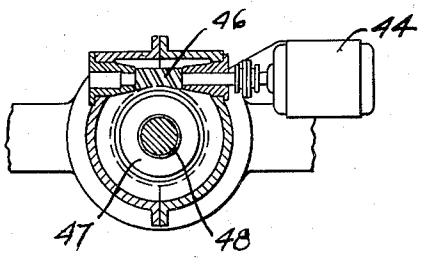
May 21, 1957 G. COZZO 2,792,730

METAL FORMING

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Fig. 2



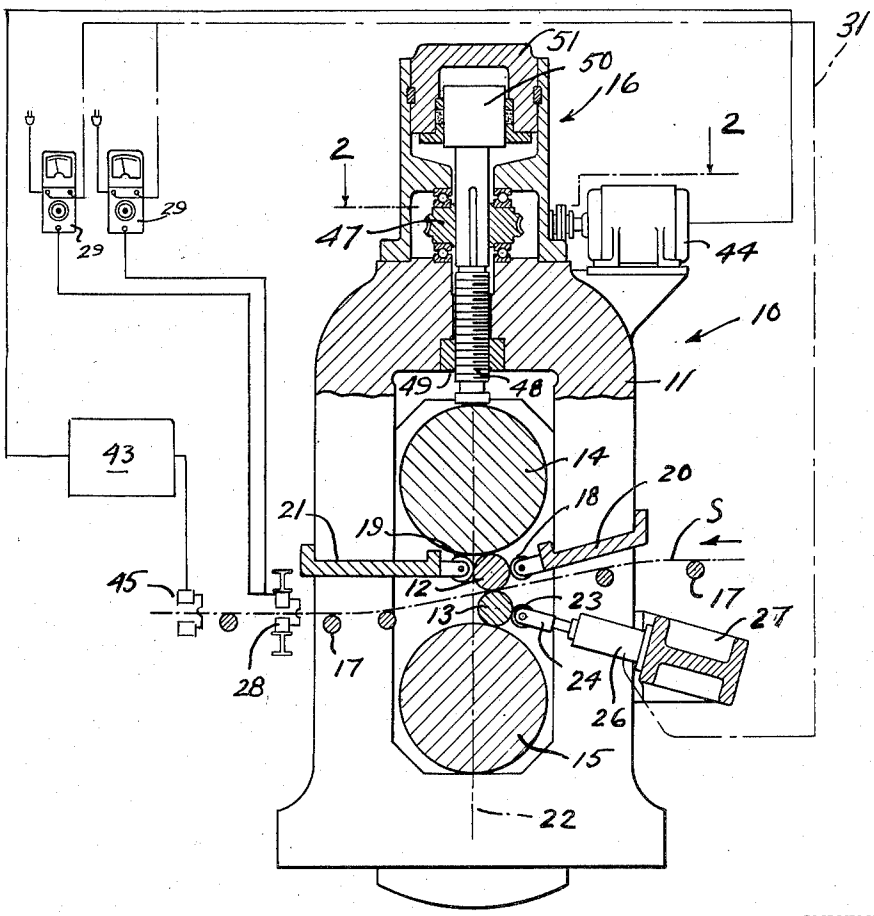


Fig. 1

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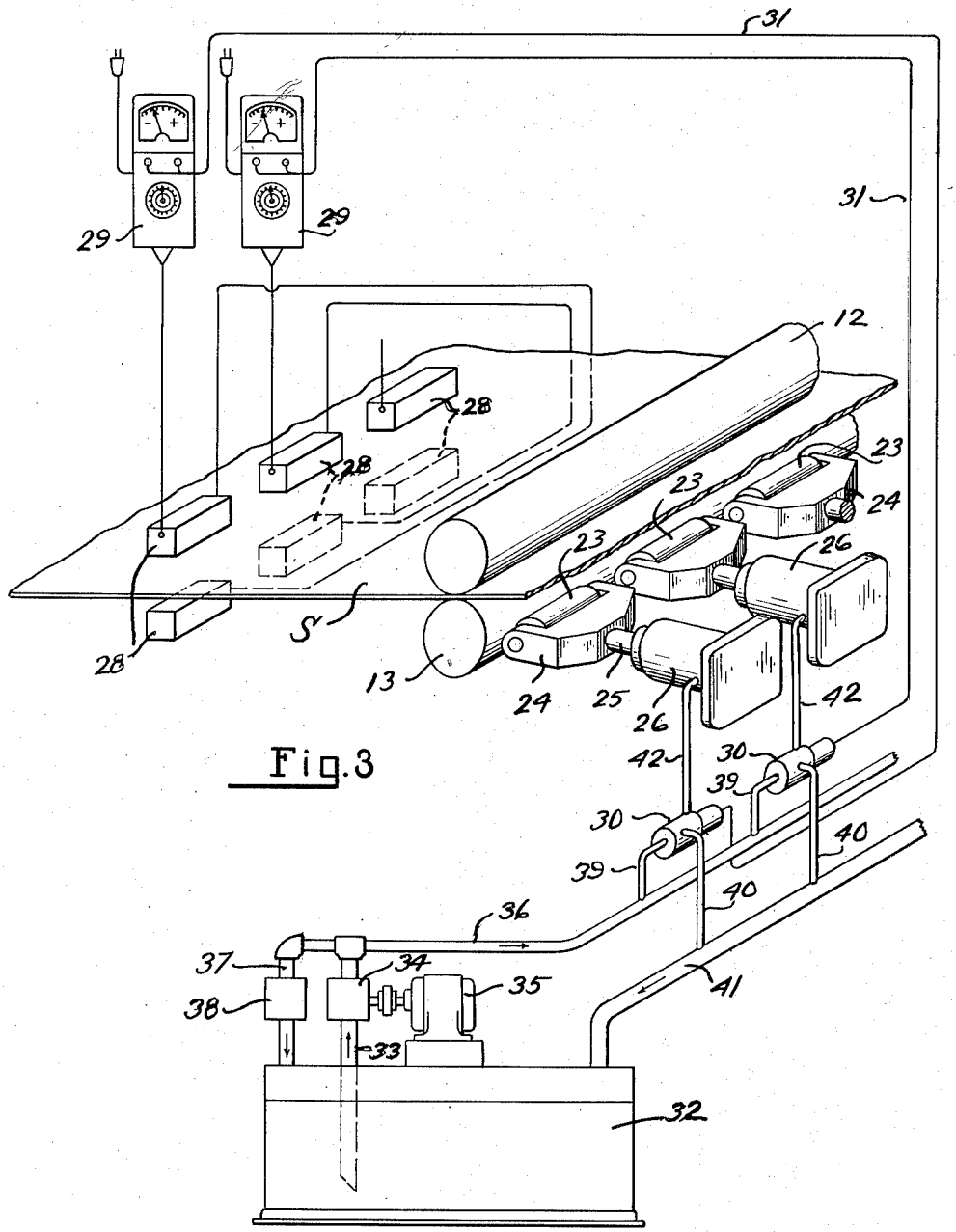


Fig. 3

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United States Patent Office 2,792,730 Patented May 21, 1957

2,792,730

METAL FORMING

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Application May 14, 1953, Serial No. 355,111

7 Claims. (Cl. 80—56)

This invention relates generally to the rolling of metal sheets or continuous strips, and is particularly directed to the rolling of very wide metal sheets or strips to a relatively small uniform or longitudinally tapered thickness, especially in rolling mills of the type usually referred to as four-high mills.

Conventional four-high mills include upper and lower working rolls between which the metal sheets or strips are fed and backing rolls in rolling contact with the relatively small diameter working rolls along lines of contact which are substantially diametrically opposed to the lines of contact of the working rolls with the metal sheet or strip. The working and backing rolls are mounted at their opposite ends in bearing blocks or chocks in the mill housings, and a roll pressure changing or screw-down mechanism is operatively connected to the bearing blocks for changing the pressure on the rolls and the thickness of the material being rolled as it passes through the mill. It is known that the minimum thickness of the rolled sheet or strip, in the absence of the application of tension to the sheet or strip during rolling, is largely limited by the diameter of the working rolls. That is, given a rolling mill with a screw-down mechanism capable of exerting a certain maximum pressure on the rolls, the minimum thickness of the rolled sheet or strip that is obtainable is smaller with relatively small diameter working rolls and larger with relatively large diameter working rolls. Thus, very thin metal sheets or strips can be obtained with a conventional rolling mill by using small diameter working rolls. However, when it is desired to roll metal sheets or strips which are both very thin and very wide and without resorting to the imposition of tension on the sheet or strip, a difficulty is encountered, for the small diameter working rolls required to produce a very thin rolled sheet do not have sufficient rigidity for the length thereof and tend to bow out from between the backing rolls to produce a rolled sheet or strip which is of non-uniform thickness across the width thereof.

