United States Patent [19]

Gallucci et al.

[11] **3,753,461**

[45] **Aug. 21, 1973**

[54] **BENDING-ROLL UNIT FOR CONTINUOUS-CASTING MACHINE**

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[73] Assignee: **United States Steel Corporation**, Pittsburgh, Pa.

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[21] Appl. No.: **208,776**

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

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

[58] **Field of Search** 164/82, 83, 282, 164/283

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Assistant Examiner—John S. Brown
Attorney—Walter P. Wood

[57] **ABSTRACT**

A bending-roll unit for continuous-casting machines, where the unit directly follows a guide-roll rack and precedes a curved roll rack. The unit embodies a combination of driven rolls and idlers arranged in opposed pairs. One of the driven rolls is a fulcrum roll which defines the tangent line where a casting first acquires a curvature. Other driven rolls above and below the fulcrum roll sustain the reaction forces. These driven rolls also supply the initial tractive force which propels the casting and thus eliminate the need for separate driven pinch rolls usually located above the bending rolls. Floating idlers confine the casting against bulging. The unit may be used with either a flexible starter bar or slightly modified with a rigid bar.

11 Claims, 5 Drawing Figures

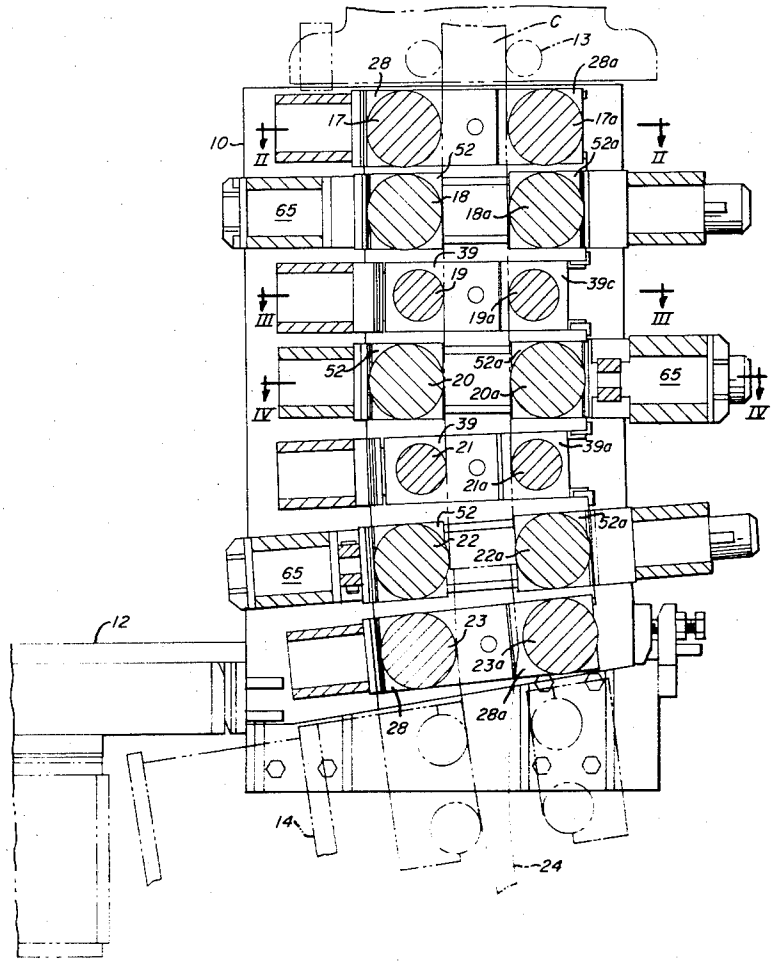

FIG. 1

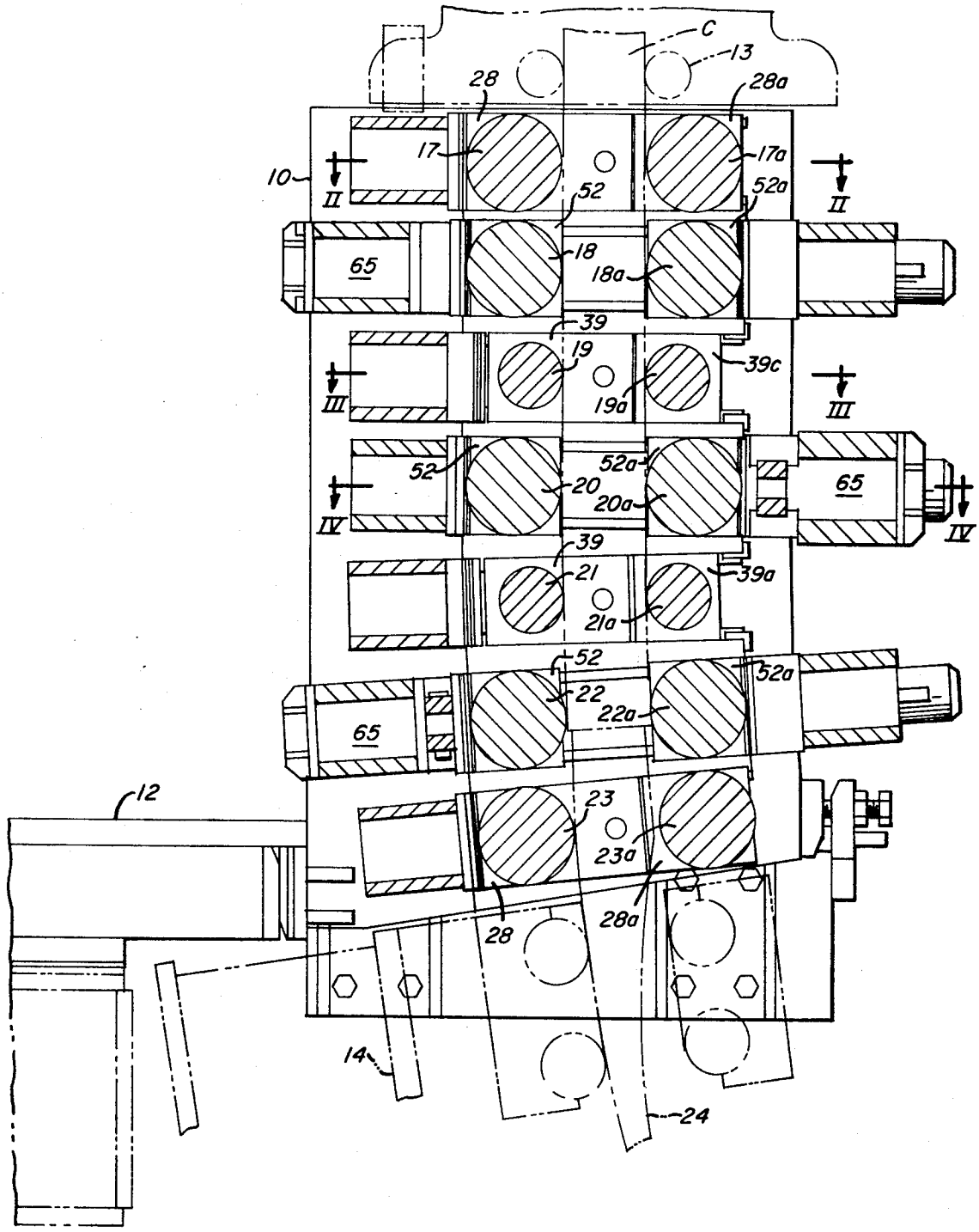
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FIG. 2

