United States Patent

[11] 3,590,908

[72] Inventors **Kurt Reinfeld;**
Emmanuel V. Gouye, both of Pittsburgh, Pa.

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[73] Assignee **Koppers Company, Inc.**

[54] **APPARATUS FOR BENDING CONTINUOUS CAST SLABS**
7 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **164/282**
[51] **Int. Cl.** **B22d 11/12**
[50] **Field of Search** 164/82, 281, 282, 283

[56] **References Cited**

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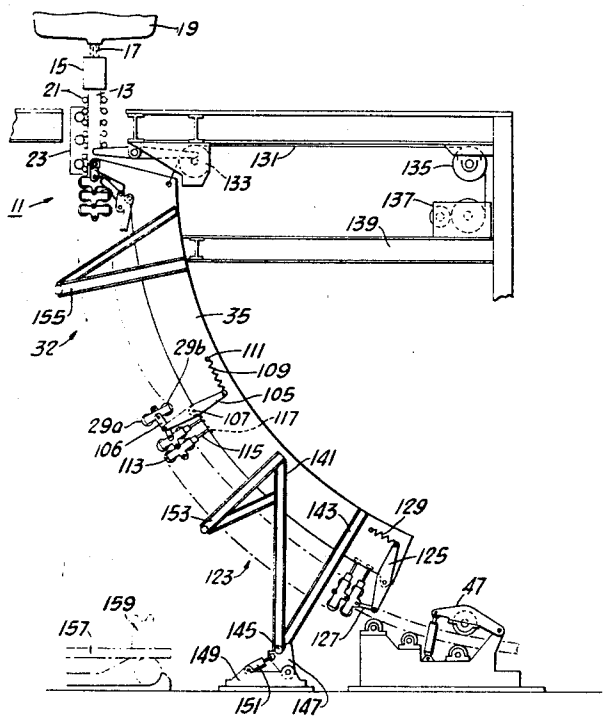
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Primary Examiner—J. Spencer Overholser
Assistant Examiner—John E. Roethel
Attorneys—Sherman H. Barber and Olin E. Williams

ABSTRACT: A slab emerging from a casting mold is supported by an articulated roller chain resiliently biased and mounted to a frame. Groups of rollers comprising such chain are mounted to equalizing brackets, and one group of rollers is secured to a piston-cylinder assembly. When the piston cylinder assembly is actuated, the rollers connected thereto exert a bending force on the slab which curves and is supported by the articulated roller chain.



