United States Patent [19]

Moneagle et al.

[11] **3,759,456**

[45] **Sept. 18, 1973**

[54] **RIBBON FEED AND CORRECTION DEVICE FOR A HIGH SPEED PRINTER**

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[73] Assignee: **International Business Machines Corporation**, Armonk, N.Y.

[22] Filed: **June 23, 1971**

[21] Appl. No.: **155,925**

[52] **U.S. Cl.** **242/57.1**
[51] **Int. Cl.** **B65h 25/26**
[58] **Field of Search** .... 242/57.1, 57, 67.3 R, 242/54 R, 55; 226/3, 18, 21, 22, 23; 250/202, 250/219 R, 219 DR, 219 WE

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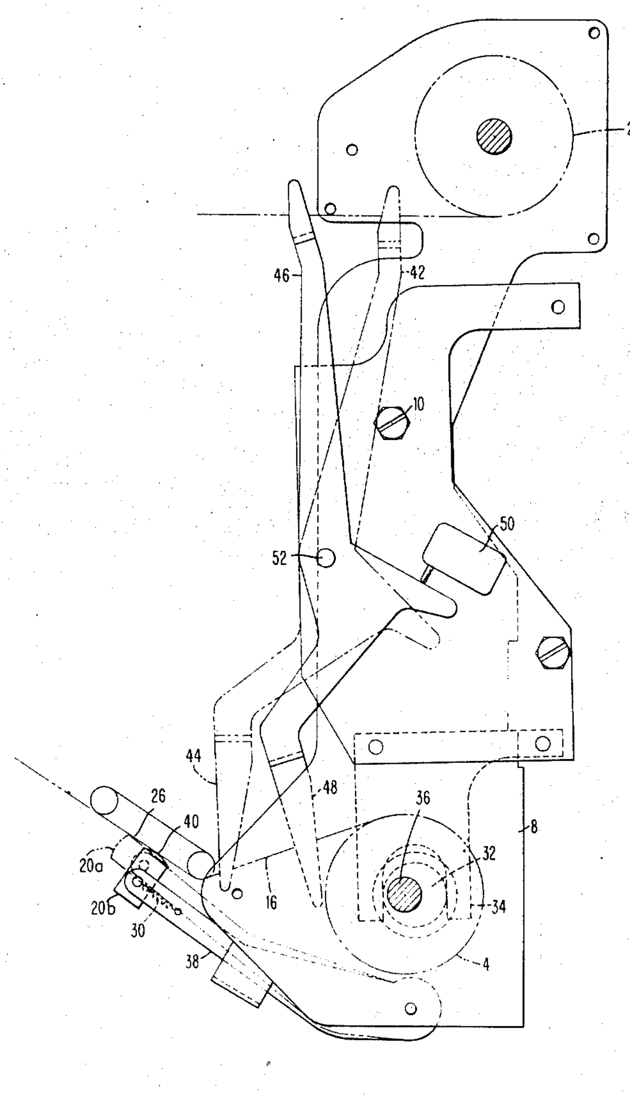
[57] **ABSTRACT**

A ribbon correction device aligns a web by deliberately skewing a pair of pivoted winding spools to steer the ribbon continuously toward a given median point along the axis of a spool. The device automatically compensates for the effect of a change in the direction of rotation of the winding spool, by means of a single sensing device.

