United States Patent

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[31] 148,137

[54] ROLLING MILL WITH PRESTRESSED HOUSING
5 Claims, 5 Drawing Figs.

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[51] Int. Cl. B21b 13/14
[50] Field of Search 72/241, 237, 247, 243, 248, 242, 199, 245

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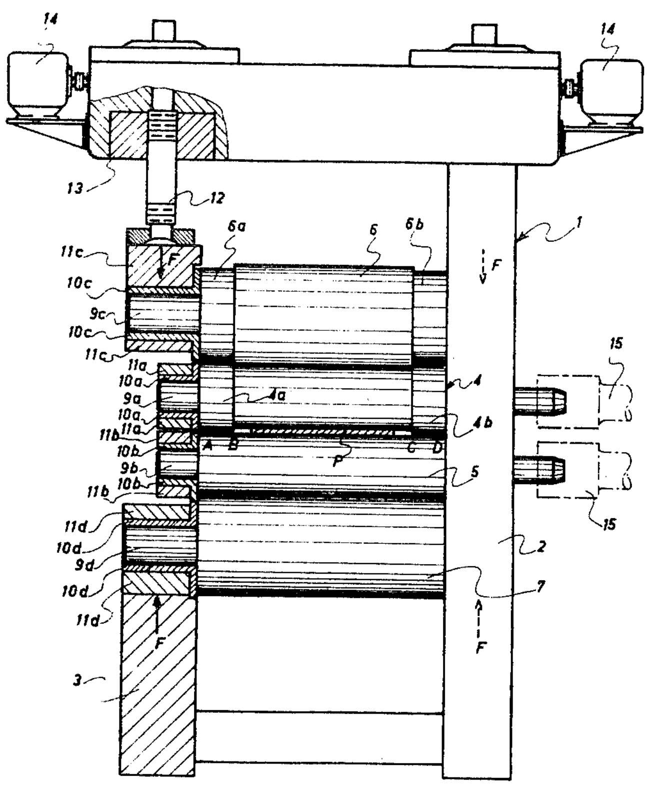
ABSTRACT: In a four-high mill, the two working rolls have bearing surfaces in rolling contact with each other. Pressure is exerted upon the two mating backup rolls and transmitted to the bearing surfaces along their entire length whereby the bearing surfaces of the working rolls are held in pressure engagement with each other while a rolling space is defined therebetween to permit the product to pass therethrough.



