United States Patent [19]

Melead

[11] **3,796,390**

[45] **Mar. 12, 1974**

[54] **WINDING, UNWINDING AND TENSIONING APPARATUS**

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[73] Assignee: **Beloit Corporation,** Beloit, Wis.

[22] Filed: **Apr. 14, 1972**

[21] Appl. No.: **244,300**

Related U.S. Application Data

[62] Division of Ser. No. 83,730, Oct. 26, 1970, Pat. No. 3,692,251.

[52] **U.S. Cl.** **242/75.5,** 226/195

[51] **Int. Cl.** **B65h 25/04,** B65h 25/22

[58] **Field of Search** 242/75.5, 75, 75.51, 75.52, 242/75.53; 226/25, 44, 195

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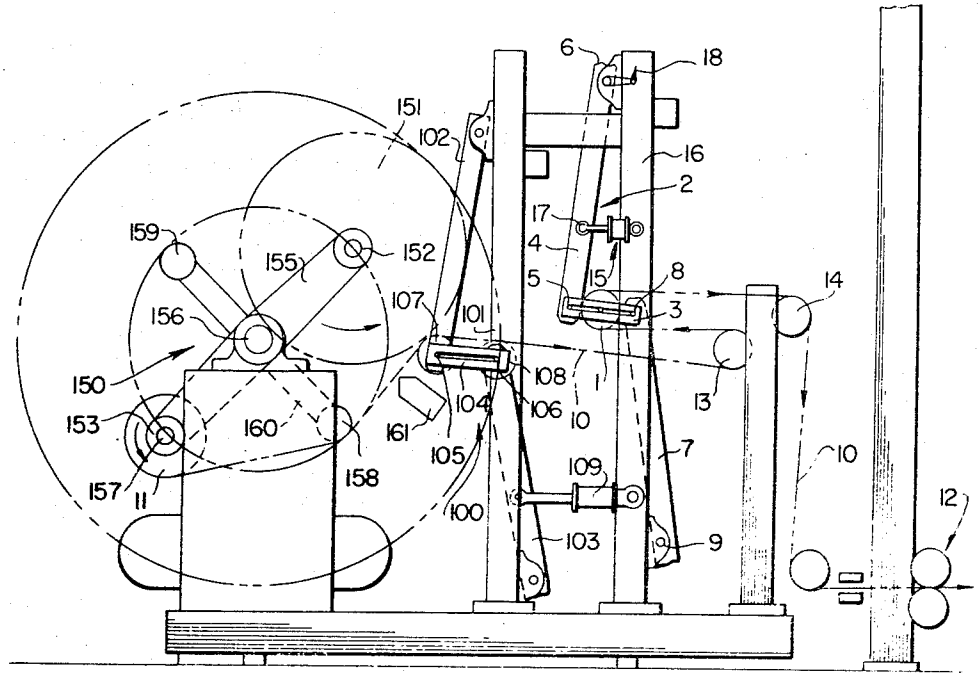
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Assistant Examiner—Edward J. McCarthy
Attorney, Agent, or Firm—Larson, Taylor & Hinds

[57] **ABSTRACT**

The invention relates to filament tension regulation apparatus useful to regulate the tension in a moving filament such as during the winding or unwinding or a web or threadlike filament. The invention relates further to a web guide roller assembly for assisting in the movement of a web relative to a roll of the web material such as a splicing roll apparatus useful in web unwinding or a lay-on roll apparatus for use in web winding. The invention further relates to web unwinding apparatus, to web winding apparatus, and to web winding and unwinding apparatus involving combinations of the splicing roll apparatus, the lay-on roll apparatus, and web tension regulating apparatus. The filament tension regulation apparatus comprises a roller mounted for rotation in members disposed at the ends of the roller, the members being supported by pivot arms extending upwardly and downwardly of the member. The arms are of equal length and the roller is centrally located on the member between the pivot areas such that the roller is capable of horizontal motion supported by the pivot arms. The moving filament engages the roller in such a way that horizontal force is applied to the roller in a direction in opposition to a desired pre-determined horizontal force. Changes in filament tension relative to the pre-determined horizontal force cause horizontal motion of the roller and this motion is utilized to adjust tension to a desired value such as by changing filament speed. The web guiding roll apparatus comprises a pair of rollers mounted for rotation and pivotally supported by pivot arms as in the case of the filament tension regulating device. The rollers, however, are located at points symmetrical about a point midway between the pivot arms and thus will undergo pivoting motion. The arms are of equal length and the rollers are preferably of equal mass whereby the device is easily moved into and out of engagement with a web roll for splicing during unwinding or for forming a nip during winding.