9 Claims, 14 Drawing Figures



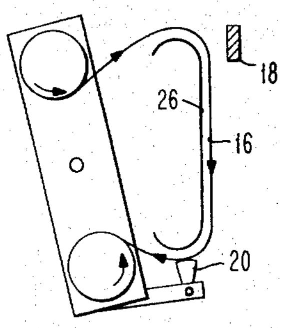


FIG. 1a

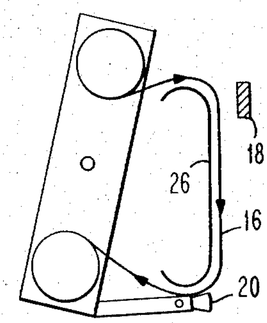


FIG. 1b

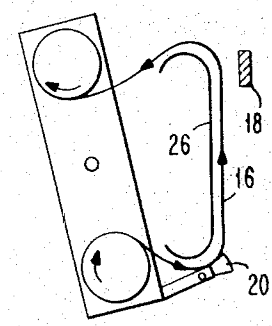


FIG. 1c

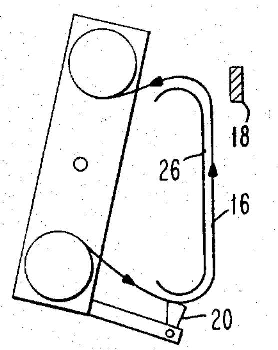


FIG. 1d

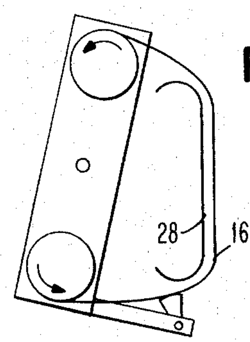


FIG. 1e

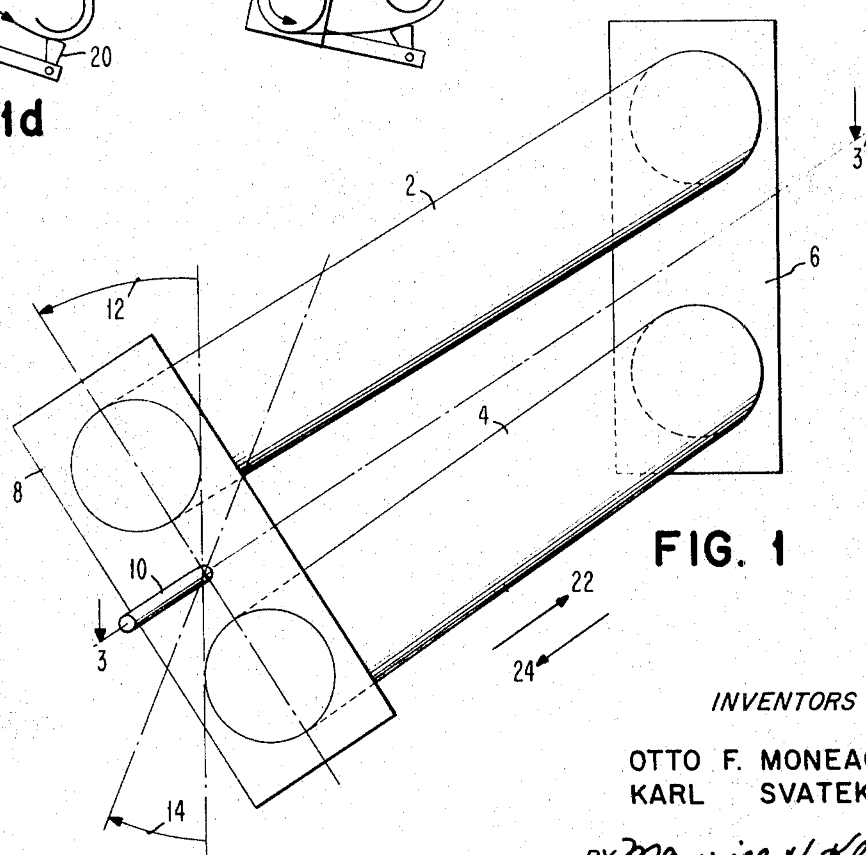


FIG. 1

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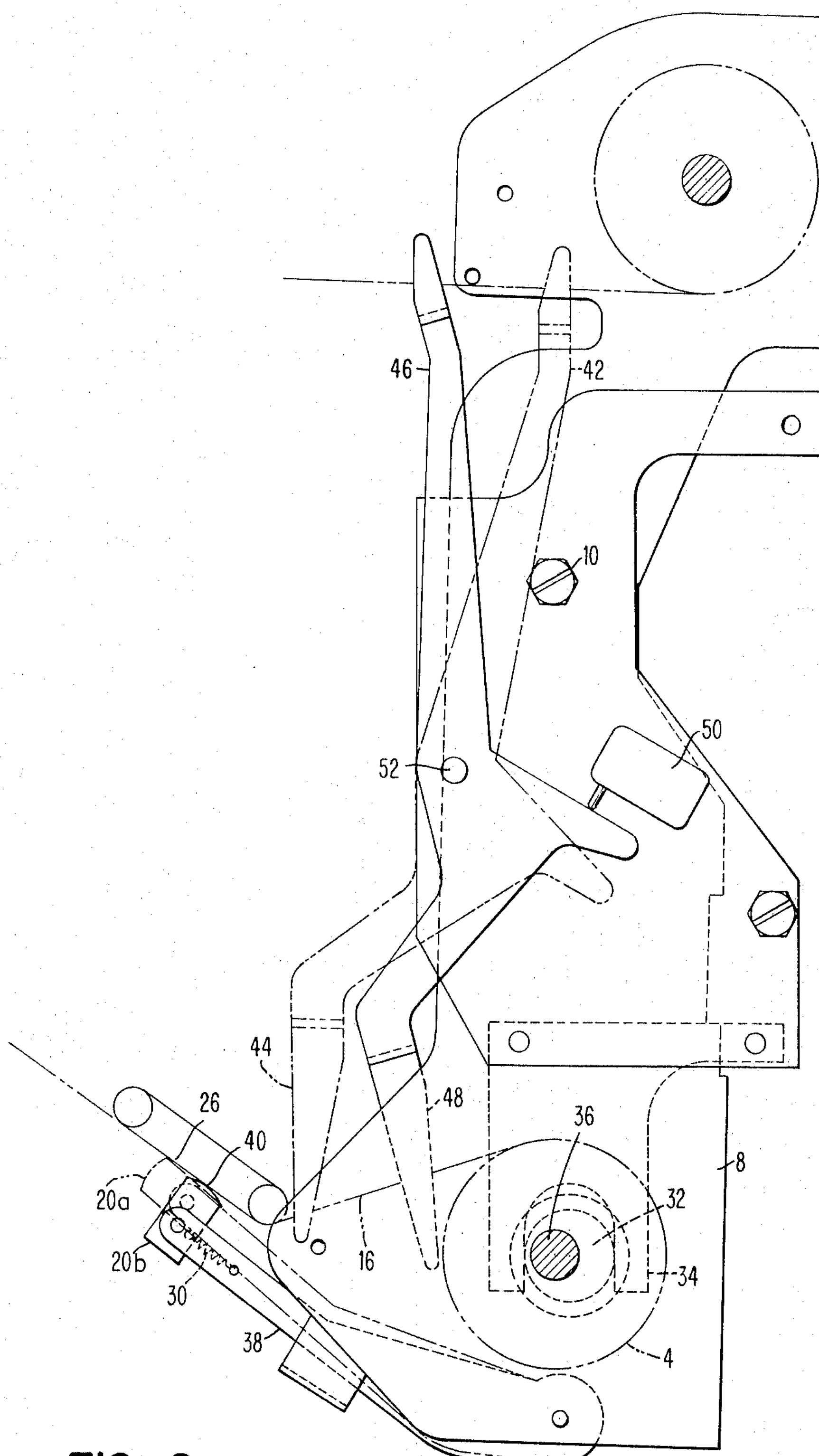
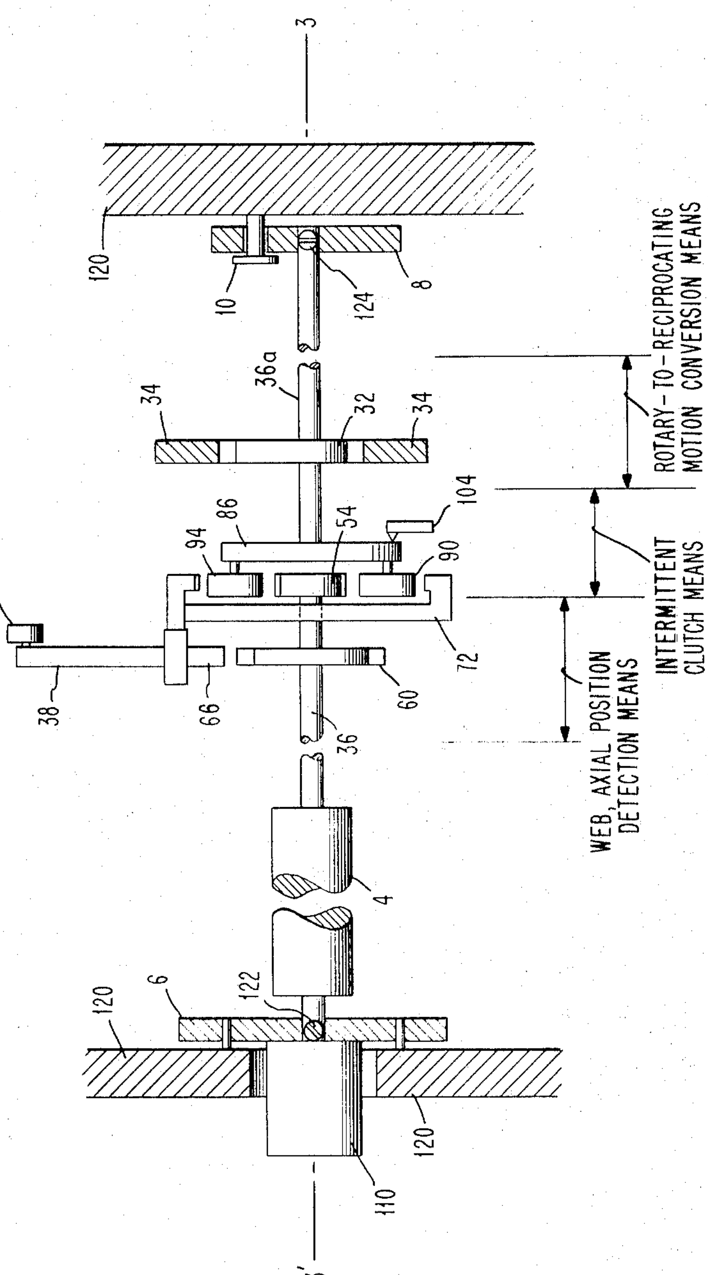


FIG. 2

FIG. 3


ROTARY-TO-RECIPROCATING MOTION CONVERSION MEANS
INTERMITTENT CLUTCH MEANS
WEB, AXIAL POSITION DETECTION MEANS

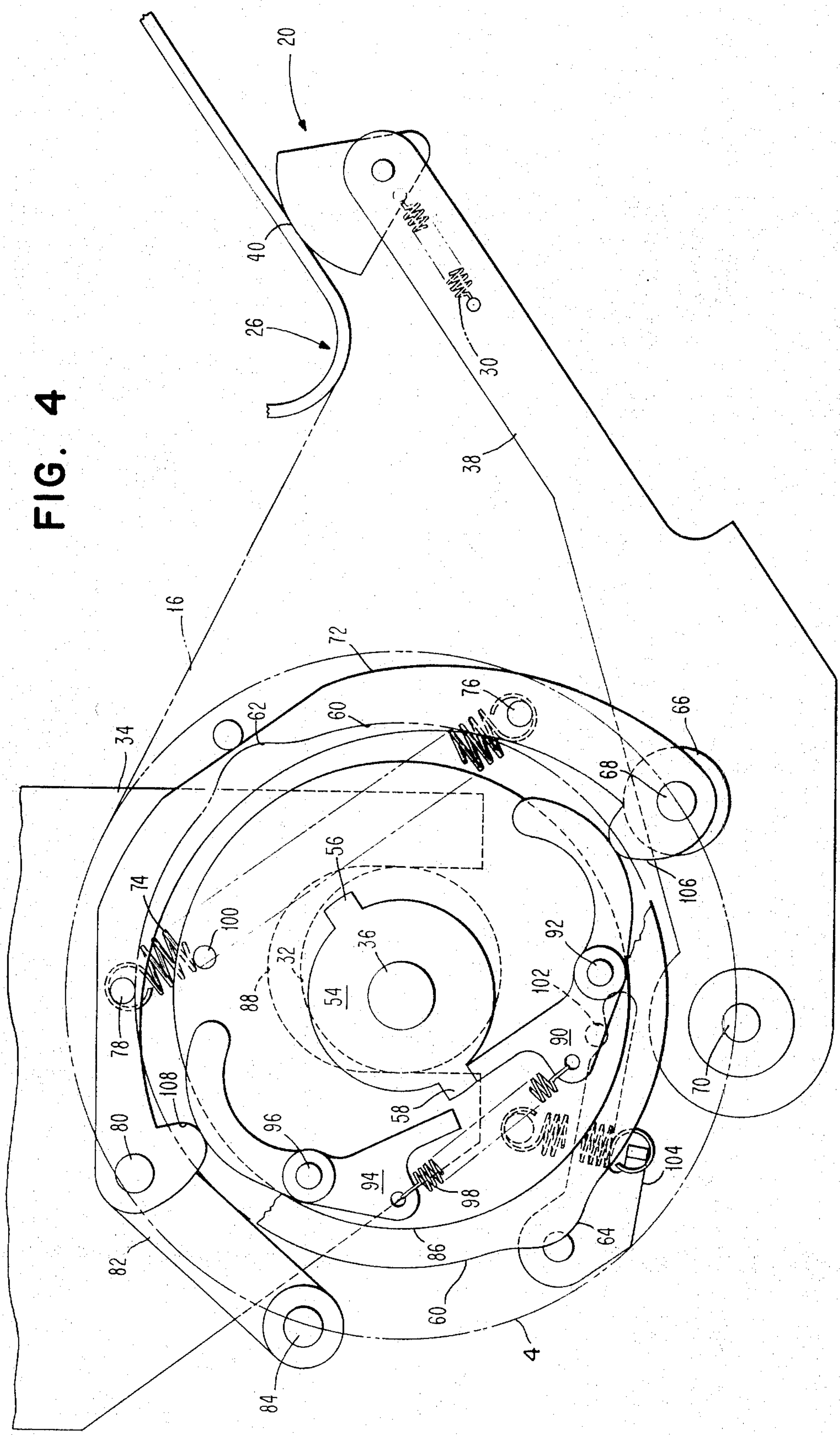

20
40
26
30
38
16
72
34
62
60
76
66
68
56
106
74
100
36
92
32
88
54
102
78
90
108
58
70
80
96
94
98
104
64
86
60
82
4
84

