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Jepsen(10) **Pub. No.: US 2009/0031777 A1**(43) **Pub. Date: Feb. 5, 2009**(54) **METHOD FOR THICKNESS REGULATION
DURING A HOT-ROLLING PROCESS**(75) Inventor: **Olaf Norman Jepsen, Siegen (DE)**

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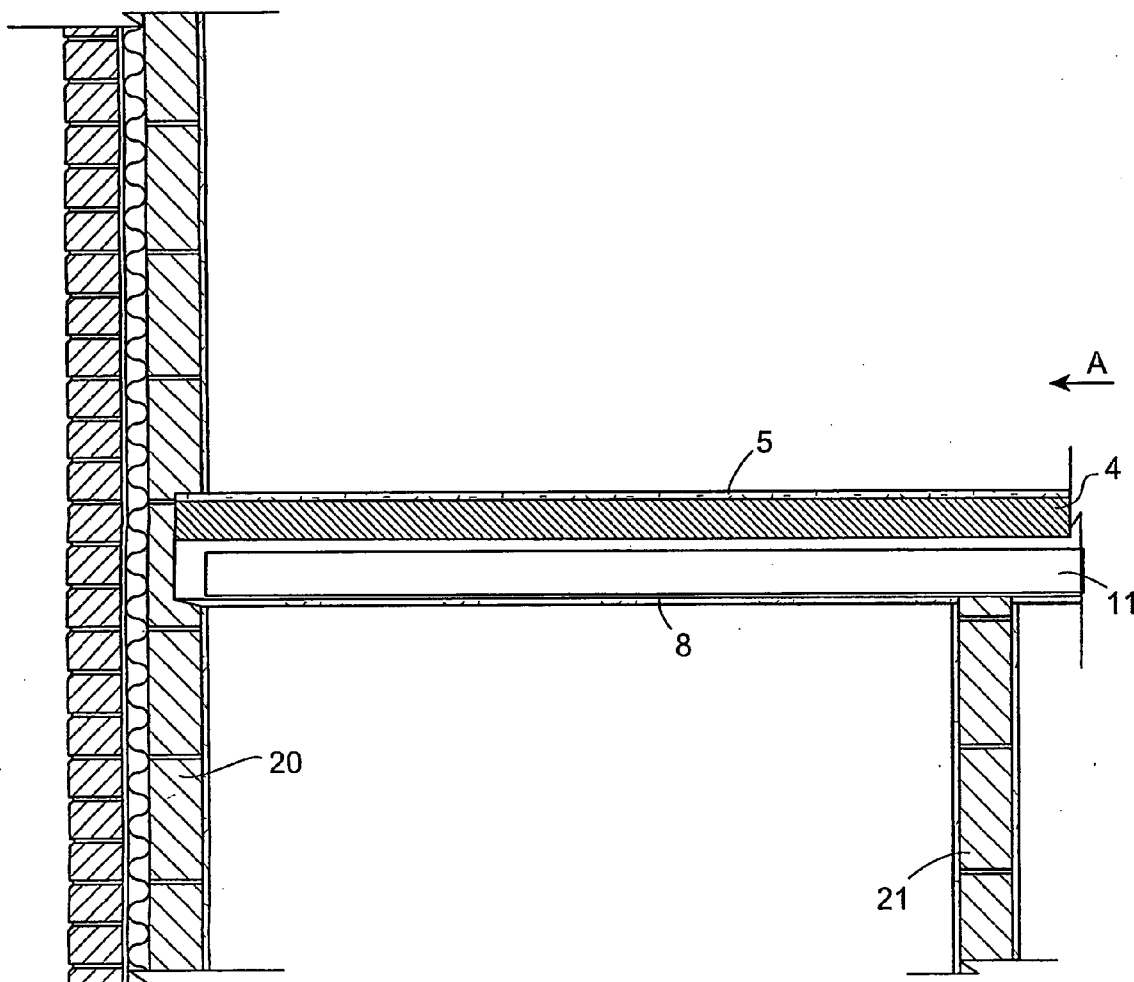
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B21B 37/58 (2006.01)(52) **U.S. Cl.** **72/10.7**(57) **ABSTRACT**

A flooring system comprises a preformed composite panel having a first sheet (2), a second sheet (3) and a core of insulating material between the first and second sheets (2, 3). In one case the sheet (2) is a generally flat top sheet and the sheet (3) is a profiled bottom sheet. A floor such as a wood effect floor (5) is laid over the flat top sheet (2). An acoustic barrier layer 6 is located between the floor (5) and the sheet (2). The profiling of the sheet (3) defines channels (7) for location of service ducts/conduits (11). A planar facing (8) is applied over the profiled sheet, bridging the channels (7).



