# United States Patent [19]

**Riemersma**

[11] **3,836,089**

[45] **Sept. 17, 1974**


[54] **WEB SPLICING, UNWINDING AND FORWARDING APPARATUS**


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[73] Assignee: **The Procter & Gamble Company,** Cincinnati, Ohio



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[52] **U.S. Cl.**..... **242/58.1,** 226/189, 242/75.4

[51] **Int. Cl.**..... **B65h 19/18,** B65h 51/20

[58] **Field of Search**..... 242/58.1, 75.4, 75.43, 242/75.44, 55.01; 226/38, 189, 195



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*Primary Examiner*—John W. Huckert
*Assistant Examiner*—Edward J. McCarthy
*Attorney, Agent, or Firm*—Thomas J. Slone; John V. Gorman; Richard C. Witte



[57] **ABSTRACT**

An improved web splicing, unwinding and forwarding apparatus for unwinding web from a succession of supply rolls and forwarding web uninterruptedly to downstream apparatus at substantially constant velocity under substantially constant tension. The improvements include: means for maintaining a low level of tension in the web except during splicing transients and the like during which transients web tension is caused to increase whereby the periods of such transients are reduced; and, means for sensing the rate of increasing the length of web looped through the apparatus and means responsive to such rate means for preventing the length of such loop from exceeding the capacity of the apparatus. The latter improvement functions to prevent the loop of web from becoming slack.


**7 Claims, 9 Drawing Figures**

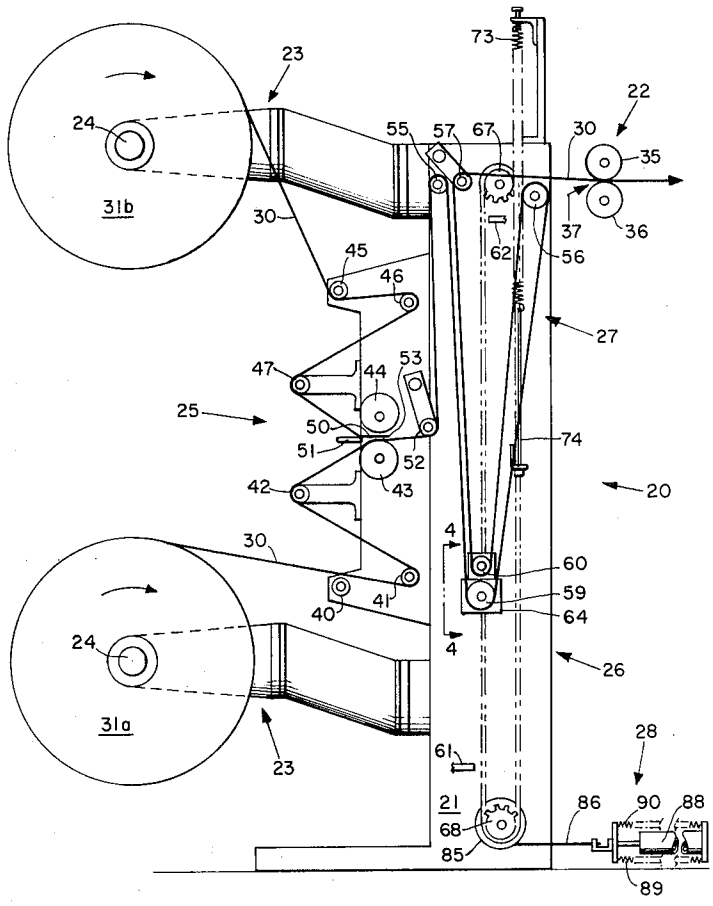


Fig. 1

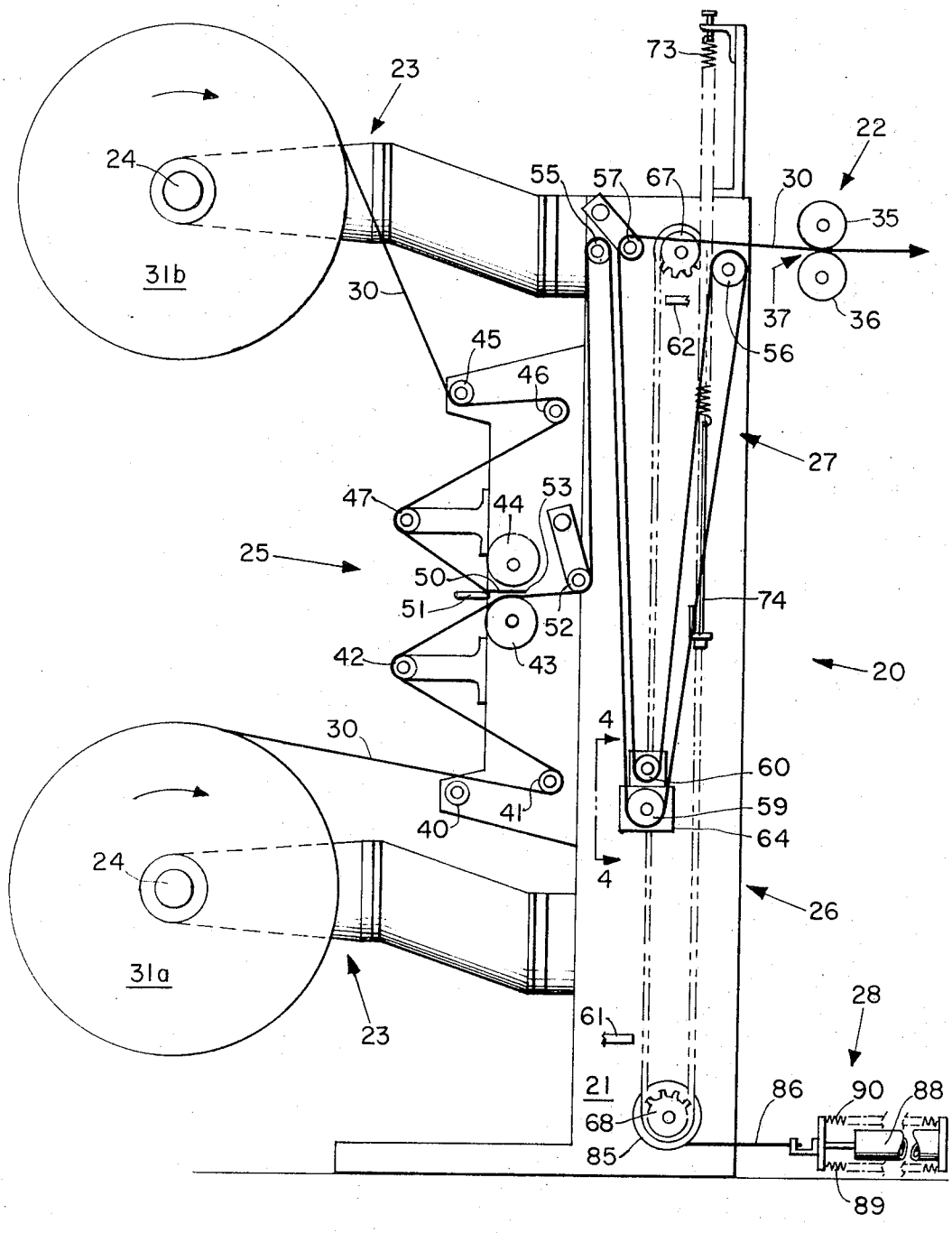

73
23
22
24
55
57
67
30
35
31b
30
37
36
62
56
45
46
27
47
44
53
25
50
74
51
52
42
43
20
30
4
60
59
64
40
41
24
4
26
31a
23
28
61
21
86
90
88
68
85
89

