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(54) **Vertical continuous casting method and casting apparatus.**

(57) Disclosed are a method and an apparatus for vertical continuous casting. In the vertical continuous casting wherein a strand formed in a water-cooled mold is drawn down vertically therefrom without being incurvated light reduction means is positioned just prior to the solidefication completing point of the strand and light reduction strong enough to compensate contraction caused by solidification is applied to the strand, then, formation of central cavities is prevented and central segregation is lessened. The light reduction pinch rolle are provided variably in position up and down along the strand.

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VERTICAL CONTINUOUS CASTING METHOD AND CASTING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to an improvement of a vertical continuous casting or casting technique of obtaining cast pieces through drawing a strand formed in a water-cooled mold downward without incurvating, and cutting the strand.

State of the Art

Nowadays, a continuous casting process holds an important position in a steel casting. However, a horizontal continuous casting process is something problematical in a technical aspect, and hence is only tried in part, and thus what is overwheling today is a curved and vertical continuous casting. The vertical continuous casting is rather disadvantageous to require a high structure for the equipment, entailing a high cost of equipment. Accordingly, employed prevailingly is the curved continuous casting wherein a strand is incurvated (a water-cooled mold being structured practically so as to provide the curved strand) to extend horizontally, thereby keeping a height of the casting equipment within a certain limit. The strand extending horizontally is rectified to be straight with pinch rolls and cut with a frame cutter into cast pieces.

However, such process comprising curved casting and horizontal rectification is not necessarily preferable for some special steel in respect of a quality protection. For example, the rectification operation often causes cracks on the strands of valve steel, high-speed steel and so forth. This kind of steel will have to be subjected to the vertical continuous casting wherein a strand is formed without curvature in the water-cooled mold, drawn straightly downward and cut to cast pieces.

In the vertical continuous casting, from applying a light reduction to a strand coming out of the water-cooled mold at a position immediately before an unsolidified portion disappears in the interior of the strand, a contraction due to solidification is compensated, and thus, formation of cavities at the center of the strand may be prevented, and center segregation is lessened as well. Thus, cast pieces of better quality can be obtained.

However, in the case of such steel for which the light reduction is effective, a multiple kind is produced relatively in a small quantity in most cases, thus not only a sectional size of the strand varies but also a pertinent drawing speed varies so often, therefore, an optimal position at which the light reduction is to be applied, namely, the point at which the unsolidified portion in th strand disappears may vary one from another.

SUMMARY OF THE INVENTION

The object of this invention is to provide a method and apparatus for vertical continuous casting wherein a light reduction is applied to a strand at an optimal position at all times in coping flexibly with casting conditions fluctuating frequently so that the cast pieces of superior quality may be produced.

DRAWINGS

Fig. 1 is a longitudinal sectional view showing a state of strand interior and a position for light reduction in a continuous casting.

Fig. 2 is a conceptional side view showing a principal part for general construction of a vertical continuous casting apparatus according to this invention.

Fig. 3 to Fig. 5 are detailed drawings exemplifying a mechanism for providing the light reduction means variably in position in the apparatus of Fig. 2; wherein Fig. 3 is a side view, Fig. 4 is a sectional view taken on line I - I of Fig. 3, and Fig. 5 is a sectional view taken on line II - II of Fig. 3.

Fig. 6 is a side view similar to Fig. 3, representing another example of the mechanism for providing the light reduction means variably in position in the apparatus of Fig. 2 likewise.

DETAILED EXPLANATION OF PREFERRED EMBODIMENTS

In a continuous casting method for drawing a strand formed in a water-cooled mold vertically, the method of the present invention comprises, as shown in Fig. 1, positioning light reduction means (4), or pinch rolls representatively, just prior to a solidification completing point of a strand (5A) or a point at which an unsolidified portion (52) within a shell (51) disappears, applying light reduction strong enough to compensate contraction caused by solidification of the strand.

In a vertical continuous casting apparatus comprising, as shown in Fig. 2, substantially a water-cooled mold (1) and its ancillary equipment, drawing drive rolls (2) and a strand cutter (3) provided

downward the water-cooled mold, and provided with means (not illustrated) for feeding a molten metal to the water-cooled mold, the apparatus of the present invention comprises providing light reduction means (4) variably in position downward the water-cooled mold so as to apply light reduction strong enough to compensate contraction due to solidification to the strand just before the solidification completing point of the strand. A reference character (58) denotes a cast piece obtained from cutting the strand, which will be carried away by a separate device one by one.