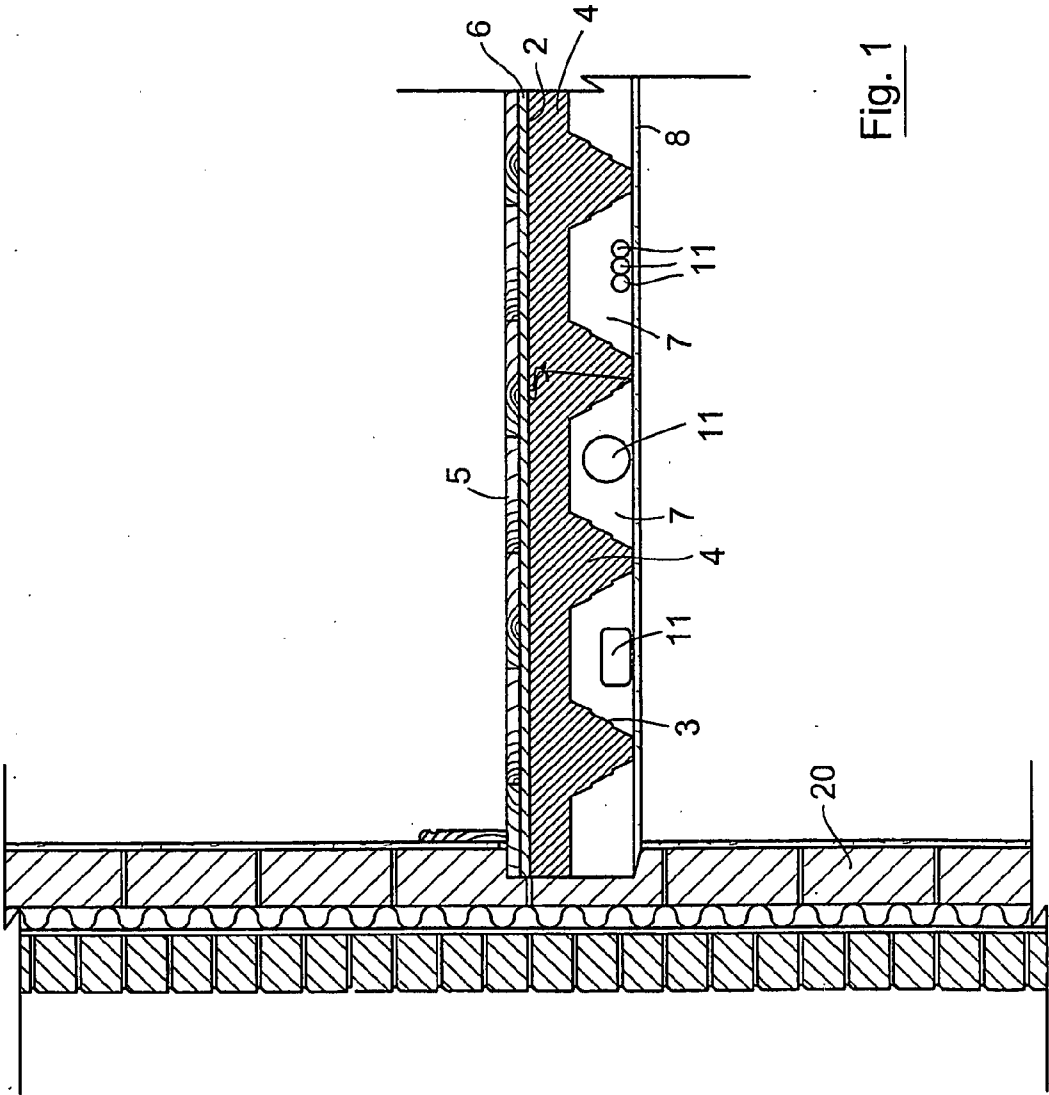


Fig. 1

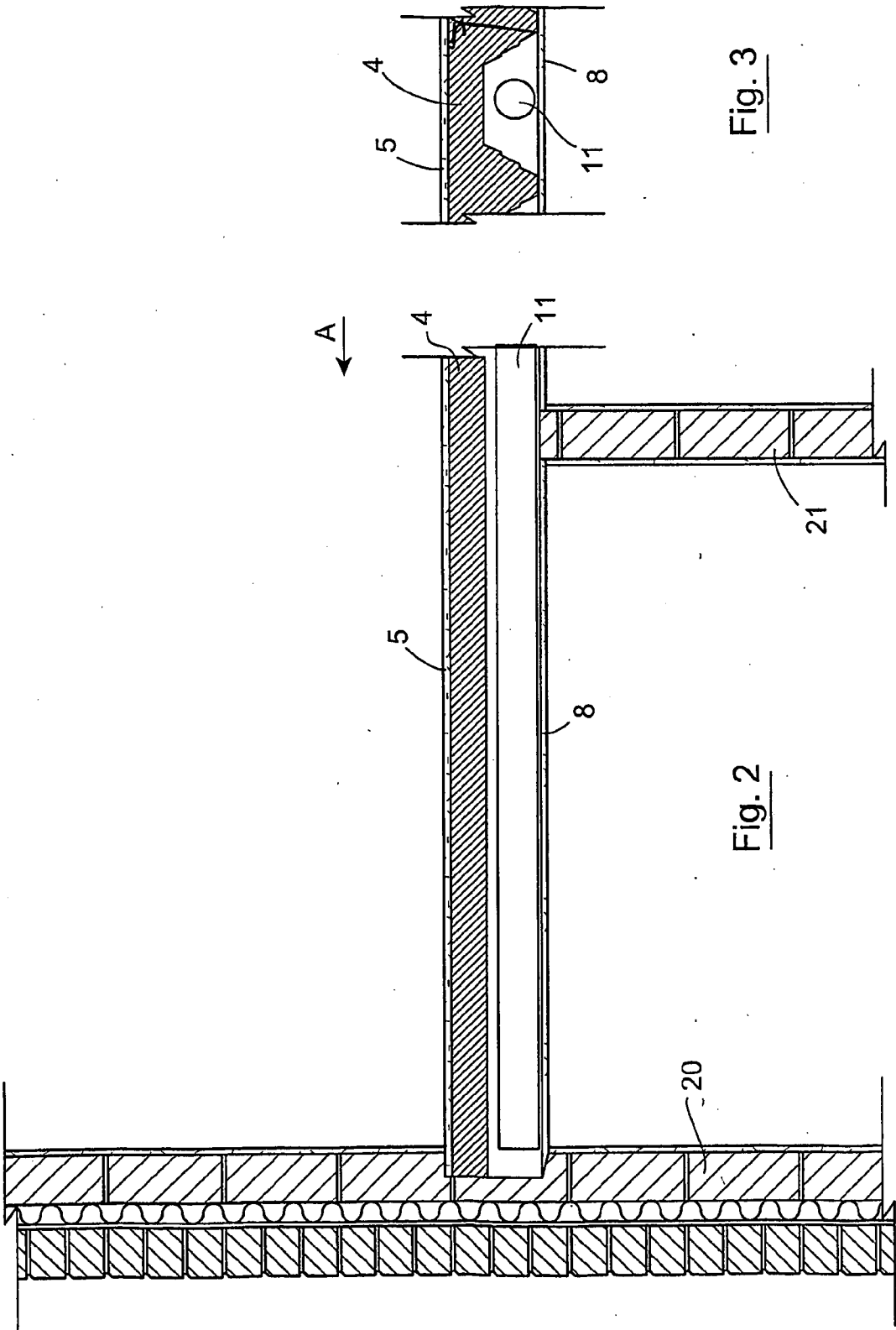


Fig. 3

Fig. 2

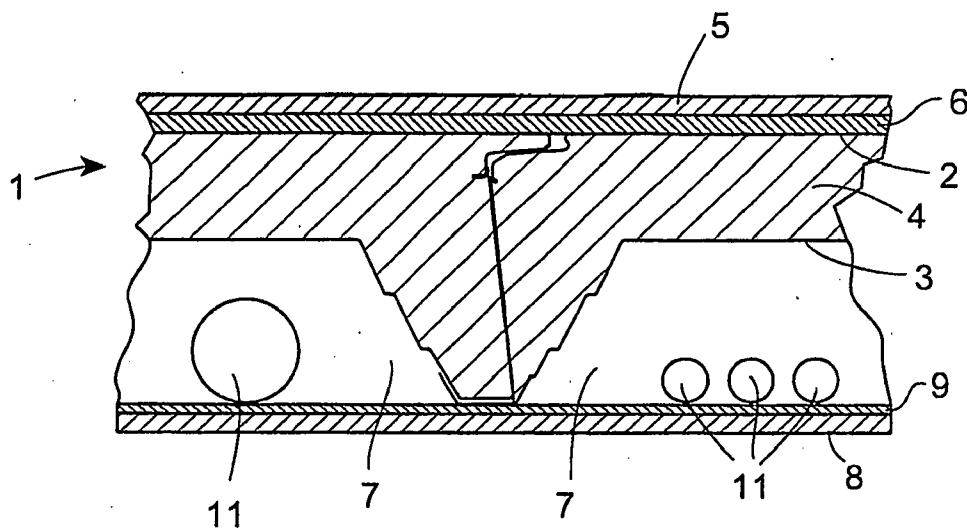


