July 4, 1950 G. H. FARRINGTON 2,513,927

WEB GUIDING APPARATUS

Filed Oct. 18, 1944 3 Sheets-Sheet 1

Fig. 1

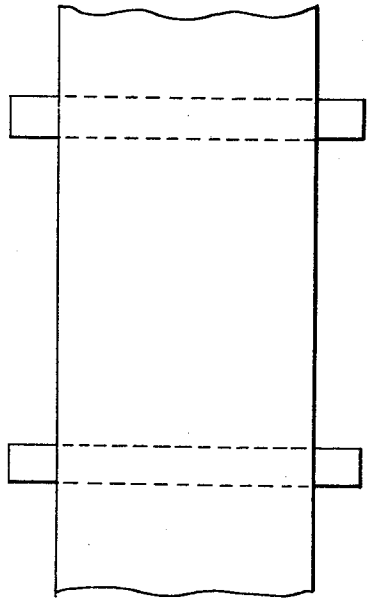
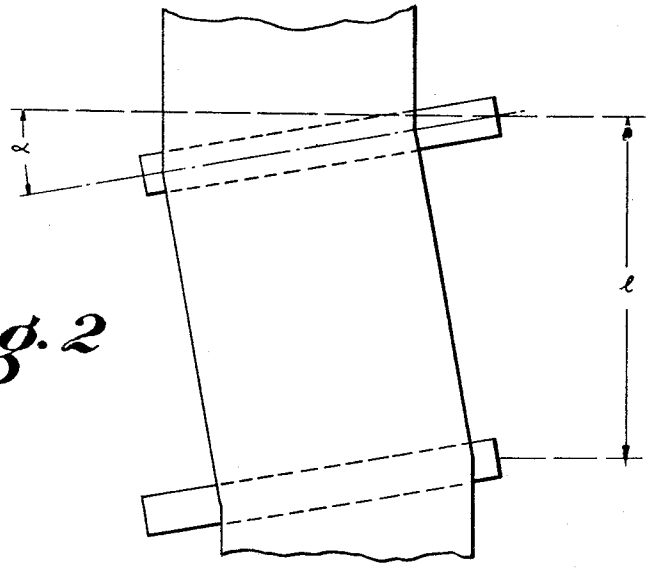