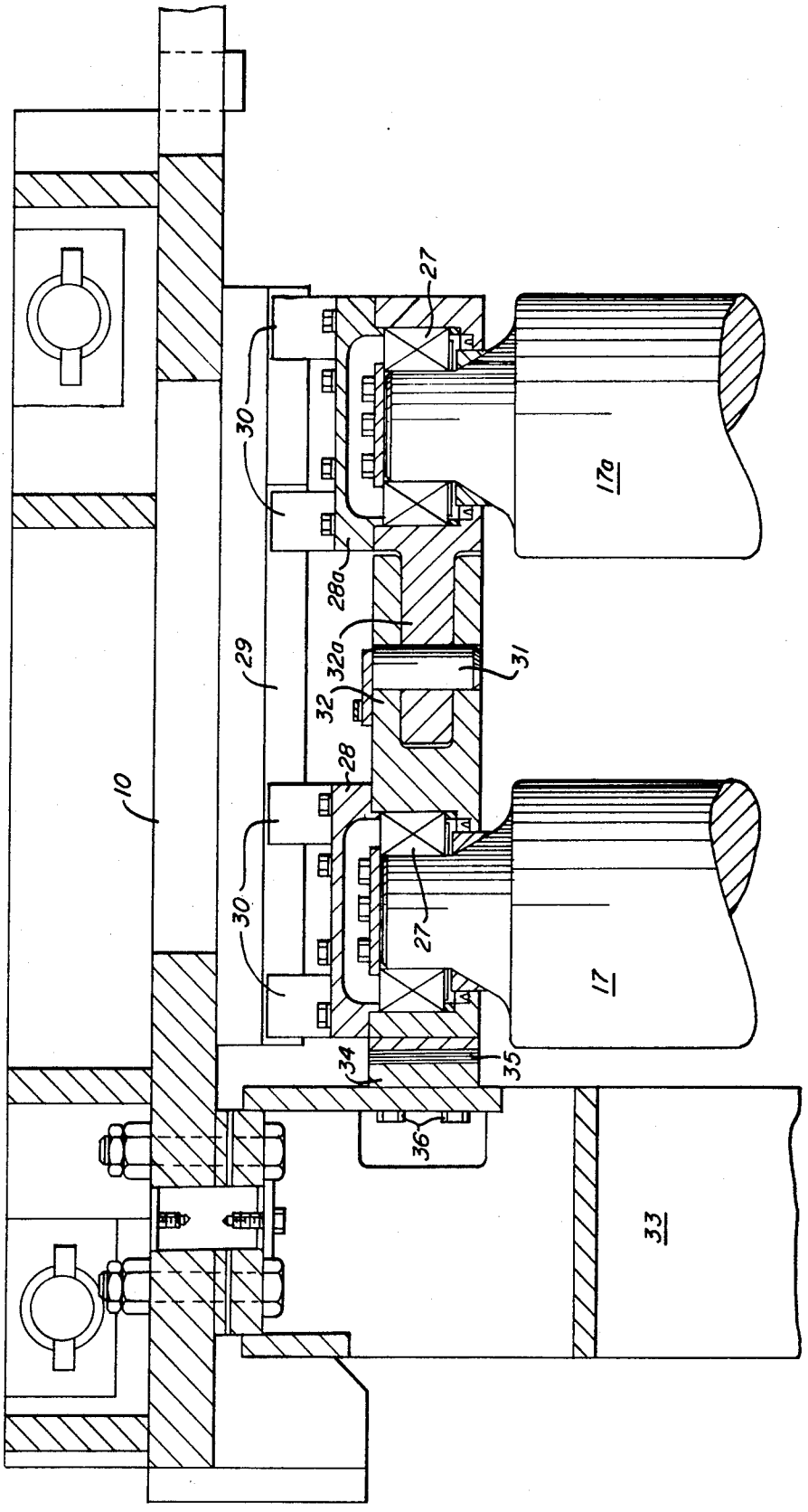

FIG. 3

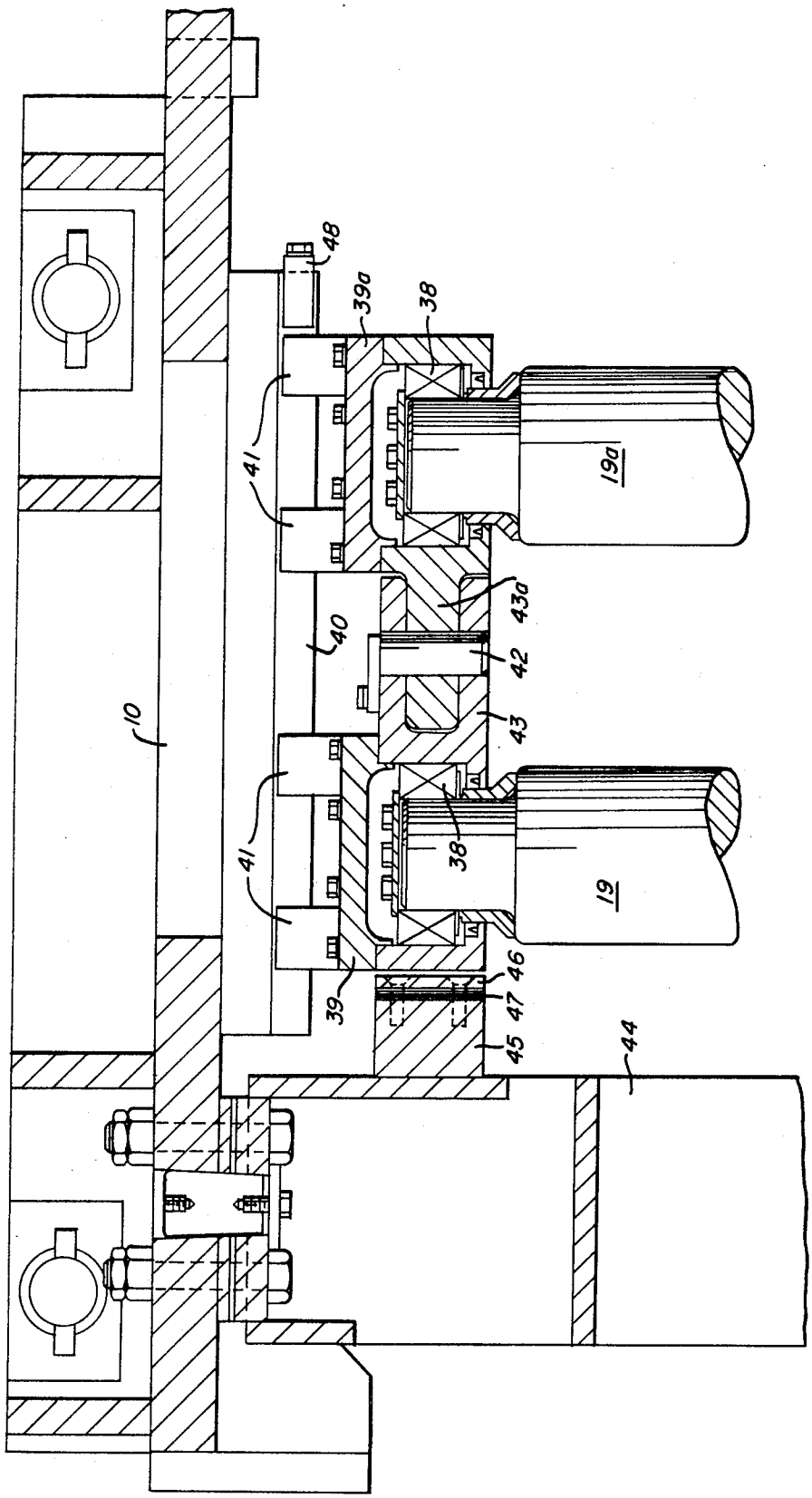

FIG. 4

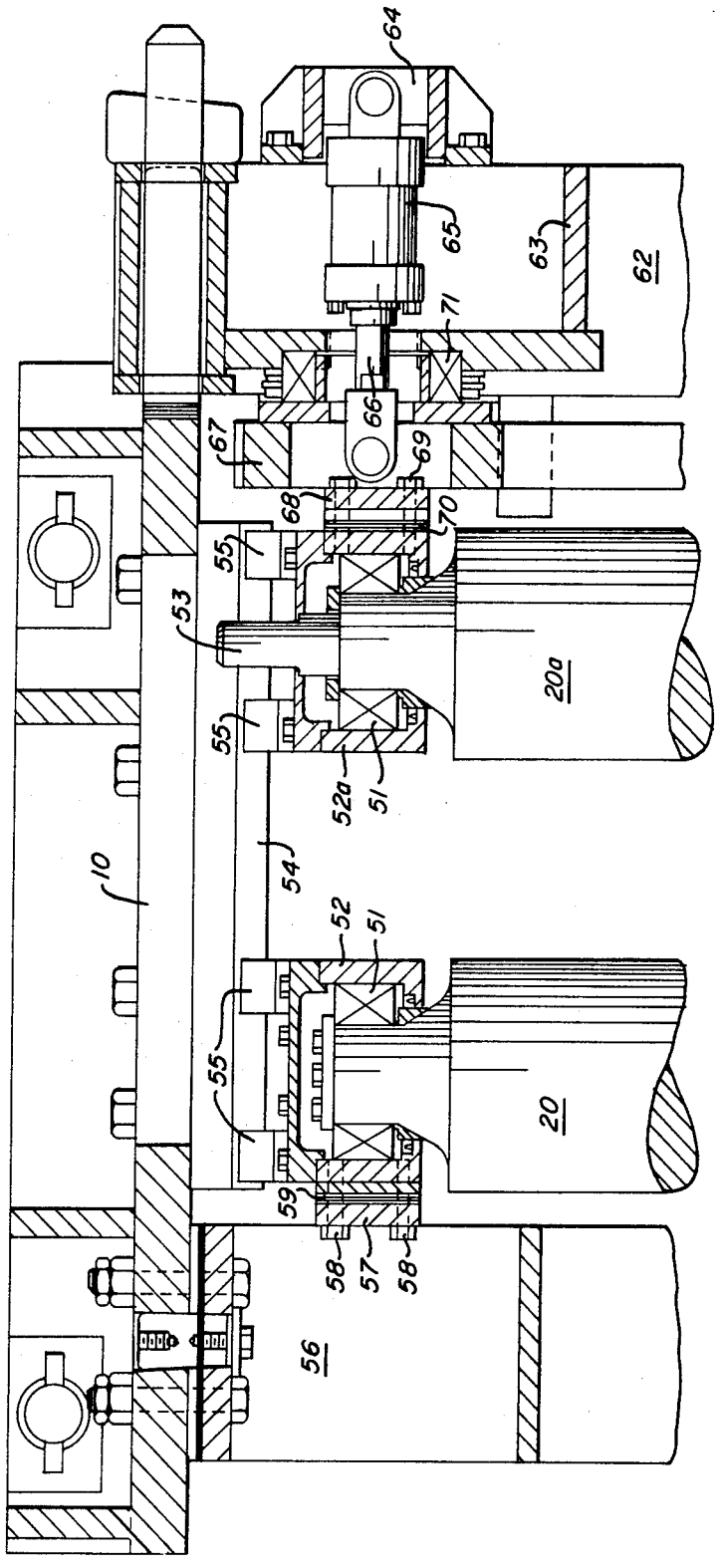
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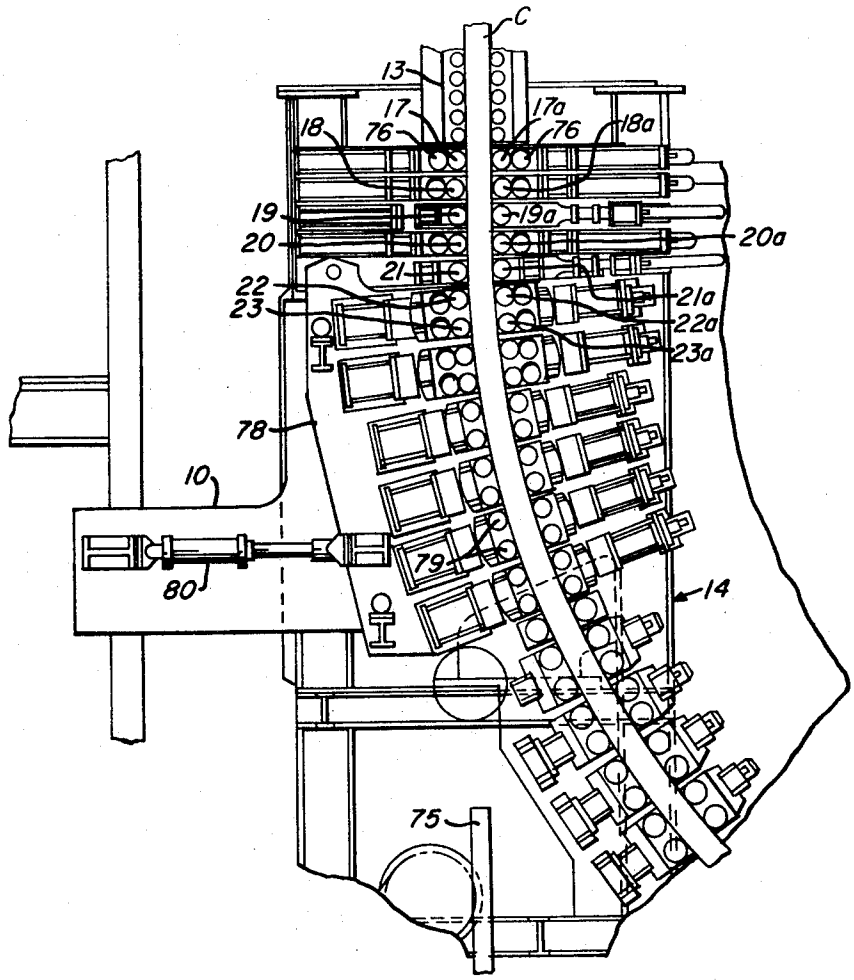
FIG. 5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BENDING-ROLL UNIT FOR CONTINUOUS-CASTING MACHINE

This invention relates to an improved bending-roll unit for a continuous-casting machine.

In a conventional continuous-casting operation, liquid metal is poured through an open-ended water-cooled vertically oscillating mold. A casting, which at this stage has only a relatively thin solidified skin and a liquid core, emerges continuously from the lower end of the mold. Immediately beneath the mold the casting travels through a guide-roll rack, usually idlers, where water is sprayed on its surface to effect further solidification. In the type of casting machine with which our invention is concerned, the mold is straight-sided, and the guide rolls define a vertical path of travel for the casting. At the beginning of a casting operation, a starter bar, which may be either flexible or rigid, is used to close the lower end of the mold. Below the guide rolls the casting travels between bending rolls which impart a curvature to the casting, and thence through a curved roll-rack, which changes its direction of travel from vertical to horizontal. Thereafter the casting is straightened and severed to appropriate lengths. If a flexible starter bar is used, it usually travels through the bending rolls and curved roll-rack ahead of the casting and is disconnected from the leading end of the casting beyond the straightener. If a rigid bar is used, it is disconnected from the leading end of the casting ahead of the curved roll rack.

