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Burkhardt et al.

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[54] **STRAND GUIDE APPARATUS FOR CONTINUOUS CASTING**

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[52] **U.S. Cl.** **164/282**

[51] **Int. Cl.** **B22d 11/12**

[58] **Field of Search** 164/82, 282, 283; 193/35; 226/176, 177, 196, 199

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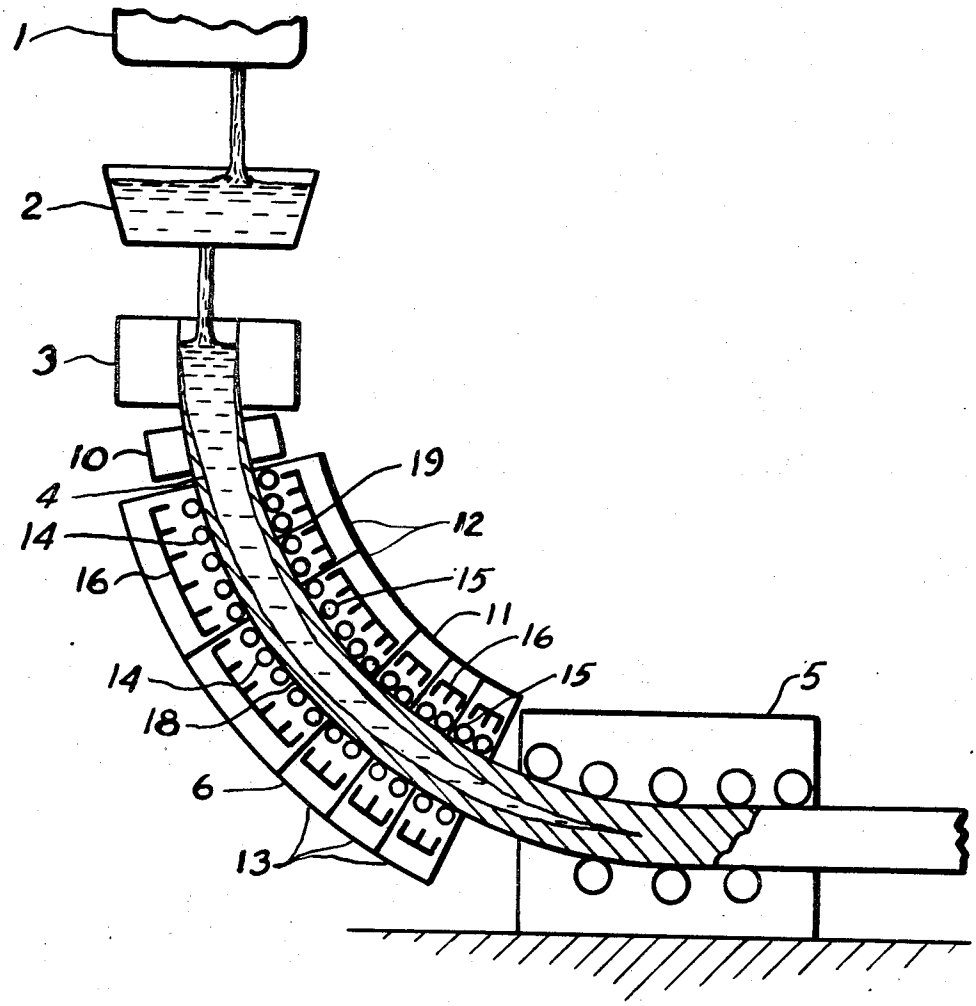
[57] **ABSTRACT**

A guideway for the secondary cooling zone of curved type continuous casting plants in which guide rollers are carried in pivotally mounted yokes adapted to equalize the load on the guide rollers.

