United States Patent

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[33] **Great Britain**
[31] **52852/67, 15928/68 and 15929/68**

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[54] **APPARATUS FOR PROCESSING SHEET AND STRIP MATERIAL**
12 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **72/241,** 72/242, 72/246
[51] **Int. Cl.** **B21b 13/14,** B21b 29/00
[50] **Field of Search** 72/240, 241, 242, 243, 163, 164, 165, 245

[56] **References Cited**

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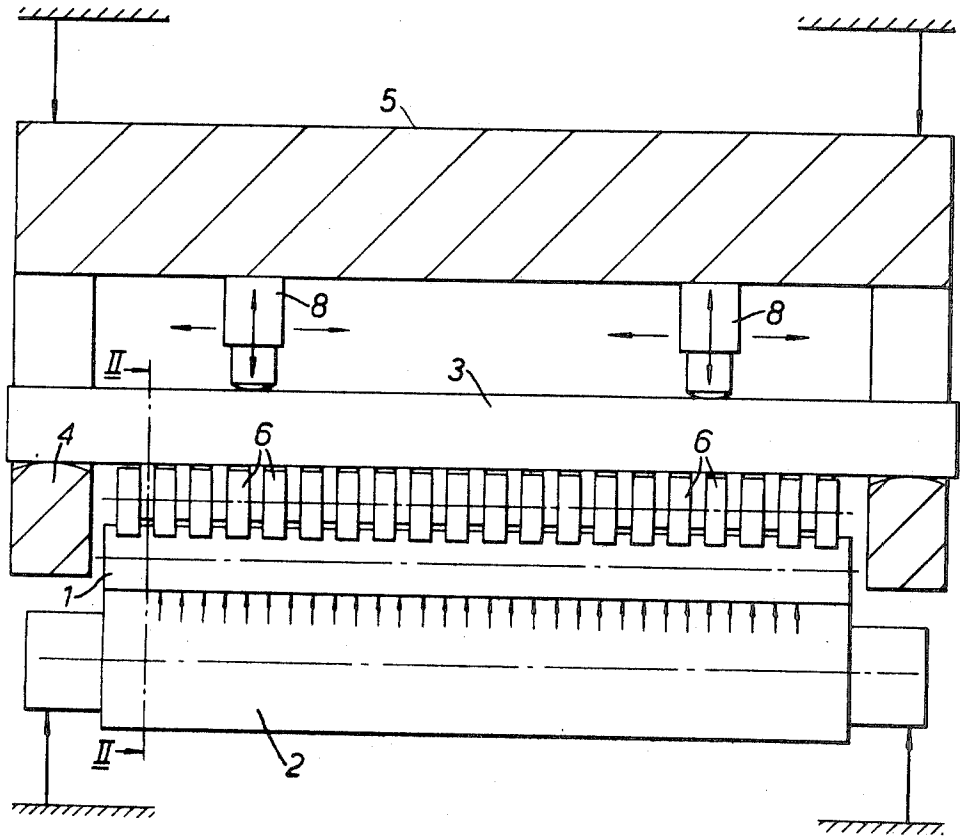
ABSTRACT: A machine for processing sheet and strip material such as a temper bending machine or a rolling mill has a pair of work rolls between which the material is processed and at least one of the rolls is engaged along its length by a plurality of casters which are supported on a flexible beam extending parallel to the axis of the roll. Means, conveniently in the form of hydraulic piston and cylinder assemblies are provided for flexing the beam to apply forces to the roll which oppose other forces which act on the roll during processing. In this way any tendency of the roll to bend and thereby produce sheet or strip of nonuniform shape is overcome.



