Dec. 11, 1951 K. E. WILHELM 2,578,620

METHOD OF CONTROLLING THREAD TENSION

Filed April 30, 1948 3 Sheets-Sheet 1

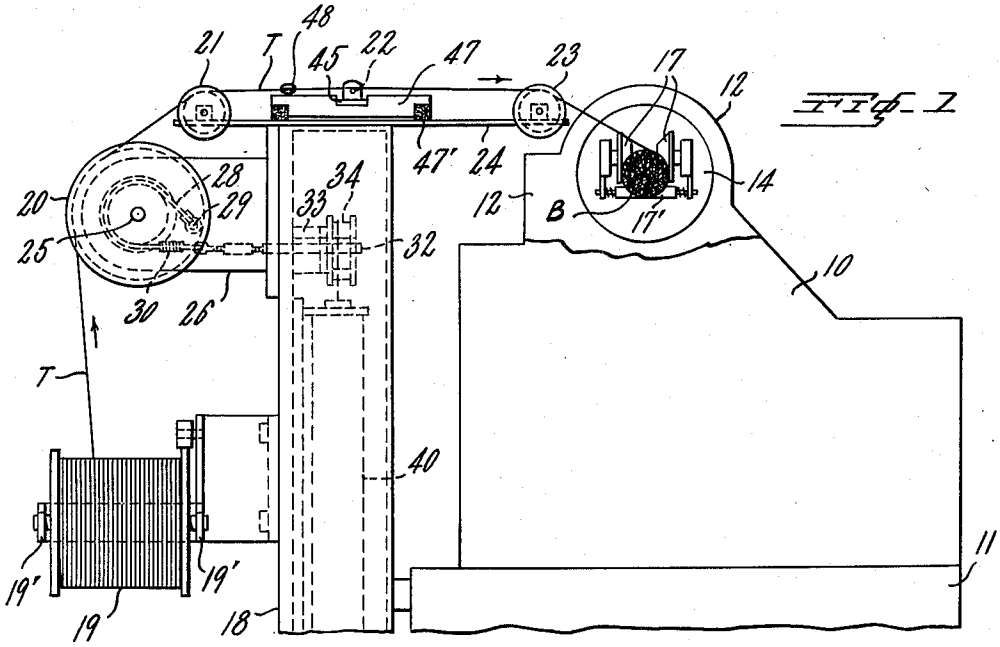


