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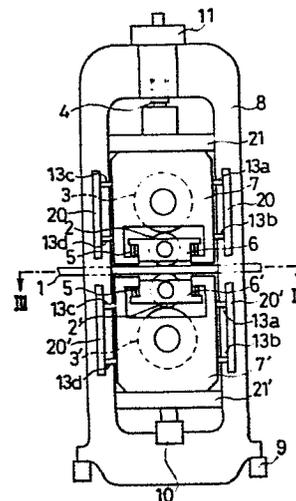
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⑤④ Four high mill of paired-roll-crossing type.

⑤⑦ A four high mill of a paired-roll-crossing type comprises an upper and a lower equalizer beams (21,21') held in contact, respectively, with the uppermost and lowermost surfaces of upper and lower backup roll (3,3') bearing cases (7,7') and made movable upwardly and downwardly within a housing, (8) roll-crossing devices mounted in the housing to turn the bearing cases that contain upper and lower work chocks (6,6') about a common vertical axis on the same horizontal plane so that upper and lower pairs of rolls can cross each other, and devices for separately setting the left and right roll gaps ( $\epsilon_1$ ,  $\epsilon_2$ ) between upper and lower work rolls (2, 2'). The mill further comprises work roll-bending devices mounted at both ends of the work rolls (2, 2').

FIG.1



This invention relates to improvements in a four high mill of a paired-roll-crossing type.

In recent years the demand for accuracy of thickness in the width direction of rolled metals has become more and more exacting. The demand has been met by initial crowning of rolls for rolling mills to make up for the deflections of the rolls under rolling load. This counter-measure necessitates having a large variety of initially crowned rolls in reserve, since the rolls must be replaced by those crowned otherwise whenever the rolling condition, such as the width or thickness or both of the slab or strip, are to be changed. The replacement of rolls lowers the rate of mill operation. Moreover, the crowning effect on rolls is highly variable because of the wear and thermal expansion of the rolls with the progress of rolling operation. For these reasons there has been an incessant need in the art for means of controlling the thickness of the workpiece width-ways on rolling mills without the necessity of changing the rolls.

As a solution to this control problem, bending of the work rolls has been proposed and has proved fairly effective. However, the strengths of the work roll shafts place limits upon the bending forces applicable, and the roll-bending method is not satisfactorily capable of correcting the thickness ununiformity in the width direction of the

workpiece. Especially where the mill has a relatively narrow rolling width for the length of rolls, the end cannot be fully achieved in most cases because of the interference by the contacting ends of the backup rolls and work rolls.

5           Therefore, the introduction of a rolling mill has been urgently called for which can freely control the thickness of the metal widthwise according to changes in the given rolling conditions, while using the same rolls.

10           Another disadvantage of the prior art is the necessity of frequently replacing the mill rolls, especially the work rolls, due to rapid wear on rolling operations. Conventional mills are designed to receive slabs or strips in such a manner that the middle point of the roll length matches the center of width of each passing piece. Consequently, the middle portions of the rolls wear faster than  
15           the end portions, and a common practice has been to remove each roll for replacement when its middle portion has worn beyond a predetermined limit. This means that the roll must be dismantled when its both ends are yet to reach  
20           the wear limits. The short life and frequent replacement of the rolls have lowered the rate of mill operation, and this has combined with the economical loss due to roll wear to have a serious effect upon the cost of product.

25           Thus, with the view to eliminating the disadvantages of the conventional rolling mills, this applicant has

already proposed novel four high mills, as disclosed in the specifications (with drawings) of copending Japanese Patent Application Nos. 138837/1978 and 59327/1979, which are capable of controlling the thickness extensively width-  
5 wise of the workpiece using the same rolls and more than doubling their ordinary spans of life.

Those rolling mills, of the four high type, include means for separately setting the left and right roll gaps, oil hydraulic jacks for roll bending, and a paired-roll-  
10 crossing mechanism which can be adjusted to move the pair of the upper work roll and backup roll and the pair of the lower work roll and backup roll to cross each other at predetermined angles with respect to a line normal to the rolling direction. In this way they can attain the end  
15 described above.

However, when the paired-roll-crossing mechanism is adjusted to turn the upper and lower pairs of rolls to the points where they cross at certain angles to a line normal to the rolling direction, there will occur horizontal  
20 deviations of the center points of the upper backup roll bearings and those of the reduction screws, away from each other. Bending moments corresponding to the amounts of deviations will develop in the screws, adversely affecting the screw operation. Similarly, the center points of the  
25 lower backup roll bearings and those of reduction cylinders

undergo relative horizontal deviations, producing bending moments in the cylinders, too, and thereby having unfavorable effects upon the same.