FIG. 4

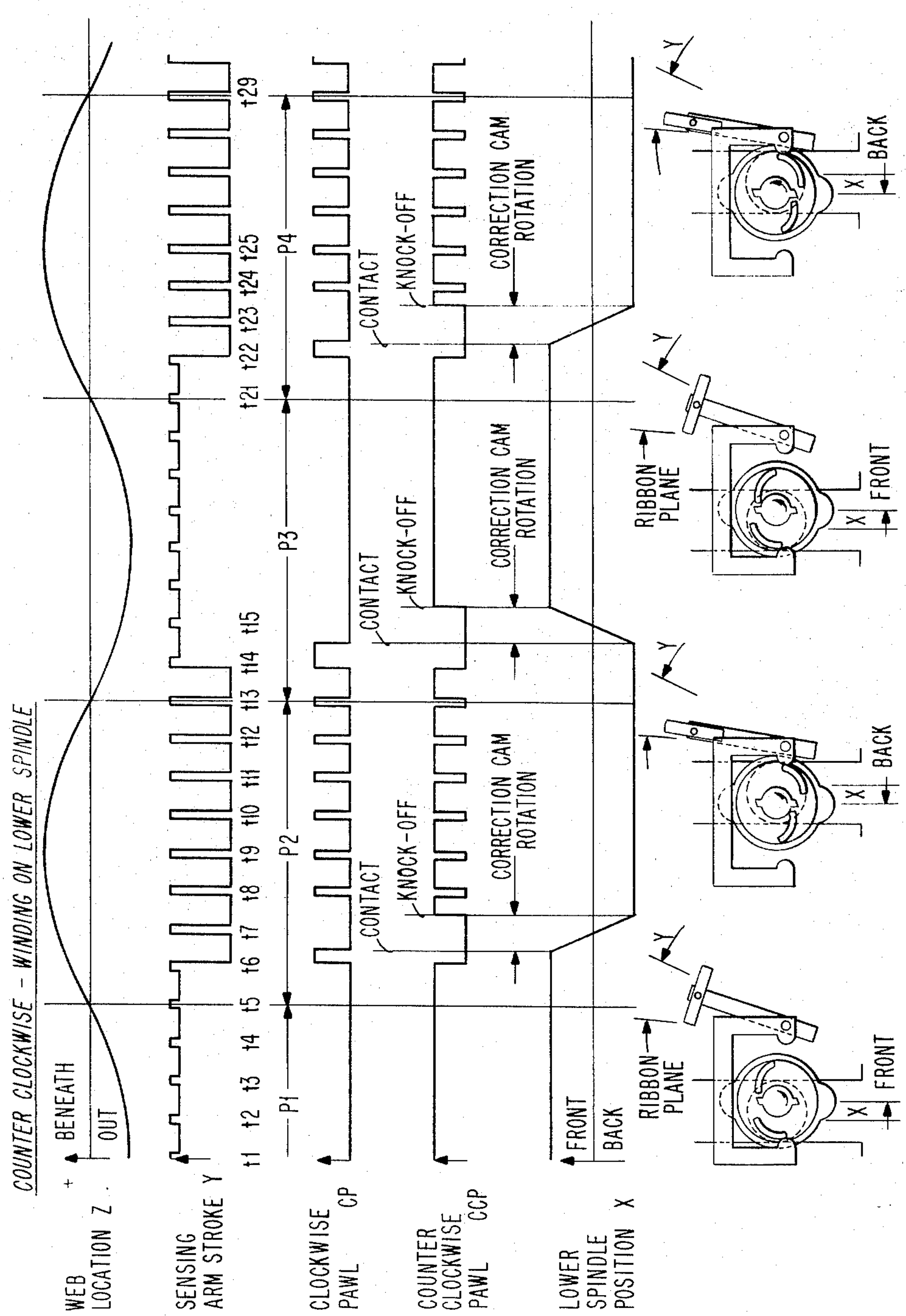

COUNTER CLOCKWISE - WINDING ON LOWER SPINDLE
WEB LOCATION Z
BENEATH
OUT
SENSING ARM STROKE Y
CLOCKWISE PAWL CP
COUNTER CLOCKWISE PAWL CCP
LOWER SPINDLE POSITION X
FRONT
BACK
t1 t2 t3 t4 t5 t6 t7 t8 t9 t10 t11 t12 t13 t14 t15 t21 t22 t23 t24 t25 t29
P1
P2
P3
P4
CONTACT
KNOCK-OFF
CORRECTION CAM ROTATION
RIBBON PLANE
Y
X
FRONT
BACK

FIG. 5

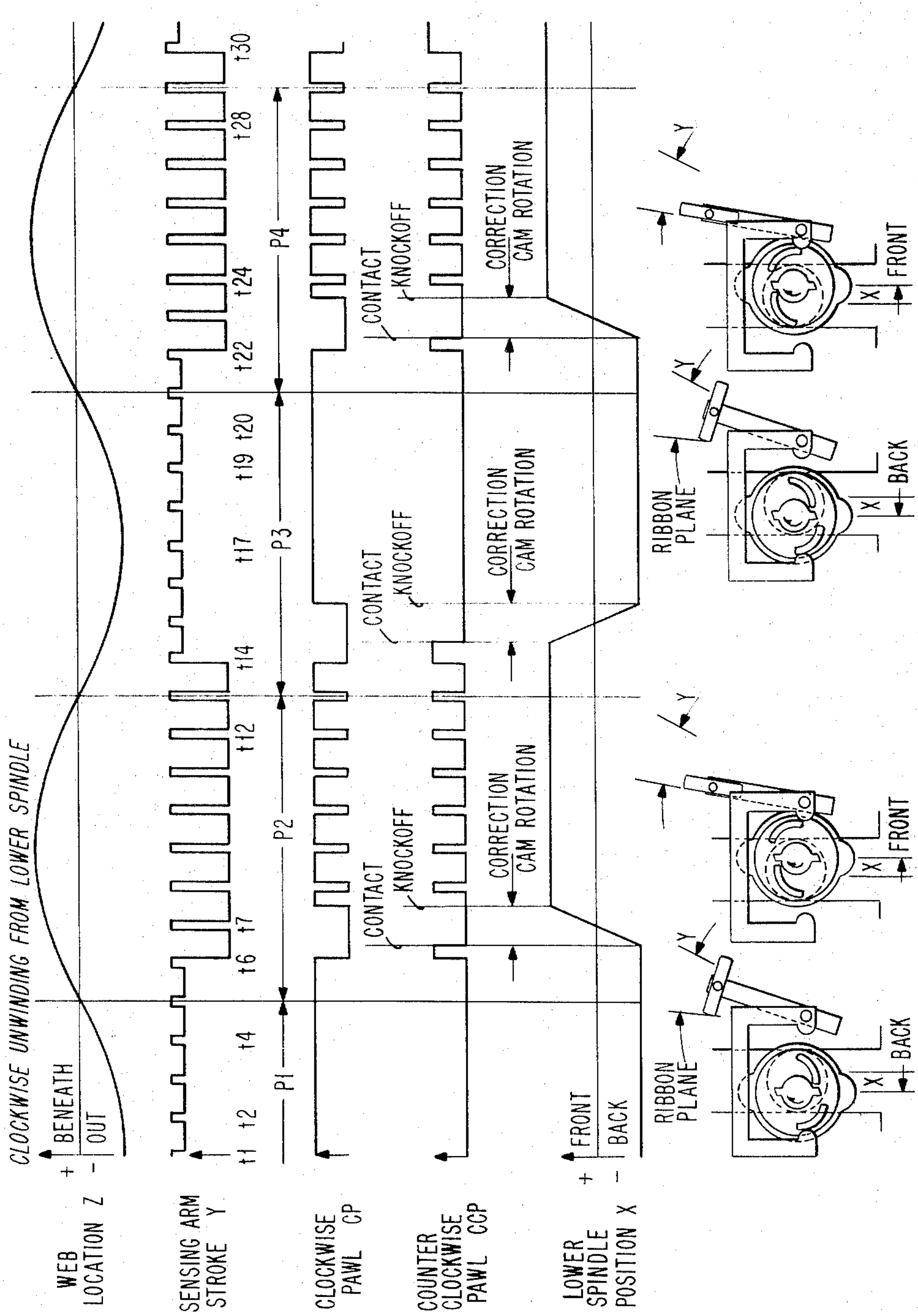

CLOCKWISE UNWINDING FROM LOWER SPINDLE
WEB LOCATION Z
BENEATH
OUT
SENSING ARM STROKE Y
CLOCKWISE PAWL CP
COUNTER CLOCKWISE PAWL CCP
LOWER SPINDLE POSITION X
FRONT
BACK
t1 t2 t4 t6 t7 t12 t14 t17 t19 t20 t22 t24 t28 t30
P1
P2
P3
P4
CONTACT
KNOCKOFF
CORRECTION
CAM ROTATION
RIBBON PLANE
Y
X