Fig. 4

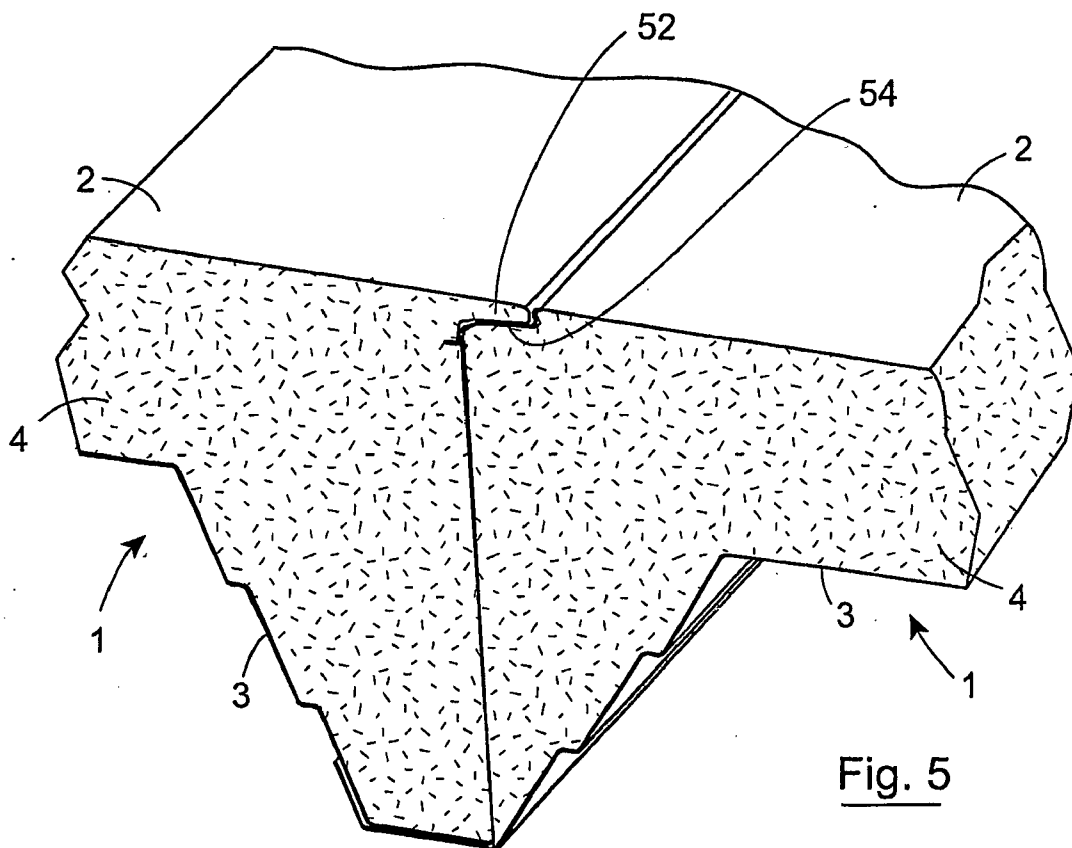


Fig. 5

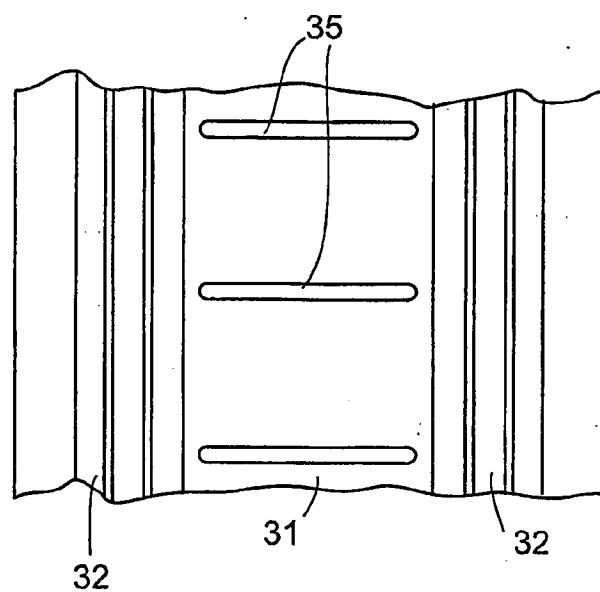


Fig. 7