10 Claims, 5 Drawing Figures



2 Sheets-Sheet 1

FIG.1

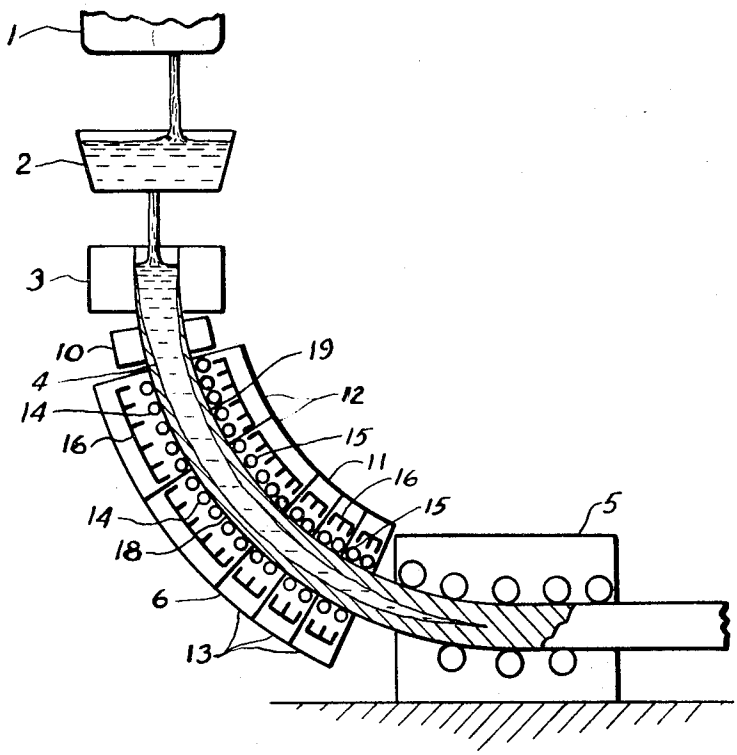


FIG.3

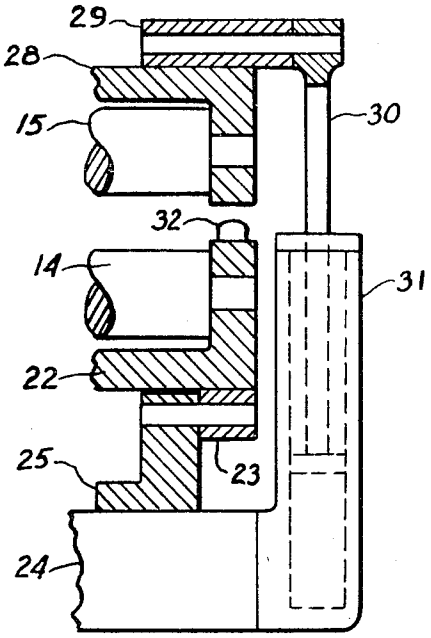


FIG.2

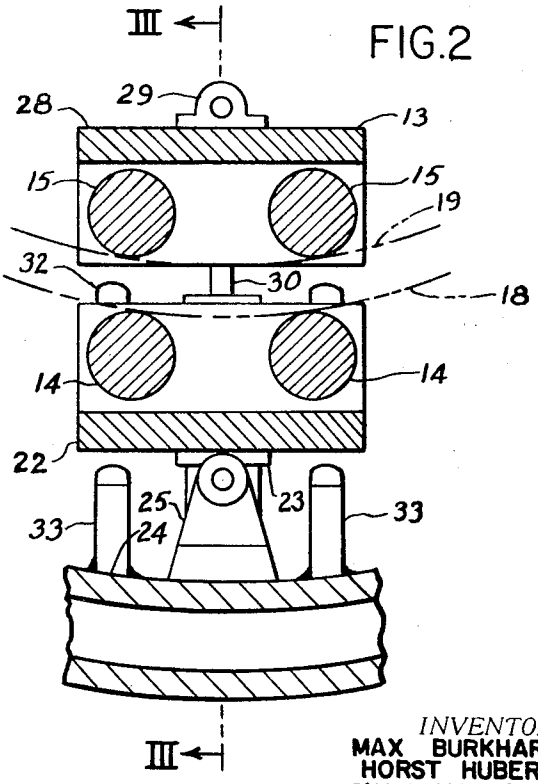


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FIG. 4

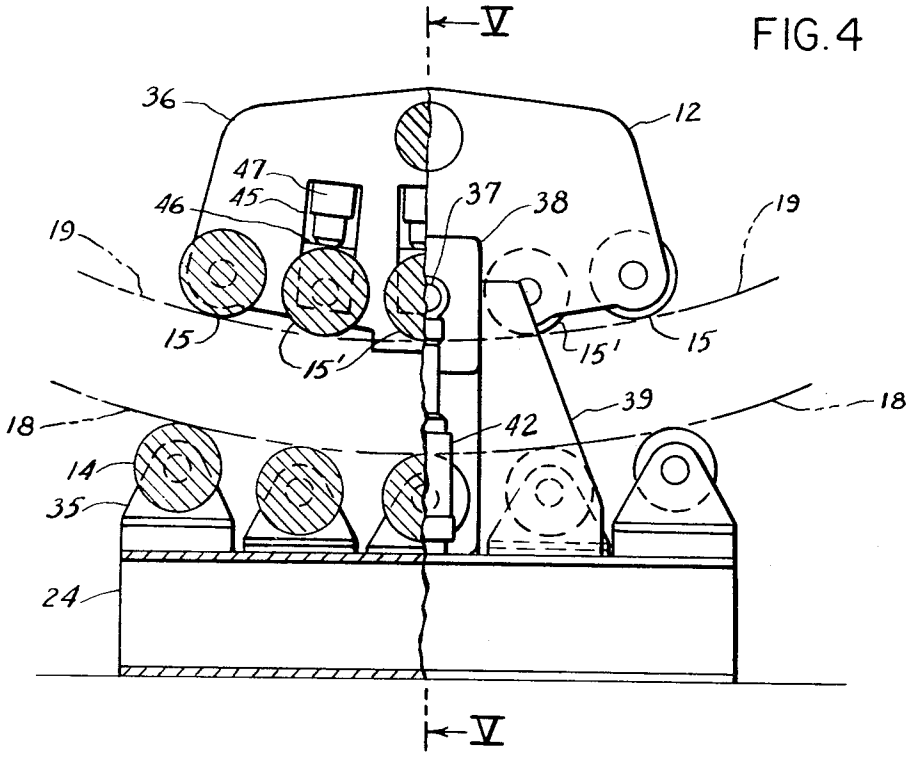
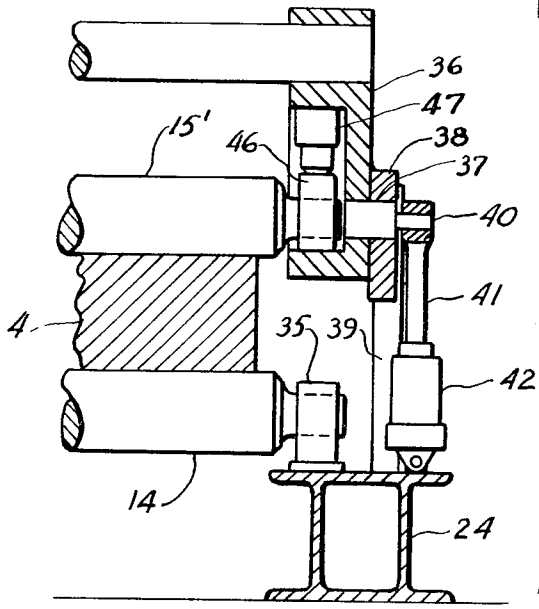


FIG. 5



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STRAND GUIDE APPARATUS FOR CONTINUOUS CASTING

The present invention relates to apparatus for guiding a continuous casting through a secondary cooling zone of curved type continuous casting plants.

A known arrangement in curved type plants is to divide the guideway or apron in the secondary cooling zone into sections fitted with rollers which define upper and lower curved guide tracks for guiding the curved casting or continuously cast strand. In another conventional arrangement one track of the guideway, for example the track on the inside of the curve, is adjustable with respect to the casting axis to adjust it to the casting cross-section, while the track on the outside of the curve is rigidly attached to supporting structure.

In such arrangements the rollers of the guideway are adjusted to the cross-section of the intended casting and to its hypothetical curvature whilst the plant is inoperative, i.e., whilst it is cold, in order to guide the casting precisely and to distribute the forces uniformly between the rollers. However, it has been found that non-uniform heating and hence non-uniform thermal distortion of the guide means whilst casting proceeds are impossible to avoid, and that individual rollers are therefore unevenly loaded.

Completely uniform cooling of the casting during operation cannot be achieved, particularly not in that part of the casting that has already substantially solidified, because the casting parameters change. By way of example, the cooling water on the inside of the curve of the casting runs off irregularly and the resultant non-uniformity of the cooling effect causes irregular shrinkage and the generation inside the casting of non-uniform thermal stresses. The casting therefore deviates from its theoretical curvature and thereby submits the individual rollers to unequal loads and possible overloads.

