United States Patent

Nellen et al.

[15] 3,693,393

[45] Sept. 26, 1972

[54] **ROLLING OF METAL INGOTS INTO BANDS**

[72] Inventors: **Wilhelm Nellen,** Dortmund-Hoechsten/Sommerberg; **Theodor Sevenich; Hans Wladika,** both of Dortmund, all of Germany

[73] Assignee: **Hoesch Aktiengesellschaft,** Dortmund, Germany

[22] Filed: **June 25, 1970**

[21] Appl. No.: **49,852**

[52] **U.S. Cl.** **72/226,** 72/250, 72/227, 72/366

[51] **Int. Cl.** **B21b 39/00**

[58] **Field of Search**.....72/199, 234, 200, 226, 201, 72/250

[56] **References Cited**

UNITED STATES PATENTS

1,771,688 7/1930 Nye .....72/234 X

3,110,204 11/1963 Schulte et al.....72/201

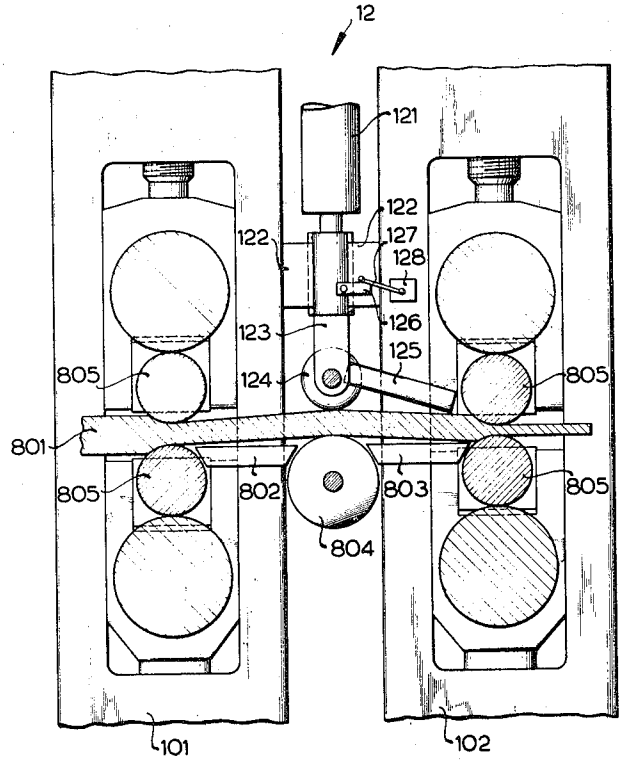
Primary Examiner—Milton S. Mehr

Attorney—Jennings Bailey, Jr.

[57] **ABSTRACT**

In a process for the continuous or semi-continuous hot rolling of metal ingots into bands with a high specific band weight, especially 30–40 kg per mm of band width, the material is heated, descaled, prerolled and reduced in thickness during the final rolling under tension in the longitudinal direction. During prerolling and/or intermediate rolling, the ingot is reduced in thickness under compressive stresses in the longitudinal direction. The pre-stage and/or the intermediate stage of the rolling mill are provided with roller controls such as to produce this longitudinal compression.

6 Claims, 14 Drawing Figures



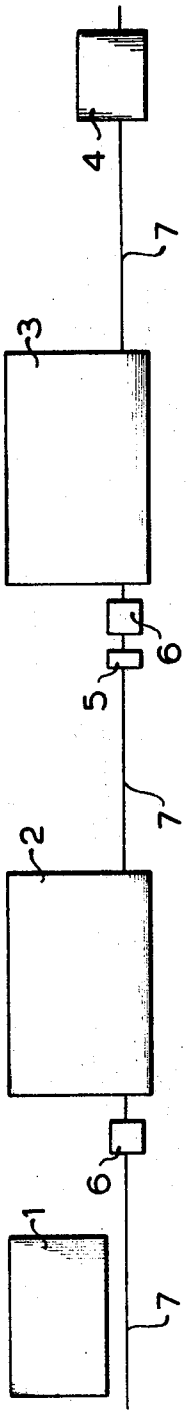


FIG.1

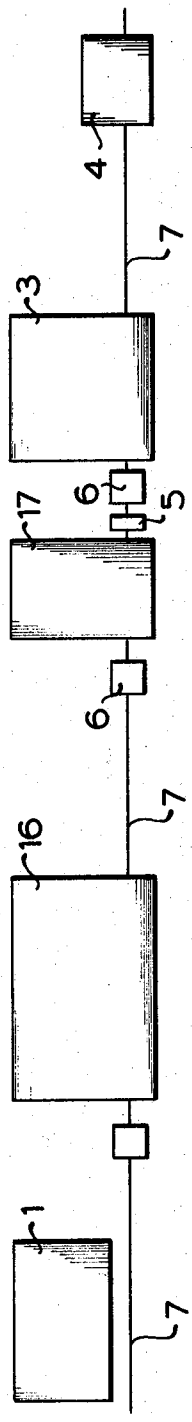


FIG.2

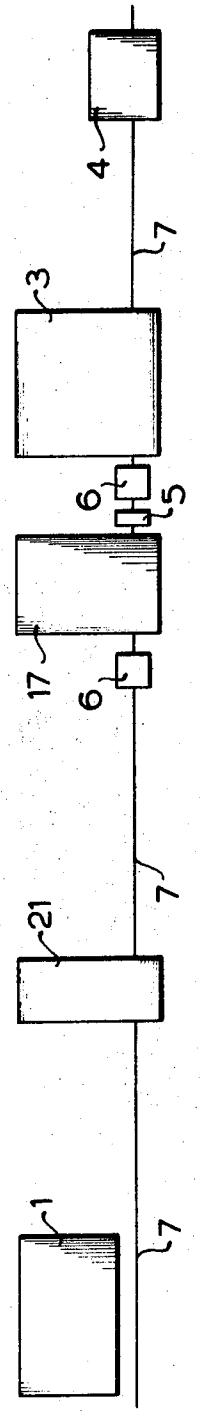


FIG.3

INVENTORS
WILHELM NELLEN
THEODOR SEVENICH
HANS WLADIKA
BY
Jenning Bailey Jr.

