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[72] Inventor **Victor J. Mistele**
Colgate, Wis.

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[73] Assignee **Faustel, Inc.**
Butler, Wis.

[54] **WEB-TENSION CONTROL APPARATUS**
13 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **242/75.43**
[51] **Int. Cl.** **B65h 25/22**
[50] **Field of Search** 242/75.43, 75.42

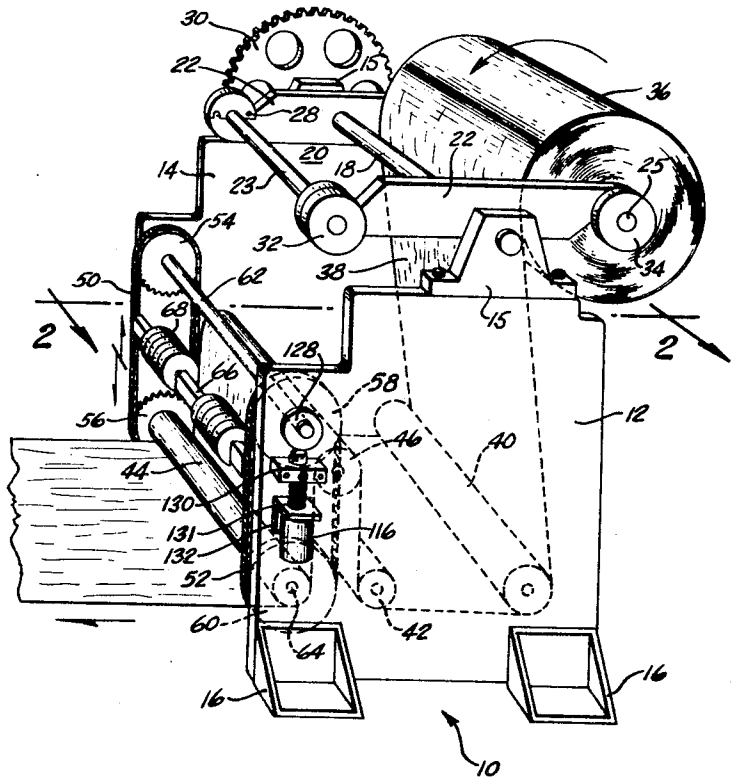
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Primary Examiner—George F. Mautz
Assistant Examiner—Gregory A. Walters
Attorney—James E. Nilles

ABSTRACT: A web-tension control apparatus for maintaining tension in a web being unwound from a roll in an unwind stand. The stand has a brake for retarding rotation of the roll and a sensory means, such as a dancer roll, for sensing the tension of the web being unwound. The apparatus includes control means for generating an operating signal level and a signal means operable by the sensory means for altering the operating signal level to establish a range of tension regulating signals for application to the brake. The operating signal level provided by the control means may also be altered, responsive to the sensory means to change the range of the tension-regulating signals.