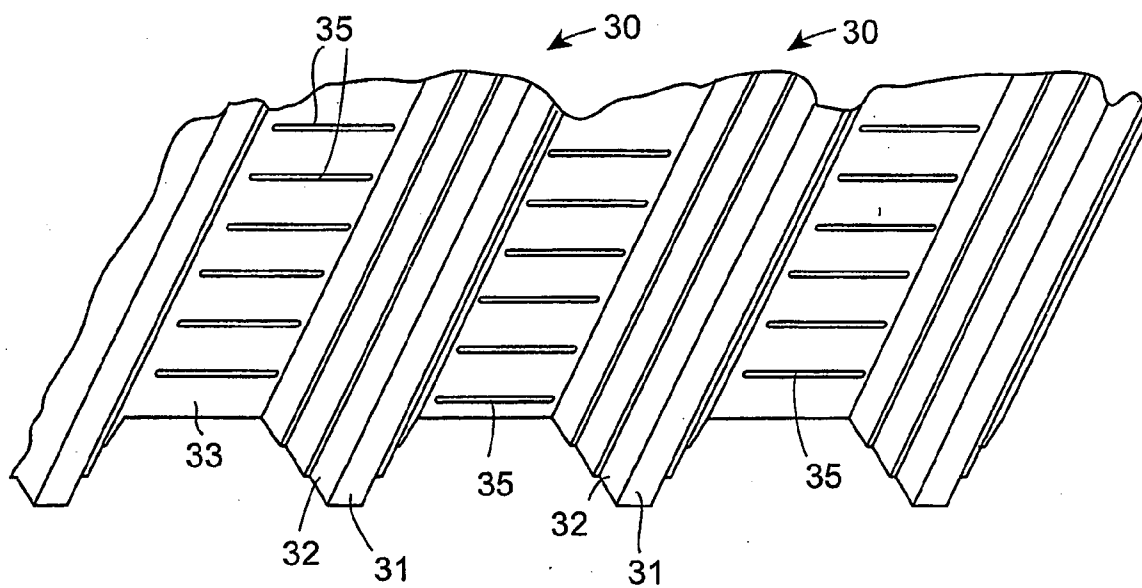


Fig. 6

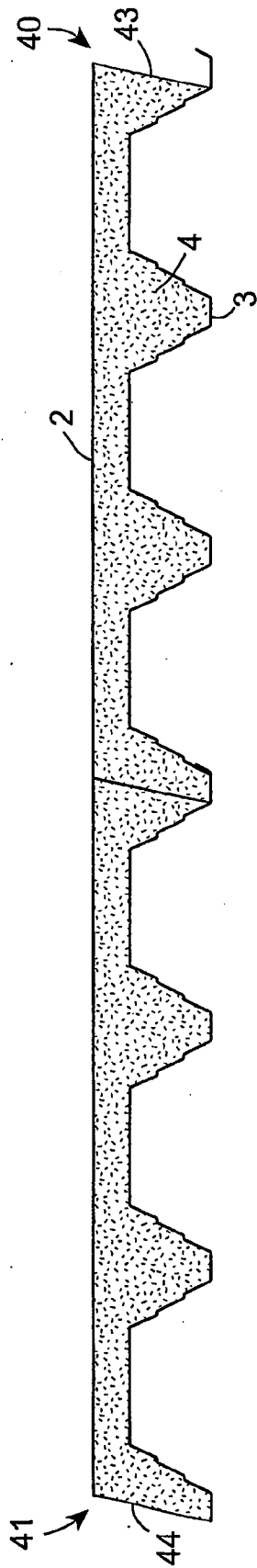


Fig. 8(a)

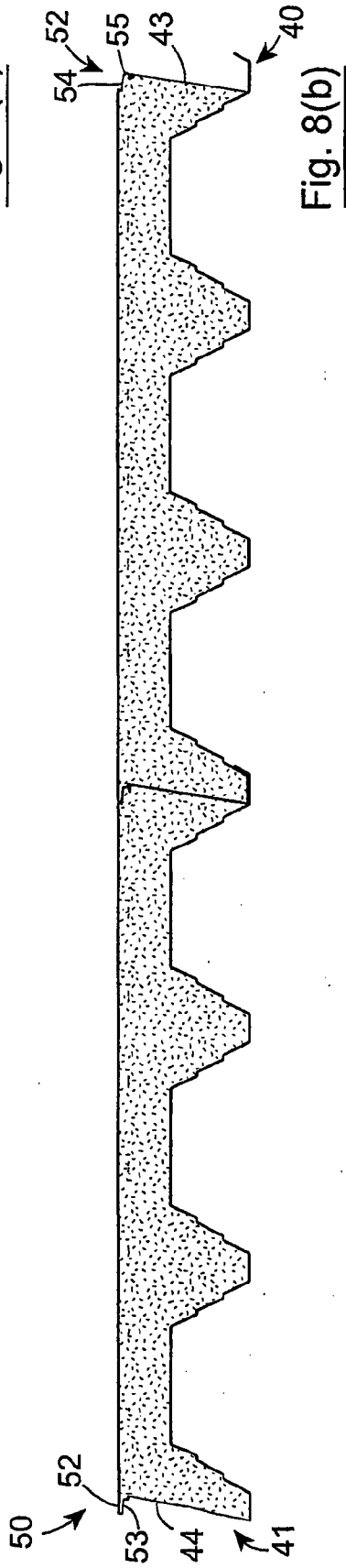


Fig. 8(b)

