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Seney

[11] **3,777,959**

[45] **Dec. 11, 1973**

[54] **APPARATUS FOR MONITORING AND CONTROLLING TENSION IN AN ADVANCING FLEXIBLE ELONGATE MATERIAL**

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[52] **U.S. Cl.** **226/25**, 226/195, 226/44

[51] **Int. Cl.** **B65h 25/00**

[58] **Field of Search** 226/44, 195, 25, 226/24

[56] **References Cited**

UNITED STATES PATENTS

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3,343,008	9/1967	Bancroft	307/119
3,385,491	5/1968	Helms	226/195 X
3,556,369	1/1971	Ferguson	226/195

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Attorney—Howard P. West, Jr.

[57] **ABSTRACT**

An apparatus for detecting and regulating tension in a textile rope being pulled in a path from a source through a tension adjusting means by an advancing means includes a beam pivotally mounted for angular movement about an axis transverse to the beam and a guide arrangement to direct the rope through the beam pivot axis. One guide of the arrangement is carried by the beam at a location downstream of the pivot axis, the other being located upstream of the pivot axis. Passing the rope through the axis nullifies the effect of changes in frictional properties of the rope on tension induced deflection of the beam. Means are provided for detecting the amount of said angular movement of the beam and transducing it into a signal to actuate a control means for operating the tension adjusting means.

