United States Patent

Burkhardt et al.

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[54] **WITHDRAWAL AND STRAIGHTENING APPARATUS FOR CONTINUOUS CASTING**

[72] Inventors: **Max Burkhardt,** Zurich, Switzerland; **Horst Huber,** Roselle Park, N.J.; **Christian Chateau,** Saint-Chamond, France

[73] Assignees: **Concast AG,** Zurich, Switzerland; **Concast Incorporated,** New York, N.Y.

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

[58] **Field of Search** ..164/82, 282, 283; 72/160, 163, 72/166

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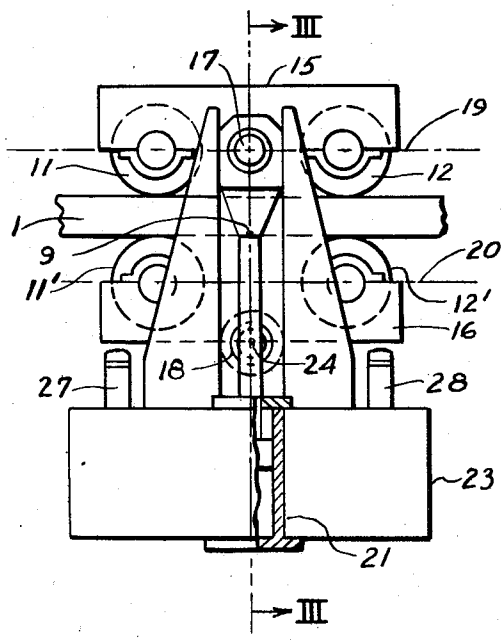
Primary Examiner—R. Spencer Annear

Attorney—Sandoe, Hopgood & Calimafde

[57] **ABSTRACT**

In a withdrawal and straightening apparatus for continuous casting machines, banks of withdrawal and straightening rolls are mounted above and below the casting, the rolls of each bank being mounted in tiltable yokes which adjust themselves to the curvature of the casting and distribute the loads on the rolls. The rolls of the upper bank are adjustable by hydraulic means connected to the yokes to accommodate castings of different thickness.