FIG. 6

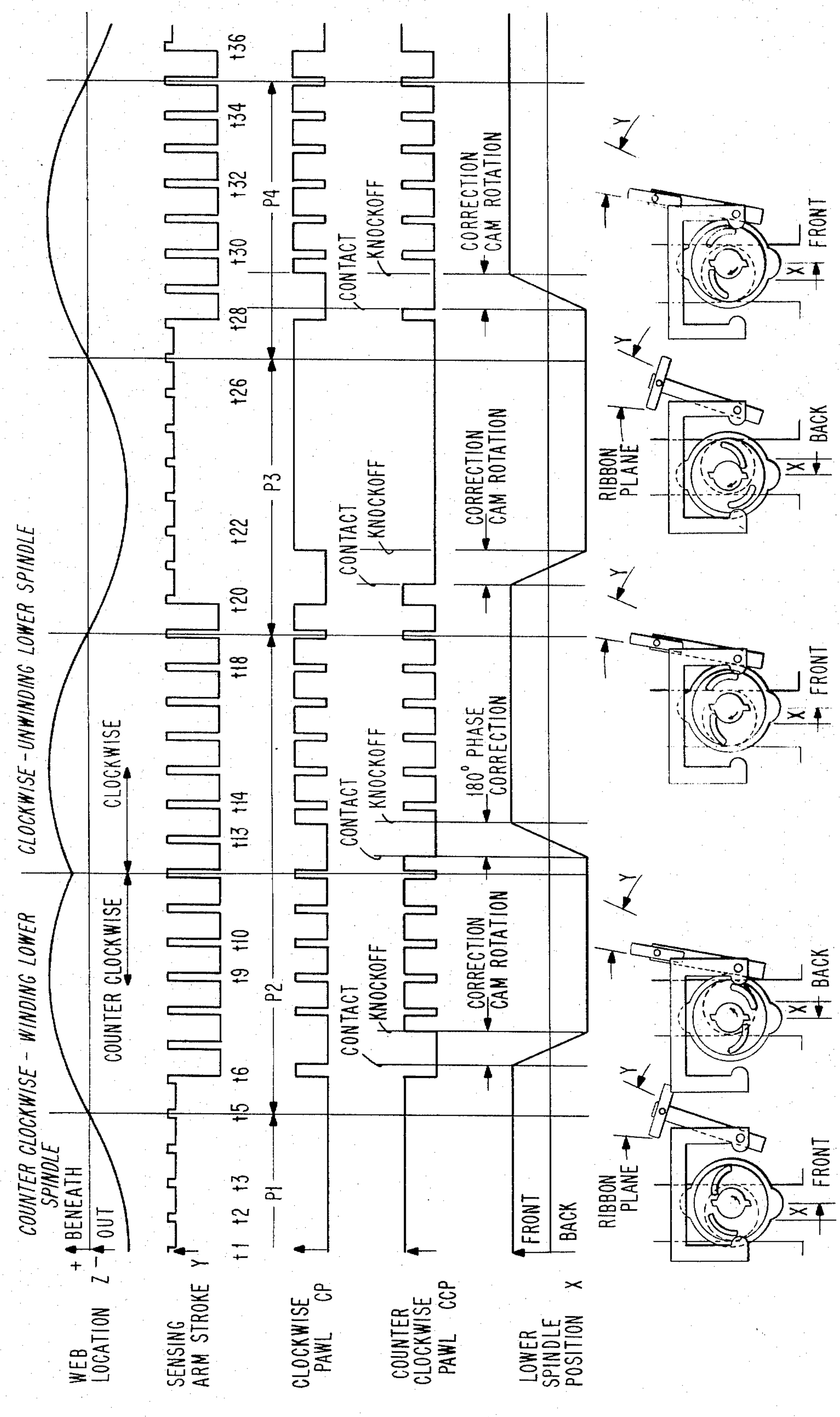

WEB LOCATION Z
+ BENEATH
- OUT
SENSING ARM STROKE Y
CLOCKWISE PAWL CP
COUNTER CLOCKWISE PAWL CCP
LOWER SPINDLE POSITION X
FRONT
BACK
COUNTER CLOCKWISE - WINDING LOWER SPINDLE
CLOCKWISE - UNWINDING LOWER SPINDLE
COUNTER CLOCKWISE
CLOCKWISE
t1 t2 t3 t5 t6 t9 t10 t13 t14 t18 t20 t22 t26 t28 t30 t32 t34 t36
P1
P2
P3
P4
CONTACT
KNOCKOFF
CORRECTION CAM ROTATION
180° PHASE CORRECTION
RIBBON PLANE
FRONT
BACK
Y
X

FIG. 7

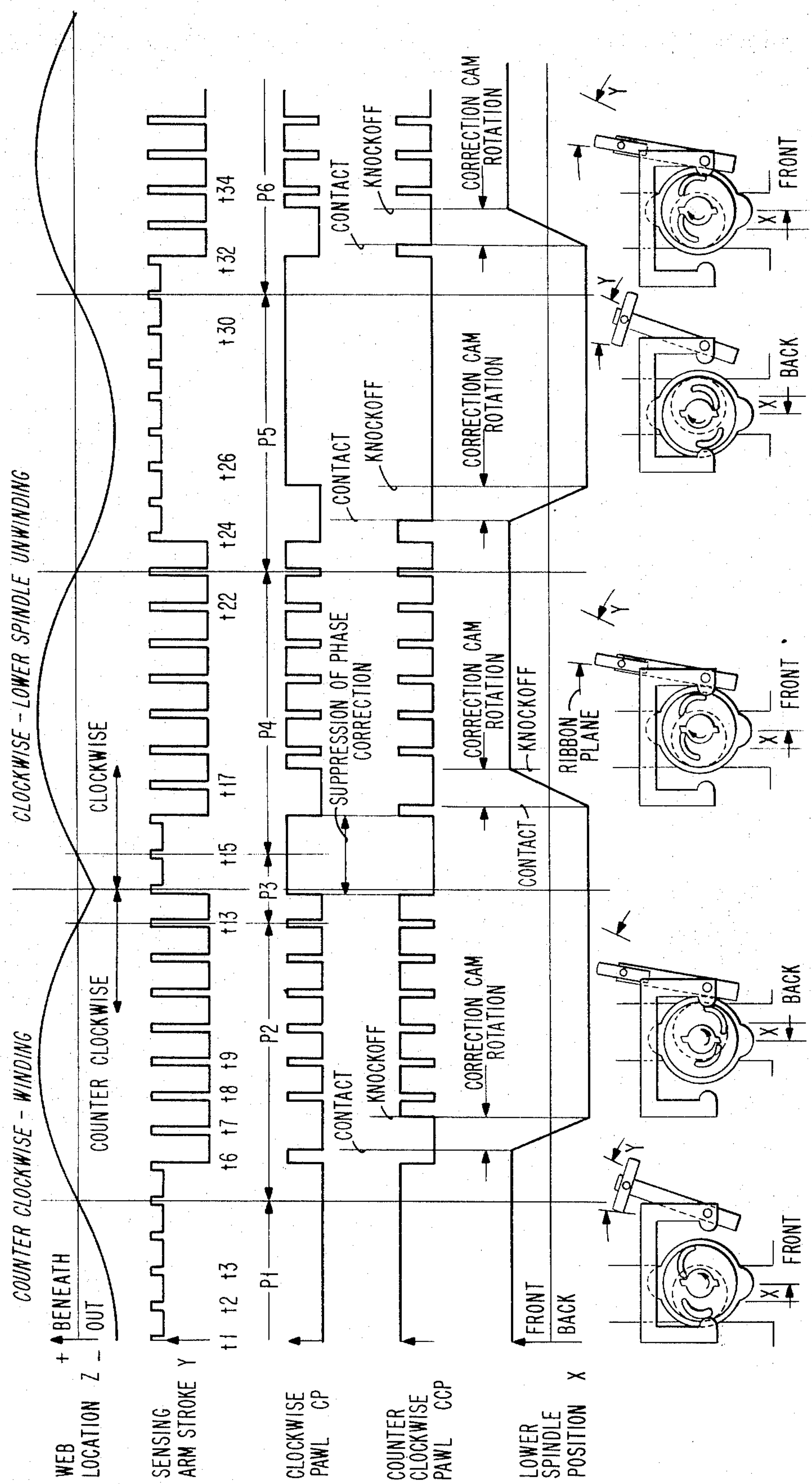
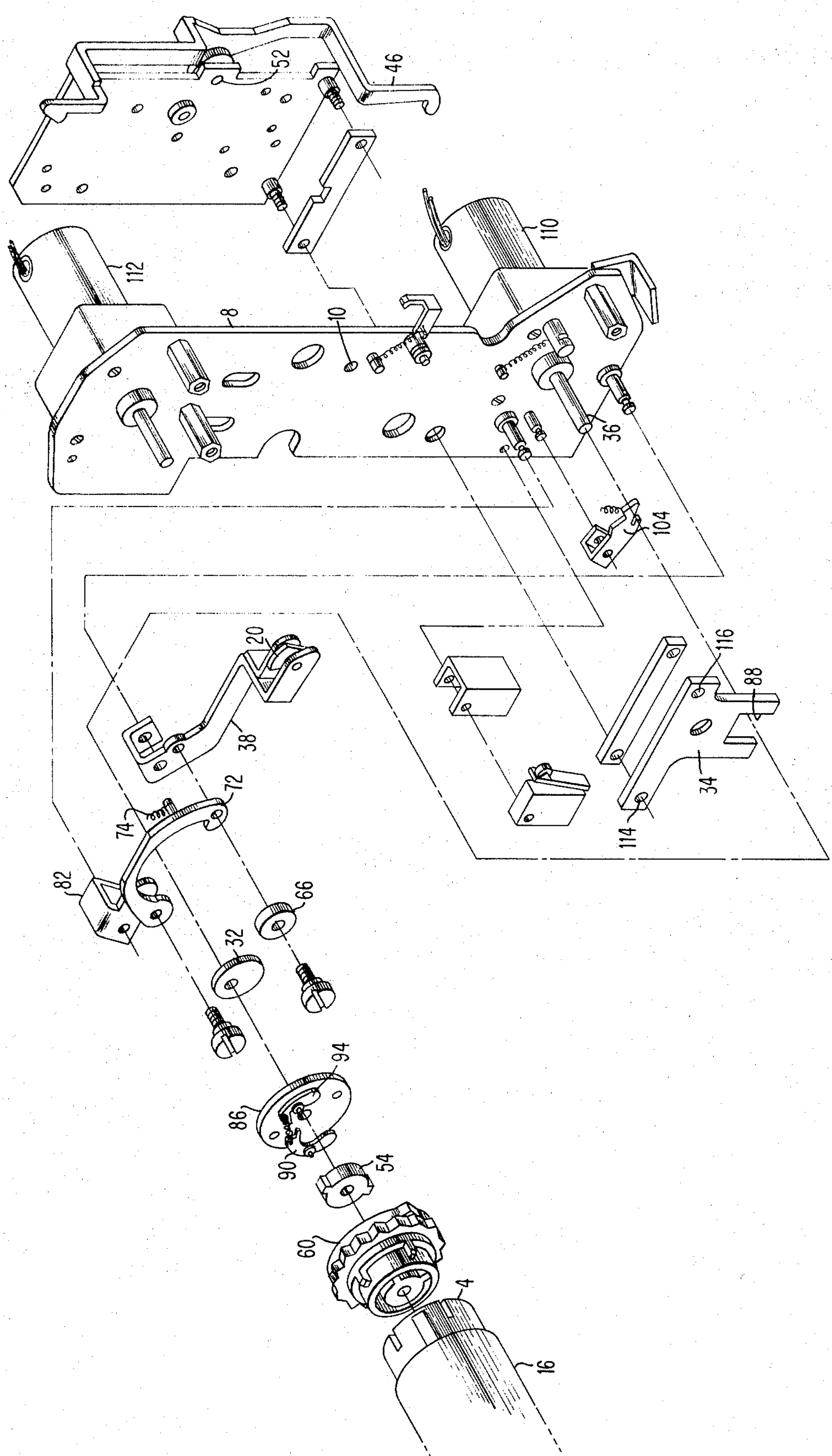

WEB LOCATION Z
+ BENEATH
– OUT
SENSING ARM STROKE Y
CLOCKWISE PAWL CP
COUNTER CLOCKWISE PAWL CCP
LOWER SPINDLE POSITION X
FRONT
BACK
COUNTER CLOCKWISE - WINDING
CLOCKWISE - LOWER SPINDLE UNWINDING
COUNTER CLOCKWISE
CLOCKWISE
t1 t2 t3 t6 t7 t8 t9 t13 t15 t17 t22 t24 t26 t30 t32 t34
P1 P2 P3 P4 P5 P6
CONTACT
KNOCKOFF
SUPPRESSION OF PHASE CORRECTION
CORRECTION CAM ROTATION
RIBBON PLANE
X
Y