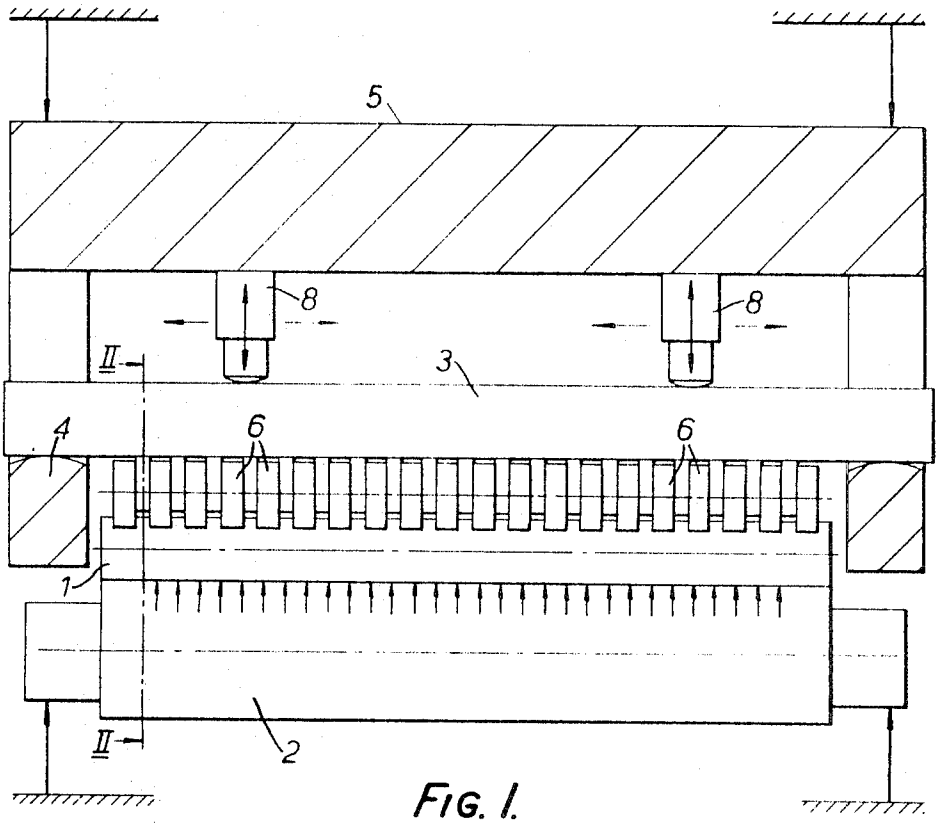


FIG. 1.

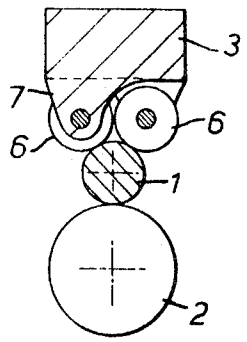


FIG. 2.

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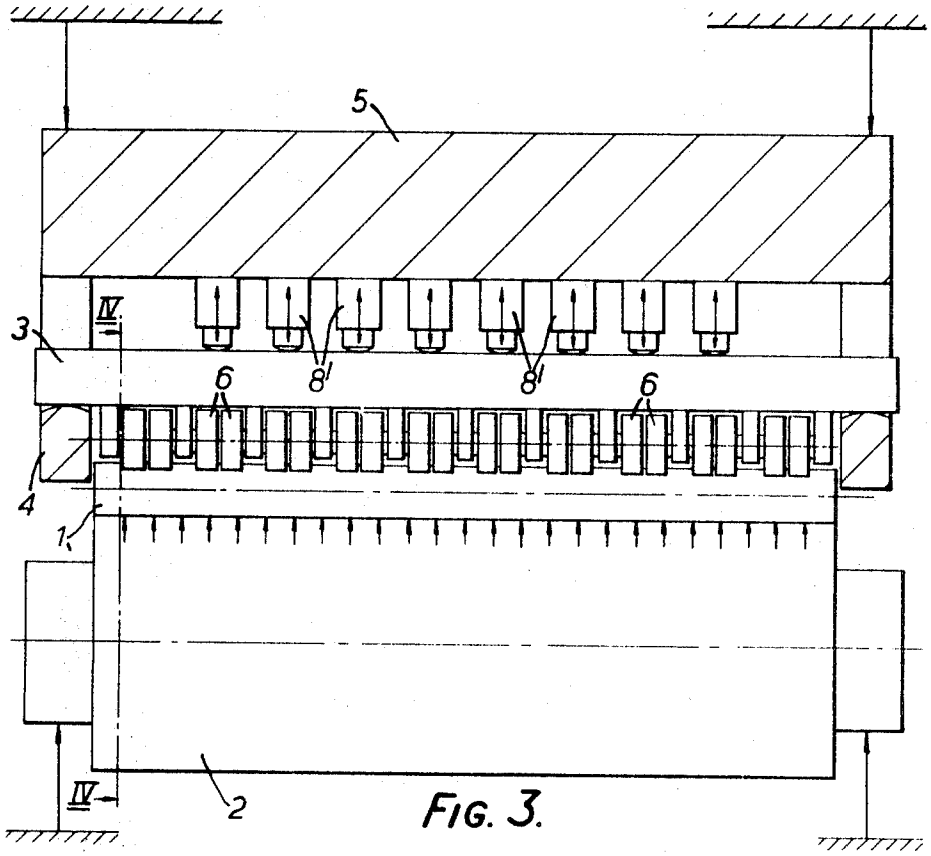