In modern low-profile machines the casting does not solidify throughout until it has passed through the curved roll-rack and straightener. A tractive force is applied to the casting in the vicinity of the bending rolls to bend it and propel it between the various rolls. At this location the skin is quite thin and great care must be exercised in applying the necessary force. Otherwise internal defects may appear in the casting, or the skin may bulge or crack, or actually rupture and permit a break-out of liquid metal. Most machines used heretofore have power driven pinch rolls located above and/or below the bending rolls for supplying the tractive force. Such pinch rolls add to the height of the machine.

An object of our invention is to provide an improved bending-roll unit which embodies a combination of driven rolls, idler rolls journaled on fixed axes, and floating idler rolls to confine the casting against bulging and at the same time apply a tractive force in a way to avoid damaging the casting.

A further object is to provide an improved bending-roll unit in which the bending rolls themselves are driven, whereby they also apply the initial tractive force for propelling the casting and eliminate the need for separate power-driven pinch rolls for this purpose, thus contributing to reduction of the machine height.

A further object is to provide an improved bending-roll unit in which the actual bending rolls include driven rolls and idlers arranged in opposed pairs interspersed with floating idlers to confine the casting.

In the drawings:

FIG. 1 is a vertical section view of a bending-roll unit constructed in accordance with our invention for use with a flexible starter bar;

FIG. 2 is a horizontal half-section on line II—II of FIG. 1;

FIG. 3 is a horizontal half-section on line III—III of FIG. 1;

FIG. 4 is a horizontal half-section on line IV—IV of FIG. 1; and

FIG. 5 is a partly diagrammatic side elevation view of a modified unit for use with a rigid starter bar.

The embodiment of our bending-roll unit shown in FIG. 1 includes rigid spaced-apart upright frame members **10** fixed to a supporting structure **12.** The unit is installed in a continuous-casting machine directly below a guide-roll rack **13** and ahead of a curved roll-rack **14,** but we have not shown these parts in detail since they can be of conventional construction. Our unit includes opposed pairs of rolls as follows from left to right and top to bottom: (a) a pair of idlers **17–17*a*** journaled on fixed axes, (b) a shiftable driven roll **18** and an idler **18*a*** journaled on a fixed axis, (c) a pair of floating idlers **19–19*a***, (d) an idler **20** journaled on a fixed axis and a shiftable driven roll **20*a***, (e) a pair of floating idlers **21–21*a***, (f) a shiftable driven roll **22** and an idler **22*a*** journaled on a fixed axis, and (g) a pair of idlers **23–23*a*** journaled on fixed axes. Rolls **17–17*a***, **18–18*a***, **20–20*a***, **22–22*a***, and **23–23*a*** sustain the forces required to bend the casting. These rolls are illustrated as of relatively large diameter (for example 12 inches) to enable them to sustain such forces, but alternatively we can use smaller rolls equipped with back-up rolls, as in the modification shown in FIG. **5.** Rolls **19–19*a*** and **21–21*a*** can be of smaller diameter (for example 8 inches), since they serve merely to maintain the casting in line with the force-sustaining rolls and prevent the skin from bulging. The function of the individual rolls is explained in detail hereinafter. FIG. **1** shows diagrammatically a portion of a flexible starter bar **24,** which can be conventional, and a casting C within our bending roll unit.

FIG. **2** shows the structure in which we journal the uppermost pair of idlers **17–17*a***. The structure in which we journal the lowermost pair **23–23*a*** is similar; hence we do not repeat the showing. Rolls **17** and **17*a*** are journaled in bearings **27** housed within chocks **28** and **28*a*** respectively. The inside face of the frame member **10** carries a fixed horizontal guideway **29.** The outer faces of chocks **28** and **28*a*** carry tabs **30** which rest on this guideway. The two chocks are tied together with a pin **31** which extends through interfitting projections **32** and **32*a*** on the chocks. A transverse member **33** extends between the two frame members **10** at the left as viewed in FIG. **2** and is bolted thereto. The transverse member carries a fixed abutment **34.** We insert shims **35** between the faces of chock **28** and abutment **34.** A plurality of bolts **36** extend through abutment **34** and shims **35** and into the wall of chock **28** to hold the assembly of the two chocks **28** and **28*a*** in a fixed position.

