

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[51] **Int. Cl.²** **B05B 1/14**

[58] **Field of Search** 239/550, 568; 198/35

[56] **References Cited**

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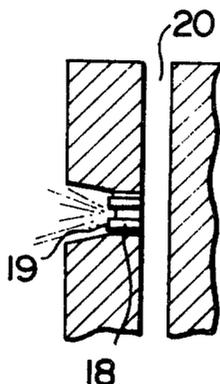
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Primary Examiner—Lolyd L. King

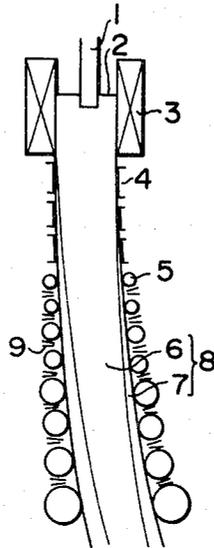
[57] **ABSTRACT**

An apparatus for supporting and guiding the slab in the secondary cooling zone of a continuous casting machine. In at least part of the secondary cooling zone of a continuous casting machine, one or more pairs of stationary roller support structures each having a surface spaced a constant distance from a corresponding surface of the slab and carrying a plurality of rollers having the same diameter as the afore-said distance and adapted to roll over the peripheral surface of the support structure with the descent of the slab are provided to support and guide the slab. The rollers extend at right angles to the direction of withdrawal of the slab and adapted to proceed in a direction parallel to the corresponding surface of the slab. Each roller support structure is constituted by a plurality of guide bars spaced from one another and defining a space, in which a liquid steel stirring means is accommodated.