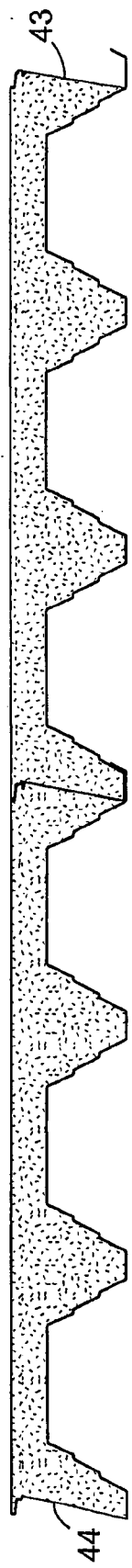


Fig. 8(c)

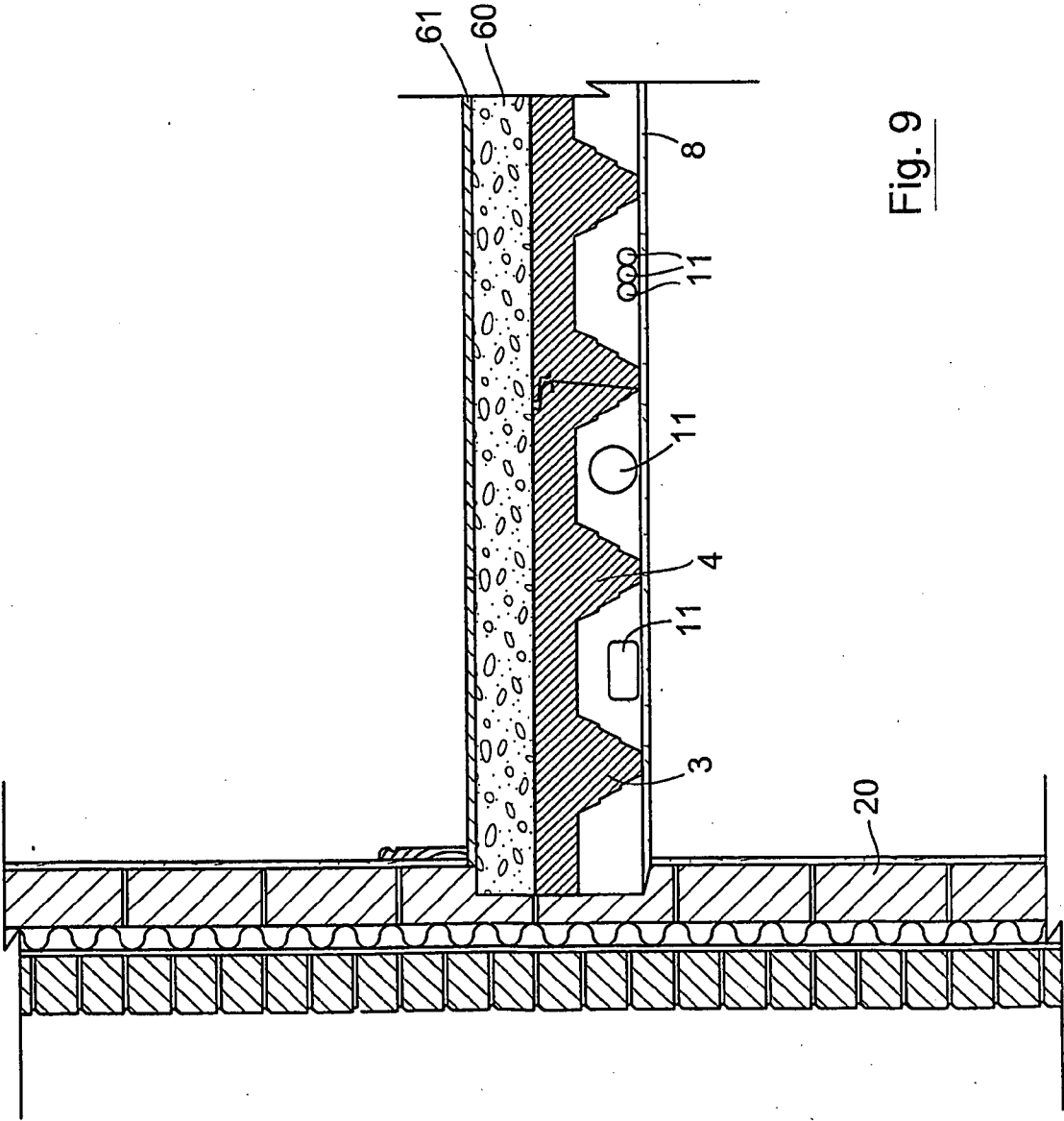


Fig. 9