FIG. 8


52
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110
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10
36
104
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38
116
88
34
114
72
74
82
66
32
94
86
90
54
60
4
16

FIG. 9

RIBBON FEED AND CORRECTION DEVICE FOR A HIGH SPEED PRINTER

BACKGROUND OF THE INVENTION

Broad webs such as a printer ribbon of woven fabric will stretch unevenly during the winding process even if constant tension is applied. Trail-off is the tendency of the web to move across the spool when being wound thereupon. Heretofore, compensation for the consequent axial trail-off of the web was accomplished by one or more of the following methods. (1) An axial displacement of the entire spool was effected to produce a corrective force on the web. (2) A tension idler was brought to bear upon one edge of the web to force the web to migrate in the direction of lesser longitudinal tension. (3) One or both winding spools was pivoted so as to move in the direction of winding thus causing a gradient in the longitudinal tension across the width of the web, the web then responding by migrating in the direction opposite to the gradient. (4) A pair of steering rollers woluld be positioned along the length of the web and laterally displaced in opposite directions, thus causing an axial gradient in the longitudinal tension in the web, forcing it to move in the direction opposite to the gradient. All of the above techniques have the disadvantage of periodically imposing high stresses and strains in the fabric of the web, thus shortening the life of the ribbon. Other approaches to trail-off correction have included auxiliary, pivoted, steering roller mechanisms in addition to the winding spools. But in every case the mechanical mechanism for effecting the trail-off correction requires a large number of parts and employs electronic or hydraulic sensing means for detecting the axial position of the web, and for instituting the mechanical displacement necessary to correct, therefor. Electronic or hydraulic sensors are costly and space consuming, with their associated power supplies, fluid reservoirs, etc. In electronic detection of the web position where photodetectors are employed, one disadvantage is the tendency of such photodetectors to accumulate ink and paper debris, thus causing them to erroneously signal the presence of a printer ribbon and in fact initiate an erroneous correction.

The high speed printers employed as input/output equipment for computers, run at speeds of 2,000 plus printed lines per minute. The ribbons employed in such printers are as wide as the document printed, and must move longitudinally across the print line at speeds comparable to that of the document itself. Such ribbons, repeatedly exposed to high impact hammer blows during the course of the printing operation, have a wear rate which exceeds that in less demanding applications. Where trail-off correction techniques are employed, which induce tension gradients across the width of the ribbon in order to correct for lateral displacements, the wear rate of the ribbon increases.

Upon reversal, the direction of traversal of the web along the spool reverses. This behavior is called a 180° phase shift in the trail-off direction. The prior art teaches that detection mechanisms for correction of traversal under this condition must be duplicated, one at each end of the spool. Heretofore, solution of this problem was accomplished by complex electronic apparatus employing a multiplicity of photoelectric sensors. Differential tensioning techniques have also been employed with their attendant high wear producing characteristics. Although the prior art devices are adequate for general purpose spooling of broad webs, no simple, reliable device having a small number of parts, has yet been devised to compensate for the trail-off in bi-directional winding applications such as the spooling of high speed printer ribbons.

OBJECTS OF THE INVENTION

An object of the invention is to provide a simplified and improved means for effecting a trail-off correction in a web being wound upon a spool.

Another object of the invention is to more reliably accomplish trail-off correction for a ribbon in a high speed printer than heretofore accomplished by prior art devices.

Another object of the invention is to automatically correct with a single device, for trail-off of a web on a spool when winding in either direction.

These and other objects of the invention will become apparent to those skilled in the art from the more detailed description which follows.

SUMMARY OF THE INVENTION

The trail-off of the broad ribbon web in a high speed printer is simply and effectively compensated for by the subject invention, by means of controllably changing the state of relative skew between the play-out spool and the take-up spool. The play-out spool and the take-up spool are pivotally and rotatably mounted in a twistable frame such that alternate states of twist in the frame will impart alternate states of relative skew between the spools. Each of the two spools can alternately assume the role of take-up spool or play-out spool. The spools are rotatably driven by a motor, and an end of web reversing means reverses the direction of drive of the motor when the end of the web is detected before playing off either spool. The twist which imparts the trail-off correction is brought about by a rotary-to-reciprocating motion conversion means which is intermittently driven by an intermittent clutch means at such times when a web axial-position detection means senses a change in the axial position of the web as it is wound upon either the first or the second spool. The web is thereby steered into alternate directions of axial motion as the take-up spool and the play-out spool assume their alternate states of relative skew, as is controlled by the web axial-position detection means. By means of the coaction of these elements, the printer ribbon web may be evenly wound on either spool, automatically.

The invention accomplishes the web axial trail-off correction function in an improved manner by not imparting a gradient in the longitudinal tension across the web, thus conferring a longer life to printer ribbons. Furthermore, the axial trail-off correction function is accomplished by the invention with a smaller number of mechanical parts than has heretofore been accomplished by prior art devices. In addition, the invention accomplishes the trail-off correction function automatically, without regard to changes in the winding direction.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a simplified diagram of the relative position of the first and second winding spools during both a winding and unwinding operation.

FIG. 1*a* through 1d show the preferred web winding configuration.

FIG. 1*e* shows an alternate web winding configuration.

FIG. 2 is a detailed drawing indicating the relative position of the spools, correction cam, and sensing arm.

FIG. 3 is a semi-schematic diagram depicting the working relationship of the elements of the invention.

FIG. 4 depicts in detail the relative positions of the double pawl clutch, correction cam, sensing cam, sensing arm, web and lower spool.

FIG. 5 is a timing diagram indicating how the trail-off correction is effected for counter-clockwise motion of the lower spool.

FIG. 6 is a timing diagram indicating how the trail-off direction is effected during clockwise rotation of the lower spool.

FIG. 7 is a timing diagram indicating how the 180° phase shift correction is effected when the edge of the web is not at the reference point.

FIG. 8. is a timing diagram indicating how the simultaneous 180° phase shift correction and the web trail-off correction are effected when the edge of the web is at the reference point at the time of the change in direction of rotation.

FIG. 9 is an exploded view of the elements in the ribbon correction device.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The trail-off correction is accomplished by imparting a relative skew between the take-up and the play-off spools. To induce this skew and to control its magnitude and direction, a twistable frame means mounted to the machine frame, is employed. The spools are pivotally and rotatably mounted in a first base plate which is rigidly attached and a second base plate which is pivotally mounted to the machine frame. The pivot point for the second base plate is located substantially midway between the mounting position for the first and second spools. Thus when the second base plate is pivoted about the pivot point, the adjacent end of the first spool is displaced in a forward direction by substantially the same distance as the displacement of the corresponding end of the second spool in the backward direction. Thus there is substantially no difference in the longitudinal stress in the web between that for the extreme forward skew and that for the extreme reverse skew of the two spools.

FIG. 1 is a simplified diagram showing the relative position of the spools during the trail-off correction sequence. Having reference to FIG. 1, upper spool 2 and lower spool 4 are rotatably and pivotally mounted on fixed plate 6 and are rotatably and pivotally mounted in pivoted plate 8 such that when plate 8 is rotated about the pivot 10, spools 2 and 4 assume a skew position with respect to one another. The web 16 is wound about the upper spool 2 in a clockwise direction and proceeds thence over backing surface 26 and is then wound in counterclockwise fashion about the lower spool 4. In such configuration, when the ribbon is moving from upper spool 2 to lower spool 4 and the ribbon is not present at the reference point under the sensing finger 20, the upper spool 2 is pivoted away from the print line 18 by equal displacements such that the ribbon is caused to be steered toward the observer such that it will subsequently migrate across the imaginary reference point beneath the sensing finger 20. When this transition condition obtains, the sensing finger 20 falls, causing the sensing arm to undergo a relatively large displacement. At this time of transition, the pivoted plate 8 is rotated about the pivot 10 such that the upper spool 2 is skewed toward the print line and the lower spool 4 is skewed away from the print line as in FIG. 1b. This displacement, after the ribbon overcomes its inertia in the original direction of motion, effects the desired change in the direction of motion, away from the observer.

In FIG. 1*c*, when the ribbon is moving from the lower spool 4 to the upper spool 2 and the ribbon is under the sensing finger 20, the upper spool 2 will be away from the print line 18 and the lower spool 4 will be toward the print line 18 such that the preferred direction of trail-off motion is away from the observer. When the transition point occurs, where the ribbon passes from beneath the reference point, a corrective skew displacement takes place. The upper spool 2 moves toward the print line 18 and the lower spool 4 moves away from the print line 18 such that the ribbon will tend now to be steered toward the observer, as in FIG. 1d.

The preferred embodiment for the wound web configuration is that shown in FIGS. 1*a* through *d*, that is where the web winds off of the first spool and onto the second spool at those respective spool surfaces closest to one another. FIG. 1e shows an alternate embodiment where the web is wound off of the first spool and onto the second spool at those respective spool surfaces which are at the extreme distances from one another. The trail-off correction sequence for both configurations, however, will be the same since the relative direction of rotation of the upper and lower spools at any one time is always the same for each of these configurations.

FIG. 2 shows an end view of the twistable frame means and the relative positions of the web, the web axial-position detection means, the end-of-web reversing means, the driving means and the rotary-to-reciprocating motion conversion means. The web, wound between the upper and lower spools, is periodically sampled by the web axial-position detection means for its presence or absence at a reference point midway between the extreme axial displacements of the web. When the edge of the web traverses the reference point, the amplitude of the periodic displacements of the detection means changes, ultimately causing the rotary-to-reciprocating motion conversion means to displace the twistable frame means into its alternate state of twist. The state of relative skew between the first and second spools is thereby changed imparting the desired trailoff correction to the axial motion of the web.

Referring to FIG. 2, the lower spool 4, onto which is wound the web 16, is concentric with the shaft 36 for the correction cam 32. The sensing arm 38 whose oscillations are derived from the rotary motion of shaft 36, causes the sensing finger 20*b* to periodically pass through the reference point 40 such that when the web is absent from reference point 40, the sensing finger will remain in the standing position 20*b*. However, when the web is present over reference point 40, the sensing finger will assume the fallen position 20*a*. The consequent change in the magnitude of the displacement of the sensing arm 38 institutes a 180° rotation of correction cam 32 effecting the displacement of the pivot plate **8** about pivot **10** thus effecting the change in the relative skew of spools 2 and 4.