3 Claims, 18 Drawing Figures



F I G. 1



F I G. 2

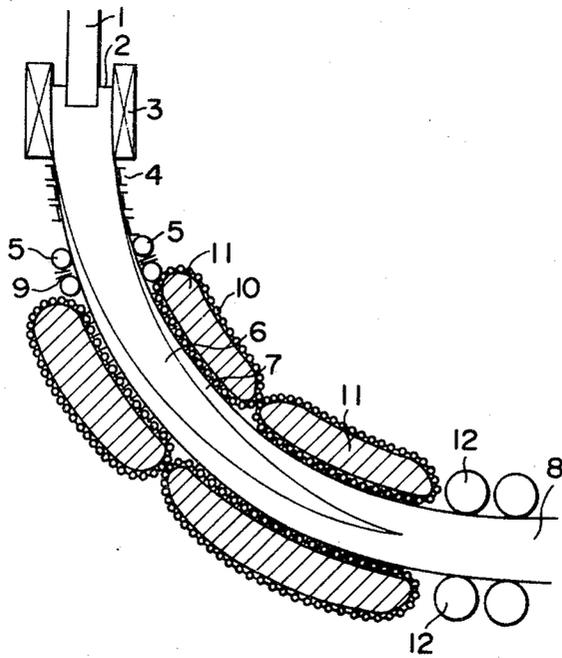


FIG. 3A

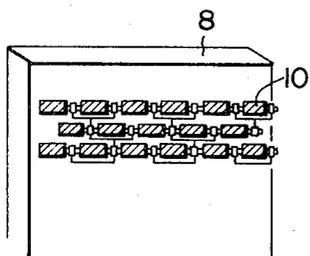


FIG. 3B

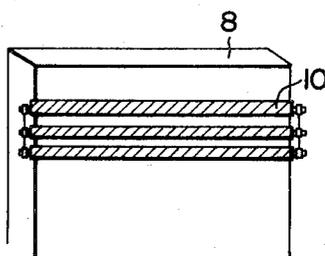


FIG. 3C

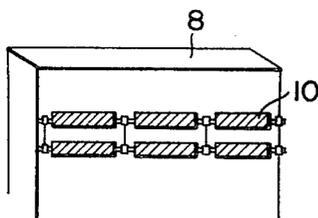


FIG. 3D

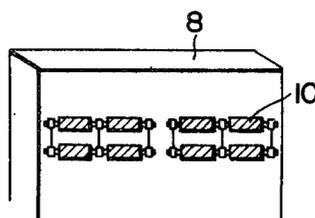


FIG. 4A

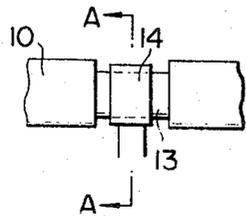


FIG. 4B

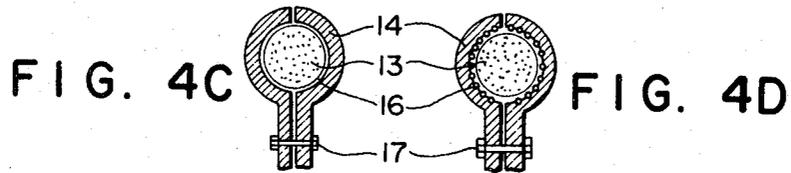
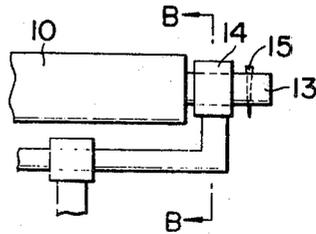