10 Claims, 3 Drawing Figures



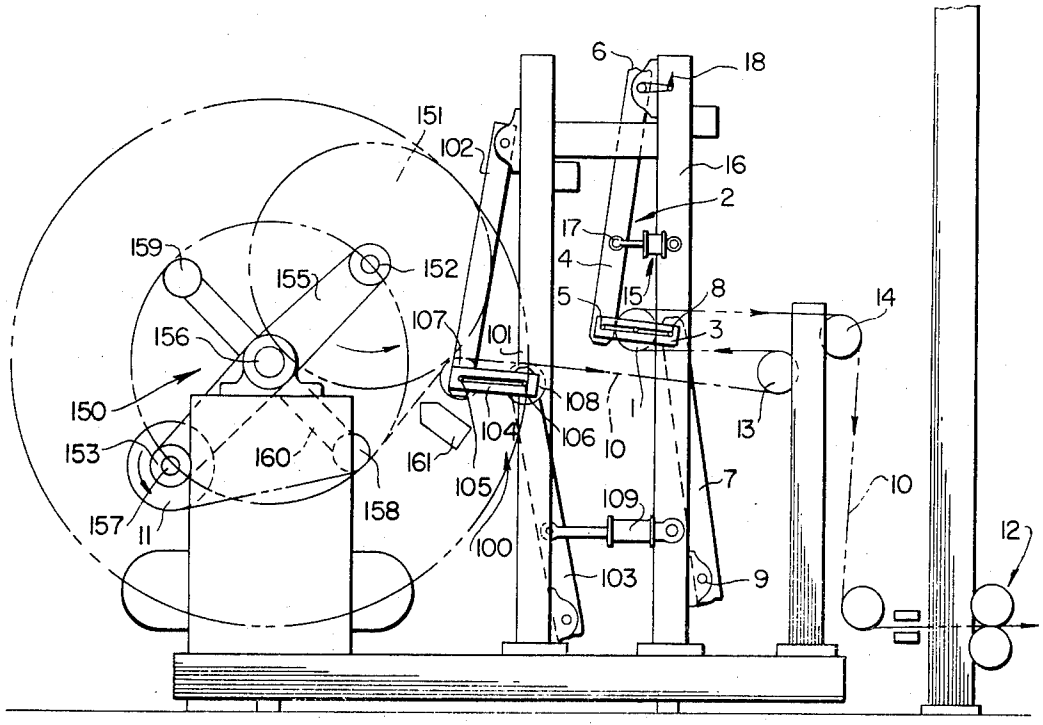

6
18
151
102
16
2
17
159
4
152
155
5
15
8
14
107
101
3
156
150
108
1
13
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158
109
12
100
103
9