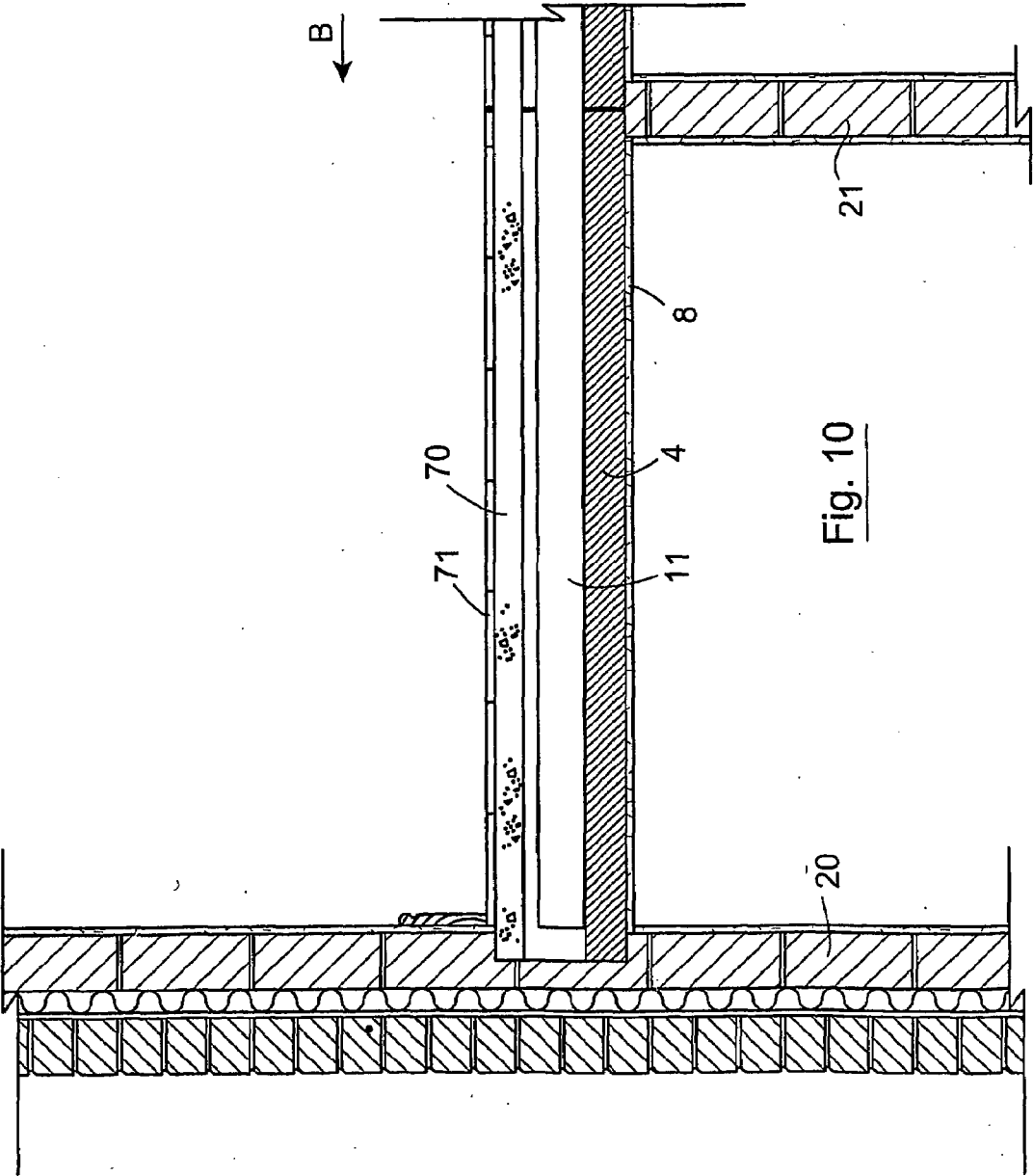


Fig. 10

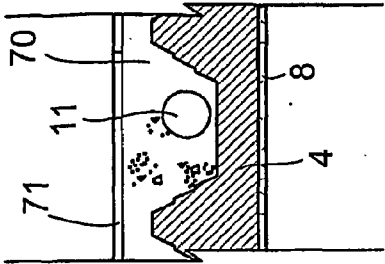
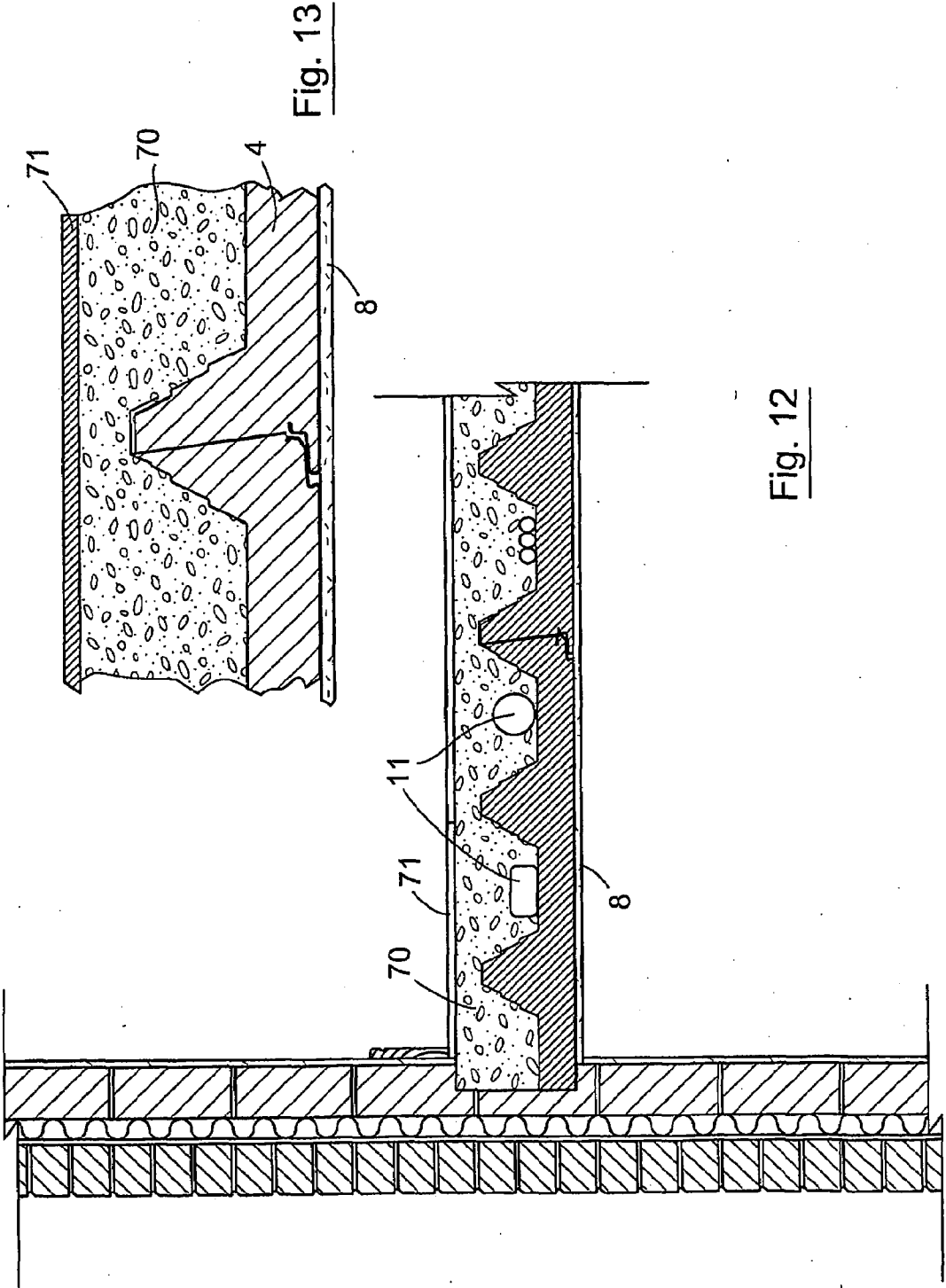