FIG. 2 shows the relative position of the ribbon reversing arm **46**, motor reversing switch **50**, the motor for upper spool 2 and the motor for lower spool **4**. The ribbon drive is accomplished by two motors designated upper **112** and lower **110**. While one motor is driving or winding, a limited voltage is provided to the opposite motor to control the ribbon tension. The ribbon only moves during printing and stops approximately **120** ms after the end of printing, at which time one half of the voltage is supplied to both ribbon drive motors, urging them in opposite directions to maintain tension in the ribbon. The ribbon reversing function is accomplished by the pivoted reversing arm **46** which is shifted by reversing bars attached to each end of the ribbon near the point were the ribbon attaches to the respective spools **2** and **4**. When the arm **46** is operated, it in turn actuates motor reversing switch **50** that determines which motor will wind the ribbon in the proper direction. The ribbon reversing arm **48** is pivoted at **52**.

Turning now to FIG. **3**, the semi-schematic diagram depicts the working relationship of the various elements of the invention. The sectional view is taken along the axis of pivot **10** in FIG. **1**. Mounted on machine frame **120** is fixed base plate **6** and pivoted base plate **8**, together which make up the twistable frame means. The pivoted base plate **8** can undergo angular displacements with respect to the machine frame **120**, about the pivot **10**. The lower spool shaft **36** is mounted in fixed base plate **6** through a universal coupling **122** and is mounted in pivoted base plate **8** by universal coupling **124** such that said twistable frame means can undergo twist displacements without binding the shaft **36**. Driving means **110** is mounted to the twistable frame means and drives shaft **36** through universal coupling **122**. Mounted on shaft **36** is the lower spooling means **4**, the sensing cam **60**, and the ratchet **54**, each of which is continuously driven by the motor **110**. The sensing arm **38**, pivotally mounted on the twistable frame means, is periodically driven by the sensing cam **60** through the sensing cam follower **66**. Sensing finger **20** pivotally mounted on the end of sensing arm **38**, is driven into periodic engagement with the moving web. Correction cam shaft **36*a***, rotatably mounted on the twistable frame means and not directly connected to the lower spool shaft **36**, carries the pawl carrier **86** and the correction cam **32**, which rotate in unison with the correction cam shaft **36a**. Pivotally mounted on pawl carrier **86** are pawls **90** and **94**. Link lever **72** connected with sensing arm **38**, periodically actuates pawls **90** and **94** in timed relation with the rotation of ratchet **54**. When a change takes place in the magnitude of the periodic displacements of sensing arm **38**, due to the detection of a change in the position of the edge of the web, link lever **72** causes pawl **90** or **94** to engage ratchet **54**. Pawl carrier **86** is thereby caused to rotate with the engaged ratchet until the detent **104** causes the pawl carrier **86** to cease its rotation after 180°, at which time link lever **72** causes the engaged pawl **90** or **94**, to disengage the ratchet **54**. The correction cam follower **34**, within which the correction cam **32** rotates, is rigidly fixed to the machine frame. When the correction cam **32** rotates within cam follower **34**, the correction cam shaft **36*a***, and therewith the twistable frame means, undergoes a lateral displacement with respect to the machine frame, base plate **8** pivoting about pivot **10**. Since correction cam **32** rotates in unison with pawl carrier **86**, when sensing arm **38** causes the pawls **90** or **94** to engage ratchet **54**, pawl carrier **86** thereby undergoes rotation causing correction cam **32** to rotate within correction cam follower **34** by 180°. This induces the desired twist displacement in the twistable frame means. The change in the relative skew between the upper and the lower spooling means induced by the twist displacement in the twistable frame means, imparts the necessary lateral steering correction to the web as it winds upon either the upper or the lower spool. In order to clarify the description of the working relationship between the elements, FIG. **3** has been simplified with respect to the relative position of the parts in the preferred embodiment. In the preferred embodiment, the driving means **110** is mounted on the pivoted base plate **8** and the correction cam shaft **36a** is hollow, the lower spool shaft **36** passing therethrough and directly connected with the driving means **110**. The sensing arm **38**, sensing cam follower **66**, and link lever **72** together comprise the web, axial-position detection means. The ratchet **54**, the pawl carrier **86** and its associated pawls **90** and **94**, together with the detent **104** comprise the intermittent clutch means. The correction cam **32** and the correction cam follower **34** together comprise the rotary-to-reciprocating motion conversion means. The combination of the intermittent clutch means and the rotary-to-reciprocating motion conversion means constitutes the reciprocating drive means.

FIG. **4** shows the elements comprising the web axial-position detection means, the intermittent clutch means, and the rotary-to-reciprocating motion conversion means.

The web axial-position detection means comprises the sensing cam **60**, a sensing arm means, and the sensing finger **20**. The sensing arm means comprises the sensing arm **38**, link lever **72**, spring **34**, and lever **82**.

The intermittent clutch means comprises the ratchet **54**, pawl carrier **86**, pawls **90** and **94**, and detent **104**.

The rotary-to-reciprocating motion conversion means comprises the correction cam **32** and the correction cam follower **34**.

The web axial-position detection means senses the traversal of the edge of the web across the reference point **40**, and at such time undergoes a change in the amplitude of its periodic displacements causing the engagement and rotation of the intermittent clutch means. Since the pawl carrier of the clutch means and the correction cam of the rotary-to-reciprocating motion conversion means are mounted together, they rotate in unison and thus impart the desired controlled displacement to the twistable frame means.

Referring to FIG. **4**, shaft **36**, which is the shaft of the drive motor which is mounted to the pivot plate **8** and which drives the lower spool **4**, drives the ratchet **54** and sensing cam **60**. Ratchet **54** onto which are mounted in diametric opposition teeth **56** and **58**, is fixedly attached to the shaft **36** and fixedly attached to sensing cam **60**. Sensing cam **60** has the lobes **62** and **64** diametrically opposed to one another and aligned with the the teeth **56** and **58** of ratchet **54**. The lobes **62** and **64** on sensing cam **60** periodically engage the sensing cam follower **66**. Sensing cam follower **66** is attached by pin **68** to the sensing arm **38**. Sensing arm **38** is pivoted on stud **70** which in turn is mounted on pivot plate **8**. Sensing finger **20** mounted on sensing arm **38** and loaded by spring **30** is periodically displaced through the reference point **40.** When the web **16,** which is drawn across the backing surface **26,** covers the reference point **40,** the sensing finger **20** collapses thus causing the sensing arm **38** to traverse a larger magnitude displacement than it does when web **16** is absent from reference point **40.** The periodic displacements of sensing arm **38** are coupled to link lever **72** through the pin **68.** Link lever **72** is biased by spring **74** so that sensing cam follower **66** will always engage sensing cam **60.** Link lever **72** is connected to lever **82** through pin **80** and lever **82** is pivoted about stud **84** which in turn is anchored to the plate **8.** When lobes **62** or **64** of sensing cam **60** engage sensing cam follower **66,** link lever **72** is displaced so as to effect the alternate engagement and disengagement of pawls **90** and **94.** Pawl carrier **86** is fixedly attached to correction cam **32.** Correction cam **32** engages the surface **88** of correction cam follower **34** which is rigidly attached to the machine frame. Thus, when correction cam **32** rotates within the surface **88** of correction cam follower **34,** the shaft **36** is laterally displaced with respect to the machine frame. Mounted on pawl carrier **86** is counterclockwise pawl **90** which pivots on pin **92** and clockwise pawl **94** which pivots on pin **96.** Pawls **90** and **94** are spring loaded in the engagement position by pawl spring **98.** Detent pins **100** and **102** engage the detent **104** at 180° intervals on the pawl carrier **86.** The assemblage of pawls **90** and **94** mounted on pawl carrier **86,** with the detent **104** and ratchet **54,** comprises a double pawl clutch. When the sensing arm **38** undergoes a large displacement, that is, when web **16** covers the reference point **40,** link lever **72** also undergoes a larger displacement. Lobe **106** on link lever **72** will engage the tail of pawl **90** when sensing arm **38** undergoes its larger displacement. Thus during counterclockwise rotation when the web is present and the sensing arm has undergone a larger displacement, counterclockwise pawl **90** will not engage the teeth **56** or **58** of ratchet **54** as it rotates with the spool **4.** However, when the transition point occurs at which web **16** traverses reference point **40** and no longer covers reference point **40,** sensing finger **20** will remain at a standing position preventing sensing arm **38** from undergoing its larger displacement. Thus, lobe **106** of link lever **72** will not contact the tail of counterclockwise pawl **90.** Thus as one of the teeth **56** or **58** of ratchet **54** rotates into engagement position as the ratchet rotates in its counterclockwise direction, that tooth will engage counterclockwise pawl **90** causing pawl carrier **86** and the attached correction cam **32** to rotate in unison with the ratchet **54,** in a counterclockwise direction for 180° until the tail of counterclockwise pawl **90** engages the lobe **108** of link lever **72,** thus causing the disengagement of pawl **90** from the tooth of ratchet **54.** The motion of pawl carrier **86** is arrested by the engagement of detent pin **100** or **102** with detent **104.** The rotation of the correction cam **32** through 180° will have, by virtue of its contact with the surface **88** of correction cam follower **34,** caused the lateral displacement or skewing of the shaft **36** with respect to the machine frame. Because shaft **36** is rotatably mounted in pivot plate **8,** pivot plate **8** will have pivoted about its pivot point thus causing a corresponding displacement in the opposite direction for the upper spool. A graphic explanation of the interaction of sensing arm **38,** clockwise pawl **94** and counterclockwise pawl **90** and of the relation between the corrective displacement of shaft **36** and the position of the web with respect to reference point **40,** can be gained by studying the timing diagram shown in FIG. **5.**

OPERATION

The objective of the operation of the invention is to impart a correction to the trail-off direction of the web as it traverses a given median point in the axial direction. To accomplish this the web axial-displacement detection means undergoes a periodic displacement through the reference point. When the web is present the periodic displacements are larger than when the web is absent from the reference point. When the edge of the web traverses the reference point, the consequent change in the amplitude of the periodic displacements triggers the intermittent clutch means to engage, thereby rotating the correction cam in the rotary-to-reciprocating motion conversion means. The motion conversion means induces a twist displacement in the twistable frame means, and thereby a change in the relative skew of the first and second spools upon which the web is wound. The web is thereby steered such that the direction of axial trail-off is reversed, the net effect of which is to accomplish an even winding of the web onto either spool.