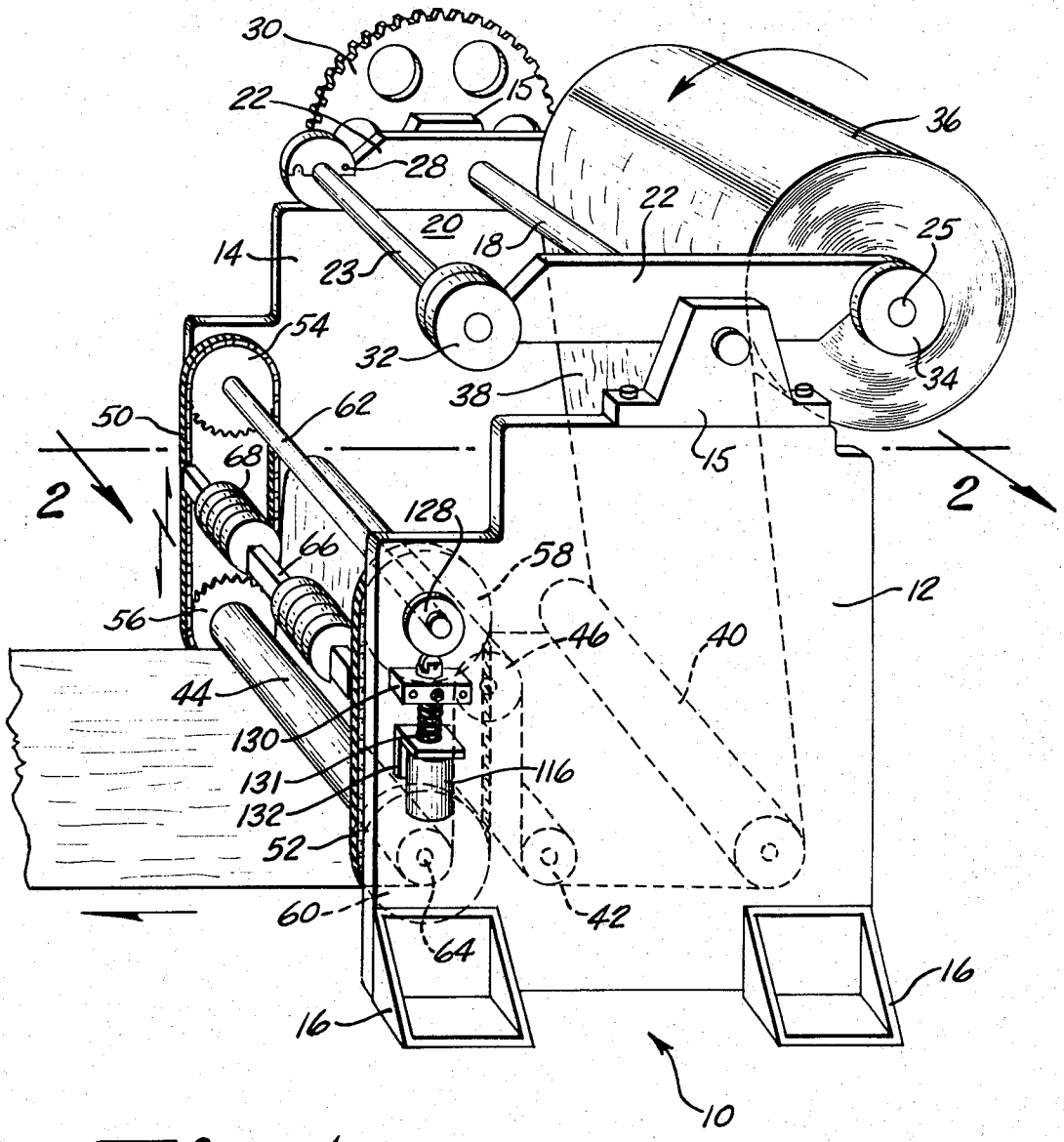
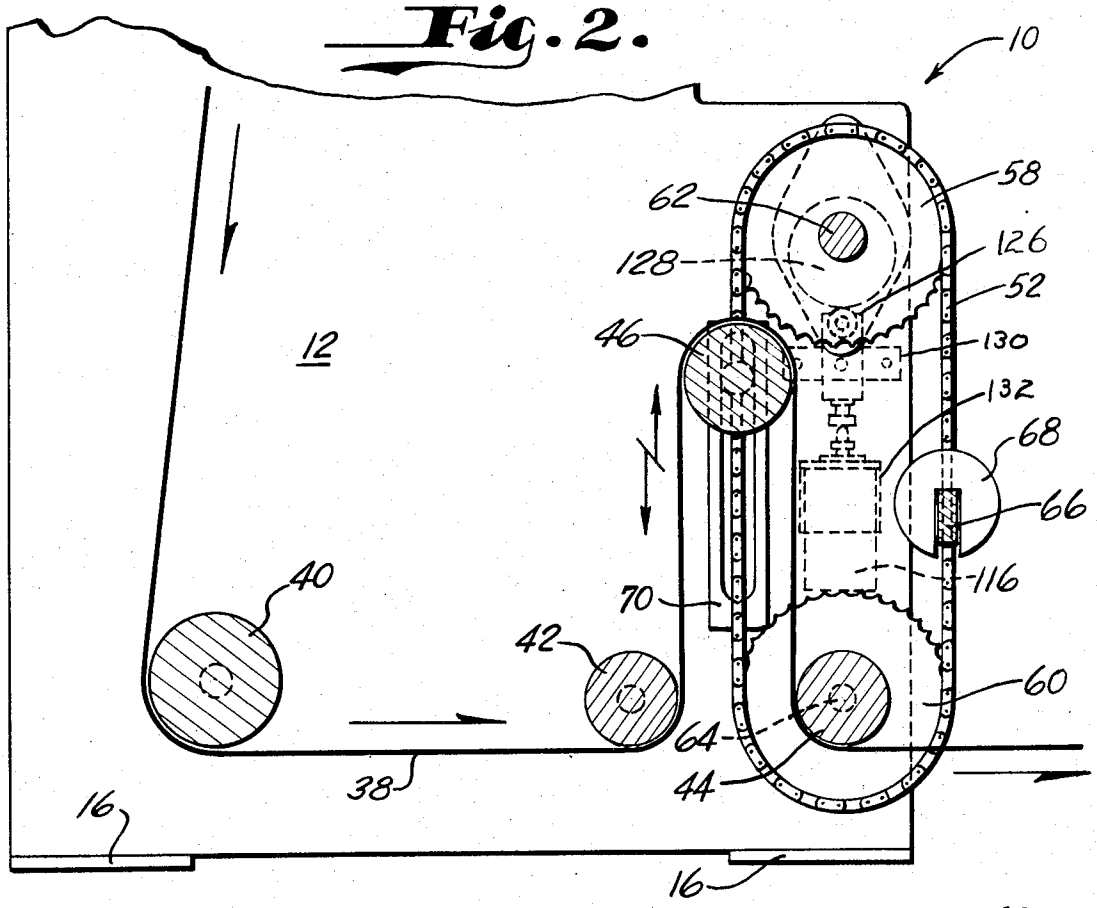