Fig. 1

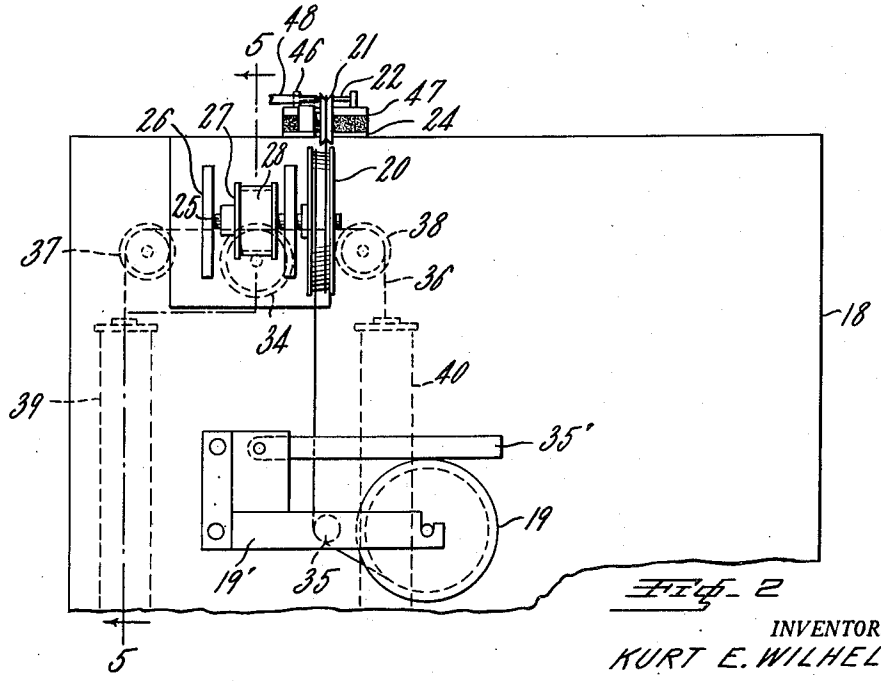


Fig. 2

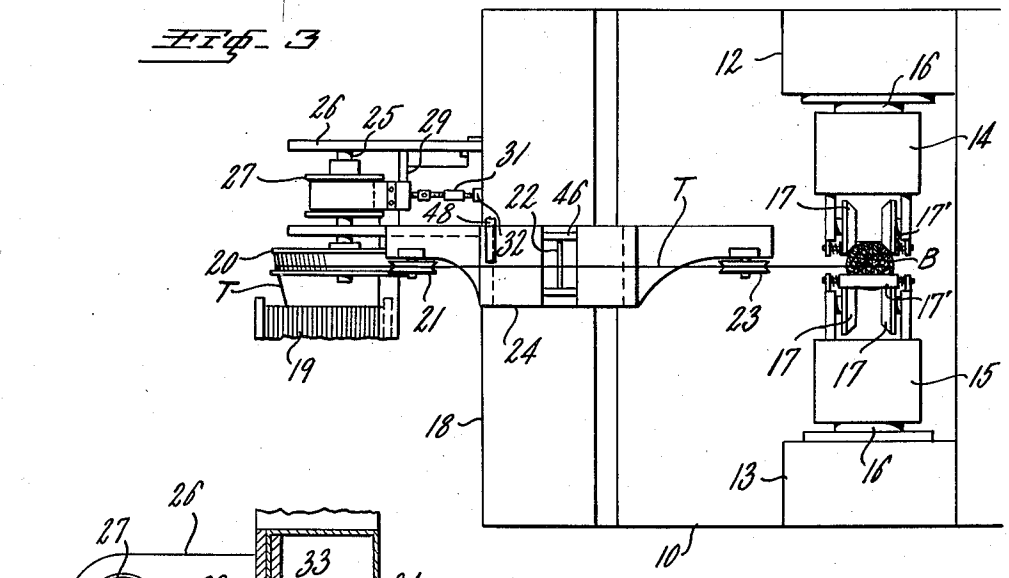
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Fig. 3