FIG. 4

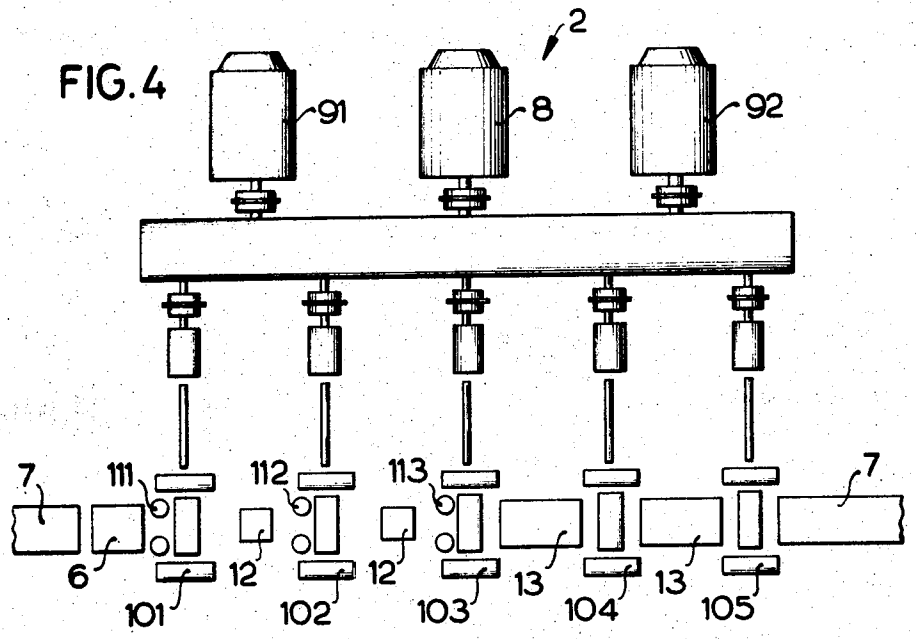
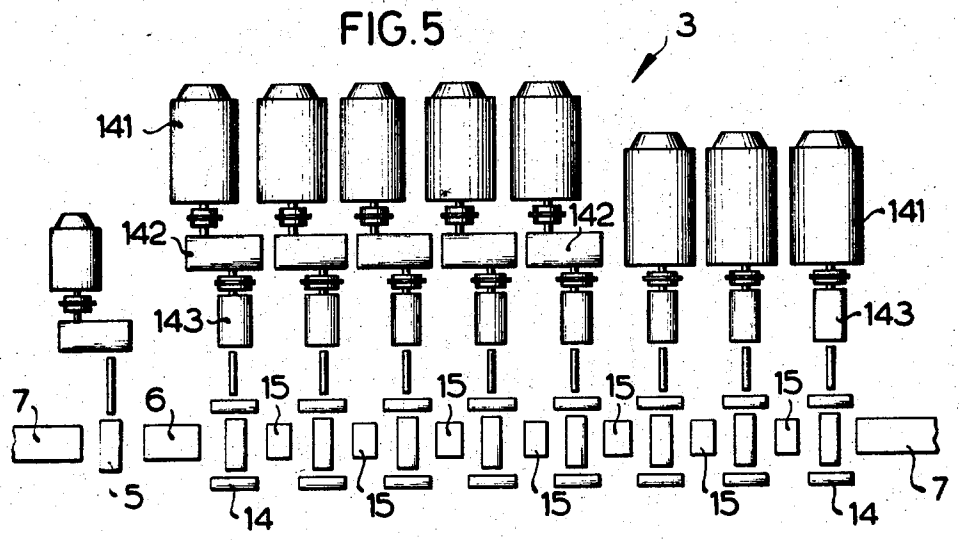