FIG. 5A

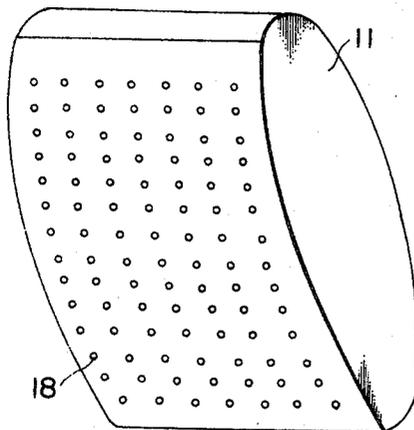


FIG. 5B

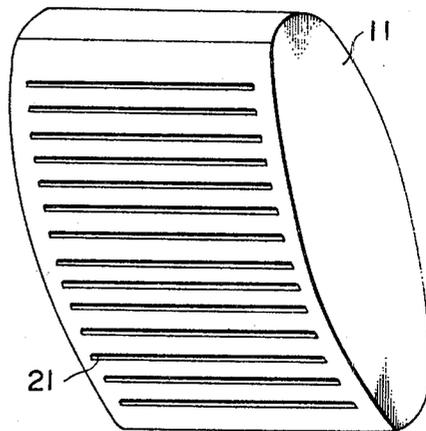


FIG. 5C

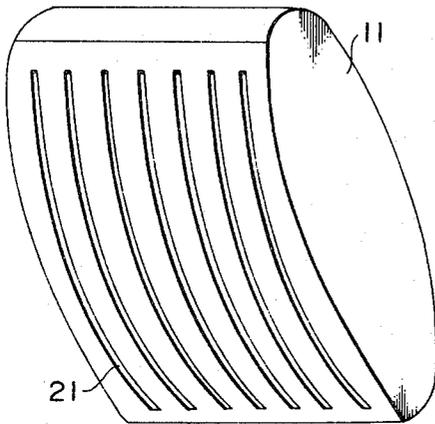


FIG. 5D

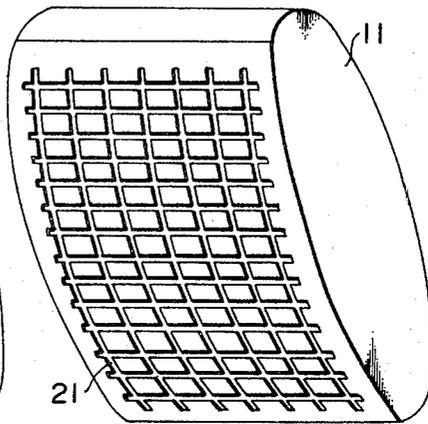


FIG. 6A

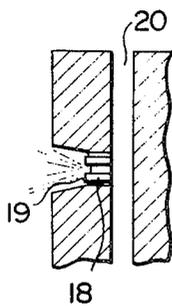
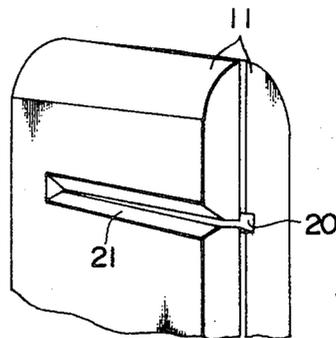
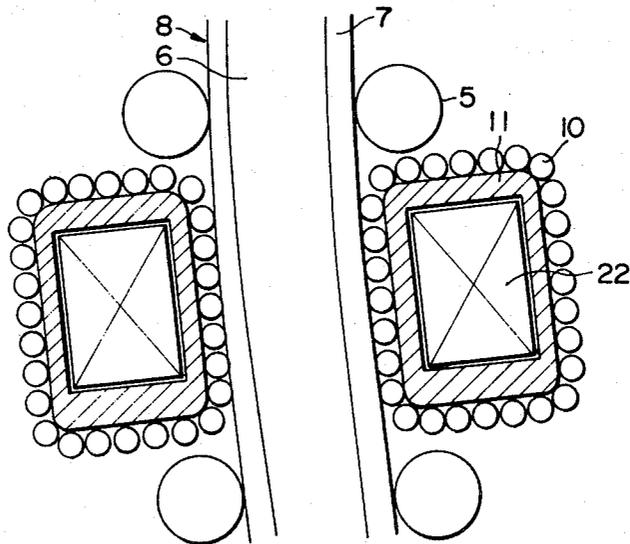


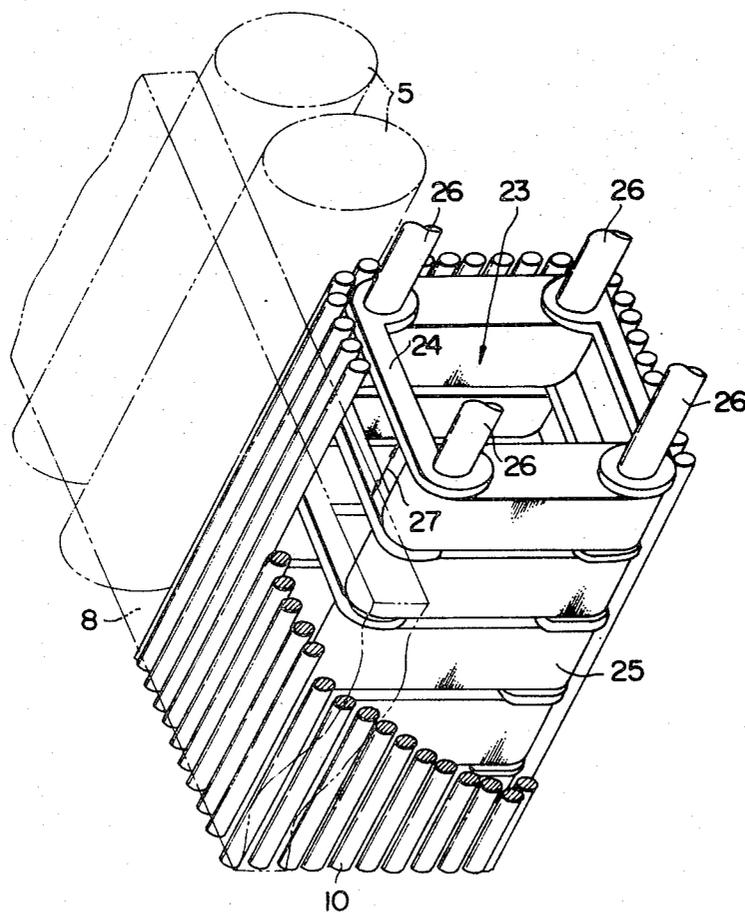
FIG. 6B



F I G. 7



F I G. 8



APPARATUS FOR SUPPORTING AND GUIDING SLAB IN THE SECONDARY COOLING ZONE OF CONTINUOUS CASTING MACHINE

This invention relates to means for supporting and guiding continuously cast slab in the secondary cooling zone of a continuous casting machine and, more particularly, to such support and guide means which is provided with a liquid steel stirring means for improving the macroscopic and microscopic irregularities in the slab.

The continuous casting is usually carried out in the manner as shown in FIG. 1. The liquid steel cast into a mold 3 forms a solidified shell 7 about several millimeters to 20 millimeters in thickness within the mold, and is withdrawn by pinch rollers while accelerating the solidification in the secondary cooling zone by spraying water 9 ejected from the holes formed in cooling plates 4, openings formed in cooling grids and the gaps between rollers 5. In the continuous casting of steel, the thermal conductivity of which is low, the solidification of the slab requires a long time, depending upon the thickness of the slab, and usually a long secondary cooling zone is required. Therefore, the conventional continuous casting equipment has a large height, so that a non-solidified portion subject to high static pressure of the liquid steel may be presented. In consequence, the deformation or so-called bulging of the shell is likely to result unless the machine adjustment such as the adjustment of the roller gap is sufficient. Accordingly, the continuous casting equipment has undergone a design change from vertical type to S-type for reducing the static pressure. However, this measure does not basically solve the above problem. In the figure, reference numeral 1 designates a submerged nozzle, numeral 2 powder, and numeral 6 non-solidified steel.