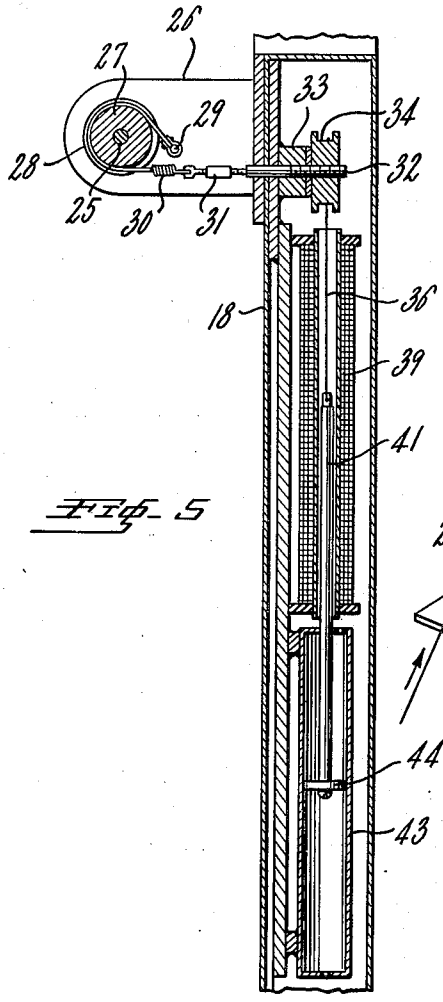


Fig. 5

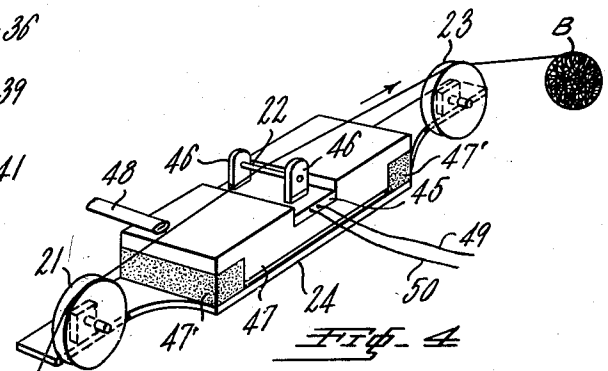


Fig. 4

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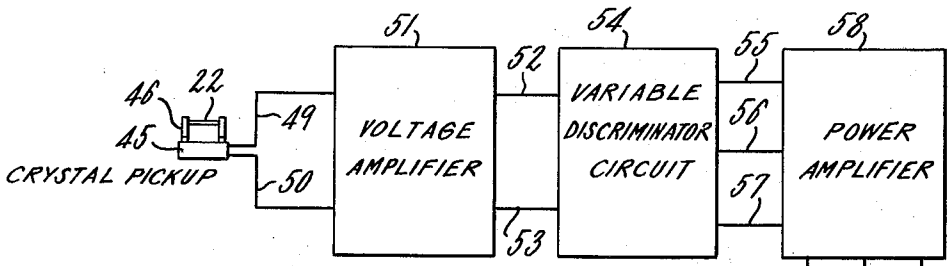


Fig. 6

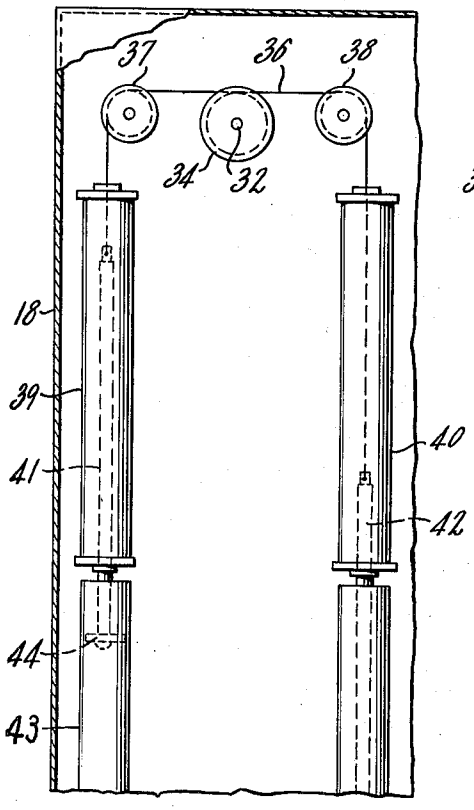


Fig. 7

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METHOD OF CONTROLLING THREAD TENSION

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7 Claims. (Cl. 242—45)

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The present invention relates to a novel method of controlling the tension of a thread or strand during a winding operation, so as to keep its tensile stress or pounds per square inch tension substantially constant. This method is particularly well adapted to control the tension of a rubber thread in winding golf balls, but may be used to tension other types of threads. The present invention constitutes an improvement over the method of controlling thread tension described and claimed in my Patent No. 2,425,909.

In manufacturing golf balls and particularly the better grade golf balls, it is desirable to wind the rubber thread on the golf ball core under high tension to thereby increase the hardness of the ball body and increase its flight, but if high tension is used the thread is likely to break frequently during the winding operation. Such breakage is due largely to the fact that golf ball thread cannot be made absolutely uniform in cross section by the methods now in use, so that if the tension placed upon the rubber thread during a golf ball winding operation is kept high and substantially constant as heretofore, irrespective of variations in the size of the thread, the portions of the thread that are over-sized will be under-stretched and the portions that are under-sized will be over-stretched. This over-stretching causes thread breakage and also produces variations in the hardness of the balls wound. In other words, the practice heretofore has been to wind the rubber thread on the core under a selected constant load, with the result that the thread tension was less in some regions upon the ball than in others.

The primary object of the present invention is to change the control of the tension of a thread being wound, on a golf ball for example, from one of tensile force to one of tensile stress. If the tensile force is continuously adjusted to maintain the tensile stress constant, a high mean stress can be utilized in winding golf balls with a uniform high hardness and with a low thread breakage.