Fig. 2



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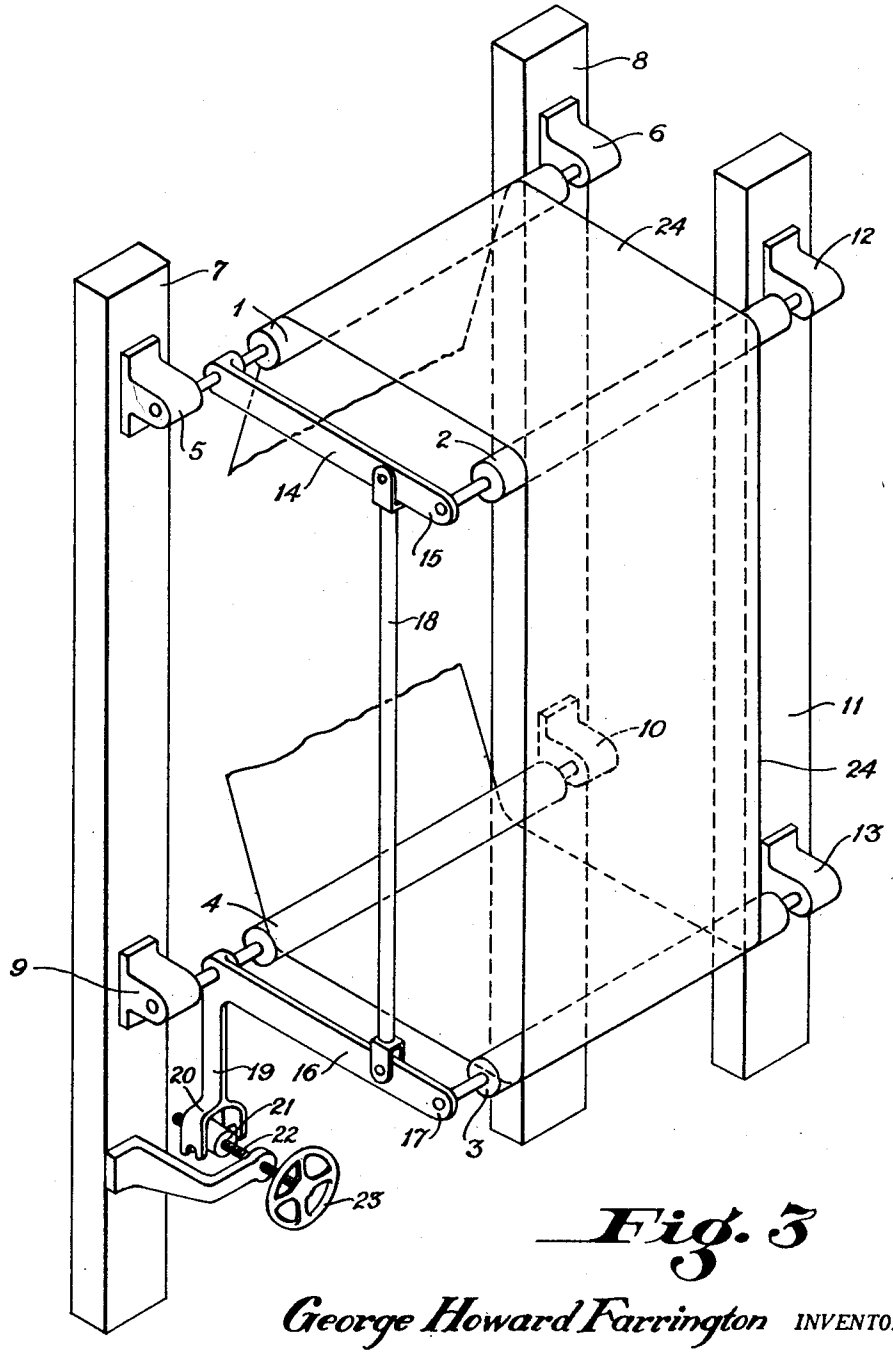