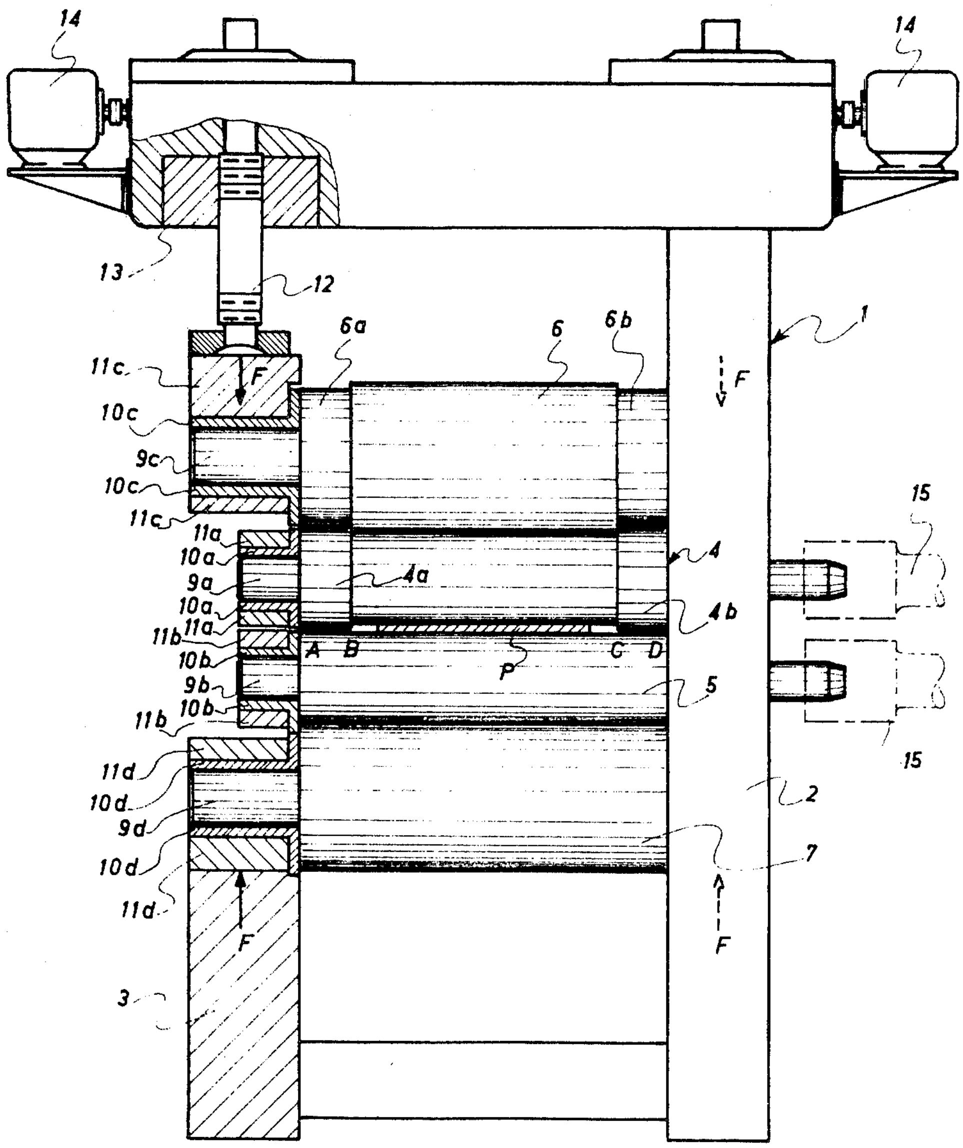


FIG. 1

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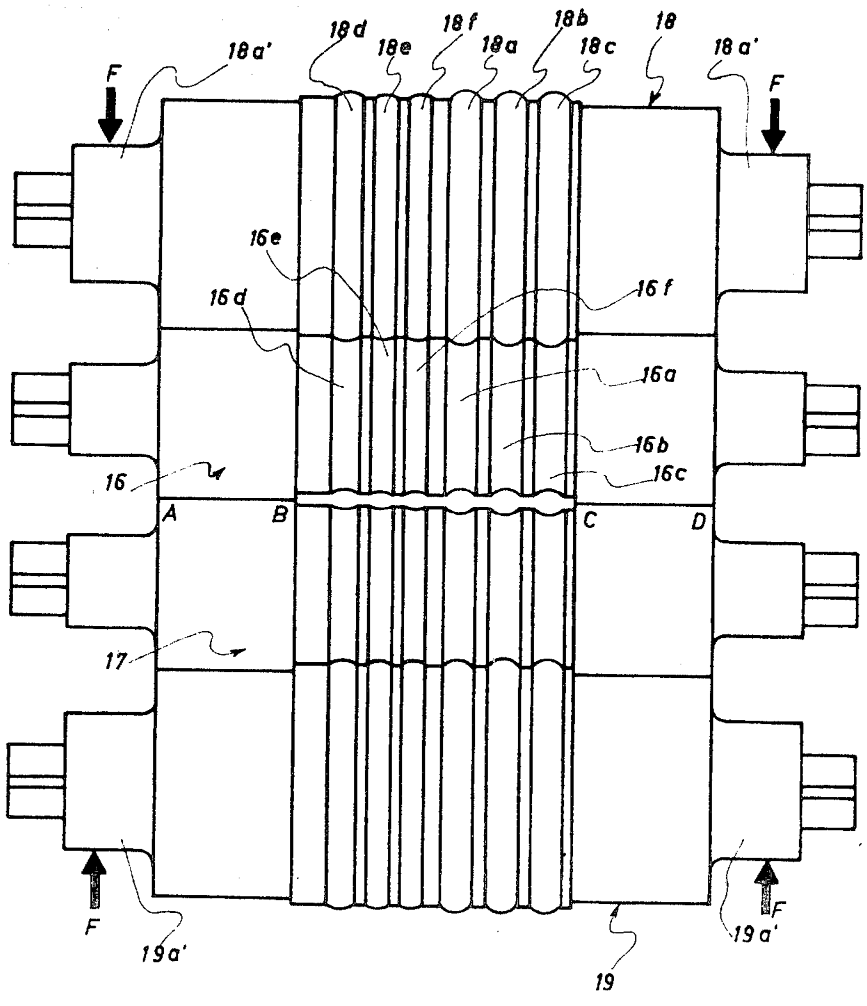

