

## ABSTRACT

Machine for leveling a strip of material comprising: a lower fixed back plate (1) from which extend a plurality of vertical beams (2a, 2b), the beams being located on either side of a longitudinal axis of movement of the strip of material, a lower fixed leveling cassette (5b), during operation of the leveling machine, the lower fixed leveling cassette (5b) bearing against the fixed back plate (1), an upper leveling cassette (5a), each cassette having a plurality of rollers (51a, 51b) spaced out and mounted rotatably in bearings (52) on axes perpendicular to the longitudinal axis of movement (P) of the material, characterized in that the leveling machine also includes: an upper fixed back plate (11) rigidly connected to the vertical beams (2a, 2b) and rigidly attached to the upper extremity of each beam (2a, 2b), movable means (9) for coupling the upper leveling cassette (5a) to the upper back plate (11) enabling movement of the upper leveling cassette, means (10) for moving the upper leveling cassette (5a) in vertical translation in relation to the upper fixed back plate (11) between a resting position in which the rollers (51a) of the upper leveling cassette (5a) are not close to the rollers (51b) of the lower leveling cassette (5b) and a leveling position in which the rollers of the upper leveling cassette are close to the rollers of the lower leveling cassette in order to cause the strip to follow an undulating route.

## AMENDED CLAIMS

received by the International Bureau on July 21, 2010

(21.07.2010)

### CLAIMS

1. A machine for leveling a strip of material comprising:

- a lower fixed back plate (1) from which extend a plurality of vertical beams (2a, 2b), the beams being located on either side of a longitudinal axis of movement of the strip of material,
- a lower fixed leveling cassette (5b), during operation of the leveling machine, the lower fixed leveling cassette (5b) bearing against the fixed back plate (1),
- an upper leveling cassette (5a),

each cassette having a plurality of rollers (51a, 51b) spaced out and mounted rotatably in bearings (52) on axes perpendicular to the longitudinal axis of movement (P) of the material,

characterized in that the leveling machine also includes:

- an upper fixed back plate (11) rigidly connected to the vertical beams (2a, 2b) and rigidly attached to the upper extremity of each beam (2a, 2b),
- movable means (9) for coupling the upper leveling cassette (5a) to the upper back plate (11) enabling movement of the upper leveling cassette,
- means (10) for moving the upper leveling cassette (5a) in vertical translation in relation to the upper fixed back

plate (11) between a resting position in which the rollers (51a) of the upper leveling cassette (5a) are not close to the rollers (51b) of the lower leveling cassette (5b) and a leveling position in which the rollers of the upper leveling cassette are close to the rollers of the lower leveling cassette in order to cause the strip to follow an undulating route, the movement means being able to offset the bending of the upper leveling cassette (5a) caused by the separation stress attributable to the passage of the strip to be leveled.

2. The leveling machine as claimed in the preceding claim, characterized in that the moveable coupling means (9) include:

- a first set of cylinders (111) placed on one side of an imaginary vertical plane passing through the longitudinal axis (P) of movement of the strip of material, each cylinder of the first set being fixed firstly to a flange (113) of the fixed upper back plate (11) and secondly to a retaining hook (56a) of the upper leveling cassette (5a),
- a second set of cylinders (112) placed on the other side of the imaginary vertical plane, each cylinder (112) in the second set being fixed firstly to a part (114) movable in relation to the fixed upper back plate (11) and secondly to a retaining hook (56b) of the upper leveling cassette (5a).

3. The leveling machine as claimed in the preceding claim, characterized in that each movable part (114) is fixed to a flange (1100) of the fixed upper back plate (11) and at least one of the movable parts (114) is driven in rotation by drive means.

4. The leveling machine as claimed in the preceding claim, characterized in that the rotating drive means include at

least one cylinder (115), each cylinder being linked firstly to at least one movable part (114) and secondly to a flange (1200) of the upper back plate of the leveling machine.

5. The leveling machine as claimed in the preceding claim, characterized in that, when a <sup>rotating</sup> drive cylinder (115) is actuated, at least one set comprising a movable part (114) and one cylinder (112) from the second set of cylinders is moved in rotation from a vertical position to a retracted position, the retracted position enabling the upper leveling cassette (5a) to be removed from the leveling machine.

6. The leveling machine as claimed in any one of the preceding claims, characterized in that the lower leveling cassette (5b) comprises a plurality of uprights (55b) extending upwards from the base of the leveling cassette.

7. The leveling machine as claimed in any one of the preceding claims, characterized in that each vertical beam (2a, 2b) has an inner vertical contact surface (21a) intended to cooperate with another contact surface to guide at least one leveling cassette (5a, 5b) of the leveling machine in translation.

8. The leveling machine as claimed in the preceding claim, characterized in that the lower leveling cassette (5b) has at least one outer vertical contact surface (59) intended to cooperate with an inner vertical contact surface (21a) of a vertical beam (2a, 2b) such as to guide the lower leveling cassette (5b) in translation.

9. The leveling machine as claimed in the preceding claim, characterized in that at least one inner vertical contact surface (59) of the lower leveling cassette (5b) belongs to an

upright (55b) of the lower leveling cassette (5b) extending upwards from the base of the leveling cassette.

10. The leveling machine as claimed in any one of the preceding claims, characterized in that the lower leveling cassette (5b) has an inner contact surface (57b) intended to guide the upper leveling cassette (5a) in translation.

11. The leveling machine as claimed in any one of the preceding claims, characterized in that the upper leveling cassette (5a) has at least one outer contact surface (55a) to guide it in translation that is intended to cooperate with another contact surface of an element (2a, 2b, 5b) of the leveling machine.

12. The leveling machine as claimed in the preceding claim, characterized in that each outer contact surface (55a) of the upper leveling cassette (5a) is convex.

13. The leveling machine as claimed in one of claims 11 and 12 if it is dependent on claim 7, characterized in that each outer contact surface (55a) of the upper leveling cassette (5a) cooperates with an inner vertical contact surface (21a) of a beam (2a, 2b).

14. The leveling machine as claimed in one of claims 11 and 12 if it is dependent on claim 10, characterized in that each outer contact surface (55a) of the upper leveling cassette (5a) cooperates with an inner vertical contact surface (21a) of the lower leveling cassette (5b).

15. The leveling machine as claimed in any one of the preceding claims, characterized in that the means for moving the upper leveling cassette (5a) in vertical translation

include a plurality of closing cylinders (10) rigidly connected to the fixed upper back plate (11) and the upper leveling cassette (5a).

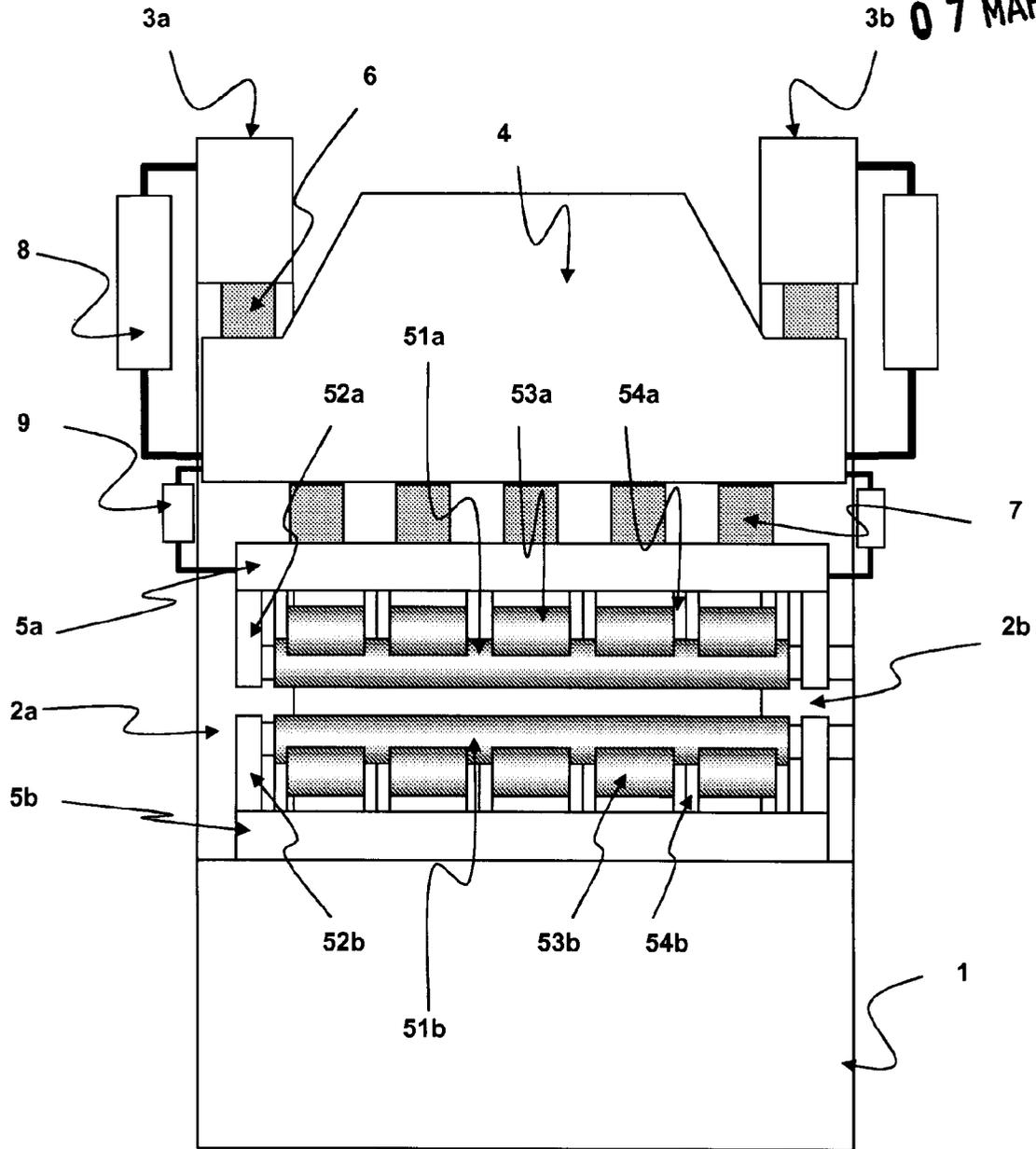
16. A flexible leveling cassette intended to cooperate with a leveling machine as claimed in any one of the preceding claims, characterized in that a thickness (e) of the upper leveling cassette (5a) varies between a maximum value (e1) and a minimum value (e2) and in that it comprises a plurality of zones (Z1) of maximum thickness (e1) intended to cooperate with the closing cylinders (10) of the leveling machine, the zones of maximum thickness (e1) being separated from one another by a zone (Z2) of minimum thickness (e2) helping to reduce the deformation inertia of the cassette (5a).

17. The leveling cassette as claimed in claim 16 or 17, characterized in that the maximum thickness value (e1) is between 1.5 and 4 times the minimum thickness value (e2) and is preferably between 2 and 2.5 times this value.

Dated this 07/03/2012

  
HRISHIKESH RAY CHAUDHURY  
OF REMFRY & SAGAR  
ATTORNEY FOR THE APPLICANTS

07 MAR 2012



Art antérieur

Fig. 1

ORIGINAL

07 MAR 2012

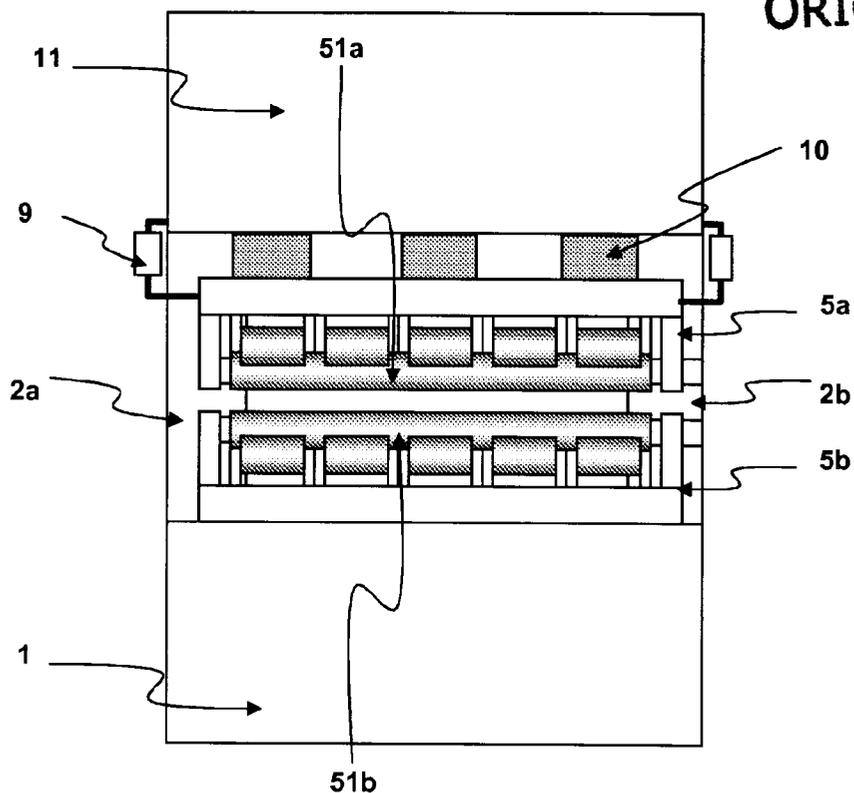


Fig. 2

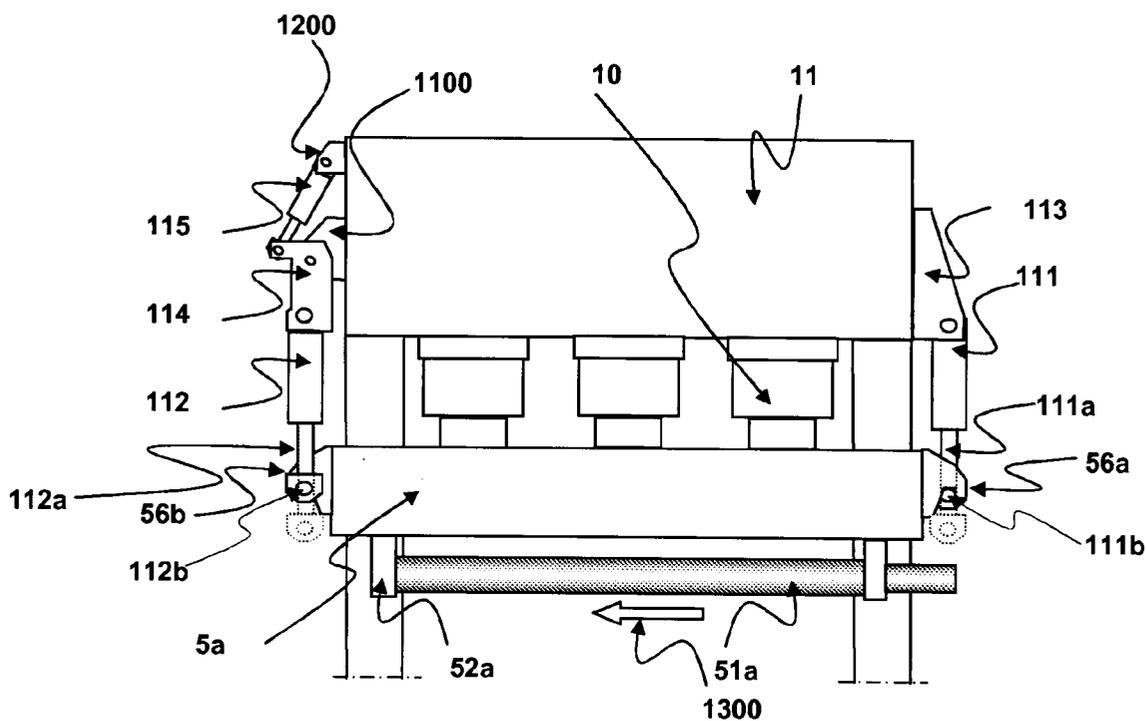
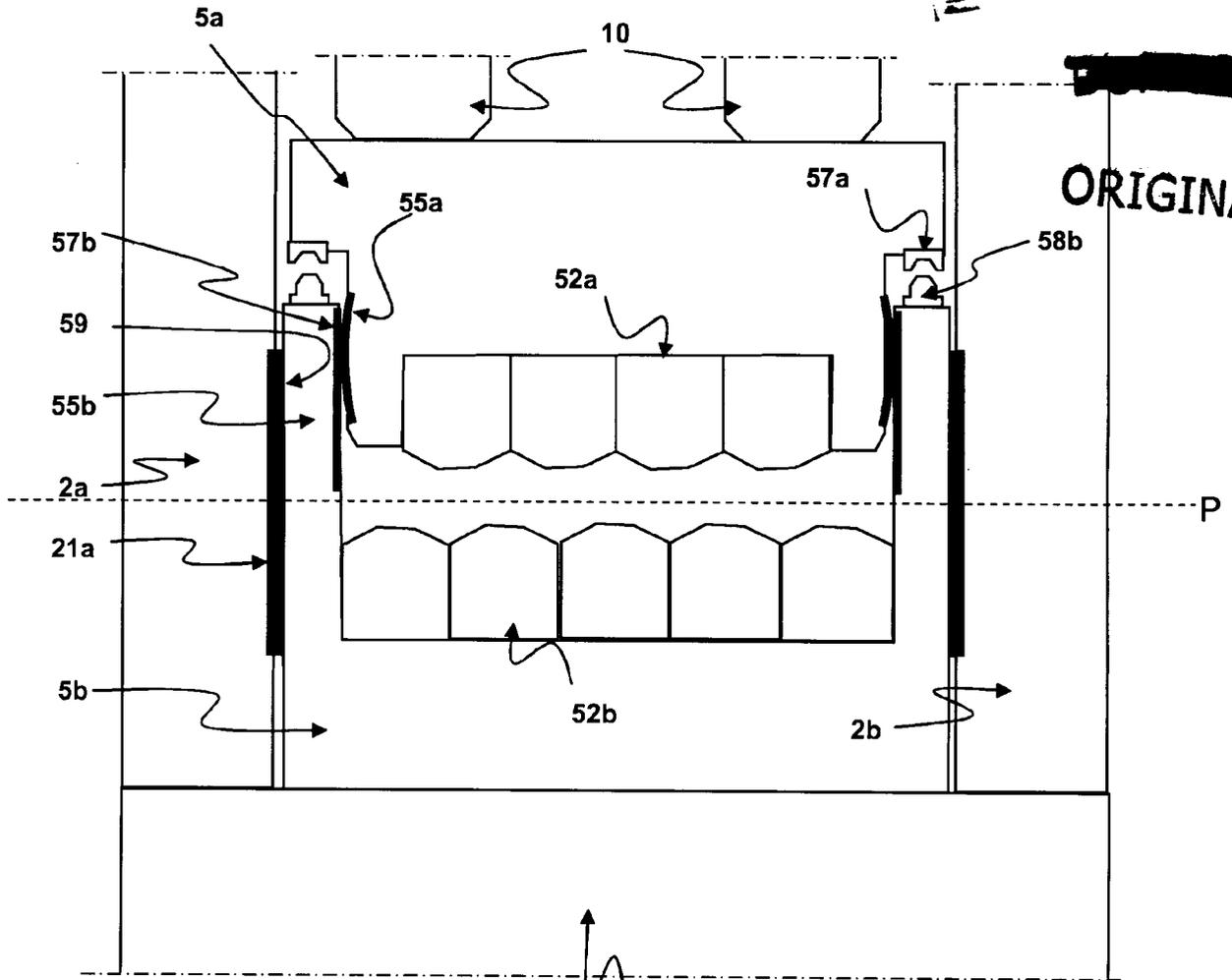


Fig. 3

07 MAR 2012



ORIGINAL

Fig. 4

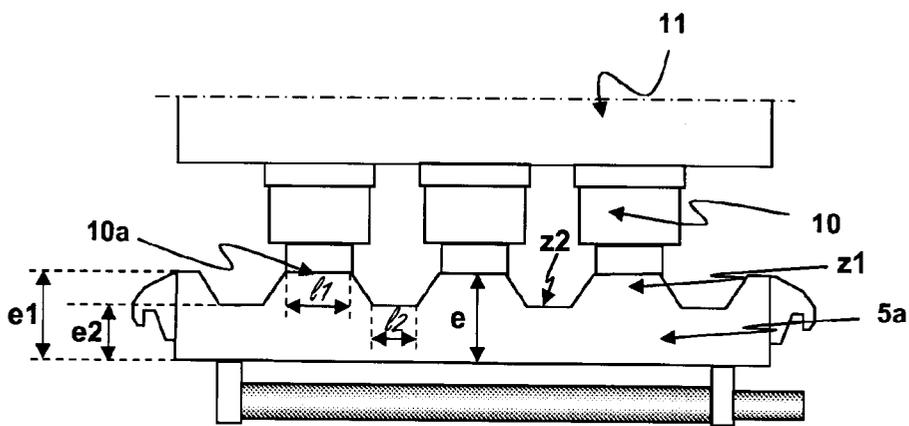


Fig. 5

## **Leveling machine with multiple rollers**

The invention relates to a machine for leveling thick metal plates or strips that, henceforth, shall be referred to generically as "strips".

Leveling devices, known as levelers, are used to remove flatness defects in strips following hot or cold rolling. Indeed, for example after the hot rolling, cooling and conditioning phases, the rolled products may have non-developable flatness defects, such as defects known as edge wave or center buckle, or developable flatness defects, such as bowing defects. These geometric defects visibly affect rolled products.

Levelers with multiple rollers arranged such that they overlap, establishing an undulating route for the strip, which is then subjected to bending effects in alternating directions, are used to level such rolled metal strips.

A metal plate or strip leveling installation comprises, in general, a lower leveling cassette and an upper leveling cassette, each fitted with a plurality of leveling rollers that are in direct contact with the strip. These leveling rollers are usually supported by support rollers.

These two leveling cassettes are included in the structure of the leveler which comprises vertical beams, the bottoms of which are rigidly connected by a generally fixed back plate and the tops of which are rigidly connected by horizontal upper beams.

The lower cassette is supported by the lower back plate and the upper cassette is supported by a pressure frame to which it is bolted.

Most commonly, the lower cassette is fixed and the upper cassette can move vertically in order to adjust the gap between the leveling rollers and thereby determine the undulating route of the strip. This gap and the transfer of the cassette separation stress, attributable to the resistance of the strip, are effected by hydraulic closing cylinders bearing on one side against the upper beams and on the other against the pressure frame.

A motorized drive system makes it possible to actuate the rollers in rotation and, by friction, to move the strip forward at a given speed. This involves at least one motor driving at least one reduction gear that actuates at least one gearbox at the required speed that distributes the rotation torques to the different lower and upper leveling rollers by means of spindles connected at one end to the outputs of the gearbox and at the other end to the end trunnions of the rollers.

Figure 1 is a schematic view of a leveling machine in the prior art in which the upper cassette 5a is supported by a pressure frame 4 that is movable vertically using hydraulic cylinders bearing against the upper horizontal cross members 3a, 3b rigidly connected to the vertical beams. The machine comprises a fixed lower back plate 1 supporting a lower leveling cassette 5b rigidly connected to two pairs of vertical beams 2a, 2b. The top of each beam 2a, 2b is connected to a horizontal cross member 3a, 3b. A pressure frame 4 guided in vertical translation between the beams 2 is forced on to the upper cassette 5a by four closing cylinders

6. Each cassette 5a, 5b has several leveling rollers 51a, 51b supported by bearings 52a, 52b and held by support rollers 53a, 53b, themselves supported by bearings 54a, 54b. The leveling machine also includes return cylinders 8 enabling the pressure frame 4 and therefore the upper cassette 5a to be moved upwards.

In order to offset the bending of the cassettes, the lower back plate and the upper pressure frame caused by the separation stress attributable to the passage of the strip, several systems have been invented, such as using bend correction cylinders between at least the upper cassette and the pressure frame thereof. Thus, the leveling machine shown in Figure 1 is fitted with correction cylinders 7 placed between the pressure frame 4 and the upper leveling cassette 5a. Coupling devices 9 attach the upper leveling cassette 5a to the pressure frame, while enabling movement of the upper leveling cassette 5a under the action of the correction cylinders 7.

Other solutions for correcting the bending of cassettes, the lower back plate and the upper pressure frame under the separation stress caused by passage of the strip have been invented. Accordingly, document EP 0 570 770 discloses the use of cylinders arranged between the upper leveling rollers and the upper pressure frame of a leveling machine. These cylinders enable the bending of the leveling rollers occurring during passage of the strip of material between the rollers to be offset. These offsetting rollers act in conjunction with cylinders enabling an upper frame with a rigidly connected upper leveling cassette to be moved. The leveling machine is also fitted with a plurality of sensors measuring the deformation of the rollers and providing information to a

processor that controls the offsetting cylinders and the cylinders enabling the frame to be moved.

Document JP A 2000 326012 also discloses a leveling machine comprising a plurality of offsetting cylinders installed between an upper frame and the upper rollers of a leveling machine. Other cylinders bearing against horizontal cross members change the position of the upper leveling rollers by acting on the upper back plate of the leveling machine.

Document US 5 461 895 discloses a leveling machine that, to offset the longitudinal bending of the leveling rollers, comprises a combination of pressure cylinders acting on the middle of the upper cassette and traction cylinders acting on the extremities thereof.

The use of an increasing number of closing and correcting cylinders complicates leveling machines and increases the height of said machines as several levels of these cylinders are stacked. Accordingly, known leveling machines comprise a stack of superimposed layers formed by an upper cassette, bend correction cylinders, the pressure frame, main closing cylinders and upper horizontal cross members. A leveling machine for very wide, thick strips can weigh more than 600 tons and be more than ten meters high. A pressure frame on its own may weigh more than 70 tons. It is therefore important to minimize the mass and size of leveling machines.

The invention is intended to address the problems identified above and, in particular, to limit the stacking of structural members and cylinders in order to limit the height of the machine and, in particular, the length of the vertical beams. It is also intended to provide a leveling machine of lesser volume and mass than known leveling machines, while fulfilling

the same functions and, in particular, enabling the bending of leveling cassettes caused by the passage of the material being leveled to be offset.

In consideration of these objectives, the first object of the invention is a machine for leveling a strip of material comprising:

- a lower fixed back plate from which extend a plurality of vertical beams, the beams being located on either side of a longitudinal axis of movement of the strip of material,
- an upper leveling cassette and a lower fixed leveling cassette, during operation of the leveling machine, the lower fixed leveling cassette bearing against the fixed back plate, each cassette having a plurality of rollers spaced out and mounted rotatably in bearings on axes perpendicular to the longitudinal axis of movement of the material,

characterized in that the leveling machine also includes:

- an upper fixed back plate rigidly connected to the vertical beams and rigidly attached to the upper extremity of each beam,
- movable means for coupling the upper leveling cassette to the upper back plate enabling movement of the upper leveling cassette,
- means for moving the upper leveling cassette in vertical translation in relation to the upper fixed back plate between a resting position in which the rollers of the upper leveling cassette are not close to the rollers of the lower leveling cassette and a leveling position in which the rollers of the upper leveling cassette are close to the rollers of the lower leveling cassette in order to cause the strip to follow an undulating route.

According to other advantageous characteristics:

- the mobile coupling means comprise:
  - a first set of cylinders placed on one side of an imaginary vertical plane passing through the longitudinal axis of movement of the strip of material, each cylinder of the first set being fixed firstly to a flange of the fixed upper back plate and secondly to a retaining hook of the upper leveling cassette,
  - a second set of cylinders placed on the other side of the imaginary vertical plane, each cylinder in the second set being fixed firstly to a part movable in relation to the fixed upper back plate and secondly to a retaining hook (56b) of the upper leveling cassette,
- each movable part is fixed to a flange of the fixed upper back plate and at least one of the movable parts is driven in rotation by drive means,
- the rotating drive means include at least one cylinder, each cylinder being linked firstly to at least one movable part and secondly to a flange of the upper back plate of the leveling machine,
- when a drive cylinder is actuated in rotation at least one set comprising a movable part and one cylinder from the second set of cylinders is moved in rotation from a vertical position to a retracted position, the retracted position enabling the upper leveling cassette to be removed from the leveling machine,
- the lower leveling cassette comprises a plurality of uprights extending upwards from the base of the leveling cassette,
- each vertical beam has an inner vertical contact surface intended to cooperate with another contact surface to guide

at least one leveling cassette of the leveling machine in translation,

- the lower leveling cassette has at least one outer vertical contact surface intended to cooperate with an inner vertical contact surface of a vertical beam such as to guide the lower leveling cassette in translation,
- at least one inner vertical contact surface of the lower leveling cassette belongs to an upright of the lower leveling cassette extending upwards from the base of the leveling cassette,
- the lower leveling cassette has an inner contact surface intended to guide the upper leveling cassette in translation,
- the upper leveling cassette has at least one outer contact surface to guide it in translation that is intended to cooperate with another contact surface of an element of the leveling machine,
- each outer contact surface of the upper leveling cassette is convex,
- each outer contact surface of the upper leveling cassette cooperates with an inner vertical contact surface of a beam,
- each outer contact surface of the upper leveling cassette cooperates with an inner vertical contact surface of the lower leveling cassette,
- means for moving the upper leveling cassette in vertical translation include a plurality of closing cylinders (10) rigidly connected to the fixed upper back plate and the upper leveling cassette.

The invention also relates to a flexible leveling cassette the thickness of which varies between a maximum value and a minimum value, and that is intended to cooperate with a leveling machine as defined above.

Advantageously, the leveling cassette comprises a plurality of maximum-thickness zones intended to cooperate with the closing cylinders of the leveling machine, the maximum-thickness zones being separated from one another by a minimum-thickness zone.

Furthermore, the maximum thickness value may be between 1.5 and 4 times the minimum thickness value and may preferably be between 2 and 2.5 times this value.

The total height of the leveling machine according to the invention is therefore less than known machines and, unlike leveling machines in the prior art, it does not have conventional pressure frames or horizontal cross members, which saves tens of tons from the structure and lightens the leveling machine according to the invention.

Furthermore, in relation to leveling machines in the prior art, the invention also enables the retraction cylinders to be removed from the pressure frame and the upper cassette, which represents a significant saving as these cylinders, of which there are normally four, have to be powerful enough to lift a mass of up to around 100 tons. Furthermore, they usually have significant travel in order to enable the closing cylinders to be disassembled. These cylinders are therefore very heavy and require the implementation of high-pressure hydraulic circuits and a significant quantity of oil. Removal of all of these devices has the additional effect of reducing the mass of the leveling machine by several tens of tons.

Other characteristics and advantages of this invention are set out in a detailed non-limiting embodiment provided with reference to the figures, in which:

- Figure 1, as already described, is a front schematic view of a leveling machine in the prior art,
- Figure 2 is a front schematic view of a leveling machine according to the invention,
- Figure 3 is a detailed view showing a leveling cassette connected to the upper back plate of a leveling machine according to the invention,
- Figure 4 is a cross-section view of Figure 1,
- Figure 5 is a cross-section view of a flexible upper leveling cassette used in a leveling machine according to the invention.

It should be noted that the figures only show the elements required to understand the invention, it being understood that the leveling machine includes all of the elements (not shown) required to drive the leveling rollers in rotation.

The leveling machine according to the invention shown in Figure 2 includes a lower back plate 1, fixed during use of the leveling machine, supporting a lower leveling cassette 5b. Two pairs of vertical beams 2a, 2b extend upwards from the lower back plate 1 and are fixed rigidly to this latter. Furthermore, each pair of vertical beams 2a, 2b is placed on one side of an imaginary vertical plane passing through the longitudinal axis of movement P (shown in Figure 4) of the strip of material. A fixed upper back plate 11 is attached rigidly to the upper extremity of each of the vertical beams 2a, 2b.

The leveling machine also comprises closing cylinders 10 attached firstly to the fixed upper back plate 11 and in contact secondly with an upper face of the upper leveling cassette 5a. When deployed, the closing cylinders 10 bear against the back plate 11 and force the rollers 51a of the

upper leveling cassette 5a against the material to be leveled. The closing cylinders therefore cause firstly the rollers 51a of the upper leveling cassette and the rollers 51b of the lower leveling cassette 5b to move closer together and secondly, as a function of the relative vertical movement thereof, they offset the bending of the upper leveling cassette 5a caused by the separation stress generated by passage of the strip to be leveled.

Coupling means 9 attach the upper leveling cassette 5a to the back plate 11, while enabling vertical movement of the upper leveling cassette 5a under the action of the closing cylinders 7.

Figure 3 shows an embodiment of the coupling means. The upper leveling cassette 5a bearing the leveling rollers 51a and the bearings 52a thereof is coupled to the upper back plate 11 by means of two cylinders 111 supported on the roller drive side by flanges 113 of the upper back plate 11. Each head of the cylinder 111 is engaged in a retaining hook 56a of the upper leveling cassette 5a. For this purpose, each head of the cylinder 111 may include a cylindrical retaining portion 111b, the axis of which is perpendicular to the axis of the rod 111a of the cylinder 111. The upper leveling cassette 5a is also coupled to the upper back plate 11 by means of two more cylinders 112 supported on the side opposite the roller drive side by L-shaped parts 114 that are moveable in rotation in relation to the fixed upper back plate 11. Each head of the cylinder 112 is engaged in a retaining hook 56b of the upper leveling cassette 5a. For this purpose, each head of the cylinder 112 may include a cylindrical retaining portion 112b the axis of which is perpendicular to the axis of the rod 112a of the cylinder 112. Furthermore, each cylindrical retaining portion 111b, 112b may include two vertical stops located on

either side of each retaining hook 56a that are intended to stop the upper leveling cassette 5a in horizontal translation. The cylinders 111, 112 therefore support the upper leveling cassette 5a while assisting the relative movements between the upper leveling cassette 5a and the upper back plate 11 under the action of the cylinders 10.

Each movable part 114 is fixed to an axle of the back plate 11 and can turn about this axle, each axle being supported by a flange 1100 of the back plate 11. At least one additional cylinder 115 able to pivot at least one movable part 114 extends between one extremity of the movable part 114 and one other flange 1200 of the back plate 11.

To remove the leveling equipment 5a and 5b, the rods of the closing cylinders 10 extend until the upper leveling cassette 5a is resting on the lower leveling cassette 5b. The rods 111a and 112a of the retaining cylinders 111, 112 follow the movement of the upper leveling cassette 5a downwards. Once the upper leveling cassette 5a is resting on the lower leveling cassette 5b, the rods 111a and 112a of the retaining cylinders 111, 112 continue their downward movement until each retaining hook 56a is released. By retracting, the additional cylinder 115 pivots the supporting element 114 which retracts the cylinder 112 upwards and the upper leveling cassette can be removed in the direction of the arrow 1300, from the side opposite the drive side of the leveling rollers 51a.

As mentioned previously, in leveling machines in the prior art, the pressure frame is guided between the vertical beams and the upper leveling cassette is coupled thereto using devices that follow the movements of the bend correction cylinders. In order to prevent double vertical guidance of the pressure frame and the cassette, which may cause butting and

jamming, the upper cassette is not guided between the vertical beams or between the uprights of the lower cassette. In the machine according to the invention, the absence of the pressure frame enables the cassette to be guided itself between the vertical beams or between the uprights of the lower cassette, which considerably improves the precision of the movements thereof.

Figure 4 shows an embodiment of the system for guiding the leveling equipment between the beams 2a and 2b. It should be noted that Figure 4 is a schematic cross-section view of the leveling machine taken through the bearings 52a and 52b, in a plane parallel to the imaginary vertical plane passing through the longitudinal axis of movement of the strip of material.

In general, each vertical beam 2a, 2b has an inner vertical contact surface 21a intended to cooperate with another contact surface to guide at least one leveling cassette 5a, 5b of the leveling machine in translation.

More specifically, the lower leveling cassette 5b includes vertical uprights 55b extending upwards from the base of the lower cassette 5b to guide it outside the leveling machine during assembly and disassembly operations. Each upright 55b includes an outer vertical surface 59 in contact with an inner vertical surface 21a of one of the beams 2a, 2b such as to ensure a precise positioning and to guide the lower leveling cassette 5b in translation. The uprights 55b and the lower leveling cassette 5b are therefore connected by a sliding joint. The two contact surfaces 59 and 21a extend at least partially facing one another.

Furthermore, each upright 55b of the lower leveling cassette 5b is positioned such as to act as a translational guide for

the upper leveling cassette 5a. Consequently, each upright of the lower leveling cassette 5b also includes an inner vertical surface 57b in contact with an outer surface 55a of the upper leveling cassette. The contact surfaces 55a and 57b, extending at least partially facing one another when the leveling machine is fully assembled, cooperate to guide the upper leveling cassette 5a in translation in relation to the lower leveling cassette 5b. As the upper leveling cassette 5a is framed by the uprights 55b, the upper and lower leveling cassettes are therefore linked by a sliding joint which guarantees the relative positioning thereof to a high degree of accuracy. Furthermore, each outer contact surface 55a of the upper leveling cassette may be slightly convex. This enables an inclined position of the upper cassette 5a in relation to the lower cassette 5b between the strip input side between the leveling rollers and the output side.

Furthermore, the top of each of the uprights 55b of the lower leveling cassette 5b has a positioning contact 58b intended to receive a supporting element 57a of the upper leveling cassette 5a. During the cassette removal and replacement phases in the leveling machine, each positioning contact 58b receives a supporting element 57a, which guarantees the rigid attachment of the two cassettes.

In another embodiment not shown in the figures, the lower leveling cassette 5b does not have uprights 55b and the upper leveling cassette is guided in vertical translation directly by the beams 2a, 2b of the leveling machine. Thus, each outer contact surface 55a of the upper leveling cassette 5a cooperates with an inner vertical contact surface 21a of one of the beams 2a, 2b. The lower leveling cassette 5a is therefore connected to the uprights 2a, 2b of the leveling machine by a sliding joint.

In order to limit the wear generated by friction when guiding each of the elements in the leveling machine in translation, the contact surfaces 21a, 56b, 57b and 55a may be coated with an abradable material, encouraging parts such as surface-hardened steel plates to slide against one another.

To ensure that the closing cylinders 10 are able to correctly perform the function of correcting the leveling roller bend, there should preferably be at least six of them operating between the upper back plate 11 and the upper cassette 5a. As shown in Figures 2 to 5, the closing cylinders 10 are arranged in line in the same direction as the longitudinal axis of the rollers. In the embodiment according to the figures, the leveling machine has two lines of three closing cylinders 10 each. A first line of three closing cylinders 10 acts on the side the strip enters the upper leveling cassette 5a, while another line of closing cylinders acts on the output side of the leveling cassette, as shown schematically in Figure 4.

An additional condition for the correct operation of roller bend correction is the deformation capacity of the upper leveling cassette in the same direction as the longitudinal axis of the rollers. This condition is easily satisfied when leveling thick strips, which involves very high levels of upper- and lower-cassette separation stress. In the case of thinner strips, it may be necessary to change the shape of the upper leveling cassette in order to reduce the bending inertia thereof.

Figure 5 shows an example of an upper leveling cassette having a greater bending deformation capacity than upper leveling cassettes in the prior art. The lower leveling cassette 5a shown in Figure 5 has a lower deformation inertia than upper

leveling cassettes in the prior art. In this cross-section view of a part of a leveling machine according to the invention, the thickness  $e$  of the upper leveling cassette 5a varies between a maximum value  $e_1$  and a minimum value  $e_2$ . Each support surface of the closing cylinders 10 is located in a zone  $z_1$  where the thickness  $e$  of the upper leveling cassette 5a is greatest in order to ensure maximum resistance of the upper leveling cassette 5a against the bend-correction and closing stresses transmitted by the closing cylinders 10. Preferably, the length  $l_1$  of each zone of maximum thickness  $z_1$  is at least equal to the diameter of the extremity 10a of the cylinder 10 with which it is in contact. Furthermore, the zones  $z_2$  of minimum thickness  $e_2$  between the zones  $z_1$  of maximum thickness help to reduce the deformation inertia of the upper cassette 5a and thereby to achieve rapid and efficient bend correction. These zones  $z_2$  have a length  $l_2$  less than the length  $l_1$ .

The embodiment shown in Figure 5 includes five zones  $z_1$  of maximum thickness, two at the extremities of the upper leveling cassette 5a and three in the supporting portions of the upper leveling cassette 5a cooperating with the closing cylinders 10. These zones  $z_1$  of constant maximum thickness  $e_1$  are separated by three zones  $z_2$  of constant minimum thickness  $e_2$ , facilitating the bending of the whole of the upper leveling cassette 5a. The upper leveling cassette therefore has a cross section in the shape of saw teeth truncated at the upper and lower parts thereof.

By way of example, the maximum thickness value may be between 1.5 and 4 times the minimum thickness value and may preferably be between 2 and 2.5 times this value.