FIG. 1

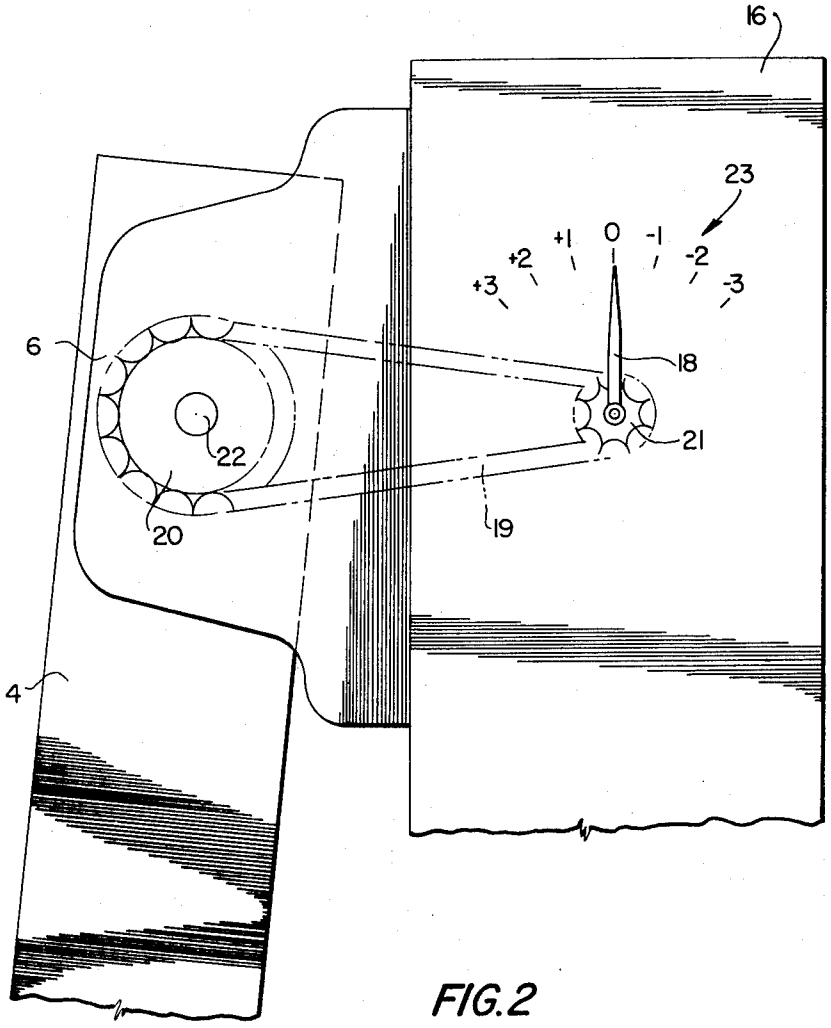


FIG.2

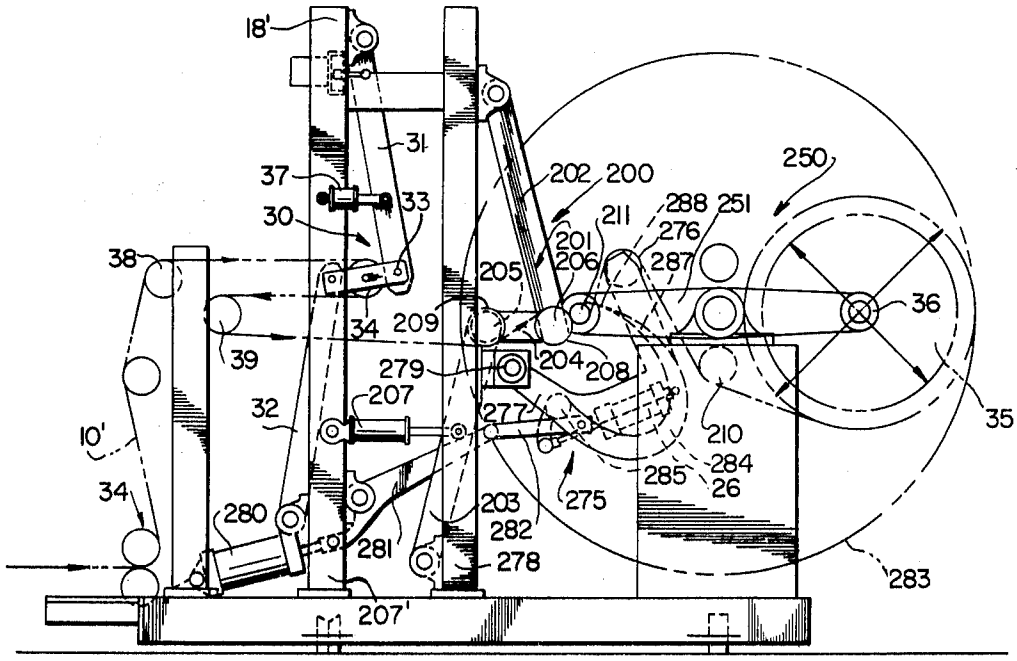

18'
31
37
33
30
38
34
39
32
10'
34
280
281
207'
207
279
209
205
202
200
201
206
211
288
251
276
287
250
36
35
204
208
277
210
285
284
26
275
203
282
278
283

FIG. 3

WINDING, UNWINDING AND TENSIONING APPARATUS

This is a division, of application Ser. No. 83,730 filed Oct. 26, 1970 now U.S. Pat. No. 7,692,251.

BACKGROUND OF THE INVENTION

This invention relates to winding and unwinding apparatus. In one aspect, the invention relates to apparatus for the regulation of the tension of a moving filament, such as a web. In another aspect, the invention relates to web tension control apparatus useful in web unwinding and web winding. In still another aspect, the invention relates to web guiding roll apparatus useful in splicing during web unwinding and laying-on during winding. In yet another aspect the invention relates to web unwinding apparatus including a splicing roll assembly and web tension regulating apparatus according to the invention, to web winding apparatus including a lay-on roll assembly and web tension regulating apparatus according to the invention, and to a web unwinding and winding apparatus involving web tension regulating apparatus and web guide roller apparatus according to the invention.

Web unwinding and winding operations are well known and involve either the unwinding of a web from a roll of the web material or the winding of a length of web onto a core to form a roll of the web material. The web material is under some tnesion and in most cases web tension must be controlled for effective winding or unwinding. It will be apparent that the size of the roll will continuously change during the operation. For example, in winding, the roll increases in size. Therefore, at constant RPM, the web speed continuously increases which increases web tension as the web is wound resulting in a relatively loose web in the inner portion of the web and a relatively tight outer portion. This can result in extremely poor roll characteristics, web breakage, and the like. Where the web is elastic, such as a plastic sheet, increased tension can result in drawing the sheet which reduces its thickness and cross section. The operation is additionally complicated by the fact that the winding and unwinding operations are continuous. That is, after a roll is unwound, the leading end of a fresh roll is spliced onto the trailing end of the unwound roll in a suitable device such as a turret unwinder which sequentially indexes fresh rolls into a splicing position. Similarly, after a roll is wound, a continuous winder such as a turret winder is used to index an empty core into position for winding and after a roll is fully wound, the moving web is severed and the leading edge is keyed to the empty core.

In order to control the web tension in these devices, there are several known web tension regulating devices which generally function to monitor web tension relative to pre-determined value which value may be constant or may vary as the operation proceeds. For example, in winding an elastic web it is frequently desireable to decrease web tension as the run progresses while unwinding is frequently performed at constant web tension. Once a change relative to a desired value of web tension is detected, the web tension is adjusted to the desired value in any convenient way such as by changing web speed, by changing web drag, or both. While several devices, such as dancer rolls, transducers, and the like, are known to detect changes in web tension, these devices have one or more disadvantages such as lack of sensitivity, lack of "forgiveness," excess friction, and the like.

It is also known in winding and unwinding a web to use a web guiding roller. In winding, a roller is used to lay a leading web end on a fresh core by forming a pressure nip into which the web end is introduced. After the roll is initially formed on the fresh core, the lay-on roller is usually spaced from the winding roll surface. In a continuous operation, the roller is moved from a position in adjacency with the surface of a wound roll to form a pressure nip with a fresh core. In unwinding, a splicing roll positioned in engagement with the moving web is moved towards a fresh web roll to engage the trailing end of the unwound roll with the leading end of the fresh roll. The splicing roll is subsequently removed from its splicing position in readiness for the next splicing operation. The lay-on rolls and splicing rolls used heretofore are usually pivotally mounted and suffer from several disadvantages such as the necessity of large forces to move these rollers rapidly from one position to another as in the case of continuous winding and unwinding.