Fig. 2

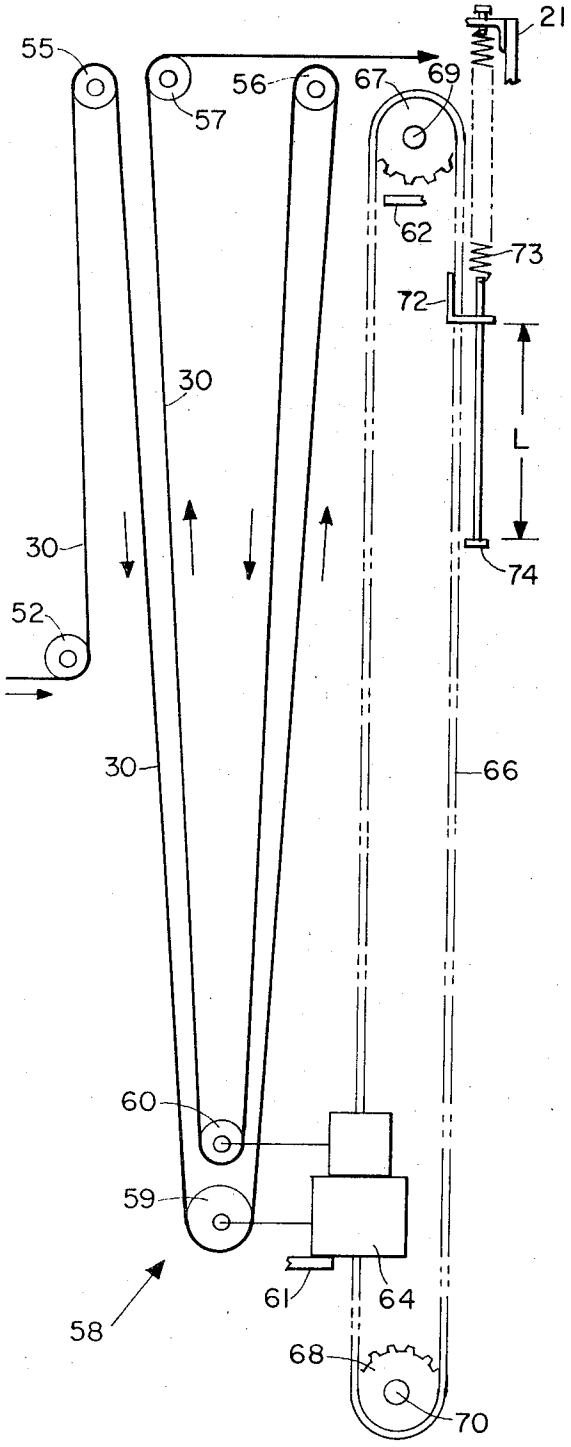

55
56
57
67
69
21
62
73
72
30
L
74
52
66
60
59
61
64
58
68
70

Fig. 3

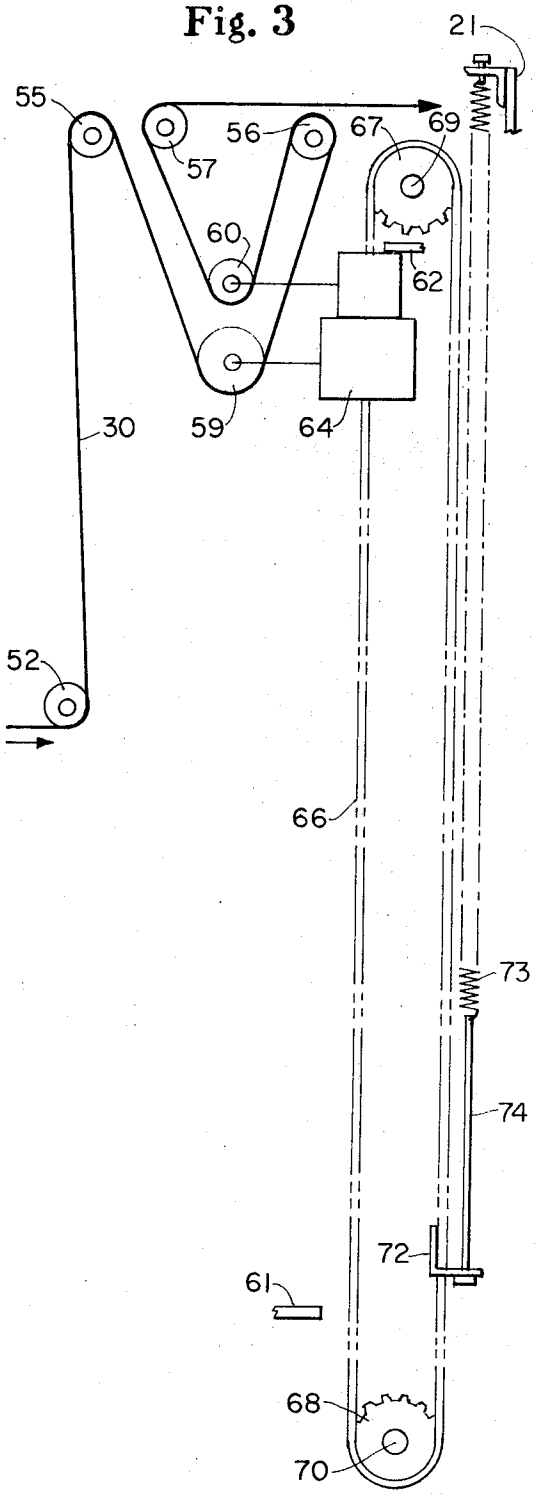

55
56
57
67
69
21
60
62
59
64
30
52
66
73
74