FIG. 2

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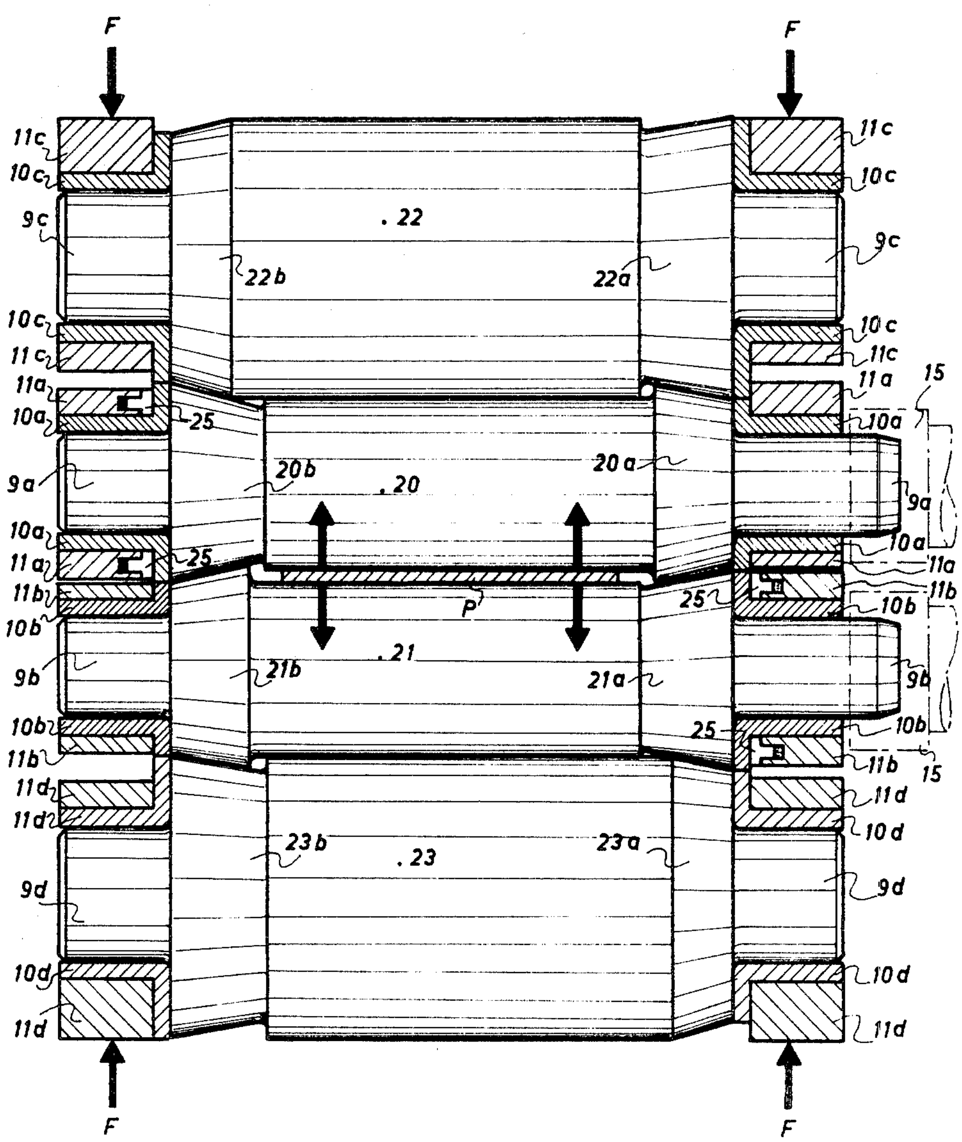