Fig. 3

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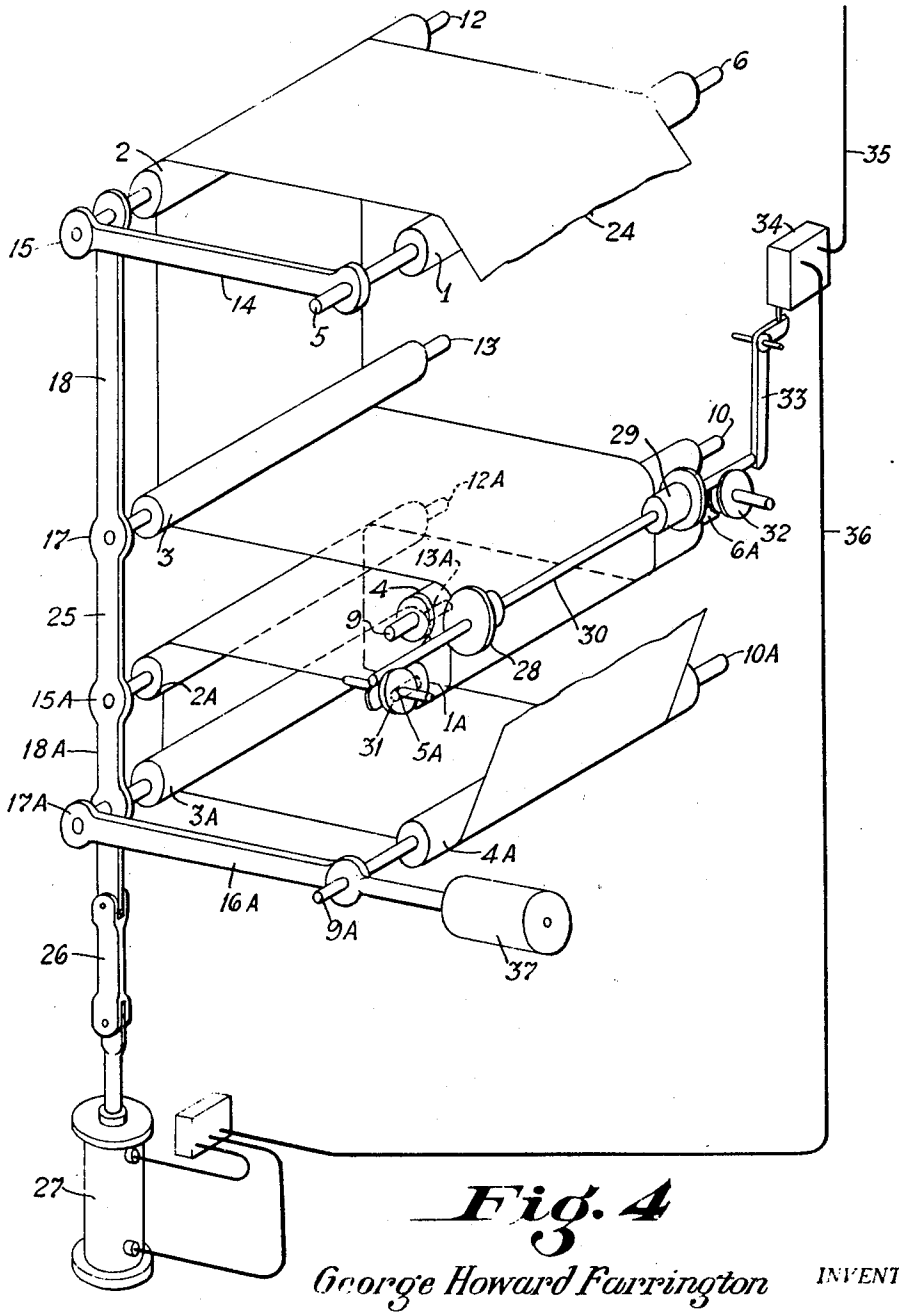


Fig. 4

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WEB GUIDING APPARATUS

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6 Claims. (Cl. 271—2.6)

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This invention relates to apparatus for guiding travelling webs of material.

It is well known in the handling of long webs of material such as film, paper or fabric in which the web is drawn over rollers from one position to another, that there is a tendency for the web to make lateral movements to and fro on the rollers and so run out of true. Thus, where some processing operation is to be effected on the travelling web, e. g. the application of a coating or the printing of a design, such processing operation is not uniformly applied to the web. Moreover, the winding up of the web results in an uneven roll of material, which is undesirable.

A method which has been suggested for overcoming the difficulty is to pass the web over a roller which can be inclined at an angle to its normal position. The web tends to move along the inclined roller and the method employed is to attempt to correct successive divergences of the web from its true path by variably inclining such roller. This method is, however, most unsatisfactory since the desired correction is applied only very slowly and the apparatus takes some time to reach any sort of equilibrium. Moreover, it is not possible to compute accurately in advance how great an inclination of the roller would be required for any particular divergence of the web from its true path, though after considerable experience under relatively stable conditions a reasonable guess can sometimes be made.

The present invention is concerned with web-guiding apparatus which reacts quickly, quickly reaches equilibrium, and overcomes the difficulties referred to above.

According to this invention, apparatus for correcting the lateral divergence of a travelling web of material from its true path comprises essentially a pair of parallel cylindrical rollers over which the web is constrained to pass and means for moving the said rollers in sympathy with one another from a normal position in which their axes are at right angles to the direction of track of the web between them to enter angular positions, the movement being such that the axes of the said rollers always remain substantially parallel to one another and such that the length of the total track of the web is substantially unaltered.