In addition, since the roller diameter has to be progressively increased according to the height from the meniscus, i.e., the static pressure of liquid steel, at a position where the static liquid steel pressure is high the distance between adjacent support points is large. Thus, as the slab passes through a succession of roller gaps it is locally subjected to repeated bulging and compression, so that its character would be extremely deteriorated due to such defects as concentration of certain components of the liquid steel at the position of final solidification and inner cracks.

The bulging δ_{max} is related to the static pressure of the liquid steel and the roller gap as

$$\delta_{max} = (60/384) \cdot (Pl^4/Ed^3)$$

where E is Young's modulus, d thickness of solidified steel, P static pressure, and l interroller distance. It will be seen from the equation that bulging is greater the greater the static pressure of the liquid steel and interroller distance. This phenomenon of bulging cannot be avoided in the roller apron system shown in FIG. 1 irrespective of the machine adjustment. It may be thought to substitute a cooling plate, cooling grid system or a walking beam system for the roller apron in the secondary cooling zone of FIG. 1. However, in case of the former substitute the drawing of the slab is considerably hard due to very great friction with the cooling plates or cooling grids, giving rise to various troubles in the operation and various defects in the slab. The latter substitute has too complicated mechanism to make suf-

ficient maintenance, and in this case worse results are prone compared to the roller spron system.

In the mean time, the continuously cast slab produced with the set-up shown in FIG. 1 is subjected to forced cooling from its surface, so that the inner structure of the product differs from that of the ordinary ingots due to a greater cooling speed compared to the case of the ordinary ingots. Also, the type of steel or casting conditions may frequently produce the defects inherent in the continuously cast slab, such as inner cracks, mocoporosity and sharp segregation of molt components in a region of final solidification. These defects have adverse effects upon the quality of the final products, and various measures have been investigated. It is already known that the above effects can be reduced or eliminated by adequately stirring the non-solidified steel in the secondary cooling zone.

The methods of causing a stirring phenomenon in the liquid steel through the outer shell or metal vessel include one, in which the stirring forces are provided electrically, that is, by means of electromagnetic induction, and one, in which current is directly passed in the liquid steel while simultaneously applying a magnetic field thereto. Some of these methods are now in practical use. In any of these methods, the magnetic flux produced by a stirring means has to penetrate into inner parts of the liquid steel, and it is advantageous to make the distance between the stirring means and shell as small as possible and avoid as much as possible any intervening object obstructing the penetration of the flux. If it is intended to assemble a stirring means into the presently available continuous casting equipment without substantially modifying the construction thereof, various difficulties are encountered because an increased magnetic force generating capacity is required for the stirring means. In addition, in the case of assembling the stirring means into the continuous casting apparatus, rollers at positions where the stirring means is intended to be mounted have to be removed. In this case, some or other slab supporting means replacing the rollers is required since in the secondary cooling zone of the continuous casting non-solidified steel is still present within the outer solidified shell, with the shell subject to bulging due to the static pressure of the liquid steel.

A first object of the present invention is to provide means for supporting and guiding a slab in the secondary cooling zone, which permits to overcome the aforementioned drawbacks inherent in the prior art, and also which comprises a stationary roller support structure having a surface extending parallel to and spaced a constant distance from a corresponding surface of the slab and a plurality of rollers rolling over an endless surface of said roller support structure with the descent of the slab and adapted to process along the gap between said roller support structure and slab, each said roller having a diameter equal to relevant dimension of said gap.

A second object of the invention is to provide a device for supporting and guiding a slab in a continuous casting machine, which device comprises a liquid steel stirring means as well as a roller support and rollers.

