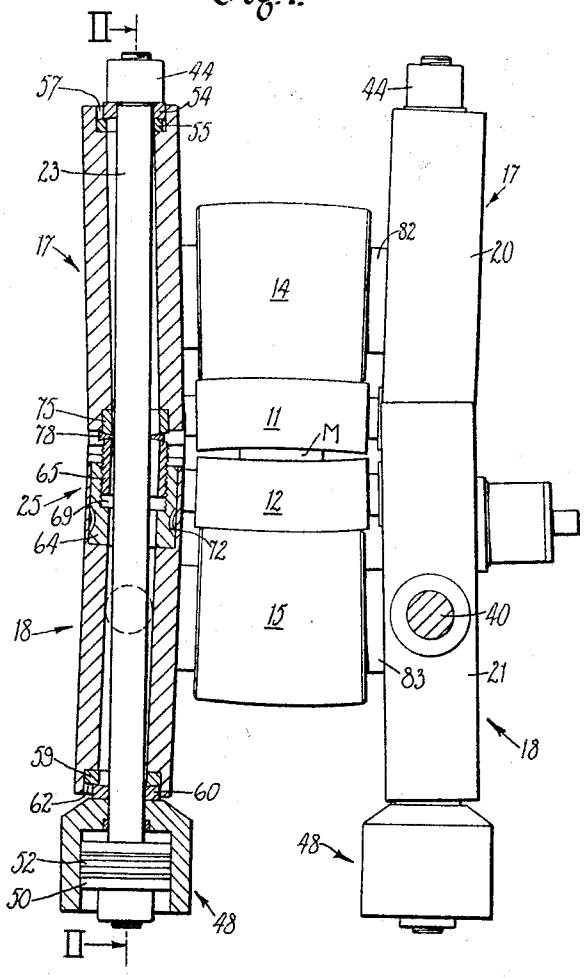
Nov. 22, 1966 J. A. TRACY 3,286,501

PRE-STRESSED ROLLING MILLS

Filed July 30, 1963 3 Sheets-Sheet 1

Fig. 1.



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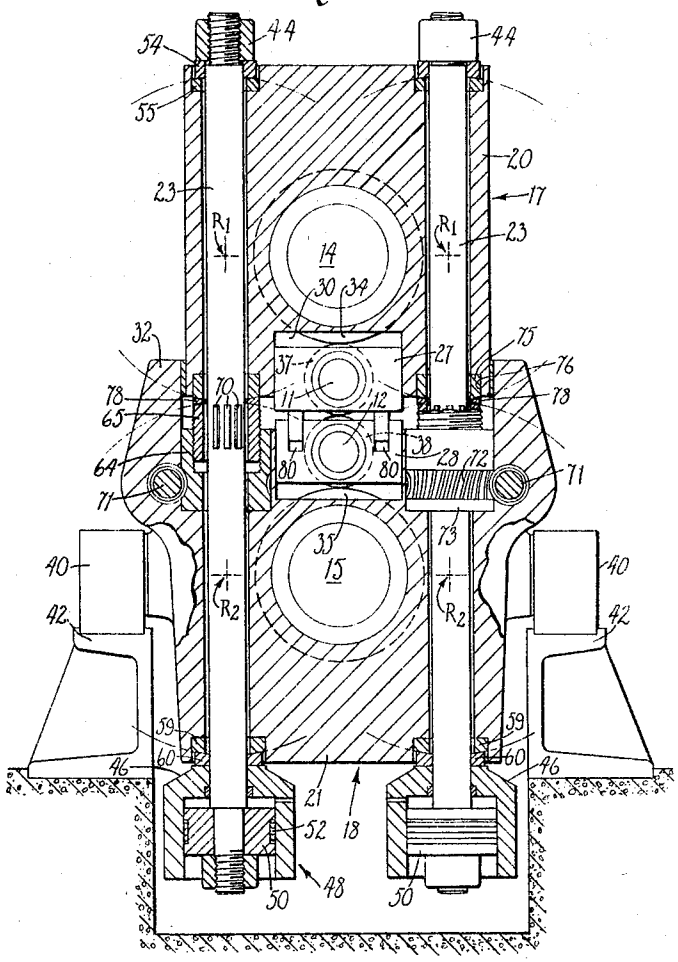
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Nov. 22, 1966 J. A. TRACY 3,286,501

PRE-STRESSED ROLLING MILLS

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Fig. 2.



