

United States Patent

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3,331,568, which is a division of Ser. No.
111,367, May 19, 1961, abandoned.
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[56]

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[54] **TENSION DRIVE SYSTEM AND TENSION
REGULATOR MECHANISM FOR RELATIVELY
THIN MATERIALS**
6 Claims, 5 Drawing Figs.

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242/75.2

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153, 147, 148, 149, 150, 151, 152, 45, 75.2, 75.3

ABSTRACT: A tension regulator mechanism is described for regulating the tension in a thin material running from a source of supply to a takeup reel. A constant tension is provided in the thin material by running this along a frictional surface and controlling the amount of surface area of the thin material in contact with the frictional surface. In one embodiment, a longitudinal frictional surface is provided and in another embodiment, the frictional surface control is provided by a unique coupling mechanism.

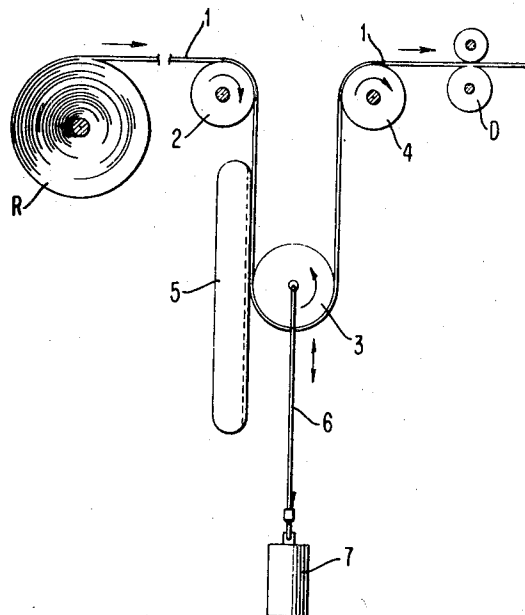


FIG. 1A

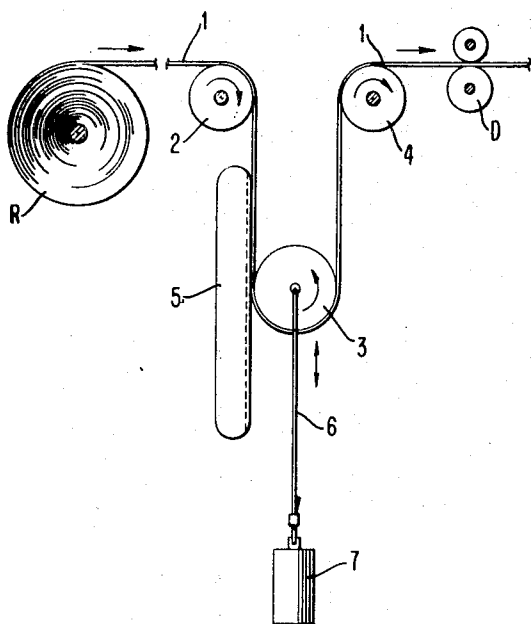


FIG. 1B

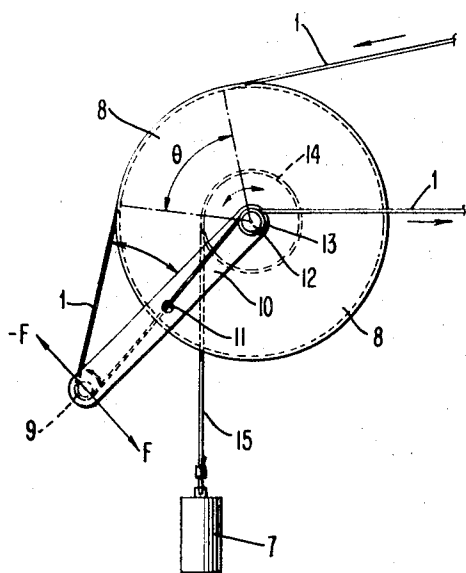
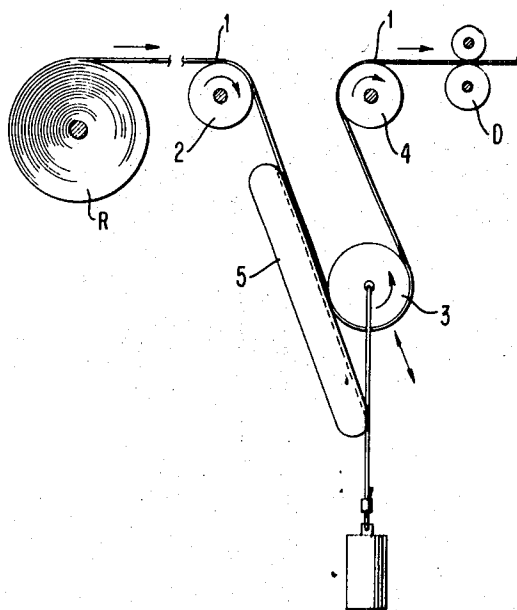
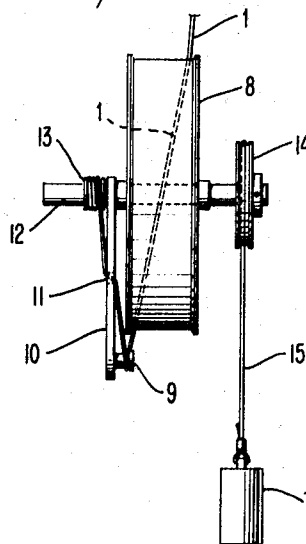


