May 28, 1929. J. G. CALLAN 1,714,846

METHOD AND APPARATUS FOR STEERING BELTS

Original Filed May 15. 1922 5 Sheets-Sheet 1

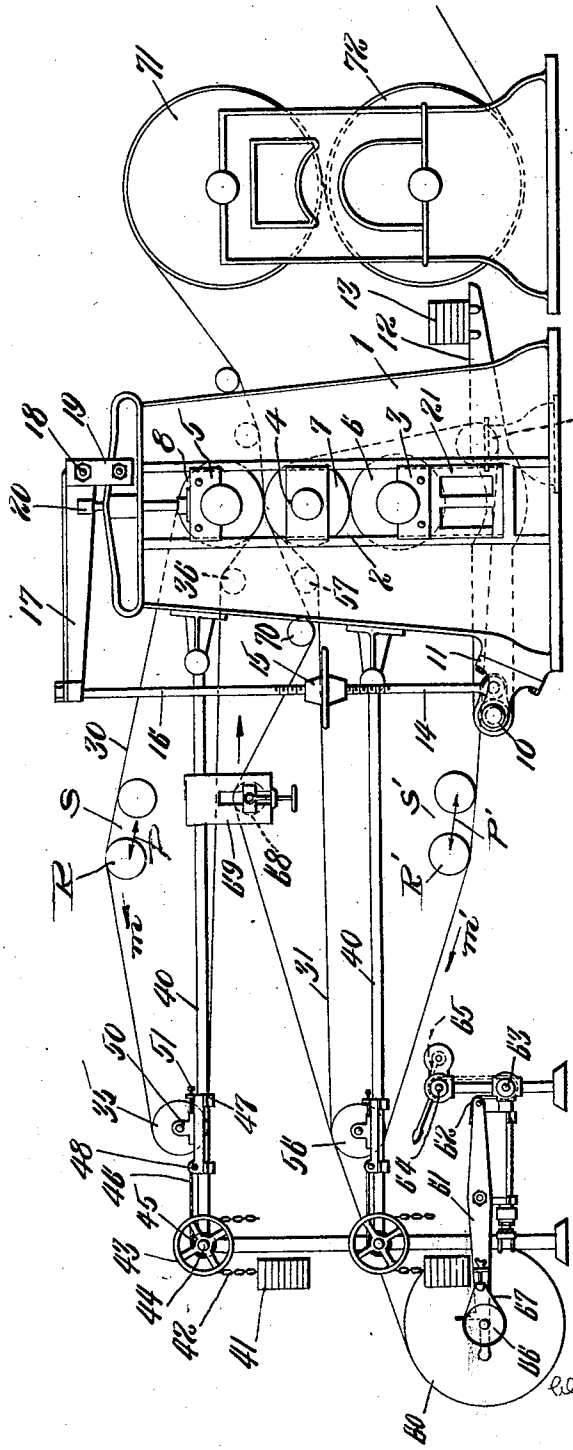


Fig. 1.

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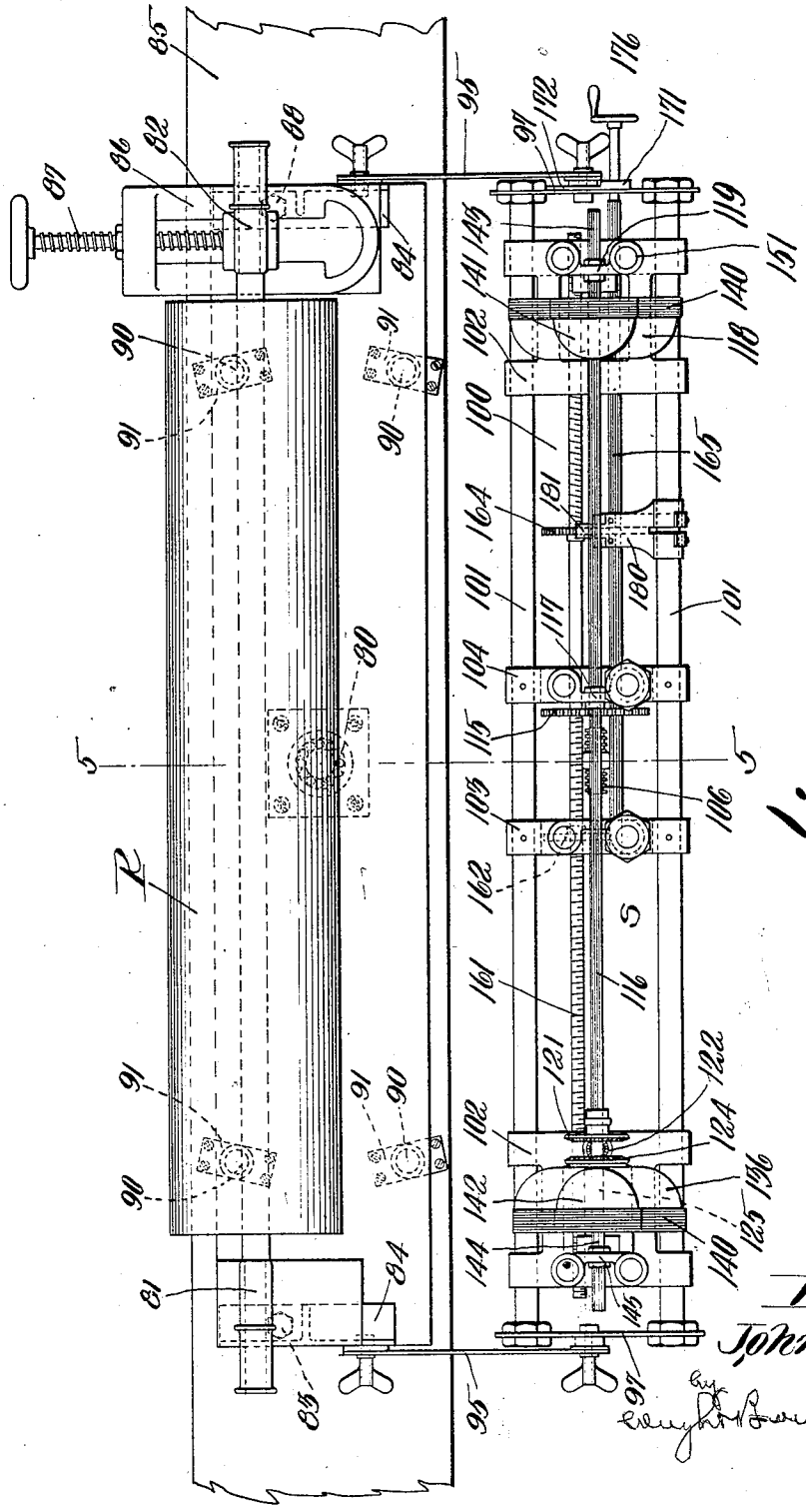


Fig. 2.

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METHOD AND APPARATUS FOR STEERING BELTS

Original Filed May 15, 1922 5 Sheets-Sheet 3

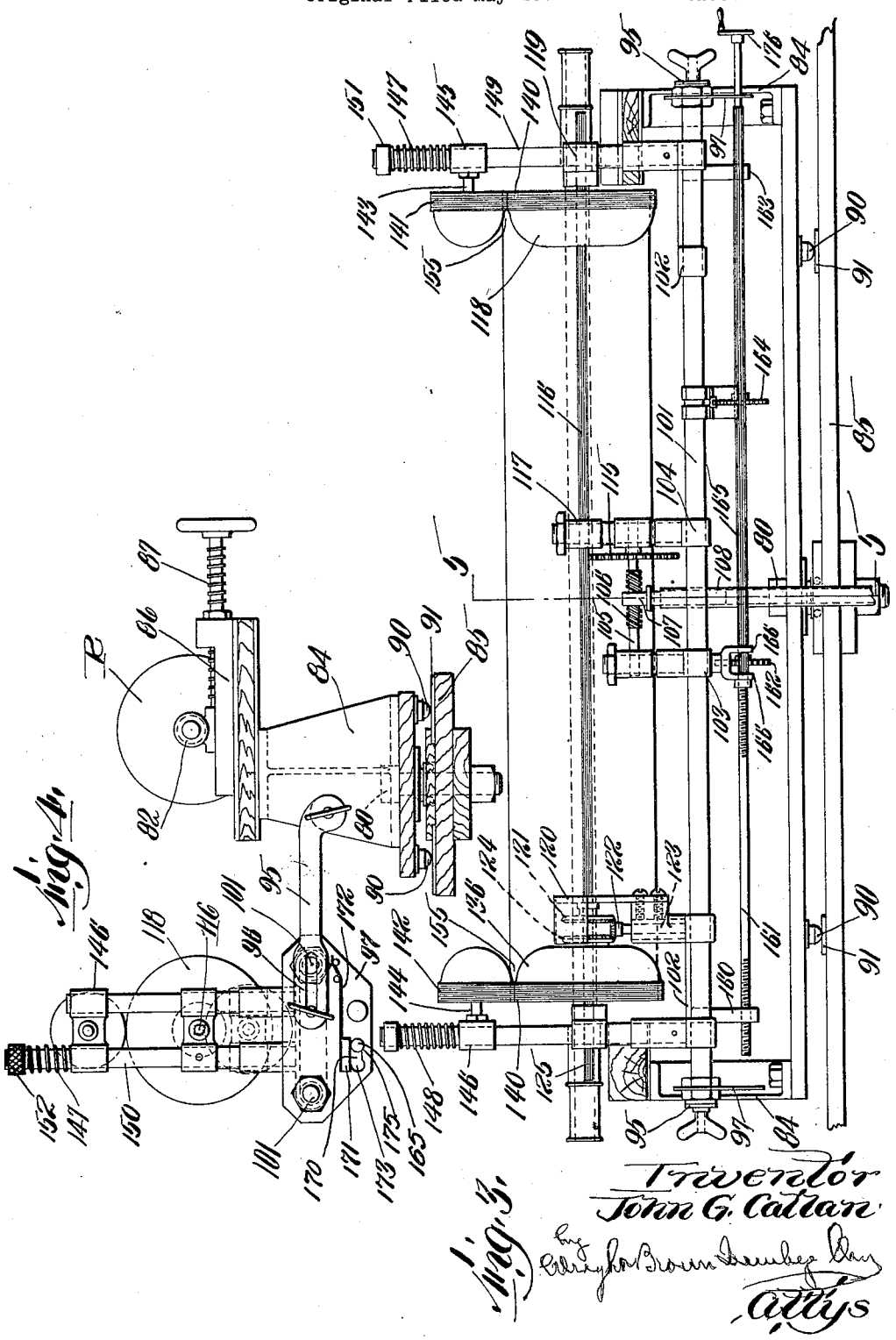


Fig. 4.

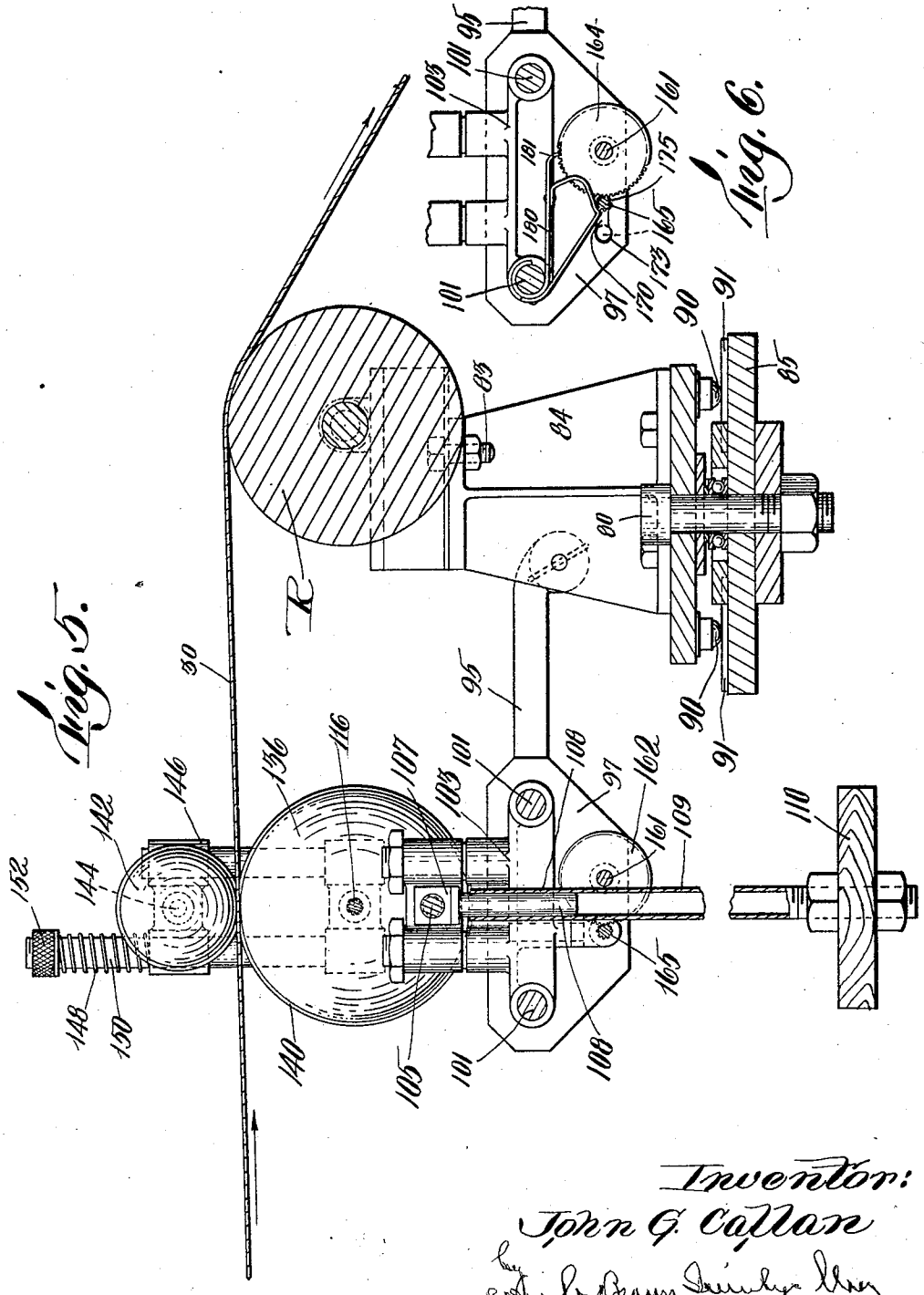
Fig. 5.

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METHOD AND APPARATUS FOR STEERING BELTS

Original Filed May 15, 1922 5 Sheets-Sheet 4



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METHOD AND APPARATUS FOR STEERING BELTS

Original Filed May 15, 1922 5 Sheets-Sheet 5

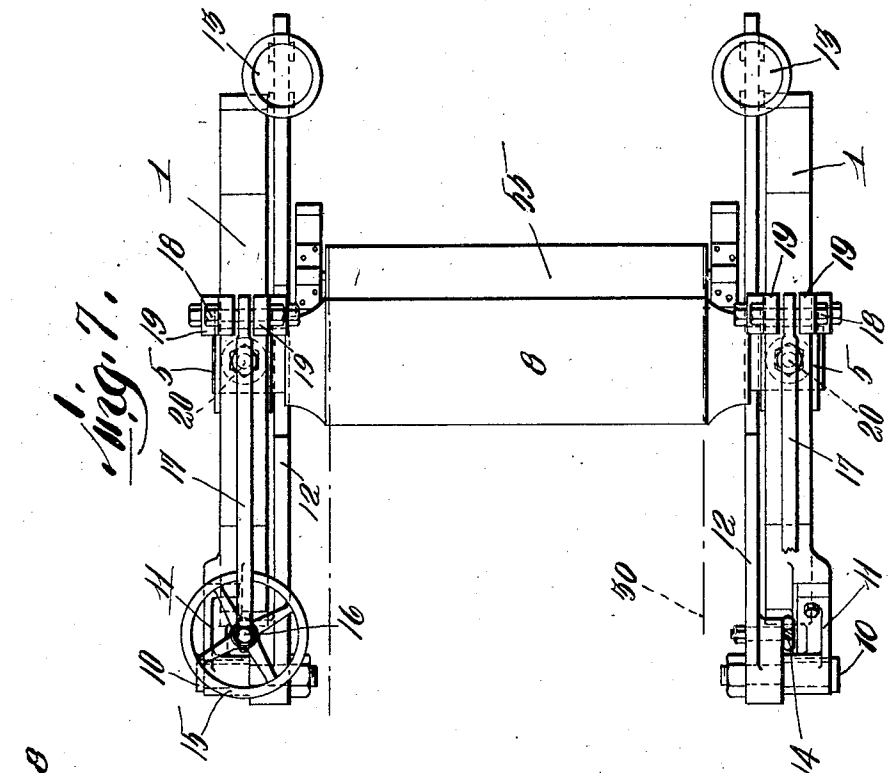


Fig. 7.

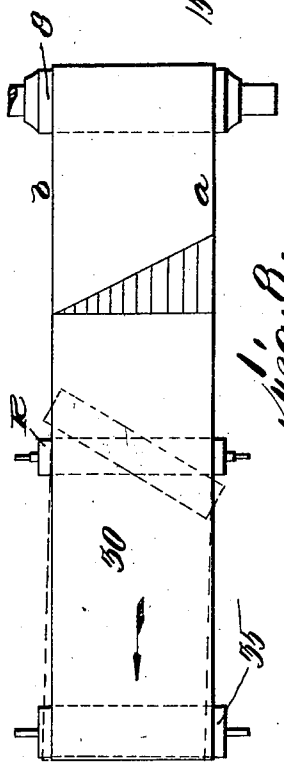


Fig. 8.

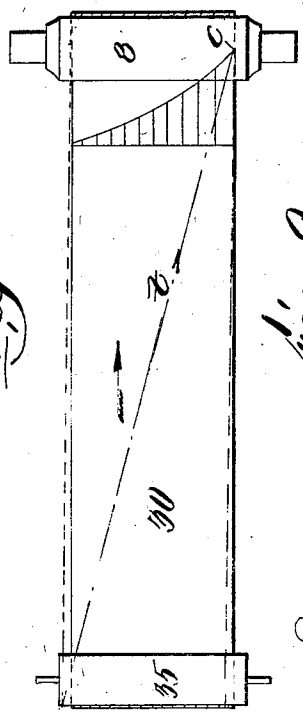


Fig. 9.

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Patented May 28, 1929. 1,714,846

UNITED STATES PATENT OFFICE.

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METHOD AND APPARATUS FOR STEERING BELTS.

Application filed May 15, 1922, Serial No. 561,140. Renewed April 15, 1929.

This invention relates to the method and apparatus for guiding belts into the nip between a pair of cooperating pressure rolls. More specifically it has application to the guiding of continuous belts of multiply textile fabric through the nip between a pair of calender or similar rolls, preferably one hard and the other softer, pressed heavily together in a machine for imparting a fabric-like surface to paper. The method, however, is of general application wherever a belt or web is to be guided in a nip between rolls or their equivalent.

The art of guiding flat belts on to cylindrical pulleys is well known. When it is desired to cause a belt to shift along the pulley face it is urged edgewise at a point somewhat ahead of that where it makes its on-going contact with the pulley, an action which guides the belt by changing the approach from a normal to a slightly angular one and which incidentally involves a loosening of the wrap of the belt around the pulley on the edge toward which traverse takes place.

Where the belt is guided into a nip between rolls instead of on to a single pulley or drum, the action involved in guiding or steering the belt differs radically from this well known action just outlined, and previous attempts to guide belts into nips have had erratic and unexpected results on account of being based on this apparent analogy which turns out not to be a true one. The conditions are in fact as follows.

Subject to small correction factors, the peripheral speed of the rolls at any point along the nip precisely determines and measures the rate at which the belt is fed through at that point since the pressure exerted by the rolls upon the belt is far too great to allow any slipping in the ordinary sense of the word. If now all the conditions are ideal, the belt feeds through at the same speed at all points of its breadth and maintains its proper lateral position and does not wrinkle as it goes into the nip. These ideal conditions are principally the following: (1) the rolls true cylinders with parallel axes under equal pressure at both ends; (2) the longitudinal center line or axis of the belt initially at right angles with the line of contact between the rolls, that is, with the nip; (3) the belt, which is joined into an endless form, of exactly the same length at both edges and also on all other intermediate lines measured parallel to the edges.

If any of these conditions be not exactly fulfilled as usually happens in practice, then without the intervention of a suitable guiding or steering device the belt fails to run true in one or the other lateral direction as will be seen from the following.

If the belt does not feed in squarely, that is, if its longitudinal edge or axis is not at right angles with the line of contact between the rolls, then obviously the belt will edge over toward one side, since the instantaneous direction of travel in any case is at right angles to the line of the nip. If the rolls are of greater diameter at one end than at the other, the end of greater diameter measures off and feeds forward a greater length of belt per revolution than the end of lesser diameter and the belt will thus gradually be thrown to a position where its longitudinal axis is no longer at right angles to the line of the nip and where it therefore edges over to one side.

If the axes of the rolls are not parallel their contact would theoretically be a point and not a line and actually with roll flexure and distortion is a warped line instead of a straight line. The effect on the feed of the belt depends on the degree of angularity, the relative position of the two rolls, and the relative hardness of the roll materials and may be erratic if the departure from parallelism is appreciable.

If the pressure at one end be materially greater than at the other, then with the heavy pressures actually used in the machine the difference in longitudinal elastic extension of the two edges of the belt, momentarily compressed as it passes through the nip, and the difference of radius of the two ends of the softer of the pair of rolls, produces a difference in the net rate of feed at the two edges as measured on the uncompressed belt. This will gradually throw the belt out of proper position.

If the belt is not of exactly the same length on the two edges, the action may be illustrated by an example. Suppose the belt to be thirty feet long on one edge and the other edge to be thirty feet plus one-tenth of an inch. Now when the rolls have run until their circumferential travel has been thirty feet,

the first-named edge will have returned to its original position while the second will lack a tenth of an inch of its initial position and this action will be multiplied with each repetition so that in the example taken, after the belt has traveled three hundred feet one edge will be an inch ahead of the other and the belt will be feeding into the nip at an angle sufficient to cause rapid edging over to one side.

Difference in length of the two edges of the belt is common in practice and is the most important cause of failure to run straight; the other departures from perfection are usually found in some degree; and the expected consequent tendency of the belt to travel over to one or the other side does actually develop. Furthermore, if without any other added procedure the belt is swung bodily back where its center line again squares with the line of the nip (as would be done if it were feeding on to a pulley) or if it is prevented from leaving there, then the inequality of feed on the two edges causes a looseness or pucker on the edge feeding in slowest, the rolls refuse to take up this slack, and it eventually forms a wrinkle which passes through the heavily weighted nip and the belt is at once cut diagonally in two and destroyed.

Many such failures of direct steering were followed in my experiments by various modifications some of which guided the belt if all ideal conditions were very closely met. Comparison of common factors of the partial successes led to the present method, which is wholly successful under commercial conditions.

The belt is put under comparatively heavy, but not destructive, initial tension, and the guiding or steering is accomplished by use of some means or mechanism that stretches one edge more than the other within the elastic limit of the material. The edge that receives the greater tension is lengthened the more and therefore progressively falls behind as the belt is measured off and fed forward by the revolution of the tightly engaged pair of rolls. This progressively corrects the angle of entry of the belt to the nip and causes it to edge over away from that side that is under the most tension. This is the essential guiding and steering method and it can be carried out in a number of ways, some of which have particular advantages. The method will be described later in further detail and afterward a preferred embodiment will be disclosed.

With regard to the initial tension it is clear that not only must the two edges of the belt keep exact pace with each other, but any and all elements parallel to the edges must keep the same step or the surface will fall into irregular wrinkles and be cut to pieces by the pressure. The initial tension may be applied by a head roll which acts to even out local irregularities of length and is a principal means of accomplishing this action, both momentarily and permanently, the latter during the early running of a new belt when it is receiving some permanent stretch as a resultant effect of this initial tension and of the crushing action of the intense pressure in the nip.

A machine designed to carry out this method is disclosed in the accompanying drawings in which

Figure 1 is a side elevation somewhat diagrammatic of the complete machine.

Figure 2 is a plan of a steering mechanism.

Figure 3 is a side elevation of the same mechanism.

Figure 4 is an end elevation of the same mechanism.

Figure 5 is a section on line 5—5 of Figure 2.

Figure 6 is a fragmentary section on line 6—6 of Figure 2.

Figure 7 is a top plan of one end of the machine.

Figures 8 and 9 are diagrammatic views illustrating two methods preferably used in conjunction by which steering may be effected.

Referring to Figures 1 and 7, at 1 are indicated a pair of spaced parallel side frames, each provided with a vertical guideway 2 to slidably receive journal blocks 3, 4, and 5 of calendering or similar superposed rolls 6, 7, and 8. The lowest roll 6 and the top roll 8 are preferably formed of steel so as to be comparatively hard, while the intermediate roll 7 is formed of relatively soft material such as highly compressed cotton. A heavy pressure is exerted to press these rolls together, as shown, this being effected independently at each end of the rolls, there being fulcrumed on a pin or pintle 10 fixed in a bracket 11 projecting from one edge of each frame member 1, a lever 12 having a weight 13 at its free end. Near the fulcrum 10 is pivoted the lower end of a link 14, the upper end of each threaded in the hub of a hand wheel 15. Also threaded in the upper end of this hub is a link 16 engaging at its upper end a lever 17 fulcrumed at 18 to a pair of brackets 19 fixed to the top of the frame 1. The links 14 and 16 are reversely threaded in the hand wheel so that by turning this wheel their effective length may be shortened or lengthened as required. Near the fulcrum 18, the lever 17 bears on a post 20 which projects through a guideway in the upper end of the frame 1 and is fast at its lower end in the bearing block 5. The lower bearing block 3 is supported on a bracket 21 fixed in the lower part of the guideway 2. By this means the weights 13 acting through multiplied lever arms exert a heavy pressure between the rolls. The rolls 7 and 8 are the calender rolls which cooperate to form a nip through which the belt is to be guided. Pressure ex-

erted at either end of the roll 8 may be adjusted by changing the weights 13. Adjustment of this pressure differentially corrects for slightly conical shapes of rolls and also causes a local elongation of the belt to cause a steering action as above described.

A pair of fabric belts between which the paper to be finished is passed are shown at 30 and 31. The upper belt 30 passes through the nip between the rolls 7 and 8, around over the top of the roll 8 and in an upwardly inclined direction over a steering mechanism, indicated generally by S, which will be later described. It then passes in a downwardly inclined direction over a head roll 35, then back and over a guide roll 36 carried by the frame 1 which is so positioned as to cause the belt to engage the roll 8 somewhat in advance of the nip between it and the roll 7. This engagement with the roll 8 serves to smooth out local wrinkles which might otherwise cause trouble when the nip is reached.

The head roll 35 is carried on horizontal ways as 40 and is urged away from the calender rolls by means of heavy weights, such as 41, each weight being fixed to a chain 42 passing over a chain wheel 43 carried by a shaft 44. A pair of small drums 45 fixed to this shaft have wound thereon cables 46, the forward end of each of which is attached to a carriage 47, which is slidable on each way 40. The carriages 47 on opposite ways may be connected for simultaneous movement by a crossbar 48. It is desirable that the angular position of the head roll may be adjusted in order to conform somewhat closely to any inequality of lengths of opposite edges of the belt to avoid placing too great a load on the steering mechanism. For this purpose the head roll may be journaled in bearings 50, each individually adjustable on its carriage 47 by means of a screw 51.

The lower belt 31 passes between the rolls 8 and 7 and then downwardly to a guide roll 55 near the base of the machine. From beneath this guide roll the belt travels upwardly about the steering device S′ and around a head roll 56 which may be mounted in the same manner as the roll 35. From the head roll the belt passes beneath the guide roll 57 positioned somewhat below the horizontal plane of the nip between the rolls 7 and 8, so as to engage the roll 7 in advance of the nip for the same purpose as that described in connection with the guide roll 36 for the belt 30.

The paper to be calendered is shown as in the form of a roll 60 which is supported at the end of a pair of levers, one of which is shown at 61 in Figure 1, the weight of the paper roll being held by a chain or cable 62 passing down over a belt pulley 63 and then upwardly to a winding drum 64, which is normally held from rotation by means of a locking pawl 65. The roll of paper is prevented from rotating too freely by means of a brake drum 66 fixed to rotate therewith and about which is passed an adjustable brake band 67. The paper may be supported in any other suitable manner as this forms no part of the present invention. The paper is led from the roll 60 up over a tension roller 68 vertically adjustable in a frame 69 supported from the ways 40. After passing over this roller it passes beneath a guide roller 70 and then between the belts 30 and 31, through the nip between the rollers 7 and 8, then about a pair of hot dryer rolls 71 and 72 and to a mandrel (not shown) where the finished paper is rolled.

In the form that I prefer an automatically operated steering mechanism is provided, having also a hand operated means for rectifying irregularities during the first run of the belt when it is stretching to permanent shape and for compensating approximately for large differences in length of edges so that the automatic gear may not be overburdened. For the hand controlled function one edge or the other of the belt is given excess stretch by adjusting the weighted head roll in the manner above described to a slightly angular position. This is not usually necessary, except temporarily with a new and uncommonly irregular belt.

The automatic mechanism, in general, comprises a steering roll, as R, which is shown more in detail in Figures 2 to 5 inclusive, which is pivoted to swing about an axis positioned substantially centrally of its length as shown at 80. The automatic mechanism S, S′ that I have found best bears some physical resemblance to the rolls used to steer Fourdrinier wires, felts on ruling machines and the like, differing particularly therefrom in that it does not act on a substantially flat part of the belt, but is placed in the vertex of an angle formed by the approaching and receding stretches of the belt, the angularity of the two stretches being different relative to the plane of swing of the guiding roll, as shown in Figure 1, in which the double arrows P and P′ indicate the plane of swing of the steering rolls which are shown at R, R′. This mechanism, if suitably proportioned can be placed at any point in the traverse of the belt where there is room for it, but it works best in the position shown in Figure 1 engaging a part of the belt approaching the head roll and receding from the calender rolls, the direction of motion of these belts being indicated by the arrows *m*, *m*′.

The action of this steering mechanism involves two partly independent actions which combine to adjust the position of the belt in the following manner. When the belt becomes displaced from its desired position it actuates a suitable mechanism such as will be later described which swings the steering roll in the plane indicated by the arrows P and P′. It will be seen from Figures 1 that the plane of the belt on the stretch approach-

ing the steering roll is more nearly parallel to the plane in which the roll swings than is that of the receding part of the belt. On account of this the end of the roll that swings in the direction that the belt is going, stretches that edge of the belt, while the opposite swing of the other end of the roll may stretch its edge less, or not at all, or release tension upon it, according to the exact angular relation between the plane of approach and the plane of swing of the roll. This differential stretching of one edge, which is the edge from which it is desired to guide the belt, is alone sufficient to steer the belt fairly well when ideal conditions are approximated, but with the arrangement of parts shown there is another stretching action which coincidently stretches the edge of the belt locally just as it enters the nip on the side from which it is desired to steer it. This is as follows.

When the steering roll is swung as described, it tends to directly displace the belt sidewise toward that end of the roll that is swung "upstream" or in a direction opposite to that in which the belt is traveling. This action is well understood in connection with steering devices employed to guide Fourdrinier wires, and it more or less displaces the belt in the stated direction on the head roll. This displacement alone in the absence of any comparatively heavy initial tension would only throw the belt over to a position where it would present to the nip on the losing edge still more slack which the nip is entirely incapable of taking up and would therefore develop no steering action. Where there is sufficient initial tension the following action occurs. When the belt is thrown to one side of the head roll, as shown in dotted lines in Figure 9 which illustrates the lower portion of the upper belt 30 between the head roll and the nip, the normal lines of tension parallel to the center line of the belt are relieved, and there is substituted a main diagonal line of tension, as shown by the arrow *t*, extending from the corner at the head roll and at the edge toward which the belt is moved, to the diagonally opposite corner at the nip, this being shown in Figure 9 in a somewhat exaggerated degree. As any given element of the belt passes through this diagonal it is momentarily stretched in a diagonal direction, the longitudinal component of which is much greater than the lateral component when the steering gear is located as shown in Figure 1. Just as the belt enters the nip this stretch is fairly local at the edge from which it is desired to steer the belt, that is, at the point *c*, and the momentary elongation at the instant of entering the nip has the same effect as an equal permanent elongation from direct stretching of the whole edge, namely, to tend to cause that side to fall progressively behind and consequently to tend to steer the belt over to the opposite side. That is the same side toward the direct stretching action steers it, the more tightly stretched edge being shown at *a* in Figure 8 and the less stretched edge at *b*, this direct stretch being caused, as before described, by the swinging of the steering roll R to the dotted line position in Figure 8. As in the case of the direct stretch this diagonal stretch alone will steer the belt when ideal conditions are approximated.

It will now be shown why the combination of the two actions is more effective than either alone under probable departures from ideal conditions. With the direct stretching action, due merely to the swinging of the roll in the unsymmetrical gable of the belt passing over or under it, the degree of stretch is greatest at one edge, least at the other, and varies progressively and evenly between, this being shown diagrammatically by the shaded stress triangle in Figure 8. With the diagonal tension due to forcing the initially stretched belt over sidewise on the head roll, the stretch is somewhat localized at and near one edge, and drops at first rapidly and afterward more slowly at points progressively approaching the other edge, this being indicated in the shaded stress diagram in Figure 9. Now if the belt were of exactly equal lengths at the edges and the median portion, then the first-named symmetrical stretching action would be the one sought, and it could be easily obtained by swinging a belt-steering roll contacting with a nearly flat portion of the belt about an axis parallel with the center line of the belt at the place of contact, or by initially taking up slack on the head roll by adjusting it to the proper angular position. The reason that the more elaborate method as described is more satisfactory is that the incidents and accidents of operation always lead to a slight additional stretching of the unsupported edges of the belt, and a judicious superposition of the diagonal pull, which localizes the steering tension at the edge, compensates for this and leads to an extremely satisfactory guiding action which is not fully duplicated by either method alone on commercial belts of common degrees of departure from complete flatness and symmetry. This at least is my theory as to the reason for the excellent results actually attained with the empirically determined relation between the two actions that I have found best. I have found that a good action is achieved with a thirty foot belt making a total deflection from plane of from twenty to thirty degrees as it passes over the steering roll, divided so that the belt approaches the roll in a plane not far from parallel to that in which the roll swings, and recedes from the roll in a plane making a twenty or thirty degree angle with this plane of swing. With these proportions this mechanism will ordinarily hold belts of easily noticeable edge sag and difference of length on the two edges within a half inch of desired

location in the nip throughout their periods of life.

An added precaution against the development of puckers and consequent destructive wrinkles at the edges is the use of the guide rolls 36 and 57 which bring the belts into contact with the calender rolls at a point some distance ahead of the nip as shown in Figure 1 so as to wrap the belts over substantial arcs of the calender rolls before reaching the nip.

Referring now more particularly to Figures 2 to 5, the steering roll R is journaled at opposite ends in bearings 81 and 82. As shown in Figure 2, the bearing 81 is fixed by a single bolt 83 to a frame member 84 which is pivoted by a pin at 80 to a cross frame member 85. The bearing 82 is adjustable along a guide block 86 by means of an adjusting screw 87, the block 86 being fastened by a single bolt 88 to the frame 85. By this means the angularity of the roll relative to the frame 84 may be adjusted according to conditions, the bearings swinging about the securing bolts, so as to relieve the automatically adjusting mechanism to be described from the entire adjustment necessary to cause the belt to run true. The cross frame member 85 may be supported in any suitable manner as by mounting it on the guides 40 and may be made angularly adjustable thereon by any suitable means, if desired, to change the angle of the plane of swing of the roll relative to the gable formed in the belt by this roll. In order to support the ends of the frame 84, ball castors, as shown at 90, may be fixed to the lower face of the frame 84 and bear on wear plates 91 fixed to the cross frame member 85. To opposite ends of the frame 84 are fixed the ends of links 95, the opposite ends of which are adjustably fixed as by means of bolt and slot connections 96 to end plates 97 of steering actuating mechanism indicated generally by 100.

The end plates 97 of this mechanism are carried at the ends of a pair of spaced guide rods 101 on which are slidably mounted adjacent the end plates brackets 102, while toward their center, the guide rods 101 have fixed thereto a pair of spaced brackets 103 and 104. Journaled at opposite ends in the brackets 103 and 104, as shown in Figures 2 and 3, is a short shaft 105 having its central portion 106 formed as a screw with a coarse pitch. In threaded engagement with this screw is a nut 107 provided with a shank portion 108 depending within the upper end of a vertically extending tube 109 (see Figure 5) which is fixed at its lower end in a cross frame member 110 of the machine. This construction permits the nut 107 to oscillate slightly about a vertical axis but prevents it from other motion. Consequently rotation of the shaft 105 acts to move the brackets 103 and 104 laterally carrying the entire mechanism 100 therewith and through the links 95, imparting swinging motion to the roller R about the pivot 80. Turning motion is imparted to the shaft 105 by means of a gear 115 fixed thereto meshing with a pinion wire 116 journaled in a bearing 117 extending upward from the bracket 104 and having its adjacent end slidably keyed to a friction wheel 118 beyond which it is journaled in a bearing 119 in one of the brackets 102. The opposite end of the pinion wire 116 is now slidably journaled in a housing 120 carried by the opposite bracket 102 and has fixed thereto within the housing a bevel gear 121 meshing with a bevel pinion 122 carried by a vertical stub shaft 123 which pinion in turn meshes with a bevel gear 124 mounted to rotate with a shaft 125 to which is fixed a friction wheel 136. The friction wheels 118 and 136 are formed with outer bearing faces 140 with which engage similar smaller mating friction wheels 141 and 142. These wheels are carried by stub axles 143 and 144 fixed in vertically sliding bearings 145 and 146 and are urged downwardly into contact with the wheels 118 and 136 by means of springs, as shown at 147 and 148, surrounding one of a pair of guide pins 149 and 150 having adjusting nuts 151 and 152 on their upper ends. Adjacent the friction bearing surfaces 140 the friction wheels are formed somewhat conical so as to present wedge-shaped grooves 155 into which the opposite edges of the belt may pass when the belt travels laterally, these wheels being normally so spaced apart as to just clear the belt edges when the belt is in its normal lateral position. If the belt travels to one side or the other it engages in one or the other of the notches 155, its longitudinal motion causing rotation of the corresponding friction wheel and imparting rotation in one or the other direction, depending on the friction wheels engaged, to the pinion wire 116, consequently rotating the gear 115 and imparting lateral motion to the roll-moving mechanism and consequently swinging the roll in a direction to steer the belt away from the friction wheels engaged thereby. This motion of the mechanism 100 laterally is such as to move the friction wheels themselves in the direction of the travel of the belt which is to be corrected, thus tending to move the friction wheels out of engagement with the belt to stop further swinging of the steering roll. Should the roll not be swung sufficiently, however, and the belt continue to edge over, it is evident that it will contact with the wheels again and impart further corrective motion to the steering roll. Should the corrective motion have been sufficient to cause the belt to move in the opposite direction any overthrow in this direction causes the belt to contact the opposite set of friction rolls to cause a return motion of the steering roll to prevent over correction, this mechanism

serving as one type of follow up device such as is commonly employed in power-steering mechanisms.

It is desirable that the distance between the sets of friction rolls should be adjustable to provide for different widths of belt and also that they should be adjustable as a unit relative to the calender rolls so that the normal lateral position relative thereto may be predetermined. For this purpose one of the brackets 102, herein shown as the left hand bracket in Figures 2 and 3, is provided with a threaded depending lug 160 in which engages the threaded end of a shaft 161. Also threaded on this portion of the shaft 161 is a gear wheel 162. The opposite end of the shaft 161 is oppositely threaded with the same pitch through a lug 163 depending from the opposite bracket 102, while fixed to this shaft is a gear 164 of the same size as gear 162. Meshing with the gear 162, which as before stated, is threaded on the shaft 161, is one end of a piece of pinion wire 165 journaled between a pair of forked arms 166 depending from the bracket 103, these arms 166 holding the pinion wire in mesh with the gear 164. The opposite end of the pinion wire extends through one of the end plates 97 in a U-shaped slot 170 of such size that the wire may be brought down into either of the sides of the slot as 173 and 175 and be there retained by an arm 171 (see Figure 4) urged downwardly thereagainst by a spring 172. When the pinion wire rests in side 173 of the slot 170, it is out of mesh with the gear 164 while when it is in the opposite side 175 of this slot it is in mesh with the gear 164. The outer end of this pinion wire carries an actuating handle 176. If now the pinion wire is engaged in the side 175 and is turned, rotation is imparted to both the gears 162 and 164 in the same direction. Rotation of the gear 162 is effected at the same angular velocity as the rotation of the shaft 161 since the gears 162 and 164 are of the same size. There is therefore no relative motion of the shaft and gear 162 and hence the shaft is longitudinally fixed relative to the brackets 103 and 104. The lugs 160 and 163 are thus caused to move toward or from each other depending on the direction of rotation of the handle 176 since they engage oppositely threaded portions of the shaft. This action thus increases or decreases the spacing of the sets of friction wheels without changing the lateral position of the axis centrally therebetween. In case the pinion wire is moved to occupy the slot side 173, it is out of mesh with the gear 164 so that the screw shaft 161 is not revolved when handle 176 is turned but the gear 162 is screwed thereon, thus carrying both the brackets 102 together relative to the bracket 103, the spacing of the sets of friction wheels not being effected, but both being moved together laterally to position the belt. When the pinion wire is out of mesh with the gear 164, it is desirable that the screw shaft 161 be held from rotation. For this purpose a pawl shown in Figure 6 at 180 may be employed. This consists of a plate engaging at one end over one of the guide rods 101, having a depressed portion engageable by the pinion wire 165 so as to hold its edge 181 out of mesh with the gear 164 when the pinion wire is in engagement therewith, but when the pinion wire is out of engagement therewith, as in the dotted line position in Figure 6, permitting the edge 181 to fall into engagement with the teeth of the gear 164 to prevent rotation thereof. This pawl may be made to engage the sides of the gear 164 so as to hold it in proper position relative thereto, sliding along the guide rod 101 when the friction wheels are being adjusted together laterally. These friction wheels are preferably covered with friction material such as cork linoleum.

It will be seen from this description that rough preliminary steering adjustments may be effected by hand by adjusting the angular position of the head roll and by applying differential pressure at opposite ends of the nip, and that more accurate final adjustments are effected automatically, as conditions require, by means of the swinging steering roll which acts in two different ways to perform its intended function.

Having thus described an embodiment of this invention it should be evident to those skilled in the art that many changes and modifications might be made therein without departing from its spirit or scope as defined by the appended claims.

I claim:

1. The method of guiding a belt into a nip between two rolls pressed together under heavy pressure which comprises running the belt under heavy tension and applying a differential tension to opposite edges of the belt to tend to maintain the belt in a definite lateral position.

2. The method of guiding a belt into a nip between two rolls pressed together under heavy pressure which comprises running the belt under heavy tension and applying a differential tension longitudinally of the belt at opposite edges to tend to maintain the belt in a definite lateral position.

3. The method of guiding a belt into a nip between two rolls pressed together under heavy pressure which comprises running the belt under heavy tension and imparting a localized edge tension thereto at the nip at one edge to tend to maintain the belt in a definite lateral position counteracting any normal tendency for the belt to move laterally.

4. The method of guiding a belt into a nip between two rolls pressed together under heavy pressure which comprises running the belt under heavy tension and

imparting a diagonal tension extending to one edge at said nip to impart a local stretch of said edge at the nip to tend to maintain the belt in a definite lateral position, counteracting any normal tendency of the belt to travel laterally.

5. The method of guiding a belt into a nip between two rolls pressed together under heavy pressure which comprises running the belt under heavy tension and applying a differential tension longitudinally to opposite edges of the belt, and a diagonal tension extending to one edge of said belt at the nip to tend to maintain the nip at a definite lateral position counteracting any normal tendency of the belt to travel laterally.

6. The method of guiding a belt into a nip between two rolls pressed together under heavy pressure which comprises running the belt under heavy tension and applying a differential tension longitudinally to opposite edges of the belt and imparting to the edge more heavily tensioned an additional local tension at said nip to tend to maintain said belt in a definite lateral position.

7. The method of guiding a belt into a nip between two rolls pressed together under heavy pressure which comprises running the belt under heavy tension and applying a differential tension longitudinally to opposite edges of the belt and imparting a tension diagonal to said belt extending to the more heavily tensioned edge at the nip to tend to maintain said belt in a definite lateral position.

8. The method of guiding a belt into a nip between two rolls pressed together under heavy pressure which comprises running the belt under heavy tension and applying a differential tension longitudinally to opposite edges of the belt and imparting to the edge more heavily tensioned an additional local tension at said nip, said tensions being automatically adjusted to tend to maintain the belt in a definite lateral position.

9. The method of guiding a belt into a nip between two rolls pressed together under heavy pressure which comprises running the belt under heavy tension and applying a differential tension longitudinally to opposite edges of the belt and imparting a tension diagonal to said belt extending to the more heavily tensioned edge at the nip to tend to maintain said belt in a definite lateral position, said tensions being automatically adjusted to tend to maintain the belt in a definite lateral position.

10. The method of guiding an endless belt passing through the nip between a pair of pressure rolls which comprises differentially adjusting the pressure exerted by said rolls at opposite edges of said belt to effect a variable local elongation thereof at the nip.

11. The method of guiding an endless belt through the nip of a pair of pressure rolls which comprises imparting a differential tension to opposite edges of said belt and differentially adjusting the pressure exerted by said rolls at opposite edges of said belt to effect a variable elongation thereof of the nip supplementing the variable elongation due to said tension.

12. The method of guiding an endless belt through the nip of a pair of pressure rolls which comprises automatically imparting a differential longitudinal tension to opposite edges of said belt proportional to and such as to oppose normal tendency to lateral movement of said belt, and differentially adjusting the pressure exerted by said rolls at opposite edges of said belt to effect a variable elongation thereof at the nip supplementing the variable elongation due to said tension.

13. The method of guiding an endless belt through the nip of a pair of pressure rolls which comprises imparting a differential longitudinal tension to opposite edges of said belt, a tension diagonally across the width of said belt to the heavier tensioned edge at the nip, and imparting a differential pressure to said rolls on said belt to impart a local elongation thereof at the nip supplementing the elongations due to said tensions.

14. The method of guiding a belt between cooperating relatively hard and soft pressure rolls which comprises exerting differential pressure on said belt between said rolls whereby the effective measuring diameter of said relatively soft roll is decreased at the end of greater pressure.

15. In a machine of the class described, a pair of rolls, means for pressing said rolls together under heavy pressure, an endless flat belt passed between said rolls, and steering means for said belt arranged to differentially stretch opposite edges of said belt to tend to maintain the belt in a definite lateral position.

16. In a machine of the class described, a pair of rolls, means for pressing said rolls together under heavy pressure, an endless flat belt passed between said rolls, and steering means for said belt arranged to differentially elongate opposite edges of said belt to tend to maintain the belt in a definte lateral position.

17. In a machine of the class described, a pair of rolls, means for pressing said rolls together under heavy pressure, an endless flat belt passed between said rolls, steering means for said belt arranged to impart variable differential elongation to opposite edges of said belt, and means for controlling the extent of such elongation automatically.

18. In a machine of the class described, a pair of rolls, means for pressing said rolls together under heavy pressure, an endless flat belt passed between said rolls, and means acting in a plurality of ways each controlled

by motion of the belt for imparting a differential elongation of opposite edges of said belt at the nip of said rolls.

19. In a machine of the class described, a pair of rolls, means for pressing said rolls together under heavy pressure, an endless flat belt passed between said rolls, and means acting in a plurality of angular directions for imparting a differential elongation of opposite edges of said belt at the nip of said rolls.

20. In a machine of the class described, a pair of pressure rolls, an endless flat belt passed through the nip between said rolls, a head roll over which said belt passes and imparting an initial heavy tension thereto, and steering means acting to steer the belt onto said head roll, said steering means also acting to impart a differential stretch to opposite edges of said belt.

21. In a machine of the class described, a pair of rolls, means for pressing said rolls together under heavy pressure, a flat belt passed between said rolls, and means acting to differentially elongate opposite edges of said belt as it passes through the nip between said rolls to counteract lateral motion of said belt.

22. In a machine of the class described, a pair of rolls, means for pressing said rolls together under heavy pressure, an endless flat belt passed between said rolls, and means actuated on lateral movement of said belt to differentially elongate opposite edges thereof to counteract said lateral movement.

23. In a machine of the class described, a pair of cooperating calender rolls between which a belt may pass, a head roll, an endless belt passed about said head roll and through the nip between said calender rolls, means for initially tensioning said belt, and means for imparting an additional variable tension differentially between opposite edges thereof to counteract tendency of the initially stretched belt to travel laterally in the nip between said calender rolls in either direction from a definite position.

24. In a machine of the class described, a pair of cooperating calender rolls between which a belt may pass, a head roll urged away from the nip between said calender rolls, an endless belt passed between said calender rolls and over said head roll and initially tensioned by said head roll, a roll mounted to swing in a plane and engaging said belt to form a gable therein unsymmetrically related to the plane of swing of said roll, and means to swing said roll to impart a differential stretching action to opposite edges of the belt to cause said belt to tend to assume a definite lateral position relative to said calender rolls.

25. In a machine of the class described, a pair of cooperating calender rolls between which a belt may pass, a head roll urged away from the nip between said calender rolls, an endless belt passed between said calender rolls and over said head roll and initially tensioned by said head roll, a roll mounted to swing in a plane and engaging said belt to form a gable therein unsymmetrically related to the plane of swing of said roll, and means controlled by the lateral position of said belt to swing said roll to impart a differential stretching action to opposite edges of the belt to cause said belt to tend to assume a definite lateral position relative to said calender rolls.

26. In a machine of the class described, a pair of cooperating calender rolls between which a belt may pass, a head roll urged away from the nip between said calender rolls, an endless belt passed between said calender rolls and over said head roll and initially tensioned by said head roll, a roll mounted to swing in a plane and engaging said belt to form a gable therein unsymmetrically related to the plane of the swing of said roll, means controlled by the lateral position of said belt to swing said roll to impart a differential stretching action to opposite edges of the belt to cause said belt to tend to assume a definite lateral position relative to said calender rolls, and means for predetermining said definite lateral position.

27. In a machine of the class described, a pair of cooperating calender rolls between which a belt may pass, a head roll urged away from the nip between said calender rolls, an endless belt passed between said calender rolls and over said head roll and initially tensioned by said head roll, a roll mounted to swing in a plane and engaging said belt to form a gable therein unsymmetrically related to the plane of swing of said roll, and means controlled by the lateral position of said belt and actuated by the longitudinal travel of said belt to swing said roll to impart a differential stretching action to opposite edges of the belt to cause said belt to tend to assume a definite lateral position relative to said calender rolls.

28. In a machine of the class described, a pair of cooperating calender rolls between which a belt may pass, a head roll urged away from the nip between said calender rolls, an endless belt passed between said calender rolls and over said head roll and initially tensioned by said head roll, a roll mounted to swing in a plane and engaging said belt to form a gable therein unsymmetrically related to the plane of swing of said roll, means controlled by the lateral position of said belt and actuated by the longitudinal travel of said belt to swing said roll to impart a differential stretching action to opposite edges of the belt to cause said belt to tend to assume a definite lateral position relative to said calender rolls, and means for predetermining said definite lateral position.

29. In a machine of the class described, a pair of cooperating pressure rolls, a belt

passed between the nip of said rolls, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, said steering roll being movable in a plane unsymmetrically related to said gable, pairs of opposed friction wheels beyond opposite edges of said belt and normally out of contact therewith to be engaged and rotated by longitudinal movement thereof on lateral movement of said belt between the wheels of either pair, and connections between said friction wheels and steering roll acting by the rotation of said wheels to move said steering roll in said plane to tend to steer said belt in a direction out of engagement with the actuated friction wheels.

30. In a machine of the class described, a pair of cooperating pressure rolls, a belt passed between the nip of said rolls, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, said steering roll being movable in a plane unsymmetrically related to said gable, friction wheels beyond opposite edges of said belt and normally out of contact therewith to be engaged and rotated on lateral movement of said belt by longitudinal movement thereof, connections between said friction wheels and steering roll acting to move said steering roll in said plane to tend to steer said belt in a direction out of engagement with the actuated friction wheels, and a follow up mechanism acting to move said friction wheels out of contact with said belt on the moving of said steering roll.

31. In a machine of the class described, a pair of cooperating pressure rolls, a belt passed between the nip of said rolls, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, said steering roll being movable in a plane unsymmetrically related to said gable, pairs of friction wheels beyond opposite edges of said belt and normally out of contact therewith to be engaged and rotated on lateral movement of said belt by longitudinal movement thereof, connections between said friction wheels and steering roll acting by the rotation of said wheels to move said steering roll in said plane to tend to steer said belt in a direction out of engagement with the actuated friction wheels, and means for adjusting the normal positions of said friction wheels to determine the normal lateral position of said belt.

32. In a machine of the class described, a pair of cooperating pressure rolls, a belt passed between the nip of said rolls, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, said steering roll being movable in a plane unsymmetrically related to said gable, friction wheels beyond opposite edges of said belt and normally out of contact therewith to be engaged and rotated on lateral movement of said belt by longitudinal movement thereof, connections between said friction wheels and steering roll acting by the rotation of said wheels to move said steering roll in said plane to tend to steer said belt in a direction out of engagement with the actuated friction wheels, and means for adjusting the spacing of said friction wheels to conform to various widths of belts.

33. In a machine of the class described, a pair of cooperating pressure rolls, a belt passed between the nip of said rolls, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, said steering roll being movable in a plane unsymmetrically related to said gable, friction wheels beyond opposite edges of said belt and normally out of contact therewith to be engaged and rotated on lateral movement of said belt by longitudinal movement thereof, connections between said friction wheels and steering roll acting by the rotation of said wheels to move said steering roll in said plane to tend to steer said belt in a direction out of engagement with the actuated friction wheels, means for adjusting the normal positions of said friction wheels to determine the normal lateral position of said belt, and means for adjusting the spacing of said friction wheels to conform to various widths of belts.

34. In a machine of the class described, a pair of cooperating pressure rolls, a head roll, an endless belt passed through the nip of said pressure rolls and over said head roll, means to impart a heavy initial tension to said belt, and means acting on the belt as it approaches said head roll and in response to lateral movement of said belt to steer it in the opposite direction to said lateral movement onto said head roll whereby a diagonal stretch in said belt is produced extending to the edge of the belt at said nip on the side toward which said lateral movement is taking place.

35. In a machine of the class described, a pair of cooperating pressure rolls, a head roll, an endless belt passed through the nip of said pressure rolls and over said head roll, means to impart a heavy initial tension to said belt, and means acting on the belt as it approaches said head roll and in response to lateral movement of said belt to steer it in the opposite direction to said lateral movement onto said head roll whereby a diagonal stretch in said belt is produced extending to the edge of the belt at said nip on the side toward which said lateral movement is taking place, said steering means acting to differentially stretch opposite edges of said belt to cause a greater stretch on the edge toward which said lateral movement is taking place.

36. In a machine of the class described, a pair of cooperating pressure rolls, a head roll, a belt passed between the nip of said

pressure rolls and over said head roll, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, means for permitting swinging movement of said steering roll in a plane unsymmetrically related to said gable, a pair of sets of friction wheels disposed beyond the normal positions of the lateral edges of said belt, one or the other of said sets being engaged by the belt passing therebetween and rotated by longitudinal movement of said belt on lateral displacement thereon, and means actuated by rotation of said wheels to swing said steering roll in a direction to overcome said lateral displacement.

37. In a machine of the class described, a pair of cooperating pressure rolls, a head roll, a belt passed between the nip of said pressure rolls and over said head roll, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, means for permitting swinging movement of said steering roll in a plane unsymmetrically related to said gable, a pair of sets of friction wheels disposed beyond the normal positions of the lateral edges of said belt, one or the other of said sets being engaged and rotated by longitudinal movement of said belt on lateral displacement thereof, and means actuated by rotation of said wheels to swing said steering roll in a direction to overcome said lateral displacement and to move said engaged wheels in the direction of such displacement.

38. In a machine of the class described, a pair of cooperating pressure rolls, a head roll, a belt passed between the nip of said pressure rolls and over said head roll, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, means for permitting swinging movement of said steering roll in a plane unsymmetrically related to said gable, a pair of sets of friction wheels disposed beyond the normal positions of the lateral edges of said belt, one or the other of said sets being engaged and rotated by longitudinal movement of said belt on lateral displacement thereon, means actuated by rotation of said wheels to swing said steering roll in a direction to overcome said lateral displacement and to move said engaged wheels in the direction of such displacement, and means to adjust both sets laterally to define the normal position of said belt.

39. In a machine of the class described, a pair of cooperating pressure rolls, a head roll, a belt passed between the nip of said pressure rolls and over said head roll, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, means for permitting swinging movement of said steering roll in a plane unsymmetrically related to said gable, a pair of sets of friction wheels disposed beyond the normal positions of the lateral edges of said belt, one or the other of said sets being engaged and rotated by longitudinal movement of said belt on lateral displacement thereon, means actuated by rotation of said wheels to swing said steering roll in a direction to overcome said lateral displacement, and means for adjusting the spacing of said sets of wheels to conform to belts of different widths.

40. In a machine of the class described, a pair of cooperating pressure rolls, a head roll, a belt passed between the nip of said pressure rolls and over said head roll, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, means for permitting swinging movement of said steering roll in a plane unsymmetrically related to said gable, a pair of sets of friction wheels disposed beyond the normal positions of the lateral edges of said belt, one or the other of said sets being engaged and rotated by longitudinal movement of said belt on lateral displacement thereon, means actuated by rotation of said wheels to swing said steering roll in a direction to overcome said lateral displacement, and means for adjusting said sets of rolls together laterally of said belt.

41. In a machine of the class described, a pair of cooperating pressure rolls, a head roll, a belt passed between the nip of said pressure rolls and over said head roll, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, means for permitting swinging movement of said steering roll in a plane unsymmetrically related to said gable, a pair of sets of friction wheels disposed beyond the normal positions of the lateral edges of said belt, one or the other of said sets being engaged and rotated by longitudinal movement of said belt on lateral displacement thereon, means actuated by rotation of said wheels to swing said steering roll in a direction to overcome said lateral displacement, means for adjusting the spacing of said sets of wheels to conform to belts of different widths, and means for adjusting said sets of rolls together laterally of said belt.

42. In a machine of the class described, a pair of cooperating pressure rolls, a head roll, a belt passed between the nip of said pressure rolls and over said head roll, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, means for permitting swinging movement of said steering roll in a plane unsymmetrically related to said gable, a pair of sets of friction wheels disposed beyond the normal positions of the lateral edges of said belt, one or the other of said sets being engaged and rotated by longitudinal movement of said belt on lateral displacement thereon, means actuated by rotation of said wheels to swing said steering roll in a direction to overcome

said lateral displacement and to move said engaged wheels in the direction of such displacement, and means to adjust the spacing of said sets to conform to belts of different widths.

43. In a machine of the class described, a pair of cooperating pressure rolls, a head roll, a belt passed between the nip of said pressure rolls and over said head roll, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, means for permitting swinging movement of said steering roll in a plane unsymmetrically related to said gable, a pair of sets of friction wheels disposed beyond the normal positions of the lateral edges of said belt, one or the other of said sets being engaged and rotated by longitudinal movement of said belt on lateral displacement thereon, means actuated by rotation of said wheels to swing said steering roll in a direction to overcome said lateral displacement and to move said engaged wheels in the direction of such displacement, means to adjust both sets laterally to define the normal position of said belt, and means to adjust the spacing of said sets to conform to belts of different widths.

44. In a machine of the class described, a pair of cooperating pressure rolls, a head roll, a belt passed between the nip of said pressure rolls and over said head roll, means to tension said belt, a steering roll over which said belt passes and which forms a gable therein, means for permitting swinging movement of said steering roll in a plane unsymmetrically related to said gable, a pair of sets of friction wheels disposed beyond the normal positions of the lateral edges of said belt, one or the other of said sets being engaged and rotated by longitudinal movement of said belt on lateral displacement thereon, means actuated by rotation of said wheels to swing said steering roll in a direction to overcome said lateral displacement and to move said engaged wheels in the direction of such displacement, and means to adjust both sets laterally to define the normal position of said belt.

In testimony whereof I have affixed my signature.

JOHN GURNEY CALLAN.