4 Claims, 4 Drawing Figures

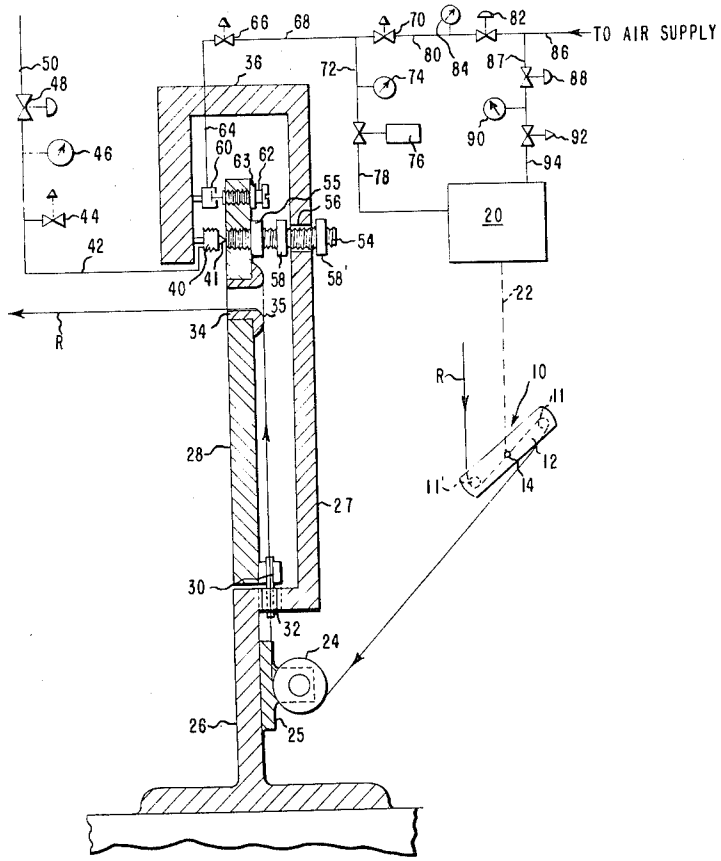


FIG. 1

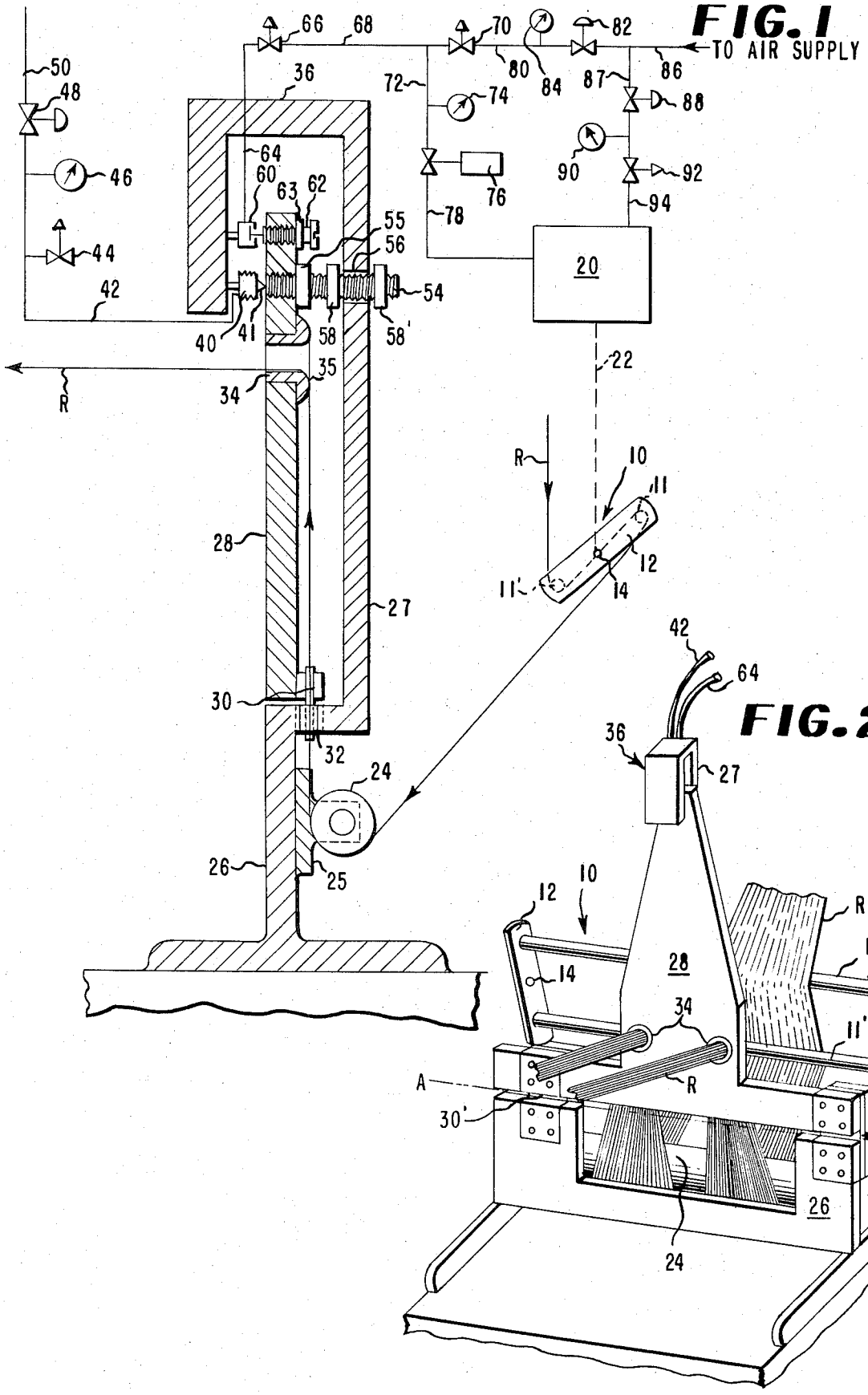

TO AIR SUPPLY
66
68
70
80
84
82
86
87
88
72
74
90
92
94
76
78
50
48
46
44
42
36
64
60
63
62
55
56
54
40
41
58
58'
20
22
R
34
35
28
27
30
32
24
26
25
10
11
12
14
11'