FIG. 3

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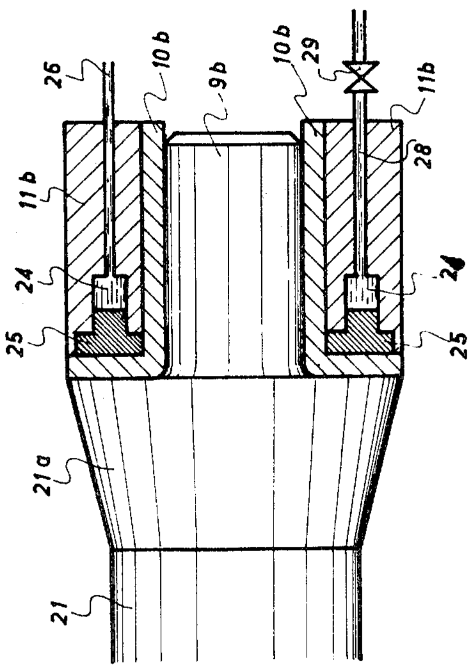

FIG.5

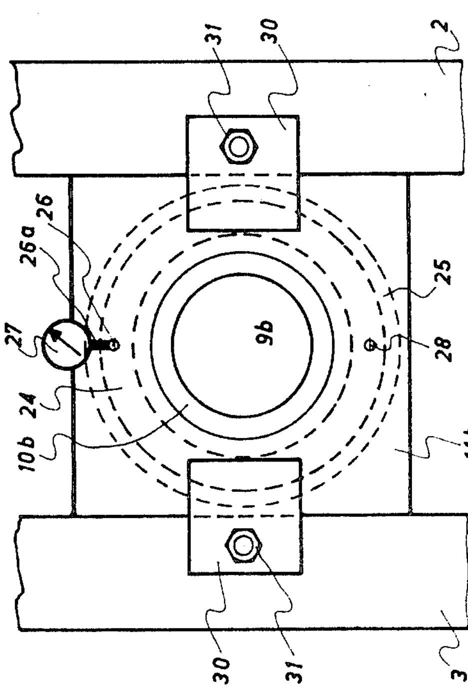

FIG.4

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ROLLING MILL WITH PRESTRESSED HOUSING

The present invention relates to improvements in four-high mills with a prestressed housing.

Prestressed rolling mill housings are known and comprise rigid elements joining two opposed bearings chocks which are placed under compression by exerting thereon a pressure force superior to, and opposing, the rolling pressure exerted upon the working rolls by a product passing therebetween during rolling.

The effect of such devices is to reduce the length of the "-mechanical chain" which causes yielding of the housing and thus reduces the extent of mill spring. However, since there remains such a mechanical chain which suffers a change of stress at the moment when the product is introduced between the working rolls, a certain amount of mill spring remains. Therefore, such known prestressed housings are usually provided with an automatic mill spring compensation device. Nevertheless, whatever type of mill spring compensating system is used, the correction remains faulty because the curve of mill spring as a function of the forces applied thereto is only imperfectly known. This makes it impossible rigorously to determine the thickness of the product being rolled.

It is obvious that the prestressed housings will increase in perfection the shorter the "mechanical chain" which causes the mill spring because this reduces the amount of compensation needed to produce a rolled article of constant thickness, and consequently the requirements for the mill spring compensating device.

It is accordingly an object of the present invention to overcome the above disadvantages and to provide a novel four-high mill with a prestressed housing wherein the housing is subjected, when running on no load to a pressure force superior to, and opposing, the rolling pressure exerted upon the working rolls by a product passing therebetween during rolling. In accordance with this invention, the mill comprises two cooperating working rolls, and each working roll has at each end a bearing surface in rolling contact with the corresponding end bearing surface on the other working roll. Each of the two backup rolls is in pressure contact with a respective working roll, and each backup roll has a diameter at each point along its length such that the backup roll mates along the entire length with the working roll in pressure contact therewith. Means is provided for exerting the pressure force upon the ends of the backup rolls, and this force is transmitted by the backup rolls to the working rolls through their end bearing surfaces and along their entire length whereby the bearing surfaces of the working rolls are held in pressure engagement with each other while a rolling space is defined between the working rolls to permit the product to pass therethrough.

In accordance with one embodiment, the end bearing surface of at least one of the working rolls has a diameter larger than the diameter of the central portion of the roll extending therebetween, the rolling space being defined between the central portion of the one roll and the other roll, and the backup roll in pressure contact with the one working roll has end bearing surfaces in rolling contact with the end bearing surfaces of the one working roll whose diameters are smaller than the diameter of the central portion of the backup roll extending therebetween.