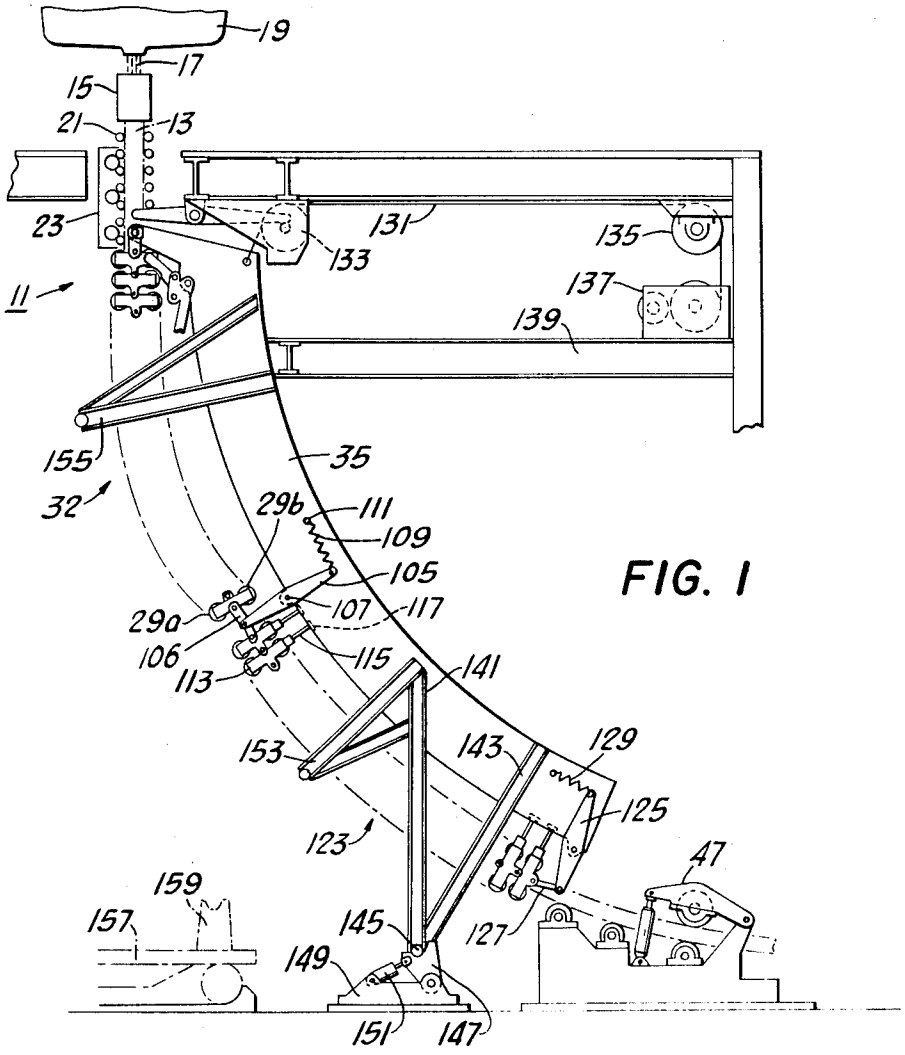


FIG. 1

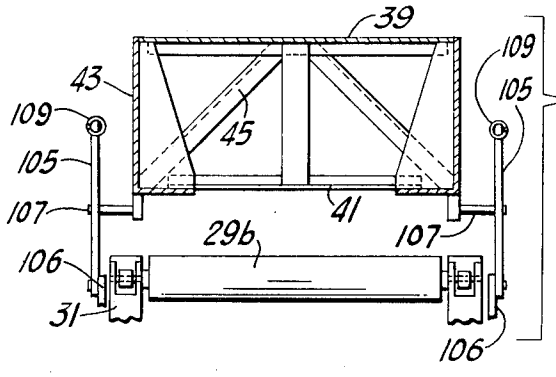


FIG. 4

INVENTORS
KURT REINFELD &
EMMANUEL V. GOUYE
BY Sherman A. Barker
Attorney

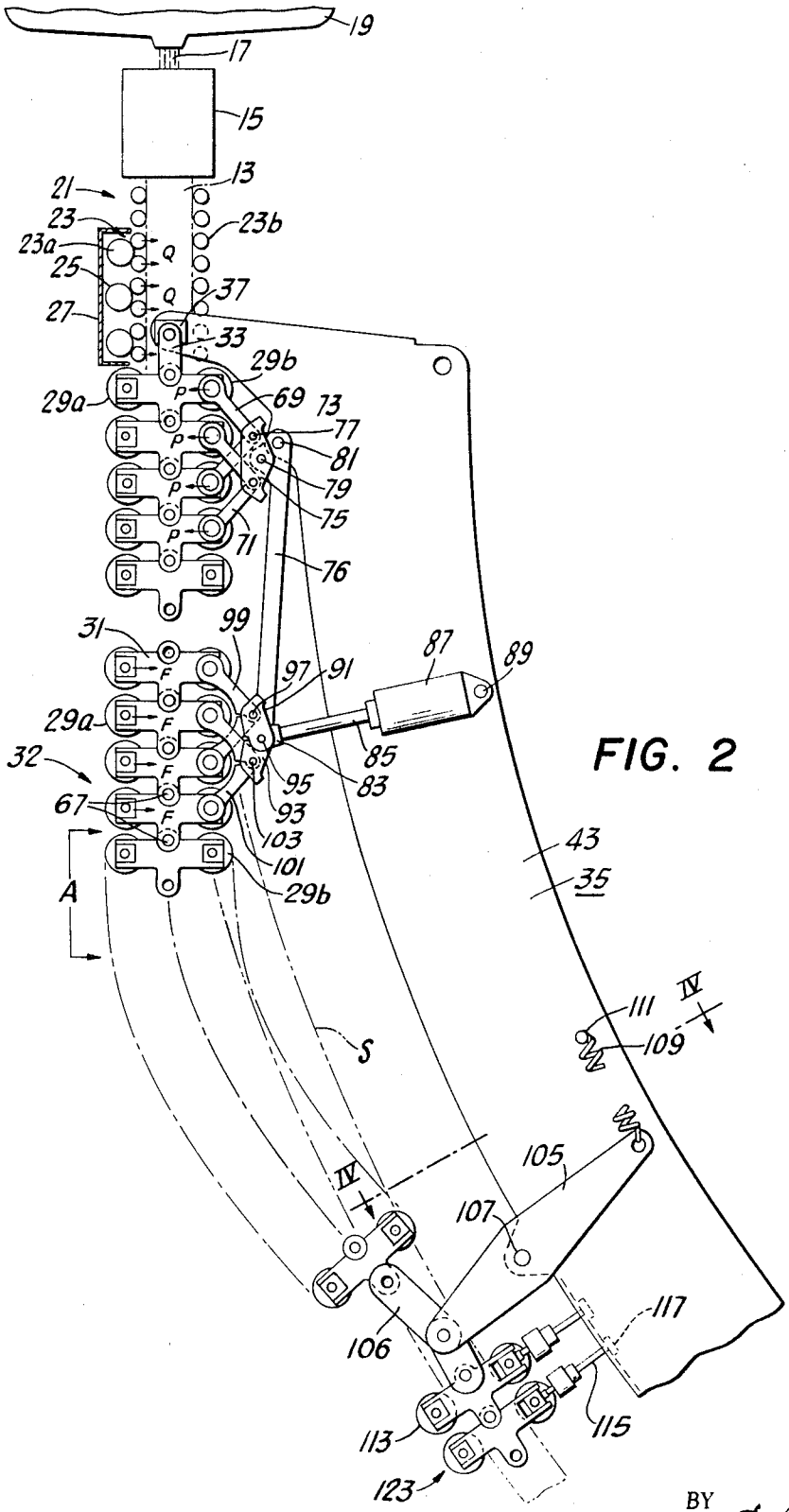


FIG. 2

INVENTORS
KURT REINFELD &
EMMANUEL V. GOUYE

BY
Sherman H. Barber
Attorney

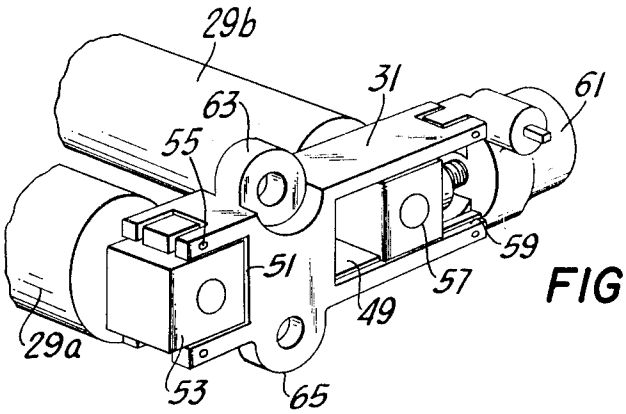


FIG. 3

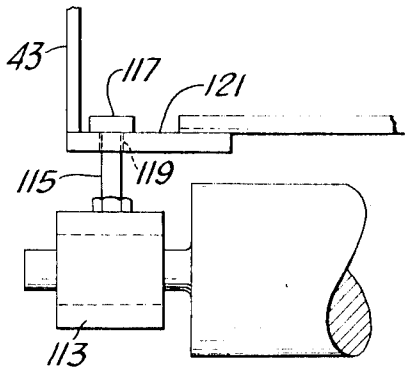


FIG. 6

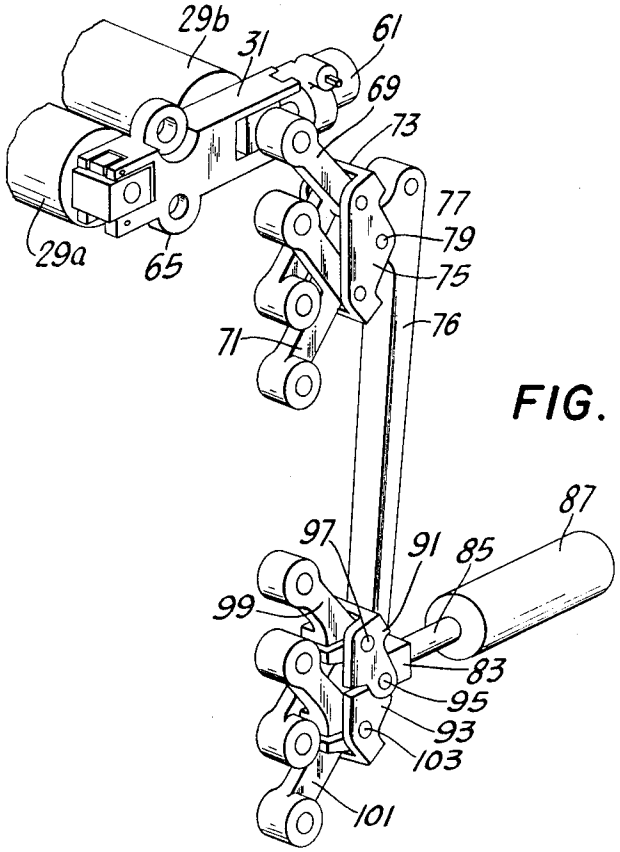


FIG. 5

INVENTORS
KURT REINFELD &
EMMANUEL V. GOUYE
BY
Shermant H. Barber
Attorney

APPARATUS FOR BENDING CONTINUOUS CAST SLABS

BACKGROUND OF THE INVENTION

In the art of continuous metal casting, it has been relatively easy heretofore to bend continuous cast strands having square cross-sectional dimensions of, say 4"×4", and sections as large even as 8"×8". But, it has been hazardous to bend continuously cast slabs using the