FIG. 5



INVENTORS
WILHELM NELLEN
THEODOR SEVENICH
HANS WLADIKA
BY

FIG. 6

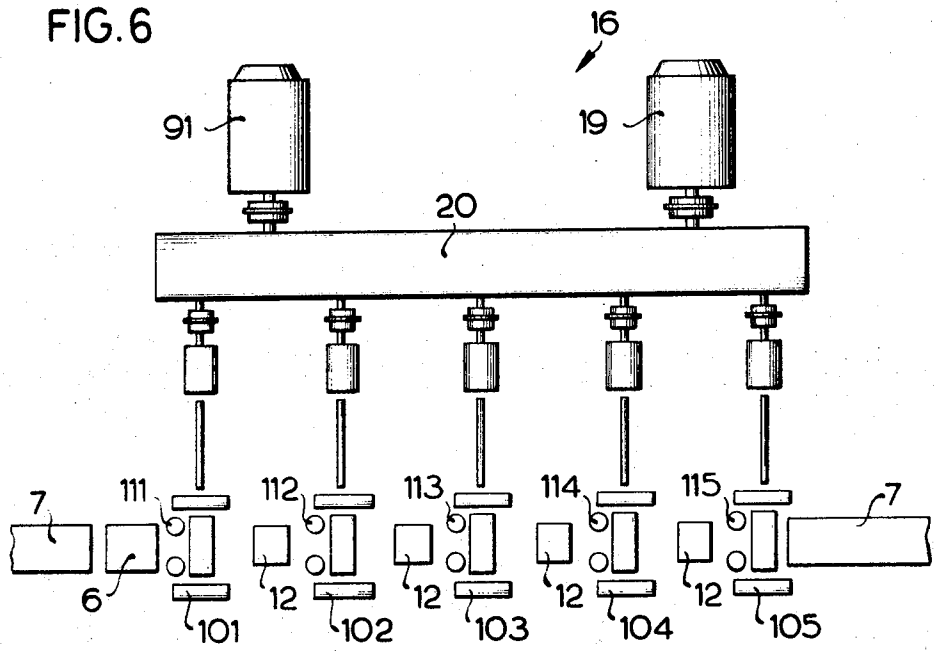
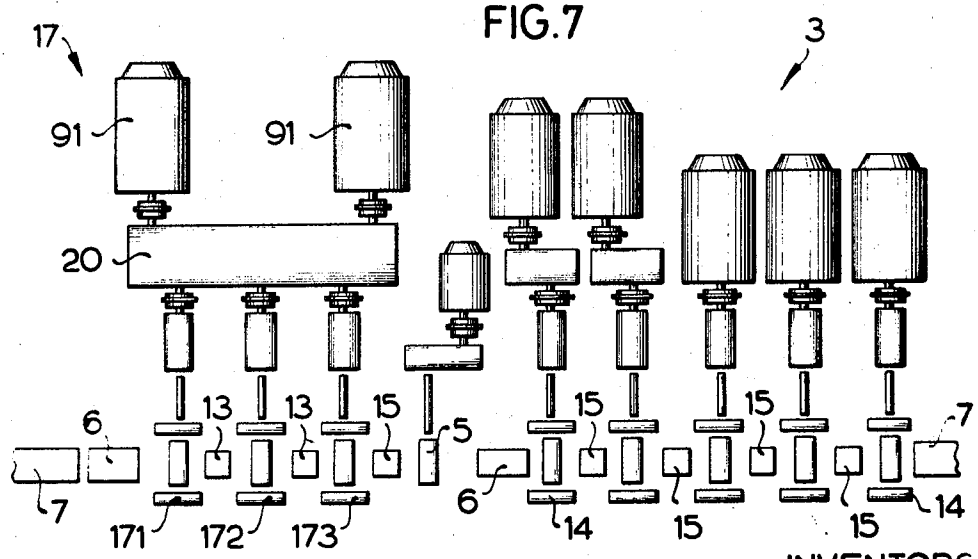