FIG. 3.

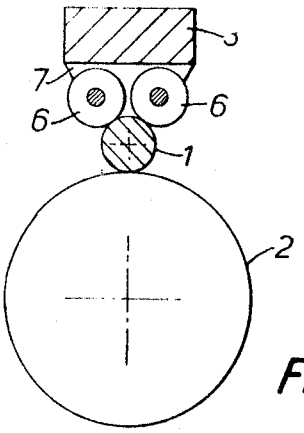

FIG. 4.

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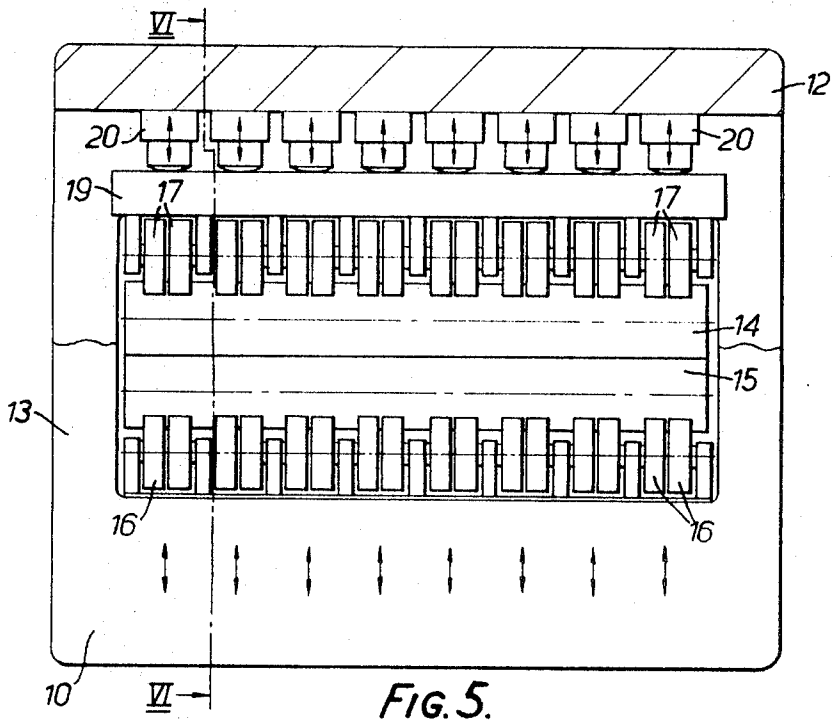

FIG. 5.

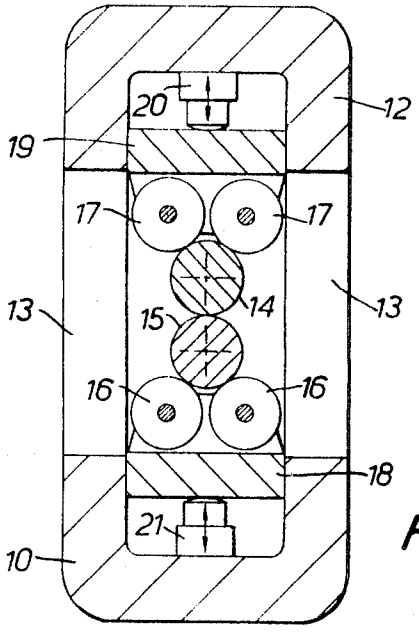

FIG. 6.