Fig. 1.

INVENTOR:
VICTOR J. MISTELE
BY: James E. Nilles
Att'y

Fig. 2.



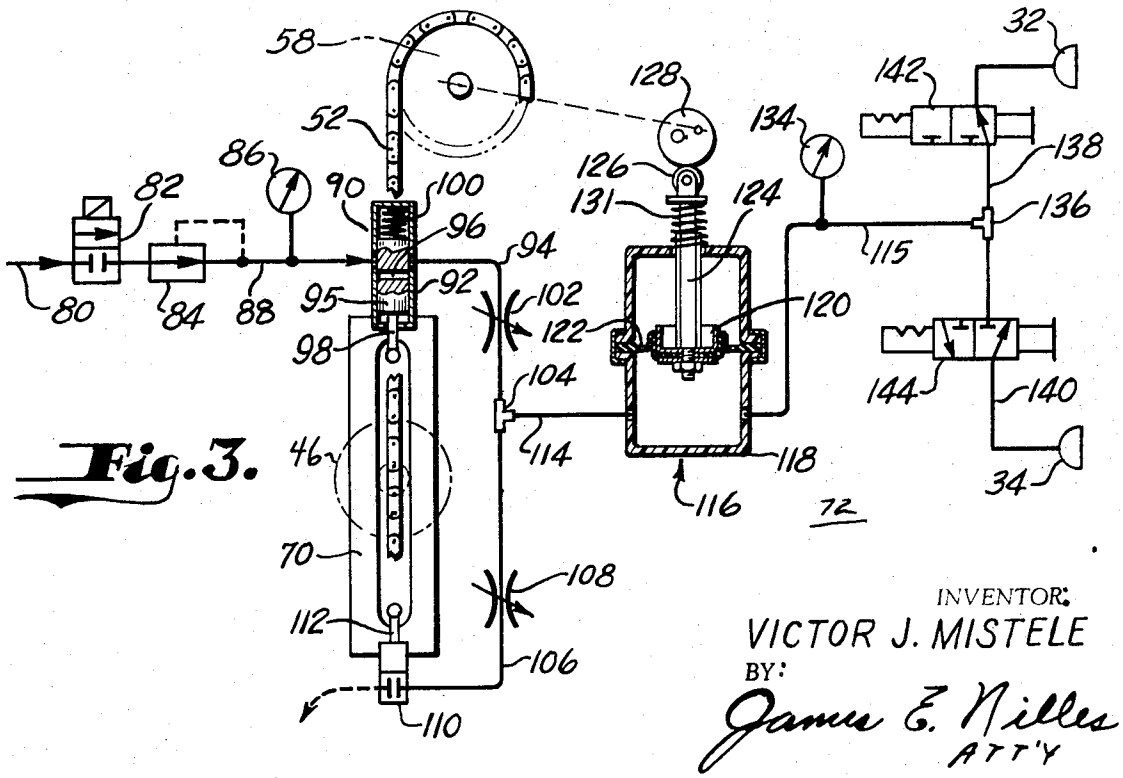


Fig. 3.