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PRE-STRESSED ROLLING MILLS

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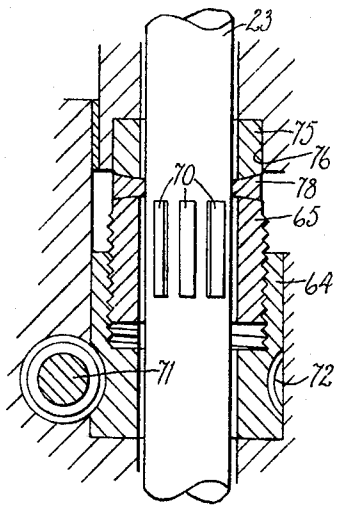


Fig. 3

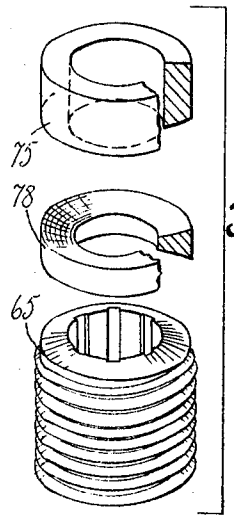


Fig. 4

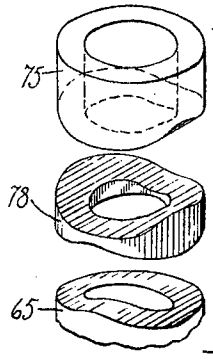


Fig. 5

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United States Patent Office 3,286,501
Patented Nov. 22, 1966

3,286,501

PRE-STRESSED ROLLING MILLS

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Filed July 30, 1963, Ser. No. 298,653
Claims priority, application Great Britain, Aug. 3, 1962, 30,071/62, 30,072/62
6 Claims. (Cl. 72—237)

The present invention relates to pre-stressed rolling mills, and is particularly applicable to "frameless" mills of the type in which the bearing chocks at each side are interconnected by pre-stressed columns, each assembly of chocks and columns forming, in effect, part of the mill frame.

In the conventional construction of mills of this type, the columns are held in a stressed condition by bearing nuts screwed on the ends of the columns and bearing against the top of the upper chocks and the bottom of the lower chocks. The roll gap for the reception of material to be rolled is adjusted by the insertion of shims or other spacing means between the upper and lower chocks. The setting of these mills to obtain a roll gap of predetermined size is, however, a difficult and tedious operation, since the shims suffer deformation when subjected to the pre-stressing force and the pre-stressing force must be released before shims can be inserted or withdrawn from between the chocks.

It has been proposed to provide a pre-stressed "frameless" mill with adjustable screw jacks positioned between the upper and lower chocks, and with bearing nuts screwed on the ends of the columns, the pitch of the screw threads on the jacks being equal to the pitch of the screw threads on the bearing nut. The screw nuts are, however, subjected to the full pre-stressing force and the frictional resistance to rotation of the nuts, while under the full pre-stressing force, is too great to permit adjustment of both the screw nuts and the jacks during rolling.

Furthermore, in known constructions of mills of this type, the assembly of chocks and columns forms a very rigid structure. The chocks and bearings must consequently be machined and mounted together with a high degree of accuracy in order to prevent any misalignment of the roll necks in the bearings, and the pre-stressing force must be removed before any relative adjustment between the chocks can be effected.

One of the objects of the invention is to provide an improved construction of a pre-stressed frameless mill in which the roll gap may be adjusted during rolling when the columns are in a stressed condition.

Another object of the invention is to provide an improved construction of a pre-stressed rolling mill which facilitates erection of the mill and reduces the possibility of misalignment of the bearings, even when the rolls are subjected to an exceptionally large separating force.

According to the invention, there is provided a "frameless" mill of the type referered to, wherein the upper and lower chocks are spaced apart by adjustable jacks, and the columns are maintained in a stressed condition by hydraulic means, the jacks being adjustable to vary the spacing between the chocks, and hence the roll-gap between the rolls during rolling.

The hydraulic means may consist of piston and cylinder units, of which the pistons are mounted on the columns, and the cylinders are slidable relative to the columns, and held against the chocks by hydraulic pressure. During rolling the pre-stressing force is opposed by the separating force acting on the rolls due to the deformation of the material, so that the screw jacks are subjected to only the difference between the pre-stressing and separating

forces. The loading on the screw jacks is thus sufficiently small to enable the chocks to be adjusted during an actual rolling operation.