FIG. 2A

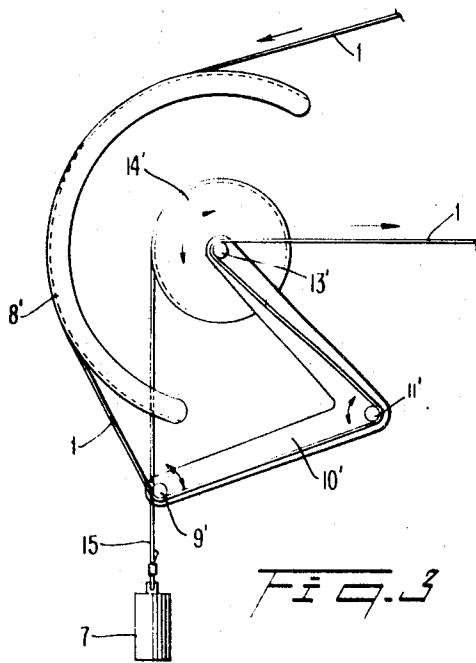
FIG. 2B



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TENSION DRIVE SYSTEM AND TENSION REGULATOR MECHANISM FOR RELATIVELY THIN MATERIALS

This is a division of U.S. Pat. application Ser. No. 667,872 filed June 7, 1967, now abandoned, which is a division of U.S. Pat. application Ser. No. 363,034 filed Feb. 11, 1964 now U.S. Pat. No. 3,331,568 which is a division of U.S. Pat. application Ser. No. 111,367 filed May 19, 1961, now abandoned. This invention relates to a tension drive system and tension regulator mechanism for relatively thin materials such as wire, paper, magnetic tape, thread, rope, or the like.

The invention is useful in wire-drawing machines, printing presses, solenoid-winding machines, magnetic tape recorders, textile-weaving machines, and other machines or applications in which relatively thin materials are drawn by tension from one location to another. The invention is characterized by novel means for maintaining a constant, predetermined tension in the material under wide variations in the driving force applied thereto or the load thereon.

In many diverse branches of science and technology it is necessary to maintain the tension in some relatively thin material at a constant, predetermined level under wide variations of load or driving force. For example, any variation of wire tension in a solenoid-winding machine will cause variations in the electrical characteristics of the solenoids wound thereby. Any variation of paper tension in a cylindrical printing press will at best blur the printing thereon and at worst break the paper and disrupt the printing operation. Any variation of wire tension in a wire-drawing machine will cause variations in the diameter and strength of wire drawn thereby. And any variation of tape tension in a magnetic recording or reproducing system will cause wow or flutter in the signal recorded or reproduced thereby.

Many different tension regulator devices have been constructed in the past to meet the above noted needs. Most of these prior art devices are electromechanical servosystems containing a tension transducer for sensing variations of tension in the material, a servoamplifier for amplifying the output signal of the tension transducer, and a tension control device for changing the tension in response to the output signal of the servo amplifier. Although these prior art devices perform their intended function, they do have several serious disadvantages which are inherent in servosystems of the above noted type. In the first place, the structure of these prior art devices is rather complicated, and they are therefore relatively expensive to manufacture and relatively difficult to maintain in operation. Furthermore, since they contain electrical circuits they are subject to failure through loss of electrical power or breakdown of electrical circuit components. In addition, their transient response is limited to a relatively slow speed, because of the separate feedback circuit, and they are subject to zero drift because of the electrical components in their feedback circuit. ("Zero drift" refers to an undesired change in the null output level of the servosystem. For example, if the system starts out holding the tension at 45 pounds it might, through changes of temperature or voltage level, end up holding the tension at 50 pounds instead. In this case the zero or null output level is said to have drifted from 45 pounds to 50 pounds. This zero drift, it should be noted, does not have to be accompanied by any change in accuracy or response time, which are entirely different matter).

Accordingly, one principal object of this invention is to provide a tension drive system and tension regulator mechanism for maintaining a constant, predetermined tension in a relatively thin material under wide variations in the driving force applied thereto or the load thereon.