At the end of the casting process the withdrawal of the casting must be stopped for a few minutes to allow for the formation of a cap on the end of the casting. This increases the non-uniformity of the cooling effect and the tail end of the casting assumes a much smaller curvature. Consequently the overloads to which the rollers are submitted are significantly greater during the final withdrawal of the casting from the plant after the stoppage. All these effects become significantly worse if the casting, as the result of some trouble such as a metal breakout, remains in the guideway for some time. The overloads lead to fractures of the rollers and to damaged roller bearings, and protracted stoppages of the plant are the result.

It is the object of the present invention to prevent individual rollers of the roller guideway from being dangerously overloaded and to permit the guideway within limits to adapt itself to the changing shape of the casting.

This object is achieved in accordance with the invention by the provision of apparatus for guiding a continuous casting through a secondary cooling zone of a curved type continuous casting plant, comprising a guideway divided into sections and incorporating a plurality of rollers in each section which define curved guide tracks for guiding opposite sides of the casting, wherein at least part of one of the guide tracks in at least one of the sections is defined by at least two rollers which are mounted in a common pivotable yoke.

At least one of the sections may also have at least part of the other guide track defined by at least two rollers mounted in a common rotatable yoke. In such a section or sections, the pivotable yoke of the track on the outside of the curve may be pivoted to a fixed supporting structure and the pivotable yoke of the track on the inside of the curve may be adjustable with respect to the guided surface of the casting. In another section or sections, all the rollers forming the track on the outside of the curve may be journalled in bearings rigidly affixed to the supporting structure whilst the pivotable yoke of the track on the inside of the curve is adjustable with respect to the guided surface of the casting. A complete guideway may be composed of sections of both kinds mentioned.

In order to take up the forces acting on the rollers in the longitudinal direction of the casting guideway, guideways rigidly connected to the supporting structure may be provided within which the adjustable and pivotable yoke may move.

Conveniently each end of a pivotable yoke may be connected to a piston-and-cylinder unit.

When the end of a casting having a smaller curvature passes the first roller in a yoke in the direction of travel of the casting, the next roller would be subjected to an excessively high load. In order to avoid this the deflectability of a pivotable yoke can be limited.

If a pivotable yoke contains at least three rollers journalled in bearings in fixed positions in the yoke only the two outer rollers would be reliably rotated by the travelling casting, whereas the intermediate roller or rollers might fail to make contact by virtue of the described non-uniform curvature of the casting. They would not then be rotated and thermal cracks would form in the rollers. In order therefore to ensure that these intermediate roller or rollers will also be rotated, they are preferably made individually movable perpendicular to the casting surface and urged towards the casting surface by loading means.

Embodiments of the invention are shown by way of example in the accompanying diagrammatic drawings of which:

FIG. 1 is a schematic representation of an arc-type plant comprising a sectionalized guideway apron divided in accordance with the invention;

FIG. 2 is a cross-sectional view of a two-roller guideway section;

FIG. 3 is a cross-sectional view section of one side of the guideway section, taken on the line III—III in FIG. 2;

FIG. 4 is a part cross-sectional view of a five-roller guideway section, and

FIG. 5 is a cross-sectional section of one side of the guideway section taken on the line V — V in FIG. 4.

With reference to FIG. 1, molten steel flows from a ladle 1 into a tundish 2 and from the latter into a curved continuous casting mold 3 wherein it forms a continuously cast strand or casting 4 which contains a liquid core. The said casting is withdrawn by a withdrawing and straightening apparatus 5 and is cooled as it passes through a secondary cooling zone 6.

The secondary cooling zone 6 includes cooling plates 10 below the mold 3 and an arcuate guideway 11 for guiding the cast strand or casting 4. The guideway 11 is sub-divided into strand guide sections 12 and 13. Each such section 12 and 13 carries rollers 14 and 15 for guiding the casting 4. Coolant delivery means 16

are located adjacent the rollers 14 and 15 for the purpose of conventionally cooling and thus solidifying the casting. Each section 12 comprises five rollers 14 defining a track 18 on the outside and five rollers 15 defining a track 19 on the inside of the curve of the guideway, whereas the sections 13 each carry only two pairs of rollers 14, 15 defining each of the two curved tracks. In the embodiment under consideration each pair of cooperating rollers 14,15 of the strand guide sections 12 and 13 are disposed along the two curved tracks to opposite sides of the casting or strand 4, and each roller pair may be advantageously arranged in a respective plane extending radially with respect to the lengthwise axis of the arcuate guideway 11.