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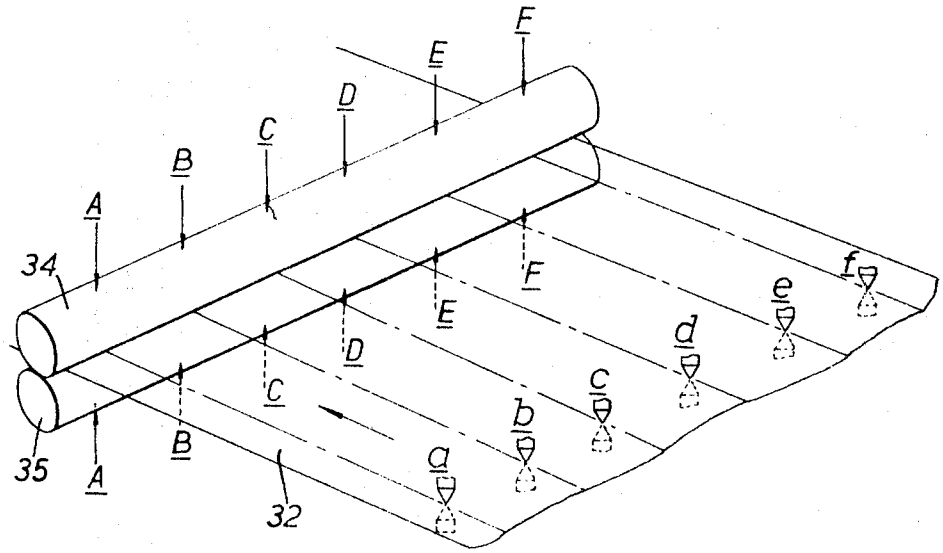

FIG. 7.

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APPARATUS FOR PROCESSING SHEET AND STRIP MATERIAL

This invention relates to apparatus for processing sheet or strip material by passing the material between a pair of work rolls and in particular to means for compensating at least one roll against forces exerted on that roll during processing.

The apparatus may be a rolling mill for reducing the gauge of metallic sheet or strip or it may be a temper bending machine for processing metallic sheet or strip having a discontinuous yield point. In both cases the work rolls have forces exerted on them during processing and the forces may be sufficiently large to cause one or both of the rolls to bend so that the shape of the material being processed is affected. By shape is meant the variation in thickness of the material across its width, that is, normal to the direction in which it is being processed. When one or both of the work rolls bends due to the forces acting thereon the material being processed usually becomes thinner at its edges than at its center.

According to the present invention apparatus for processing sheet or strip material includes a pair of work rolls between which the material is processed, at least one of the rolls having a flexible beam extending parallel to the longitudinal axis of the roll, a plurality of casters supported by the beam and each acting against said roll and means for flexing the beam to thereby apply forces to the roll which oppose other forces exerted on the roll during processing.

The forces exerted on the rolls by the rolling load during processing may tend to bend one or both of the rolls and if only one roll tends to bend this can be compensated for by flexing the beam sufficiently to apply compensatory forces to that roll and thereby prevent the roll from bending.

When the apparatus is in the form of a temper bending machine it is usual for one work roll to be of much smaller diameter than the other roll and consequently it is the smaller diameter roll which tends to bend and the compensatory forces are applied to this roll. When the apparatus is a rolling mill it is usual for both rolls to be of the same diameter and in which case both rolls may tend to bend and each roll is then provided with compensatory forces which oppose the forces acting on the roll during rolling.

According to a second feature of the present invention apparatus for processing metallic sheet or strip material includes a pair of work rolls between which the material is processed, at least one of the rolls having a pair of flexible beams positioned on opposite sides of the roll and each extending parallel to the longitudinal axis of the roll with each beam having a plurality of casters which act against the roll and also having means for flexing the beam to thereby apply forces to the roll which oppose other forces exerted on the roll during processing.