The present invention seeks to improve the method of the above cited patent for controlling thread tension, and to provide apparatus for carrying out the present method which is more simple to manufacture and operate than that disclosed in said patent.

The present invention makes use of the well known physical law which states that the natural frequency of vibration of a thread stretched between two fixed points is determined by the ratio

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of the stretching force to the linear density (mass per unit length along the thread). This ratio can also be expressed as the ratio of the tensile force stretching the thread to the product of the volume density times the cross sectional area of the thread. In the rubber thread used in winding the body of golf balls the density is practically constant, but the cross sectional area exhibits uncontrolled variations. It follows from this physical law that if the tensile force is automatically and continuously adjusted so that the natural frequency of vibration of a definite length of the advancing thread is held constant, then the tensile force per unit cross-section area, that is the stress, will necessarily be constant and can be maintained at a high value; and this is what is desired to produce a golf ball of high resilience.

It will appear from the foregoing that if a rubber thread being wound upon a golf ball core under tension is caused to pass over two spaced points a fixed distance apart, and the length of thread between these two points is kept vibrating at its natural frequency, the rate of such vibration will vary (1) with the tension of the thread and (2) with the size of such thread.

In accordance with the present method the tensile stress in an advancing thread is kept practically constant by advancing the thread under tension over a supporting bar and causing a definite length of this thread to vibrate between the bar and a spaced support, so that as this thread vibrates it will exert a varying downward pressure on said bar. The frequency of these pressure variations will correspond to the frequency of thread vibration, so that a simple and convenient way of determining the rate at which the thread is vibrating is to detect electrically the frequency of the pressure variations upon such bar. Then compare the frequency of these pressure changes with a selected standard frequency and automatically adjust the tension of the thread as changes in its rate of vibration are detected. In this way the rate at which the thread vibrates can be kept substantially constant, to thereby keep the tensile stress of the thread at a selected value and enable high density golf balls to be wound with few thread breaks.

The above and other features of the method of the present invention will be further understood from the following description when read in connection with the accompanying drawings which illustrate one good practical form of apparatus for carrying out the method.

In the drawings:

Fig. 1 is an end view with parts broken away, of a golf ball winding machine having associated therewith tension controlled mechanism constructed in accordance with the present invention;

Fig. 2 is a front elevation of the tension control mechanism and supporting cabinet shown in Fig. 1;

Fig. 3 is a top plan view of Fig. 1;

Fig. 4 is a perspective view of apparatus for supporting the running thread so that it will vibrate between two spaced points;

Fig. 5 is a sectional view taken on the line 5—5 of Fig. 2;

Fig. 6 is a rear view of the interior of the cabinet showing the solenoids and associated parts to be described; and

Fig. 7 is an electric block diagram of mechanism for varying the tension upon the thread to keep its rate of vibration substantially constant.

The present invention may be employed to control automatically the tension of a thread, strand or filament whether or not it is advancing, but is particularly well adapted to control the tension of a rubber thread wherein a slight variation in load upon the thread will produce a substantial change in its length. The thread tensioning mechanism contemplated by the present invention is shown in connection with a golf ball winding machine of the general type disclosed in the Cobb Patent No. 1,270,009.

The winding machine shown comprises a metal casing 10 mounted upon a frame 11 adapted to support the winding machine at the desired distance from the floor. The casing 10 is formed with the housings 12 and 13 which are spaced apart, as shown in Fig. 3, to provide therebetween an opening in which the ball supporting heads 14 and 15 operate. These heads are supported and rotated by axially aligned shafts 16 and are mounted for limited longitudinal movement to facilitate the introduction of a ball B between the heads, and also the increase in the size of the ball as the thread is wound thereupon. The heads 14 and 15 rotate at the same speed and turn the ball upon the longitudinal axis of the shafts 16 to wind the thread in a plane extending through the center of the ball at right angles to such axis. The ball is actually supported by the discs 17 and antifriction rollers 17' provided upon the heads 14 and 15. These discs are periodically rotated relatively to the heads to turn the ball and distribute the windings uniformly over its surface, as more fully explained in the Cobb patent.