72
61
68
70

Fig. 8

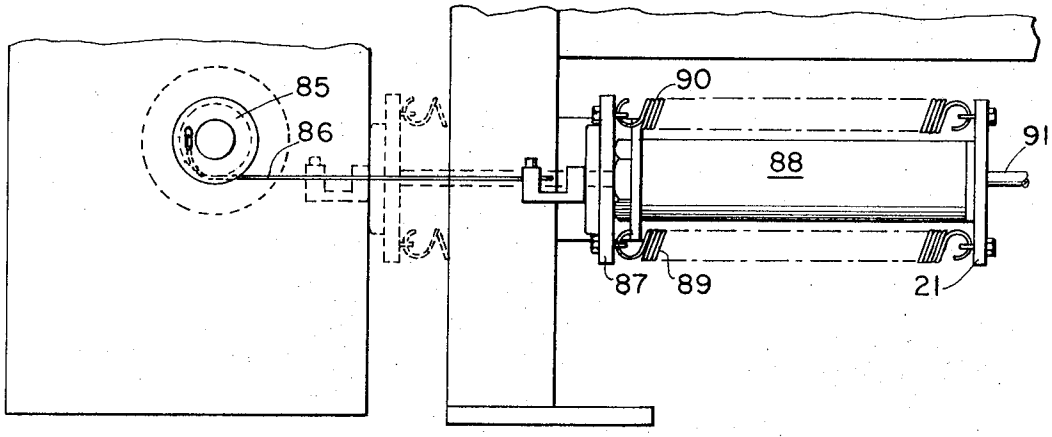



Fig. 4

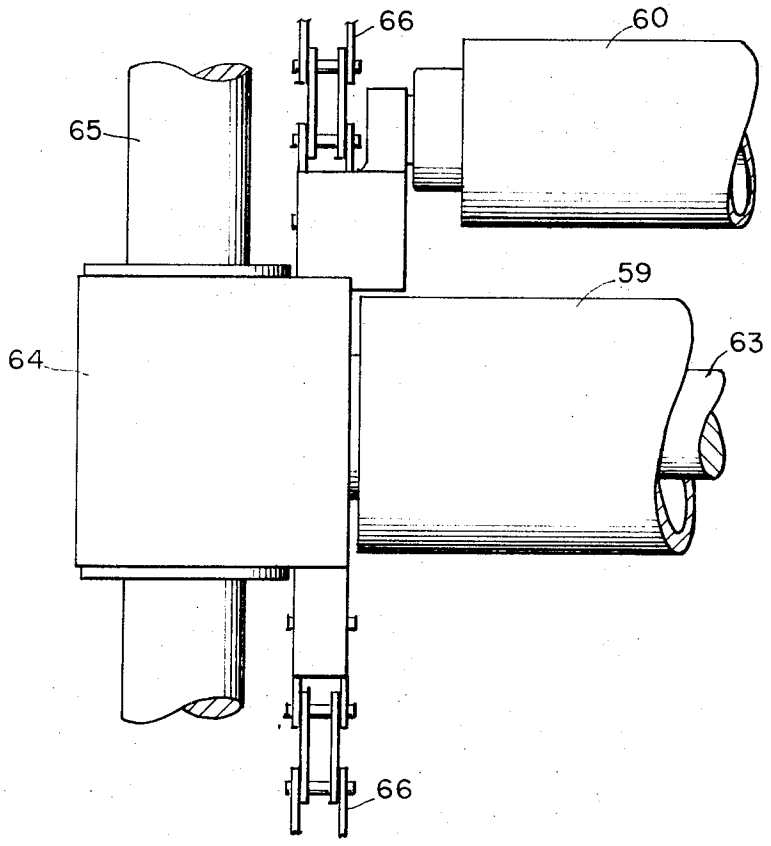


Fig. 6

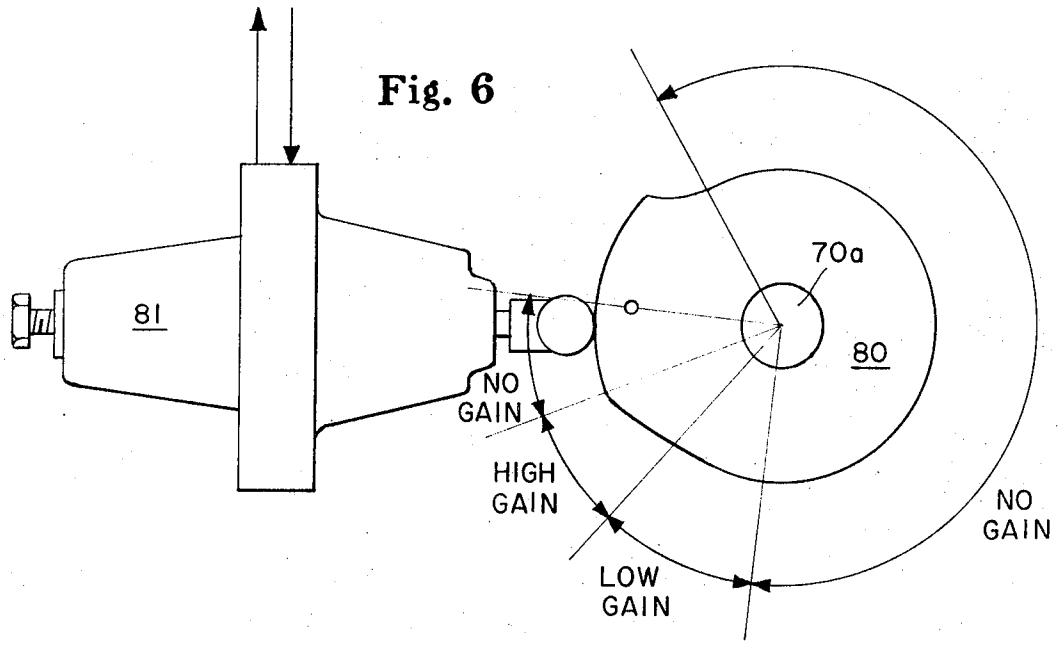
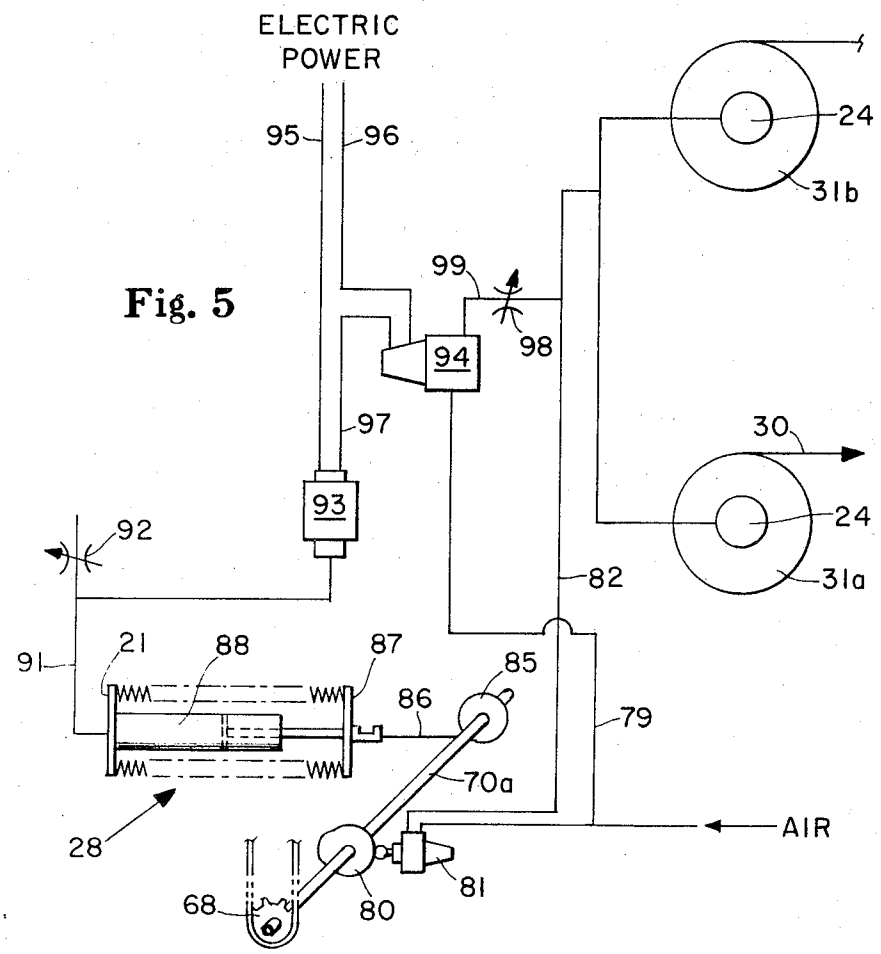