It is an object of the present invention to provide a filament tension regulating apparatus which is free from the disadvantages mentioned above. It is a further object to provide a filament tension regulating apparatus having a roller which is mounted for rotation on a member pivotally mounted in such a way that the roller undergoes horizontal motion with minimum friction. It is still a further object to provide a web guide roller assembly, such as a splicing roll assembly or a lay-on roll assembly, for guiding motion of a web relative to a roll of web material which is free from the disadvantages of such assemblies known heretofore. It is still a further object to provide a lay-on roll assembly for winding and a splicing roll assembly for unwinding which are free from several of the disadvantages for such assemblies known heretofore. It is still a further object of the present invention to provide improved web winding apparatus including the improved web tension regulating apparatus and lay-on roll apparatus according to the present invention, to provide improved web unwinding apparatus including the improved web tension regulating apparatus and splicing roll apparatus according to the present invention, and to provide an improved web unwinding and winding apparatus including the improved tension regulating device, the improved splicing roll device, and the improved lay-on roll device according to the present invention.

BRIEF SUMMARY OF THE PRESENT INVENTION

The foregoing objects and others which will be apparent to those having ordinary skill in the art are achieved by an improved filament tension regulating device, an improved web guide roll assembly, and winding and unwinding apparatus including same.

A filament tension regulating aparatus according to the present invention includes a roller which is mounted for rotation in members pivotally supported in such a manner that the roller is moveable horizontally in a direction normal to the roller axis. The roller is positioned with its axis transverse to a moving filament, such as a web, in engagement with the filament such that the filament applies a horizontal force biasing the roller in a horizontal direction substantially normal to the roller axis due to tension in the moving filament. The roller is mounted for rotation at each end by a

member which is pivotally secured at a first pivot point to a first pivot arm extending generally upward and at a second pivot arm extending generally downward. The pivot arms and member are mounted for motion in a vertical plane transverse to the roller axis. Each pivot arm is pivotally secured to a fixed support thereby pivotally supporting the member. The pivot arms are of equal length and the roller axis lies at the midpoint of a line connecting the first and second pivot points on each roller support member. The roller is thus capable of moving for a limited distance in a purely horizontal plane in a direction normal to the roller axis. The pivot arms and member forming the support for the roller are generally in the configuration of a "Z" turned on its side and hence the support assembly will be referred to hereinafter as a Z bar. The filament tension regulating device alao includes means to bias the roller with a desired amount of force in a horizontal direction opposite to that induced by web tension and thus the horizontal motion or position of the roller gives an indication of actual web tension relative to a desired web tension. The pivoting support provides a massive dancer roll operating horizontally with minimal friction which is very responsive to changes in web tension thus providing close control.

A guide roll assembly according to the invention includes a pair of Z bar support assemblies arranged as in the case of the tension regulating assembly. In this case, however, the bar includes a pair of rollers, mounted at or adjacent the first and second pivot points respectively at points located symmetrically with respect to a point located midway of said first and second pivot points. The rollers are preferably of equal mass thus providing a balanced unit. While each roller undergoes pivoting motion in a direction normal to the roller axis, the rollers move with little friction and, due to the balanced design, will assume any given position under static conditions. Thus, the rollers are easily moved when in contact with a running web. The guide roll assembly is particularly useful as a lay-on roll or a splicing roll in which case the device will include means to move the roll into adjacency with, respectively, a fresh core for winidng or a fresh roll for unwinding. Web winding and unwinding apparatus according to the invention are readily integrated to form an improved continuous web winding and unwinding operation.

DETAILED DESCRIPTION OF THE INVENTION

There follows a detailed description of a preferred embodiment of the invention, together with accompanying drawings. However, it is to be understood that the detailed description and accompanying drawings are provided solely for the purpose of illustrating a preferred embodiment and that the invention is capable of numerous modifications and variations apparent to those skilled in the art without departing from the spirit and scope of the invention.

FIG. 1 is a diagrammatic side elevation view of a web unwinding apparatus including a web tension regulating device and splicing roll device according to the present invention;

FIG. 2 is a diagrammatic side elevation of a portion of FIG. 1 showing details of a roll position indicator; and

FIG. 3 is a diagrammatic side elevation view of a web winding apparatus including a web tension regulating device and lay-on roll device according to the present invention.