Accordingly, it is an object of the present invention to provide a rolling mill of the described character capable of producing very thin and wide rolled sheets or strips which are of uniform thickness across the width thereof.

Another object is to provide a rolling mill having the foregoing characteristics and arranged to produce longitudinally tapering sheets or strips, wherein the roll pressure changing or screw-down mechanism is sensitively responsive to control for obtaining a uniform taper.

In accordance with the present invention, a four-high rolling mill of the described character is provided with auxiliary backing means in rolling contact with one of the working rolls to resist bowing of the latter from between the main backing rolls, including a laterally arranged series of auxiliary backing rolls. In addition, auxiliary backing rolls also may be used in conjunction with the other working roll.

Each of the auxiliary backing rolls of the laterally arranged series is independently mounted and urged with a variable pressure against the corresponding axial portion of the related working roll. A control system is provided for varying the contact pressure of each of the auxiliary backing rolls against the corresponding portion of the working roll and includes a laterally arranged series of gauge mechanisms responsive to the thickness of the rolled sheet or strip exiting from between the working rolls at the related lateral position, with each of the gauge mechanisms being operative to vary the contact pressure of a corresponding one of the auxiliary backing rolls to correct any bowing of the working roll and thereby avoid deviations in the thickness of the rolled sheet or strip across the width thereof.

Further, in accordance with the present invention, the roll pressure changing or screw-down mechanism includes screw shafts driven by a suitable reversible motor and engaging the roll carrying chocks for the upper backing roll in the usual manner and an hydraulic motor or cylinder acting on each screw shaft to provide a substantial proportion of the pressure to be exerted by the roll pressure changing mechanism so that the screw shafts can be driven by relatively small and responsive electric motors to provide the sensitivity of control required when longitudinally tapered sheets or strips are being rolled.

The above, and other objects, features and advantages of the invention will be apparent in the following description, when it is read in connection with the accompanying drawings, forming a part hereof, and wherein:

Fig. 1 is a diagrammatic, vertical sectional view of a rolling mill embodying the present invention;

Fig. 2 is a fragmentary, horizontal sectional view taken along the line 2—2 of Fig. 1; and

Fig. 3 is a schematic, perspective view of the essential elements included in the exemplary embodiment of the invention illustrated in Fig. 1 some of the parts being omitted for clarity.

Referring to the drawings in detail, and initially to Fig. 1 thereof, a four-high rolling mill is there shown and generally identified by the reference numeral **10**. The rolling mill **10** includes the usual housing **11** which supports chocks (not shown) carrying upper and lower working rolls **12** and **13**, respectively, and upper and lower backing rolls **14** and **15**, respectively. The working rolls **12** and **13** are disposed between the backing rolls **14** and **15**, and a roll pressure changing or screw-down mechanism, generally identified by the numeral **16**, engages the roll carrying chocks of the upper backing roll **14** to urge the upper backing roller downwardly with a variable pressure and thereby vary the contact pressure between the working rolls **12** and **13**. The metal sheet or strip S to be rolled is fed in the direction of the arrow on Fig. 1 between the working rolls **12** and **13** over guiding or conveying rollers **17**, and the mill is driven by a suitable constant speed motor (not shown) in the usual manner.

Assuming that there is a maximum force that can be exerted by the screw-down mechanism **16**, the minimum thickness to which the sheet S can be rolled is determined in large measure by the diameters of the working rolls **12** and **13**. In any given rolling mill, and in the absence of tension applied to the sheet or strip during rolling, the minimum thickness achievable is reduced as the diameters of the working rolls are decreased. However, as the diameters of the working rolls are decreased, the resistance to bending of such rolls is correspondingly reduced so that, when a very wide sheet or strip is to be rolled to a very small thickness, the small diameter working rolls required for that thickness are insufficiently rigid for the length thereof and the working rolls **12** and **13** have a tendency to bow-out intermediate their supported ends from between the backing rolls **14** and **15**. Such bowing of the working rolls will produce a crowned rolled

sheet or strip, that is, having a greater thickness at the center than at the opposite edge portions thereof.