FIG. 2

42
64
36
27
10
12
14
28
R
11
12
14
11'
34
A
30'
30
A'
26
24

FIG. 3

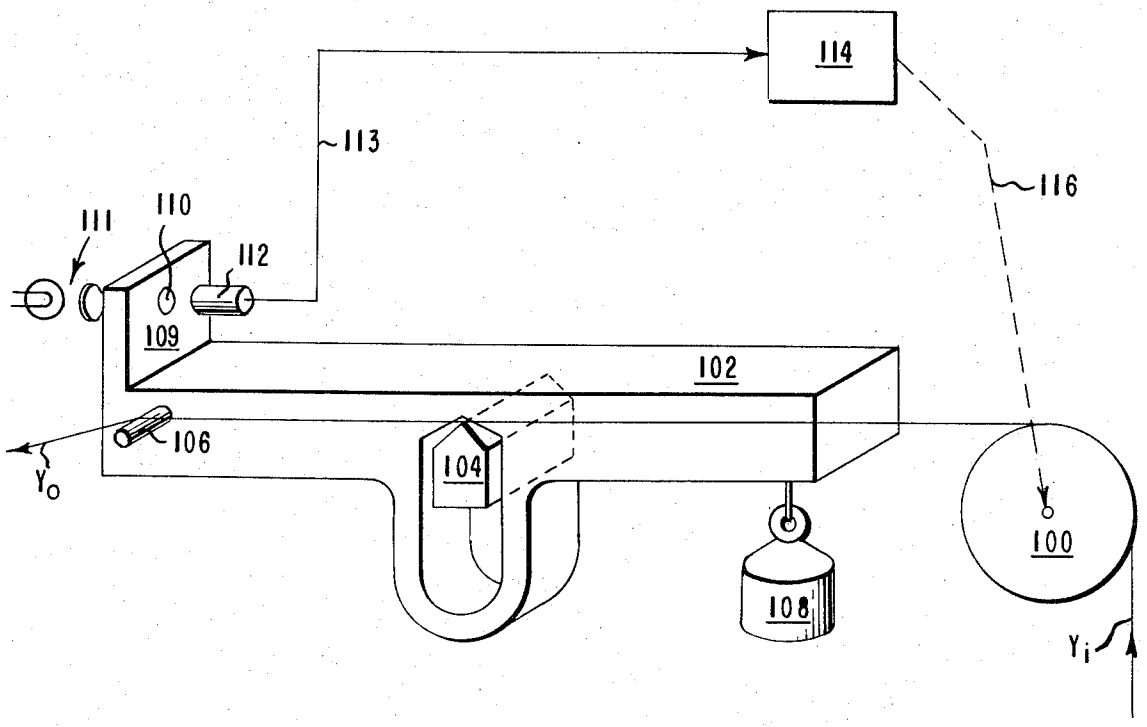
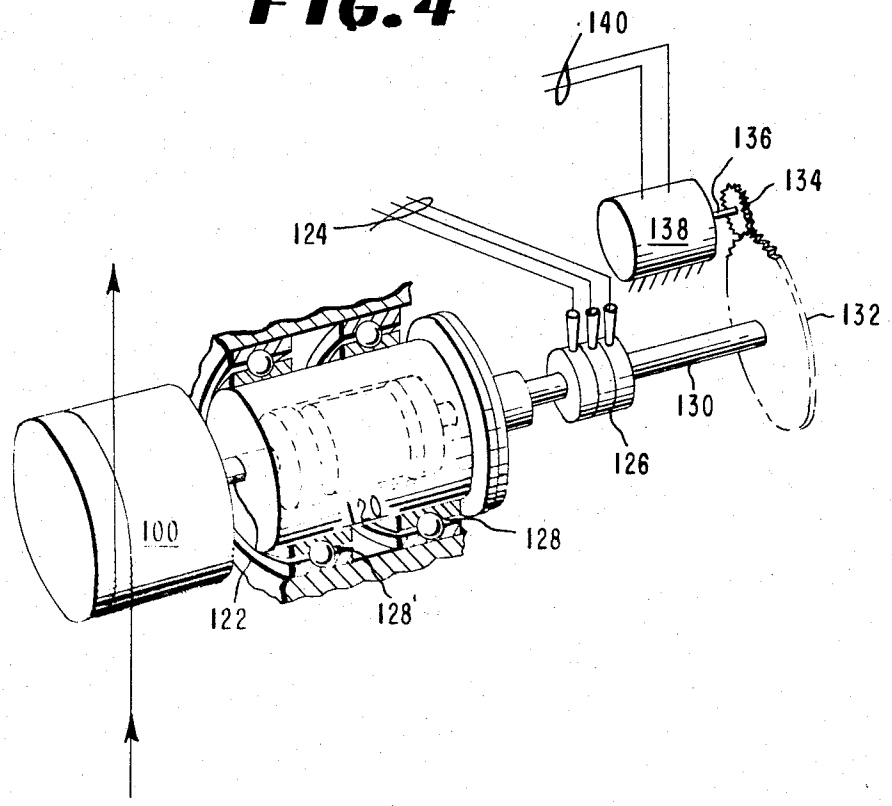

114
113
116
111
110
112
109
102
106
104
108
100
Y_o
Y_i

FIG. 4


140
136
134
124
138
132
130
126
120
128
100
122
128'

APPARATUS FOR MONITORING AND CONTROLLING TENSION IN AN ADVANCING FLEXIBLE ELONGATE MATERIAL

BACKGROUND OF THE INVENTION

This invention concerns apparatus for the measurement and regulation of dynamic tension in moving flexible elongate structures such as textile yarns or ropes. More specifically, it relates to tension monitors that compensate for the effects of speed and friction variability between the monitor and the moving material.