INVENTOR:
VICTOR J. MISTELE
BY:
James E. Nilles
ATT'Y

WEB-TENSION CONTROL APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an electrically controlled, supply roll brake tension device for use with unreeling apparatus.

2. Description of the Prior Art

The present invention relates to web-tension control apparatus suitable for use with web-unwind stands and the like. Such stands are used on conjunction with web-treating apparatus, as for example, coaters, laminators, rotary printing presses, and the like. The web to be treated is provided in a supply roll which is placed on the stand. The lead end of he web is threaded through the web-treating apparatus in preparation for he treating or converting operation during which the web will be unwound by rotating the storage roll. To provide tension on the web as it is undergoing treatment, a brake is provided in the unwind stand to retard or hold back the rotation of the supply roll.

Satisfactory operation of the web-treating apparatus requires that the tension of the web remain at a desired level regardless of changes in roll-diameter, material-type, material-width, and material-gauge thickness. A means to sense the tension of the web is therefore provided either in the unwind stand or in the web-treating apparatus. Most commonly, this is a dancer roll which is a weighted roll placed on the unwound portion of the web so as to form a loop or bight therein. The dancer roll is movable normal to the unlooped portion of the web so that movement of the roll is an indication of the change in the tension of the web. If the tension in the web increases, the loop is reduced in size and the roll moves accordingly. if the web tension decreases, the loop is enlarged causing a corresponding movement in the dancer roll.

The actual tension existing in the web, as sensed by the dancer roll, is utilized to provide a control signal which operates the brake on the unwind stand to bring the actual tension of the web into conformity with the desired web tension.

In prior art web-tension controls, stability has been a serious problem. As the tension in the web can vary over a wide range, extending from a slack condition up to the breaking strength of the web material, the tension control similarly must be operable between wide limits. The construction and operation of prior art tension controls generally required that they possess a high speed of response to rapidly bring the web to the desired tension within the aforesaid wide tension range. However, once the web was at the desired tension, the wide operating limits and speed of response of the tension control caused instabilities, such as hunting and the like. Further, as normal tension regulation required only a narrow control range within the operating limits of the control, large portions of the operating span of the control were essentially wasted.

SUMMARY OF THE PRESENT INVENTION

It is, therefore, the object of the present invention to provide an improved web-tension control apparatus.

It is another object of the present invention to provide an improved web-tension control apparatus which incorporates an air cylinder as an operative element thereof.

It is a further object of the present invention to provide an improved web tension control apparatus which operates with complete stability over a wide operating span or scope.

It is yet another object of the present invention to provide an improved web-tension control apparatus which obtains such wide span, stable operation by establishing, within the operating limits of the control a narrower range of tension-regulating signals. The tension-regulating signals are based on an operating signal level which is adjustable, within the operating span of the control, to similarly change the range of the tension-regulating signals to levels necessary for maintaining the tension of the web. Through the use of an adjustable,

but narrow, range of tension-regulating signals, the erratic operation encountered in prior art wide span, high response controls is eliminated, and stable tension regulation is provided to the web.

Briefly, the present invention provides apparatus for maintaining tension in a web being unwound from a roll in an unwind stand or the like. The unwind stand includes a signal responsive brake means for retarding the rotation of the roll to regulate the tension of the web. The unwind stand also has a sensory means cooperable with the unwound portion of the web and which is movable in accordance with web tension to provide a signal corresponding to the actual tension of the web.

The apparatus includes control means for establishing an operating signal level within the apparatus. The apparatus further includes a signal means coupled to the control means and to the sensory means for altering the operating signal level responsive to the sensory means to establish a range of web tension-regulating signals. The signal means provides a web tension-regulating signal within the range to the brake means to maintain the desired tension in the web.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a web unwind stand incorporating the web tension control apparatus of the present invention;

FIG. 2 is a fragmentary cross-sectional view of a portion of the web unwind stand shown in FIG. 1 and showing additional details of the web-tension control apparatus of the present invention on an enlarged scale, the view being taken from the far side of FIG. 1; and

FIG. 3 is a schematic diagram of the pneumatic circuit incorporated in the web-tension control apparatus of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The Web Unwind Stand

Turning now to the FIGS., and particularly to FIG. 1, there is shown therein a typical web unwind stand of a type with which the web-tension control apparatus of the present invention may be used. Unwind stand **10** includes a pair of spaced vertical base members **12** and **14** having gussets **16** for affixing the unwind stand to the floor or other suitable foundation. A journal **15** is mounted on the upper edge of members **12** and **14** for supporting pivot shaft **18**.

A turret **20** is mounted on pivot shaft **18** so that it may be revolved or turned over with respect to the stationary portions of stand **10**. The turret includes a pair of arms **22**, which are fixedly mounted on pivot shaft **18**, one adjacent each of journals **15**. Each of the arms **22** includes portions extending diametrically from a center portion to which shaft **18** is affixed. The opposite ends of arms **22** includes a means for receiving a pair of spindles **23** and **25** to which may be affixed the web supply rolls for unwinding. Arms **22** are mounted in indentical angular position on pivot shaft **18** so that the spindles lie parallel to pivot shaft **18**. A catch **28** at each end of arms **22** removably retains the spindles in the arms. Pivot shaft **18** and turret **20** are revolved or turned over by gear **30** mounted on pivot shaft **18**. Gear **30** may be rotated by a motor or other means, not shown, to place one or the other of spindles **23** or **25** in an unwind position. Spindle **25**, having web supply roll **36** thereon, is shown in such a position in FIG. 1. While roll **36** on spindle **25** is being unwound, spindle **23** may be loaded with another supply roll. When the unwinding of supply roll **36** on spindle **25** is complete, spindle **23** with the next supply roll is rotated into the unwind position to continue the supply of web material to the web treating apparatus.

Arms **22** includes brake means cooperable with the spindles when the spindles are mounted in the ends of the arms. Specifically, brake means **32** is mounted on one of arms **22** so as to retard the rotation of spindle **23**. Brake means **34** is similarly mounted on one of arms **22** for retarding the rotation of spindle **25** and web supply roll **36**.

Brake means 32 and 34 may comprise any suitable commercially available type of brake. At present, it has been found preferable to use a fiction type of brake having bands or pads which are pneumatically applied to spindles 23 and 25, or elements associated therewith, to retard the rotation of the spindles.

Web 38 is unwound from roll 36 and strung across guide rolls 40, 42, and 44. Rolls 42 and 44 may be closely spaced so as to permit a loop to be formed in web 38 by dancer roll 46.

Dancer roll 46 is rotatably supported at either end by endless chains 50 and 52 strung between sprockets 54 and 56 and 58 and 60, respectively. Sprockets 54 and 58 are mounted on a common shaft 62 journaled in base members 12 and 14, while sprockets 56 and 60 are likewise mounted on a common shaft 64 journaled in base members 12 and 14. Shaft 64 may serve as an axle for guide roll 44.

A counterweight is affixed to chains 50 and 52 opposite dancer roll 46. The counterweight consists of bar 66 extending between the chains, on which a selected plurality of horseshoe shaped weights 68 may be placed. These weights are used to set the tension level desired in web 38 in the following manner. For purposes of example, it may be assumed that dancer roll 46 and bar 66 weigh the same. In the absence of a web around dancer roll 46 and in the absence of weights 68 on bar 66, the dancer roll apparatus will be in equilibrium, as the dancer roll and bar exert equal and oppositely directed forces on chains 50 and 52.

When a web is placed around dancer roll 46 and a tensile force exerted thereon, a downward force is exerted on dancer roll 46 placing the dancer roll apparatus in a condition of disequilibrium. To restore the equilibrium of the dancer roll apparatus, weights 68 are placed on bar 66 to counterbalance the downward force exerted by web 38. It may be readily appreciated that the number of weights 68 placed on bar 66 may be selected so that the counterbalancing, equilibrating force exerted by the weights is equal to the force exerted on dancer 46 by web 38 when web 38 is under the desired tension.

Variations in the tension of web 38 from the desired tension cause dancer roll 46 to move upward or downward from the equilibrium position. For example, when web 38 is stressed to less than the desired degree, counterweights 68 will cause dancer roll 46 to rise. When web 38 is stressed to a greater than desired tension, the web will pull dancer roll 46 downward. The vertical movement of dancer roll 46 is assisted by guide 70 mounted on the insides of base members 12 and 14 and through which the ends of the axle of dancer roll 46 may extend. See FIG. 2. Guides 70 also serve to limit the travel of dancer roll 46.

Web Tension Control Apparatus

The web-tension control apparatus is described in so far as incorporating pneumatically operating devices. However, it will be appreciated, and it is to be understood, that the devices controlled by other mediums, as for example, electricity, may be used, if desired. Web-tension control apparatus 72 may be supplied with pneumatic pressure from supply line 80 containing air at a typical supply pressure of 120 pounds per square inch. See FIG. 3. Supply line 80 is connected to web-tension control apparatus 72 through a solenoid valve 82. Solenoid valve 82 is operable by the web-treating apparatus associated with unwind stand 10 so that solenoid valve 82 is closed when the web-treating apparatus is shut down, thereby retaining the existing pneumatic pressure in web-tension control apparatus 72 during such periods of shutdown and preventing the application of high pressures when the web treating apparatus is restarted. For example, in instances when web 38 breaks, the web-treating apparatus must be shut down to rethread the web. Due to the complete loss of web tension associated with web breakage, web-tension control apparatus 72, as hereinafter described, would normally apply high pneumatic pressure to brake 34 and a large amount of retarding force to supply roll 36 in an effort to restore web tension. However, the abruptness of such retardation has often resulted in additional breakage of the web. Thus, solenoid valve 82 is provided to retain the air pressure at the level existing before shut down to facilitate restarting the web-treating apparatus without additional web breakage.

A pressure regulator 84 is connected to solenoid valve 82 to reduce the air pressure in supply line 82 to a more suitable level of, for example, 60 lbs. per square inch (p.s.i.). Air-pressure gauge 86 is provided at the outlet of pressure regulator 84 in air line 88.

Air line 88 is connected to the surrounding atmospheric pressure through two series connected pneumatic limit valves which are used to establish an operating pressure level in web-tension control apparatus 72. The pneumatic limit valves are operable by dancer roll 46 at its extreme upper and lower positions. The valves are shown both in a typical mechanical configuration and in pneumatic symbol form in FIG. 3.

Limit valve 90 is used to sense when dancer roll 46 is approaching the upper limit established by guide 70. Limit valve 90 may comprise a sleeve 92 mounted on or adjacent guide 70 and having a diametrically opposed inlet, connected to air line 88, and outlet, connected to air line 94. A plunger 95, having a hole 96, is positioned in sleeve 92 so that hole 96 may be moved into alignment with the inlet and outlet of the sleeve to open the limit valve. Plunger 95 has arm 98 extending from sleeve 92 for moving the plunger by coaction with dancer roll 46. A spring 100, in the enclosed end of sleeve 92, biases plunger 95 against the movement provided by dancer roll 46 and retains limit valve 90 in the normally closed state.

Air line 94 contains a variable resistance means such as variable orifice 102 to throttle changes in pressure admitted into air lime 94 by limit valve 90. Air line 94 is connected through T-connection 104 to air line 106 which contains a variable orifice 108. Air line 106 terminates at normally closed, pneumatic limit valve 110 which may be similar in construction to limit valve 90. When open, valve 110 discharges to atmosphere. Limit valve 110 is mounted on the lower portion of guide 70 so that actuating arm 112 extending therefrom is operable by dancer roll 46 to open the valve when the dancer roll approaches the extreme low limit of travel in guide 70.

Air line 114 is connected to T-connection 104. An air cylinder 116 is interposed in air line 114 for altering the pressure in the air line. Air cylinder 116 includes an enclosed housing 118 in which is mounted piston 120. An inlet in housing 118 is connected to air line 114 while an outlet is connected to air line 115. To aid in providing a seal between housing 118 and piston 120, a flexible diaphragm 122 may be stretched across the face of piston 120 and affixed to the inner walls of housing 118. Piston 122 is movable by piston rod 124 having roller 126 on the exposed end thereof for engagement with cam 128.

Cam 128 is mounted coaxially with sprocket 58 on shaft 62 so that rotation of sprocket 58, as a result of up-and-down movement of dancer roll 46, rotates cam 128. Piston rod 124 may be inserted through guide 130 mounted on base member 12 for coaction with cam 128. While the air pressure in housing 118 below piston 120 is normally sufficient to retain roller 126 in abutment with cam 128, spring 131 may be provided on piston rod 124 for this purpose. Air cylinder 116 is affixed to base member 12 by bracket 132.

Rotation of cam 128 causes movement of piston 120 in housing 118 and an alteration of the pressure in air lines 114 and 115. Cam 128 is mounted on shaft 62 in a manner such that the rotation of the cam as dancer roll 46 rises, responsive to a lessening of the tension in web 38, causes a downward movement of piston 120 and an increase in the air pressure in housing 118 and air lines 114 and 115. The rotation of cam 128 as dancer roll 46 falls causes piston 120 to rise, reducing the air pressure in housing 118 and air lines 114 and 115. The pressure in air line 115 may be sensed by air pressure gauge 134.

Airline 115 is connected to brake means 32 and 34 on the web-roll-receiving spindles 23 and 25 through T-connection 136 and airlines 138 and 140. Valves 142 and 144 are interposed in air lines 138 and 140, respectively, or placing one or the other of brake means 32 or 34 in the actuatable state.

Operation

It may be assumed that the web-treating apparatus is in position and that unwind stand **10** is unreeling web **38** at the desired tension. Under such conditions, web-tension control apparatus **72** will have been pressurized by supply line **80** through pressure regulator **84** and limit valve **90** to a predetermined level of, for example, 30 p.s.i., and will energize brake means **34** to provide sufficient retarding force to roll **36** to generate the desired tension.

Under such conditions, the regulation of the tension of the web is controlled solely by air cylinder **116**. This air cylinder, along with air lines **114** and **115**, will be at the 30 p.s.i. pressure level established by limit valve **90**. However, if dancer roll **46** rises, indicating the tension in web **38** is too low, sprocket **58** and cam **128** are rotated to depress piston rod **124** and piston **122**, reducing the volume of housing **118** below the piston and increasing the pressure therein to, for example, 33 p.s.i. This increase in pressure is transmitted to brake **34** through air lines **115** and **140** to increase the retarding action of the brake and the tension in the web.

If dancer roll **46** falls, pursuant to an increase in the tension in the web, sprocket **58** and cam **128** are rotated to allow piston rod **124** and piston **120** to rise, decreasing the pressure in air cylinder **116** and in air lines **115** and **140** to, for example, 27 p.s.i. and decreasing the braking action of brake means **34**.

The cut of cam **28** and the size and shape of air cylinder **116** determine the range or pressure alteration which will be provided in web-tension control apparatus **72** as dancer roll **46** moves in guide **70**. The range of pressure alteration effectuated by the movement of piston **120** in housing **118** may typically be 10 p.s.i., so that the operating range of a web tension control apparatus having an operating air pressure of 30 p.s.i., is 25–35 p.s.i. By the use of a narrow pressure range of 10 p.s.i., the abruptness or jerkiness found in prior art systems operable between wide limits and incorporating large operative pressure variations of, for example 0–60 p.s.i., is eliminated in the present system.

Situations may occur in which the 10 p.s.i. range of air cylinder **116** is insufficient to provide or maintain the desired tension in web **38**. For example, even if the maximum pressure alteration of air cylinder **116** is applied to the operating air pressure in airline **115**, the air pressure of 35 p.s.i. when applied to brake means **34** may be insufficient to generate the braking action necessary to maintain web tension. In such a case, dancer roll **46** will move upward until it strikes arm **98** of limit valve **90**, opening the valve to allow air pressure from air line **88** to enter air lines **94** and **114**, air cylinder **116**, and air line **115** to raise the air pressure therein, and increase the braking action of brake means **34**. For example, the pressure in the air lines may be increased by 5 p.s.i. through the opening of limit valve **90** so that the pressure in air lines **115** and **140** is 40 p.s.i. Assuming this is sufficient to increase the tension in web **38** to the desired level, dancer roll **46** is moved away from limit valve **90** by the increased web tension, closing the valve and retaining the increased pressure in air lines **114**, **115** and **140**, and air cylinder **116**.

By the above described operation of limit valve **90**, the operating pneumatic pressure in web-tension control apparatus **72** has been increased by 5 p.s.i. from 30 p.s.i. to 35 p.s.i. Air cylinder **116** continues to regulate the tension of web **38** by means of cam **128** over a 10 p.s.i. range. However, the 10 p.s.i. range is applied to the newly established pressure of 35 p.s.i. so that the operating range is from 30 to 40 p.s.i. rather than from 25 to 35 p.s.i. as was formerly the case. The admission of 5 p.s.i. of air pressure to air lines **114**, **115** and **140**, is throttled by orifice **102** to provide a slow change in air pressure, thereby lending stability to the web-tension control apparatus.

If the web tension in web **38** is in excess of that which can be controlled by air cylinder **116**, dancer roll **46** will be pulled downward by the web, striking limit valve **110** and opening the valve to allow some of the air pressure in air lines **114**, **115** and **140**, and air cylinder **116** to be bled off to the atmosphere. This reduces the operating pressure in the air lines, as for example, by 5 p.s.i. to 25 p.s.i. so that air cylinder **116** regulates over a 10 p.s.i. range extending from 20 to 30 p.s.i. This reduces the retarding action of brake means **34** and the tension in web **38**. Orifice **108** provides for a slow, stable reduction in the air pressure of web-tension control apparatus **72**.