In accordance with the present invention a rolling mill of the described character is provided with mechanisms for obtaining roller sheets or strips of equal thickness across the width thereof even though small diameter and long working rolls are employed in connection with the rolling of very wide and thin sheets or strips. Such mechanisms may include auxiliary backing rolls 18 and 19 arranged in front and in back of one of the working rolls, the upper working roll 12 in the illustrated embodiment (Fig. 1). The auxiliary backing rolls 18 and 19 are rotatably supported by fixed brackets 20 and 21, respectively, in rolling contact with the working roll 12 and act to prevent any displacement of the latter in the direction normal to the plane, indicated at 22, passing through the axes of rotation of the main backing rolls 14 and 15.

Since the working rolls 12 and 13 are preferably supported with their axes of rotation offset in one direction relative to the plane 22 passing through the axes of the main backing rolls, it is apparent that any deflection of the working rolls will be generally in the offset direction. Thus, in Fig. 1 the working rolls 12 and 13 have their axes disposed in front of the vertical plane passing through the axes of the main backing rolls and any deflection of the lower working roll 13 must occur generally in the forward direction. Accordingly, a laterally arranged series of auxiliary backing rolls 23 are disposed in front of the lower working roll 13 and in rolling contact with related axial portions of the latter. Each of the auxiliary backing rolls 23 is individually supported to bear rearwardly against the related portion of the lower working roll with a controllably variable pressure. By way of example, in the illustrated embodiment of the invention, each of the auxiliary backing rolls 23 is rotatably carried by an individual yoke 24 mounted on a ram 25 working in an hydraulic, or other pressure fluid, cylinder 26. The cylinders 26 are mounted on a common beam or housing part 27 with their axes intersecting the axis of rotation of the lower working roll 13 and inclined slightly from the horizontal in the rearward and upward direction so that the auxiliary backing rolls 23 act against the related axial portions of the lower working roll 13 in a direction which substantially bisects the angle formed between the tangents to the roll 13 at the points of contact of the latter with the lower main backing roll 15 and with the upper working roll 12. Thus, the auxiliary backing rolls 23 act to wedge the related axial portions of the lower working roll 13 between the rolls 12 and 15 and resist bowing of the lower working roll.

Further, in accordance with the present invention, the force exerted by each of the laterally arranged series of auxiliary backing rolls 23 is controlled in response to the actual thickness of the portion of the sheet or strip rolled by the related axial portion of the lower working roll, and more particularly in response to the deviation of that actual thickness from a predetermined or preselected thickness. Thus, as the rolling mill 10 operates, a control arrangement, hereinafter described in detail, measures or senses the thickness of the rolled sheet or strip at various locations across the width thereof and acts in response to the deviations of such measured thicknesses from a preselected thickness to vary the pressures in the several pressure fluid cylinders 26 and thereby either increase or decrease the force exerted by the auxiliary backing rolls 23 acting against the axial portions of the lower working roll corresponding to the portions of the sheet having thickness deviations so that the rolling pressure between such axial portions of the lower working roll and the upper working roll is either increased or decreased, as the case may be, to correct such deviations from the preselected thickness and provide a rolled sheet of uniform thickness across the width thereof.

A thickness gauge 28 is disposed at the exit side of the roll stand in alignment with each of the auxiliary backing rolls 23 to measure or sense the thickness of the related portion of the rolled strip S. Each of the thickness gauges 28 may be of the kind known as the "Electro-Limit" or the "Beta Ray Continuous" gauges, such as are manufactured by the Pratt & Whitney Co., of Hartford, Connecticut. Each gauge 28 produces an electrical signal which is related to the thickness of the sheet or strip passing therethrough, and this signal is transmitted through suitable electrical connections to a corresponding meter 29 which provides a visual indication of the thickness. Preferably, the meters 29 are of the "null" type which can be adjusted to read zero if the actual thickness measured by the corresponding gauge 28 is correct. If the actual thickness measured by a gauge 28 deviates from the preselected thickness, the corresponding meter 28 will show a plus or minus reading indicating that the actual thickness is greater or less than, respectively, the preselected thickness.