With reference to FIG. **4,** when the lower spool **4** is undergoing clockwise rotation, it is clockwise pawl **94** which alternately engages and disengages the teeth of ratchet **54,** thus effecting the controlled displacement of shaft **36.** The timing diagram depicted in FIG. **6** is of assistance in understanding the sequence of events which effect the trail-off correction during clockwise rotation. When the web **16** does not appear beneath the reference point **40,** sensing arm **38,** as urged by sensing cam **62**'s actuation of cam follower **66,** undergoes a small displacement Y. Clockwise pawl **94** is, and remains in, the open position and counterclockwise pawl remains in a closed position. Correction cam is so placed so that the shaft **36** is displaced back from the print line by the distance X. This corresponds to the period P1 in FIG. **6.** At the time *t***5,** the transition time, web **16** traverses reference point **40,** sensing finger **20** collapses causing sensing arm **38** to undergo a larger displacement Y, link lever **72** causes lobe **108** to release the clockwise pawl **94,** the clockwise rotation of ratchet **54** causes one of its teeth **56** or **58** to engage the clockwise pawl thus initiating the rotation of the pawl carrier **86** and thus the rotation of the correction cam **32.** The clockwise rotation of correction cam **32** continues for 180° of rotation until the tail of clockwise pawl **94** engages the lobe **106** of link lever **72.** At this point, clockwise pawl **94** is disengaged from the tooth of ratchet **54** and the detent **104** simultaneously engages detent pin **100** or **102** thus arresting the rotation of the correction cam **32.** At this point the shaft **36** has been displaced by a distance X toward the print line, that is, to the front, and the period **P2** in FIG. **6** has commenced. During this period the web will continue to cover the reference point **40** thus causing the sensing arm stroke Y to be large. At every stoke of the sensing arm **38,** lobe **106** of link lever **72** engages clockwise pawl **94** just prior to the approach of the tooth **56** or **58** of ratchet **54,** thus avoiding engagement and rotation when no correction is needed. When, as at time *t***13** in FIG. **6,** the transition point occurs where web **16** traverses reference point **40** from beneath the finger to outside the region of the sensing finger **20,** sensing finger 20 will remain standing. As a result, the periodic oscillations of sensing arm 39 are of smaller magnitude. During the first rotation of the tooth 56 or 58 of ratchet 54 to the point of potential engagement with clockwise pawl 94, the tail of clockwise pawl 94 is no longer engaged by lobe 106 of link lever 72. Thus, pawl 94 engages tooth 56 or 58 of ratchet 54 and again a 180° rotation of pawl carrier 86, and thus, of correction cam 32, is effected. This action is depicted at times *t*14 to *t*16 in FIG. 6. Shaft 36 is seen to be displaced back to its original position of magnitude X and is now farther away from the print line than is the axis of the upper spool.

FIG. 7 illustrates the sequence of events that occurs when the direction of rotation of the spools is reversed at a time when the web is not at a transition point. Period P1 in FIG. 7 is identical to period P1 in FIG. 5 and period P2 in FIG. 7 is identical to period P2 in FIG. 5 up to the time t12. At time *t*12 the direction of rotation of the lower spool is reversed from counterclockwise to clockwise, as is the direction of rotation of the upper spool. The direction of motion of the web can be seen to immediately reverse, illustrating the 180° phase shift phenomenon at time *t*12. Clockwise pawl 94 engages tooth 56 or 58 of ratchet 54 in the first stage of the commencement of clockwise rotation of ratchet 54. Clockwise pawl 94 remains engaged with ratchet 54 until pawl carrier 86 has rotated 180° at which time clockwise pawl 94 engages lobe 106 of link lever 72. Recalling that the web is beneath sensing finger 20, sensing arm 38 is undergoing large displacements thus, lobe 106 will be in position to disengage clockwise pawl 94 for every 180° rotation of ratchet 54 until the web undergoes a transition point at *t* 19. It is seen that from *t*14 on through *t*35 in FIG. 7, the sequence of events is identical to that in normal clockwise rotation of spool 4, as is shown in FIG. 6. Thus, 180° phase shift correction upon a change in the direction of rotation of the spool, is accomplished automatically by virtue of the interaction of the double pawl clutch assembly, the sensing cam, and the sensing arm.

FIG. 8 illustrates the sequence of events that occur when the direction of rotation of the spools is reversed at a time when the edge of the web is traversing reference point 40. Periods P1 and P2 in FIG. 8 are identical to periods P1 and P2 in FIG. 5 and period P3 in FIG. 8 is identical to period P3 in FIG. 5 up to the time *t*14. At time *t*14, the direction of rotation of the lower spool is reversed from counterclockwise to clockwise, as is the direction of rotation of the upper spool. The direction of axial motion of the web can be seen to immediately reverse. Since the web has just passed the transition point at t13, a trail-off correction would normally have gone into effect at time *t*14 so that the web could be steered back toward the reference point 40. However, by reversing the direction of rotation of spool 4, the normal trail-off correction becomes unnecessary and indeed if made at this time, would cause the web to spiral off uncontrollably along the axis of the spool. However, the interaction of the double pawl clutch, the sensing cam and the sensing arm, cause a suppression of the 180° phase shift correction, which commences at *t*14 and remains in effect until the edge of the web is sensed to have once again traversed reference point 40, at which time the normal clockwise sequence of events commences, as is shown in FIG. 6. From time t1 to time *t*14 in FIG. 8, the normal clockwise sequence of events has taken place. Had spool reversal not occurred at time *t*14, the smaller magnitude displacement Y of sensing arm 38 would have prevented the engagement of lobe 106 of link lever 72 with the tail of counterclockwise pawl 90, thus causing the normal engagement with ratchet 54 resulting in the corrective rotation of correction cam 32. However, since the direction of spool rotation was reversed to clockwise at time *t*14, the counterclockwise pawl 90 is no longer effective. If, at the time of spool reversal, the edge of the web 16 had not been traversing reference point 40, but was still beneath the sensing finger 20 as is shown in FIG. 7, the larger magnitude displacement Y of sensing arm 38 would have prevented lobe 108 of link lever 72 from engaging the tail of clockwise pawl 94; thus permitting the clockwise pawl to engage the ratchet 54, thus causing the 180° phase shift correction to commence, as would normally have taken place. However, where spool reversal takes place at or immediately after the time at which the edge of the web 16 traverses the reference point 40, neither of the foregoing corrective sequences should take place. To accommodate this requirement, at time *t*14 in FIG. 8, sensing arm 38 commences its smaller magnitude displacements, causing lobe 108 of link lever 72 to contact the disengage clockwise pawl 94 from its potential engagement position with ratchet 54. Clockwise pawl 94 remains in the disengaged position during the period required for the edge of web 16 to return to reference point 40 under the influence of the reversed direction of rotation of spool 4. After the edge of web 16 is detected by sensing finger 20, to have traversed reference point 40, which occurs at time t16 in FIG. 8, sensing arm 38 recommences its larger magnitude displacements causing lobe 108 to link lever 72 to disengage the tail of clockwise pawl 94, at which time ratchet 54 is engaged and correction cam 32 is rotated for a normal clockwise trail-off correction. After time *t*16 the nomal clockwise correction sequence obtains as is shown in FIG. 6. The period of time between *t*14 and *t*16 in FIG. 8, is the period for suppression of the 180° phase correction.

Referring now to FIG. 9 the relative placement of the various parts previously described, is shown. The motor 110 which drives lower spool 4, is mounted on pivot plate 8. Motor 112 also mounted on plate 8 drives the upper spool. Pivot plate 8 rotates about pivot 10 which is affixed to the machine frame. Sensing cam 60 and ratchet 54 are fixedly attached together and are in turn fixedly attached to shaft 36. Pawl carrier 86 to which is fixedly attached correction cam 32, are rotatably mounted on shaft 36. Correction cam follower 88 is mounted at points 114 and 116 to the machine frame and thus serves as the fixed reference point for the lateral displacement of shaft 36. Sensing cam follower 66, mounted on sensing arm 38, is driven by sensing cam 60 such that sensing finger 20 periodically engages the web, when present. Link lever 72, attached to sensing arm 38, oscillates as the sensing arm is actuated by the sensing cam, and successively actuates clockwise pawl 94 and counterclockwise pawl 90 as the shaft 36 rotates. The state of relative skew between the spools, as mechanically controlled by the position of the web, causes the web to be evenly wound upon the spools, regardless of the direction of rotation.

FIG. 9 depicts the ribbon dirve and sense system. The ribbon drive and sense system consists of three functions: the ribbon drive, ribbon reversing and ribbon skew correction.

The ribbon drive is accomplished by two motors designated upper **112** and lower **110.** While one motor is driving or winding a limited voltage is provided to the opposite motor to control the ribbon tension. The ribbon only moves during printing and stops approximately 120 ms after the end of printing. At this time, one half voltage is supplied to both ribbon drive motors to maintain tension.