81
70a
80
NO GAIN
HIGH GAIN
LOW GAIN
NO GAIN

Fig. 5


ELECTRIC POWER
95
96
24
31b
99
98
94
97
30
93
92
24
82
31a
91
21
88
87
85
86
79
70a
AIR
28
68
80
81

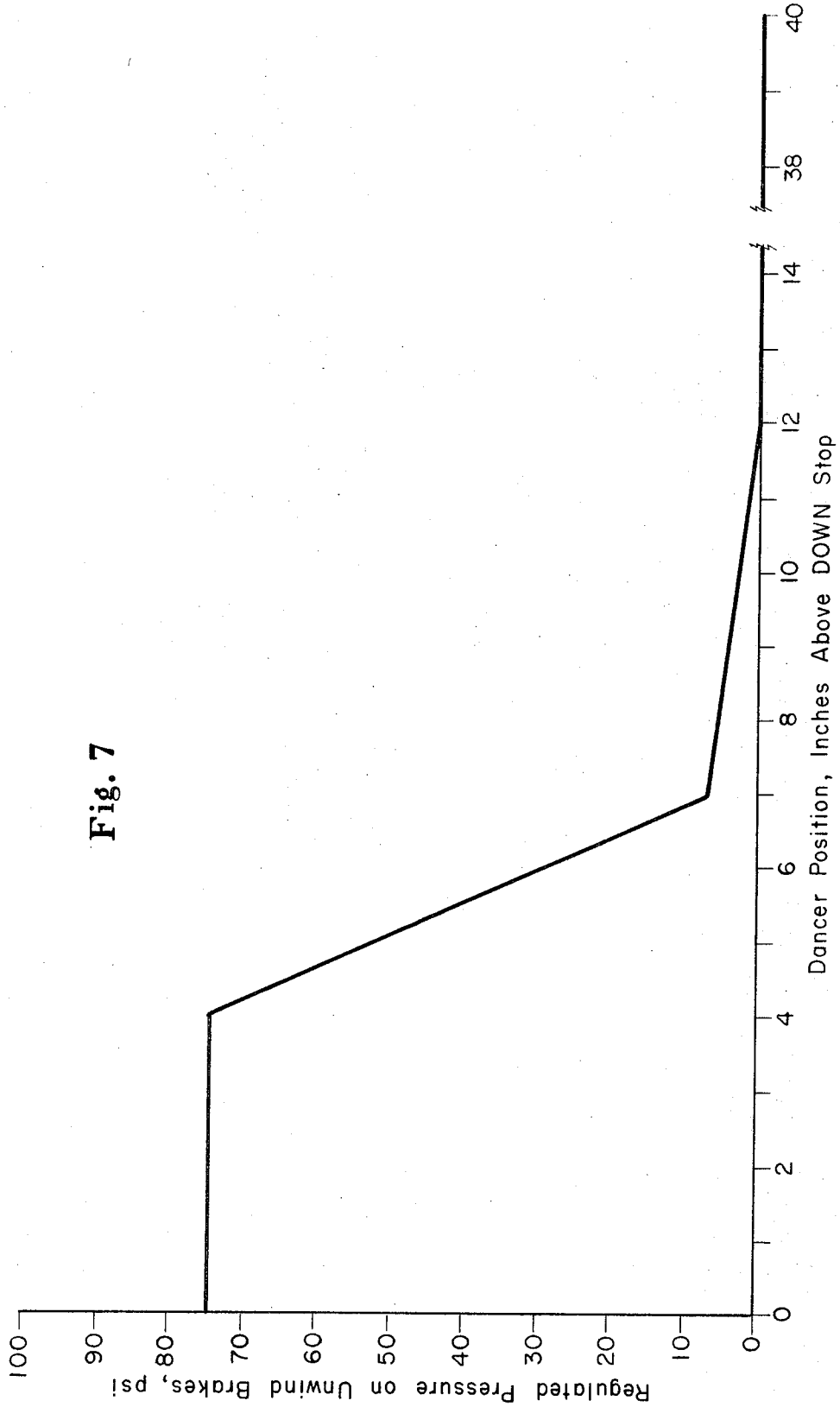
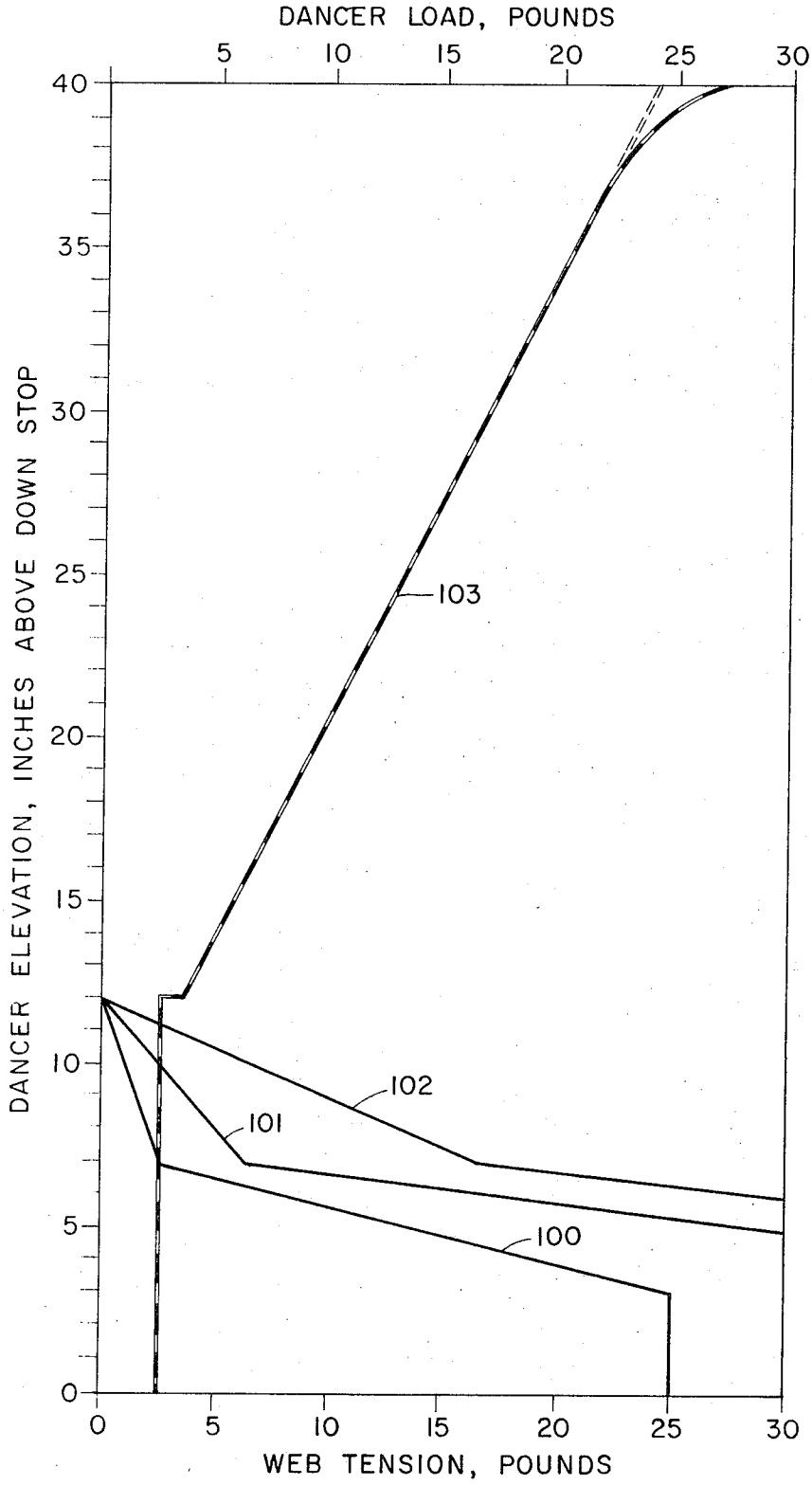

Regulated Pressure on Unwind Brakes, psi
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
38
40
Dancer Position, Inches Above DOWN Stop

Fig. 7

Fig. 9


DANCER LOAD, POUNDS
5
10
15
20
25
30
40
35
30
25
20
15
10
5
0
DANCER ELEVATION, INCHES ABOVE DOWN STOP
103
102
101
100
0
5
10
15
20
25
30
WEB TENSION, POUNDS

# WEB SPLICING, UNWINDING AND FORWARDING APPARATUS

## FIELD OF THE INVENTION

This invention relates generally to providing apparatus for continuously forwarding web material such as one mill polyethylene into a web consuming apparatus such as a converter for manufacturing disposable diapers. Continuous forwarding is enabled through successively splicing the leading edge of a new roll of web to the trailing edge of a just depleted roll of web. Such an apparatus, commonly called an unwind stand, normally includes some means for controlling web tension during steady state operation and, to a degree, during splicing transients and the like. The present invention relates to providing a low tension unwind stand having improved means for causing and controlling increased tension in the web during splicing and other major transients whereby the equipment can be re-stabilized quickly.

## BACKGROUND OF THE INVENTION

In order to continuously supply a web consuming apparatus with web from a succession of rolls of web material each new roll must be spliced to the preceding roll. Desirably, this is done without diminishing the rate of forwarding web to the web consuming apparatus. Such splicing is commonly accomplished by stopping the trailing edge of the just depleted roll while the leading edge of the succeeding roll is spliced to it.

Accumulator means defining a variable length looped path for the web are provided between the splicing means and the web forwarding means to store and pay out the web required by the web consuming apparatus during the splicing interval. That is, while the trailing edge of a just depleted roll of web is stopped to perform a splice, web is forwarded to the web consuming apparatus from the accumulator whereby the length of web stored therein is diminished. After the splice is completed, tension in the web acts tangentially on the new roll of web whereby the new roll of web is caused to accelerate.

The length of web which must be provided by the accumulator during a splicing operation is dependent on the time required to perform the splice and on the time required for tension in the web to accelerate the new roll to line velocity.

Certain web converting processes require that web materials such as distensible thermoplastic films be forwarded under very low tension although the web material is capable of withstanding relatively high tension loads without breaking. An example of such converting operations is the combining of polyethylene film with cellulose pads to make absorbent disposable diapers having a substantially impervious covering. If the plastic film is cut to length while distended, and is joined with a cellulose pad before it returns to its unstressed length, the film will cause the pad to become distorted.

The prior art discloses a variety of approaches for controlling web tension in unwind stands incorporating web accumulators. Representative prior art U.S. Patents include U.S. Pat. No. 1,637,892 issued Aug. 2, 1927 to Winthrop W. Benner et al., U.S. Pat. No. 2,062,008 issued Nov. 24, 1936 to Arthur P. Lewis et al., U.S. Pat. No. 2,242,751 issued May 20, 1941 to Owen D. McFarland, U.S. Pat. No. 2,494,402 issued Jan. 10, 1950 to William H. Mursch, U.S. Pat. No. 2,631,847 issued Mar. 17, 1953 to Clarence L. Hornberger, and U.S. Pat. No. 3,414,208 issued Dec. 3, 1968 to Richard A. Butler, Jr. et al. However, none of these approaches has solved the problems associated with low tension unwind stands in the manner nor to the degree of the present invention.



## SUMMARY OF THE INVENTION

The nature and substance of the invention will be more readily appreciated after giving consideration to its major aims and purposes. The principle objects of the invention are recited in the insuing paragraphs in order to provide a better appreciation of its important aspects prior to describing the details of a preferred embodiment in later portions of this description.

A major object of the invention is providing an improved, low tension, web splicing, unwinding and forwarding apparatus wherein a low level of steady state web tension can be maintained and in which web tension is increased during splicing transients in order to shorten such splicing induced transient intervals.

Another major object of the present invention is providing an improved web splicing and forwarding apparatus comprising an accumulator having an underslung, web supported dancer and means responsive to dancer rate-of-descent for preventing slack in the web looped through the accumulator.

Yet another major object of the invention is providing an improved web splicing, unwinding and forwarding apparatus comprising an underslung, web supported dancer which apparatus comprises means for normally maintaining a low level of tension in the web and means for increasing web tension during splicing transients, and comprises means responsive to the rate of dancer descent for preventing slack in the web looped through the accumulator.

These and other objects are achieved by providing an improved web splicing, unwinding and forwarding apparatus for unwinding web from a succession of supply rolls and forwarding web uninterruptedly to downstream apparatus at substantially constant velocity under substantially constant tension. The improved apparatus includes a frame, splicing means, web forwarding means, web unwinding means including means for revolvingly mounting a plurality of rolls of web for unwinding them and braking means for applying a controllable braking force to retard such unwinding. The apparatus further includes a web accumulator means intermediate the web forwarding means and the splicing means. The accumulator means includes a vertically movable underslung web loading dancer assembly and a plurality of idler rollers defining a looped path of variable length for the web, the length of the looped path being inversely related to the displacement of the dancer assembly above the lower end of its range of travel. Means are provided for normally controlling the unwind braking force as a dependent function of dancer elevation to maintain a substantially constant low level of web tension. The improved apparatus may comprise means for maintaining substantially constant dancer loading only throughout a lower range of dancer elevations and means for increasing dancer loading in a predetermined manner with respect to dancer elevations above said lower range. Alternatively or conjunctively, the improved apparatus may com-

prise means for increasing, in a predetermined manner, unwind brake loading above its normal dancer-elevation-dependent value during periods when the dancer is decending at a rate equal to or greater than a predetermined rate.

## BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter regarded as forming the present invention, it is believed the invention will be better understood from the following description taken in connection with the accompanying drawings in which:

FIG. **1** is a diagramic fragmentary side elevational view of a web splicing, unwinding and forwarding apparatus embodying the present invention.

FIG. **2** is an enlarged scale diagramatic side elevational view of the accumulator portion of the apparatus shown in FIG. **1** having the dancer disposed against the DOWN stop.

FIG. **3** is en enlarged scale diagramatic side elevational view of the accumulator of the apparatus of FIG. **1** having the dancer disposed against the UP stop.

FIG. **4** is a fragmentary front elevational view of the dancer assembly of the apparatus shown in FIG. **1** taken along line **4—4** thereof.

FIG. **5** is a diagramatic pictorial schematic of the tension control system for the apparatus shown in FIG. **1.**

FIG. **6** is an enlarged scale view of the dancer operated cam and air pressure regulator shown in FIG. **5** which are used to control unwind braking as a function of dancer elevation in the apparatus shown in FIG. **1.**

FIG. **7** is a graph showing the dependent relation of regulated brake pressure to dancer displacement from the DOWN stop of the dancer assembly.