According to another embodiment of the invention, each working roll has additional bearing surfaces intermediate the end bearing surfaces in rolling contact with corresponding bearing surfaces on the other working roll, concave rolling portions being defined between said additional bearing surfaces to permit elongated products to pass therethrough, and the backup rolls having corresponding bearing surfaces respectively mating with the bearing surfaces and concave rolling portions of the working rolls.

According to a further embodiment, each working roll has a central portion defined by a rectilinear generatrix, and the end bearing surfaces of the working rolls are frustoconical end portions of a median diameter about the same as the diameter of the central portion, one of the conical end portions converging and the other conical end portion diverging in respect of the central portion, the two working rolls being arranged in wedged engagement and axially movable in respect of each other for defining an adjustable rolling space therebetween, and each backup roll has a central portion defined by a rectilinear generatrix and conical end portions of a median diameter about the same as the diameter of the central portion, one of the conical end portions of each backup roll converging and the other conical end portion diverging in respect of the central portion of the backup roll, the two backup rolls being arranged in wedged engagement with the respective working rolls.

The term "rolling space," as used throughout the specification and the claims, designates either a space of uniform cross section for rolling flat products, or a space of varying cross sections for rolling a plurality of long products, for instance.

In the four-high mill of the present invention, the rigid elements under compression of the prestress are part of the working rolls themselves and are constituted by the end portions of the working rolls.

The pressure force, superior to the expected rolling force, when running on no load, is exerted through the bearing chocks of the backup rolls. Therefore, if there is imparted to the backup rolls a shape such that each backup roll will mate fully with the associated working roll along the entire length thereof, mill spring will be reduced practically to zero. The deformations of the end portions of the working rolls, which are partly flattened during prolonged operation of the mill, are the primary cause for variations in the thickness of the rolled strips. It will be noted, however, that the pressure exerted upon the working rolls is reduced by the counterpressure exerted upon the rolls by the product being rolled. Thus, the rolling mill of this invention will show very small deformation which may be readily compensated.

The above and other objects, advantages and features of the present invention will become more apparent from the following detailed description of certain preferred embodiments thereof, taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic view, partially a section, of a four-high rolling mill with a prestressed housing for strips of constant thickness;

FIG. 2 is a schematic illustration of the rolls of a four-high mill for rolling a elongated products;

FIG. 3 is a schematic view, partly in section, of a four-high mill for rolling strips of adjustable thickness;

FIG. 4 is a detailed view of a device permitting the axial displacement of the working rolls; and

FIG. 5 is a sectional view of FIG. 4.

Referring now to the drawing and first to FIG. 1, there is seen a prestressed rolling-mill housing 1 comprising two vertical columns 2 and 3 having journals receiving the two working rolls 4 and 5, as well as two backup rolls 6 and 7 of larger diameter than the diameter of rolls 4 and 5.

The working roll 4 is of a special type. It comprises two shoulder portions 4*a* and 4*b* at its respective ends. The diameter of the shoulder portions exceeds that of the central portion of the roll which serves as the working surface for rolling the product. The shoulder portions of the working roll 4 engage, and are supported by, the working roll 5 in a flat contact plane thus defining a central space of constant thickness between rolls 4 and 5 wherethrough a flat product *P* may be introduced for rolling.

A backup roll 6 of a special type cooperates with working roll 4 and the backup roll 7 cooperates with working roll 5. As will be seen, the backup roll 6 comprises two neck portions 6*a* and 6*b* at its respective ends. The diameter of the neck portions is smaller than that of the central portion of the backup roll. The neck portions of the backup roll mate with the shoulder portions of the working roll and the central portions of the working and backup rolls also mate.

The trunnions **9***a* and **9***b* of the working rolls **4** and **5** are mounted in journal bearings **10***a* and **10***b* which, in turn, are held in bearing chocks **11***a* and **11***b*. The same mounting is provided for supporting the trunnions **9***c* and **9***d* of backup rolls **6** and **7** in journal bearings **10***c* and **10***d* in bearing bearing chocks **11***c* and **11***d*.