Another principal object of this invention is to provide a tension drive system and tension regulator mechanism which is simpler in structure, faster in response, and more accurate in operation than those heretofore known in the art.

A further principal object of this invention is to provide a tension drive system and tension regulator mechanism which is lower in cost, more reliable in operation, and easier to maintain than those heretofore known in the art.

Other principal objects and advantages of the invention, as well as numerous secondary objects and advantages thereof, will be apparent to those skilled in the art from the following description of several specific embodiments thereof, as illustrated in the attached drawings, in which:

FIG. 1A shows a first general embodiment of the invention;

FIG. 1B shows a modification of the apparatus illustrated in FIG. 1A;

FIG. 2A is a side view of a second general embodiment of the invention;

FIG. 2B is an end view of the general embodiment shown in FIG. 2A;

FIG. 3 is a side view of a modification of the apparatus shown in FIG. 2A.

In accordance with the tension drive system of this invention there is provided a means for applying a drive force to a relatively thin material and a means for developing a frictional restraining force on the relatively thin material when it moves in response to the drive force. The frictional restraining force, of course, opposes the driving force, but it is not large enough to stop the motion or to injure the material.

In accordance with the tension regulator mechanism of this invention, the frictional restraining force is variable as an inverse function of the tension in the material such that the restraining force drops when the tension increases and vice versa. Thus any changes of tension due to variations in the driving force or the load are counteracted by opposite changes in the frictional restraining force to hold the tension constant at a predetermined value. In the tension regulator mechanism of this invention the variation of tension is not detected in a separate tension transducer and coupled around a separate feedback path such as used in the prior art devices. Instead, the restraining force generator of this invention is adapted to perform all of the functions required to maintain a constant tension in the material. This eliminates many parts and makes the tension regulator of this invention simpler in structure, faster in response, lower in cost, more reliable in operation, and more accurate than those heretofore known in the art.

The null or zero output level of this invention is controlled by a highly stable reference force, such as the force of gravity, so that zero drift is reduced to a minimum. This reference force is used to press the moving material against a frictional surface, by way of a variable mechanical force coupling, to produce the frictional restraining force. The variable force coupling is adapted to automatically vary its output in response to any changes of tension in the material so as to counteract those changes. Thus in this invention the changes of tension are detected directly by the means for counteracting those changes.

The means by which the above noted features of the invention are embodied will be better understood from the following description of the embodiments shown in the drawings. Referring to FIG. 1A, one general embodiment of the invention contains a tape or thread 1 which is moved from left to right on the drawing by a driving force applied by drive roller D, which can be driven by any suitable motor means. The tape or thread 1 is drawn from a storage reel R and is moved through a first fixed pulley 2, a floating pulley 3, and a second fixed pulley 4. The floating pulley 3, which is pulled downward by a weight 7, is positioned so as to rub the tape or thread 1 against a frictional rubbing block 5. If the tension in the string 1 is increased, floating pulley 3 will rise, thus decreasing the frictional force, and if the tension in string 1 is decreased, floating pulley 3 will drop, thus increasing the frictional force. The system will stabilize at a tension level given by the equation

$$T + \mu x = T_o = \frac{W}{2} \quad (1)$$

where T is the tension at the input of the device, T_o is the tension at the output side of the device, μ is the friction factor between the thread and the block 5, x is the length of contact between thread 1 and block 5, and W is the weight of weight 7.

Therefore, it will be understood that when the input tension T varies within

$$\frac{W}{2} > T > \frac{W}{2} - \mu l \quad (2)$$

where l is the total length of body 5, the balancing according to the equation (1) is always established. In other words, the variation of the input tension T within the condition (2) is perfectly stabilized to $T_o = W/2$ at the output side. This system is therefore a perfect tension servosystem without a stationary error. The pulleys 2, 3, and 4 may be fixed guides having friction, which would increase the output tension but which would not alter the operation of the device or impair its regulating action.

FIG. 1B is a modification of the apparatus shown in FIG. 1A. The friction block 5 is inclined in this modification to make good contact, but the operation is similar to FIG. 1A.

FIG. 2A and 2B show thread 1 being moved along a curved frictional block 8. From block 8 the thread 1 is pulled along a pulley 9 mounted on a lever 10 and then through a hole 11 cut in lever 10, which is rotatable around a shaft 12. From hole 11, thread 1 is introduced via a pulley 13 to the output side of the device.

The lever 10 is fixed to a wheel 14 which is driven to rotate counterclockwise by means of a weight 7 which is coupled to wheel 14 through string 15. Therefore the tangential force at pulley 9 is a constant force F .

The tension T_o of the thread 1 at the outlet from the frictional block 8 is therefore balanced out by F in accordance with the equations:

$$T_o \cos \Theta = F, T_o = T e \mu \theta \quad (3)$$

μ is the friction factor between thread 1 and block 8, θ is the base of the natural logarithm, T is the tension at the input of the device, T_o is the tension at the output of the device, Θ is the angle between lever 10 and the point where string 1 leaves block 8, and θ is the angle of contact between string 1 and block 8.