Many different devices are shown in the art for detecting and holding the tension constant in a running flexible element. Many of such devices employ a "force triangle" type of tension measuring principle wherein two fixed guides or rolls are mounted at two corners of an equilateral or isosceles triangle with a third guide or roll at the apex. This third roll is held in place by a mechanical forcing means arranged so that the force can be measured. The flexible element is passed around the three guides or rolls in such a manner that tension tends to force the apex toward the base. The force required to hold the movable roll in place or the displacement of the movable roll against a calibrated load measures the tension in the running flexible element. One particular device, as disclosed by Seney in U. S. Pat. No. 2,767,576, employs a pivotably balanced beam arrangement to monitor the force on the third (apex) guide or roll. In another arrangement, as disclosed by Ferguson in U. S. Pat. No. 3,556,369, tension in a strand is monitored by way of the torque exerted by the strand when it is passed in an S-shaped path over two guides mounted at opposite ends of a diameter of a disc, or ends of a bar, rotatable about a fixed pivot at the center of the disc or bar.

All of these prior art devices have served satisfactorily to measure tension and/or provide feedback for tension regulation under some conditions. However, when highly precise tension regulation or measurement is needed or where the frictional properties of the yarn against the detector vary considerably, the prior art devices are often not acceptable.

SUMMARY OF THE INVENTION

An apparatus for detecting and regulating tension in a flexible elongate structure advancing in a path from a source through a tension adjusting means and a first guide means to an advancing means for the structure. The apparatus comprises a beam located between the first guide means and the advancing means and pivotally mounted at one location for angular movement about an axis transverse to the beam. The beam carries a second guide means spaced from said one location, the first and second guide means direct the structure in a path through the transverse axis. Means for measuring the amount of said angular movement and transducing said movement into signals are coupled to a control system whereby the signals actuate the control system which operates the tension adjusting means. The tension is regulated to an extent required to null the angular movement of the beam.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional elevation view of a textile rope ball warper tension regulating system with associated schematic pneumatic circuit diagram.

FIG. 2 is a perspective partial view of the tension transducer mounting arrangement for the apparatus of FIG. 1.

FIG. 3 is a beam balance tension transducer for high speed yarn tension regulation.

FIG. 4 is a vernier servo feed roll speed regulator in perspective.

Turning first to FIGS. 1 and 2, the invention is described in the form of apparatus arranged to provide accurate tension regulation for a textile rope ball warper. A textile rope R is received from a creel supply not shown and introduced over one or more servo controlled tension adjusters **10.** These adjusters or tension regulating means comprise two parallel tension bars **11, 11'** mounted in end plates **12** which are journalled about axis **14** for rotation by action of a pneumatic servo system **20,** i.e., control means, through mechanical linkage **22.** A guide roll **24,** i.e., a first guide means, is journalled to roll mounting **25** which in turn is fixed to tension transducer frame **26.** Frame **26** has off-set portion **27** arranged to provide room for elongated tension transducer beam **28** pivotally mounted at one end for rotational movement above the lower portion of frame **26** and about an axis A, A' transverse to the beam by means of two beam flexure pivots **30.** Pivots **30** are made of materials such as thin spring steel or Beryllium copper. They are spaced toward each end of the frame and beam so that a vertical passageway **32** is available for passage of rope R from the exit edge of roll **24** vertically upward to eyelet guides **34,** i.e., second guide means, which are placed in appropriate holes through beam **28** above pivots **30** and structured so that the rope R, in passing from roll **24** to contact guides **34** at surface **35,** must pass vertically upward through the line of the transverse axis A, A' (FIG. **2**) of flexure pivots **30.** An advancing means or winding mechanism, e.g., the ball warper (not shown) is located so that rope R must pass through eyelets **34** in a substantially horizontal direction. Frame off-set portion **27** is further extended upward, across and partly downward to form an upper cap portion **36** of the frame adjacent to and surrounding the top portion of beam **28.** A set point pneumatic bellows **40** is attached near the lower left end of cap portion **36** and aligned near the upper end of beam **28** so that finger **41** of the bellows **40** can exert a preset force on beam **28** near its upper end. A pneumatic line **42** extends back from bellows **40** past bleed valve **44,** gage **46,** and thence to regulator valve **48.** Line **50** receives air from a pressure source not shown to supply valve **48.** An elongated bolt **54** is threaded to the upper end of beam **28** in a position to receive finger **41** and tightened in place by means of nut **55.** The bolt extends to the right of beam **28** through a hole **56** in frame portion **27.** Nuts **58, 58'** are threaded onto bolt **54** to provide mechanical limiting arrangement for the movement of beam **28.** A beam deflection indicator control valve **60** is attached to the inside of cap **36** just above bellows **40.** A zero adjusting screw **62** is threaded to the upper part of beam **28** in a position to engage the actuating end of valve **60.** Lock nut **63** is positioned on screw **62** in order to lock this screw in position after zero adjustment. Pneumatic line **64** extends from valve **60** to rate control valve **66** and line **68** extends from valve **66** to a second rate control valve **70.** A branch line **72** from line **68** connects to solenoid actuated stand-by valve **76** after passing gage **74.** Line **78** extends from valve **76** to pneumatic