FIG. **8** is an enlarged fragmentary view of the dancer rate-of-descent sensing mechanism embodied in the tension control system shown in FIG. **5.**

FIG. **9** is a composite graph showing dancer loading versus dancer elevation, and showing brake-induced web tension versus dancer elevation.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and particularly to FIGS. **1, 2** and **3,** there is shown an improved web splicing, unwinding and forwarding apparatus **20** (alternatively referred to as unwind stand **20**) which is a preferred embodiment of the present invention comprising frame **21,** web forwarding means **22,** roll support means **23,** unwind braking means **24,** web splicing means **25,** web accumulator **26,** transient dancer loading means **27,** and dancer rate-of-descent responsive means **28.**

The ensuing description of the preferred embodiment unwind stand **20** is of such an unwind stand which is configured and adjusted to unwind and forward web from 21 inch diameter rolls of one mill polyethylene, 16 inches wide, at line velocities of up to about 750 feet per minute. Such rolls weigh about 140 pounds and commonly have 3½ inch diameter spools. However, it is not intended to thereby limit the scope of the present invention to such sizes and velocity.

For convenience also, the present invention is described as improving the performance of unwind stand **20** during splicing induced transients. Although improved performance during splicing induced transients is believed to be a primary benefit of the present invention, the present invention generally improves the overall operation of unwind stand **20.**

Briefly, web forwarding means **22** acts to unwind rolls **31** of web material **30** while braking means **24** provides torque to retard such unwinding in order to establish and maintain desired tension in web **30.** Web splicing means **25** is provided to splice a new roll of web **30** to a just depleted roll of web so that web can continuously be forwarded by web forwarding means **22** at a substantially constant velocity to downstream apparatus even during splicing transients and the like. Transient dancer loading means **27** enables maintaining a low level of web tension during normal, steady state operation while providing increased web tension during splicing and other major transients. Such increased tension is provided to quickly accelerate a new roll of web whereby the length of web stored in accumulator **26** can be small as compared to the length that would be required if tension were not increased during such transients. Dancer rate-of-descent responsive means **28** is provided to increase unwind braking torque in a predetermined manner whenever the rate-of-descent of the dancer equals or exceeds a predetermined value. The predetermined manner of increasing braking torque and the predetermined rate-of-descent are selected to prevent the dancer from reaching the DOWN stop which would otherwise precipitate slack in the web.

In order to accomplish such a splice, the trailing edge of a just depleted roll of web is substantially slowed while the leading edge of a new roll of web is secured to it. During a splicing interval, web forwarding means **22** withdraws web stored in web accumulator **26.** Following the splicing operation, web forwarding means **22** applies tension through the web which, acting tangentially on the new roll, causes the new roll of web to accelerate until its peripheral velocity equals and then exceeds the forwarding velocity of web **30** passing through web forwarding means **22.** The fact that the roll must have a peripheral velocity greater than the forwarding velocity in order to reload the accumulator, necessitates reducing the peripheral velocity of the roll to equal the forwarding velocity before the dancer reaches the DOWN position. The dancer rate-of-descent responsive means **28** enables doing this as will be described more fully after completing the description of the preferred embodiment of the present invention.

Web forwarding means **22,** FIG. **1,** comprises nip rollers **35, 36** which are so disposed and so configured to form a nip **37** therebetween for engaging web material **30** whereby web can be forwarded to downstream apparatus. Rollers **35** and **36** are driven by means not shown in FIG. **1** to provide the desired web forwarding velocity.

Upper and lower roll support means **23,** FIG. **1,** are provided for mounting rolls **31**a, **31**b of web material **30** so that they are freely rotatable in the unwind direction except when such rotation is retarded by braking means **24.**

Braking means **24,** alternatively referred to as brakes **24,** comprises pneumatically actuated brakes which are secured to frame **21** so that they can act, through means not shown, to apply torque to retard unwinding rolls **31***a* and **31***b* in the direction indicated. As will

later be described in more detail, the braking torque provided by brakes **24** is controllable by controlling the pressure of air supplied to them.

Web splicing means **25**, as shown in FIG. **1**, is provided with idler rollers **40, 41** and **42** for guiding web **30** from roll **31***a* between splicing rollers **43** and **44**. Splicing means **25** is further provided with idler rollers **45, 46** and **47** for guiding a web **30** from roll **31***b* to between splicing rollers **43** and **44**. Briefly, the splicer is prepared to perform a splice by applying pressure sensitive splicing tape **50** to the transversely extending leading edge of the new roll of web and to secure tape **50** to transversely extending support **51** so that the leading edge **53** of splicing tape **50** extends between splicing rollers **43** and **44**. The splicing rollers **43** and **44** are mounted on eccentric axes so that when they are simultaneously rotated, they will press splicing tape **50** against the trailing edge of web **30** from a just depleted roll of web.

Because it is believed that the splicing operation and means therefore are not critical with respect to the present invention, the means for synchronizing the rotation of splicing rollers **43** and **44** to perform the splice as described is not shown. Suffice it to say that it is believed to be within the range of skill or persons having ordinary skill in the art to provide means for synchronizing the rotation of the splicing rollers. Such means might comprise, for instance, a photo electric detector.

After a splice is completed, a new roll of web is installed on roll support means **23** to replace the just depleted roll. Then the newest roll of web would be prepared for splicing its leading edge to the trailing edge of roll **31***b* upon depletion of roll **31***b*. Thus, rolls of web **31** are alternately forwarded from the upper and lower roll support means **23** to enable web forwarding means **22** to uninterruptedly forward web **30** to downstream apparatus at substantially constant velocity.

Accumulator means **26**, FIG. **1**, is provided intermediate web forwarding means **22** and web splicing means **25** for the purpose of storing a loop of web of sufficient length to permit web forwarding means **22** to uninterruptedly forward web **30** to downstream apparatus even during splicing operations when infeed into the accumulator is momentarily stopped and until the new roll of web is accelerated to line velocity. Another function of the accumulator is to provide means for establishing and maintaining a low level of the tension in web **30** during steady state operation.

The web accumulator **26**, FIGS. **1, 2** and **3**, comprises frame supported, rotatably mounted idler rollers **55, 56** and **57**, a vertically movable, underslung dancer assembly **58**, and vertically extending guides **65**, FIG. **4**, secured at their ends to frame **21**. The accumulator also comprises two loops of chain **66**, two upper sprockets **67**, two lower sprockets **68**, shafts **69, 70**, DOWN stop **61**, and UP stop **62**.

The dancer assembly **58**, only one end of which is shown in enlarged scale in FIG. **4**, comprises hollow aluminum dancer idler rollers **59, 60** to reduce the inertia of the dancer. Rollers **59, 60** are rotatably supported at both ends of guide blocks **64**. Each guide block **64** is provided with bushing means not shown for telescoping a guide **65** through it. Tie bar **63**, disposed within dancer idler roller **59**, is non-rotatably secured to guide blocks **64** to increase the structural integrity of dancer assembly **58**. Because guides **65** extend vertically, dancer assembly **58** has a vertically extending range of travel. As also indicated in FIG. **4**, means is provided for securing a chain to each end of dancer assembly **58** which chain is looped about upper sprockets **67** and lower sprockets **68**, FIGS. **2** and **3**, mounted on shafts **69, 70** respectively. Shafts **69, 70** are rotatably secured to frame **21**. The lower sprockets **68** are non-rotatably secured to shaft **70**. By thus coupling the dancer assembly **58** to the loops of chain **66**, vertical movement of dancer assembly **58** is translated into rotational movement of shaft **70** and linear motion of a yoke **72**. The purpose of yoke **72** will be described in conjunction with describing transient dancer loading means **27**, and the functions associated with rotating shaft **70** will be described in conjunction with describing the control of unwind braking means **24** and in describing dancer rate-of-descent responsive means **28**.