FIG. 7

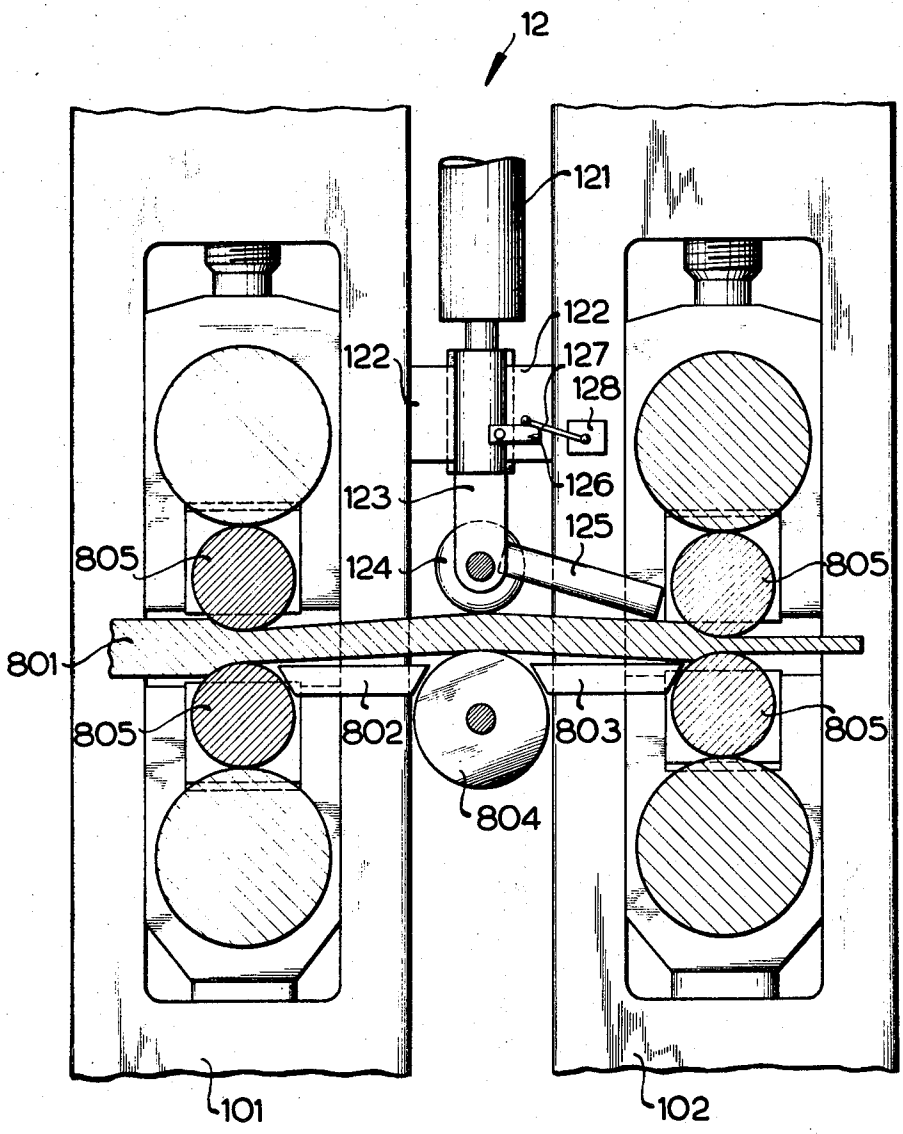


INVENTORS
WILHELM NELLEN
THEODOR SEVENICH
HANS WLADIKA

BY

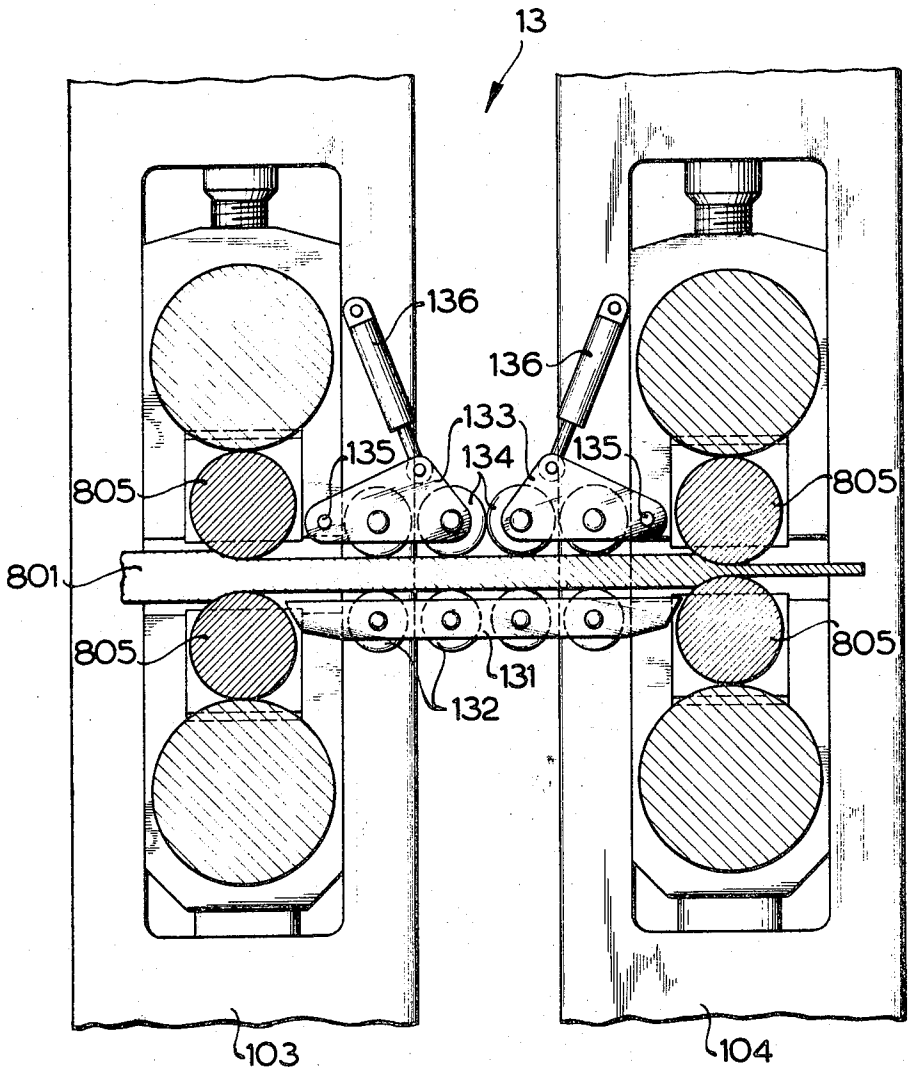
Thomas B. Bailey

FIG.8



INVENTORS
WILHELM NELLEN
THEODOR SEVENICH
HANS WLADIKA
BY

FIG. 9



INVENTORS
WILHELM NELLEN
THEODOR SEVENICH
HANS WLADIKA

BY

FIG.10

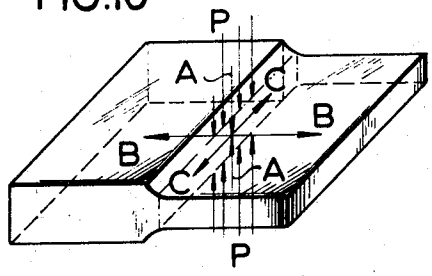


FIG.11

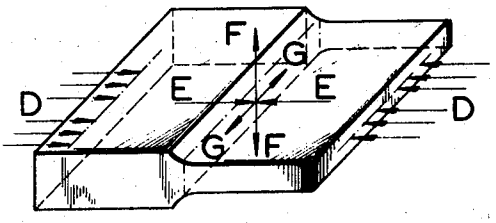


FIG.12

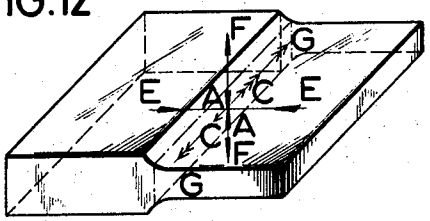


FIG.13

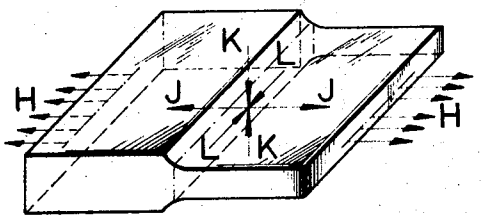
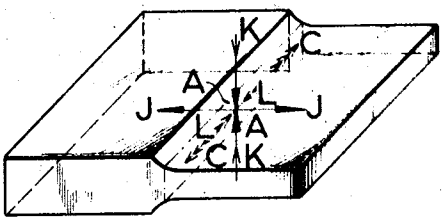