same technique and apparatus due to the larger cross section of the slabs and due to the larger mass of liquid molten metal in the central core of the slab.

How the apparatus of the present invention effectively bends continuous cast slabs in an efficient manner, without danger of undue distortion to the slab contour and without fear of causing a breakout, will be readily apparent to those skilled in the art from the following description.

SUMMARY OF THE INVENTION

Apparatus for bending a continuous cast slab includes spaced apart groups of rollers mounted to equalizing brackets interconnected together and with other rollers as a slab-supporting chain. One group of rollers is fixed as a fulcrum about which the slab curves, and one other group of rollers is movable and exerts bending forces on the slab.

For a further understanding of the invention and for features and advantages thereof reference may be made to the following description, taken in conjunction with the drawing, which shows for the purpose of exemplification one embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWING

One embodiment of the invention is illustrated in the drawing wherein:

FIG. 1 is a schematic elevational view of a continuous slab-casting machine including apparatus in accordance with the invention;

FIG. 2 is a schematic elevational view, at a larger scale, of a portion of the apparatus of FIG. 1;

FIG. 3 is a schematic perspective view of a double-roll support bracket portion of the apparatus of FIG. 1;

FIG. 4 is a sectional view along line IV–IV of FIG. 2;

FIG. 5 is a schematic perspective view of a proportioning bracket portion of the apparatus of FIG. 2; and

FIG. 6 is a sectional view of a detail of a portion of the apparatus of FIG. 1.