With reference to FIG. 1, a filament tension regulating device according to the present invention includes a roller 1 having its ends supported by a pair of Z bars 2, one only being shown in the drawing. The Z bar 2 includes a member 3 to which is secured a first pivot arm 4 pivotally secured to member 3 at a first pivot point 5, extending generally upwards of a member 3 and pivotally secured to a fixed support by means of a suitable pivot 6. The Z bar also includes a second pivot arm 7 pivotally secured to the member 3 at a second pivot point 8, extending generally downward of member 3 and pivotally secured to a fixed support by means of a suitable pivot 9. Member 3 is thus pivotally supported by pivot arms 4 and 7 by means of pivots 5, 6, 8 and 9 for motion in a plane transverse to the roller axis. The roller 1 is mounted for rotation at a point midway between pivots 5 and 8 and pivot arms 4 and 7 are equal in effective length. That is, the distance between pivots 5 and 6 is the same as the distance between pivots 8 and 9. Upon pivoting motion of the pivot arms 4 and 7 in the plane of the paper, it will be seen that the roller axis, and hence the roller, undergoes pure horizontal motion for a limited distance in a direction substantially normal to the roller axis. Thus, if arm 7 pivots to the right in the sense of FIG. 1, pivot point 8 will undergo at first a rising pivoting motion to the right followed by a lowering pivoting motion to the right. At the same time, pivot point 5 will undergo a corresponding initial lowering pivoting motion followed by a rising pivoting motion and thus a point midway between pivot points 5 and 8 will undergo pure horizontal motion to the right. There is a finite limit to the extent of pure horizontal motion depending on the arm lemgth, the separation of pivot points 8 and 5, the location of pivot points 6 and 9 relative to one another and to pivot points 5 and 8. For example, upon continued motion to the right, the device would reach a point where upper arm 4 and member 3 are in longitudinal alignment at which point further motion to the right would be impossible. On continued motion to the left, lower arm 7 and member 3 would ultimately be in longitudinal alignment and further motion would cause all points in member 3 to move downwardly. Between these limits, motion of roller 1 is limited to pure horizontal motion and this motion is utilized to control filament tension according to the present invention. The device preferably includes stops to limit the roller to horizontal motion between these limits.

A filament, such as a web 10 is drawn from a roll 11 by a pair of driven rollers 12 driven by a motor not shown. The web traverses two rollers of a web guiding roll assembly 100 which is described in more detail below. The web is guided in engagement with the tension regulating roller 1 by conventional rollers 13, 14 such that tension in a moving web applies a horizontal force to the right in the sense of FIG. 1 biasing the roller in that direction due to tension in the moving web. By engaging the web and roller at equal angles with respect to the horizontal, a substantially horizontal biasing force is ensured. In the embodiment shown, the web is essentially horizontal and the angles of web incidence are each about 0° with respect to the horizontal, resulting in a 180° wrap on the tension roller. The angles of incidence can be varied to provide more or less wrap as desired.

Web tension is requlated according to the invention by the action of the tension regulation roller **1.** For purposes of illustration it will be assumed that the web is to be unwound at a tension of 100 lbs. Since the web is wrapped 180° around roller **1,** the web moving at correct tension applies a total force of 200 lbs. to roller **1** to the right in the sense of FIG. **1.** This is balanced according to the invention by an opposing force applied to roller **1** by any suitable means such as a hydraulic piston and cylinder **15** pivotally connected to upper pivot arm **4** and to a fixed support **16** to apply a substantially horizontal biasing force to roller **1** to the left in the sense of FIG. **1.** The biasing force should be evenly applied to the tension roller **1** and, for this reason, a second piston and cylinder is arranged on the other Z bar assembly in the manner shown in FIG. **1.** Alternatively, the upper pivot arms and frames **16** may be connected by members against which the iston force is applied. In this case, a symmetrical force can be applied against the tension roller **1** by a single piston located between the Z bar assemblies midway of the roller axis. Preferably, however, a plurality of pistons are provided between the Z bar assemblies to apply a uniform force to the roller. In this illustrative example, 10 pistons **15** each having an effective area of one square inch are pivotally secured at a point **17** midway between pivot points **5** and **6** on arm **4.** Accordingly, hydraulic pressure of 40 psi in each cylinder will apply the proper force of 200 lbs to bias the roller **1** to the left in the sense of FIG. **1.**

With the roller **1** positioned at any given location in its path of purely horizontal motion, the roller will remain stationary if the web tension is the correct desired value of 100 lbs. However, if the tension increases, roller **1** will move to the right and if tensio decreases roller **1** will move to the left. Thus, the motion or relative position of the roller gives an indication of web tension relative to a desired value established by the pressure in pistons **15.** The piston pressure is set, of course, by conventional compressor means not shown and may be a constant value as in the case of most unwinding operations, or it may be a changing value if desired. In any event, at any given moment in time, the position or motion of roller **1** is a measure of web tension relative to a desired set value.

The position of the roller is conveniently detected relative to a reference point which may be located at any point along the path of horizontal motion of the roller such as midway along the path. The reference point can be indicated in any convenient manner such as by aligning a moving part of the Z bar assembly, such as the roller, witl a fixed reference point such as frame **16.** Preferably, however, a position indicator **18** shown in more detail in FIG. **2,** is provided. The indicator comprises a rotatably mounted pointer **18** actuated by a chain **19** engaging sprocket wheels **20** secured to shaft **22** which is secured to arm **4** and sprocket wheel **21** secured to pointer **18.** Upon an increase in web tension, arm **4** pivots counterclockwise in the sense of FIGS. **1** and **2** and this causes pointer **18** to rotate counterclockwise. A scale **23** is conveniently located on upport frame **16** to indicate the nature (increase or decrease) of a change in tension. The magnitude of the change in tension is indicated by the rate of motion of the roller **1** and pointer **18** and the scale may include numerical values as shown to provide means for visually approximating the magnitude of web tension changes.

Once a change in web tension is indicated, correction is made to adjust web velocity or web drag or both to adjust the web **1**tension back to its desired value. The adjustment is made until pointer **18** comes to rest at which time web tension will again be balanced by the opposing force applied by pistons **15.**

In a preferred embodiment, the roller is returned to its zero reference point after each correction in web tension. For example, assuming that pointer **18** moves counterclockwise from 0, indicating an increase in web tension, the operator adjusts web tension by reducing the speed of rollers **12** or by reducing drag on the supply roll or on drag rolls not shown, or by several of these techniques. In a preferred embodiment, the tension is regulated by regulating web speed and the operator, in the given example, simply reduces web speed until motion of pointer **18** is arrested. As mentioned above, the pointer is preferably returned to its zero point and this is done by further reducing web speed until the pointer returns to its zero point. Web speed is then adjusted as required to maintain the pointer at its zero reference point.

While the device can be readily manually operated as described above, adjustment of web tension is preferably done automatically and it will be understood that a control motion can easily be derived from motion of any portion of the Z bar assembly. This motion can be used directly, such as by mechanical linkage, to control web tension, such as by adjusting web speed as described above. Preferably, however, a transducer is utilized to change the mechanical motion into a signal, such as a pneumatic or electrical signal, which is utilized in a conventional manner to regulate web tension. For example, sprocket wheel **21** may comprise a rheostat controlling the speed of driven rollers **12.** A voltage increase in the rheostat setting resulting from clockwise rotation of sprocket wheel **21,** for example, could be utilized to increase the speed of driven rollers **12** until roller **1** returns to its zero reference position. It will be understood that conventional control means are useful to control web tension from a signal derived from motion of an element of the Z bar assembly. It will be further understood that such conventional controls include means to adjust the rate of change in web tension in response to a rate of change in motion.

It will be apprent from FIG. **1** that the pistons **15** move arm **4** in pivotal manner and thus the horizontal biasing force applied by the pistons is not purely horizontal at all times. For this reason it is preferred, when a piston arrangement such as shown in FIG. **1** is used, to position the piston such that it acts horizontally when roller **1** is in its zero reference position. Accordingly, if the motion of the roller is confined to an area closely adjacent to the zero point, the force applied by the pistons will be essentially horizontal.

The horizontal biasing force applied by pistons **15** can, of course, be applied by other means such as by springs, and at other locations such as at lower arm **7** or member **3.** The biasing force can be applied to members **3** at a point midway between pivot points **5** and **8** to obtain a purely horizontal biasing force. It is preferred, however, to locate the biasing means remote from roller **1** to provide free access to the roller and a short piston stroke.

The tension regulating device described in FIG. 1 can also be used to regulate web tension in a winding operation in a manner which will be substantially self-explanatory. The web will be fed as a continuous sheet from the left in the sense of the drawings and wound into a core located to the right in the sense of the drawings. A winding apparatus of this type is shown in FIG. 3. The Z bar tension control assembly 30 is constructed in the same manner as that in FIG. 1 and comprises upper pivot arm 31, lower pivot arm 32, member 33 linking the pivot arms, and roller 34 mounted for rotation on member 33 midway between the pivot points for arms 31 and 32. The web 10' is drawn generally to the right through isolating driven nip rolls 34 in the sense of the drawing as a roll 35 of the web is being wound on driven core 36. A plurality of air cylinders 37 apply a biasing force to roller 34 to the right in opposition to the horizontal force induced to the left by tensions in the moving web thus providing for web tension control by regulation of web winding speed, by the speed of drive nip rolls 34, or both. The web is guided around roller 34 with 180° wrap by means of conventional guide rollers 38, 39. Tension is regulated as described in connection with the unwinding device of FIG. 1, a pointer 18' being provided, for example, to indicate motion of roller 34. The pointer assembly is conveniently constructed as shown in FIG. 2. The winding device shown in FIG. 3 also includes a lay-on roll assembly 200 which will be described on more detail below.

While the filament tension regulating device described above has been described in detail with respect to winding and unwinding of a web, it will be apparent that the Z bar assembly can be used to control tension in any moving filament such as threadlike filaments. For example, the tension in moving fibers, wires, ropes, yarns and the like can be regulated by the Z bar device as well as webs such as sheets of plastic, paper, metal foil, and the like. The invention is particularly suited to control the tension in moving webs of plastic, paper or laminations of these materials and is free from several of the disadvantages of the devices used heretofore for this purpose. The device is particularly suited to web unwinding or winding operations which are described in more detail below in connection with splicing and lay-on rolls according to the invention useful, respectively, in these operations.

A splicing roll assembly according to the invention is indicated as 100 in FIG. 1, and comprises a pair of Z bar assemblies 101 one only being shown in the drawing including a first upwardly extending pivot arm 102, a second downwardly extending pivot arm 103 and a member 104 connected to the pivot arms at first and second pivot points 105 and 106. The construction and arrangement of the Z bar assemblies is, to this point, identical with the Z bar tension assembly, pivot arms 102 and 103 being equal in length. However, in the splicing roll assembly, a pair of rollers 107, 108 are mounted for rotation adjacent pivot points 105 and 106, the roller axis being located symmetrically of the mid point of a line connecting pivot points 105 and 106. The roller axes are preferably located on said line and conveniently located at pivot points 105 and 106. The rollers are preferably of equal mass and mounted symmetrically such that the Z bar assembly is balanced. Thus, within the limits of pure horizontal motion which is undergone by the point of member 104 lying midway between first points 105 and 106, the assembly is balanced and will assume any given horizontal position under static conditions. Due to the pivot type support, the rollers are very easily moved to the left or right in a direction normal to the roller axis for assisting in the movement of the web 10 relative to roll 11 of the web material.

In a continuous web winding or unwinding operation, the Z bar assembly 100 shown in FIG. 1 is used for splicing. A conventional turret unwinder 150 is utilized to index a fresh web roll into an unwinding position occupied by roll 151 in FIG. 1. The splicing roll is then moved to the left in the sense of FIG. 1 to engage the trailing edge of an unwound web roll with the rotating web of the fresh web roll. The web from the fresh roll is thus spliced onto the trailing end of the web from unwound roll 11.

At the moment in time depicted in FIG. 1, a fresh roll 151 is in position to be spliced onto the trailing end of an unwound web roll 11. The Z bar web splicing roll assembly includes means, such as a double acting air cylinder 109 capable of moving the splicing roll 107 to the left in the sense of FIG. 1 to engage the trailing end of the unwinding web from roll 11 with the rotating periphery of the fresh roll 151. The inner surface of the leading end of the fresh roll is temporarily secured, for example by adhesive, to the subadjacent web surface and the outer surface of the leading end of the fresh roll, or the adjacent surface of the trailing end of the unwound roll, or both, is provided with means, such as a pressure-sensitive adhesive, to join the webs.

The turret unwinding device 150, of conventional type, includes variable speed motors (not shown) to drive the roll cores 152 and 153 counterclockwise. Fresh roll 151 is indexed into position for splicing as shown in FIG. 1 by rotating arm 155 clockwise about shaft 156 by a motor not shown. At the same time, unwound roll 11, which is mounted for rotation on shaft 157 on the other end of arm 155, rotates clockwise into the position shown in FIG. 1, with web 10 passing over one of two guide rollers 158, 159 rotatably mounted on arm 160 positioned at right angles with respect to arm 155. Guide rollers 158, 159 guide the web from the core to splicing roller 107 away from central supporting shaft 156 of the turret unwinder. After roll 11 is nearly fully unwound, fresh roll 151 is brouht to web speed. When a splice is to be made, air cylinder 109 is actuated to move the Z bar splicing roll assembly 100 to the left to force aplicing roll 107 against the under surface of the unwound web 11 which is, in turn, pressed against the fresh roll, the surface of which is moving at web speed. The pressure sensitive adhesive between the engaged sheets effects the splice and a knife 161 can be employed if desired to sever the trailing end of the unwound roll. The knife can be mounted in any convenient manner and may be rotatably mounted adjacent or at the axis of splicing roll 107. Once the splice is effected, air piston 109 is actuated to move splicing roll 107 to the right and the Z bar guide roll assembly 101 is positioned such that roller 107 is out of engagement with roll 151 during the unwinding thereof. As roll 151 unwinds, the core of unwound roll 11 is removed from arm 155 and replaced with a fresh roll. This fresh roll is ultimately indexed into the splicing position occupied by roll 151 in FIG. 1 and the latter is simultaneously indexed into the position occupied by unwound roll 11, thus completing a

splicing sequence. The system is then in readiness for a further splicing sequence for continuous winding.

While the web **10** is shown guided over the top of both rolls **107** and **108**, it will be understood that the web can pass over one and under the other. Further, while clockwise indexing has been illsutrated with the fresh roll being spliced to the upper surface of the unwinding web, splicing to the under surface of that web can be effected simply by counterclockwise indexing. If a knife for severing the trailing web end is utilized, it must be positioned for counterclockwise indexing and bottom splicing. The knife is therefore preferably mounted for severing action for rotation about the axis of splicing roll **107** since only a single knife is required for either top or bottom splicing, only its direction of rotation being changed. If a knife is otherwise mounted as shown in FIG. **1**, the knife must be moveable between an operable position for bottom splicing and an operable position for top splicing or two knives must be provided.

A lay-on roll assembly is shown in FIG. **3** as **200** and comprises a pair of Z bar assemblies **201** one only being shown in the drawing similar in configuration to the splicing roll assembly **101** shown in FIG. **1**, including a first upwardly extending pivot arm **202**, a second downwardly extending pivot arm **203** and a member **204** connected to the pivot arms at first and second pivot points **205** and **206**. A dual acting air cylinder **207** is pivotally connected to a fixed frame support **207** and to lower pivot arm **203** of each Z bar **201** to move the roller **208** and roller **209** to the right and left in the sense of the drawings in a direction normal to the roller axes in the same manner as the splicing roller assembly **100** in FIG. **1**.

At the moement in time depicted in FIG. **3**, the web **10'** is being wound on a roll **35** rotatably driven in a counterclockwise direction on core **36** rotatably mounted on arm **251** of a conventional turret winder **250**. Web **10'** is guided from the Z bar tension unit **30** by means of roller **39** underneath roll **209**, over lay-on roll **208** and forms a nip with the lay-on roll and a fresh core **211** driven by a motor (not shown) at web speed. The web is guided around core **211** by means of guide roll **276** forming part of an enveloping cutter assembly **275** to be described in more detail below. The web then passes over guide roller **210** and to the wound roll **35**.