FIG.14



INVENTORS
WILHELM NELLEN
THEODOR SEVENICH
HANS WLADIKA

BY

ROLLING OF METAL INGOTS INTO BANDS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a process for the continuous or semi-continuous hot rolling of metal ingots into metal bands with a high specific band gravity, especially 30 –40 kg per mm of band width, in which the rolling material is heated, descaled, prerolled and during the finishing rolling is reduced in width under tension in the longitudinal direction. The invention also relates to a rolling mill with roller stands arranged one after another in a line, which are divided into stand groups comprising a pre-stage and a finishing stage, and if desired an intermediate stage, which is constructed for carrying out the process.

2. The Prior Art

In hot strip rolling mills, in which the strips are rolled from steel or non-ferrous materials, the roll stands, which are constructed as throughput stands, are arranged in the line one behind the other and in part are grouped together into stand groups. Often individual roll stands are constructed as so-called reverse stands or return stands. In these known rolling mills, in the first 4 to 6 stands designated as a pre-stage, the goods are rolled as far as possible in such a way that they are not stressed by longitudinal stresses, in order to avoid constriction in the band width. In order to accomplish this, the first four to six stands, in which the roll goods are reduced from for example 250 mm to about 30 mm in thickness, are spaced at such distances that the strip can run free between them, so that the pre-stage,especially if the strip is to be rolled into a band of high specific gravity, is very long.

After the pre-rolled band has left the pre-stage, a further free passage is no longer possible because of the great length of the rolled goods, so that the last five to seven stands of the rolling pair must be set close together in the so-called finish stage. In the rolls of the finishing stage, which, depending on the band width to be achieved, are spaced apart by distances of 2 and 5 meters, the strip is rolled simultaneously. It is then not possible in the finishing stage to roll in a free path as in the free stage. The band tension between the stages is however with the aid of loop controls kept as small as possible.

In consequence of the length of the pre-stage, in which the band can be transported only with a limited speed, for the passage of the band through the pre-stage a comparatively long time is required, so that the band is subjected to excessively strong cooling. The cooling is, dependent upon the selected distances of the stands from one another, stronger the greater the specific band weight. In order to reduce the length of the pre-stage and lengthen the cooling time, it has been proposed for increasing the band width to bring together the last two or three stands of the pre-stage into one group. The cooling of the band, and especially of the rear end of the band, is especially strong at the gap in the roller band between the last stand of the pre-stage and the finishing stage, because the band which is here already very thin is fed only very slowly into the finishing stage. To decrease the heat losses it has been proposed to increase the thickness of the pre-band, that is, to shorten the length of the pre-band, and to roll this pre-band in a finishing stage with a higher number of stands. Limits are set however to the increase of the pre-band thickness by the rolls in the finishing stage, because the differences in width between the beginning of the band and the end of the band, which in the finishing stage are rolled without the pull of the loop regulators, is impermisably greater as the bands become thicker.

SUMMARY OF THE INVENTION

The invention has the purpose to provide a process for hot rolling of metal ingots and a rolling mill for carrying out this process, by means of which increased specific band weight through increase of the incoming partly rolled or pre-band is achieved, the length of the structural arrangement of a hot band rolling mill is substantially reduced, the equipment to be installed is decreased and the heat loss of the band being rolled can be decreased. It is a further purpose to provide a process for hot rolling of metal ingots by which a substantially equal width over the whole length of the band can be obtained.

These purposes are achieved according to the invention in that the metal ingot is reduced in thickness by pre-rolling or intermediate rolling under compressive stresses in the longitudinal direction, the value of the longitudinal pressure on the strip advantageously being accomplished through changing the width of the rolled goods passing through the roll gap. Advantageously this change can be produced through changing the roller speed or the roll gap. In order to avoid tensional stresses in the rolled goods, advantageously the width of the rolled goods passing through the pre-rolls (preliminary rolls) or intermediate rolls from one roll stand to the following roll stand is kept somewhat greater than the outgoing width and the roll speed in the following roll stand is increased or in the preceding roll stand is decreased to such an extend that the outgoing width of the roller goods is equal to the ingoing width. Instead of increasing or decreasing the roller speed, a corresponding change of the roll gap can be accomplished.

The rolling mill provided for carrying out the rolling process according to the invention is characterized by the fact that, between the roll stands of the pre-stage under supports are positioned, and, between the work rolls of the roll stands of the pre-stage and/or the roll stands of the intermediate stage and/or the roll stands of the finishing stage traveling band guides are provided above and below the roller goods. According to an advantageous construction of the rolling mill according to the invention, rolling tables are provided beneath the rolled goods, and between the rolling tables a turning support roller, and above the rolled goods an upwardly and downwardly movable roll running on the rolled goods, are provided, the latter being mounted in a roll holder running in guides and being adjustable in height by means of a controllable adjustable cylinder, the upper surface of the support roller being arranged above the upper surface of the work roll. In a further construction of the new rolling mill, a device is arranged on the roll holder for moving the control lever of a potentiometer, for example, by which the speed of the driving motor and a working roll can be adjusted. Advantageously there are also, between the working rolls of the pre-stage and of the

working rolls of the intermediate stage, rolling tables beneath the rolled goods with turnable rollers and above the rolled goods at each roll stand a roll holder turnable about a pivot and containing rolls which are adjustable by means of an hydraulic cylinder against the rolled goods. Advantageously the working rolls in an emergency can be switched off by means of the hydraulic cylinder through a contact manometer or an end switch and the speed of the work roll can be controlled by means of a potentiometer coupled with the roll holder.

