

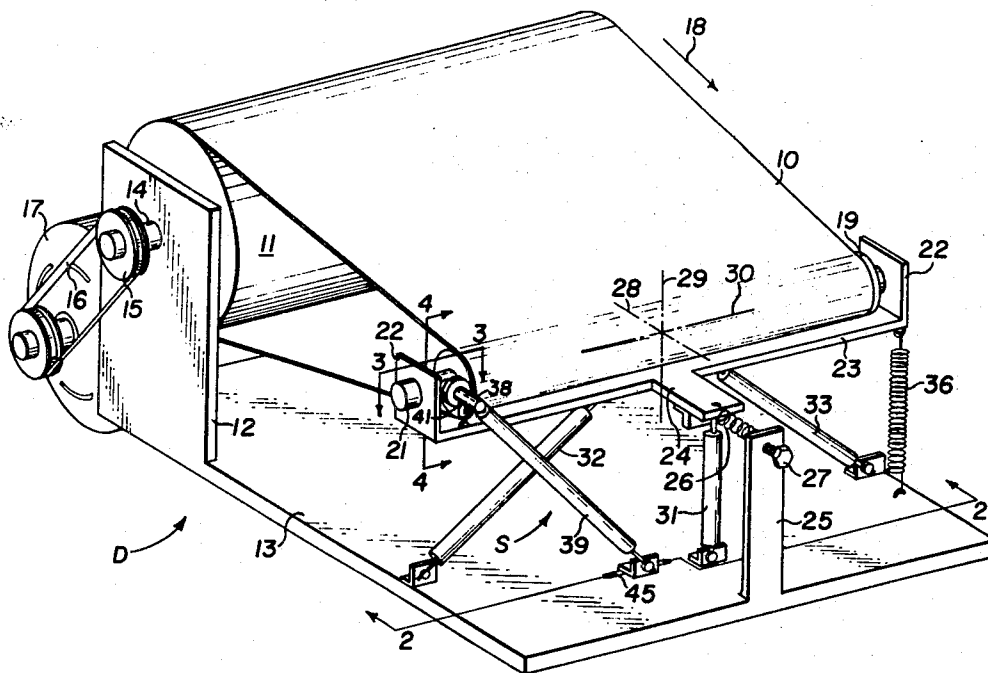
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 [22] Filed **Aug. 27, 1968**
 [45] Patented **Nov. 17, 1970**
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[56] **References Cited**
UNITED STATES PATENTS
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[54] **BELT-TRACKING SERVO**
 10 Claims, 5 Drawing Figs.

[52] U.S. Cl..... 198/202
 [51] Int. Cl..... B65g 15/62
 [50] Field of Search..... 198/202;
 226/23, 22, 21; 74/242

ABSTRACT: A belt-tracking servo is provided wherein a belt passes over a roller which has three degrees of freedom, being pivotal about a steering axis and a swing axis and translatable along the steering axis. A mechanical servomechanism senses movement of the edge of the belt causing the roller to be pivoted about the steering axis so that the belt tracks properly.



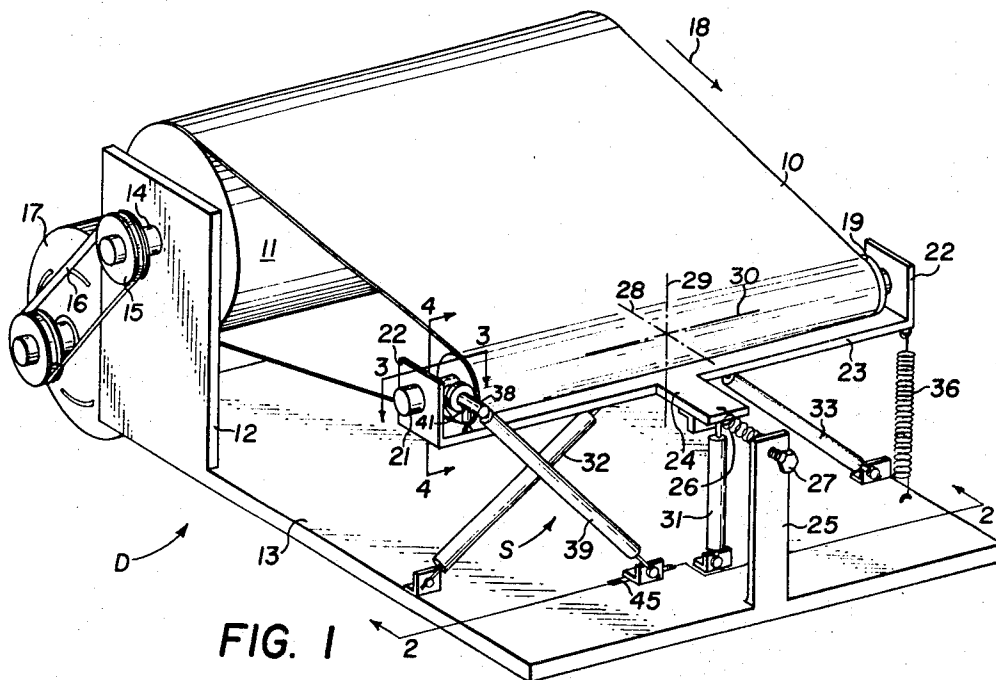


FIG. 1

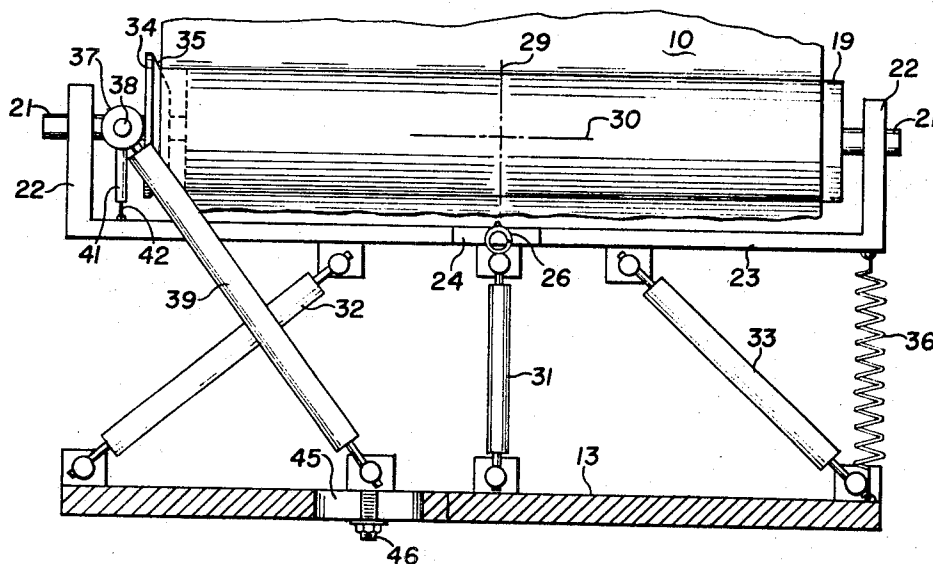


FIG. 2

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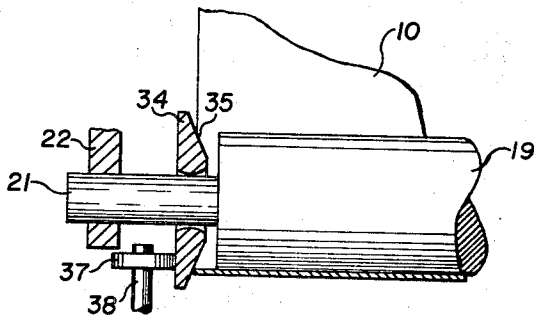


FIG. 3

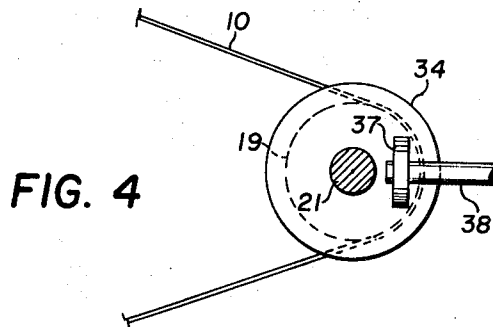


FIG. 4

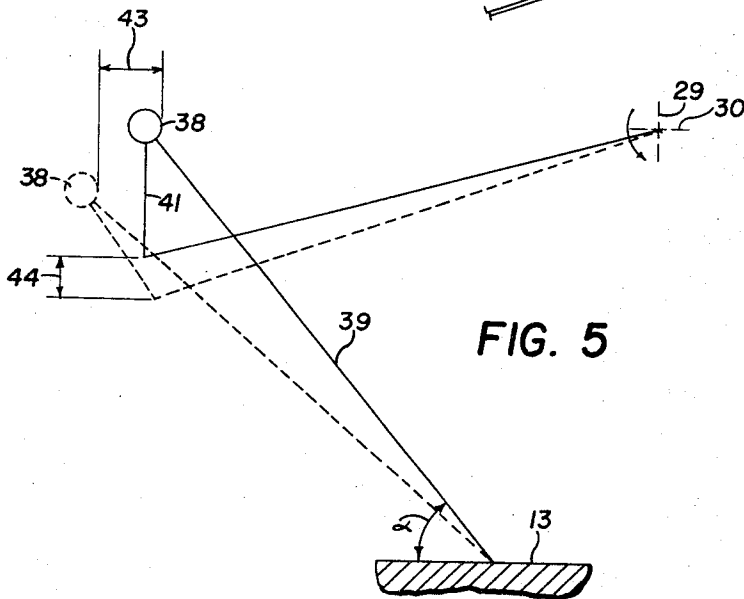


FIG. 5

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BELT-TRACKING SERVO

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a belt-tracking device, and more particularly to a belt-tracking device having a mechanical servo which pivots a roller, over which a belt extends, about a steering axis so that the belt tracks properly.

2. Description of the Prior Art

Various attempts have been made in the prior art to provide guides and suitable constraints for flexible belts or webs which are fed from a supply roll to a takeup roll. Also, similar devices have been provided for endless belts. Idler rollers have been provided which are self-aligned by a belt or web which tends to run off of one side of the rollers.

One such device is disclosed in U.S. Pat. No. 2,225,276 wherein the rollers are mounted on a pivot axis which is at approximately a 45° angle to both the steering axis and the swing axis of the roller. When the web tends to run to one side of this device, the roller will pivot about the pivot axis so as to drive the web back in the opposite direction. As used in the specification and claims, the term "steering axis" is the axis perpendicular to the roller axis passing through the midpoint of the roller and lying in the plane bisecting the included angle between adjacent portions of the web as it approaches and leaves the roller. The term "swing axis" is an axis perpendicular to both the steering axis and the roller axis and extending through the midpoint of the roller.

In a device disclosed in U.S. Pat. No. 2,653,700, a main roller is mounted in a carriage which is pivotally mounted about a vertical axis and is provided with a friction roller at the outer edge of the main roller which is engaged by the belt when it runs off the end of the roller thereby causing the carriage to be pivoted about the vertical pivot so that the main roller drives the belt back to a center position. However, neither of these devices are entirely satisfactory when used with a noncompliant belt because the tension on the belt will be uneven. Furthermore, some of the prior art systems are not very sensitive to web misalignment and must rely on a relatively gross misalignment before correction is made. Thus, the web tends to weave back and forth across the roller mechanism rather than tracking accurately. If the web is an endless belt, the roller must be able to pivot about the swing axis so that the tension across the web remains constant to facilitate proper tracking.

SUMMARY OF THE INVENTION

A web extending between two supports is basically a two dimensional device that lies in a single plane and therefore only has three degrees of freedom, *i.e.*, freedom in the direction of movement, in lateral position and in angular position. Since the position of the belt in the direction of movement is indeterminate, only two of these degrees of freedom, namely the lateral position and the angular position of the belt need be considered. The important point in properly controlling the movement of a web is not to overconstrain or underconstrain its lateral and angular movement. This means that exactly two constraints are needed on any web section between adjacent supports, such as an upstream lateral constraint only and a downstream lateral constraint only or an upstream lateral constraint and a downstream angular constraint. Proper alignment of a web is obtained with the present invention wherein the upstream portion of the web is laterally constrained by a roller or some other device over which it passes and the downstream portion of the web is laterally constrained by a downstream tracking roller, mounted in a yoke or support which does not constrain its angular position. A sensing means, such as a mechanical servo, provided adjacent one end of the downstream tracking roller causes the roller support to be pivoted about its steering axis in a direction to cause the web to move back toward the desired lateral position. When the roller is used in connection with an endless belt system, a uniform tension may be maintained across the web

by permitting the roller support also to pivot about a swing axis. Proper tension on the belt may be maintained by permitting the roller to translate along the steering axis against a resilient force, as provided by a spring. The pivotal movement about the steering axis and the swing axis and translation along the steering axis are the only degrees of freedom provided for the roller. A resilient means interconnects the roller support with the frame of the machine to cause the roller to tend to be pivoted about the steering axis so that the web tracks toward the sensing means at all times. Through a mechanical linkage between the sensing means, roller support and machine frame, the roller is pivoted in the opposite direction against the force of the resilient means so that the web is maintained continually in perfect alignment. Also, the swinging of the roller about the swing axis and translation along the steering axis will maintain proper tension even if the belt is longer on one side than on the other, such as conical, or if it varies in effective length due to a lap splice, or if it is not straight, *i.e.*, if it has a series of S-curves along its length.

Advantageously, the sensing means may include a conically faced washer which bears against the curved edge of the web as it passes around the roller. The linkage means may sense the position of the washer by a sensing wheel which engages the washer at the center of gravity of the curved web edge thereby producing a uniform and therefore minimum loading of the web edge.

Additional novel features of the invention will become apparent from the description which follows, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the servomechanism of this invention, for utilization on an endless belt;

FIG. 2 is an offset transverse section, taken along line 2-2 of FIG. 1, showing details of the servomechanism;

FIG. 3 is a fragmentary horizontal section, taken along line 3-3 of FIG. 1, showing details of the web-sensing mechanism;

FIG. 4 is a fragmentary vertical section taken along line 4-4 of FIG. 1, showing the position of the web-sensing mechanism in relationship to the edge of the web; and

FIG. 5 is a schematic representation of the angular displacement of the roller caused by lateral displacement of the web.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In accordance with this invention, the web-handling device D is provided wherein an endless web or belt 10 driven, as by a drive roller 11 around which it extends. Roller 11 is journaled in a pair of upstanding legs 12 of a frame 13, on shaft 14 to which a pulley 15 is fixedly attached. Pulley 15 is engaged by drive belt 16 connected to a drive motor 17 for driving web 10 which will be described as being driven in the direction of arrow 18.

A tracking roller 19 is journaled on a shaft 21 extending through upturned ends 22 of a yoke or roller support 23. Yoke 23 is provided with a forwardly extending tongue 24 which is connected to a leg 25 of frame 13 by means of a spring 26 which causes the roller 19 to be held in tension against web 10. This tension may be adjusted by means of adjustment screw 27 which is connected to the other end of spring 26.

Unless axis 30 of roller 19 is absolutely parallel to the axis of drive roller 11, belt 10 in time will creep to one edge or the other of roller 19 which may cause damage to the edge of the web. Since absolute accuracy is not obtainable, it is necessary to sense the lateral position of the belt and to rotate roller 19 about steering axis 28 so as to cause belt 10 to drive toward the desired lateral position.

It can be seen that three things are needed to produce a proper movement of roller 19. First, roller 19 must be mounted so as to permit the required motions but not to permit any undesired motions. Secondly there must be a means for sensing the lateral position of the belt on roller 19. And finally there must be a means for coupling the lateral belt mo-

tion to the movement of roller 19 about steering axis 28 in the proper direction to correct the lateral movement of the belt.

From FIG. 1, it can be seen that roller 19 needs to twist or pivot about steering axis 28 to drive the belt in a lateral direction. In order to apply tension to the belt, the roller must be able to translate in a direction along axis 28. Finally, in order for the tension to be uniform across the belt, roller 19 must be able to pivot about swing axis 29. However, these are the only degrees of freedom which can be permitted. Any additional degrees of freedom will cause the belt to be underconstrained.

To accomplish this result, roller 19 is supported in yoke 23 which is mounted on three flexure legs or links 31, 32 and 33. Each flexure leg consists of a stiff rod with a spring wire flexure pivot at each end thereof as shown. Leg 31, which extends between frame 13 and tongue 24, prevents rotation of yoke 23 about the roller axis but does not interfere with any other motions of the roller or yoke. The back flexure legs 32 and 33 form a virtual pivot at the center of roller 19, as can best be seen in FIG. 2, and prevents movement of the roller up and down or sideways but permits rotation about steering axis 28 and swing axis 29 and permits translation toward or away from drive roller 11 to adjust belt tension.

The lateral position of the belt is sensed, as best seen in FIGS. 2-4. Tracking roller 19 is undercut as at the left end, as viewed in FIG. 2, so that the edge of belt 10 protrudes over the end thereof and engages a washer 34 loosely journaled on shaft 21, as in FIG. 3. The washer has an inner conical surface 35 which engages the protruding edge of belt 10 as it passes around roller 19. A spring 36 extending from the right end of yoke 23, as viewed in FIGS. 1 and 2, to frame 13 tends to rotate the yoke and hence roller 19 about steering axis 28 in a clockwise direction thereby causing belt 10 to track to the left so that it always engages conical surface 35 of washer 34.

Since the belt is formed into a cylindrical shape as it passes around roller 19, the curved belt edge has considerable lateral strength over this circumferential distance and the conical surface 35 touches belt 10 only over this curved support area. As the belt moves around roller 19, washer 34 will turn therewith so no relative movement exists between it and the belt edge. A pressure roller 37 of servomechanism S touches washer 34 at the center of gravity of the curved belt edge as best seen in FIG. 4 which produces a uniform, and therefore a minimum, loading of the web edge. The center of gravity is always within this stable support area so that the washer, which is loosely journaled on shaft 21, automatically aligns itself against the edge of the belt and needs no other positioning except for a rough radial positioning produced by the loose fit on shaft 21.

Roller 37 is rotatably mounted on a sensing shaft 38 which is connected to a servoarm 39 by a flexure hinge, the opposite end of arm 39 being connected to frame 13 by another flexure hinge as shown best in FIG. 2. Sensing shaft 38 is also attached to one end of a vertical arm 41 whose opposite end is attached by means of a flexure hinge 42 to yoke 23. As can be seen best in FIG. 5, any horizontal motion of belt 10 will cause sensing shaft 38 to be moved horizontally, such as distance 43, which in turn causes a vertical movement of arm 41 through a distance, such as distance 44. Since arm 41 is connected to yoke 23, it can be seen that this vertical movement 44 will cause the yoke 23 and hence the roller 19 to pivot about steering axis 28 in a counterclockwise direction, as viewed in FIGS. 1, 2, and 5. This movement will cause the belt to move to the right and correct the misalignment. Because of the continuing force exerted by spring 36, servomechanism S continues to operate thereagainst so that belt 10 is always held in aligned position and does not swing back and forth from one side of an alignment position to the other.

If the belt were to be driven in the opposite direction, such as the direction opposite to that of arrow 18 of FIG. 1, then servoarm 39 would have to be in a quadrant adjacent to the quadrant it is in in FIGS. 1 and 2 to provide a negative feedback to roller 19 causing it to turn in a clockwise direction about steering axis 28 as viewed in the drawings.

The angle α of servo arm 39 determines the coupling factor between the lateral misalignment of the belt and the steering angle correction which is introduced. Thus, angle α determines the mechanical gain of the system. If angle α were 0° , the amount of steering axis rotation per unit of web misalignment is infinite. On the other hand, if angle α is 90° , the amount of steering axis rotation per unit of web misalignment is zero.

The lateral position of the lower end of arm 39 on base 13 determines the lateral tracking position for the web in that it determines the lateral position of the web edge-sensing means wherein the tracking roller has no further steering action, thereby providing a stable web position. To this end, a slot 45 may be provided in base 13 through which a bolt 46 extends, as seen in FIG. 2 to provide a means for making this adjustment.

From the foregoing, it can be seen that the novel features and advantages of this invention are readily apparent. A mechanical servomechanism has been provided which assures proper tracking of a web passing thereover at all times. The tracking roller is restrained so as to provide only the desired movements without providing any undesirable movements. Thus, through the mechanical linkage arrangement shown, the roller is permitted to translate in the direction of the web or to rotate about either the steering axis or swing axis. Translation of the roller facilitates adjusting the tension of the belt whereas rotation about the swing axis assures that this tension is the same across the entire width of the belt. Rotation about the steering axis adjusts the lateral position of the web. The mechanical servo through the conical washer senses the position of the belt and due to the linkage arrangement shown causes the roller to pivot about the steering axis in a direction which will tend to cause the belt to track toward the desired position. The belt is spring urged toward the servo by spring 36 in that spring 36 causes the roller to pivot in a direction to cause the belt to move toward the servomechanism. Thus, once the belt is aligned, it will stay in alignment and will not swing back and forth across the aligned position.

The invention has been described in considerable detail with reference to a preferred embodiment thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

We claim:

1. A web-tracking device for aligning a web which is adapted to come into engagement with said device along an approach plane and is adapted to leave said device along an exit plane at an included angle to said approach plane, said device comprising:

a roller mounted for rotation about a longitudinal axis and engageable by said web, said roller being pivotable about a steering axis extending through the midpoint of said roller, perpendicular to said longitudinal axis and lying in a plane substantially bisecting said included angle between said approach plane and said exit plane;

means biasing said roller for pivotal movement about said steering axis in one direction to cause said web to move laterally toward one end of said roller; and

servo means at said roller mechanically coupled to said roller, said servo means being engageable by and responsive to said lateral movement of said web at said roller to pivot said roller in the opposite direction about said steering axis to cause said web to move laterally toward the other end of said roller.

2. A web-tracking device, as claimed in claim 1, wherein said roller is journaled in a support mounted on a frame for pivotal movement about said steering axis and wherein the included angle is substantially less than 180° so that said web is engageable with a circumferential portion of said roller to form a curved edge, said servo means including:

sensing means including means engageable and movable with a curved portion of said web edge;

a first link having a first end rigidly connected to said sensing means and having a second end pivotally connected to said roller support; and

5 a second link having opposite ends pivotally connected to said sensing means and said frame, respectively, at an acute angle to said roller axis.

3. A web-tracking device, as claimed in claim 2, wherein said sensing means includes:

a washer mounted for rotation about said longitudinal axis and engageable with said curved portion of said web edge so as to move therewith as said web passes around said roller; and

a sensor engageable with said washer to sense the position thereof.

4. A web-tracking device, as claimed in claim 3 wherein said sensor includes:

a shaft connected to said first and second links; and

a sensing wheel rotatably mounted on said shaft engageable with said washer at the center of gravity of said curved belt edge.