8 Claims, 5 Drawing Figures



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SHEET 1 OF 2

FIG.1

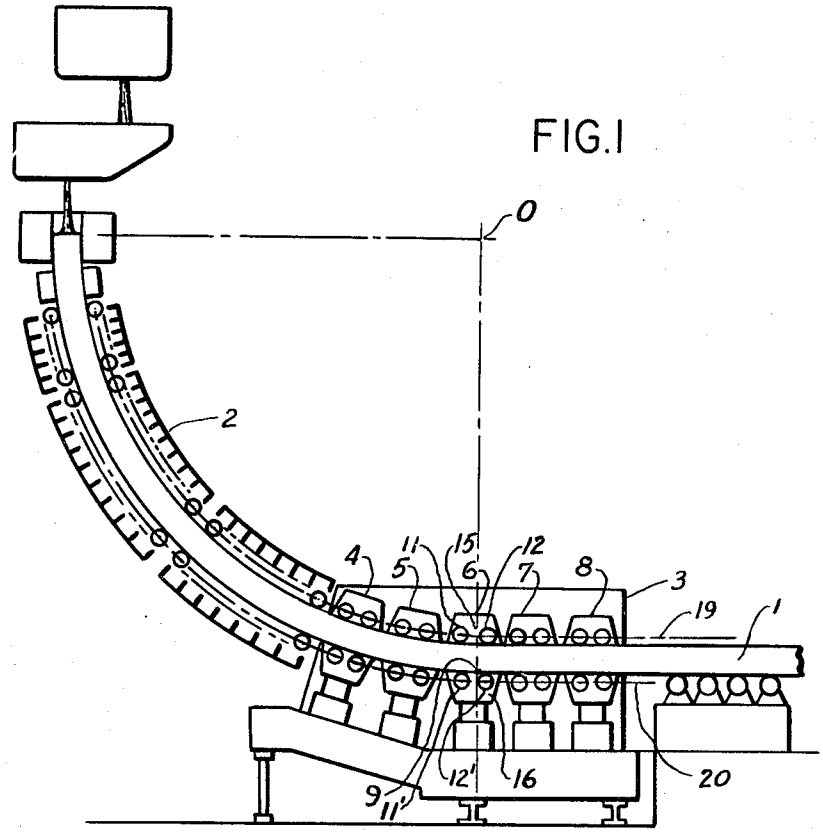


FIG.2

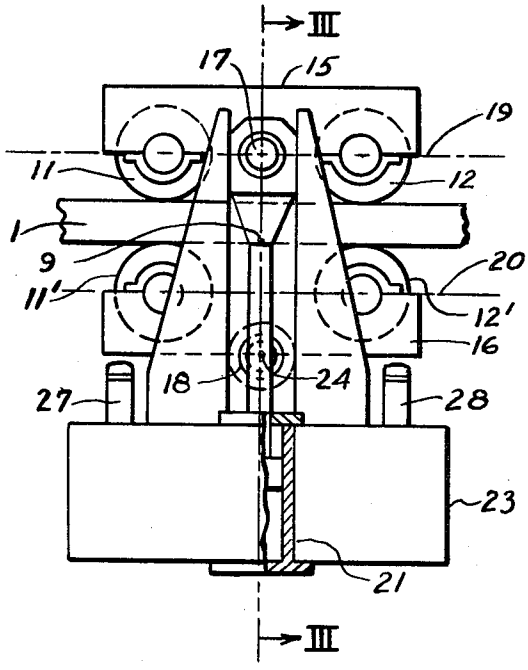
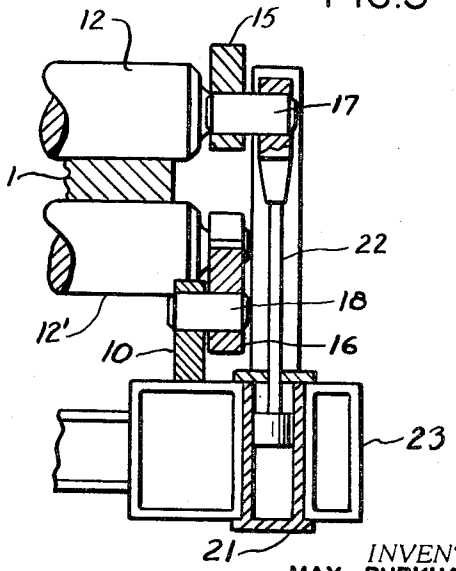