When the rollers are moved, as described above, from their normal position, the web is immediately constrained to take up a fresh position, in which the track between the two rollers is

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once more at right angles to them. In this way the desired transverse displacement of the web is effected. The effect, exaggerated, is diagrammatically illustrated in Figures 1 and 2 of the accompanying drawings. In Figure 1 the web is shown in its normal passage over the rollers, whilst in Figure 2 the new track of the film resultant on the inclination of the rollers is shown.

It is possible to calculate in advance the extent of the inclination of the rollers necessary to apply the required correction for any divergence of the web from its true path, the correction being $l \tan \alpha$ where l is the length of the track between the two rollers and α the angle of inclination of the rollers (see Figure 2). There is no tendency for the position of the web to be "over-corrected" since the inclination of the rollers causes a definite and limited movement of the web. Moreover, the system very rapidly reaches equilibrium conditions.

Although the nature of the invention has been described above with particular reference to the use of a pair of parallel cylindrical rollers, it will be appreciated that fundamentally the apparatus may consist of any two elements having parallel bearing surfaces over which the web is constrained to pass, such surfaces being inclinable as above defined. Thus, instead of cylindrical rollers there may be used non-rotatable cylindrical rods, or fixed slats or bars of any kind having a straight-line bearing surface.

In its simplest form the apparatus consists merely of two rollers and means for controlling their inclination in sympathy as defined above. In practice, however, there may be provided two further rollers so that the guiding unit consists of a train of four consecutive cylindrical rollers in which the first and fourth are freely mounted rollers in fixed bearings, and the second and third are the rollers of variable inclination as defined above. To secure the best results from the point of view of keeping the track constant, the first and second rollers in such a unit should be of the same diameter, and the third and fourth rollers be of the same diameter (though not necessarily the same diameter as the first and second rollers).

While it is possible to construct a system which, from the point of view of maintaining the length of the track of the web substantially unaffected by the movement of the inclinable rollers, is virtually geometrically correct, for most practical purposes this is not necessary. One form of the apparatus comprises a support frame

carrying the four rollers each mounted in bearings at both ends and extending to one side of the frame, the bearings at one end of each of said rollers being fixed in relation to the frame and lying at the corners of a rectangle, the bearings at the other ends of said rollers being constrained to lie at the corners of a parallelogram, the bearings at the ends of the first and fourth rollers only being fixed in relation to the frame, and means for adjusting the shape of said parallelogram about an intermediate rectangular form in which the four rollers are parallel. With such apparatus the web may be made to pass round the outside of the four rollers or round the inside of the first and fourth rollers, and round the outside of the second and third rollers.

An alternative but similar form of the apparatus is that in which, instead of the first and fourth rollers lying to one side of the second and third rollers, one of them lies to one side and the other of them to the other side, the web then taking a course in which it makes a right angle turn (or substantially so) at the second roller, and a right angle turn (or substantially so) in the opposite direction at the third roller, so that its travel to the fourth roller is in the same general direction as its travel from the first to the second roller.

The variation in the angle of inclination of the rollers of variable inclination, which form the essence of this invention, may be effected by any convenient means. Most conveniently, the variation may be effected by means of parallel radius arms the ends of which hold the bearings at one end of the inclinable rollers and which are mounted for movement about centres such that they remain parallel to one another throughout their movement, and their ends (carrying the roller bearings) move through similar arcs. Thus, where the four rollers are arranged as set forth above so that the bearings at one end lie at the corners of a rectangle and the bearings of the other end are constrained to lie at the corners of a parallelogram, there may be provided a first link pivotally mounted on the axis of the first roller extending at right angles thereto and carrying a bearing for the second roller, a second link pivotally mounted on the axis of the fourth roller extending at right angles thereto and carrying a bearing for the third roller, and a third link pivotally attached to corresponding points on said first and second links. With this arrangement the links define the shape of the parallelogram and such shape may be altered by moving the links on their pivots, the first and second links being radius arms as defined above.

The movement of the inclinable rollers may be effected manually if desired, the operator watching the web (or an indicator connected therewith) for any divergence from the true path and correcting any such divergence by a manually controlled movement of the inclinable rollers.

Alternatively, automatic control may be provided, means operated by the divergence of the web being made to cause an inclination of the rollers, such means being located immediately following the said rollers. However, as is well-known, simple automatic control of the so-called "proportional" type suffers from the defect that a correction can only be obtained at the expense of a departure from the set-point of the control apparatus. Where a sustained correction is necessary, there will be accordingly, therefore, a

sustained departure from the set-point. The magnitude of this departure depends on the so-called "sensitivity" of the apparatus; i. e. the ratio of the potential correction to the divergence of the variable from which it arises. Therefore, to keep the departure small, control apparatus of relatively high sensitivity is needed, but this is often not a solution to the difficulty as such apparatus is prone to go into self-oscillation, so-called "hunting."

A method of overcoming this difficulty in using the present apparatus with automatic control, is to employ in close succession, two guiding units in accordance with the present invention, the sensitive element which registers the divergence of the web from its true path being located between such units, and the control device being arranged to cause a simultaneous inclination of the rollers in the two units. In this way it is arranged that part of the correction is effected by the first unit and the remainder by the second unit. By so proportioning the track of the web between the second pair of inclinable rollers to that between the first pair of inclinable rollers, or alternatively by proportioning the relative roller inclination of the two units, the correction provided by the second unit can be made to be the remainder of the required correction and the resulting path of the web is thus brought to the required set-point. This is made possible by the fact that the remainder is always a certain fraction of the required correction, this fraction being

$$\frac{1}{1+S}$$

where S is the sensitivity of the control apparatus as defined above.

Although such an arrangement can be proportioned to give the required correction under equilibrium conditions for any sensitivity, it is clear that under changing conditions the second unit will apply improper correction to the web passing over it. For this reason it is desirable that the correction provided by the second unit should be kept as small as possible. This involves selecting the highest control apparatus sensitivity which the avoidance of "hunting" will permit.

If desired, an endless conveyor band may be provided passing round the two inclinable rollers of each guiding unit employed, the movement of the band along the rollers, consequent on any inclination of the rollers, causing a corresponding movement of the travelling web.

The invention will now be described with reference to the accompanying drawings which illustrate two forms of apparatus according to the invention. In these drawings:

Figs. 1 and 2 illustrate diagrammatically the principle underlying the invention, and these have been discussed above.

Fig. 3 illustrates in perspective a single-unit apparatus, adapted for manual control.

Fig. 4 illustrates in perspective a double-unit apparatus, adapted for automatic control.

Referring to Figure 3, a roller 1 is rotatably mounted in fixed bearings 5 and 6 carried on fixed supports 7 and 8. A roller 4 of similar dimensions is rotatably mounted in fixed bearings 9 and 10 on the same supports 7 and 8 and disposed so as to be parallel to the roller 1. Rollers 2 and 3 of similar dimensions are mounted on a support 11 by self-aligning bearings 12 and 13 on one end of each. A link 14 pivotally mounted

on the axis of the roller 1 extends to the roller 2 and carries a second self-aligning bearing 15 for the roller 2. A similar link 16 pivotally mounted on the axis of the roller 4 extends towards the roller 3 and carries a second self-aligning bearing 17 for the roller 3. A link 18 is pivotally attached to the links 14 and 16 at points equidistant from the axes of the rollers 1 and 4. The link 16 carries an arm 19, the arm 19 and link 16 forming a bell crank lever with its pivot on the axis of the roller 4. The arm 19 terminates in a fork 20 mounted on a nut 21 threaded on a screw shaft 22. The shaft 22 is provided with an operating handle 23. As shown the web 24 passes round the outside of the rollers 1, 2, 3 and 4 making a right angle turn at the rollers 2 and 3.