5. A web-tracking device, as claimed in claim 3, wherein said washer includes a beveled edge engageable with said curved portion of said web.

6. A web-tracking device for aligning a web passing therearound, said device comprising:

a base;

a roller having a peripheral surface and being rotatable about a longitudinal axis, said web being extendable around a portion of the peripheral surface of said roller, wherein said web approaches said roller along an approach plane and leaves said roller along an exit plane at an included angle to said approach plane, and pivotable about a steering axis extending through the center of said roller perpendicular to said longitudinal axis and lying in a plane bisecting said included angle and further pivotable about a swing axis perpendicular to said steering axis and said longitudinal axis;

a yoke rotatably supporting said roller between opposite ends thereof; 3

means supporting said yoke on said base for only 3 degrees of movement of said roller, namely:

rotation about said steering axis; translation along said steering axis; and rotation about said swing axis;

means for changing the position of and force exerted on said roller along said steering axis;

biasing means connecting said yoke to said base tending to pivot said roller in one direction about said steering axis; and

servo means connected to said yoke responsive to lateral movement of said web to pivot said roller about said steering axis in the opposite direction against said biasing means.

7. A web-tracking device, as claimed in claim 6, wherein said position changing means includes:

resilient means interconnecting said yoke and said base exerting a force on said yoke along said steering axis; and means for adjusting the force exerted by said resilient means to translate said roller along said steering axis, said roller being pivoted about said swing axis in response to any variation in force exerted across said roller by said web until said force is equalized across said roller.

8. A web-tracking device, as claimed in claim 6, wherein

said yoke has a central tongue extending generally transverse thereto to which said position changing means is attached, and said yoke-supporting means includes:

first and second spaced legs each having a first end pivotally connected to said base and a second end pivotally connected to said yoke so that a line along the axis of each leg intersects at the intersection of said longitudinal axis, said steering axis and said swing axis; and

a third leg having a first end pivotally connected to said base and a second end pivotally connected to said tongue.

9. A web-tracking device, as claimed in claim 8, wherein said servo means further includes:

web-sensing means mounted on said longitudinal axis movable along said axis in response to lateral web movement;

position sensing means engageable with and responsive to axial movement of said web-sensing means pivotally connected to said yoke and said base for pivoting said roller about said steering axis against the force of said biasing means to align said web.

10. A web-tracking device for lateral alignment of a web passing therearound, said device comprising:

a base;

a roller rotatable about a longitudinal axis and having a peripheral surface around which said web is extendable, wherein said web approaches said roller along an approach plane and leaves said roller along an exit plane at an included angle to said approach plane, said roller being pivotable about a steering axis extending through the center of said roller perpendicular to said longitudinal axis and lying in a plane bisecting said included angle, said roller being further pivotable about a swing axis perpendicular to both said longitudinal axis and said steering axis, all of said axes intersecting at a common point;

a yoke having an outwardly extending tongue, said yoke rotatably supporting said roller along said longitudinal axis between opposite ends thereof;

first and second spaced legs, each having a first end pivotally connected to said base and a second end pivotally connected to said yoke, so that a line along the axis of each leg intersects at said common point;

a third leg having a first end pivotally connected to said base and a second end pivotally connected to said tongue;

spring means interconnecting said yoke and said base, said spring means having means adjusting the force exerted by said spring means tending to translate said roller along said steering axis against the force exerted against said roller by said web;

biasing means connecting said yoke to said base tending to pivot said roller in one direction about said steering axis;

web-sensing means rotatably mounted on said longitudinal axis adjacent the other end of said yoke, movable along said longitudinal axis in response to lateral web movement; and

position sensing means engageable with and responsive to axial movement of said web-sensing means, said position-sensing means being connected to said yoke and said base for pivoting said roller about said steering axis against said biasing means to laterally align said web in response to misalignment thereof.