In order to control the pressure acting in the several pressure fluid cylinders 26 in response to the signals emanating from the gauges 28, a solenoid controlled valve 30 (Fig. 3) is associated with each of the cylinders 26 and is actuated by such signals through a suitable electrical connection 31 leading to the related gauge assembly. The pressure fluid supply system includes a reservoir 32 for containing the pressure fluid and into which an outlet pipe 33 extends. A pump 34 is connected to the outlet pipe to draw the pressure fluid from the reservoir, and the pump 34 is driven by a suitable motor 35. The discharge side of the pump 34 is connected to a supply manifold 36, and a by-pass line 37 leads back to the reservoir 32 from the supply manifold through a suitable pressure relief valve 38 for regulating the pressure in the supply manifold. Each of the valves 30 is connected to the supply manifold 36 through a pressure fluid supply pipe 39, and a return pipe 40 also extends from each valve to a pressure fluid return manifold 41 extending back to the reservoir 32. Finally, each of the valves 30 is connected to the related cylinder 26 through a connecting pipe 42. Each of the valves 30 is arranged so that, depending upon the gauge signal furnished thereto, more or less of the pressure fluid led to the valve through the supply pipe 39 is returned through the return pipe 40 to adjust the pressure within the valve, and the connecting pipe 42 communicates this adjusted pressure to the related cylinder 26.

Thus, the pressure in each of the cylinders 26 is adjusted in response to the related gauge signal to vary the force exerted by the corresponding auxiliary backing roll 23 against the lower working roll in a manner providing a rolled sheet or strip of uniform thickness across the width thereof.

While the above described arrangement is suitable for the production of flat sheets of uniform thickness across the width thereof, it may also be employed in connection with the production of sheets which are longitudinally tapered. The rolling mill 10 can be adapted for the production of longitudinally tapered sheets by providing control mechanism associated therewith for varying the pressure exerted by the screw-down mechanism 16 as the sheet or strip is fed between the working rolls. Such control mechanism may be of the kind disclosed in the co-pending application, Serial No. 265,992, filed January 11, 1952, now Patent No. 2,655,823, and is generally indicated on Fig. 1 by the reference numeral 43. The gauges 28 can be related so that any deviation in transverse thickness will be corrected. The taper control mechanism 43 controls a quick reversible motor 44 for operating the screw-down mechanism 16, the motor being driven at the desired speed in each direction for predetermined intervals to produce the required taper. However, mill deflection is present to a variable degree so that merely constantly driving the screw-down motor 44 in either direction will not produce a sheet which is uniformly tapered in the longitudinal direction. There-

fore, the taper control mechanism 43, as disclosed in the above identified co-pending application, preferably includes a taper corrective or compensating arrangement for correcting the speed of the screw-down motor from its basic speed to a speed changing a predetermined amount at the times or places required, as indicated by a gauge 45, so as to produce a sheet or strip of uniform longitudinal taper.

It is apparent that the accuracy or uniformity of the longitudinal taper will depend to a large extent upon the sensitivity or responsiveness of the screw-down motor 44 to the correcting impulses emanating from the gauge actuated compensating arrangement. Thus, it is desirable to employ a relatively small and sensitive electric motor for operation of the screw-down mechanism 16. In order to permit the use of such a small motor, the screw-down mechanism 16, in accordance with the present invention, includes a worm 46 (Fig. 2) driven by the shaft of the motor 44 and meshing with a worm gear 47 which is splined or keyed on a vertical screw shaft 48 bearing downwardly at its lower end against the bearing blocks or chocks of the upper backing roll 14. The screw shaft 48 extends threadably through a nut member 49 fixed in the housing 11. Thus, as the shaft 48 is rotated by the motor 44 through the meshing gears 46 and 47, the screw shaft is either raised or lowered, depending upon the direction in which the motor is driven.