The force of pressure *F* is exerted upon the rolling mill by tightening pressure screw **12** which exerts pressure on the trunnions **9***c*, **9***d* of the backup rolls through bearing chocks **11***c*, **11***d*. Therefore, the working rolls are substantially restrained from bending and mill spring is reduced to a minimum.

Any residual mill spring would result primarily from flattening of the rolls at the lines of contact $\overline{AB}$ and $\overline{CD}$. This flattening is a function of the backing pressure per unit of length. The variations in thickness resulting therefrom are, however, quite small and generally acceptable in commercial practice. It may be completely eliminated by maintaining the backing pressure along the lines $\overline{AB}$ and $\overline{CD}$ constant by equally varying **2***F* and the rolling force along the line $\overline{BC}$.

An automatic mill spring compensation device may, for instance, consist of a closed loop control receiving as input information the difference between a linear reference backing force and the linear backing force applied, for example, to contact line $\overline{CD}$. This force may be measured continuously by a suitable pressure gage. The output of the control is a function of this input information and is used to control hydraulic or mechanical means producing the screwing force and thus keeping the linear backing force constant. Thus, the flattening of the working roll portions in contact with each other will be invariable, and the rolled product will leave the mill at a rigorously constant thickness.

The other parts of the rolling mill are conventional. The bearing chock **11***c* of the upper backup roll **6** is in contact with the lower end of the pressure screw **12**, the upper end of the screw being threadedly received in nut **13** mounted on top of column **3** and driven by motor **14**, the same arrangement being present on the other side of the housing on column **2**. The working rolls **4**, **5** are also driven in a known manner by means of motors which rotate the transmission shafts **15**, **15** of the rolls.

FIG. **2** shows a second embodiment of the invention. The support housing of the hour-high mill is the same as that of the embodiment of FIG. **1** and, therefore, has been omitted, this embodiment differing by the form of the rolls. Both working rolls **16** and **17** are of a special type, being identical in the illustrated embodiment. Each roll defines six adjacent circumferential grooves for rolling elongated products of which three grooves **16***a*, *16b* and **16***c* are larger than the other three grooves **16***d*, **16***e* and **16***f*. The two rolls press against each other only along the contact lines $\overline{AB}$ and $\overline{CD}$ in the illustrated embodiment but it will be understood that they may also be in pressing contact along short straight contact lines between adjacent ones of the grooves between the points B and C. The two backup rolls **18** and **19** are also of a special type and also identical. Each backup roll has a series of projecting bead portions **18***a*, **18***b*, **18***c*, **18***d*, **18***e* and **18***f* mating with the corresponding grooves in the working rolls.

In this embodiment, the screwing force *F* exerted upon the trunnions **18***a*′, **18***a*′ and **19***a*′, **19***a*′ of the backup rolls through the interposed bearing chocks which are identical with those shown in FIG. **1**. This force, as in the embodiment of FIG. **1**, is greater than the counterforce resulting from the rolling. Under these conditions, the working rolls will remain in pressure contact in the zones $\overline{AB}$ and $\overline{CD}$ during rolling and the rolls constantly remain at the same relative position. The thickness of the rolled product thus remains constant.

The above-described embodiment of the invention for simultaneously rolling a plurality of bars has the particular advantage of avoiding all relative radial movement of the working rolls when one of the bars is removed from the mill. This is a well-known cause of irregularities in the sections of rolled bars in conventional rolling mills. According to this embodiment of the present invention, a plurality of bars with very precisely determined cross sections may be produced simultaneously.

FIG. **3** represents another system which makes it possible to adjust the thickness of rolled strips in a four-high mill with a prestressed housing. The housing is again identical with that of FIG. **1** and any parts designated by like reference numerals are of like structure and serve the same function.

As in the other embodiments, the mill comprises a pair of working rolls **20** and **21**, with a pair of backup rolls **22** and **23**. Each roll comprises a central portion having a rectilinear generatrix and two frustoconical end portions respectively designated as **20***a*, **20***b*, **21***a*, **21***b*, **22***a*, **22***b* and **23***a*, **23***b*. The median diameter of the two frustoconical end portions of each roll is substantially the same as the diameter of the central portion of the roll, the two end portions being so arranged on each roll that one converges towards, while the other diverges from, the central portion of the roll. The two working rolls are so positioned in relation to each other that their straight generatrixes define a space therebetween into which may be introduced a strip P to be rolled.