The light reduction means and a technique for providing it variably in position are arbitrary, however, devices shown in Fig. 3 to Fig. 5 will be exemplified as typical. The device is constructed such that three pairs of pinch rolls (41a, 41b, 4lc) are mounted on a frame 42, and the frame (42) is made movable vertically along four pieces of vertical guide columns (43). Each pinch roll is mounted slidably on the frame to advance and retreat by hydraulic cylinders (44a, 44b, 44c) fixed on the frame to pinch the strand (5A) from opposite sides, driven by motors (45a, 45b, 45c), and is capable of applying a desired light reduction on the strand metal.

Positions of the pinch rolls (41a to c) can be changed by worm-jack mechanisms (7) moving vertically from having four pieces of vertical bars (46) on a lower portion of the frame (42) rotated according to rotations of a motor (6) and male screws of the vertical bars engaged with fixed female screws.

Fig. 6 indicates another mode of providing the light reduction means variably in position. In this apparatus, a construction of the light reductions means, namely, the frame and the pinch rolls fitted thereon and other parts is same as the example described above, however, what is different is that a vertical movement of the frame is realized by taking up and delivering a wire (9) laid on pulleys (8a, 8b, 8c, 8d and 8e).

(Operation)

A position of the light reduction means is made variable, adjusted to a solidification completing point fluctuating according to conditions such as steel kind to be subjected to the continuous casting, sectional size of a strand, drawing speed and others, and from carrying out a light reduction at an optimal position, the effect will be enhanced so high.

A determination of the solidification completing point will be made, for example, as follows. That is, since a thickness (D) of the shell (51) of a strand coming out of the water-cooled mold increases, as a time (t) passes, in the relation:

$D = k\sqrt{t}$

a value of k is determined on a techinque wherein a spike is driven, for example, in the strand and then a cast metal is cut to determine whether or not an unsolidified portion is present at the position, and thus the solidification completing point in the strand can be estimated accoding to the above equation.

Recently, there established is a techinque for detecting a solidification completing point by utilizing the phenomenon that a propagation speed of ultrasonic wave varies in solid and liquid. It is therefore preferable that a device for detecting a solid/liquid interface on an ultrasonic wave is added to the light reduction means (4), a solidification completing point in a strand is found to postion the light reduction means in starting the operation, light reduction is thus performed precisely, and when the solidification completing point fluctuates according to changes in steel kind to be subjected to the continuous casting and in casting conditions, the light reduction means is made to follow thereto and the position is modified accordingly.

The strand is drawn by the aforementioned drawing drive rolls, therefore a driving force is not required for the light reduction pinch rolls to have. However, the light reduction pinch rolls will be utilized advantageously for inserting dummy bars into the water-cooled mold when starting the casting operation. The object is attained by providing a driving function to the light reduction pinch rolls, therefore, the aforementioned apparatus is provided with a driving motor.

According to this invention, a light reduction just prior to a solidification completing point in casting a special steel vertically and continuously can be now realized at an optimal position always corresponding to the strand sectional size and changes in casting conditions. Thus, a quality product is ready for securing in meeting severe requirements on quality for the special steel such as prevention of center cavities, lessening of center segregation and so forth.

Claims

1. A continuous casting method, wherein a strand formed in a water-cooled mold is drawn down vertically therefrom, characterized in that a solidification completing point of the strand is determined, that light reduction means is positioned just prior thereto, and that light reduction strong enough to compensate contraction caused by solidification is applied the strand.

2. A vertical continuous casting apparatus comprising a water-cooled mold (1) and its ancillary equip-

ment, drawing drive rolls (2), and a strand cutter (3) both positioned downward the water-cooled mold, and provided with means for feeding a molten metal to the water-cooled mold, characterized in that light reduction means (4) is provided variably in position downward the water-cooled mold so as to apply light reduction strong enough to compensate contraction caused by solidification to a strand just prior to the solidification completing point of the strand.