A storage loop of web **30** comprising two nested V's is formed by threading web **30** through accumulator **26** as shown in FIG. **1**. The dancer assembly is operable between a DOWN stop **61** and an UP stop **62** which stops are secured to frame **21** and are provided with suitable cushioning means not shown. In the preferred embodiment of unwind stand **20**, DOWN and UP stops **61** and **62** respectively are spaced to provide a vertical range of travel for dancer assembly **68** of about forty inches for use with 21 inch diameter rolls of polyethylene as described hereinbefore.

One side of two substantially identical sides of the transient dancer loading means **27** which is incorporated in the preferred embodiment of the improved unwind stand **20** is shown in FIGS. **2** and **3**. Each side of means **27** comprises a tension spring **73** intermediate frame **21** and the smaller end of a headed rod **74** so that spring **73** and rod **74** depend from frame **21**. Yoke **72** is provided with a clearance aperture through which rod **74** will freely pass except for its headed end. As shown in FIG. **2**, when the dancer is against DOWN stop **61**, a length L of rod **74** extends below yoke **72**. Thus, referring to only one side of means **27**, upon upward movement of dancer assembly **58**, yoke **72** passes over the length L of rod **74**. Upon continued upward movement of dancer assembly **58**, yoke **72** engages the headed end of rod **74** whereupon spring **73** will be elongated. Referring to FIG. **3** in which the dancer assembly is shown against UP stop **62**, it will be observed that spring **73** has been extended by the action of yoke **72** through rod **74** as described. Length L in the preferred embodiment apparatus is about 12 inches.

From the foregoing description of the transient dancer loading means **27**, it will be obvious that the dancer imparted load on the web, hereinafter the dancer load, on web **30** will essentially be the weight of dancer assembly **58** through stroke L and will be the sum of the weight of dancer assembly **58** and tension in springs **73** through the remainder of the dancer's range of travel.

The means for controlling braking torque applied by brakes **24** to retard unwinding the rolls **31***a*, **31***b* of web **30** is shown in the diagrammatic schematic FIG. **5**. Pressurized air is received from a suitable source therefore to pressurize tubing **79** to a pressure of about 75 pounds. Cam **80**, secured on shaft **70***a* is driven by shaft **70** through a suitable gearbox for synchronized rotation therewith. Cam **80** operates air pressure regulator **81** through a follower mechanism as better illustrated in enlarged scale in FIG. **6**.

In the preferred embodiment of the unwind stand **20**, cam **80** is ground and indexed with dancer elevation to provide the regulated pressure for the unwind brakes **24** versus the dancer elevation as graphed in FIG. **7.** As is evident from examining FIG. **7**, maximum pressure is applied to brakes **24** through tubing **82** between the zero and three inch levels of dancer elevation as measured from DOWN stop **61.** The pressure is rapidly reduced between the 3 and 7 inch levels to a value of 8 p.s.i. Between the 7 and 12 inch levels of dancer elevation, pressure is gradually reduced from 8 p.s.i. to 0 p.s.i. 0 p.s.i. air is applied to tubing **82** through regulator **81** while the dancer is between the 12 and 40 inch levels.

Dancer rate-of-descent responsive means **28** is shown, FIG. **5,** to comprise winching sheave **85,** cable **86,** bracket **87,** air cylinder **88,** tension springs **89, 90,** tubing **91,** adjustable bleed orifice **92,** pressure operated switch **93,** solenoid valve **94,** and electric wires **95, 96** and **97.** Also, the discharge port of solenoid valve **94** is connected to tubing **82** through an adjustable orifice **98** and tubing **99.**

Referring now to FIG. **8,** cylinder **88** is shown in enlarged scale with its piston rod connected by cable **86** to winching sheave **85** so that upward travel of the dancer assembly **58** will extend the piston rod and, upon downward movement of the dancer assembly, springs **89** and **90** will act through bracket **87** to retract the piston of the air cylinder. Thus, air is drawn into tubing **91** through bleed orifice **92** during upward movement of the dancer assembly which air is pressurized within cylinder **88** upon downward movement of the dancer assembly **58.** The pressure developed by cylinder **88** is a function of the dancer rate-of-descent and the adjustment of bleed orifice **92.** Because switch **93** is only operated to its closed position by a higher than ambient pressure, it is closed only when the dancer rate-of-descent equals or exceeds a predetermined value. Bleed orifice **92** is used to adjust the predetermined rate.

Upon closing of switch **93,** electric power is applied from a suitable source to solenoid valve **94** which then ports unregulated pressurized air from tubing **79** to tubing **82** through tubing **99** and orifice **98** and thence to brakes **24** whereby increased braking is effected whenever the dancer rate-of-descent equals or exceeds the predetermined value. Switch **93** will open when the dancer's rate-of-descent decreases to below the predetermined rate and the pressure in tubing **91** bleeds down through bleed orifice **92.**

Air pressure regulator **81** is a continuous bleed type regulator which acts to bleed its discharge line to ambient whenever the pressure in the discharge line exceeds the pressure which the regulator is positioned for. Thus, upon the opening of switch **93** causing solenoid valve **94** to be degenerized, valve **94** closes. Then, with no air applied to tubing **82** through valve **94,** the pressurized air in tubing **82** will bleed through regulator **81** whereby brakes **24** are depressurized to whatever pressure regulator **81** is positioned for by cam **80** (i.e., the elevation of dancer assembly **58**).

The operation of the improved unwind stand **20** embodying the present invention can be understood best by describing the sequence of events which occur during an interval from just after stand **20** has stabilized after a splicing event until steady state operation is achieved again after the next splicing event. The following description describes splicing roll **31*b***, FIG. **1,** to roll **31*a*** with the understanding that rolls disposed in the upper and lower roll supports will be spliced alternately.

Referring to FIG. **9,** curves **100, 101,** and **102** show web tension versus dancer elevation for 21, 10, and 3½ inch diameter rolls respectively which curves reflect the effect of regulating brake pressure as a function of dancer elevation, FIG. **7.** Referring again to FIG. **9,** dancer load curve **103** reflects the fact that the dancer load consists only of the dancer weight between the 0 and 12 inch levels of the dancer travel and is increased above the 12 inch level due to the elongation of springs **73** as described hereinbefore.

The intersection between curves **100** and **103,** FIG. **9,** indicates that dancer **58** of unwind stand **20** is balanced with the dancer at about the 7 inch level because web tension is then equal to dancer load. The intersections between curve **103** and curves **101** and **102** further indicate that as a roll of web is depleted and its diameter decreases to the 3½ inch spool diameter, the dancer will rise to about the eleven inch level in order to reduce regulated braking pressure to maintain a substantially constant low level of tension in the web of about 2½ pounds.