FIGS. 2 and 3 illustrate one of the sections 13 in detail. The track 18 on the outside of the curve is defined by the two rollers 14, whereas the track 19 on the inside of the curve is defined by the two rollers 15. The rollers 14 are journalled in a pivotally mounted yoke 22. Each end of the yoke 22 carries a bearing block 23 which is hinged to a pillow block 25 firmly secured to a supporting structure 24.

The rollers 15 are journalled in a pivotally mounted yoke 28 which at each end carries a bearing block 29 to which a piston rod 30 of a piston-and-cylinder unit 31 firmly secured to the structure 24 is attached and connected by a hinge pin so that the yoke can pivot about the hinge pins. The piston-and-cylinder units 31, of which one is provided at each end of the yoke, serve firstly to support the yoke 28 and secondly for adjusting the pivotable yoke 28 with respect to the casting surface. This makes it possible to adjust the yoke 28 to the cross-section of the casting, but it may also serve to limit the displacement of the yoke 28 for the purpose and effect described in U. S. Pat. application Ser. No. 814,247, filed on Apr. 8, 1969.

For limiting the pivotal movement of the yoke 28 the yoke 22 is provided with stops 32. The pivotal movement of the latter yoke 22 is limited by stops 33 attached to the supporting structure 24. The magnitude of the pivotal movement of the yokes must depend upon the general design of the plant and may, for example, be 10 mm for a casting that is 150 mm thick.

FIGS. 4 and 5 illustrate one of the sections 12 comprising five roller pairs. The rollers 14 define the track 18 on the outside of the curve. Bearings 35 which support the rollers 14 are rigidly secured to the supporting strcuture 24. However, the rollers 15 which define the inside track 19 of the curve are journalled in a yoke 36 provided with trunnions 37 mounted in sliding blocks 38. The sliding blocks 38 are movable in guideways 39 that are rigidly connected to the structure 24. The trunnions 37 are formed with extension pins 40 upon which are mounted the piston rods 41 of piston-and-cylinder units 42 anchored to the supporting structure 24. These piston and cylinder units 42 serve to adjust the yoke 36 with respect to the casting surface. The object of such adjustment is the same as that already described with reference to FIG. 3. As an alternative the track 19 on the inside of the curve may be rigid and the track 18 on the outside of the curve may be arranged to be adjustable.

The bearings for the two outside rollers 15 in the section 12 are rigidly fixed in the pivotally mounted yoke 36, whereas the three inner rollers 15' are individually mounted for freedom of movement perpendicularly to the guided surface of the casting. For this purpose the yoke 36 contains guideways 45 in which the bearings 46 of the rollers 15' are movably guided. The bearings are pressure-loaded towards the casting by loading means 47 installed in the yoke. The loading means 47 may contain springs or a hydraulic fluid and preferably apply a constant or substantially constant pressure urging the rollers 15' towards the casting. The adjustment of the bearings 46 in the direction towards the casting is arranged so that the rollers 15' may move a few millimeters beyond the designed position of track 19 on the inside of the curve of the guideway thus ensuring that, despite the above-mentioned variations in geometry of the casting, the rollers 15' will be reliably rotated by engagement with the casting. The adjustment of the bearings 46 away from the casting is limited by the loading means 47 and is so adjusted that the rollers 15', in conjunction with the rollers 15, define the required curve to prevent the casting from bulging beyond the prescribed limits.

The invention is not intended to be limited to the described embodiments. The sections may each contain three, four or some other number of rollers. Moreover, instead of each section containing only one pivotable yoke it may comprise several. If the plant is used for the production of castings of only one cross-section, the arcuate tracks of the guideway need not be adjustable. In plants for casting relatively smaller cross-sections only the section preceding the withdrawing and straightening machine need be construed as proposed by the present invention, the other sections being fitted with rollers mounted in fixed bearings.

Moreover, in plants in which high casting rates are employed and the still-liquid core of the casting extends into the horizontal run of the casting beyond the withdrawing and straightening machine the proposed arrangement may also be used in the horizontal run of the track.

In order to permit the rollers to adapt themselves to major deviations in the curvature of the casting the rollers defining the inside and outside tracks of the guideway in some sections may be jointly displaceable within given limits perpendicular to the guided surface of the casting.

We claim as our invention:

1. Apparatus for guiding a continuous casting through a secondary cooling zone of a curved type continuous casting plant, comprising a guideway divided into sections and incorporating a plurality of rollers which define curved guide tracks for guiding opposite sides of the casting, wherein one of the guide tracks on the inside of the curve in at least one of the sections is defined by at least two rollers which are mounted in a common pivotally mounted yoke, and wherein the other guide track on the outside of the curve of said section is defined by at least two rollers mounted in a common pivotally mounted yoke, each end of the pivotally mounted yoke on the inside of the curve being connected to a piston-and-cylinder unit to adjust such yoke perpendicularly to the guided casting surface.

2. An apparatus for guiding a continuous cast strand through a secondary cooling zone of a curved type continuous casting plant, comprising a guideway for guiding a continuously cast strand, said guideway being divided into a plurality of strand guide sections, each of said strand guide sections comprising a plurality of guide rollers, said guide rollers of each guide section being arranged in cooperating pairs situated at opposite

sides of the continuously cast strand to define a pair of opposed curved guide tracks for guiding opposite sides of the continuously cast strand as it moves through said guideway, said cooperating pairs of guide rollers being disposed in radially extending planes of said curved guide tracks, a common pivotably mounted rigid yoke supporting at least two rollers of at least one of said strand guide sections, said yoke having a single pivot axis between said rollers, said yoke being mounted on one side of the casting for pivotal movement with respect to and independent of the rollers at the other side of the casting, said pivotably mounted yoke supporting said rollers for free pivotal movement to compensate for variations in the geometry of the continuously cast strand and to substantially equalize possibly arising uneven loading of the pivotably mounted rollers due to irregular thermal distortion of the guideway or the presence of irregular thermal stresses at the continuously cast strand.

3. The apparatus as defined in claim **2,** further including an additional common pivotably mounted yoke for at least part of the other curved guide track formed by at least two rollers of one of the strand guide sections for pivotably mounting said last-mentioned at least two rollers of said other curved guide track.

4. The apparatus as defined in claim **3,** further including stop means for limiting the movement of each common pivotably mounted yoke.

5. The apparatus as defined in claim **3,** wherein one of the curved guide tracks of said pair of oppositely situated curved guide tracks defines an outside curved guide track and the other an inside curved guide track for respective outside and inside surfaces of the continuously cast strand, said additional common pivotably mounted yoke for said other guide track being associated with said outside curved guide track and said common pivotably mounted yoke for said one curved guide track being associated with said inside curved guide track, a fixed support structure, means for pivotably mounting said additional common pivotably mounted yoke associated with said outside curved guide track at said fixed support structure, and means for adjustably mounting said common pivotably mounted yoke associated with said inside curved guide track so as to be movable substantially perpendicularly towards and away from the inside surface of the continuously cast strand.

6. The apparatus as defined in claim **5,** wherein said adjustably mounting means comprises a piston- and cylinder unit operatively connected with said common pivotably mounted yoke associated with said inside curved guide track for adjusting said common pivotably mounted yoke in a direction perpendicular to said inside surface of the continuously cast strand.

7. The apparatus as defined in claim **2,** wherein one of the curved guide tracks of said pair of oppositely situated curved guide tracks defines an outside curved guide track and the other an inside curved guide track for respective outside and inside surfaces of the continuously cast strand, a fixed supporting structure, bearing means rigidly affixed to said fixed supporting structure, each roller of at least one of the strand guide sections associated with said outside curved guide track being journalled in said bearing means, said common pivotably mounted yoke which pivotably supports said at least two rollers being associated with said inside curved guide track for the inside surface of the continuously cast strand, means for adjustably mounting said common pivotably mounted yoke for movement substantially perpendicular to the longitudinal axis of the cast strand guideway in a direction towards and away therefrom and perpendicular to the inside surface of said cast strand.

8. The apparatus as defined in claim **7,** wherein said adjustably mounting means comprise guideways rigidly connected with said fixed supporting structure, said common pivotably mounted yoke being movable in said guideways.

9. The apparatus as defined in claim **7,** wherein said adjustably mounting means comprises a piston- and cylinder unit operatively connected with each end of said common pivotably mounted yoke for displacing said common pivotably mounted yoke perpendicularly with respect to the casting surface in a direction towards and away therefrom.

10. The apparatus as defined in claim **2,** further including at least three rollers mounted in said common pivotably mounted yoke, said three rollers defining two outer rollers journalled in fixed positions in said common pivotably mounted yoke, means for mounting the at least one other remaining roller of said at least three rollers so as to be movable in a direction perpendicular to the guided casting surface towards and away therefrom, and loading means for urging said remaining roller in the direction towards said casting surface for contact therewith.

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