In use, the operative in control of the device watches (either directly or on a suitable indicator) the divergence of the web from its true path. When a divergence occurs he screws the shaft 22 in or out and thus causes the arm 19 and link 16 to pivot, thus raising or lowering the link 18 and causing the bearings 15 and 17 to move up or down, thus causing the rollers 2 and 3 to be varied in inclination in sympathy with one another. Movement of the bearings 15 and 17 downwards sets up a diagonal tension across the web 24 lying between the rollers 2 and 3 and causes the web to move along those rollers to a new position (dictated by the amount of the inclination of the rollers 2 or 3) nearer to the bearing 13. Similarly, movement of the bearings 15 and 17 upwards causes a movement of the web 24 along the rollers 2 and 3 nearer to the bearing 17.

Referring to Figure 4, the apparatus comprises two guiding units each of the same general type as that illustrated in Figure 3. For the sake of simplicity the supporting frame work has been omitted from the drawing. The apparatus comprises four rollers 1, 2, 3 and 4 disposed as in Figure 3, fixed bearings as in Figure 3 being provided at 5, 6, 9, 10, 12 and 13, and four similar rollers 1A, 2A, 3A and 4A disposed as in Figure 3 and being provided with fixed bearings 5A, 6A, 9A, 10A, 12A and 13A. For simplicity the actual bearings have been omitted from the drawing, and these reference numerals indicate their position. A link 14 pivotally mounted on the axis of the roller 1 carries a bearing 15 for the roller 2, and a link 18 connecting therewith carries a bearing 17 for the roller 3. Similarly, a link 16A pivotally mounted on the axis of the roller 4A carries a bearing 17A for the roller 3A, and a link 18A connecting therewith carries a bearing 15A for the roller 2A. Whereas in Figure 3 a link is provided pivotally mounted on the axis of roller 4 and carrying a bearing for roller 3, this link is omitted from the first unit of the apparatus of Figure 4 and no corresponding link is provided in the second unit. Instead a link 25 is provided directly connecting the bearings 17 and 15A. Attached to the link 16A at the bearing 17A is a system of links 26 connected to a power cylinder 27. All the connections between the links are pivotal.

Between the rollers 4 and 1A there is provided a device for registering the lateral divergence of the web from its true path. This device is made as light as possible and consists of a pair of flanged rollers 28 and 29 arranged to make contact with the edges of the web 24, these flanged rollers being carried on a shaft 30 mounted for reciprocating movement on two grooved wheels 31 and 32. At one end of the shaft 30 is provided a bell crank lever 33 arranged to operate a pressure control device 34 having a linear response. This control device is fed with air from a main supply through a line 35. The control line pressure is transmitted through a line 36 to the power cylinder 27. A counter-balance weight 37 is provided on the lever 16A to reduce the amount of work necessary by the power cylinder 27 in operating the link work.

In operation, the flanged wheels 28 and 29 move in sympathy with any divergence of the web from its true path and thus cause the shaft 30 to move laterally to the same extent as dictated by the divergence. Such movement causes the lever 33 to pivot and thus causes a change in the control line pressure from the device 34. This, transmitted through the line 36 causes a movement of the piston in the power cylinder 27, and thus causes the link 26 to move up or down (according to the direction of the initial divergence) and therefore causes the bearings 15, 17, 15A and 17A to move up or down, with a resulting change in the inclination, in sympathy, of the rollers 2, 3, 2A and 3A.

By careful design of the apparatus and control devices it may be arranged that for any divergence of the web from its true path the inclinable rollers are caused to incline to an extent which is just sufficient to correct such divergence.

What I claim is:

1. Apparatus for correcting the lateral divergence of a travelling web of material from its true path which comprises first, second, third and fourth cylindrical rollers each mounted in bearings at both ends, the bearings at one end of each of said rollers lying at the successive corners of a rectangle, the bearings at the other ends of said rollers being constrained to lie at the succesive corners of a parallelogram, the bearings at both ends of the first and fourth rollers being fixed in position, the bearings at one, common, end only of the second and third rollers being fixed in position, the first and second rollers being of the same diameter and the third and fourth rollers being of the same diameter, and means for adjusting the shape of said parallelogram about an intermediate rectangular form in which the four rollers lie parallel to one another.