3. The continuous casting apparatus according to claim 2, wherein a device for detecting a solid/liquid interface with ultrasonic wave is added to the light reduction means for determining the solidification completing point in the strand so as to position the light reduction means thereto, and when the solidification completing point fluctuates, to vary the position of the light reduction means accordingly thereto.

4. The continuous casting apparatus according to claim 2, wherein the light reduction means is slidable to a frame moving vertically along vertical guide columns, and comprises at least a pair of pinch rolls provided so as to pinch the strand from opposite sides of it by hydraulic cylinders.

5. The continuous casting apparatus according to claim 4, wherein a drive function is provided to the pinch rolls of the light reduction means to serve as dummy bar pinch roles at the same time.

FIG. 1

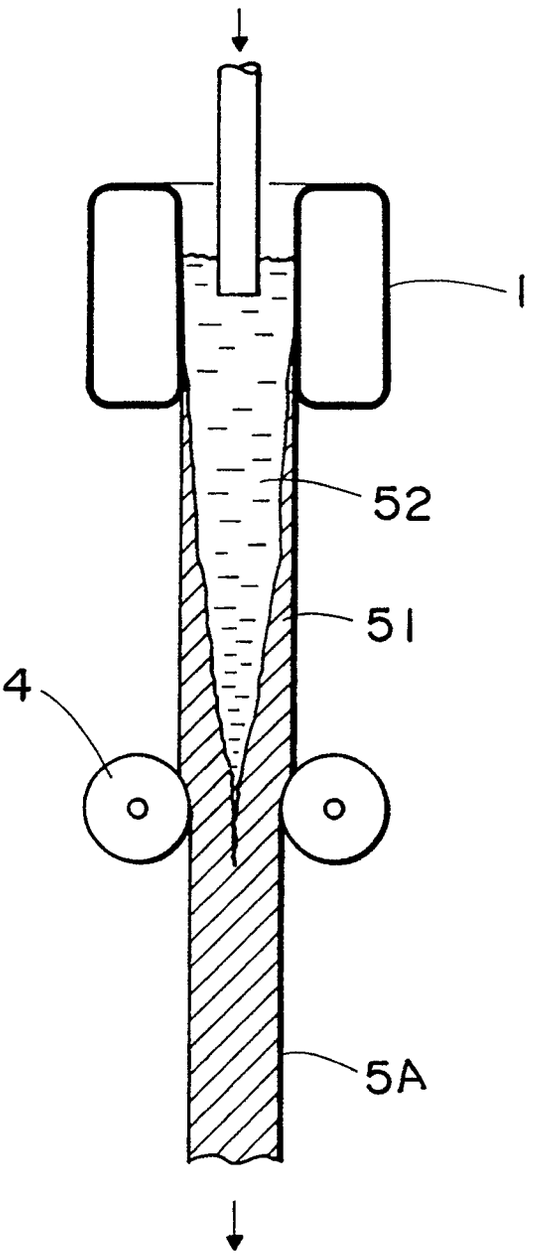

FIG. 2

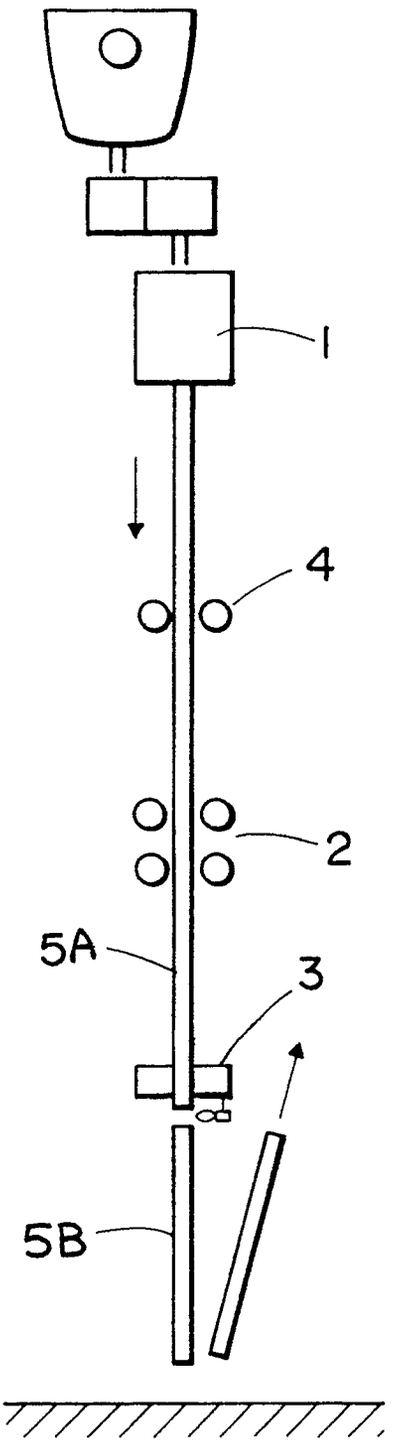

FIG. 3

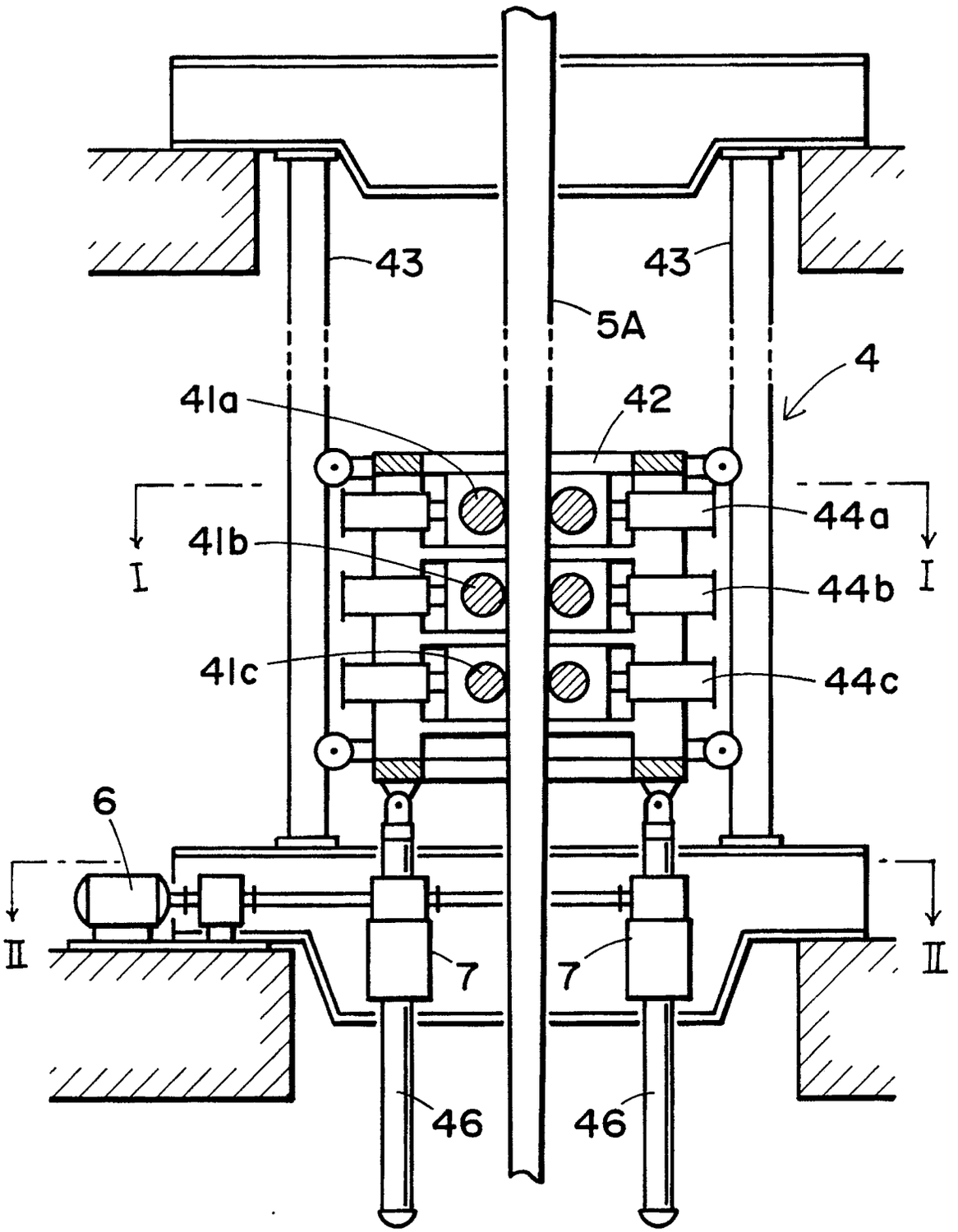

FIG. 4

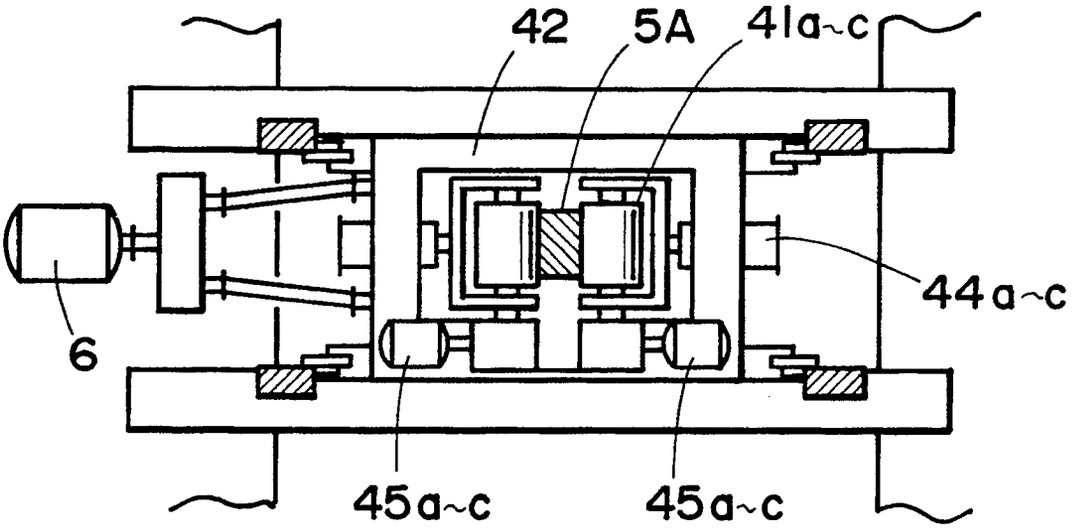

FIG. 5

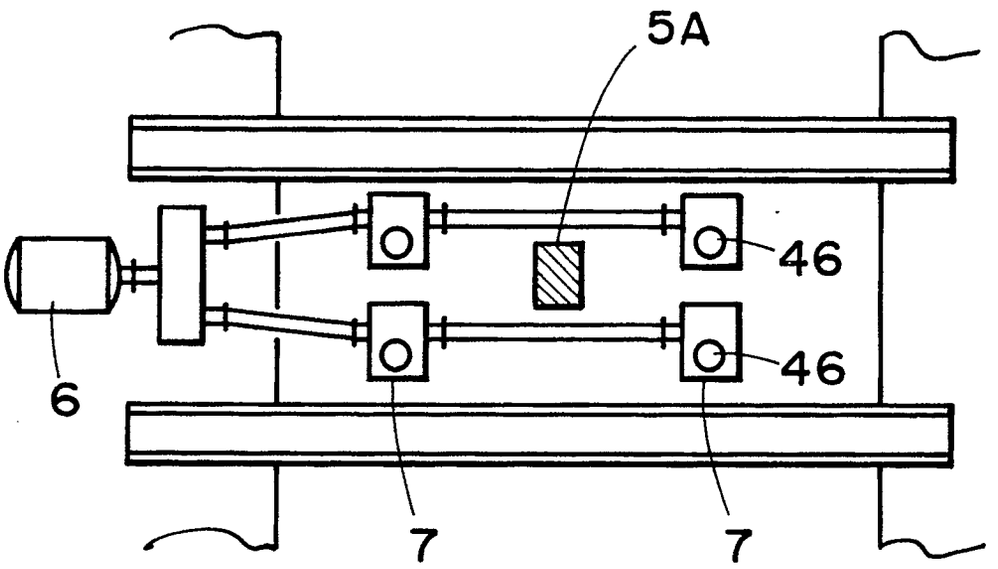

FIG. 6