In the drawing:

FIG. 1 is a pictorial sectional view of a prior-art continuous casting machine;

FIG. 2 is a pictorial sectional view of a continuous casting machine embodying the invention;

FIGS. 2A to 3D show examples of the bulging prevention roller mechanism according to the invention;

FIGS. 4A and 4B are fragmentary side views showing bearing portions of the bulging prevention roller mechanism;

FIGS. 4C and 4D are sectional views respectively taken along line A—A in FIG. 4A and line B—B in FIG. 4B;

FIGS. 5A to 5D are perspective views showing examples of the roller support structure according to the invention;

FIGS. 6A and 6B show, respectively in sectional view and side view, a cooling water spraying mechanism in the roller support structure;

FIG. 7 is a pictorial sectional view of another embodiment of the apparatus for supporting and guiding a slab incorporating a liquid steel stirring means; and

FIG. 8 is a perspective representation of the construction of the supporting and guiding apparatus shown in FIG. 7.

The invention will now be described in conjunction with some embodiments thereof.

FIG. 2 shows an embodiment of the apparatus for supporting and guiding a slab according to the invention. Liquid steel is poured through a submerged nozzle 1 provided in a tundish into a mold 3, and as the solidification of the steel proceeds the resultant slab 6 is with continuously drawn by pinch rollers 12. The slab here is supported and guided in its progress through the secondary cooling zone by one or more pairs of stationary roller support structures 11 each having a surface extending parallel to and spaced a constant distance from a corresponding surface of the slab and carrying a plurality of rollers 10 extending at right angles to the direction of slab withdrawal and rolling over its endless surface. The rollers 10 have the same diameter as the gap between the slab and their support 11 and roll along that gap, thereby supporting and guiding the slab. Since the slab is supported by the roller support structures 11 via the rollers 10, it is possible to reduce the roller diameter. Also, since there is no need of increasing the roller diameter for increasing static pressure of the liquid steel, it is possible to reduce the distance between adjacent support points. Thus, the phenomenon of repeated bulging and compression that results in the case of the roller apron system can be eliminated.

Further, since the rollers are displaced in the direction of the slab withdrawal as they roll along the gap between the slab and roller support with the withdrawal of the slab, friction between roller and slab and between roller and roller support, and hence wear, is reduced. In the embodiment of FIG. 2, the rollers belonging to each roller support are rotatably tied in the form of an endless row or band and are automatically fed back from the outlet on the side of the pinch rollers to the inlet on the side of the mold. As is shown, the apparatus for supporting and guiding a slab in the secondary cooling zone according to the invention consists of a plurality of support sections. However, it may consist of a single support section as well. Also, while the above embodiment of the supporting and guiding means is provided over only part of the secondary cooling zone, it may be provided along the entire secondary cooling zone as well.

The arrangement of the rollers 10 for the prevention of bulging will now be discussed. Some arrangements of the examples are shown in FIGS. 3A to 3D and 4A to 4D. In the arrangement of FIG. 3B, rollers 10 each hav-

ing a length greater than the width of the slab are arranged in a row. In the examples of FIGS. 3A, 3C and 3D, a plurality short rollers 10 are arranged end to end, and end-to-end arrangements of rollers are arranged in a row or rows with adjacent end-to-end roller arrangements flush with or staggered from each other. These rollers may have their shafts 13 mounted in bearings 14 which are tied to one another, as shown in FIGS. 4A and 4B. The bearing may be a metallic bearing as shown in FIG. 4C, or it may be a ball bearing with balls 16 as shown in FIG. 4D. The diameter of the roller 10 may range from 10 to 150 millimeters.

The construction of the roller support 11 will now be discussed in connection with examples shown in FIGS. 5A to 5D, 6A and 6B. It is an important point of cooling by spraying water to obtain uniform cooling lest thermal stress should result due to the thermal cycle of sudden cooling. This may be achieved by arranging such that the slab surface other than the portions in contact with the bulging prevention rollers is uniformly subjected to the spray. In the example of FIG. 5A, a number of spray nozzles 18 are provided on the roller support 11, whereby spray water can be issued from gaps between adjacent bulging prevention rollers 10. Each spray nozzle 18 here is screwed into a hole formed in the wall of the roller support 11. It is to be noted that the tip 19 of the nozzle is disposed on the inner side of the roller support surface (as shown in FIG. 6A). FIG. 6B shows an alternative way of supplying the spray water. Here, the roller support consists of two halves, one of which is formed with a cooling water supply groove 20 for supplying the cooling water to be sprayed. In the examples of FIGS. 3B to 5D, number of vertical slits or horizontal slits or both vertical and horizontal slits 21 for issuing the spray water are formed in the roller support 11.