Fig. 11



METHOD FOR THICKNESS REGULATION DURING A HOT-ROLLING PROCESS

[0001] The invention concerns a method for automatic gage control during rolling, especially hot rolling, with at least one rolling stand, where factors that are considered include the present mean position of the adjustment cylinders of the rolling stand and their total rolling force.

[0002] DE 20 20 402 discloses a method for calculating the gage G1 of a thin, hard workpiece after a reducing pass through a reducing mill train with opposing rolling surfaces and a measuring instrument for measuring the roll separating forces, which are produced during the passage of the workpiece through the opposing rolling surfaces during a reducing operation, in which

[0003] (a) a signal that is a measure of the gage G5 is generated, which is determined by the point of intersection of an appropriate mill stretch curve and an appropriate workpiece deformation curve for the reducing operation,

[0004] (b) a signal that is a measure of a gage G3 is generated, which is determined by the point of intersection of the measured force curve and the mill stretch curve,

[0005] (c) a signal that is a measure of a range of uncertainty is generated, which is determined by the difference between signals representing the gages G5 and G3,

[0006] (d) a signal that is a measure of a calculated stretch error is generated by varying the signal that represents the range of uncertainty as a function of the draft predicted for the reducing pass, of the mill stretch predicted for the reducing pass, and of the relative probability of error in predicting both draft and mill stretch, and

[0007] (e) a signal that is a measure of the calculated gage G1 is generated by adding the signal that represents the gage G3 to the calculated stretch error.

[0008] DE 26 57 455 A1 describes a method for compensating roll deformation in rolling stands with prestressing that can be automatically controlled, in which the strip thickness is automatically controlled by hydraulic actuators, and in which the contact force (F_a), which is the sum of the rolling force and the automatically controllable prestressing force according to the following equation:

$$F_a = (F_{a0} + (F_r - F_{r0})) * c_a / (c_i + c_a),$$

is varied by hydraulic prestressing cylinders in such a way that, to the base set value (F_{a0}) of the contact force, a supplementary set value is added, which is formed from the difference between the actual value (F_r) of the prestressing force and the initial value (F_{r0}) of the prestressing force and is evaluated with the ratio ($c_a / (c_i + c_a)$) of the spring stiffness (c_a) of the outer part of the stand to the sum of the spring stiffness (c_i) of the inner part of the stand and the spring stiffness (c_a) of the outer part of the stand.

[0009] DE 16 02 195 A1 discloses a method for calculating the gage of thin, hard workpieces, in which

[0010] a signal that is a measure of the gage G5 is generated, which is determined by the point of intersection of an appropriate mill stretch curve and an appropriate workpiece deformation curve for the reducing operation,

[0011] a signal that is a measure of a gage G3 is generated, which is determined by the point of intersection of the measured force curve and the mill stretch curve,

[0012] a signal that is a measure of a range of uncertainty is generated, which is determined by the difference between signals representing the gages G5 and G3,

[0013] a signal that is a measure of a calculated stretch error is generated by varying the signal that represents the range of uncertainty as a function of the mill stretch predicted for the reducing pass and of the relative probability of error in predicting both draft and mill stretch, and

[0014] a signal that is a measure of the calculated gage G1 is generated by adding the signal that represents the gage G3 to the calculated stretch error.

[0015] Until now, the so-called gage meter principle for determining the present strip gage has been used for automatic gage control during hot strip rolling. To this end, the measured S_{DS} , S_{OS} of the adjustment cylinders is corrected by the calculated mill stretch g (see also FIG. 1). The mill stretch g is calculated with the use of the measured rolling force F_{DS} , F_{OS} and a mill stretch curve $1/M_G$. The strip gage determined in this way is then compared with the gage set value and automatically controlled. Besides the measurements of position and rolling force, an exact mill model is needed for this method.

[0016] In the rolling of hard materials and thin strip, small inaccuracies in the mill model lead to relatively large errors in the strip gage and sometimes instability of the automatic gage control system.