When a splice is initiated, the stopping of the trailing edge of the just depleted roll **31*a*** of web **30** causes dancer assembly **58** to move upwardly towards UP stop **62,** FIG. **3.** As the dancer moves upwardly, the dancer load on the web causes the web tension to increase as indicated by the dancer load curve **103,** FIG. **9.** Thus, after the splice is completed, an increased level of tension is applied through web **30,** FIG. **1,** to the newly spliced roll **31*b*** of web **30** which will cause the new roll **31*b*** of web to accelerate. The dancer assembly **58** will continue to rise, as will web tension, until the peripheral velocity of the newly spliced roll of web equals the velocity of web being forwarded through nip **37.** Because the dancer assembly will have risen above the 12 inch level by the time the splice is completed, the new roll of web is accelerated without being retarded by brakes **24.**

Therefore, at the time the peripheral velocity of the newly spliced roll of web equals the velocity of web being forwarded through nip **37,** a large torque is still being applied to roll **31*b*** through web **30** to continue to accelerate the newly spliced roll. This causes the peripheral velocity of roll **31*b*** to exceed the velocity of web **30** through nip **37** whereupon the dancer assembly **58** will begin to travel downwardly to reload the storage loop in accumulator **26.** It is at this time when no retarding brake force is being demanded by virtue of the dancer elevation that the dancer rate-of-descent responsive means **28** acts to apply braking torque to the overspeeding roll to prevent the dancer from descending to the DOWN stop **61** which would cause web **30** to go slack.

As the dancer moves downwardly past the twelve inch level, normal braking force as a function of dancer elevation is applied to brakes **24** whereupon the dancer will again stabilize at about the 7 inch level. The response of the system can be adjusted through bleed orifice **92** to achieve rapid stabilization.

Referring again to FIG. **9,** the high levels of web tension that are induced by brakes **24** when the dancer is in the 0 to 7 inch range of travel are provided primarily to quickly stop high inertia rolls of web in the event nip

rollers **35, 36** are quickly slowed or stopped. However, this range of dancer travel is operative during start-up and will become operative if the dancer moves to below the 7 inch level during transients such as post-splice stabilization. However, the brake control system functions substantially the same during such events as during a quick stop by applying increased regulated air pressure to brakes **24** as a function of dancer elevation.

While the preferred embodiment of the improved unwind stand **20** has been described for use in unwinding rolls of polyethylene having an initial diameter of 21 inches, a terminal diameter of 3½ inches, a width of 16 inches, and a weight of 140 pounds, at a velocity of up to about 750 feet per minute, it is not intended to limit the scope of the present invention to such material, the size of the roll described, or to such range of velocity. It is believed that it will be obvious to those skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the invention and it is intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

What is claimed is:

**1.** An improved web splicing, unwinding and forwarding apparatus for unwinding web from a succession of supply rolls and forwarding web uninterruptedly to downstream apparatus at substantially constant velocity under substantially constant tension, said apparatus including a frame, splicing means, web forwarding means, unwinding means including means for revolvingly mounting a plurality of said rolls for unwinding them and braking means for applying a controllable braking force to retard said unwinding, web accumulator means intermediate said forwarding means and said splicing means, said accumulator means including a vertically moveable underslung web loading dancer assembly and a plurality of idler rollers defining a looped path of variable length for said web, the length of said path being inversely related to the displacement of said dancer assembly above the lower end of its range of travel, and means for normally controlling said braking force as a dependent function of dancer elevation to maintain substantially constant web tension, the improvement comprising means for maintaining substantially constant dancer loading only throughout a lower range of dancer elevation and means for increasing dancer loading in a predetermined manner with respect to dancer elevations above said lower range.

**2.** An improved web splicing, unwinding and forwarding apparatus for unwinding web from a succession of supply rolls and forwarding web uninterruptedly to downstream apparatus at substantially constant velocity under substantially constant tension, said apparatus including a frame, splicing means, web forwarding means, unwinding means including means for revolvingly mounting a plurality of said rolls for unwinding them and braking means for applying a controllable braking force to retard said unwinding, web accumulator means intermediate said forwarding means and said splicing means, said accumulator means including a vertically moveable underslung web loading dancer assembly and a plurality of idler rollers defining a looped path of variable length for said web, the length of said path being inversely related to the displacement of said dancer assembly above the lower end of its range of travel, and means for normally controlling said braking force as a dependent function of dancer elevation to maintain substantially constant web tension, the improvement comprising means for maintaining substantially constant dancer loading only throughout a lower range of dancer elevation and means for increasing dancer loading in a predetermined manner with respect to dancer elevations above said lower range, said means for increasing said dancer loading comprising a spring, and spring engaging means for adding spring force to said dancer loading as a direct function of dancer displacement above said lower range.

**3.** The improved web splicing, unwinding and forwarding apparatus of Claim **2** wherein said spring is a tension spring having one end secured to said frame, and said spring engaging means comprises a rod and yoke assembly intermediate the other end of said spring and said dancer.

**4.** An improved web splicing, unwinding and forwarding apparatus for unwinding web from a succession of supply rolls and forwarding web uninterruptedly to downstream apparatus at substantially constant velocity under substantially constant tension, said apparatus including a frame, splicing means, web forwarding means, unwinding means including means for revolvingly mounting a plurality of said rolls for unwinding them and braking means for applying a controllable braking force to retard said unwinding, web accumulator means intermediate said forwarding means and said splicing means, said accumulator means including a vertically moveable underslung web loading dancer assembly and a plurality of idler rollers defining a looped path of variable length for said web, the length of said path being inversely related to the displacement of said dancer assembly above the lower end of its range of travel, and means for normally controlling said braking force as a dependent function of dancer elevation to maintain substantially constant web tension, the improvement comprising means for increasing, in a predetermined manner, brake loading above its normal dancer-elevation-dependent value during periods said dancer is descending at a rate equal to or greater than a predetermined rate, said apparatus further comprising means for maintaining substantially constant dancer loading only throughout a lower portion of said range of dancer elevations, and means for increasing dancer loading in a predetermined manner as a function of dancer elevation above said lower portion of said range of dancer elevations.

**5.** An improved web splicing, unwinding and forwarding apparatus for unwinding web from a succession of supply rolls and forwarding web uninterruptedly to downstream apparatus at substantially constant velocity under substantially constant tension, said apparatus including a frame, splicing means, web forwarding means, unwinding means including means for revolvingly mounting a plurality of said rolls for unwinding them and braking means for applying a controllable braking force to retard said unwinding, web accumulator means intermediate said forwarding means and said splicing means, said accumulator means including a vertically moveable underslung web loading dancer assembly and a plurality of idler rollers defining a looped path of variable length for said web, the length of said path being inversely related to the displacement of said dancer assembly above the lower end of its range of travel, and means for normally controlling said braking force as a dependent function of dancer elevation to

maintain substantially constant web tension, the improvement comprising means for increasing, in a predetermined manner, brake loading above its normal dancer-elevation-dependent value during periods said dancer is descending at a rate equal to or greater than a predetermined rate, said means for increasing brake loading comprising rate sensing and signaling means for sensing whenever said rate equals or exceeds said predetermined value and for providing an output signal during such periods, and means responsive to said signal for increasing said braking.

**6.** The improved web splicing, unwinding and forwarding apparatus of claim **5** wherein said braking means are pneumatically operated and said means for increasing said braking force comprises an electrically operated valve and means for operating it to bypass the normal source of dancer-position-dependent regulated pressure supplied to said braking means.

**7.** The improved web splicing, unwinding and forwarding apparatus of claim **4** wherein said means for increasing said dancer loading comprises a spring, and spring engaging means for adding spring force to said dancer loading as a direct function of dancer displacement above said lower range.

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