DETAILED DESCRIPTION

FIG. 1 illustrates schematically a continuous casting machine **11** for making and bending continuously cast slabs **13** that emerge from a vertically reciprocable casting mold **15** into which flows molten metal **17** from a tundish **19**.

The continuous cast slab **13** has a rectangular cross section from which slabs of finite length may be severed in the manner and by means of the apparatus described in application Ser. No. 812,979 filed Apr. 3, 1969.

Below the bottom of the mold **15**, there are a plurality of vertically arranged slab-supporting rollers **21** arranged in opposite pairs. Such rollers **21** are located in the spray chamber zone wherein sprays of water impinge upon and cool the outer surface of the cast slab **13**.

Below the slab-supporting rollers **21**, there is another group of rollers **23** that are arranged also in opposite pairs; such rollers being designated **23***a*, **23***b*, and there being several pairs of such rollers disposed vertically, as shown in FIGS. **1** and **2**. Pairs of rollers **23***a*, **23***b*, are journaled in a suitable stationary fixed structure **27**.

Below the pairs of rollers **23***a*, **23***b* there are other pairs of rollers **29***a*, **29***b* which are horizontally arranged on opposite sides of the cast slab **13**. The rollers **29***a*, **29***b* of each pair are journaled in a double-roll bracket **31** having the form shown generally in FIG. **3**. Each roll-bracket **31** is pin connected to another double-roll bracket to form an articulated roller chain **32** for supporting the cast slab **13**. The uppermost double-roll bracket **31** is pin connected to a link **33** on each side of a support frame **35** that carries two anchors **37**, about as shown in FIG. **4**.

The support frame **35** may have any suitable shape such as a truss type of structure comprising upper **39** and lower **41** chord members, with vertical sideplates **43** of angular cross section and intermediary diagonal tie members **45**. The sideplate members **43** may, of course, also be truss-type structures if preferred. The support frame **35** extends arcuately, as shown in FIG. **1**, from a location just below the structure that supports the casting mold **15** to a lower terminus adjacent bending and straightening rolls **47**.

Each double-roll bracket **31** is a generally rectangular-shaped member that has a elongate slot **49** in one end and a shorter slot **51** in the opposite end. A bearing **53** is fixedly mounted as by pins **55** in the slot **51**, and the roller **29***a* is journaled in this bearing **53**. A similar bearing **57** is disposed in the elongate slot **49** and is cooperative with grooves **59** that permit the bearing **57** to move laterally toward and away from the fixed bearing **53**. The roller **29***b* is journaled in the bearing **57**.

A screwjack **61** is fixed to the double-roll bracket **31** where shown, and is connected to the bearing **57**. The screwjack may be operated either manually or by a power tool to move the bearing **57** and roller **29***b* nearer to, or further away from the roll **29***a*, which remains in a fixed position. The cast slab **13** is located between the rollers **29***a*, **29***b*, and by means of the screwjack **61** the rollers **29***a*, **29***b* may be spaced apart a distance equal to the thickness of the slab **13**.

The top and the bottom surfaces of the double-roll support bracket **31** have perforated ears or lugs **63**, **65** respectively and, the lug **65** coacts with the lug **63** of an adjacent bracket above and below so that when a pivot pin **67** is inserted into the hole in each cooperating lug, the double-roll supporting brackets are pivotally connected together as the articulated chain **32**.

The uppermost group of rollers **29***b* are also journaled individually in arms **69**, **71** of a proportioning bracket **73**. The proportioning bracket **73** (FIG. **5**) has a channel-shaped housing **75** to which the arms **69**, **71** are pivotally connected as by pins **77**. The housing **75** itself is pivotally connected as by pin **79** to an elongate arm **76** that is pivotally connected as by pin **81** (FIG. **2**) to the sideplate member **43** of the supporting frame **35**.

The lower end of the elongate member **76** is fixed to a rectangular-shaped blocklike portion **83** that is secured to the free end of a piston rod **85** that cooperates with a fluid-actuated cylinder **87**. The fluid-actuated cylinder is pivotally secured as by pin **89** to the sideplate member **43**, about where shown in FIG. **2**.

A pair of channel-shaped housings **91**, **93** are pivotally connected together and to the blocklike portion **83** by means of a common pivot pin **95**. To the housing **91**, there is pivotally connected, as by pivot pin **97**, an equalizing arm **99**, and in like manner an equalizing arm **101** is pivotally connected as by pivot pin **103** to housing **93**.

At a point about midway along the length of the articulated roller support chain **32**, one end of an arm **105** is connected to the slab-supporting chain **68** by means of a connecting link **106** and the arm is pivotally mounted, as by pivot pin **107**, to the sidewall **43** of the supporting frame **35**. The free other end of the arm **105** is secured to one end of a tension spring **109** that is also secured to the sidewall **43** by a pin **111**.

Below the arm **105**, pairs of double-roller brackets **113** (FIG. **6**) are mounted to rods **115** that have a tee-head **117** at one end. The tee-head of each rod **115** cooperates with a slot **119** in a bottom flange portion **121** of the sidewall **43** of support frame **35**.

The double-roller brackets **113** are similar to the double-roller brackets **31** except that rod **115** is fixedly secured to the bracket **113**. The upper end of the interconnected double-roller brackets **113**, forming a roller chain portion **123**, are

also pivotally connected to the lower end of the roller chain 32 and to the arm 105. The lower end of the roller chain portion 123 is connected to another pivoted arm 125 by means of a connecting link 17. The arm 125, like arm 105, is resiliently biased by a spring 129, like spring 109, to the sidewall 43.

The upper end of the support frame 35 is connected to a cable 131 that passes over sheaves 133, 135 mounted to the structural support for the casting mold and the cable 131 is wound onto the drum portion of a powered hoisting winch 137 that is mounted to the other horizontal supporting structure 139. The lower end of the support frame 35 is provided with a pair of fixed legs 141, 143 having a common shaft 145 that cooperates with a pivotable fulcrum 147. The fulcrum 147 is pivotable about a base 149 by means of a fluid-actuated cylinder 151.

The support frame 35 also has two other fixed legs 153, 155; the leg 153 being located adjacent the lower supporting leg 141, and the leg 155 being located adjacent the upper end of the support frame 35. These legs 153, 155 coact with a horizontally movable car 157 on which is mounted a support cradle 159.

In operation, molten metal 17 is continually poured into mold 15 which is cooled in a normal manner, and a cast slab 13 emerges continually from the bottom of the mold. The cast slab is straight as it descends, and the leading edge of the strand 13 first engages the rolls 29*a* in the region A shown in FIG. 2. The slab at first flexes the roller chain 32 so that the upper portion of it is vertically straight; the arm 105 pivoting clockwise against the tension spring 109.

As soon as the leading edge of the strand passes zone A, the piston-cylinder 87 is actuated so that the rollers 29*a* in the group of rollers linked to the equalizing arms 99, 101, exert forces F against one surface of the slab 13. These forces F are resisted by reactionary forces P exerted by rollers 29*b* against the opposite surface of the slab, and other fulcrum reactionary forces Q are exerted against the one surface of the slab by the fixed group of rollers 23*a*.

As the rollers 29*a* urge the leading edge portion of the slab 13 toward the right, as viewed in FIG. 2, the slab curves toward the right and finally, after the leading straight portion of the slab has passed through the straightener rolls, the slabs follows the arcuate path shown in dotted outline in FIG. 2.

Those skilled in the art will recognize that, when the upper portion of the roller-supporting chain 32, is in the position shown in FIG. 2, the lower portion of the chain moves upwardly and to the left, as viewed in FIG. 1. The tee-headed bolts slide in the slots provided in the lower horizontal flange of the support frame. The lower portion of the roller chain is also resiliently biased by an arm, wherefore, the chain assumes a curve that follows the dotted outlines of the slab shown in FIG. 2.

Those skilled in the art will recognize several significant features and advantages of the present invention among which are:

That the apparatus for bending slabs is effective to bend slabs of various thickness and width, the roller brackets including one roller that is adjustably positionable;

That the equalizing brackets and the rollers journaled thereto equally distribute the bending forces exerted on the slab by each roller;

That a plurality of rollers is used in each group or cluster so that the force exerted by each roller does not cause distortion or a breakout to the thin skin of the cast slab, but yet the cumulative forces of all of the rollers in any group is effective;

That the equalizing bracket directly connected to the piston-cylinder assembly is articulated so that each pair of rollers adjust to the changing curvature of the slab; and

That the roller-supporting chain can move out from its normal curved slab-supporting line, when forced out by the descending straight portion of the slab, but the chain being resiliently biased supports the slab in an arcuate path.

We claim:

1. A continuous casting machine comprising:
a. a tundish containing molten metal that flows into
b. a vertically reciprocable mold wherein the molten metal partially solidifies and from which a cast slab continually emerges;
c. a plurality of rollers disposed below said mold that exert reactionary forces on such slab;
d. a support frame;
e. means pivotally supporting one end of said frame;
f. means connected to the other end of said frame for holding said frame in operative relation to said mold;
g. a flexible chain for supporting said slab after it emerges from said mold said chain comprising:
i. a plurality of pairs of roll brackets pivotally interconnected together, each said bracket including
1. a fixed bearing and a movable bearing, with
ii. a pair of rollers journaled in each pair of brackets and on opposite sides of said slab, with
iii. means for moving said movable bearing relative to said fixed bearing;
h. means pivotally connecting one end of said flexible chain to said frame at a location adjacent said plurality of rollers;
i. means connected to the other end of said flexible chain for linearly extending said chain;
j. equalizer arms pivotally mounted to said frame;
k. first equalizer brackets mounted to said equalizer arms with each first equalizer bracket being mounted to a roller bracket;
l. second equalizer brackets mounted to said equalizer arms with each second equalizer bracket being mounted to a roller bracket, said first equalizer brackets being disposed and spaced-apart relation to such second equalizer brackets; and
m. means connected to said equalizer arm urging the rollers in the brackets mounted to said second equalizer brackets against said slab to bend said slab about the rollers mounted to the first equalizer brackets.

2. The invention of claim 1 wherein:
a. said means for linearly extending said chain includes:
i. an arm pivotally mounted to said frame,
ii. a link connecting said arm to said chain, and
iii. resilient bias means engaging said arm to pivot it and urge said chain in a linear direction.

3. The invention of claim 2 including:
a plurality of pairs of other roll brackets pivotally interconnected together, each said roll bracket including:
i. a fixed bearing and a movable bearing, with
ii. a pair of rollers journaled in each pair of roll brackets, and
iii. means for moving said movable bearing relative to said fixed bearing; and
b. means connecting each pair of other roll brackets to said frame whereby said other roll brackets are maintained in spaced-apart relation to said frame.

4. The invention of claim 3 wherein:
a. said plurality of pairs of other roll brackets are connected to said flexible chain; and including
b. means for linearly moving said plurality of other roll brackets relative to said frame.

5. The invention of claim 1 wherein:
a. said means connected to the other end of said frame includes a wire rope that is operatively connected to a powered winch.

6. The invention of claim 1 wherein:
a. said means pivotally supporting said frame includes:
i. arms fixed to said frame that engage
ii. a pivotable support, and
iii. means for pivoting said support for adjusting the position of the one end of said frame.

7. The invention of claim 1 including:
a. a backup roller coacting with each pair of said plurality of rollers that coact with one side of said slab.