The advantages of the process and apparatus according to the invention are first of all that a continuous pre-stage can be substantially shortened. Besides a smaller temperature drop in the roll goods results, which makes it possible on the one hand to reduce the temperature of the ingot heating oven, which precedes the rolling stage, up to about 100°C and in this respect to save fuel and repair costs, and on the other hand to increase the specific gravity of the band, which leads to cost advantages in the purchase and operation in respect to the path of travel of the band and the after-connected finishing machines. In addition, a band of equal width along its whole length is produced, because the decrease in band width developed by the unavoidable band stresses in the finishing stage are compensated by the additional broadening of the band over the greater part of the band length in a group of frames in which the band is rolled with compressive stresses in the longitudinal direction.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** shows diagrammatically a rolling mill embodying the invention;

FIG. **2** is a plan view of a pre-stage of the mill of FIG. **1**;

FIG. **3** is a plan view of the intermediate and finishing stages;

FIGS. **4** and **5** are diagrammatic showings of two additional embodiments of a rolling mill;

FIG. **6** shows in plan view a modification of a pre-stage;

FIG. **7** shows in plan view an intermediate stage and a finishing stage to be used with the pre-stage of FIG. **6**;

FIG. **8** shows a cross-section through two successive roll stands of a pre-stage or intermediate stage according to either FIG. **4** or FIG. **6**; machine the

FIG. **9** is a cross-section through two successive roll stands of a finishing stage and;

FIGS. **10** to **14** are diagrams of the stress ratio in the rolled goods during the rolling.

Referring to FIG. **1**, a completely continuous hot rolling mill is shown, which consists of a warming oven group **1**, a pre-stage **2**, a finishing stage **3**, and a reel group **4**. Preceding the pre-stage **2** is a scale washer **6**, and following the pre-stage **3** are a trimmer **5** and a scale washer **6**. The individual machine groups of the roller stages are connected with each other by roller tracks **7**.

As appears from FIG. **4**, the roll stages **101** to **105** of the pre-stage **2** are driven through a synchronous motor **8** and direct current motors **91** and **92**. By changing the speed of the direct current motor **91**, a change of the roll speeds of the roll stands **101**, **102** is brought about, whereas by a change of the speed of the motor **92** the roll speed of the stands **104** and **105** is changed. However each of the stands of the pre-stage **2** can be driven individually through controllable motors.

The stands **101**, **102**, **103** of pre-stage **2** are provided with vertical rolls **111**, **112**, **113**. Between the stands **101**, **102** or **102**, **103** are under supports **12**, while between the stands **103**, **104** and **104**, **105** band guides **13** are arranged, the construction and finishing of which will be explained below. The finish stage **3** (FIG. **1**) which in its detail is shown in FIG. **5**, is constructed in a known way; the stands **14** are individually driven from controllable direct current motors **141** through transmissions **142** and cam rolls **143**. Between the stands loop control devices **15** are provided.

An ingot in the completely continuous hot band rolling arrangement of FIG. **1** as well as in the pre-stage according to FIG. **2** and the finishing stage according to FIG. **3** is rolled in the following manner.

The ingot heated to rolling temperature is discharged from one of the ovens of the heating oven group **1** onto the roller table **7** and moves on this to the pre-stage **2**. Before its entry into the pre-stage **2** the ingot is freed of heat scale by passing through a scale washer **6**. The ingot now in the pre-stage is reduced in thickness in the horizontal stands **101** to **103** without longitudinal tension in the goods and in breadth in the vertical compression stands **111**, **112**, **113**. The under support **12** between the roll stands **101**, **102** and **102**, **103** controls together with the roll pressure measuring device in the vertical compression stands **111**, **112**, **113** the speed of the motor and therewith the longitudinal forces in the rolled goods. In the stands **104**, **105** the increase of band breadth in the rolled goods is accomplished with longitudinal pressure forces. The value of the pressure forces is advantageously determined by changing the roll speed in the stands **104**, **105** through the speed of the motors **92**. The motor speed and or the roll gap is advantageously so adjusted that the broadening in the intermediate part of the band differs from that in the band ends in such a way that a variable contraction between the band ends and the center portion, which later results from the variable tension of the loop controls **15** in the finishing stage, is fully compensated.

The pre-band leaving the pre-stage **2** runs under the roller through **7** to the edger **5** where it is cropped, after which it is descaled in scale washer **6** and passes to the roll stands of the finishing stage **3** where the band is reduced in the known way to the finished band thickness.

If from a starting ingot width, bands of widely different widths are to be produced, advantageously a grouping of the roller stands according to FIG. **2** is used. The roll stages, which work as a completely continuous arrangement, consists of a heating oven group **1**, the pre-stage **16**, the intermediate stage **17**, the finishing stage **3** and the winding group **4**. The individual machine groups are connected to each other by rolling tables **7**. The pre-stage **16**, there intermediate stage **17** and the final stage **3** also include between them scale washers **6**. Between the intermediate stage **17** and the scale washer **6** is an edger **5**. In front of the horizontal stands **101** to **105** of the pre-stage **16** (FIG. **6**) are vertical compression stands **113** to **115**, and also the under support **12**. Between the stands **171**, **172**

(FIG. 7) are band guides 13 and between the stand 173 and the edger 5 as well as between the stands 14 of the finishing stage 3 a loop lifter 15 is arranged.