Since the slopes of the conical end portions of the working rolls are identical and the two rolls are in wedged engagement, as axial displacement of one roll in respect of the other will cause a change in the central space defined therebetween, thus changing the thickness of the strip to be rolled.

For this purpose, an axial displacement mechanism is provided, which is most clearly shown in FIG. **4** and **5**.

This mechanism is housed in the bearing chock **11***a* at the left in FIG. **3** and the bearing chock **11***b* at the right in FIG. **3**.

This mechanism includes an annular chamber **24** in each bearing chock which is filled with a hydraulic liquid, for instance oil, and which is closed at the side facing the respective frustoconical end portion **21***a* or **21***b* of the roll by an annular piston **25** which slides in the chamber. A feed conduit **26** connects the chamber **24** to a source of a liquid under pressure (not shown), and a manometer **27** is connected to conduit **26** by branch conduit **26***a*. A return conduit **28** may remove the hydraulic liquid from the circuit, a valve **29** being mounted in the return conduit.

FIG. **4** shows the mounting of the bearing chock **10***a* on columns **2** and **3** by means of plate **30** and bolt **31**, which is conventional and permits the bearing chocks of the rolling mill of this invention to be immobilized.

The axial displacement is effected in the following manner:

The hydraulic liquid pressure is controlled by manometer **27** so as to exert a desired axial pressure on pistons **25**. In this manner, the two pistons will move the rolls **20** and **21** in opposite axial directions to increase the central space therebetween. When the hydraulic pressure is reduced, for example by opening valves **29**, the two rolls will move in the reverse direction to reduce the central space therebetween.

The herein described and illustrated axial roll displacement mechanism is merely illustrative and other systems will readily occur to those skilled in the art, for instance by using the transmission shafts connected to motors **15** for this purpose.

As will be appreciated, the backup rolls **22** and **23** are also in wedged engagement with the working rolls **20** and **21**. The diameters of the central rectilinear portions of the backup rolls are considerably larger than those of the working rolls to limit mill spring. They are in contact with the working rolls along their entire lengths and are thus displaced with them. The screwing forces *F* exerted upon the trunnions of the backup cylinders through the bearing chocks **11***c* and **11***d* are thus uniformly distributed over the entire lengths of the working rolls in any working position. Thus, the thickness of the product to be rolled can be adjusted very accurately, as in the other embodiments of this invention.

It will be noted from FIG. **3** that the median diameters of the frustoconical roll portions are about the same as the diameters of the central roll portions. Since the peripheral speeds of the central working roll portions should be identical, for rolling strips, slippage between the conical portions is reduced to a minimum.

The mill spring compensation system described hereinabove is fully applicable to the embodiment of the rolling mill shown in FIG. 3, it being generally understood that various combinations of individual parts described in the several embodiments may be interchanged suitably without departing from the spirit and scope of the present invention.

Also, both working rolls in the embodiment of FIG. 1 may be of the special type shown for the roll 4. This may have the advantage that the rolling line of the working rolls will lie in the median plane of the strip being rolled. In this case, the peripheral speed of the working rolls at their ends will be identical and there will be no slippage therebetween. In this case, the second backup roll 7 will, of course, also have the special form of the other roll 6.

Generally, the diameters of the working and backup rolls respectively will be ground in a single operation so as to avoid any possibility of eccentricity.

The rolling mills with a prestressed housing according to the present invention have numerous advantages.

For instance the thickness of the rolled product does not depend on the supposedly uniform temperature of the rolls and the housing. Nor does it depend on the thickness of the oil film lubricating the bearings, which makes it independent of the rolling speed. In all embodiments, the mechanical chain, upon which various stresses are exerted, which may cause variable elastic deformation, is reduced to a minimum and includes neither roller bearings nor oil films. The possible variations in the thickness of the rolled product are, therefore, minimized and may readily be compensated by any of the well-known systems for compensating mill spring. Finally, the herein disclosed prestressed rolling mill housing eliminates the effects of eccentricity of the rolls, which has always been grave in four-high mills.