It is preferable for the casters of the or each beam to be freely rotatably mounted on the flexible beam with some of the casters acting against the work roll on one side of the vertical plane including the longitudinal axis of the work roll and the other casters acting against the work roll on the of the side of the vertical plane. If desired alternate casters may be arranged to act against the work roll on opposite sides of the vertical including the longitudinal axis of the work roll. The casters on opposite sides of the vertical plane may extend in overlapping relation and the casters may take the form of axially short rolls.

Means for flexing the or each beam may comprise extensible units such as electromagnetic, hydraulic, or air-operated piston and cylinder assemblies with one part of each assembly acting against the flexible beam and the other part of each assembly acting against a rigid part of the apparatus. Alternatively the means for flexing the or each beam may comprise pairs of coacting wedges or screwjacks.

When piston and cylinder assemblies are employed at least two assemblies are movable axially of the beam along the length of the beam so that the distance between the assemblies and the distance between each assembly and the ends of the flexible beam can be adjusted. In this way both the magnitude and the position of the forces applied to the flexible beam can be varied.

In an alternative arrangement the piston and cylinder assemblies are not displaceable axially of the flexible beam but more than two assemblies are provided and may either be spaced equidistant along the entire length of the beam or may be positioned over the greater part of the length of the beam but away from the end portions thereof at which the beam is supported in a rigid housing or frame. Hydraulic or air-operated piston and cylinder assemblies may be connected to a fluid supply through individual control valves so that the force applied by each assembly may be adjusted relative to the other assemblies. Alternatively, certain or all of the piston and cylinder assemblies may be interconnected so as to be supplied with fluid in parallel so that the force produced by the interconnected assemblies is substantially the same. For example, the two assemblies positioned at or adjacent the end of the beam may be interconnected and similarly the assemblies may be interconnected in pairs working inwardly from the two ends of the beam. The curvature of the flexible beam may be varied by merely increasing or decreasing the loading of certain ones of the assemblies and furthermore it is possible to vary the shape of the flexible beam and therefore the forces applied to the work roll by cutting out some of the assemblies and altering the loading on the others.

In order that the invention may be more readily understood it will now be described, by way of example only, with reference to the accompanying drawings in which:

FIG. 1 is a sectional front elevation of part of a temper bending machine,

FIG. 2 is a sectional side elevation on the line II–II of FIG. 1,

FIG. 3 is a sectional front elevation of an alternative embodiment of the invention to that shown in FIGS. 1 and 2,

FIG. 4 is a section on the line IV–IV of FIG. 3,

FIG. 5 is a sectional front elevation of a rolling mill in accordance with the invention,

FIG. 6 is a section on the line VI–VI of FIG. 5, and

FIG. 7 is a perspective diagrammatic view showing how the thickness of the strip or sheet material can be measured and the measurement utilized to control the forces exerted on the work rolls.

Referring to FIGS. 1 to 4 a pair of work rolls of a temper bending machine for processing metallic sheet or strip having a discontinuous yield point are indicated by reference numerals 1 and 2. Roll 2 is of greater diameter than roll 1 and takes the form of a solid or hollow steel cylinder having a circumferential layer of resilient material such as nylon, polyurethane or aluminum. Means (not shown) are provided for applying pressure between the work rolls.

A flexible beam 3 extends parallel to and above the axis of the work roll 1 and is supported at its ends in a housing 4 of the machine. A further beam 5 which is stiff compared with the beam 3 and which may form part of the housing is positioned above the flexible beam 3. A plurality of casters 6 are freely rotatably mounted on projections 7 on the underside of the beam 3. Each castor is in the form of an axially short roller and the rollers engage with the work roll 1 along its length. Alternate rolls or alternate pairs of rolls engage the roll on opposite sides of the vertical plane through the longitudinal axis of the roll.

Loading units for flexing the beam 3 comprise piston and cylinder assemblies 8, 8′, which are positioned between the beams 3 and 5 and one part of each assembly engages one of the beams and the other part engages the other beam. In the embodiment of the invention illustrated in FIGS. 1 and 2 only two assemblies 8 are employed and the assemblies which are either hydraulically or air operated are movable along the length of the beams.

In the embodiment of the invention illustrated in FIGS. 3 and 4 eight piston and cylinder assemblies 8′ are shown and these assemblies are fixed in spaced-apart equidistant relation

over the greater part of the length of the beam **3** particularly over the central part thereof. It is to be understood that more than or fewer than eight assemblies can be employed and if desired the assemblies may be spaced apart along the entire length of the beam. Each assembly is either hydraulically or air operated and they may be either connected to a source of hydraulic or air under pressure through individual valves (not shown) or certain or all of the assemblies may be interconnected in parallel and the interconnected assemblies connected to the supply through a single valve.

When material is to be processed it is passed between the rolls **1** and **2** so as to follow around part of the periphery of roll **1** and the roll is distorted along its length away from roll **2**. In the absence of the force-producing means of the present invention this distortion would cause uneven processing of the material across its width. By applying fluid under pressure to the piston and cylinder assemblies the flexible beam is flexed towards the work roll to apply forces along the length of the roll which opposes other forces acting on the roll due to the material in the roll gap. The forces acting on the roll due to the piston and cylinder assemblies can be made approximately equal to the other forces acting on the roll due to the material in the roll gap and thus the forces which would tend to cause bending of the work roll can be largely compensated for.

In the embodiment of the invention illustrated in FIGS. **5** and **6** where the invention is applied to a rolling mill for reducing the gauge of metallic sheet or strip, the housing of the rolling mill comprises a U-shaped member **12** joined together by vertical end supports **13**. A pair of similar work rolls **14** and **15** are positioned in the mill housing but are not supported directly therefrom. The lower work roll **15** floats on a plurality of casters **16** which are positioned along its length and the upper work roll **14** is held in engagement with the lower work roll by means of a plurality of casters **17** which are spaced apart along the length of the upper work roll. The casters **16** and **17** are in the form of axially short rollers which are freely rotatably mounted on flexible beams **18** and **19** respectively with rollers on each beam engaging the work roll with which they are associated on opposite sides of the vertical plane that includes the longitudinal axis of the work roll. The rollers may be arranged in overlapping or in line relation ad desired. The flexible beams are supported at their ends by the end members **13** of the mill housing.

A plurality of hydraulic or air-operated piston and cylinder assemblies **20** are positioned in the bight of the upperframe member **12** and are spaced apart substantially equidistant along the length of the flexible beam **19**. Each piston and cylinder assembly **20**, when energized has one part conveniently the cylinder which acts against the upper frame member **12** and a second part, the piston, which bears against the flexible beam. In a similar manner a plurality of hydraulic or air-operated piston and cylinder assemblies **21** are positioned between the flexible beam **18** and the lower frame member **10** and when the assemblies are energized, pressure is applied by the assemblies between the lower frame member and the flexible beam **18**. Hydraulic fluid or air under pressure is supplied to the piston and cylinder assemblies **20** and **21** and the fluid or air may be supplied to the assemblies through individual valves not shown so that the pressure provided by each assembly can be adjusted. Alternatively, certain or all of the assemblies associated with each beam may be interconnected and fluid or air supplied to the assemblies which are interconnected through a single valve so that the interconnected assemblies provide substantially the same force between the rigid part of the mill housing and the flexible beam. It is not necessary that all of the piston and cylinder assemblies are energized simultaneously and by adjusting the fluid or air applied to the individual assemblies the distribution of the pressure applied along each work roll can be adjusted.

In an alternative embodiment of the invention (not illustrated) one or both of the work rolls may have a pair of flexible beams positioned on opposite sides of the roll and each extending parallel to the longitudinal axis of the roll. Each beam has a plurality of casters each of which acts either directly against the roll or against the roll through an intermediate roll and each beam is provided with means for flexing the beam so that through the casters and the intermediate roll, when provided, both flexible beams apply forces to the roll which oppose other forces exerted on the roll curing processing.

Referring to FIG. **7** a metallic sheet or strip **32** is shown being passed between a pair of work rolls **34** and **35** of a mill of the type as shown in FIGS. **5** and **6**. The forces applied to each roll by the assemblies **20, 21** are indicated by the arrows A to F respectively. The position of the arrows A to F also indicate the position of the piston and cylinder assemblies relative to the rolls and a similar number of thickness gauges *a* to *f* are positioned upstream of the entrance to the rolls and are spaced apart across the width of the strip and aligned with the regions of the rolls against which the forces A to F act. The assemblies which produce the forces indicated by arrow A are controlled by the thickness gauge *a* and similarly the assemblies which produce the forces indicated by arrows B, C, D, E, F are controlled by the gauge *b* to *f* respectively. As the strip or sheet passes through the influence of the gauges *a* to *f* the thickness of the sheet or strip is measured by each gauge and these measures are used to control the forces applied to the work rolls by the piston and cylinder assemblies. The gauges thus enable the forces applied along the length of the work rolls to be adjusted automatically so that variations in the shape of the incoming strip or sheet material can be rolled out as the sheet or strip passes through the work rolls **34** and **35**. By using a similar set of thickness gauges downstream of the entrance to the rolls, a further correction can be automatically applied to the forces if this is found to be necessary. Alternatively a set of gauges positioned downstream of the rolls and controlling the piston and cylinder assemblies may be employed alone.

In accordance with the provisions of the patent statutes, I have explained the principle and operation of my invention and have illustrated and described what I consider to represent the best embodiment thereof.

What I claim is:

1. Apparatus for processing sheet material comprising a pair of spaced-apart housings, a rigid member connecting the housings, a pair of work rolls positioned one above the other and between which the material is processed, a flexible beam positioned adjacent one of the rolls and extending parallel to the longitudinal axis thereof, said beam being positioned between said one roll and said rigid member, the beam being supported at its ends by the housings, a plurality of freely rotatable casters supported by the beam and spaced apart along at least the greater part of the length thereof, the casters acting against said one roll and a plurality of separately adjustable extensible units acting between the beam and the rigid member whereby in use forces, the magnitude and position of which are adjustable, are applied to the beam to flex the beam and thereby apply forces to said one roll to oppose other forces exerted on the roll during processing.

2. Apparatus for processing metallic sheet material comprising a pair of spaced-apart housings, upper and lower rigid members connecting the housings, a pair of flexible beams supported at their ends by the housings and extending therebetween, a pair of work rolls positioned between the beams and arranged with their longitudinal axes parallel to the longitudinal axes of the beams, said beams being positioned between said rolls and said rigid members, with each beam supporting a plurality of freely rotatable casters spaced apart along at least the greater part of the length thereof and each castor acting against the roll adjacent thereto and a plurality of separately adjustable extensible units acting between each beam and one of the rigid members to apply forces, the magnitude and position of which are adjustable are applied to the beam to flex the beam and thereby apply forces to said rolls which oppose other forces exerted on the rolls during processing.

3. Apparatus as claimed in claim 1 in which some of the casters act against the work roll on one side of the vertical plane including the longitudinal axis of the roll and the other casters act against the work roll on the other side of the vertical plane.

4. Apparatus as claimed in claim 3 in which said casters are in the form of axially short rollers.

5. Apparatus as claimed in claim 1 in which each of said units is movable axially of the beam.

6. Apparatus as claimed in claim 1 in which said units are fixed in spaced-apart relation along at least the greater part of the length of the beam.

7. Apparatus as claimed in claim 1 in which said units comprise piston and cylinder assemblies.

8. Apparatus as claimed in claim 7 in which said piston and cylinder assemblies are fluid operated and said assemblies are individually supplied with fluid.

9. Apparatus as claimed in claim 2 in which some of the casters on each beam act against the adjacent roll on one side of the vertical plane including the longitudinal axis of the roll and the other casters acting against the work roll on the other side of the vertical plane.

10. Apparatus as claimed in claim 2 in which each of said units is movable axially of the beam.

11. Apparatus as claimed in claim 2 in which said units are fixed in spaced-apart relation along at least the greater part of the length of the beam.

12. Apparatus as claimed in claim 2 in which said units comprise piston and cylinder assemblies.