This invention is aimed at overcoming the drawbacks  
5 of the proposed mills, and it provides a four high mill of a paired-roll-crossing type characterized in that an upper and a lower equalizer beams are held in contact, respectively, with the uppermost and lowermost surfaces of upper and lower backup roll bearing cases and made movable upwardly  
10 and downwardly within a housing, roll-crossing devices are mounted in the housing to turn the bearing cases that contain upper and lower work roll chocks about a common vertical axis on the same horizontal plane so that upper and lower pairs of rolls can cross each other, and devices  
15 are provided for separately setting the left and right roll gaps between upper and lower work rolls.

The invention also provides a four high mill of a paired-roll-crossing type comprising an upper and a lower equalizer beams held in contact, respectively, with the  
20 uppermost and lowermost surfaces of backup roll bearing cases and made vertically movable within a housing, roll-crossing devices mounted in the housing to turn the bearing cases that contain work roll chocks about a common vertical axis on the same horizontal plane so that upper  
25 and lower pairs of rolls can cross each other, and devices

for separately setting the left and right roll gaps between upper and lower work rolls, characterized in that work roll bending devices are mounted at both ends of the work rolls.

Other objects and advantages of the present invention will become apparent when an embodiment thereof is considered in connection with the accompanying drawing, in which:

FIG. 1 is a diagrammatic front view of an embodiment of the invention;

FIG. 2 is a diagrammatic side view of the embodiment;  
10 and

FIG. 3 is a sectional view taken along line III-III of FIG. 1.

Throughout the figures the numeral 1 indicates a slab or strip of steel to be rolled by a pair of work rolls 2, 2', which are held one above another and supported, 15 respectively, by work roll chocks 6, 6' as shown. A pair of backup rolls 3, 3', in rolling contact with the non-working sides of the work rolls 2, 2', are held within upper and lower bearing cases 7, 7' for the backup rolls. 20 On tops of housing frames 8, joined together at the bottoms by shoe plates 9, are mounted a pair of screw-down devices 11 equipped with a screw 4 each. Near the lower ends of the housing frames 8, there are installed a pair of hydraulic reduction cylinders 10.

25 The pair of screw-down devices 11 equipped with the

screws 4 constitute means for separately setting the left and right roll gaps as desired between the upper and lower work rolls 2, 2'.

The upper and lower backup roll bearing cases 7, 7' are held in a suitably spaced relation within the housing 8 so they may move upwardly and downwardly along the housing frames and also, as will be described later, they may turn about their common vertical axis. As illustrated, the upper and lower work roll chocks 6, 6' are vertically slidably housed in the upper and lower backup roll bearing cases 7, 7'. Between the both ends of the backup roll bearing cases 7, 7' and those of the work roll chocks 6, 6' are interposed roll-bending devices (oil hydraulic jacks) 5, as shown in FIG. 1.

Also, between the upper backup roll bearing case 7 and the screws 4 and between the lower bearing case 7' and the hydraulic reduction cylinders 10, there are disposed equalizer beams 21, 21', respectively, which are movable upwardly and downwardly but are horizontally constrained unmovably by the inner walls of the housing 8.

Jacks 13a, 13b, 13c, and 13d are supported by brackets 20, 20', which in turn are provided, as shown, on the upper and lower portions on both sides of the housing 8. These jacks are operated so as to turn the upper and lower backup roll bearing cases 7, 7' on the same horizontal planes

about their common vertical axis. The brackets 20, 20' combine with the jacks 13a to 13d to constitute roll-crossing devices disposed in the housing 8.

The numeral 15 designates a cylinder for balancing the inner housing, mounted on top of the housing 8, with a rod 14 suspending the top roll assembly. Radial bearings 16, 16' for the work rolls 2, 2' are supported themselves by the work roll chocks 6, 6'. The work rolls 2, 2' (FIG. 3 showing only the roll 2' for simplicity) are supported at one ends by thrust pads 18 through thrust bearings 17. The thrust pads 18 are secured to the upper and lower backup roll bearing cases 7, 7' with chock plates 19.

Throughout the figures the numerals 12, 12' indicate upper and lower inner housings.

The construction of the four high mill of a paired-roll-crossing type embodying the invention has so far been described. Now as indicated in FIG. 3, let the line V-V be the centerline of width of a slab or strip being passes through the rolls (hereinafter called the "passing line"), the line X-X be a straight line that extends across the middle point of length of the rolls and parallel to the passing line V-V, the line Y-Y be a straight line at right angles to the line X-X, and the intersection of the passing line V-V and the line Y-Y be W. Then, the operation of the jacks 13a, 13b, 13c, and 13d for respective strokes

determined by calculations will cause the upper and lower backup roll bearing cases 7, 7' to turn horizontally with respect to the given point W on the line Y-Y, thus turning the upper and lower rolls 2, 2' and 3, 3' in pairs relative to each other through an angle  $\alpha^{\circ}$ . (Refer to FIG. 3.)

The initial roll gaps  $\epsilon_1$ ,  $\epsilon_2$  between the upper and lower work rolls 2, 2' can be adjusted by suitably operating the left and right screw-down devices 11. Also, proper control of the roll-bending forces  $F_1$ ,  $F_2$  is made possible by the roll-bending devices 5.

Thus, by adjusting the turning angle  $\alpha^{\circ}$ , initial roll gaps  $\epsilon_1$ ,  $\epsilon_2$  of the upper and lower work rolls 2, 2', and the roll-bending forces  $F_1$ ,  $F_2$ , the sectional contour across the workpiece 1 being rolled can be adjusted over a broad range of width.

Since the pairs of upper and lower rolls 2, 3 and 2', 3' can cross at the point W, the roll crowning effects can be made equal on the left and right portions of the rolls.

With the four high mill of a paired-roll-crossing type according to the invention, built and designed to function in the manner described above, it is possible to control the sectional contour of the workpiece over a great range of width. Further, because rolling at either end portions is possible, the work rolls may be worn while generally maintaining the original cylindrical contours.

This presents practical advantages of not only more than halved intervals of work roll changing and more than doubled total tonnage of rolling but also by far the lower cost of fabricating and regrinding the rolls 2, 2', 3, 3', which  
5 need not be crowned but may be plain cylinders, than the cost for the ordinary crowned rolls.

What is claimed is:

1. A four high mill of a paired-roll-crossing type which comprises a housing, an upper and a lower backup roll bearing cases held within the housing, an upper and a lower equalizer beams in contact, respectively, with the uppermost and lowermost surfaces of said bearing cases and made both movable upwardly and downwardly, pairs of work rolls and backup rolls in a four high arrangement, upper and lower work roll chocks installed inside said bearing cases, roll-crossing means mounted in said housing to turn said bearing cases about a common vertical axis on the same horizontal plane so that said upper and lower pairs of rolls can cross each other, and means for separately setting the left and right roll gaps between said upper and lower work rolls.
2. A four high mill according to claim 1, which further comprises work roll-bending means mounted at both ends of said work rolls.