Resume

In summary, the web tension control apparatus of the present invention provides for establishing an operating air pressure in the control apparatus by means of limit valves **90** and **110**. This operating pressure is then altered over a tension-regulating pressure range by means of air cylinder **116**, responsive to the position of the dancer roll and the tension in the web. In this manner, only a narrow range of tension-regulating signals is used to provide tension regulation to the web. Stable operation of the apparatus is obtained without loss of regulating ability.

In the event the air pressure alteration provided by air cylinder **116** is insufficient to maintain the tension at the desired level, the operating pressure of the apparatus is increased or decreased by means of limit valves **90** and **110** so that the range of air cylinder **116** is raised or lowered to a pressure range sufficient for maintaining desired web tension. Stable web-tension control apparatus is thus provided which maintains web tension between wide limits.

I claim:

1. Apparatus for maintaining tension in a web being unwound from a roll, said roll having a signal responsive brake means for retarding the rotation of the roll to regulate the tension of the unwound web and said unwound web having a shiftably mounted sensory means responsive to the tension of said web, said apparatus comprising:

shiftable fluid valve control means connected with a source of fluid pressure and engageable by said sensory means for generating an operating signal level; and

self-regulating signal means mechanically coupled to said sensory means and in fluid communication with said control means for altering said operating signal level responsive to the sensory means to establish a range of self-regulating web-tension signals and for providing a web-tension-regulating signal within said range to said brake means, said control means including means for changing said operating signal level and said range of web-tension-regulating signals.

2. The apparatus of claim **1** wherein said means for changing said operating signal level is coupled to said sensory means and is responsive to web-tension conditions outside those regulatable by said range of web-tension-regulating signals.

3. The apparatus of claim **1** wherein said brake means is responsive to pneumatic pressure signals, wherein control means generates a pneumatic pressure level within said apparatus, and wherein said signal means is responsive to said sensory means to operable a range of web-tension-regulating pneumatic signals and for providing a web-tension-regulating pneumatic signal within said range to said brake means.

4. The apparatus of claim **3** wherein said control means includes a pair of valves connected in series between a source of pneumatic pressure and a discharge and wherein said signal means is interposed between said valves, said valves being operably by said sensory means for generating a pneumatic pressure level within said signal means by admitting and discharging pneumatic pressure to and from said signal means responsive to web-tension conditions outside those regulatable by said range of web-tension-regulating signals.

5. The apparatus of claim **4** including means connected in series with said valves for throttling the variation in pneumatic pressure in said signal means.

6. The apparatus of claim **3** wherein said signal means comprises an air cylinder operable by said sensory means for establishing a web-tension-regulating pneumatic signals.

7. THe apparatus of claim **4** wherein said signal means comprises an air cylinder operable by said sensory means for establishing a range of web-tension-regulating pneumatic signals.

8. The apparatus of claim 7 wherein the sensory means is cooperable with the unwound portion of the web and movable within defined limits in accordance with the tension thereof, said air cylinder being operable by said sensory means when within said limits for establishing a range of web-tension-regulating pneumatic signals, said valves being operable by said sensory means when the latter is at said limits for generating a pneumatic signal pressure level within said signal means.

9. The apparatus of claim 8 including means for damping the movement of said sensory means.

10. The apparatus of claim 6 wherein said air cylinder has a housing connected to and said control means and pressurized to the pneumatic pressure level and further has a piston mounted in said housing for varying the volume thereof to establish a range of web-tension-regulating pneumatic signals, said piston being movable in said housing by said sensory means.

11. The apparatus of claim 10 wherein said sensory means includes a cam means rotatable in accordance with the tension of the web, said air cylinder piston being coactable with said cam for movement within said housing.

12. The apparatus of claim 8 wherein said air cylinder has a housing connected to said control means and pressurized to the pneumatic pressure level and further has a piston mounted in said housing for varying the volume thereof to establish a range of web-tension-regulating pneumatic signals, and piston being movable in said housing by said sensory means.

13. The apparatus of claim 12 wherein said sensory means includes a cam means rotatable in accordance with the tension of the web, said air cylinder piston being coactable with said cam for movement within said housing.

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