The loading on each jack, and consequently the axial deformation of each jack, is preferably maintained constant during rolling despite variation in the separating force due to variations in the thickness, width or temperature of the material being rolled. This is preferably obtained by the control system described and claimed in my co-pending British application No. 27,276/61, now Patent No. 955,164, in which the loading on each jack is continuously measured, and the pre-stressing force regulated in accordance with the loading on the jack so as to maintain the difference between the pre-stressing and separating forces substantially constant.

According to another aspect of the invention, the two chocks at each side of a pre-stressed rolling mill are provided with sets of pads positioned between the two chocks and between the chocks and the pre-stressing means, the pads of each set contacting each other on matching convex and concave surfaces respectively which are so arranged on the pads that each chock is free to tilt or rock relative to the other chock about an axis perpendicular to both the axis of the associated roll and the common plane through the axes of the rolls.

According to a further feature of this invention, intermediary pads may be provided between two parts having convex (or concave) bearing surfaces, the co-acting surfaces of the intermediary pad being of matching concave or convex shape.

In the case of a "frameless" mill, the assembly of chocks and columns at each side of the mill is preferably supported on two trunnions or pivot shafts arranged on opposite sides of the assembly and extending perpendicular to both the axis of one of the rolls and the common plane through the axes of the rolls.

The freedom of the chocks to tilt relative to one another has considerable advantages in the erection and operation of the mill. During erection, the chocks can be tilted to correct misalignment of the roll necks in the bearings, and during operation of the mill the chocks are free to follow deflections of the roll necks should the rolls be subjected to an exceptionally large separating force, thereby preventing damage to the bearings due to misalignment under heavy load.

The convex-concave pads also facilitate the erection of the mill, since the pre-stressing means always bear squarely on the adjacent pad of each associated set of pads.

The invention is applicable to both two-high rolling mills and to four-high rolling mills in which the working roll chocks are mounted on the back-up roll chocks. The term "upper chock" or "lower chock" is therefore to be construed as covering either a single chock in the case of a two-high mill or both the associated back-up roll chock and the working roll chock in the case of a four-high mill.

A preferred construction of a pre-stressed "frameless" rolling mill according to the invention will now be described by way of example with reference to the accompanying drawings, of which:

FIG. 1 is a front elevation of a rolling mill according to the invention, partly in section,

FIG. 2 is a section of the mill of FIG. 1 along the line 2—2 of FIG. 1,

FIG. 3 shows a detail of this mill on an enlarged scale,

FIGS. 4 and 5 are exploded views of two different varieties of pads.

The mill comprises two working rolls **11**, **12** arranged in superposed relationship, two back-up rolls **14**, **15** arranged one above and one below the working rolls and two chock assemblies **17**, **18** supporting the working and back-up rolls.

Each chock assembly comprises upper and lower back-up chocks **20**, **21** interconnected by two hydraulically pre-stressed columns **23** extending through aligned vertical bores in the back-up chocks **20**, **21**, two power-operated screwjacks **25** positioned between the back-up chocks, and upper and lower working roll chocks **27**, **28** which have a close sliding fit between the side walls of recesses **30** formed in the lower and upper ends of the upper and lower back-up chocks **20**, **21** respectively. The sides of the lower back-up chocks are provided with upwardly projecting lugs **32** which form guides for the upper back-up chock **20** and facilitate erection of the mill.

The working rolls **11**, **12** are rotatably mounted in bearings **37**, **38** in the working roll chocks **27**, **28** respectively, and the back-up rolls **14**, **15** are rotatably mounted in bearings **34**, **35** in the back-up chocks **20**, **21** respectively. Either the working rolls or the back-up rolls may be driven in any conventional and well-known manner. Each chock assembly **17**, **18** is supported by trunnions **40** secured to the sides of the lower back-up chocks **21** and mounted on pedestals **42** which rest on a foundation of the mill. The trunnions **40** are so arranged that their axes extend perpendicular to both the axis of the lower back-up roll **15** and the common plane through the axes of all the rolls.

The upper end of each column **23** projects above the upper back-up chock **20** and is provided with a screw nut **44**, and the lower end of each column projects below the lower back-up chock **21** and extends through an opening in the base of a cylinder **46** of a single-acting hydraulic unit **48**. The piston **50** of the hydraulic unit is secured in the lower end of the column **23**, and the cylinder **46** is axially movable relative to the piston and column. Sealing rings **52** on the piston and in the wall of the opening in the base of the cylinder **46** prevent leakage of liquid supplied to the cylinder.

Each screw nut **44** bears against a set of two superposed annular bearing pads **54**, **55** which surround the column **23** and are located in a recess **57** in the upper end of the upper back-up chock **20**, and the cylinder **46** of the hydraulic unit **48**, when supplied with liquid under pressure, bears against a similar set of two annular bearing pads **59**, **60** which surround the column **23** and are located in a recess **62** in the lower end of the lower back-up chock **21**. The outer pad **54** or **60** of each set, i.e., the pad adjacent the associated screw nut **44** or cylinder **46** fits closely around the column **23**, but is spaced from the wall of the recess **57**, **62** respectively, and the inner pad **55**, **59** of each set fits closely against the wall of the recess **57**, **62**, but is spaced from the wall of the column **23**. The adjoining faces of the two pads in each set have matching part-spherical surfaces, the radial centre R_1 or R_2 of which is located at the point of intersection of the column axis and the horizontal plane through the axis of the associated back-up roll **14** or **15**.

Each screw-jack **25** comprises outer and inner sleeves **64**, **65** surrounding the portion of the column **23** between the back-up chocks **20**, **21**, the inner sleeve **65** being screwed on a thread on the inner wall of the outer sleeve **64** and projecting above the outer sleeve. The inner sleeve **65** has a loose sliding fit on splines **70** on the column **23**, and the outer sleeve **64** is mounted in a circular recess **69** in the upper end of the lower back-up chock **21**. The outer sleeve **64** is rotatable within the circular recess **69** by a power-driven worm **71** in mesh with teeth **72** formed on the outer wall of the outer sleeve **64**, the worm being rotatably mounted in a bore **73** in the lower back-up chock **21**. Since the inner sleeve **65** of the screw jack **25** is restrained against rotation by the splines **70** on the column **23**, rotation of the outer sleeve **64** by means of the worm **71** will move the inner sleeve **65** along the splines on the column and thereby adjust the overall length of the jack **25**.

An annular loadmeter **75** is located in a recess **76** in the lower end of the upper back-up chock **20**, and an intermediate pad **78** is interposed between the upper end of the inner sleeve **65** and that load meter (FIG. 3). The adjoining faces of the inner sleeve **65**, the pad **78** and the loadmeter **75** are formed with matching part-spherical surfaces, the radial centres of which coincide with the radial centre R_1, R_2 of the part-spherical surfaces of the set of pads **54**, **55** and **59**, **60** on the upper and lower ends of the column **23**.

The working roll chocks **27**, **28** are urged apart by hydraulic piston-and-cylinder units **80**, in known manner, in order to maintain each working roll **11**, **12** in contact with its associated back-up roll **14**, **15**. The working rolls co-operate to form a roll gap for the reception of material M to be rolled, the height of the roll gap being determined by the spacing between the back-up rolls **14**, **15**, which in turn is determined by the overall length of the screw-jacks **25**.

The assembly of chocks and column at each side of the mill is pre-stressed by supply of liquid under pressure to the cylinders **46** of the hydraulic units **48**. The pressure of liquid in the hydraulic units forces the cylinders upwards against the sets of bearing pads **59**, **60** on the lower back-up chock **21** and forces the nuts **44** on the upper ends of the columns downwards against the sets of bearing pads **54**, **55** on the upper back-up chock **20**. The upper and lower back-up chocks **20**, **21** are thus forced against the upper and lower end faces of the loadmeters **75** and screw-jacks **25** respectively.

The trunnion mounting **40** on the lower back-up chocks **21** and the part-spherical surfaces on the sets of bearing pads **54**, **55** and **59**, **60**, and on the adjoining faces of the loadmeters **75**, intermediary pads **78** and screw-jacks **25** permit a small degree of tilting or rocking movement of each back-up chock about an axis perpendicular to that of the associated back-up roll and to the common plane through the axes of the rolls, the columns **22** being provided with sufficient clearance in their bores in the back-up chocks **20**, **21** to permit rocking movement of the chocks.

This freedom of tilting or rocking movement of the back-up chocks **20**, **21** is particularly advantageous during a rolling operation if the rolls are subjected to an excessively large separating force which would exert a correspondingly large bending moment on the rolls and cause a correspondingly large deflection of the back-up rolls **14**, **15**, including their necks **82**, **83**. In such circumstances, the chocks can follow the movements of the roll necks to maintain the bearings **34**, **35** in the back-up chocks **20**, **21** in alignment with the roll necks **82**, **83**. Damage to the bearings due to misalignment under heavy load is thus avoided.

The erection, dismantling and maintenance of the improved mill is particularly simple, due to the fact that the columns **23** and hydraulic units **48** are readily removable, and alignment of the roll necks in the bearings **34**, **35** is facilitated by the ability of the chocks **20**, **21** to tilt relative to one another.