FIG. **3** shows the structure in which we journal the upper pair of floating idlers **19–19*a***. The structure in which we journal the lower pair **21–21*a*** is similar; hence we do not repeat the showing. Rolls **19** and **19*a*** are journaled in bearings **38** housed within chocks **39** and **39a** respectively. The inside face of the frame member **10** carries a fixed horizontal guideway **40.** The outer faces of chocks **39** and **39*a*** carry tabs **41** which rest on this guideway. The two chocks are tied together with a pin **42** which extends through intermeshing projections **43** and **43*a*** on the chocks. A transverse member **44** extends between the two frame members **10** at the left as viewed in FIG. **3,** and is bolted thereto. The transverse member carries an abutment **45** to which we

bolt a plate 46 and a plurality of shims 47 between the abutment and plate. Guideway 40 has a stop 48 at the end opposite abutment 45. The assembly of chocks 39 and 39*a* is free to move along guideway 40 within the limits permitted by engagement of chock 39 with plate 46 or by engagement of chock 39*a* with stop 48.

FIG. 4 shows the structure in which we journal the pair of rolls 20–20*a*. These rolls are journaled in bearings 51 housed within chocks 52 and 52*a*. The driven roll 20*a* has a neck 53 which extends from the chock and is connected to a suitable drive (not shown). The inside face of the frame member 10 carries a fixed horizontal guideway 54. The outer faces of chocks 52 and 52*a* carry tabs 55 which rest on this guideway. A transverse member 56 extends between the two frame members 10 at the left as viewed in FIG. 4. The transverse member 56 carries an abutment 57 to which we fix the chock 52 with a plurality of bolts 58. We interpose shims 59 between the faces of chock 52 and abutment 57. Another transverse member 62 extends between the two frame members 10 at the right as viewed in FIG. 4, and carries a housing 63 and lug 64. We connect a fluid pressure cylinder 65 to lug 64. The cylinder lies within housing 63 and contains a reciprocable piston and piston rod 66. We connect the free end of the piston rod to a movable transverse bar 67. The bar carries an abutment 68, to which we fix the chock 52*a* with a plurality of bolts 69. We interpose shims 70 between the faces of chock 52*a* and abutment 68. We place a load cell 71 between the faces of housing 63 and bar 67. The structures in which we journal the pairs of rolls 18–18*a* and 22–22*a* are similar, except reversed, and we can omit the load cell. Hence we do not repeat the detailed showing, but in FIG. 1 identify corresponding parts with the same reference numerals.

The driven roll 20*a* defines the tangent line where the casting C first acquires a curvature. The three pairs of rolls above the tangent line define a straight path for the casting and three pairs below the tangent line a curved path. Roll 20*a* is the fulcrum roll which sustains the full force required to bend the casting. The driven rolls 18 and 22 each sustain approximately one-half the reaction force at the convex side of the casting opposite the direction of bending. In each instance pressure within the respective cylinders 65 forces the driven roll against the face of the casting C, backed up by the unyielding idler 20 at the convex side of the casting and idlers 18*a* and 22*a* at the concave side. The uppermost and lowermost pairs of idlers 17–17*a* and 23–23*a* minimize any secondary bending reactions. Rolls 17–17*a* assure that no bending forces are transmitted to the guide roll rack 13. Rolls 23–23*a* assure that the leading and trailing ends of each casting C have the proper radius to pass through the curved roll rack 14. The pairs of idlers 19–19*a* and 21–21*a* confine the casting against bulging as it travels between the pairs of rolls which actually bend the casting. These idlers float to follow the contour of the casting and thus eliminate any abnormal loading caused by misalignment of the other rolls. We control the precise position of the various idlers which rotate on fixed axes by insertion and removal of shims 35, 47, 59 and 70.

FIG. 5 shows a modification of our bending roll unit for use with a rigid starter bar 75. The pairs of rolls 17–17*a*, 18–18*a*, 19–19*a*, 20–20*a*, and 21–21*a* may be similar to corresponding rolls in the embodiment of our invention shown in FIG. 1, but in FIG. 5 we have illustrated the force-sustaining rolls 17–17*a*, 18–18*a* and 20–20*a* as of smaller diameter equipped with back-up rolls 76. The frame 10 of the modified unit includes a switch section 78 below the floating idlers 21–21*a* at the convex side of the casting C. The shiftable driven roll 22 and the idler 23 are journaled in the switch section. We still refer to the idler 23 as journaled on a fixed axis, since its axis remains fixed in any given position of the switch section. The idlers 22*a* and 23*a* may be similar to corresponding rolls shown in FIG. 1. Several rolls 79 of the curved roll rack 14 also are journaled in the switch section 78. The switch section is pivoted on a horizontal axis to the fixed portion of frame 10 and is equipped with a fluid pressure mechanism 80 for moving it between open and closed positions. The driven roll 22 shifts through only a small arc as the section opens and closes, and is equipped with a suitable flexible coupling (not shown) whereby its drive does not interfere with shifting.