servo system **20**, thus completing one part of the pneumatic circuit. In the preferred embodiment, system **20** is a Conoflow Corporation (Blackwood, N.J.) pneumatic servo type EB-51-XB-C. Another pneumatic line **80** extends from valve **70** past gage **84** to air pressure regulator **82** and thence over line **86** to supply of pressurized air not shown. Another pneumatic line **87** extends from the air supply to a second regulator **88**, past gage **90** to control valve **92** and over line **94** to pneumatic system **20**.

In operation, textile rope R is threaded in an exaggerated S-shape path around rods **11'** and **11** of tension adjuster **10**, or a series of such adjusters, and thence around guide roll **24**. From roll **24**, the rope passes vertically upward through passageway **32** in line with axis A, A' and thence around eyelet guide **34** and thereby through the tension transducer beam **28**. Rope R is then drawn off by a ball warper and made into a ball warped package of rope. The warper is not shown since it is of conventional structure. The tension transducer produces a proportional signal of 0–15 lbs. which proportionally controls rope tension through the servo system **20** by adjusting rotation of the tension adjuster bar end plates **12** between zero and full effectiveness of bars **11, 11'**. The tension set point is manually adjusted by means of air pressure regulator valve **48** by setting the pressure on bellows **40** as read by gage **46**. Bleed valve **44** protects against pressure buildup caused by any leakage that might occur in regulator **48**. Air pressure to beam deflection control valve **60** is set at 15 lbs. by means of regulator **82** and flows through flow rate control valves **70** and **66** to the control valve **60**.

Flow valve **66** is set to allow air pressure to build up to 15 lbs. on gage **74** during a time interval of 2 minutes whenever control valve **60** is closed. This occurs when tension in rope R is below set point and bellows **40** through finger **41** holds beam **28** away from actuating valve **60**. However, if valve **60** is opened, flow valve **66** allows pressure, as indicated by gage **74**, to drop to 2 lbs. in a time interval of 2 minutes. Valve **60** is opened when the tension in rope R is sufficient to force beam **28** against the pressure of bellows **40** to an extent necessary to open valve **60**.

Servo system **20** is arranged so that, as air pressure coming in over line **78** builds up due to valve **60** being closed by low rope tension, the tension adjuster **10** is caused to rotate in a direction to increase the snubbing action on the rope. This raises the tension until a balance of torque is reached between that caused by tension in the rope passing through eyelets **34** and the force of the set point bellows **40**. When tension becomes too high, the reverse action occurs.

Solenoid operated valve **76** is provided to be closed by an electrical signal when the ball warper is shut down. This holds the air in line **78** at the normal running pressure at the time of shut down. An electrical time delay relay holds valve **76** closed for a controlled period of time after startup so that the ball warper may reach operating speed before the tension regulator is allowed to start operation. This action minimizes tension surges during startup.

The level of damping action in servo system **20** is adjusted by means of regulator **88** and flow valve **92** to obtain the predetermined required pressure as indicated by gage **90**.