Erection of the mill is in addition facilitated by the sets of bearing pads **54**, **55** and **59**, **60** between the chocks **20**, **21** and both the screw nuts **44** and the hydraulic cylinders **46**, respectively. Upon rocking movement of the back-up chocks **20**, **21**, the inner pads **55**, **59** follow the movements of the back-up chocks **20**, **21**, since these pads fit closely in their locating recesses **57**, **62** in the chocks, and the outer pads **54**, **60** remain square to the screw nuts **44** and cylinders **46** respectively, since these parts in turn fit closely on the columns **23**. The bearing pads thus obviate the necessity, existing in known mills, for machining or otherwise modifying the pre-stressing means on the ends of the clumns to ensure a square fit on the chocks.

On a rolling operation, the pre-stressing force exerted on the back-up chocks **20**, **21** by the hydraulic units **48** is maintained at a value in excess of the separating force acting on the rolls. The screw jacks **25** are however only

subjected to a load corresponding to the difference between the pre-stressing and separating forces. The loading on the jacks is thus comparatively small, so that the jacks can be adjusted to vary the roll gap while a rolling operation is in progress.

The loadmeters **75** are magneto-elastic elements which provide a voltage output proportional to the loading on the element. Each loadmeter is subjected to the same loading as its associated screw-jack **25**, and the output of the loadmeter thus gives an indication of the loading on the screw-jack.

The output of each loadmeter **75** is, however, preferably arranged so to regulate the pressure of liquid in the associated hydraulic unit **48** that the loading on each loadmeter and screw-jack remains at a predetermined value. The axial deformation of the jack **25**, due to its loading, then remains constant and the roll gap between the working rolls **10**, **11** similarly remains constant. Such a control of the pre-stressing force exerted by each hydraulic unit **48** is particularly advantageous in circumstances in which the proportion of the separating force taken by the chocks at one end of the mill differs from the proportion of the separating force taken by the chocks at the other end of the mill, for example in a case in which the material being rolled is offset from the centre line of the mill.

The matching surfaces on the pads may be spherical, as shown in FIG. 4, or they may be cylindrical, as shown in FIG. 5. In the latter case, the axes of the cylindrical surfaces coincide with the axis which is perpendicular to both the axes of the associated roll and the common plane through the roll.

The invention is capable of other embodiments than the one described. For example, the upper back-up chocks **20** may be mounted on the trunnions **40**, the rolls may be arranged in a vertical position, or other changes may be made.

I claim:

1. A "frameless" rolling mill in which the bearing chocks at each side of the mill form together one assembly, and in which each assembly is interconnected by pre-stressed columns, sets of bearing pads being positioned between the two chocks of one assembly as well as between one chock of one of said assemblies and the pre-stressing means, the pads of each set contacting each other on matching convex and concave bearing surfaces respectively which are so arranged on the pads that a chock of an assembly is free to tilt or rock relative to the other chock of the same assembly and about an axis perpendicular to both the axis of the associated roll and the common plane through the axes of the rolls.

2. A "frameless" rolling mill according to claim **1**, in which one end of each column projects beyond one bearing chock of an assembly and is provided with a screw nut, the screw nut bearing against a set of two super-posed annular bearing pads which surround the column and are located in a recess in the end of said chock, and in which the opposite end of each column projects beyond the other chock of the same assembly and extends through an opening in the base of a cylinder of a single-acting hydraulic pre-stressing unit, the cylinder, when supplied with liquid under pressure, bearing against a set of two super-posed annular bearing pads which surround the column and are located in a recess in the end of said other chock.

3. A "frameless" rolling mill according to claim **1**, in which the assembly of chocks and columns at each side of the mill is supported on two trunnions or pivot shafts arranged on opposite sides of the assembly and extending perpendicular to both the axis of one of the rolls and the common plane through the axes of the rolls.

4. A "frameless" rolling mill according to claim **1**, in which an intermediary pad is provided between the two chocks of one assembly, said intermediary pad having bearing surfaces of convex or concave shape which are in contact with matching surfaces provided on the two chocks or on parts arranged between the chocks and the intermediary pad.

5. A "frameless" rolling mill according to claim **4**, in which an intermediary pad is interposed between a loadmeter bearing against one chock and an adjustable jack bearing against the other chock of the same assembly.

6. A "frameless" rolling mill according to claims **1** and **4**, in which the centres of curvature of the convex or concave bearing surfaces of the intermediary pads coincide with the centres of curvature of the bearing surfaces of the pads on the ends of a column.

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