FIG. 1

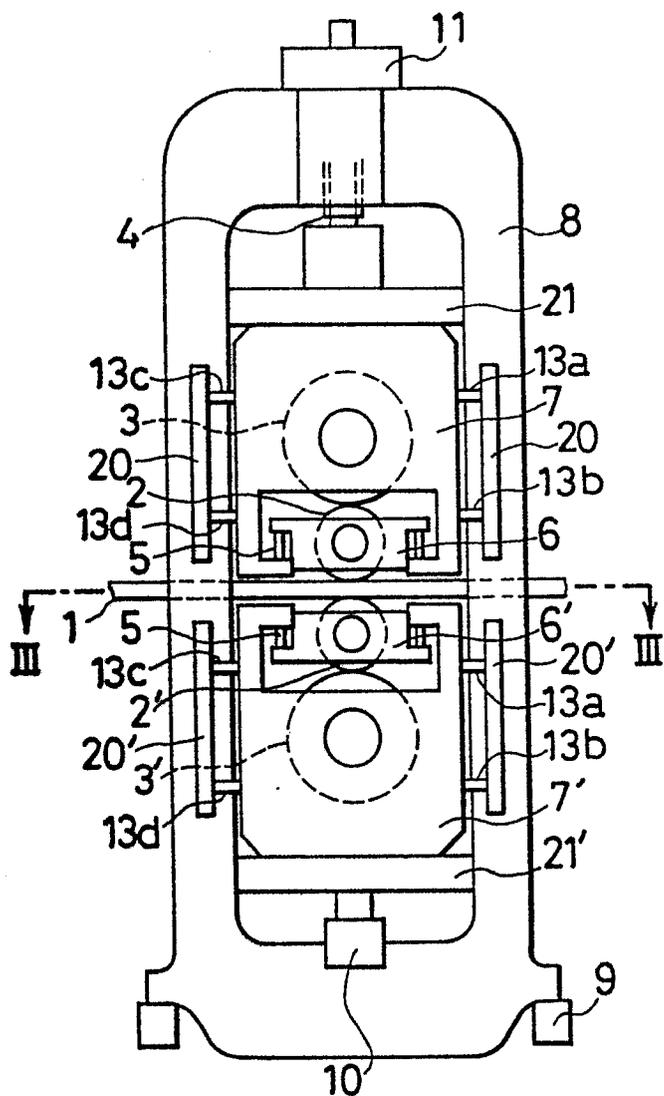


FIG. 2

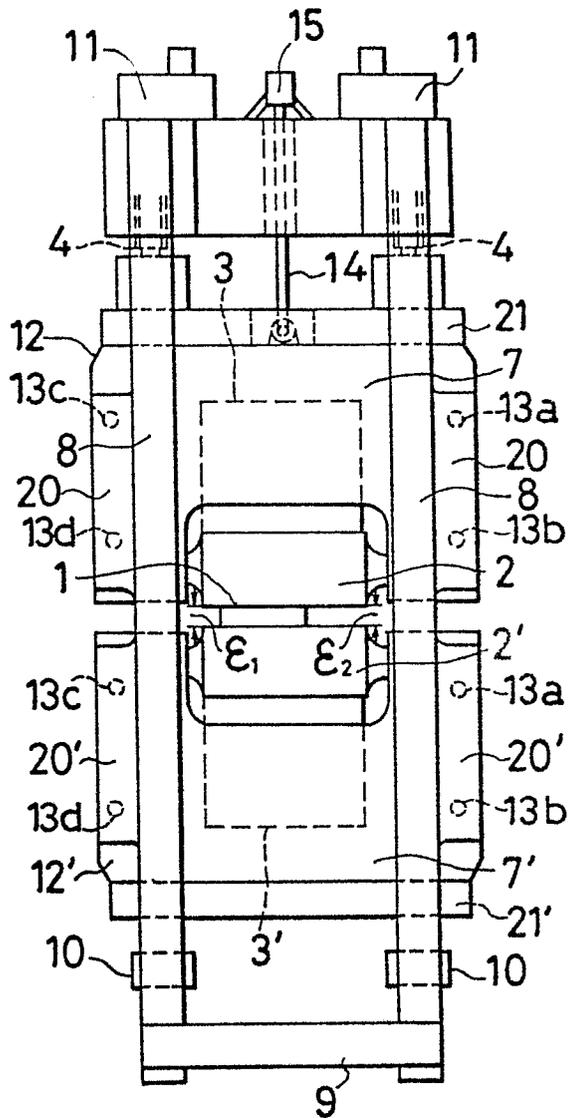
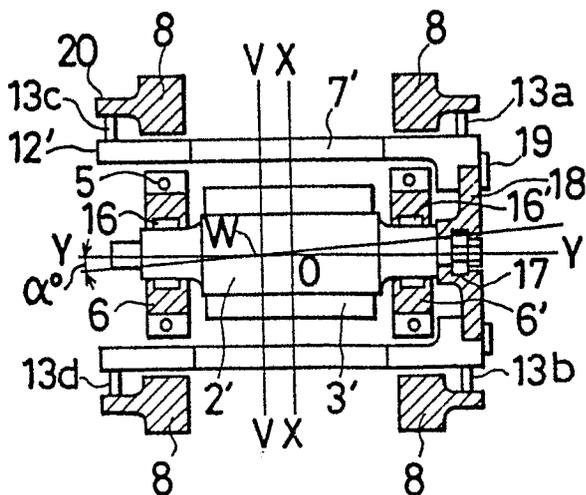


FIG. 3





DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. <sup>3</sup> )
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	<u>FR - A - 1 413 792</u> (SCHLOEMANN)	1	B 21 B 31/16
A	<u>DE - C - 459 138</u> (KRONENBERG)	1	
A	<u>CH - A - 295 443</u> (CARDING)	1	
A	<u>US - A - 2 961 901</u> (WHEELER)	1	
A	<u>US - A - 4 212 504</u> (KRYLOV)	2	
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			TECHNICAL FIELDS SEARCHED (Int.Cl. <sup>3</sup> )
			B 21 B
			CATEGORY OF CITED DOCUMENTS
			X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons
			&: member of the same patent family, corresponding document
<input checked="" type="checkbox"/> The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
The Hague	21-04-1982	SEMBRITZKI	