Since the screw shaft 48 impresses the load on the rolls of the mill, a great reaction force acts axially on the screw shaft and results in a relatively great frictional resistance to turning of the screw shaft 48 within the fixed nut member 49. Ordinarily, a relatively large motor would be required to overcome this frictional resistance, however, in accordance with the present invention, a piston 50 is provided on the upper end of the screw shaft 48 and works in a cylinder 51 secured on the housing 11. An hydraulic or other pressure fluid is supplied to the space in the cylinder 51 above the piston 50 from a suitable source (not shown) and acts downwardly on the piston 50 to relieve a substantial portion of the load from the screw shaft. Thus, the motor 44 can be relatively small for accurate control.

While a particular embodiment of the invention has been described and illustrated, by way of example, it is to be understood that various changes and modifications can be made in the details of construction without departing from the spirit of the invention except as defined in the appended claims.

What is claimed is:

1. In a four-high rolling mill having working rolls disposed between main backing rolls; first auxiliary backing rolls in front and in back of one of the working rolls and in rolling contact with the latter to prevent bowing out from between the main backing rolls, a laterally arranged series of second auxiliary backing rolls for rolling contact with the other of the working rolls, said other working roll being supported between the said one working roll, one of said main backing rolls and said second auxiliary backing rolls means individually supporting each of said second auxiliary backing rolls for movement into rolling contact with the related working roll, adjustable force means for urging said second auxiliary backing rolls against the related working roll with an adjustable force, and a plurality of laterally spaced means responsive to the variations of thickness of a sheet rolled between said working rolls and operatively connected to said adjustable force means to thereby adjust the pressure between the working rolls according to the variations in the strip and thereby maintaining the thickness of the rolled sheet constant across the sheet, said laterally spaced means being in longitudinal alignment with each of said second auxiliary backing rolls.

2. In a rolling mill; the combination of upper and lower working rolls for rolling a sheet passed therebetween, main backing rolls disposed above and below said upper and lower working rolls, respectively, the axes of said working rolls being parallel and offset relative to a plane extending through the axes of said main backing rolls, auxiliary backing means associated with at least one of said working rolls, said auxiliary backing means including a laterally arranged series of auxiliary backing rolls in rolling contact with said one working roll at the side of the latter facing away from said plane extending through the axes of the main backing rolls, the other working roll being supported between said one working roll and said one of said main backing rolls, means individually supporting each of said auxiliary backing rolls for movement of the latter toward and away from said one working roll, adjustable force means separately urging each of said auxiliary backing rolls in the direction toward said one working roll with an adjustable force to resist bowing out of said one working roll from between the related main backing roll and the other of said working rolls, adjustable force, and a plurality of laterally spaced means responsive to the variations of thickness of a sheet rolled between said working rolls and operatively connected to said adjustable force means to thereby adjust the pressure between the working rolls according to the variations in the strip and thereby maintaining the thickness of the rolled sheet constant across the sheet, said laterally spaced means being in longitudinal alignment with each of said auxiliary backing rolls.

3. In a rolling mill; the combination of upper and lower working rolls for rolling a sheet passed therebetween, main backing rolls disposed above and below said upper and lower working rolls, respectively, auxiliary backing rolls in front and in back of one of said working rolls and in rolling contact with said one working roll to prevent bowing of the latter, a series of second auxiliary backing rolls disposed in end-to-end arrangement with their axes parallel to the axis of the other of said working rolls, said other working roll being supported between the said one working roll, one of said main backing rolls and said second auxiliary backing rolls, means individually supporting each of said second auxiliary backing rolls in rolling contact with said other working roll, variable contact pressure means for urging each of said second auxiliary backing rolls against said other working roll with a variable contact pressure, and a plurality of laterally spaced means responsive to the variations of thickness of a sheet rolled between said working rolls and operatively connected to said variable contact pressure means to thereby adjust the pressure between the working rolls according to the variations in the strip and thereby maintain the thickness of the rolled sheet constant across the sheet, said laterally spaced means being in longitudinal alignment with each of said second auxiliary backing rolls.

4. In a rolling mill; the combination of upper and lower working rolls for rolling a sheet passed therebetween, main backing rolls disposed above and below said upper and lower working rolls, respectively, the axes of said working rolls being parallel and offset relative to a plane extending through the axes of said main backing rolls, first auxiliary backing rolls extending parallel to said upper working roll and in rolling contact with the latter at the front and back of said upper working roll, a series of second auxiliary backing rolls in end-to-end relationship and arranged parallel to said lower working roll, said other working roll being supported between the said one working roll, one of said main backing rolls and said second auxiliary backing rolls, means individually supporting each of said second auxiliary backing rolls in rolling contact with said lower working roll at the side of the latter facing away from said plane through the axes of the main backing rolls, adjustable contact pressure means individually urging each of said second auxiliary backing rolls against the related axial portion of said lower working roll with an adjustable contact pressure,

and a plurality of laterally spaced means responsive to the variations of thickness of a sheet rolled between said working rolls and operatively connected to said variable contact pressure means to thereby adjust the pressure between the working rolls according to the variations in the strip and thereby maintain the thickness of the rolled sheet constant across the sheet, said laterally spaced means being in longitudinal alignment with each of said second auxiliary backing rolls.

5. In a rolling mill; the combination of upper and lower working rolls for rolling a sheet passed therebetween, main backing rolls disposed above and below said upper and lower working rolls, respectively, the axes of said working rolls being parallel and offset forwardly relative to a plane extending through the axes of said main backing rolls, a series of auxiliary backing rolls in end-to-end arrangement in front of said lower working roll and with their axes extending parallel to the axis of said lower working roll, the said upper working roll being supported between said lower working roll and one of said main backing rolls, means individually supporting each of said auxiliary backing rolls for movement toward and away from said lower working roll, variable contact pressure means individually urging each of said auxiliary backing rolls in the direction toward said lower working roll for rolling contact with the latter at a variable contact pressure, said auxiliary backing rolls being located to be movable rectilinearly in directions substantially bisecting the angle enclosed by tangents to said lower working roll at the points of contact of the latter with said upper working roll and with said main backing roll below the lower working roll, and a plurality of laterally spaced means responsive to the variations of thickness of a sheet rolled between said working rolls and operatively connected to said variable contact pressure means to thereby adjust the pressure between the working rolls according to the variations in the strip and thereby maintain the thickness of the rolled sheet constant across the sheet, said laterally spaced means being in longitudinal alignment with each of said auxiliary backing rolls.

6. In a rolling mill; the combination of upper and lower working rolls for rolling a sheet passed therebetween, main backing rolls disposed above and below said upper and lower working rolls, respectively, a series of end-to-end arranged auxiliary backing rolls disposed at one side of one of said working rolls and in rolling contact with the latter, pressure fluid actuated means for each of said auxiliary working rolls operative to urge the latter individually against said one working roll with an adjustably variable contact pressure force, means for sensing deviations of the actual thicknesses of a sheet

rolled between said working rolls from a preselected thickness at laterally spaced locations corresponding to and aligned with said auxiliary backing rolls said means producing a signal upon deviation from said preselected thickness, and control means acting in response to signals from said sensing means to control said adjustably variable force exerted by said pressure fluid actuated means in the direction compensating for any deviations from said preselected thickness to thereby adjust the pressure between the working rolls according to the variations in the strip and thereby maintain the thickness of the roll sheet constant across the sheet.

7. In a rolling mill; the combination of upper and lower working rolls for rolling a sheet passed therebetween, main backing rolls disposed above and below and in rolling contact with said upper and lower working rolls, respectively, said working rolls being disposed with the axes thereof offset forwardly relative to a plane passed through the axes of said main backing rolls, auxiliary backing rolls arranged in end-to-end relationship and in rolling contact with said lower working roll at the front of the latter, the said upper working roll being supported between said lower working roll and one of said main backing rolls, means individually supporting each of said auxiliary backing rolls for movement toward and away from said lower working roll, pressure fluid motors connected to each of said auxiliary backing means, a source of pressure fluid, means for supplying pressure fluid from said source, means for returning pressure fluid to said source, valve means connected to each of said pressure fluid motors and to said pressure fluid supplying and returning means, said valve means being operative to control the pressure acting in the related pressure fluid motor; a plurality of laterally spaced control means including gauging means operative to produce electrical signals in response to deviations of the thickness of the related portion of the rolled sheet from said preselected thickness, at locations corresponding to said auxiliary backing rolls, and electric valve operating means for each of said valve means connected to the related gauging means to control the associated valve means in response to the electrical signals emanating from said gauging means to adjust the pressure between the working rolls according to variations in the strip and thereby maintain the thickness of the roll sheet constant across the sheet.

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