In operation, we open the switch section 78 before beginning a casting operation, and raise the starter bar 75. Thereafter the switch section remains open until the descending starter bar passes the bending roll unit. We employ known mechanisms for disconnecting the starter bar from the leading end of the casting, for example, as shown in an earlier patent of the present coinventor Gallucci, U.S. Pat. No. 3,448,789. After we disconnect the starter bar, we close the switch section and continue the operation as in the embodiment shown in FIG. 1.

In both embodiments the driven rolls of the bending roll unit not only serve to bend the casting but also to apply the initial tractive force for propelling the casting. Thus we avoid need for separate pinch rolls to apply tractive forces to the casting, with a resulting lowering of several feet in the height of the machine. The starter bar 24 or 75 may not be as thick as the casting C. At the start of a casting operation, the shiftable mounting of the driven rolls 18, 20*a* and 22*a* enables their respective cylinders 65 to force the roll into engagement with the starter bar, where they act initially as a brake to support the bar. We connect the load cell 71 to a suitable indicating instrument (not shown) so that we can immediately detect any improper force. Thus the casting is closely confined and all tractive forces are distributed in a way to damage the casting.

We claim:

1. A bending roll unit for a continuous-casting machine, said unit comprising a frame, a plurality of opposed pairs of rolls, means journaling said rolls in said frame, said rolls including:

a driven fulcrum roll and an opposed idler, said fulcrum roll being shiftable and defining a tangent line where a casting first acquires a curvature, said idler being journaled on a fixed axis;

a driven reaction roll and an opposed idler above said first-named idler and said fulcrum roll respectively, said reaction roll being shiftable and said second-named idler being journaled on a fixed axis;

a driven reaction roll and an opposed idler below said first-named idler and said fulcrum roll respectively, said second-named reaction roll being shiftable and said third-named idler being journaled on a fixed axis; and

idlers journaled on fixed axis above said second-named pair and below said third-named pair;

the rolls above said tangent line defining a straight path for a casting and those below said tangent line defining a curved path.

2. A bending roll unit as defined in claim **1** comprising in addition an opposed pair of floating idlers intermediate said first and second-named pairs of rolls and an opposed pair of floating idlers intermediate said first and third-named pairs of rolls.

3. A unit as defined in claim **2** in which said frame is fixed for use with a flexible starter bar.

4. A unit as defined in claim **2** in which said frame includes a switch section below said last-named floating idlers, said second-named driven reaction roll and one of said last-named idlers being journaled in said switch section for use with a rigid starter bar.

5. A bending roll unit as defined in claim **1** comprising in addition yieldable means carried by said frame urging said shiftable driven rolls toward their respective opposed idlers.

6. In a continuous-casting machine which includes a straight guide roll rack, a starter bar, a bending-roll unit directly following said rack therebelow, and a curved roll rack below said bending roll unit, the improvement in which said bending roll unit comprises a driven fulcrum roll defining a tangent line above which a casting is straight and below which a casting has a curvature, driven reaction rolls above and below said fulcrum roll at the convex side of the casting, and idlers opposed to said fulcrum and reaction rolls for engaging the opposite face of the casting, said driven rolls serving not only to bend the casting but also applying the initial tractive force for propelling the casting.

7. A bending roll unit as defined in claim **6** in which said fulcrum and reaction rolls are shiftable and said idlers are journaled on fixed axes.

8. A bending roll unit as defined in claim **6** including in addition an opposed pair of floating idlers immediately above said fulcrum roll and its opposed idler, and a second opposed pair of floating idlers immediately below said fulcrum roll and its opposed idler.

9. A bending roll unit as defined in claim **6** including in addition opposed pairs of idlers journaled on fixed axes above and below said reaction rolls and their opposed idlers.

10. In a continuous-casting machine as defined in claim **6**, said starter bar being flexible, and said rolls being journaled in a fixed frame.

11. In a continuous casting machine as defined in claim **6**, said starter bar being rigid, and rolls at the convex side of the casting below said fulcrum roll being journaled in a switch section of the frame.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,753,461 Dated August 21, 1973

Inventor(s) Francis Gallucci et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 47, after "way" insert -- not --.

Signed and Sealed this

thirteenth Day of *April 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks