Dec. 6, 1960 F. K. MAUST 2,963,070

ROLLER LEVELER

Filed Nov. 4, 1955 4 Sheets-Sheet 1

FIG. 4.

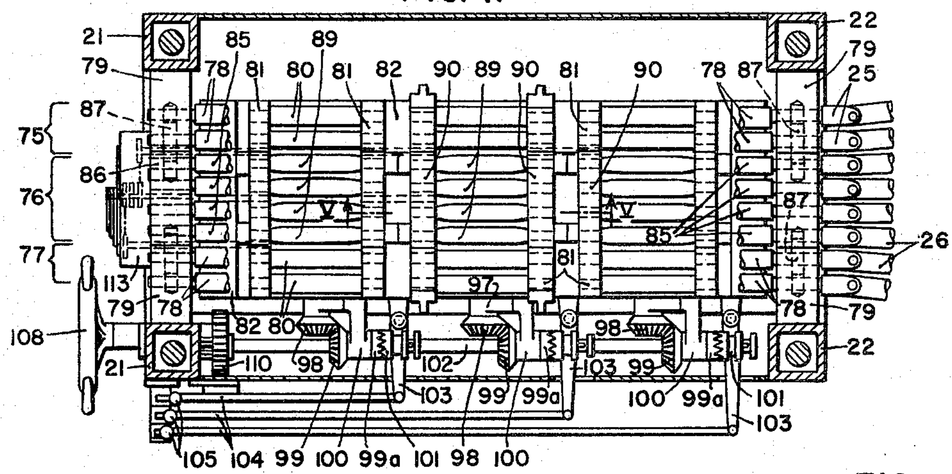


FIG. 6.

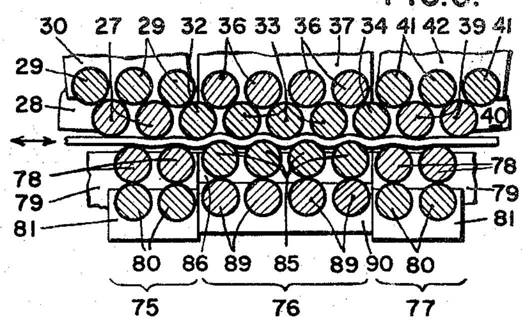


FIG. 1.

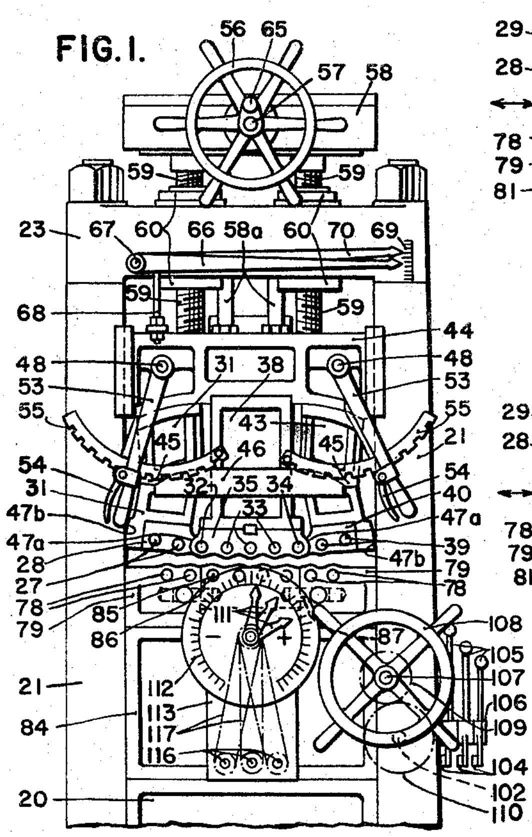
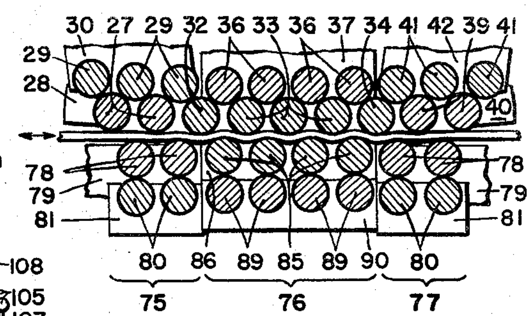


FIG. 7.



INVENTOR
FREDERICK K. MAUST
BY Lester W. Clark
his ATTORNEY

FIG. 2.

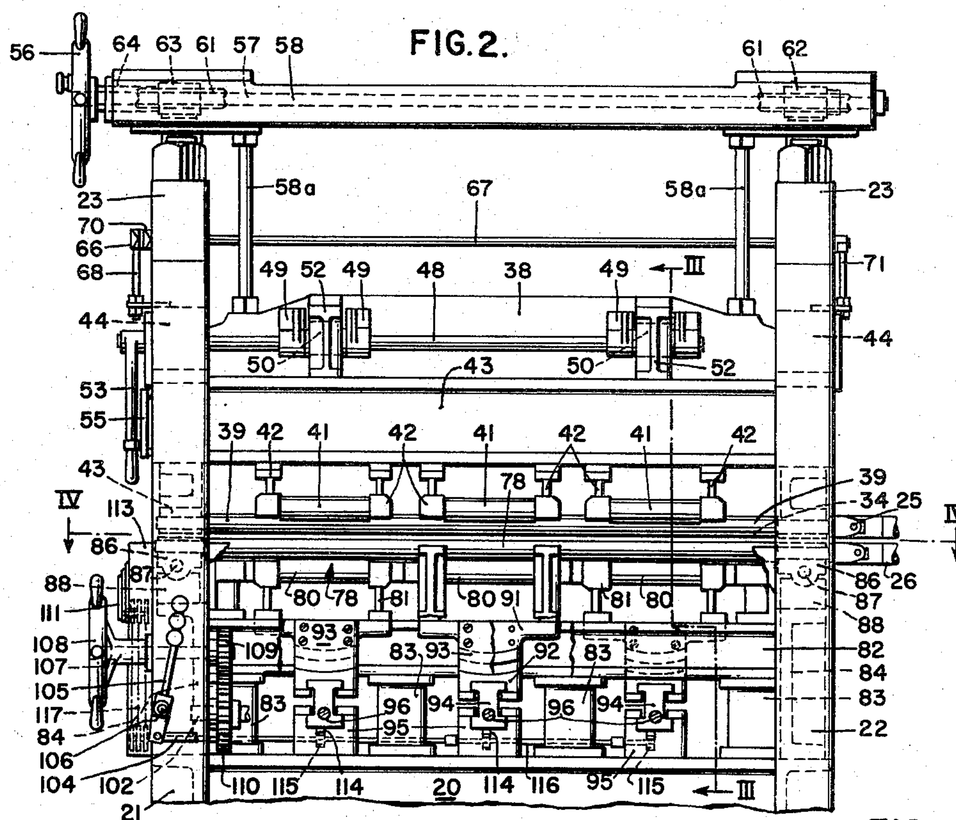


FIG. 5.

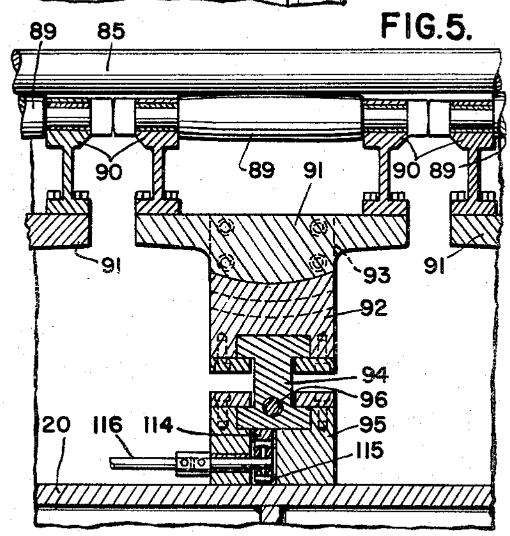
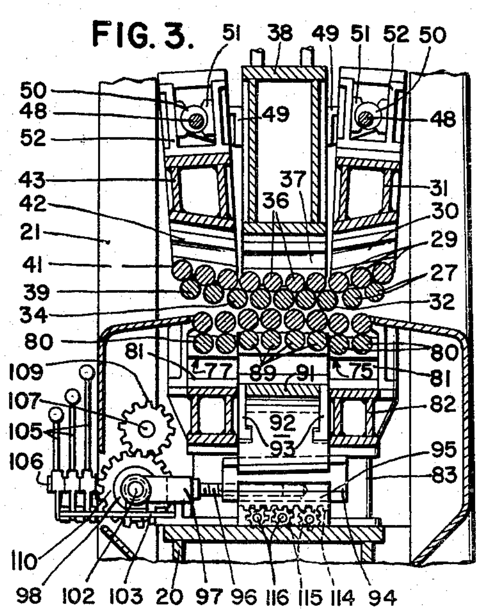


FIG. 3.



INVENTOR
FREDERICK K. MAUST
BY Lester W. Clark
his ATTORNEY

Dec. 6, 1960 F. K. MAUST 2,963,070
ROLLER LEVELER
Filed Nov. 4, 1955 4 Sheets-Sheet 3

FIG. 8.

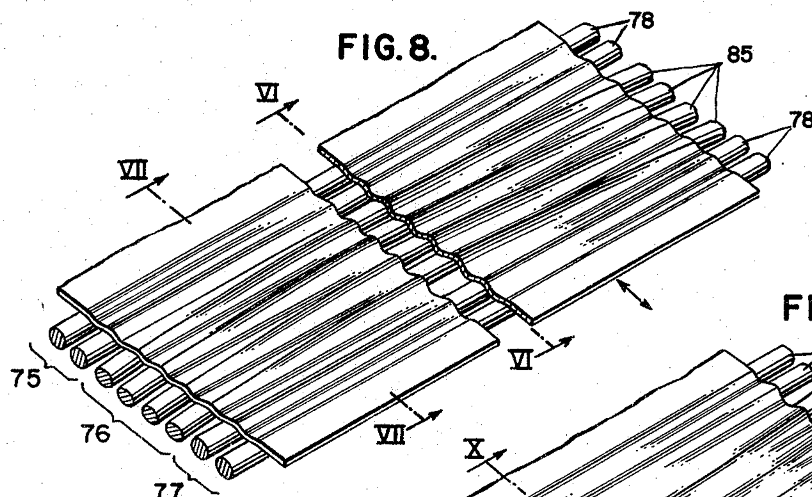


FIG. 9.

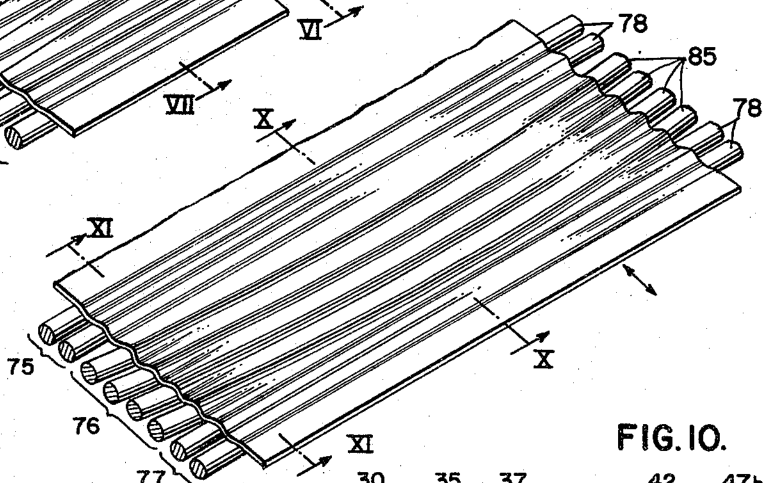


FIG. 11.

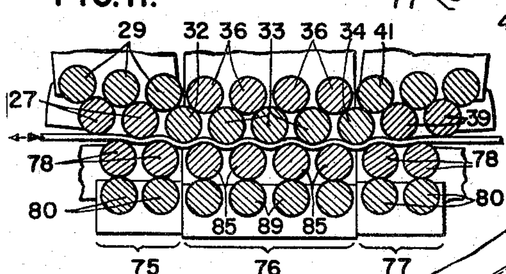


FIG. 10.

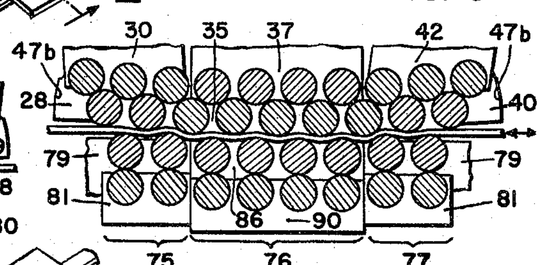
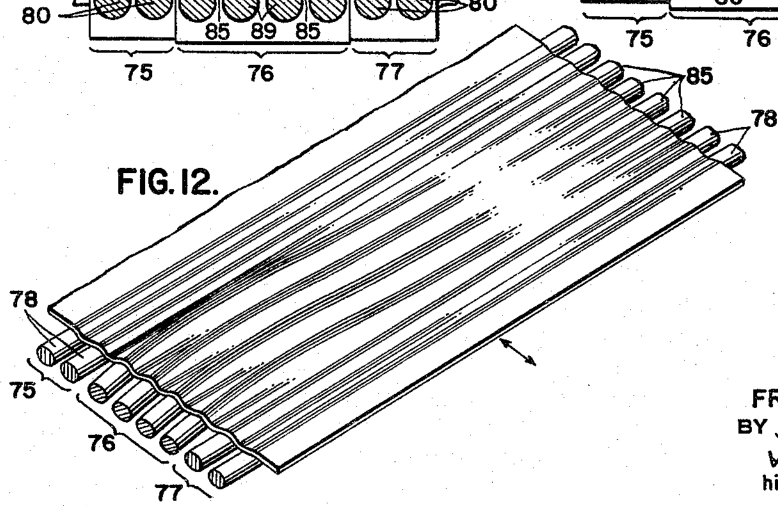


FIG. 12.



INVENTOR
FREDERICK K. MAUST
BY Lester W. Clark
his ATTORNEY

Dec. 6, 1960 F. K. MAUST 2,963,070

ROLLER LEVELER

Filed Nov. 4, 1955 4 Sheets-Sheet 4

FIG. 16.

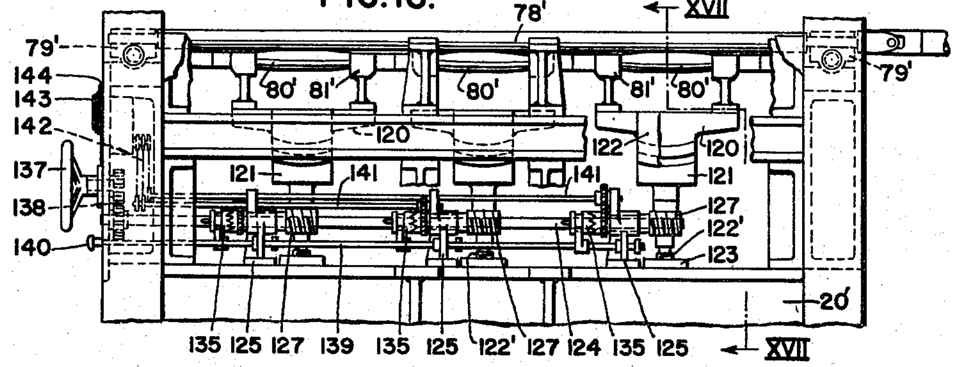


FIG. 17.

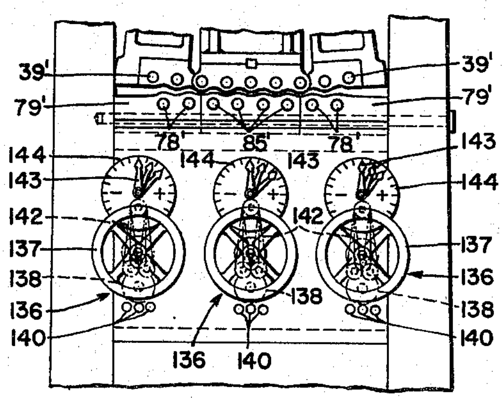


FIG. 13.

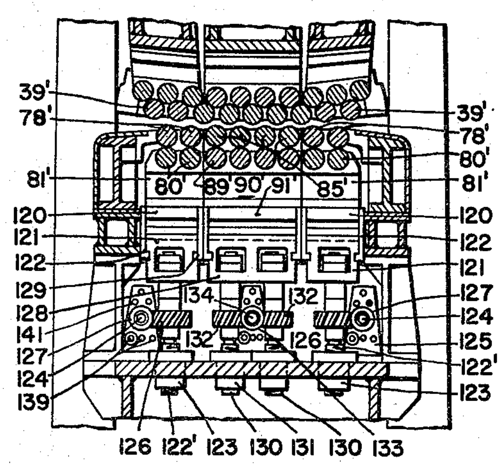


FIG. 15.

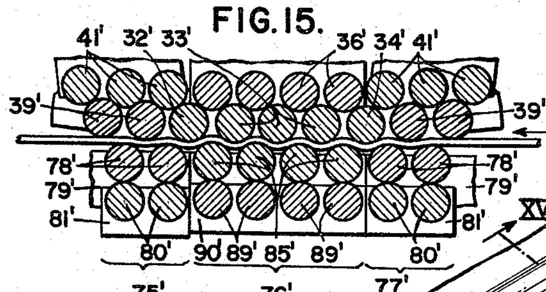
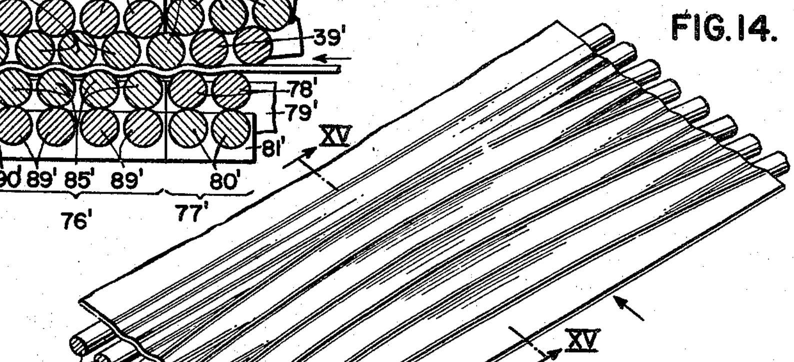


FIG. 14.



INVENTOR
FREDERICK K. MAUST
BY Lester W Clark
his ATTORNEY

United States Patent Office

2,963,070

Patented Dec. 6, 1960

1

2,963,070

ROLLER LEVELER

Frederick K. Maust, 85—36 212th St., Queens Village 27, N.Y.

Filed Nov. 4, 1955, Ser. No. 545,045

2 Claims. (Cl. 153—106)

This invention relates to roller levelers for flattening and straightening sheet and strip material, for example, sheet metal such as steel.

Sheet metal as it comes from the rolling mill, either in sheet or strip form, is typically not perfectly flat. On the contrary, each strip has a peculiar contour commonly described as the "mill shape." For many fabricating operations, substantially flat sheets are required. The flattening operation is commonly performed by a roller leveler.

The lack of flatness in sheet metal from the rolling mill may be due to the edges of the sheet being longer than the center, thus producing edge buckles, or the center portion of the sheet may be longer than its edge portions, thereby producing center buckles. In wide sheets, certain areas of the sheet between the edges and the center may be short or long as compared to the rest of the sheet. These are mill shapes mentioned above. Other defects may be described as internal stresses in the sheet. These stresses may be caused by the rolling or by passes through a roller leveler adjusted to correct faulty mill shapes as described, or both.

The roller levelers of the prior art are able to correct sheets or strips having all of these defects. A roller leveler operates by subjecting the sheet to a series of waves transverse to the direction of movement of the sheet through the leveler. When the leveler is set to correct the sheet for faulty mill shapes such as those described above, then it is adjusted so that the amplitude of the waves is greater in the short portion of the sheet than in the long portion, thereby stretching the short portion so that all portions of the sheet are made of equal length. Severe correction passes in a roller leveler invariably must be followed by a separate, so-called light "flattening" pass to knead the structure sufficiently to lay it flat by counteracting or equalizing the residual internal stresses. When the leveler is set to correct the sheet for internal stresses, each transverse wave has usually a substantially fixed amplitude across the sheet. This amplitude is decreased gradually as the sheet leaves the leveler.

The roller levelers of the prior art have not been able to make both mill shape and internal stress corrections in one pass. In operating such a leveler, it is first set for mill shape correction, and when that is accomplished, then the internal stress elimination is done in another pass, either through the same leveler with a different setting, or through another leveler.

In a roller leveler, a sheet or strip of material is subjected to transverse waves of sufficient magnitude to exceed the elastic limit of the particular material by passing it between the two banks of small diameter rolls, commonly termed straightening or work rolls. The rolls of one bank are staggered with respect to the rolls of the opposite bank. One of the banks is adjusted bodily toward or away from the other to control the wave amplitude. This adjustment is commonly known as height adjustment or screw-down.

2

Each straightening roll is backed by one or more other rolls, termed supporting or back-up rolls. The supporting or back-up rolls for each straightening roll may consist of several longitudinally separated support roll sections. When the roller leveler is to correct internal stresses, the supporting roll sections for each straightening roll are kept in substantial alignment with each other, and parallel to the straightening roll.

When it is desired to stretch preferentially one portion of the material with respect to another, then the supporting roll sections are adjusted differentially so that the straightening rolls are either deflected by the adjustment into a convex, concave or sinuous contour or are deflected into such a contour by the material when it passes between the work rolls, the particular contour always depending on the setting of the supporting roll sections. The material being treated is thereby subjected to waves whose amplitude varies transversely of the sheet. This setting of the straightening roll and supporting roll positions is termed the deflection adjustment. The degree of both height and deflection adjustments depend upon various factors, such as physical properties, thickness, hardness and mill shape of the material, etc.

When using the roller levelers of the prior art, the first step in leveling is to correct or stretch the short areas in the material by means of one or more correction passes in which the straightening rolls of one or both banks are deflected to stretch the desired areas in the material by waves whose amplitude varies transversely of the sheet.

Even though the proper length corrections are made in the sheet by these passes, the typical sheet still does not lay flat. To flatten the sheet after a severe correction pass, a second light pass is necessary in which the straightening rolls of both opposite banks are kept in substantial parallel alignment to equalize or remove the residual stresses in the work material and thus flatten and level the variously treated areas of the sheet by means of waves having substantially the same amplitude across the width of the sheet.

In order to stretch a portion of the sheet material, that portion must be preferentially stressed in the leveler beyond its elastic limit, so that it will not return to its previous dimension when it leaves the machine.

One well known type of roller leveler is called a "single tilt" type. One bank of its straightening rolls is tiltable as a unit about an axis extending transversely of the path of movement of the material through the leveler and located midway between the entry and exit ends of the machine. The opposite bank of rolls are either deflected into a suitable contour for a mill shape correction pass or they may be kept in substantially straight parallel alignment for a flattening pass. In such a leveler, the material is subjected to transverse waves of maximum depth at the entry side of the leveler. The transverse waves gradually diminish in depth or amplitude toward the exit side of the leveler. Experience has shown that such a leveler tends to mark the sheets, because the first set of rolls frequently slips on the sheet, not having frictional grip to move the sheet through the leveler without a momentary stop.

Another known type of roller leveler is termed the "double tilt" leveler and is shown and claimed in my U.S. Patents No. 2,132,426, issued October 11, 1938, and No. 2,638,143, issued May 12, 1953. In the double tilt leveler, one bank of rolls is divided transversely into three groups, which may be termed a "left-hand tilt group," a "middle group" and a "right-hand tilt group." As in the single tilt leveler, the straightening rolls are either all deflected into a suitable contour in a mill shape correction pass or they are all kept in substantially straight alignment for a flattening pass. In the double tilt leveler, the entry tilt group of rolls on the entry side subjects the material to waves gradually increasing in amplitude from a very small initial value. The middle group subjects the material to waves having a preselected maximum amplitude throughout the group. The exit tilt group on on the exit side subjects the material to waves gradually decreasing in amplitude from the maximum to substantially zero.

One main object of the present invention is to provide a backed-up roller leveler for leveling a sheet or strip of material in one single pass through a roller leveler combining both mill shape correction and flattening steps.

Another object is to provide still more traction between entry work rolls and material prior to both correcting and flattening steps than previously possible with the "double tilt" machines, by subjecting the material to waves of even transverse but gradually increasing amplitude in the pass direction at the entry side.

Another object is, in a roller leveler, to subject the material first to waves of transversely constant amplitude, gradually increasing in the direction of travel of the material from zero to a maximum amplitude in the entry tilt group of rolls, then to waves of transversely varying amplitude in the middle group of rolls to correct the mill shape of the material and finally in the exit tilt group of rolls to waves of transversely substantially constant amplitude gradually decreasing from a maximum to zero in the direction of movement of the strip material, for the purpose of flattening the material during the same pass through the roller leveler.

A further object is to provide apparatus of the type described above in a double tilt leveler.

A still further object is to provide a leveler which can level material in a single pass for correction and flattening, and which needs no readjustment for correction and flattening when the direction of operation is reversed.

Other objects and advantages of my invention will become apparent from a consideration of the following description and claims, taken together with the accompanying drawings.

In the drawings:

Fig. 1 is an elevational view of the front or control side of a roller leveler embodying the invention;

Fig. 2 is an elevational view of the roller leveler of Fig. 1, taken from the right-hand end as viewed in Fig. 1, with certain parts broken away;

Fig. 3 is a vertical cross-sectional view taken on the line III—III of Fig. 2, looking in the direction of the arrows;

Fig. 4 is a horizontal cross-sectional view taken on the line IV—IV of Fig. 2;

Fig. 5 is a fragmentary cross-sectional view on an enlarged scale taken on line V—V of Fig. 4;

Fig. 6 is a diagrammatic cross-sectional view through the center section of the upper and lower banks of rolls, taken as on the line VI—VI of Fig. 8, showing a convex deflection of the lower middle roll group;

Fig. 7 is a similar diagrammatic sectional view taken as on the line VII—VII of Fig. 8, showing the deflection of one of the side sections of the middle roll group;

Fig. 8 is a diagrammatic perspective view showing a sheet or strip passing through the leveler and being subjected to a convex deflection in the center section of the middle group of rolls;

Fig. 9 is a diagrammatic perspective view similar to Fig. 8, showing a strip subjected to a concave deflection in the center section of the middle group of rolls;

Fig. 10 is a diagrammatic cross-sectional view taken on the line X—X of Fig. 9;

Fig. 11 is a diagrammatic cross-sectional view on the line XI—XI of Fig. 9;

Fig. 12 is a diagrammatic perspective view similar to Figs. 8 and 9, showing a strip subjected to a convex deflection in a side section of the middle group of rolls;

Fig. 13 is a fragmentary cross-sectional view similar to Fig. 3, of a roller leveler embodying a modified form of the invention;

Fig. 14 is a diagrammatic perspective view of a sheet passing through the apparatus of Figs. 13, 16 and 17, with the center section of the entry group and the center section of the middle group both having convex deflections;

Fig. 15 is a diagrammatic sectional view on the line XV—XV of Fig. 14;

Fig. 16 is an elevational view similar to Fig. 2, of the modified form of apparatus shown in Fig. 13; and

Fig. 17 is an end-elevational view of the apparatus of Figs. 13 and 16, taken from the left-hand end as viewed in Fig. 16.

Referring to Figs. 1, 2, 3 and 4, the leveler comprises a base **20** on which are mounted a pair of front roll housings **21** and a pair of rear roll housings **22**. Each pair of roll housings is connected at the top by a cross piece **23**. Upper and lower rows or banks of straightening rolls extend the full width of the leveler between the roll housings **21** and **22**. The upper bank of straightening rolls are identified by the reference numerals **27**, **32**, **33**, **34** and **39**. The lower bank of straightening rolls are identified by the reference numerals **78** and **85**. The upper bank of supporting or backing up rolls are identified by the reference numerals **29**, **36** and **41**. The lower bank of supporting or backing up rolls are identified by the reference numerals **80** and **89** (Fig. 6). The drive ends (Fig. 2) of the straightening rolls have secured thereto universal couplings **25** and are driven by means of drive spindles **26** and a gear box, speed reducer and motor (not shown) as is well known in the art.

Double tilt of upper straightening rolls

The principle of the "double tilt" is described in my Patent No. 2,132,426, issued October 11, 1938. The upper bank of straightening and supporting rolls is divided into three groups. In the left-hand outer tilt roll group, as viewed in Fig. 1, straightening rolls **27** are journaled at their ends in front and rear bearing blocks **28** (Figs. 1, 6, 7) and supported by supporting rolls **29** carried in bearing blocks **30** (Figs. 3, 6, 7), the bearing blocks **28** and **30** being fastened to a wing **31**.

The straightening or work rolls **32**, **33** and **34** of the middle group are journaled at their ends in bearing blocks **35** (Fig. 1) and supported by supporting rolls **36** (Fig. 3) carried in bearing blocks **37**, the bearing blocks **35** and **37** being fastened to a center beam **38**.

In the right-hand outer tilt roll group, as viewed in Fig. 1, straightening rolls **39** are journaled at their ends in bearing blocks **40** and backed up by supporting rolls **41** (Figs. 3, 6, 7) carried in bearing blocks **42**, the bearing blocks **40** and **42** being fastened to a wing **43**. Three backing up rolls **41** are shown spaced along the longitudinal axis of each straightening roll. This particular number of backing up rolls was selected by way of example only, other numbers of rolls being entirely practical.

The center beam **38** is provided at each end with a cross head **44**, which is guided in the roll housings **21** and **22**. The two outer wings **31** and **43** which are tiltable around the center of the straightening rolls **32** and **34**, respectively, are provided at their ends with projections **45** resting on a bar **46** attached to the beam **38**. The contacting surface of projections **45** and bar **46** are concentric with the respective centers of tilting motion.

The straightening roll bearing blocks **28** and **40** of the wings **31** and **43** are positively guided around their respective tilt centers by inner and outer arcuate surfaces **47a**, **47b** which bear respectively against arcuate surfaces provided on the center straightening roll bearing block **35** and against the straight inner guide surfaces of the roll housings **21** and **22**. To tilt the wings **31** and **43** around the respective longitudinal axes of straightening rolls **32** and **34**, shafts **48**, one for each wing, are rotatably mounted in the front cross head **44** and in bearings

49 attached to the center beam 38 (Figs. 1 and 2). The shafts 48 have fixed thereon eccentrics 50, best seen in Fig. 3, which engage shoes 51 sliding in brackets 52 fastened to the top of each wing. A hand grip lever 53, fastened to each shaft 48, is provided with a swing handle 54 engaging notches in a segment 55 secured to the center beam 38. Movement of lever 53 towards or away from the center of the leveler causes the respective wing to tilt towards or away from the lower bank of straightening rolls. In other words, the work rolls mounted in the wing are set at an angle to the work rolls of the middle group which remain parallel to the lower bank of straightening rolls.

Height adjustment

The center beam 38, carrying the three groups of the upper roll bank, is suspended from a top bridge 58 by means of rigid but adjustable suspension rods 58*a*, so that the beam 38 and bridge 58 move as a unit. At each side of the leveler, a pair of lead screws 59 are journaled at one end in the tops of the cross heads 44 of the center beam 38, and at their opposite end in the top bridge 58. The screws 59 extend through and threadedly engage traveler nuts 60, which are fixed on the cross-pieces 23. Thus, the weight of the top bridge and the weight of the upper roll bank are transferred through nuts 60 to cross-pieces 23, and thence through housings 21 and 22 to base 20. Also, any upward force on the upper roll bank caused by work material passing between the upper and lower roll banks, is transferred through the nuts 60. The whole top structure may be raised or lowered by means of hand wheel 56 fastened to a shaft 57 rotatably mounted in the top bridge 58. Fixed on the upper end of each lead screw 59 is a worm gear 61 meshing with worms 62 and 63. Worm 62 is fixed on the rear portion of shaft 57 while worm 63 is mounted on a sleeve 64 encircling the front portion of shaft 57 and connected to a pin clutch 65 on hand wheel 56. By disengaging the pin clutch 65 and turning hand wheel 56, the drive for the front screws is cut out and the rear cross head 44 of the center beam 38 can be raised or lowered and thus the upper roll bank inclined towards the front or rear.

This height adjustment or screw-down may be effected manually as shown, or by power, such as an electric motor.

A pointer 66, freely mounted on a shaft 67 and actuated by a pin 68 secured to the front cross head 44, indicates the front height adjustment of the upper roll bank on a scale provided on the stationary cross-piece 23. A pointer 70, secured to the shaft 67, indicates the rear height adjustment of the upper roll bank on scale 69. A pin 71, mounted on the rear cross head 44, is pivotally connected to an arm on shaft 67, and translates its vertical movement to rotary movement of shaft 67.

Deflection adjustment

The lower bank of straightening and supporting rolls is divided in a novel manner into three groups 75, 76 and 77 (Fig. 7), the outer end groups 75 and 77 being stationary and the middle or center group 76 adjustable in height. Both the outer end groups include straightening rolls 78 journaled at their ends in bearing blocks 79. The rolls 78 are backed by supporting rolls 80 journaled in fixed bearing blocks 81 which are mounted on supporting members or beams 82 secured to base 20 by brackets 83 (Fig. 3). The straightening roll bearing blocks 79 are mounted on spacer brackets 84 (Figs. 1 and 2) which are fastened between the uprights of housings 21 and 22 to the base 20. The middle group 76 includes straightening rolls 85 journaled at their ends in bearing blocks 86 (Figs. 1 and 2) and adapted to rock around the center of pivot pins 87 (Figs. 2 and 4) which extend inwardly from the bearing blocks 79 of the two outer end groups 75 and 77. The bottom of each bearing block 86 is supported by a saddle 88 fixed on the upper part of a spacer

bracket 84. The straightening rolls 85 of the middle group are backed up by supporting rolls 89. Each roll 85 is backed up by a plurality of supporting rolls 89. The particular number of supporting rolls shown as spaced along the longitudinal axis of each work roll 85, by way of example, is three. Thus the work rolls 85 may be termed to be supported by three supporting or back up roll sections. The supporting rolls 89 as a matter of example are shown to have their axes of rotation in the same vertical plane as their respective working rolls 85. This is a matter of choice and these back-up rolls may also be arranged to nest their associated work rolls as shown for the upper work and supporting rolls 33 and 36, respectively. The back up rolls of each section are journaled in a pair of bearing blocks 90 (Figs. 4 and 5) which can be raised or lowered independently of the bearing blocks of the other sections in order to deflect the straightening rolls 85 of the middle group 76 into convex, concave, sinuous or other desirable contour. Each pair of supporting roll bearing blocks 90 is secured to a cradle 91, which seats in a saddle 92 and is positively guided therein for tilting or rocking by means of two side plates 93. Each plate 93 is provided with a tongue engaging a groove in the saddle 92. The radii of the seat of the saddle and cradle as well as the tongue and groove have one common pivot center which may be located at the point of contact between the supporting rolls 89 and the straightening rolls 85, as shown, or alternatively at the center of the rotational axis of supporting rolls 89.

Each individual saddle 92, carrying its associated cradle 91 with the bearing blocks 90 which support one section of the rolls 89 of the middle group 76, can be raised or lowered by a wedge 94, slidably engaging T slots provided respectively on the bottom of the saddle 92 and on the top of a block 95 fastened to the base 20. Each wedge has an internally threaded hole which receives a lead screw 96 (Fig. 3), journaled in a bearing block 97 and having attached to its opposite end a bevel gear 98 meshing with a bevel gear 99 fixed on a sleeve journaled in a bracket 100 attached to bearing block 97 (Figs. 3, 4, 5). Rotation of screw 96 causes wedge 94 to slide on block 95 and raises or lowers the saddle 92 and cradle 91, which are guided for vertical movement by machined surfaces on the inner side of beams 82. The adjustable back-up roll sections of the middle roll group 76 are thus also maintained against displacement in the direction of passage of the work material which is important in leveling sheets but still more so in the tension leveling of coiled material because of the considerable outside forces imposed on the roll sturcture by this method of operation. Each sleeve of bevel gears 99 is provided with jaws 99*a*, engaging a jaw clutch 101, slidably mounted on and keyed for rotation with a shaft 102, which is freely supported in the sleeves of bevel gears 99 and in the right-hand (as viewed in Fig. 1) upright of housing 21. The jaw clutches 101 are provided with a groove and may be shifted in or out of engagement by levers 103 engaging the grooves. Levers 103 are pivotally connected to shifter rods 104, which in turn are pivotally connected to hand levers 105 freely mounted on a pin 106 fastened to the side of the right-hand upright of front housing 21. Fastened to a shaft 107, journaled in the right-hand upright or housing 21, is a hand wheel 108 and a gear 109 meshing with a gear 110 secured to shaft 102 for operating the deflection mechanism.

The exact height adjustment of each supporting roll section is indicated by pointers 111 on a scale 112 fastened to a housing 113, which is secured to the spacer bracket 84. The wedge 94 of each roll section has a rack 114 meshing with a pinion 115 fastened to a shaft 116 journaled in the block 95 and housing 113. Shafts 116 transmit their motion through individual chain drives 117 to the respective pointers. Each of the three pointers shown indicates the deflection position of the respective back-up roll section. The taper on the wedges 94 and the lead of the thread on screws **96** may be so chosen that, when all clutches **101** are engaged and hand wheel **108** is turned clockwise, the three supporting roll sections **89** of the middle group **76** are raised different amounts so that the straightening rolls **85** of that group are positively deflected into a predetermined upwardly convex contour. When the hand wheel **108** is turned counterclockwise, the three supporting roll sections **89** of the middle group **76** are lowered different amounts, and as material is passed through the leveler, the straightening rolls **85** are deflected by the material into an upwardly concave contour, predetermined by the adjusted height position of each support roll section.

Operation of leveler

The upper roll bank, consisting of two outer tilt groups and one middle group of straightening rolls and their associated supporting rolls, is regulated in height for obtaining roll passes, i.e., spacing between upper and lower straightening rolls, of the desired magnitude, corresponding to the thickness of the material being treated, either uniformly by rotating hand wheel **56** with pin clutch **65** in engagement, causing all four height adjusting screws **59** to rotate, or longitudinally inclined by disengaging pin clutch **65** and thus keeping the two front screws **59** stationary.

The two outer tilt roll groups of the upper bank (double tilt) are tilted into any desired position by hand levers **54**. This adjustment will depend on the effect to be produced on the work material. When the tilt setting of the two outer tilt roll groups is identical, the same leveling effect will be obtained whether the work material is passed through the leveler from left to right or vice-versa.

If the work material requires correction, i.e., longitudinal stretching of one or more portions across the width of the sheet with respect to another portion, the straightening rolls **85** of the lower middle roll group **76** are deflected into the necessary contour by manipulating clutch levers **105** and turning hand wheel **108** which form part of the dsecribed adjustable supporting means. Figures 6, 7 and 8 show diagrammatically a correction adjustment of the lower middle work roll group **76** for stretching the center portion of the sheet or strip, while Figures 9, 10 and 11 similarly show a correction adjustment for stretching both edge portions of the material. Fig. 12 shows the straightening rolls **85** of the lower middle roll group **76** deflected to stretch an area located intermediate between the center and one outer edge of the sheet or strip. The novel leveler shown in Figs. 1 to 12 is characterized in that the end groups **75, 77** of the lower bank of work rolls are maintained in substantially straight, non-deflected positions by their respective fixed supporting means for subjecting the work material to waves of constant or fixed amplitude across its width, while the center group of work rolls **76** alone is deflectable by means of the adjustable supporting means for subjecting the work material to waves of varying amplitude across its width, described in detail previously.

By adjusting the leveler for any correction and flattening pass as shown in Figures 6 to 12, the sheet material is received and subjected first in between the lower and upper entry work roll groups to waves which individually are of fixed amplitude across the entire width of the sheet, but whose amplitude gradually increases from zero to a maximum depth as the sheet moves through the entry roll groups. These waves provide maximum traction between work rolls and material and eliminate entry marks on the material. Then in the middle work roll groups the sheets are subjected to waves of amplitude varying across the width of the sheet but remaining constant as the sheet moves through the middle group. These waves in the middle group correct the mill shape of the material. Finally when leaving, the material is subjected between the exit work roll groups to waves of fixed amplitude across the width of the sheet, but gradually diminishing from a maximum amplitude to zero at the end of the exit groups. These last waves provide a final flattening of the material and remove any residual internal stresses still left in the work material and caused by the correction of the mill shape between the deflected work rolls of the middle group.

The upper supporting or backing up rolls for each straightening roll may be divided into three sections, as best seen in Fig. 2. All three of the support roll sections may always move vertically together with their associated work rolls, so that each upper straightening roll is always substantially straight throughout its length. The reason for employing a plurality of supporting roll sections spaced along the longitudinal axes of the work rolls is to provide a large number of support roll bearings for absorbing the work load and to unyieldably support the straightening rolls along their entire length.

I have chosen, as an example, to show the upper straightening rolls straight and non-deflectable. The lower half-waves to which material is subjected in the machine by the upper work rolls are therefore shown as always having a constant transverse amplitude throughout the width of the material. The upper half-waves, whose contours are determined by the lower straightening rolls, are the only ones which are shown as varying in amplitude across the width of the material. It would be possible to construct an arrangement in which the deflection of the material by the upper rolls also varied in amplitude across the material. It will be readily understood that it would be equally easy to construct a machine in which only the lower half-waves varied in amplitude, i.e., one in which the upper rolls take over the function of the lower rolls in the machine illustrated and the lower rolls correspondingly take over the function of the present upper rolls.

Figs. 13 to 17

Those parts of the modification illustrated in these figures which correspond to their counterparts in the form described above, have been given primed reference numerals similar to the reference numerals applied to those counterparts, and will not be further described in detail.

Individual roll group deflection

In the modification illustrated in Figs. 13, 14 and 15, the lower bank of straightening and supporting rolls is divided into three groups **75′**, **76′** and **77′**, each group of supporting rolls being adjustable in height independent of each other.

This arrangement permits deflection of the lower entry work roll group **77′** (Figs. 14, 15) so that it may cooperate with the upper tilted entry work roll group to subject the material to waves of amplitude varying across the width of the sheet and increasing gradually in the direction of travel of the sheet from zero to a maximum. The lower entry work roll group thus coperates with the deflected lower middle work roll group **76′** and aids the latter in correcting the mill shape of the material when the effect of additional rolls is required for especially severe correction passes. The center group of rolls alone may in some such cases prove insufficient to cope with the existing mill shape. The lower exit work roll groups **75′** is kept in stratight alignment and cooperates with the upper tilted exit work roll group to subject the material to waves of constant transverse amplitude decreasing in the direction of travel of the sheet from a maximum to zero for flattening the material as previously described.

The straightening rolls **78′** of the outer groups **75′** and **77′** are journaled at their ends in bearing blocks **79′** and are backed up by sectionalized supporting rolls **80′** rotatably mounted in bearing blocks **81′** which are fastened to cradles **120**. The cradles seat in saddles **121** and are positively guided therein for tilting by side plates **122**, each side plate being provided with a tongue engaging a groove in saddle **121**. The cradles and saddles are similar to the structure described above for supporting the rolls 89 of the middle group of the construction shown in Figs. 1 to 12. Each saddle 121 of the individual outer support roll sections may be raised or lowered by a lead screw 122' rotatably mounted therein and threaded in a nut 123 fastened to the base 20'. Located along each outer roll group is a shaft 124, rotatably supported in bearings 125 secured to base 20'. Rotatably mounted on each shaft 124 are a plurality of worms 127, one for each section of the rolls 80', connectable to shaft 124 by jaw clutches 135 similar to the clutches 101 of Fig. 4. Each worm 127 cooperates with a helical gear 126, which is keyed to a lead screw 122' for rotation with it. A hand wheel 137 may be provided at the front of the machine to raise or lower each individual entry support roll section. These sections may be operated separately or concurrently, as determined by the operation of the clutches. The ratio of the worm gearing and the lead of the screws 122' is so chosen that rotation of shaft 124 in one direction and with all jaw clutches engaging worms 127, all supporting roll sections of the lower entry roll group are raised different amounts to deflect the associated straightening rolls into a convex contour. Rotation of shaft 124 in the opposite direction lowers the support roll sections in a similar manner and when material is passed between the upper and lower work rolls, they are deflected into a concave contour. By engaging, for instance, only one clutch and controlling the deflection of the straightening rolls near one side of the sheet as shown for the middle roll group in Fig. 12, the lower entry straightening roll group may be similarly deflected. In cooperation with the upper tilted straightening rolls 39' they will then subject the sheet to waves whose amplitude varies across the width of the sheet and increases from zero to a predetermined maximum in the direction of travel of the sheet.

Deflection of the middle group of straightening rolls 86 may be accomplished by the wedge construction shown in Figs. 1 to 4 or by means of screws illustrated in Fig. 13.

The cradles 91' of the middle work group 76', carrying the support roll bearing blocks 90' are seated in saddles 128 and positively guided therein for tilting by means of side plates 129, each plate being provided with a tongue engaging a groove in saddle 128. The radii of the seat of the saddle 128 and cradle 91', as well as the tongue and groove, have one common center which may be located at the point of contact between the supporting rolls 89' and the straightening rolls 85'. Each saddle 128 is raised or lowered by two screws 130 rotatably mounted therein and threaded in nuts 131 fastened to the base 20'. Secured to each screw 130 is a worm or helical gear 132 meshing with a worm 133 which is operatively connected to a centrally located shaft 134 by means of a jaw clutch similar to jaw clutches 135 already described in connection with the outer roll groups 75' and 77'. Shaft 134 may be rotated by a centrally located hand wheel 137 and the straightening rolls of the middle group deflected into various contours as described before.

The arrangement described permits also operation as illustrated in Figs. 1 to 12 by deflecting the middle roll group 76' only. Inasmuch as separate deflection means are provided for the lower entry, center and exit work roll groups, transverse waves of different magnitude may be selected for each group.

Three sets of indicating and control mechanisms, generally indicated by the reference numeral 136, are provided, for each deflection adjusting apparatus of the three groups of supporting rolls of the lower bank, i.e., the entry, middle, and exit groups. Since these indicating and control mechanisms are substantially identical, only one of them will be described in detail.

Each drive shaft, i.e., the shafts 124 of the entry and exit groups and the shaft 134 of the middle group, is operated by a hand wheel 137 through suitable gearing 138. The deflection adjustment mechanism of each group includes three jaw clutches 135, shown in Fig. 16 for the right-hand group of Fig. 17. Each jaw clutch is operated by a push rod 139 which extends to the front of the machine and is provided on its end with a knob 140. The operation of the hand wheel 137 and the push rods 140 is generally the same as the operation of the hand wheel 108 and the end levers 105 in the modification of Figs. 1 to 5.

The indicating mechanism for the deflection adjustment apparatus of each group of rolls comprises a shaft 141 for each section of the group, making a total of three shafts 141 for each of the three groups. Each shaft 141 is geared to a sleeve which carries one of the worms 127 or 133 and extends therefrom toward the front of the machine. The front end of each shaft 141 is connected by suitable mechanism such as a chain drive 142 schematically indicated in Figs. 16 and 17 to mechanism for driving one of three pointers 143 which cooperate with a scale 144.

The indicating and control mechanism 136 for each group of rolls is substantially the equivalent of the indicating and control mechanism provided for the middle group of rolls in Figs. 1 to 5.

General

In order to obtain efficiency in leveling, I have described my new method of deflecting work rolls in connection with a double tilt leveler. It should be understood, that my invention is not limited to the use of a double tilt leveler, but may also be utilized to advantage in connection with a single tilt leveler.

To modify a single tilt leveler of the prior art, the upper and/or lower work and support rolls may be divided into three groups and supported for independent vertical adjustment, just as the three lower work roll groups are supported in the double tilt leveler shown. Deflecting the middle group of upper and/or lower work rolls, or the middle and entry groups of work rolls in a single tilt leveler would greatly increase the efficiency of that leveler.

While I have selected to show three support or backup sections for both upper and lower work rolls, other numbers of such sections may be employed, depending on roll diameter, roll length, gauge of material and operating speed desired.

Various other changes and modifications will be obvious to those skilled in the art and I desire, therefore, that only such limitations shall be placed upon my invention as specifically set forth in the following claims.

I claim:

1. A backed-up roller leveler comprising two banks of cooperating work rolls located in staggered relation one with respect to the other, the first work roll bank being divided into entry and exit outer tilt roll groups and a middle roll group; means for tilting said entry and exit outer tilt roll groups with respect to said middle roll group, said outer tilt roll groups being tiltable around the centers of their respective adjacent work rolls of said middle roll group to subject the entering material by the entry outer tilt roll group to half-waves of substantially constant transverse amplitude gradually increasing to a maximum and to subject the material leaving the leveler by the exit tilt roll group to half-waves of substantially constant transverse amplitude gradually decreasing from said maximum to a minimum, while maintaining said half-waves of constant amplitude at a maximum during the passage of the material through said middle roll group; the second bank of work rolls being divided into an entry group, a center group and an exit group of work rolls, means for deflecting the work rolls of said last recited entry group to subject the entering material to a succession of transverse half-waves having amplitudes varying across the width of the material for gradually increasing the correction effect on the material between the entry outer tilt roll group of said first and the entry group of said second banks of work rolls; other inde-

pendent means for deflecting said center group of work rolls to subject the material to a plurality of transverse half-waves having more pronounced amplitudes varying across the width of the material than said first mentioned succession of half-waves for maximum correction effect on the material between the middle roll group of said first bank and the center group of work rolls of said second bank of work rolls; still further means adapted to deflect the exit group of work rolls of said second work roll bank for subjecting the material to a final succession of transverse half-waves having less pronounced amplitudes varying across the width of the material than said plurality of half-waves produced by said center group of work rolls, for flattening the work material between said exit outer tilt roll group of said first roll bank and the exit roll group of said second roll bank.

2. A back-up roller leveler as defined in claim 1 including bearing elements for rotatably sustaining the ends of the work rolls of the center group of said second roll bank, said other independent means comprising a plurality of adjustable supporting roll sections located along the longitudinal axes of said center group for the deflection of the latter, pivoting means for said bearing elements and other pivoting means for said adjustable supporting roll sections, whereby said bearing elements and said adjustable supporting roll sections are adapted to rock when said center group of work rolls is being deflected.

References Cited in the file of this patent

UNITED STATES PATENTS

236,853	Somers	Jan. 18, 1881
1,582,571	Budd	Apr. 27, 1926
2,049,142	Ungerer	July 28, 1936
2,091,789	Maussnest	Aug. 31, 1937
2,132,426	Maussnest	Oct. 11, 1938
2,365,114	Shields	Dec. 12, 1944
2,638,143	Maust	May 12, 1953

FOREIGN PATENTS

296,441	Germany	Feb. 12, 1917
642,790	Germany	Mar. 18, 1937
490,908	Great Britain	Aug. 23, 1938