It will be clearly understood that while now-preferred embodiments of the invention have been described and illustrated, many modifications and variations may occur to those skilled in the art without departing from the spirit and scope thereof. For instance, this invention will be readily applicable not only to metallurgy but also to the working of plastic material or glass products which may be rolled advantageously with the apparatus described and claimed herein.

I claim:

1. A four-high rolling mill comprising
   1. two cooperating working roll,
      a. each working roll having at each end a bearing surface in rolling contact with the corresponding end bearing surface on the other roll;
   2. two backup rolls, each of the backup rolls being in pressure contact with a respective one of the working rolls along the entire length of the working rolls and each backup roll having a diameter at each point along its length such that the backup roll mates along the entire length with the working roll in pressure contact therewith;
   3. means for exerting upon the ends of the backup rolls a pressure force superior to, and opposing, the rolling pressure exerted upon the working rolls by a product passing therebetween during rolling;
      b. the pressure force being transmitted by the backup rolls to the working rolls through their end bearing surfaces and along their entire length whereby the bearing surfaces of the working rolls are held in pressure engagement with each other while a rolling space is defined between the working rolls to permit the product to pass therethrough.

2. A four-high rolling mill comprising
   1. two cooperating working rolls,
      a. each working roll having at each end a bearing surface in rolling contact with the corresponding end bearing surface on the other roll,
      b. the end bearing surfaces of at least one of the working rolls having a diameter larger than the diameter of the central portion of the roll extending therebetween, the rolling space being defined between the central portion

of the one roll and the other roll;
   2. two backup rolls, each of the backup rolls being in pressure contact with a respective one of the working rolls along the entire length of the working roll and each backup roll having a diameter at each point along its length such that the backup roll mates along the entire length with the working roll in pressure contact therewith,
      a. the backup roll in pressure contact with the one working roll having end bearing surfaces in rolling contact with the end bearing surfaces of the one working roll whose diameters are smaller than the diameter of the central portion of the backup roll extending therebetween; and
   3. means for exerting upon the ends of the backup rolls a pressure force superior to, and opposing, the rolling pressure exerted upon the working rolls by a product passing therebetween during rolling,
      b. the pressure force being transmitted by the backup rolls to the working rolls through their end bearing surfaces and along their entire length whereby the bearing surfaces of the working rolls are held in pressure engagement with each other while a rolling space is defined between the working rolls to permit the product to pass therethrough.

3. The rolling mill of claim 1, wherein each working roll has additional bearing surfaces intermediate the end bearing surfaces in rolling contact with corresponding bearing surfaces on the other working roll, concave rolling portions being defined between said additional bearing surfaces to permit elongated products to pass therethrough, and the backup rolls having corresponding bearing surfaces respectively mating with the bearing surfaces and concave rolling portions of the working rolls.

4. A four-high rolling mill comprising
   1. two cooperating working rolls,
      a. each working roll having a central portion defined by a rectilinear generatrix and at each end a frustoconical bearing surface of a median diameter about the same as the diameter of the central portion, one of the conical end bearing surfaces converging and the other conical end bearing surface diverging in respect of the central portion, and
      b. the two working rolls being arranged in wedged engagement and axially movable in respect of each other for defining an adjustable rolling space therebetween;
   2. two backup rolls, each of the backup rolls being in pressure contact with a respective one of the working rolls along the entire length of the working roll and each backup roll having a diameter at each point along its length such that the backup roll mates along the entire length with the working roll in pressure contact therewith,
      a. each backup roll having a central portion defined by a rectilinear generatrix and conical end portions of a median diameter about the same as the diameter of the central portion, one of the conical end portions of each backup roll converging and the other conical end portion diverging in respect of the central portion of the backup roll, and
      b. the two backup rolls being arranged in wedged engagement with the respective working rolls; and
   3. means for exerting upon the ends of the backup rolls a pressure force superior to, and opposing, the rolling pressure exerted upon the working rolls by a product passing therebetween during rolling,
      a. the pressure force being transmitted by the backup rolls to the working rolls through their end bearing surfaces and along their entire length whereby the bearing surfaces of the working rolls are held in pressure engagement with each other while a rolling space is defined between the working rolls to permit the product to pass therethrough.

5. The rolling mill of claim 4, further comprising means for axially displacing the working rolls in respect of each other.