In order to wind a fresh roll, arm **251** of conventional turret winder **250** is rotated counterclockwise to index wound roll **35** and a fresh core **211** into the positions shown in FIG. **3**, with rollers **276** and **210** engaging the web as shown. Air cylinders **207** are then actuated to force the Z bar assembly to the right in the sense of FIG. **3** to form a pressure nip between lay-on roll **208** and the fresh core **211**. When roll **35** is sufficiently full, the enveloping knife system **275** is actuated to sever the web **10'** and to envelop the several leading end of the web further about the fresh core to initiate a new roll. The knife mechanism is then withdrawn, full roll **35** replaced on arm **251** by a fresh core, and the lay-on roll is moved to the left to any desired degree by the action of air cylinders **207**. Due to the balanced and low friction support of the Z bar lay-on roll assembly, it can be very easily urged against or away from the web roll during winding as desired. For example, it can be urged against the roll to form a tight inner roll portion and progressively relaxed as the roll is wound. Alternatively, the rolls can "float" free of any external influence, other than the moving web at a position adjacent to the winding roll. When a roll is nearly fully wound, the lay-on roll will be displaced to the left of the position shown in FIG. **3** and, at that time, the turret winder is indexed counterclockwise to the position shown in FIG. **3**. The lay-on roll is then moved to the right to form a pressure nip with a fresh core thus completing a winding sequence. It is a feature of the present system that the lay-on roll is quickly moved easily from its "full wound" to its "start wind" position and is also capable of being easily precisely located at any position during winding. The system thus provides an efficient system for continuous web winding.

The enveloping web cutter **275** shown in FIG. **3** is a preferred web winding cutter. The cutter comprises two principal elements: a roller **276** and a knife **287**. Roller **276** is positioned with its axis parallel to the axis of lay-on roll **208** and mounted for rotation adjacent the ends of arms **277** pivotally secured to side frames **278** at a pivot **279** for motion in a plane transverse to the roller axis under the influence of air cylinder **280** and linkages **281, 212**. As in the case of the Z bar assemblies, each arm **277** is located at each side of the apparatus outside of the web path. Arm **277** is moveable about pivot **279** from the extended position shown in FIG. **3** with roller **276** guiding web **10** around fresh core **211**, to a retracted position with roller **276** out of the outermost path of travel of a indexing roll indicated by phantom line **283**. A knife arm **284** is pivotally mounted on each arm **277** at pivot **285** and is moveable under the action of air cylinder **286** to move a knife blade **287** from its retracted position shown in FIG. **3** along path **288** to cut the web **10'** and to pass over and in close adjacency with fresh core **211** to guide the leading end of the cut web about the core. The underneath surface of the knife blade may be provided with suitable means such as a brush, to assist in engaging the web and core. The enveloping action caused by the knife has been found sufficient to effectively initiate a new web roll without an adhesive.

The unwinding and winding systems described above may be readily integrated. After a web is unwound, the web is processed in some manner, such as by a chemical or physical treatment, including coating, irradiating, heating, and the like, or by being laminated to a second web. In any event, it is frequently desirable to wind the processed web. The unwinding and winding system would therefore include: an unwinding stage including a Z bar splicing roll or Z bar unwinding tension regulating device or both according to the present invention; means for processing the unwound web; and a winding stage including a Z bar winding tension regulating device, a Z bar lay-on roll, or both, according to the present invention. The web processing means is or may be conveniently isolated from either or both the winding and unwinding stages by means of driven nip rolls.

What is claimed is:

1. Apparatus for regulating the tension of a moving filament comprising:

a roller having its roller axis positioned transverse to the direction of motion of a moving filament such that the moving filament applies a horizontal force against the roller in a first horizontal direction substantially normal to the roller axis due to tension in the moving filament;

a pair of roller support members rotatably supporting each end of said roller;

a first pivot arm pivotally supporting each roller support member pivotally secured to said roller support member at a first pivot point and to a fixed support at a point higher than said first pivot point;

a second pivot arm pivotally supporting each roller support member pivotally secured to said roller support member at a second pivot point and to a fixed support at a point lower than said second pivot point;

said first and second pivot arms being of equal effective length and guiding said roller support member for motion in a vertical plane transverse to said roller axis;

said roller being mounted for rotation on said roller support members with the roller axis located at a point midway of a line through the first and second pivot points whereby said roller is moveable in a horizontal path substantially normal to the roller axis; and

means for applying a pre-determined force against the roller substantially normal to the roller axis in a second horizontal direction opposite to said first direction to oppose the force on said roller due to moving web tension whereby the roller moves in said horizontal path in response to web tension relative to said pre-determined opposing force.

2. Filament tension regulating apparatus according to claim **1** further including means to detect the horizontal position of said roller.

3. Filament tension regulating apparatus according to claim **2** wherein said roller position detecting means comprises means for detecting said roller position relative to a reference point, said apparatus further comprising means to move said roller horizontally to said reference point from a position displaced from said reference point.

4. Filament tension regulating apparatus according to claim **1** further including means for changing filament tension in response to changes in the horizontal position of said roller.

5. Filament tension regulating apparatus according to claim **1** further including: means for moving a web in engagement with said roller relative to a roll of web material; and means responsive to the position of said roller to adjust the tension of the web.

6. Web tension regulating apparatus according to claim **5** wherein said web tension adjusting means comprises means for controlling web speed.

7. Web tension regulating apparatus according to claim **5** further including means for adjusting the predetermined horizontal force applied to said roller.

8. Web tension regulating apparatus according to claim **5** further including means to guide the moving web to wrap said web around said roller approximately 180°.

9. Web tension regulating apparatus according to claim **5** wherein said web roll is a take up roll on which the web is wound.

10. Web tension regulating apparatus according to claim **5** wherein said web roll is a supply roll from which said web is unwound.

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