[0017] Therefore, the objective of the invention is to improve a method of the type described above in such a way that the disadvantages specified above are avoided.

[0018] In accordance with the invention, this objective is achieved by minimizing the mill stretch component. This is accomplished by carrying out at least one additional position measurement by detecting position signals in the immediate vicinity of the roll gap of the rolling stands. In this connection, especially the position signals between the work rolls and/or the backup rolls and/or the work roll chocks and/or the backup roll chocks are to be considered/detected.

[0019] The advantage of the method of the invention is that the position measurement contains a smaller mill stretch component. Thus, only the roll flattening and the roll bending are to be considered. Other components, such as the expansion of the columns and the crossheads, do not have to be considered. Specifically in the measurement of the separation of the work roll chocks, the suspension of the Morgoil bearings, the bending of the backup rolls, and backup roll eccentricities do not have to be taken into consideration. As shown in FIG. 2, the prior-art method for automatic gage control is still used in its entirety and is improved or expanded by the features described above.

[0020] The method of the invention results in a more exact determination of the strip gage in the case of hard materials and, especially in the case of thin strip rolling, improves the dynamic behavior of the automatic gage control system.

[0021] In a further development of the invention, the signals that are obtained can also be used for automatic position control and/or for automatic swivel control and/or for calculation of the strip gage and thus for automatic control of the strip gage.

[0022] A specific embodiment of the invention is described in greater detail below with reference to the accompanying schematic drawings.

[0023] FIG. 1 shows a flowchart for automatic gage control in accordance with the prior art.

[0024] FIG. 2 shows a flowchart for automatic gage control in accordance with the invention.

[0025] FIG. 1 shows a flowchart of prior-art automatic gage control during rolling, especially hot rolling. A rolling stand consisting, for example, of a pair of work rolls AW and a pair of backup rolls SW has an operating side OS and a drive side DS. A strip B is positioned between the pair of work rolls AW. In the previously known method for automatic gage control, the cylinder position of the operating side S_{OS} and the cylinder position of the drive side S_{DS} are determined, and the present mean cylinder position S_{ACT} is determined. In addition, the total rolling force F_{ACT} is determined by determining the rolling force on the operating side F_{OS} and the rolling force on the drive side F_{DS} . The mill stretch g is calculated with the use of the total rolling force F_{ACT} and a mill stretch curve $1/M_G$. The present strip gage h_{ACT} is determined by measurement of the present mean cylinder position S_{ACT} and the calculated mill stretch g . The present strip gage h_{ACT} is compared with the strip gage set value h_{REF} and used for automatic gage control. The automatic gage controller outputs the position set value for the automatic cylinder position control system.

[0026] In accordance with the invention, the prior-art automatic control system is improved as shown in the flowchart in FIG. 2. To this end, for example, the separation of the work roll chocks on the operating side S_{ROS} and on the drive side S_{RDS} is measured, and then the mean separation of the work roll chocks S_R is determined. The value for the present mean cylinder position S_{ACT} , which continues to be determined, as in the prior art, is directly compared with the cylinder position set value S_{REF} .

[0027] The values of the rolling force on the operating side F_{OS} and the rolling force on the drive side F_{DS} also continue to be determined and lead to the total rolling force F_{ACT} . These are combined, in accordance with the invention, with a mill modulus M_R with respect to the work roll chocks, and then the mill stretch g_R with respect to the work roll chocks is determined.

[0028] In accordance with the invention, the mill modulus M_R depends on the selected position measurement. The position signals of the position measurement that are to be taken into consideration for the method, with at least one position signal being required, are determined between the work rolls AW and/or the backup rolls SW and/or the work roll chocks and/or the backup roll chocks. The mill stretch to be taken into consideration in the method of the invention is to be coordinated with the given site of the position signal that is obtained.

[0029] The separation on the operating side S_{ROS} and the separation on the drive side S_{RDS} lead to the mean separation

of the work roll chocks S_R , for example. The present strip gage h_{ACT} is determined from the separation of the work roll chocks S_R and the mill stretch with respect to the work roll chocks g_R and is then compared with the strip gage set value h_{REF} and automatically controlled.

LIST OF REFERENCE SYMBOLS

[0030]	AW work roll
[0031]	SW backup roll
[0032]	W rolling stand
[0033]	B strip
[0034]	DS drive side
[0035]	OS operating side
[0036]	F_{ACT} total rolling force
[0037]	F_{OS} rolling force on the operating side
[0038]	F_{DS} rolling force on the drive side
[0039]	S_{ACT} present mean cylinder position
[0040]	S_{OS} cylinder position on the operating side
[0041]	S_{DS} cylinder position on the drive side
[0042]	S_{REF} cylinder position set value
[0043]	h_{ACT} present strip gage
[0044]	h_{REF} strip gage set value
[0045]	S_R mean separation of the work roll chocks
[0046]	S_{ROS} separation on the operating side
[0047]	S_{RDS} separation on the drive side
[0048]	g_R mill stretch with respect to the work roll chocks
[0049]	M_R mill model with respect to the work roll chocks
[0050]	g mill stretch
[0051]	M_G mill modulus

1. A method for automatic gage control during hot rolling with at least one rolling stand, where factors that are considered include the present mean position of the adjustment cylinders of the rolling stand and their total rolling force, wherein at least one additional position measurement is carried out by detecting position signals in the immediate vicinity of the roll gap of the rolling stands and that the position signals are used for calculating the strip gage.

2. A method in accordance with claim 1, wherein the position signals are detected between the work rolls and/or the backup rolls and/or the work roll chocks and/or the backup roll chocks.

3. A method in accordance with claim 1, wherein the position signals are used for automatic position control.

4. A method in accordance with claim 1, wherein the position signals are used for automatic swivel control.

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