2. Apparatus for correcting the lateral divergence of a travelling web of material from its true path which comprises first, second, third and fourth cylindrical rollers each mounted in bearings at both ends, the bearings at one end of each of said rollers lying at the successive corners of a rectangle, the bearings at the other ends of said rollers being constrained to lie at the successive corners of a parallelogram, the bearings at both ends of the first and fourth rollers being fixed in position, the bearings at one, common, end only of the second and third rollers being fixed in position, the first and second rollers being of the same diameter and the third and fourth rollers being of the same diameter, and parallel radius arms the ends of which hold the bearings at the other ends of said second and third rollers and which are mounted for movement about centres such that they remain parallel to one another throughout their movement and their ends, carrying the said bearings, move through similar arcs, whereby, by movement of said radius arms, the shape of the said parallelogram may be varied about an intermediate rectangular form in which the four rollers lie parallel to one another.

3. Apparatus for correcting the lateral di-

vergence of a travelling web of material from its true path which comprises first, second, third and fourth cylindrical rollers each mounted in bearings at both ends, the bearings at one end of each of said rollers lying at the successive corners of a rectangle, the bearings at the other ends of said rollers being constrained to lie at the successive corners of a parallelogram, the bearings at both ends of the first and fourth rollers being fixed in position, the bearings at one, common, end only of the second and third rollers being fixed in position, the first and second rollers being of the same diameter and the third and fourth rollers being of the same diameter, a first link pivotally mounted on the axis of the first roller extending at right angles thereto and carrying a bearing for the other end of said second roller, a second link pivotally mounted on the axis of said fourth roller extending at right angles thereto and carrying a bearing for the said third roller, a third link pivotally attached to corresponding points on said first and second links, said links defining the shape of said parallelogram, and means for moving said links on their pivots to alter the shape of the said parallelogram about an intermediate rectangular form in which the four rollers lie parallel to one another.

4. Apparatus for correcting the lateral divergence of a travelling web of material from its true path which comprises two correcting units each of which consists of first, second, third and fourth cylindrical rollers each mounted in bearings at both ends, the bearings at one end of each of said rollers lying at the successive corners of a rectangle, the bearings at the other ends of said rollers being constrained to lie at the successive corners of a parallelogram, the bearings at both ends of the first and fourth rollers being fixed, the bearings at one, common, end only of the second and third rollers being fixed, the first and second rollers being of the same diameter and the third and fourth rollers being of the same diameter, a first link pivotally mounted on the axis of the first roller of the first corrective unit extending at right angles thereto and carrying a bearing for the other end of said second roller of said first unit, a second link pivotally mounted on the axis of said fourth roller of the second corrective unit extending at right angles thereto and carrying a bearing for the said third roller of said second unit, a third link pivotally mounted on the shafts of the second and third rollers of the said first unit and

the second and third rollers of the second unit, said links defining the shape of said parallelogram in each unit, and means for moving said links on their pivots to alter the shape of the said parallelogram in each unit about an intermediate rectangular form in which the four rollers in each unit lie parallel to one another and, located between the said units, a device responsive to the divergence of the web from its true path and adapted to apply to said links a movement about their pivots tending to incline the second and third rollers in each such unit to correct the said divergence.

5. Apparatus according to claim 4 wherein the distance apart of the second and third rollers in the second unit is substantially less than the distance apart of the second and third rollers in the first unit.

6. Apparatus for correcting the lateral divergence of a travelling web of material from its normal path comprising four rollers which have their guiding surfaces disposed in substantially parallel planes and form a substantially rectangular path for said web, the shaft ends of the first and last of such rollers being freely mounted in fixed bearings, the two intermediate rollers having their shaft ends on the same one end of each freely mounted in a fixed bearing and the other shaft end of each being freely mounted in a bearing which is movable through a small arc, said latter shaft ends being maintained in a parallelogram relation by means of a link joining them and being further respectively linked by an arm to the shaft end of the first and last roller respectively, and means for adjustably moving said link whereby the guiding surfaces of the second and third rollers remain parallel to one another and the total length of the path of the web from the first to the last roller remains unaltered by such movement.

GEORGE HOWARD FARRINGTON.

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