The most significant operational advantage of this invention lies in its ability to regulate the tension in a rope at the output end of the device in spite of radical changes in the frictional properties of the rope as it is received and, therefore, enable formation of uniform wound packages. This is accomplished through the fact that changes in friction of the rope against the eyelets **34** and around bars **11, 11'** are immediately detected by the tension detector which is sensitive only to changes in the tension in that part of the rope as it leaves the detector. The tension in the vertical portion of rope between guide **24** and eyelet **35** exerts no torque on beam **28** and hence has no influence on the tension detector. This leaves the detection exclusively confined to tension in the output rope end. Thus, windup tension is maintained constant in spite of wide variations in frictional properties or in speed.

Another embodiment of this invention is shown by FIGS. **3** and **4**. It takes the form of a yarn tension regulator employing a horizontal tension transducer beam and a vernier speed adjusting system for the yarn feed roll. Speed adjusting is actuated from a photoelectric beam balance detector and speed control circuit. Thus, input yarn Y_i is brought into the tension regulator from feed roll **100**. Thence, it passes through the pivot axis of tension transducer beam **102** which is the line of the knife-edge of support **104**. Next, the yarn passes over pin guide **106** and then, as output yarn Y_o, to takeup rolls not shown. Tension in Y_o is regulated by this apparatus in spite of variations in yarn to guide friction.

In this embodiment, beam **102** is counterbalanced by a set point counterbalancing weight **108** near one end of the beam opposite the end at which pin guide **106** is located. An extension **109** to one end of beam **102** has a hole **110** located therein to provide for passage of light from lamp and lens system **111** to photocell **112**, both of which are fixed in space. Signals from photocell **112** are passed over cable **113** to speed control system **114** which is mechanically linked over means **116** to feed roll **100**.

Roll **100** is mounted on shaft **122** and rotated by primary drive motor **120**. Motor **120** is an AC synchronous motor. It receives its power over cable **124** through slip ring arrangement **126**. The frame of motor **120** is mounted for rotation in bearing arrangement **128, 128'**. Slip ring system **126** is mounted on shaft **130** which is attached to the frame of motor **120** and rotates therewith. At the outer end of shaft **130** there is located a large gear **132** which meshes with gear **134**. This latter gear **134** is mounted on shaft **136** of secondary (vernier speed adjusting) motor **138**. Cable **140** is connected to the electrical circuit portion of speed control system **114** of FIG. **3**. Motor **138** and gears **134, 132** provide the linkage **116** indicated by the dashed line (FIG. **3**).

In operation, as before, when the tension in the output yarn Y_o exceeds the set point as determined by weight **108** the beam **102** is depressed so that the signal from photocell **112** over cable **113** causes the speed control system **114** to appropriately and proportionally adjust the speed of roll **100** thus bringing the tension back to the proper level. This speed adjustment is accomplished by action of motor **138** by changing the rate and/or direction of rotation of the frame of primary motor **120**.

Here again, by the principle of locating the exit tangent of roll **100** such that the yarn passes through the axis of rotation of beam **102** and thence to guide **106**, true tension can be regulated in the output yarn line Y_o

in spite of variations in friction between the yarn and guide pin **106.** This enables very precise regulation of the tension in the output end of the yarn Y_o.

The invention has been described by way of two specific embodiments. It will be evident to one skilled in the art that the particular designs of the pivotable tensioning transducer beam, the means for providing set point counter-balancing torque and the means for detecting and transducing movement of the beam to provide feedback signals to adjust the input tension are matters of variable design choice. Thus, many variations will be apparent to those skilled in the art and although illustrated in terms of monitoring tension in textile yarn or rope, this invention is generally applicable to moving flexible elongated structures such as wire, cable, screen and fabric.

What is claimed is:

1. An apparatus for detecting and regulating tension in a flexible elongate structure moving in a path from a source through a tension adjusting means and a first guide means to an advancing means for the structure, said apparatus comprising: a beam pivotally mounted at a location between its ends for angular movement about an axis transverse to said beam, said beam carrying a second guide means spaced from said location, said beam being located between and mechanically separate from said first guide means and said advancing means, said first and said second guide means directing said structure through said axis whereby the tension in said structure upstream of said second guide exerts no torque on said beam, means for detecting the amount of said angular movement and transducing said amount into a signal; and a control means for actuating said tension adjusting means, said signal being fed to said control means for actuation thereof.

2. The apparatus as defined in claim **1,** said second guide means being an eyelet having an opening through which said structure passes, said opening having a central axis in a plane perpendicular to said transverse axis.

3. The apparatus as defined in claim **1,** including means for limiting said angular movement of the beam.

4. The apparatus as defined in claim **1,** said flexible structure being a textile rope.

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