FIGS. 7 and 8 show, respectively in pictorial sectional view and fragmentary perspective view, another embodiment of the apparatus for supporting and guiding a slab in the secondary cooling zone of a continuous casting machine according to the invention. In this embodiment, a liquid steel stirring means is incorporated.

Similar to the previous embodiment, the apparatus of this embodiment, as outlined in FIG. 7, comprises a pair of roller support structures 11 each carrying a plurality of rollers 10 having a length greater than the width of the slab, the rollers 10 being rotatably tied to one another and extending at right angles to the direction of withdrawal of the slab. In this embodiment, each roller support 11 is provided with a built-in liquid steel stirring means 22. FIG. 8 shows the construction of the roller support 11 in detail. As is shown, it has an inner space 23 for accommodating the liquid steel stirring means. The space 23 is defined by a plurality of guide bars 24 extending parallel to the direction of the slab withdrawal and guide bar supports 25 extending at right angles to the slab withdrawal direction. The vertical guide bars and guide bar supports are assembled together with roller support keep bars 26 to form the frame of the roller support. The guide bars 24 may extend parallel to the direction of the slab withdrawal. The slits 27 formed between adjacent guide bars 24 and hence extending parallel to the direction of the slab withdrawal, allow ready penetration of the magnetic flux produced in the liquid steel stirring means that is disposed within the roller support frame.

Similar to the previous embodiment, the rollers 10 supporting the surface of the slab extend in a direction

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at right angles to the direction of the slab withdrawal and rotatably tied to one another to form an endless row or band surrounding the periphery of the roller support 11. Thus, with the movement of the slab the rollers 10 roll over the guide bars 24 due to frictions between them and slab 8 and also between them and guide bars 24, thereby supporting the surface of the slab so as to prevent the bulging. It will be appreciated that with the apparatus according to the invention the frictional resistance offered to the slab is substantially the same as in the case of the prior-art roller arrangements. With the movement of the slab the rollers 10 roll in the direction of the slab withdrawal at a speed one half that of the slab. Since the rollers are tied into the form of an endless row so that they roll over the periphery of the roller support, they can be cyclically supplied to the gap between the slab and the roller support frame constituted by the guide bars at a constant interval.

As has been described, the cooling water can be uniformly sprayed over the slab surface other than the portions in contact with the bulging prevention rollers 10, and it is possible to substantially eliminate thermal stress in the slab surface due to sudden cooling to obtain uniform cooling.

Also, the roller support 11, which has a surface extending along the direction of the slab withdrawal, may be a block-like structure or a welded structure, or it may be a rectangular frame constituted by guide bars 24, guide bar supports 25 and roller support keep bars 26 as shown in FIG. 8. Thus, according to the invention the construction cost can be reduced compared to the conventional roller apron system.

Further, according to the invention one or more pairs of roller support structures each constituted by guide bars defining slit-like spaces and an inner space capable of accommodating a liquid steel stirring means, each said roller support structure carrying a roller arrange-

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ment consisting of a plurality of rollers tied to one another such that they can roll over an endless peripheral surface of the support structure, are disposed in part of the secondary cooling zone, preferably after the roller apron, of a continuous casting machine incorporating liquid steel stirring means for supporting, pinching and guiding the slab in the secondary cooling zone. Thus, not only it is possible to withdraw the slab in the same way as with the usual roller arrangement, but also the bulging of the slab can be almost perfectly prevented. Further, it is possible to smoothly stir the liquid steel and very readily install the liquid steel stirring means.

We claim:

1. An apparatus for supporting and guiding a slab in at least part of the secondary cooling zone of a continuous casting machine, which comprises at least one pair of stationary roller support structures each having a surface spaced a constant distance from a corresponding surface of the slab being withdrawn, and rollers carried by said roller support structure and adapted to roll over an endless surface of said roller support structure with the descent of the slab, said rollers being adapted to proceed along the gap between the associated roller support structure and the slab, each said roller having a diameter equal to the relevant dimension of said gap, each said roller support structure having a number of cooling water spraying means, a cooling water supply duct extending within it and branch ducts connecting said respective spraying means and said cooling water supply duct, each said spraying means having its tip disposed on the inner side of the working surface of said roller support structure.

2. The apparatus according to claim 1, wherein said cooling water spraying means are nozzles.

3. The apparatus according to claim 1, wherein said cooling water spraying means are slits.

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