The roll stands 101 to 105 of the pre-stage 15 (FIG. 6) are driven by direct current motor 91 and direct current motor 19 as well as common drive 20. The roller stands 171 to 173 of the intermediate stage 17 (FIG. 7) are driven from the direct current motor 91 in some instances over a common, for example hydraulic drive 20 or by three individual direct current motors (not shown). The roll stands 14 of the finishing stage 3 are driven according to the modification shown in FIG. 5. An ingot is in the completely continuous hot rolling arrangement according to FIG. 2 rolled with the pre-stage according to FIG. 6 and the intermediate stage according to FIG. 7 in the following manner.

In the pre-stage 16, the ingot is reduced continuously in thickness from, for example 300 mm, continuously to 80 mm and in breadth for example from 1,050 to 970 millimeters through 80 millimeters, the speed of the motors 91, 19 in the manner explained below being so adjusted that the rolls of the rolled stands 101 to 105 operate with slight longitudinal pressure on the rolled goods and so produce with assurance no contraction in breadth in the middle of the pre-band. Behind the last stand 105 of the pre-stage 16, from which the pre-band issues at a speed of about 1.5 m/sec, it runs free on the rolling table 7, is transported to the scale washer 6 and enters into the intermediate stage 17. In the stands 171 to 173 of the intermediate stage 17, the pre-band is reduced in thickness under longitudinal pressure from 80 mm to 15 mm. In consequence of the pressure stresses in the longitudinal direction exerted by the rolls of the stands 171 to 173 of the pre-stage 17 on the rolled goods, the band in the intermediate section is more sharply widened than at the beginning or the end of the band. In order to make sure that the part of the band in position in the intermediate stage 17 under longitudinal pressure forces is not deflected upward or downward it is advantageous to support it between the stands 171 to 173 by belt guides.

After the exit of the band from the last stand 173 of the intermediate stage 17, it is cropped with an aid of the edger 5, freed of secondary scale in the scale washer 6 and finally finish rolled in the known manner in the stands 14 of the finishing stage 3, the additional broadening in the middle part of the band imparted in the intermediate stage 17 serving as an equalization for the contraction of the band produced by the loop lifters 15 in the finishing stage 3.

The process for the rolling of hot bands can also with advantage be applied in a semi-continuous rolling mill according to FIG. 3. The rolling mill according to FIG. 5 includes the heating oven group 1, a reversing stand 21 as well as intermediate and finishing stages 17 and 3 corresponding to FIG. 7. In the reversing stand 21 the ingot is rolled down in five stages from 300 mm thickness. Because this pre-band following each stage of rolling can run free out of the rolling stand 21, an uneven broadening of the rolled goods does not take place.

The semi-continuous rolling mill constructed in accordance with FIG. 5 shows, in relation to the space requirements, small difference in breadth and high specific band weight the same advantages as the completely continuous rolling mill of FIG. 4. The heat loss in the pre-stage is however in the semi-continuous rolling mill according to FIG. 5 greater than in the completely continuous rolling mill according to FIGS. 1 and 4, so that the heating oven in the semi-continuous mill according to FIG. 5 must operate with higher temperatures. In the re-building of the existing semi-continuous hot strip rolling mill the arrangement according to FIG. 5 has however substantial advantages because the existing reverse rolling frame 21 can be made use of.

In order to roll the goods without longitudinal stresses and only with compressive stresses in the longitudinal direction, in the stands 101 to 103 of pre-stage 2 and in the stands 101 to 105 of pre-stage 16, it is advantageous to provide between these stands a hold-down arrangement 12 as shown in FIG. 8. In this arrangement, underneath the rolled goods 801 at the exit and input between the stands such as 101 and 102 roll tables 802, 803 and between the roll tables a rotating support roll 804 are arranged, whose upper side lies higher than that of the working rolls 805 of the roll stands 101, 102. Above the rolled goods 801 a hold-down arrangement 12 is provided, which consists of an adjustable positioning cylinder 121 and a guide 122 for the roller holder 123 in which the pressure roll 124 is journalled. On the roll holder 123 a lug 126 is arranged by means of which the control lever 127 of a potentiometer 128 is operated. The guide-in member 125 is fastened to the frame 102.

The hold-down arrangement 12 described above in connection with FIG. 8 operates as follows:

The front end of the rolled goods 801 leaving the roll stand 101 passes with the speed of the work roll 805 of the stand 101 over the roll table 802 and the support roll 804 until it engages the in-guide block 125. From the in-guide block 125 the point of the roll goods 801 is bent down on the supporting roll 804 and runs between the work rolls 805 in the frame 102. The speed of the work roll 805 in the frame 102 is so adjusted that the band volume per unit of time passing through the frame 102 is somewhat smaller than the band volume per unit of time coming out of the frame 101. In this way the rolled goods 801 lift the roll 124 together with the roll holder 123 against the pressure of the positioning cylinder 121. The roll holder 123 then presses with the lug 126 the control lever 127 of the potentiometer 128 upwards, which through a conventional switch arrangement reduces the speed of the driving motor of the work rolls 805 or reduces the roll gap until the band volume running into this frame is equal to the band volume leaving through the roll frame 102.

The rolled goods, both between the roll stands 101, 102 and in the roll gaps, for the process of the rolling process, while they are lifted up from the support roll 804, are under pressure forces in the longitudinal direction which are determined by the pressure in the position cylinder 121. By changing this pressure the pressure forces exerted on the rolled goods can be varied as desired. They must however always be so low or so adjusted that the band in front of or behind the roller is not buckled upward.