The ribbon reversing function is accomplished by a pivoted reversing arm **42** which is shifted by reversing bars attached to each end of the ribbon near the point where the ribbon attaches to the spools. When the arm is operated, it in turn operates a switch **50** that determines the motor that will wind the ribbon in the proper direction. The ribbon reversing arm is pivoted at **52.**

The ribbon skew correction is accomplished by pivoting the ribbon drive unit to change the line of ribbon winding in relation to the direction of ribbon feed. The operation is controlled by the sensing finger **20** and arm **38.** The sensing finger mechanically checks to see if the moving ribbon is beneath it. If the ribbon is under the arm, the movement of the ribbon causes the finger to pivot which in turn allows the arm to drop. This sets the drive pawl **94** or **90** which rotates the correction cam **32** 180° to pivot the twistable frame means. There are two pawls, one drives when the lower ribbon spool is winding, the other drives when the lower spool is unwinding. The twistable frame means stays in the pivoted position as long as the finger continues to sense the ribbon. Once it is determined that the ribbon has shifted from under the finger, the sensing arm again sets the drive pawl and rotates the twistable frame means back to the starting position by turning the correction cam 180°. A sensing cam **60** is provided to raise the finger, via the sensing arm, twice each spool revolution, to permit the ribbon to feed under the finger eliminating the possibility of the ribbon rolling up against the finger instead of moving under it.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and the scope of the invention.

We claim:

1. In combination with a device for evenly winding a web onto a spool of the type comprising a fixed machine frame, a twistable frame means mounted on said machine frame, said twistable frame means capable of assuming either of two states of twist, a first and a second spooling means, said first and second spooling means pivotally and rotatably mounted in said twistable frame means, said two states of twist imparting alternate states of relative skew between said first and said second spooling means, said first spooling means winding said web from said second spooling means and said second spooling means winding said web from said first spooling means, a rotary driving means for rotatably driving said first and second spooling means, a web axial-position detection means, a reciprocating drive means, said reciprocating drive means intermittently actuated by said detection means when a change is detected in the axial-position of said web as it is wound upon either said first or said second spooling means, said twistable frame means driven by said reciprocating drive means so as to assume either of said two states of twist, said web steered into alternate directions of axial motion on said first or said second spooling means by said alternate states of relative skew, said state of skew controlled by said detecting means sensing the presence or absence of said web at a reference point substantially midway between the extreme axial displacements of said web, wherein the improvement resides in said reciprocating drive means which further comprises:

- a ratchet means continuously driven by said rotary driving means,
- a pawl means opposed to said ratchet means and intermittently engagable therewith under the control of said web axial-position detection means,
- a rotary-to-reciprocating motion conversion means connected to said pawl means,
- said motion conversion means being intermittently driven by said pawl means when said detection means causes said pawl means to engage said ratchet means,
- said rotary-to-reciprocating motion conversion means contacting to said machine frame and said twistable frame means so as to impart a relative displacement therebetween when driven by said pawl means.

2. In the improved device for evenly winding a web onto a spool of claim **1,** wherein said web axial-position detection means further comprises:

- a sensing cam, rotatably mounted on said twistable frame means and continuously driven by said rotary driving means,
- said sensing cam having at least one lobe,
- a sensing arm, mounted on said twistable frame means and resiliently urged into engagement with said sensing cam, said sensing arm periodically displaced by the lobes on said cam, through an arc over said reference point,
- said sensing arm undergoing relatively large displacements when said web is present and relatively small displacements when said web is absent from said reference point,

3. In the improved device for evenly winding a web onto a spool of claim **2,** wherein said reciprocating drive means further comprises:

- said ratchet means, rotatably mounted on said twistable frame means and continuously driven by said rotary driving means,
- said ratchet means possessing a number of teeth equal to the number of lobes on said sensing cam,
- said ratchet means rotating in unison with said sensing cam,
- a pawl carrier means,
- said carrier means rotatably mounted on said twistable frame means in a position coaxial with and opposed to said ratchet means,
- a first pawl, pivotally mounted on said carrier means,
- said first pawl mounted so as to be resiliently urged into engagement with said ratchet means when said ratchet means undergoes clockwise rotation,
- a second pawl, pivotally mounted on said carrier means,
- said second pawl, mounted so as to be resiliently urged into engagement with said ratchet means when said ratchet means undergoes counterclockwise rotation,

a resilient detent means mounted on said twistable frame means and positioned so as to stop the rotation of said pawl carrier means at every 180°,

said sensing arm periodically contacting and pivotally displacing said first and said second pawls, as it is driven by said sensing cam in timed rotation with the rotation of said ratchet means,

said pawl displacement causing said first pawl to avoid engagement with said ratchet means during clockwise rotation of said ratchet and causing said second pawl to avoid engagement with said ratchet during counterclockwise rotation of said ratchet,

said sensing arm omitting contact with said first pawl during clockwise rotation of said ratchet or omitting contact with said second pawl during counterclockwise rotation of said ratchet, when a change in the magnitude of said periodic displacements of said sensing arm occurs,

said displaced pawl engaging said ratchet means when said change in the magnitude of said sensing arm displacements takes place, said pawl carrier means thereby being driven into rotation,

said pawl carrier rotation continuing until said detent means halts said rotation, at which point said sensing arm contacts said engaged pawl, disengaging said pawl,

said pawl carrier means remaining stationary in its new state as long as said periodic sensing arm displacements retain their new magnitude.

4. In the improved device for evenly winding a web onto a spool of claim 3 wherein said reciprocating drive means further comprises:

a correction cam rotatably mounted on said twistable frame means and rotating in unison with said pawl carrier means,

a cam follower rigidly attached to said machine frame,

said correction cam rotatably mounted within said cam follower,

said twistable frame means undergoing a twist displacement when said correction cam is rotatably driven by 180° within said cam follower by means of the controlled rotation of said pawl carrier means,

said state of relative skew of said first and second spooling means being altered by the controlled displacement of said twistable frame means,

said web being steered into alternate directions of axial motion along said first and second spooling means, by the controlled changes in said relative skew,

whereby said web may be evenly wound on either said first or said second spooling means, automatically.

5. In the improved device for evenly winding a web onto a spool of claim 1, wherein the rotary driving means further comprises:

a first reversible motor mounted on said twistable frame means,

said first motor driving said first spooling means,

a second reversible motor mounted on said twistable frame means,

said second motor driving said second spooling means,

said first motor, when driving said first spooling means so as to wind said web thereupon, being fully energized to advance the web, while said second motor being energized in the direction opposing the advance of the web, at a magnitude of substantially one half that of said first motor, thus imparting a drag force on the web,

an end-of-web reversing means for detecting the end of the web before it unwinds from the spooling means supplying said web, said reversing means automatically reversing the driving direction of said first and second motors, said second motor becoming fully energized so as to advance the web in the direction reversed to its preceding motion and said first motor becoming energized at one half its preceding magnitude and in the direction opposed to the new direction of advance for the web,

whereby said web remains in tension without regard to its direction of advance.

6. In the improved device for evenly winding a web onto a spool of claim 1, wherein the web axial-position detection means further comprises:

a sensing cam continuously driven by said rotary driving means,

a sensing arm mounted on said twistable frame means so as to be resiliently urged into engagement with said sensing cam,

said sensing arm being periodically lifted and lowered over said reference point by means of said sensing cam,

a collapsible finger means, pivotally mounted on said sensing arm,

said finger means located substantially over said reference point,

said finger means frictionally engaging said web when present at said reference point, when said cam lowers said sensing arm,

said finger means following the advancing motion of said web, when frictionally engaging the web causing the finger means to collapse and the sensing arm to undergo a relatively large displacement,

said finger means remaining in a standing position on a supporting surface for said web, when said web is absent from said reference point, when said sensing cam lowers said sensing arm, thereby limiting the sensing arm to a relatively small displacement,

said sensing arm periodically actuating said pawl means as said sensing cam lifts and lowers said sensing arm,

said rotary-to-reciprocating motion conversion means being driven by said pawl means when the magnitudes of the periodic displacements of said sensing arm change,

said changes in magnitude of said sensing arm displacement corresponding to axial motion of the edge of said web at said reference point, the change from small to large magnitude indicating the presence of said web and the change from large to small magnitude indicating the removal of said web at said reference point.

7. In the improved device for evenly winding a web onto a spool of claim 1, wherein the rotary-to-reciprocating motion conversion means further comprises:

a correction cam rotatably mounted on said twistable frame means and intermittently driven by said pawl means,

a cam follower rigidly attached to said machine frame, said correction cam rotatably mounted within said cam follower,

said twistable frame means undergoing said twist displacement when said correction cam is rotatably driven within said cam follower by means of said pawl means.

8. In the improved device for evenly winding a web onto a spool of claim **1**, wherein the pawl means further comprises:

a pawl carrier means,

said carrier means rotatably mounted on said twistable frame means in a position coaxial with and opposed to said ratchet means,

a first pawl, pivotally mounted on said carrier means,

said first pawl being resiliently urged into engagement with said ratchet means when said ratchet means undergoes clockwise rotation,

a second pawl, pivotally mounted on said carrier means,

said second pawl being resiliently urged into engagement with said ratchet means when said ratchet means undergoes counterclockwise rotation,

said web axial-position detection means contacting and pivotally displacing said first and second pawls in timed relation with the rotation of said ratchet means,

said displacements causing each of said pawls to avoid engagement with said ratchet.

9. A device for evenly winding a web onto a spool, comprising:

a fixed machine frame,

a plate pivotally mounted on said machine frame,

a first spool pivotally and rotatably mounted between said plate and said machine frame,

a second spool pivotally and rotatably mounted between said plate and said machine frame,

said plate imparting a relative skew between said first and said second spool when displaced about its pivot point,

a reversible motor mounted on said plate for rotatably driving said first and said second spool in either direction,

a switching means mounted on said plate for reversing the direction of drive of said motor when the end of said web is detected unwinding from either of said spools;

a double pawl clutch rotatably mounted on said plate and continuously driven by said motor;

a mechanical web-edge detection means mounted on said plate,

said detection means periodically actuating said double pawl clutch in timed relation with the rotation of said clutch;

a cam rotatably mounted on said plate,

a cam follower rigidly mounted on said machine frame;

said cam rotatably engaging said cam follower and being intermittently driven by said double pawl clutch when said detection means senses a change in the axial position of said web as it is wound upon either said first or said second spool;

said pivot plate being driven through an angular displacement about its pivot point as said cam is controllably driven into rotation by said double pawl clutch;

said web undergoing a trail-off correction due to the change in the relative skew of the first and second spools as controlled by said detecting means sensing the presence or absence of said web at a reference point substantially midway between the extreme axial displacements of said web;

whereby said web may be evenly wound on either said first or said second spool, automatically.

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