FIG.3



INVENTORS
MAX BURKHARDT
HORST HUBER
CHRISTIAN CHATEAU

BY

Sandoe, Hopgood & Calimafde

ATTORNEYS

FIG.4

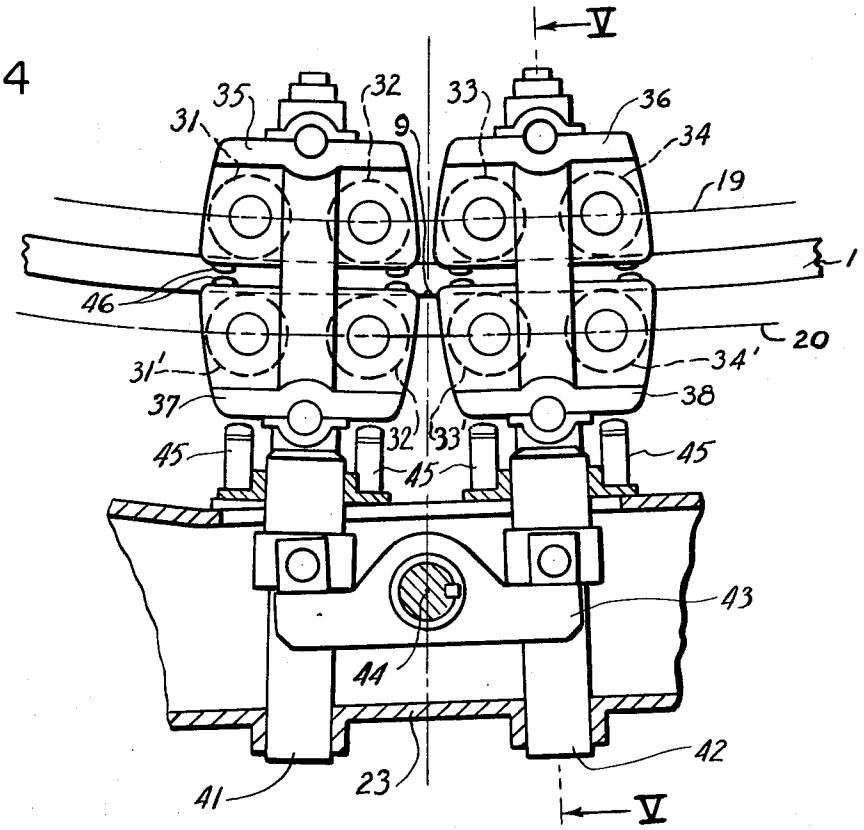
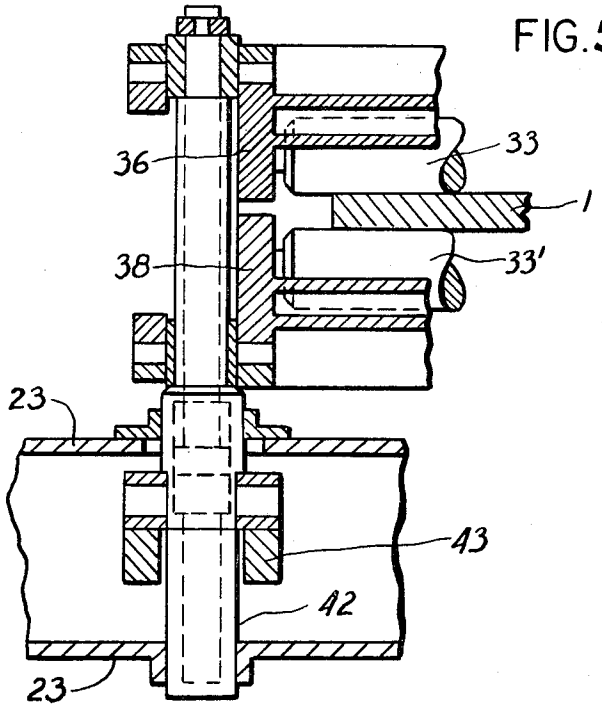


FIG.5



INVENTORS
MAX BURKHARDT
HORST HUBER
CHRISTIAN CHATEAU
BY Sandoe, Hopgood + Calimafde
ATTORNEYS

WITHDRAWAL AND STRAIGHTENING APPARATUS FOR CONTINUOUS CASTING

The invention relates to a withdrawal and straightening apparatus for continuous casting, wherein the path of the casting is changed from a curved into a straight path between two facing banks of rolls below and above the casting.

In conventional curved type casting plants, particularly for casting slabs, the casting issuing from the curved apron is generally straightened by using a so-called tangent roll. This roll is located in a bank of rolls on the outside of the curve at the point of transition between the curved and the straight path of the casting known as the tangent point. Since this roll is frequently exposed to heavy loads its diameter must be fairly large. However, this large diameter also necessitates a correspondingly wide separation from adjacent rolls of the bank, causing the unsupported length of the casting to be longer than is desirable. In high speed plants, particularly in slab casting plants, the liquid crater in the casting normally extends at least into the neighborhood of the withdrawal and straightening apparatus. A wide roll spacing, therefore, increases the risk that ferrostatic pressure may cause bulging of the casting. In conventional plants it has therefore become the practice to associate a larger backing roll with a smaller tangent roll. Although this enables the roll spacing to be reduced, it also entails other operating drawbacks which must be accepted.

In practice it transpires that it is not necessarily the tangent roll that is called upon to bear the greatest loads during straightening. The rolls preceding and following the tangent point may also function as the straightening points and bear heavy loads. This is the case more particularly when colder castings are to be straightened. The result is that rolls having design diameters that are too small may be fractured by excessive load distributions and thereby cause expensive hold-ups.

Other difficulties arise because shrinkages occur when colder castings are being withdrawn. As a result, loads may be applied to the withdrawal and straightening rolls in the inside bank that sometimes cause these rolls to fracture. Moreover, when withdrawing cold castings, the end of the casting may exert greater forces on these rolls and damage them.

It is also desirable that the withdrawal and straightening rolls apply a contact pressure to the casting that is as evenly distributed as possible to prevent the skin of the casting from being damaged.

For precisely guiding a casting in the mold axis it is already known in continuous casting machines of the vertical type to mount two withdrawal rolls on each side of the straight casting in a yoke and to attach the yokes to the free ends of cranked double-armed levers, whereas the other ends of the levers are in a force-locking coupling engagement. By virtue of this arrangement a moment acting on one lever produces a contrary deflection of the other lever, so that the contact pressure of the facing withdrawal rolls is the same. However, this withdrawal apparatus is unsuitable for straightening a curved casting, as obtained in curved type casting plants.

In order to achieve uniform contact pressure of the withdrawal and straightening rolls on the casting, the rolls facing the concave side of the casting in one known withdrawal and straightening machine are mounted in a yoke. The ends of the yoke are attached to hydraulic thrust generating devices for pressing the rolls against the casting. Since the rolls are mounted in a yoke that is guided on both sides and can only move in the vertical, some rolls may be overloaded and fracture. Moreover, when the straightening conditions change, it is not possible to adapt to the changed loading.

The object of the present invention is to provide a withdrawal and straightening apparatus which avoids the above-described objections, particularly roll fractures, and permits the straightening system to adapt itself to existing loading conditions even though the rolls are spaced closely together. Another object of the invention is to simplify existing withdrawal and straightening apparatus by utilizing standard elements and thereby reducing the cost.

The contemplated objects are achieved by mounting at least two rolls of at least one bank of rolls as a unit in a tiltable yoke.

By thus mounting the rolls in a tiltable yoke they can adapt themselves to different loading conditions. If the dimensions of the casting are such that the tangent roll must be expected to be exposed to considerable forces then this roll may be replaced by two rolls mounted in a tiltable yoke. The load which would normally affect the tangent roll can thus be equally divided between the two rolls in the bottom bank of rolls. Alternatively several such tiltable yokes could be provided in the bottom outer bank of rolls in order to take further advantage of the compact design and favorable distribution of forces. Preferably the pivot axis of one yoke is contained in a vertical plane which contains the tangent point and the center of curvature. It is useful to mount two rolls in one yoke but if desired several rolls, for instance three, may be mounted in a yoke.

In the further development of this principle two tiltable yokes each carrying two rolls, for example, may themselves be mounted on a common tiltable yoke. If the pivot axis of the common yoke is in a vertical plane containing the tangent point, then the loads due to the straightening action can be distributed evenly within a still wider range without any individual roll being overloaded.

This principle of load distribution between several rolls also applies to the upper bank of rolls. If uneven load distributions arise, due, for example, to thermal stresses and the distortion of the casting during a stoppage caused by a breakout of metal, then the tilting movement of a yoke carrying at least two rolls avoids damage being done to the withdrawal and straightening rolls of the upper bank.

For lifting and lowering a yoke, as for the purpose of adjusting the withdrawal rolls to casting cross sections of different thickness, hydraulic means are provided. By connecting the mounting of a yoke to the piston of a hydraulic actuator, only a single hydraulic cylinder and piston is needed on each side of the casting for adjusting all the rolls in the yoke. A special support for the upper yoke, as in plants hitherto known, is thus rendered unnecessary. Should lateral thrusts arise, then these are transmitted by the yoke downwards into the supporting structure or framework.

In particular cases, as at the end of a casting operation, due to the temporary interruption needed for the formation of a cap, it is possible for the end portion of the casting to cause tilting and overloading of individual rolls as it passes under the yoke. This can be prevented by the provision of one or more simple mechanical stops which take up the thrusts and transmit them into the framework.

The number of rolls mounted in one yoke may differ but must be at least two. This is particularly important in that part of the withdrawal and straightening apparatus which precedes the tangent point, i.e., that which is associated with the curved portion of the casting.

Other details of the invention will be described with reference to embodiments shown in the drawings.

FIG. 1 is a side elevation, schematically represented of curved-type plants provided with the proposed withdrawal and straightening apparatus.

FIG. 2 is a side elevation of a section of the withdrawal and straightening apparatus.

FIG. 3 is a section taken on the line III — III in FIG. 2.

FIG. 4 is a side elevation of a different embodiment, and

FIG. 5 is a section taken on the line V — V in FIG. 4.

Referring to FIG. 1 a casting 1 travels first down a curved apron 2 comprising a plurality of sections curved about a center O, and then enters a withdrawal and straightening apparatus 3. This withdrawal and straightening apparatus has two banks of rolls 19 and 20 on opposite sides of the casting and comprises a plurality of sections 4, 5, 6, 7, 8. A selectable number of said rolls are driven and effect the withdrawal of the casting 1 which, having passed through the withdrawal and straightening apparatus, continues as a straightened strand to travel along a roller bed to a point where it may be subdivided by cutting devices. At the tangent point 9, the curved path becomes straight. In this embodiment each roll section has two rolls 11, 12 in the upper bank 19 and two rolls 11', 12' in the lower bank 20. The pairs of rollers are mounted in tiltable yokes 15 and 16, respectively, as shown in FIGS. 2 and 3 which illustrate an individual section. The yoke 15 pivots on a pin 17 and the yoke 16 pivots on a pin 18.

On each side of the casting is a hydraulic actuator comprising a cylinder 21 and a piston rod 22. The cylinder is fitted into a supporting frame 23 and located therein. The pivot pin 18 is connected by a member 10 to the frame 23 and the pivot pin 17 is connected to a piston rod 22. This hydraulic actuator permits the two rolls 11, 12 of the upper bank 19 to be moved perpendicularly to the casting to adjust the rolls to castings of different cross sections. The yoke on the pivot pin 17 permits the rollers to adapt themselves to the curvature of the casting and the load to be evenly divided between the two rolls.

The yoke 16 containing the rolls 11', 12' in the outer bank 20 of rolls likewise provides a favorable distribution of the forces generated during straightening. It is desirable to dispose a section of the described kind in such a way that the pivot axis 24 of the bottom yoke lies in a plane through the tangent point 9 and the center of curvature O. In curved type plants in which the apron has several different radii of curvature this plane preferably contains the radius of curvature of the apron section directly preceding the withdrawal and straightening apparatus. Stops 27, 28 are attached to the structure 23 to prevent excessive tilting movements of the yoke 16.

The center section shown in FIGS. 4 and 5 of a different embodiment of the withdrawal and straightening apparatus preceded and followed by two further sections designed as shown in FIG. 2, comprises four rolls 31, 32, 33, 34 in the upper bank and 31', 32', 33', 34' in the lower bank 20 of rolls, but two each of the rolls, 31, 32, 33, 34, 31', 32', 33', 34' are mounted in a separate yoke 35, 36, 37, 38. The upper rockable yokes 35 and 36 are each connected on each side of the casting to a hydraulic actuator consisting of a cylinder 41, 42 and the associated piston rod. By operation of the actuators the perpendicular spacing of the two banks 19, 20 of rolls can be varied.

The two bottom rockable yokes 37 and 38 are connected to the hydraulic cylinders 41, 42. Both cylinders are movable in the frame 23 and pivotably connected to the supporting arms of a common yoke 43. The yoke 43, which has a pivot axis 44 that preferably lies in a plane through the tangent point 9 and the center of curvature O normal to the casting axis thus carries the two yokes 37 and 38 on the interposed cylinders. This arrangement enables the loads arising at the tangent point to be distributed between four rolls permitting the diameter and spacing of the rolls to be further reduced. The deflectability of the yokes is limited by stops 45, 46.

Within the scope of the present invention any number of sections can be associated on the unit construction principle so that, according to the casting rate and the resultant crater depth, the formation of bulges can be controlled. Particular sections comprising for instance one yoke above and one below the casting, may be freely movable transversely of the casting axis and transversely of the pivot axes of the yokes, so that the rolls of both yokes can follow the motions of the casting without the distance between the upper and bottom bank of rolls being changed.

In the same way it is possible to provide a major number of rolls, say three rolls instead of two rolls in one yoke. Alternatively, one or more tiltable yokes may be provided in only one bank of rolls, for instance the inner bank 19 of rolls.

It will be understood that the invention is also applicable to plants with a partly curved apron.

According to requirements any desired rolls may be driven rolls. For example, in the embodiment illustrated in FIG. 4 the rolls 31, 32, 31', 32', 33', 34', may be driven by conventional means.

We claim as our invention:

1. A withdrawal and straightening apparatus for continuous casting plants, wherein the casting is conveyed from a curved into a rectilinear path between two facing banks of withdrawal and straightening rolls disposed above and below the casting and defining said path, characterized in that at least two casting withdrawal and straightening rolls adjacent each other in at least one of said two facing banks of rolls are mounted as a unit in a tiltable yoke, said yoke having means defining a pivot axis for mounting said yoke to

be tiltable for adjustment of said at least two withdrawal and straightening rolls to the curvature of the casting and to safeguard against fracture of said withdrawal and straightening rolls due to possible roll overloading during the casting withdrawal and straightening operations.

2 A withdrawal and straightening apparatus according to claim 1, characterized in that at least one tiltable yoke carries rolls in the bank of rolls disposed below the casting.

3. A withdrawal and straightening apparatus for continuous casting plants, wherein the casting is conveyed from a curved into a rectilinear path between two facing banks of rolls disposed above and below the casting, the improvement comprising a tiltable yoke for mounting as a unit at least two rolls of at least one bank of rolls, said tiltable yoke carrying said at least two rolls of the bank of rolls disposed below the casting, said tiltable yoke having a pivot axis lying in a vertical plane through the tangent point and the center of curvature of the casting.

4. A withdrawal and straightening apparatus according to claim 1, characterized in that two tiltable yokes which carry rolls disposed below the casting are mounted on a common tiltable yoke.

5. A withdrawal and straightening apparatus for continuous casting plants, wherein the casting is conveyed from a curved into a rectilinear path between two facing banks of rolls disposed above and below the casting, the improvement comprising at least two tiltable yokes for carrying rolls disposed below the casting, each of said tiltable yokes having mounted thereat at least two rolls of said bank of rolls disposed below the casting, a common tiltable yoke for mounting said two tiltable yokes, said common tiltable yoke having a pivot axis lying in a vertical plane through the tangent point and the center of curvature of the casting.

6. A withdrawal and straightening apparatus according to claim 1, characterized in that at least one tiltable yoke which carries rolls in the bank of rolls disposed above the casting is movable by hydraulic means in a direction normal to the casting axis.

7. A withdrawal and straightening apparatus according to claim 6, characterized in that a tiltable yoke is connected on each side to a hydraulic cylinder which is guided and held in the frame.

8. A withdrawal and straightening apparatus according to claim 1, characterized in that the range of movement of the tiltable yoke is limited by stops.

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