In order that the rolled goods 801 or the band between the roll stands 103 to 105 (FIG. 4) or 171 to 173 (FIG. 7) may be prevented from buckling either up

or down under the compression forces, they are supported above and below through a belt guide **13**, as shown in FIG. **9**. The strip guide shown in general by **13** is arranged between the schematically shown roll stands **103**, **104**. It consists of a roll table **131** with turnable rolls **132**, which is fastened between the roll stands **103**, **104** beneath the rolled goods **801**. Above the rolled goods **801** are two roll holders **133** with rolls **134**, which are turnable on the pivots **135** and by means of cylinder **136** are pressed against the travelling rolled goods **801**. The hydraulic pressure in the cylinder **136** is advantageously so adjusted that with the contemplated compression forces in the rolled goods **801** cannot lift the roll holder **133**. If disturbances arise in the roll stage in the form of bends in the band which lift up the roll holders **133**, so that a pressure increase arises in the cylinder **136**, the roll stage is switched off by a contact manometer or an end switch not shown. Advantageously the roll holder **133** can also be coupled with a potentiometer, by which the roll speeds of the work rolls **103**, **104** are controlled.

For the division of forces in the rolled goods contemplated, the rolling process according to the invention is as follows.

The beginning of the band and the end of the band are rolled in two groups of stands, for example in the pre-stage **2** or the pre-stage and intermediate stage **16**, **17** as well as in the finishing stage **3**, without forces in the rolling direction. Thus the roll pressure P during the deformation in the roll gap (disregarding the friction between the rolls and the rolled goods between then), as in shown in FIG. **10**, creates in the direction of the rolled goods thickness the compressive force A. The compressive force A brings about through its transverse component in the longitudinal direction of the rolled goods the tension B and in the transverse direction of the rolled goods the tension C. The deformation of the rolled goods in the direction of their thickness, length and width in these areas of the strip, because, besides the roll pressure, no other external force operates on the goods, are determined only by the size of the tensions A, B, and C.

In the first stage group, for instance in the pre-stage **2**, or the pre-stage **3** and intermediate stage **16**, **17** the strip, to the extent that it is rolled simultaneously in two ro more frames, through adjustment of the respective differences in turning speed between the individual frames is subjected to the compression force indicated in FIG. **11** at D, which produces in the rolled goods in the longitudinal direction the compressive forces E with their transverse components F, G.

The strains of the forces P, D (FIGS. **10** and **11**) are superimposed in FIG. **12**. The transverse component F (open arrows) works against the pressure A (closed arrows) and increased the roll pressure. The transverse component G (double open arrows) work in the same direction as the transverse component C (triple open arrows) and increases the width. The beginning of the band and the end of the band after the exit from the first group of frames is narrower than the mid-part.

In the second frame group, for example in the finishing group **3**, the goods are rolled in a known way with loop lifters **15**. Insofar as the strip is running in two or more stands, the loop lifter **15** engages from beneath against the band and creates in it a tension which in FIG. **13** is shown at H, which creates in the longitudinal direction of the band the tensions J with perpendicular components K, L in the direction of band thickness and band breadth. The strains of the forces P, H (FIGS. **10** and **13**) are superimposed according to FIG. **14**. Here the transverse component K (open arrows) works in the same direction as the tension A (closed arrows). Thereby the roll pressure P supplements the longitudinal force I. The transverse component L (double open arrows) works against the transverse component C (triple open arrows) and increases the widening. In the second group of frames the beginning of the band and the end of the band broaden more than the middle of the band. There results an equalization of the unequal broadening along the length of the band in the pre-stage **2** and in the finishing stage **3** and in the pre-or intermediate stage **16** and **17** and in the finishing stage **3**.

We claim:

1. Process for at least semi-continuous hot rolling of metal ingots to metal bands with a high specific band weight, in which the ingots are heated, pre-rolled, and while under tension in the longitudinal direction finish-rolled to reduce their thickness, which comprises reducing the metal ingot in thickness by pre-rolling prior to the finish rolling while subjecting it to compressive force in the longitudinal direction.

2. Rolling mill comprising a plurality of roll frames arranged in a line one after another, including a group of frames comprising a pre-stage and a group of frame comprising a finish stage, having between at least two successive roll frames of the pre-stage hold down means for preventing buckling of the goods, and means to drive the rolls of said successive frames at such relative speeds relative to the roll gaps as to produce a compressive force in the goods between the rolls in said two frames.

3. Rolling mill as claimed in claim **2**, in which said hold down means includes rolling tables adjacent each of the roll frames beneath the path of the roll goods therebetween, a rotatable support roll between the rolling tables, and a pressure roll for engaging the roll goods from above between the frames, means mounting the pressure roll for substantially vertical movement and means to press the pressure roll against the goods.

4. Rolling mill as claimed in claim **3**, in which the upper surface of the support roller is higher than the upper surface of the lower rolls of the roll frames.

5. Rolling mill as claimed in claim **3**, in which said pressure roll supporting means includes a vertically movable roll holder, a potentiometer, and means carried by said roll holder for adjusting the setting of the potentiometer.

6. Rolling mill as claimed in claim **2**, in which said hold down means comprises a plurality of rolls rotatably mounted between successive roll frames beneath the band of the roll goods and at least one roller frame having rollers turnably mounted and pivoted on one of said roll frames in a position to overlie the goods passing between the roll frames, and means to exert a force on said roller frame so as to force it against the goods being rolled.

* * * * *