It is clear from equations (3) that the output tension T_o will be constant over a wide range of variation in θ which can be varied from zero to more than 100° . Although the embodiment of FIGS. 2A and 2B is more complex than the embodiment of FIGS. 1A and 1B, it will handle larger variations of tension.

The pulley 9 may be a fixed guide, but the pulley 13 should not have any friction for accurate control. The hole 11 may be omitted, if desired, and thread 1 may be guided to pulley 13 by other means. The direction of thread travel may be reversed if desired. Instead of the weight 7 in FIGS. 1A, 1B and 2A, 2B, a torque motor, a spring, pneumatic force means, or the like can be used to generate the reference force.

FIG. 3 shows a modification of the apparatus shown in FIGS. 2A and 2B. This modification is adapted to handle flat material such as magnetic tape. An arcuate frictional block 8' is engaged by the tape 1. A crank 10' is used instead of the lever 10 in FIGS. 2A and 2B. The tape is guided along crank 10' by pulleys 9', 11', and 13'. The pulleys 9' and 13' correspond in function to the pulleys 9 and 13 of FIGS. 2A and 2B. Crank 10' is also attached to a wheel 14 which is driven to rotate as in the case of FIGS. 2A and 2B.

The tension regulator of this invention can be embodied in many other ways. Of course, two or more embodiments can be combined if desired. The cylindrical friction block in FIGS. 2A and 2B maybe rotated to give a large relative velocity between the thread and the block, if desired, to produce a constant dynamic friction factor. The pulleys or rollers may be replaced by fixed posts or guides except for the special case *i.e.*, the case in which the engaging angle varies, if the excess friction is not objectionable. If wear of the friction surface must be avoided, the friction block may be rotated or displaced automatically or manually. The friction block may be a form of tape, such as the ink ribbon of the typewriter.

For magnetic wire or the like, magnetic force can be utilized to make good contact between the wire and the friction sur-

face. For dielectric film or tape electrostatic force may be employed for the same purpose. The reference force may be derived from weights, springs, solenoids, motors, pneumatic means, oil pressure apparatus, or the like. The mechanism of this invention may oscillate if the mechanical damping of the system is low; in this case appropriate damping means, such as oil dampers, air dampers, mechanical friction dampers, or the like may be added to the pivot of the lever, to the spring, or to the weight. A little oscillation, however, might enhance transient response.

The tension regulator mechanism of the invention is useful in a very wide field of application. The moving material may be tape, wire, paper, thread, cloth, rope, or the like. The invention can be used in tape-treating apparatus, coil winders, wire-treating apparatus, metal plate-treating devices, printing machines, paper fabrication, building machines, rope twistors, or the like. In all of these applications the tension is fully stabilized by the novel tension regulator of this invention and the production is performed quite uniformly.

While the principles of the invention have been described in connection with the above specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of the invention as set forth in the accompanying claims.

I claim:

1. A device for regulating the tension in a line of thin material running from a source of supply to a takeup mechanism comprising:

first and second support means to support a line of thin material so as to create a catenary therebetween;

a pulley positioned against the thin line of material and upon the inside of said catenary, said pulley having a weight attached thereto, said pulley and weight being suspended from the line of thin material and exerting a force thereon so that the line of thin material is caused to proceed substantially linearly from said first support means to said pulley and from said pulley to said second support means, said pulley and weight being free to move in the vertical plane in response to the depth of said catenary; and

means to frictionally engage a varying length of the line of thin material, running between said pulley and said support means, the length of the line of thin material in frictional engagement therewith varying in proportion to the depth of the catenary.

2. The device of claim 1 wherein said means to frictionally engage the line of thin material comprises a flat surface in continuous contact with said pulley.

3. A tension regulator mechanism for regulating the tension in a thin material running from a source of supply to a takeup reel comprising:

means supporting a loop of the thin material;

a friction block having a longitudinal flat surface with an area thereof in frictional contact with the outer side of the loop of thin material;

a pulley supported by the loop and in contact with the inner side of the thin material loop;

said pulley being positioned adjacent the longitudinal flat surface of the friction block with the thin material between the flat surface and the pulley for movement of the pulley relative to the flat surface in response to varying tensions in the thin material; and

means providing a preselected force to the pulley in a direction tending to increase the area in frictional contact with the thin material, said force being chosen to provide a tension in the thin material of a preselected magnitude.

4. The device as recited in claim 3 wherein said force applying means comprises a weight.

5. The device as recited in claim 4 wherein said friction block has its longitudinal surface inclined relative to the horizontal.

6. The device as recited in claim 5 wherein said thin material comprises a flat tape.