In the construction shown a cabinet 18 is provided that is adapted to support or house the thread tensioning means. This cabinet is positioned in front of and is secured to the golf ball winding machine. The rubber thread T is supplied to the golf ball B under tension from a spool 19 supported by a bracket 19' secured to the front of the cabinet, as will be apparent from Figs. 1 and 3. The thread is led upwardly from the supply spool 19 to and around a thread tensioning drum 20 and then over a grooved wheel 21. It then passes horizontally to slide over a bar 22, and then over a second grooved wheel 23. The parts 21, 22 and 23, as best shown in Fig. 4, are supported by a plate 24 adapted to be secured rigidly to the top of the cabinet 18. The thread T upon leaving the wheel 23 passes to the ball B being wound and is pulled forward from its supply package 19 as the ball is rotated by the heads 14 and 15.

The rubber thread T is preferably wound upon the ball B under high tension so as to increase the hardness of the ball. The means shown for tensioning this thread comprises the thread tensioning drum 20, above mentioned, and about which the thread is looped one or more times to prevent it from slipping relatively to the drum surface. This drum is rigidly secured to a shaft 25 that is rotatably supported by the bracket 26 which extends frontwardly from the face of the cabinet 18. This shaft 25 also has rigidly secured thereto a brake drum 27, about which there is looped the brake band 28. One end of this band is anchored to a pin 29 secured to the bracket 26 and the other end has secured thereto a spring 30, a turn buckle 31, and a threaded bolt 32. This bolt extends into the cabinet 18 and through a hole in a block 33 in the cabinet, and has mounted on its protruding end a threaded pulley 34. The arrangement is such that rotation of this pulley in one direction will tighten the brake band 28 about its drum 27 and rotation of this pulley in the opposite direction will lessen the tension upon this brake band.

It will be understood from the mechanism so far described that when the golf ball winding machine is operated to rotate the ball B, the thread T will be unwound from the spool 19 to pass upwardly around a roller 35 and then to the drum 20. A weight 35' resting upon a rim of the spool 19 keeps this spool from rotating too freely. This thread passes from the tensioning drum 20 over the spaced free running grooved wheels 21 and 23 having located therebetween the bar 22 over which the thread slides. The amount of tension placed on the thread T is controlled by turning the threaded pulley 34 to thereby control the force with which the brake band 28 is applied. Rotation of the pulley 34 is secured, in the construction shown, by looping around this pulley several times to prevent slippage a fine wire 36 so that one end portion of this wire extends laterally to a grooved pulley 37 and then downwardly, and the other end portion extends laterally in the opposite direction to a pulley 38 and then downwardly. The arrangement is such that a downward pull upon one end of the wire 36 will rotate the pulley 34 in one direction and a downward pull at the other end of this wire will rotate the pulley in the opposite direction.

The means shown for exerting a downward pull upon the opposite ends of the wire 36 to cause this wire to rotate the pulley 34 comprises the solenoids 39 and 40 mounted within the cabinet 18. One of these solenoids has the sliding iron core 41 which is secured to an end of the wire 36, and the other solenoid has the sliding iron core 42 which is secured to the other end of the wire 36. The arrangement is such that each core may travel a substantial distance within its solenoid during which the force exerted on the core depends only on the current through the solenoid and not on the core position to thereby turn the threaded pulley 34 through a sufficient number of revolutions to control the tension upon the brake band 28 throughout the desired range. The cores 41 and 42 extend downwardly beyond their respective solenoids to enter the dash pots 43 containing a viscous liquid such as oil that acts upon discs 44 attached to the lower end of the cores to prevent the cores from moving too rapidly, and thereby prevent what is known as hunting. The construction of the solenoids is such that the weight of their cores will keep the wire 36 under tension, and when one core is raised as a result of its solenoid becoming excited the other core

will move downwardly under the influence of gravity. In this way a very simple and effective means is provided for automatically controlling the brake action upon the brake drum 20, but other means for controlling this drum may be used.

The mechanism so far described, with the exception of the rod 22, is similar to that described in my patent above mentioned. In accordance with the patent disclosure the rate at which the thread vibrates is detected by an electric light disposed at one side of the vibrating thread and a phototube disposed at the other side of such thread, so that the beam of light will be interrupted on each up stroke and each down stroke of the vibrating thread, the interrupting of the light is utilized to control through electrical means the braking action upon the thread.

In contrast with this light beam detecting means of the patent the present invention contemplates a simpler form of means for detecting the rate of thread vibrations comprising a crystal pick-up 45, such as a Rochelle salt crystal, having rigidly secured thereto to extend upwardly from one face thereof the posts 46 which support the bar 22 above mentioned. This bar may be made of hard metal having a smooth wear resistant surface but is preferably made of Carboloy which is a tungsten carbide product that is extremely hard and well adapted to resist wear caused by a thread sliding over its surface. The crystal pick-up 45 is shown as mounted in a relatively deep notch formed in the upper face of a heavy metal bar 47, and the crystal is firmly cemented to the bottom and side walls of this notch. The metal bar 47 is large and heavy so that its frequency of vibration will be much slower than that of the vibrating thread, and its has the rubber mountings 47' which yieldingly support it in spaced relation to the plate 24. Although a crystal pick-up is preferred other types of what are known as "contact microphones" may be used, and the expression "vibration pick-up" is herein used to cover broadly the sensitive pick-up used to respond to the variations in pressure exerted by the vibrating thread upon the bar 22.

The thread T is kept vibrating between the supports 21 and 22 at its natural frequency. One way to accomplish this is to provide an air jet 48 placed at right angles to the thread such that the air from the jet forces the thread from its equilibrium position and out of the air stream; the elasticity of the thread causes the thread to return past the equilibrium position and the air will now push it in the opposite direction where the process is repeated. The thread is thus caused to vibrate at right angles to the air jet and at its natural frequency. The vibrating thread rests upon the bar 22 as it slides over this bar and it will exert a varying downward pressure upon the bar due to its vibrations between the pulley 21 and this bar. The distance of the second pulley 23 from the bar 22 is not important since it serves primarily to prevent the thread from bending sharply about the bar, but it should be spaced far enough from the bar to prevent the thread at this side of the bar from vibrating at half of the wave-length at which it vibrates between the pulley 21 and bar 22. The cycles of change in pressure upon the bar 22 by the thread will correspond to the thread vibrations, and the frequency of these cycles are detected by the crystal pick-up, as these changes in pressure upon the crystal will cause it to produce a sinusoidal signal of the same frequency as that of the vibrating thread. This signal is conducted by the wires 49 and 50 to the electrical apparatus shown in block diagram in Fig. 7, and a sinusoidal signal affords a very satisfactory form of electrical control of the thread tension.

These wires 49 and 50 lead to a voltage amplifier 51 to increase the voltage of the signal supplied by the crystal pick-up. The amplified signal is then conducted by the wires 52 and 53 to the frequency discriminator circuit 54 and this frequency discriminator is variable so that it will operate at the desired selected frequency. Wires 55, 56 and 57 connect the frequency discriminator circuit 54 to a power amplifier 58. The action of the discriminator 54 and power amplifier 58 is such that when the incoming signal has the desired frequency, such for example as 1,000 vibrations per second, the voltage supplied to the solenoid coils 39 and 40, that are connected to the amplifier 58 by the wires 59, 60 and 61, will be equal. Equal current through these coils will means that the cores 41 and 42 will not move. If however the incoming signal supplied by the crystal pick-up 45 does not have the desired frequency; that is the frequency of the discriminator 54, the currents through the coils 39 and 40 will no longer be equal and movement of the cores will result. This movement of the cores will rotate the pulley 34 in one direction or the other to vary the brake action and thereby change the tension of the thread T to restore it to the desired frequency of vibration, and this in turn will produce the desired tensile stress or pounds per square inch tension in the thread. As soon as the desired frequency of thread vibration has been attained the movement of the cores stops, and they remain still until further readjustment is called for.

The voltage amplifier 51, variable discriminator circuit 54, and power amplifier 58 may all be of well known construction, and may be practically identical with those circuits disclosed in my patent above mentioned except that due to the use of a crystal pick-up that produces a sinusoidal signal the voltage amplifier 51 herein used may be simpler than that employed in said patent. The discriminator circuit 54 may be set in a well known manner by means of a calibrated dial to control it for any desired frequency.

It is found in practice that the thread supporting bar 22 which is connected directly to the crystal pick-up 45 forms an extremely simple and practical means for detecting the rate of thread vibrations, and that the sinusoidal signal produced by this crystal pick-up is very well adapted to control the tension of the thread so as to keep its rate of vibration approximately constant at the selected rate, to thereby keep the tensile stress of the thread at a selected value.

Having thus described my invention, what I claim and desire to protect by Letters Patent is:

1. The method of controlling the tensile stress in an advancing thread, which consists in advancing the thread under tension over a supporting point, causing a definite length of the thread to vibrate between said point and a second support at the natural frequency for such length so that the cycles of change in pressure exerted upon said point by the thread will correspond to the thread vibrations, electrically detecting the frequency of these cycles of change in pressure and comparing them with a selected standard frequency, and automatically adjusting the tension of the thread as change in the frequency of such cycles occur to thereby keep the tensile stress of the thread at a selected value.

2. The method of controlling the tensile stress in an advancing thread, which consists in advancing the thread under tension over a supporting point, causing a definite length of the thread to vibrate between said point and a second support at its natural frequency so that the cycles of change in pressure exerted upon said point by the thread will correspond to the thread vibrations, electrically detecting the frequency of these cycles of the change in pressure and comparing them with a selected standard frequency and automatically adjusting the tension of the thread to keep its rate of vibration approximately constant.

3. The method of controlling the tensile stress in an advancing thread, which consists in advancing the thread under tension over a supporting point, causing a definite length of the thread to vibrate between said point and a second support at its natural frequency so that the cycles of change in pressure exerted upon said point by the thread will correspond to the thread vibrations, electrically detecting by means of a crystal pick-up the frequency of these changes in pressure and comparing them with a selected standard frequency, and automatically adjusting the tension of the thread to keep the tensile stress of the thread at a selected value.

4. The method of controlling the tensile stress in an advancing thread, which consists in advancing the thread under tension over two spaced pulleys and over a supporting point located between the pulleys, causing the length of thread between said point and a pulley to vibrate at its natural frequency so that it will exert pressure upon said point that varies in cycles that correspond to the thread vibrations, electrically detecting these cycles of change in pressure and comparing their frequency with a selected standard frequency, and automatically adjusting the tension of the thread to keep its rate of vibration approximately constant.

5. The method of controlling the tensile stress in an advancing thread, which consists in advancing the thread under tension over two spaced pulleys and over a bar located between the pulleys, causing the length of thread between said bar and a pulley to vibrate at its natural frequency so that it will exert pressure upon the bar that varies in cycles that correspond to the thread vibrations, connecting this bar to a vibration pick-up so that these cycles of changes in pressure will produce corresponding electrical signals, and employing these signals to control the thread tension so as to keep its tensile stress at a selected value.

6. The method of controlling the tensile stress in an advancing thread, which consists in advancing the thread under tension over two spaced pulleys and over a bar located between the pulleys, causing the length of thread between said bar and a pulley to vibrate at its natural frequency so that it will exert pressure upon the bar that varies in cycles that correspond to the thread vibrations, connecting this bar to a vibration pick-up so that these cycles of changes in pressure will produce a sinusoidal signal of the frequency of thread vibrations, and utilizing this signal to keep the rate of thread vibration approximately constant.

7. The method of automatically regulating the tension upon a rubber thread so as to keep its tensile stress constant, which consists in advancing the thread under tension over a supporting point, causing a definite length of the thread to vibrate between said point and a second support at its natural frequency so that it will exert pressure upon said point that varies in cycles corresponding to the thread vibrations, electrically detecting the frequency of these cycles of the change in pressure and comparing them with a selected standard frequency, and automatically adjusting the tension of the thread as changes in such frequency occur.

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