

Aug. 19, 1947.

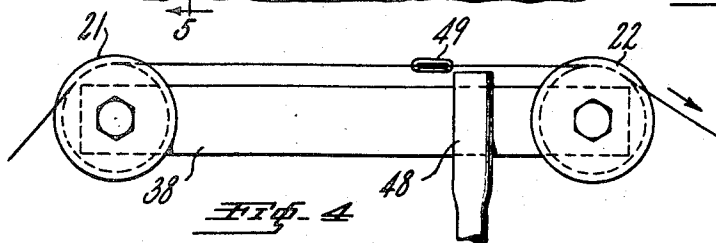
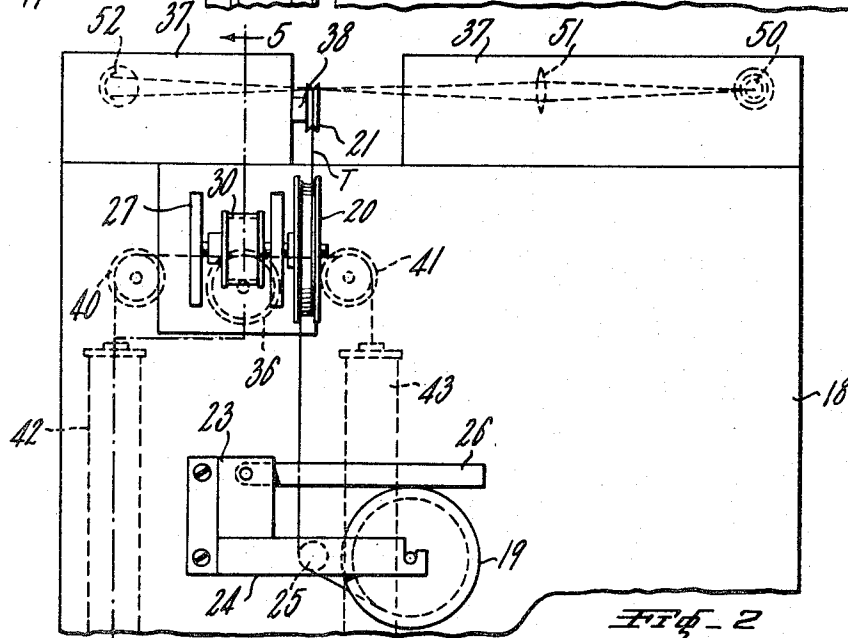
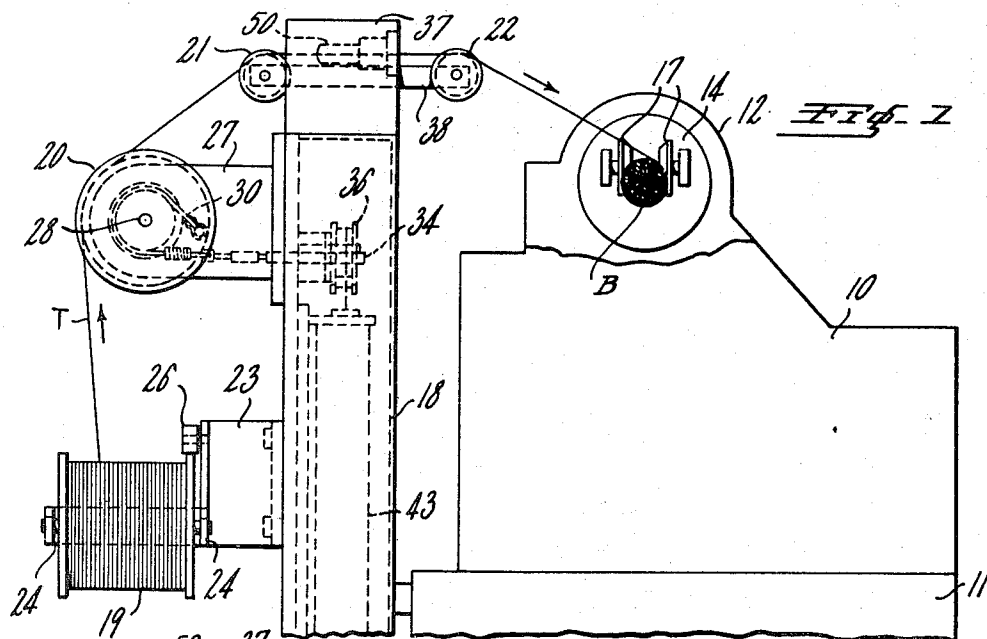
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2,425,909

METHOD OF CONTROLLING THREAD TENSION

Filed Dec. 14, 1945

3 Sheets-Sheet 1



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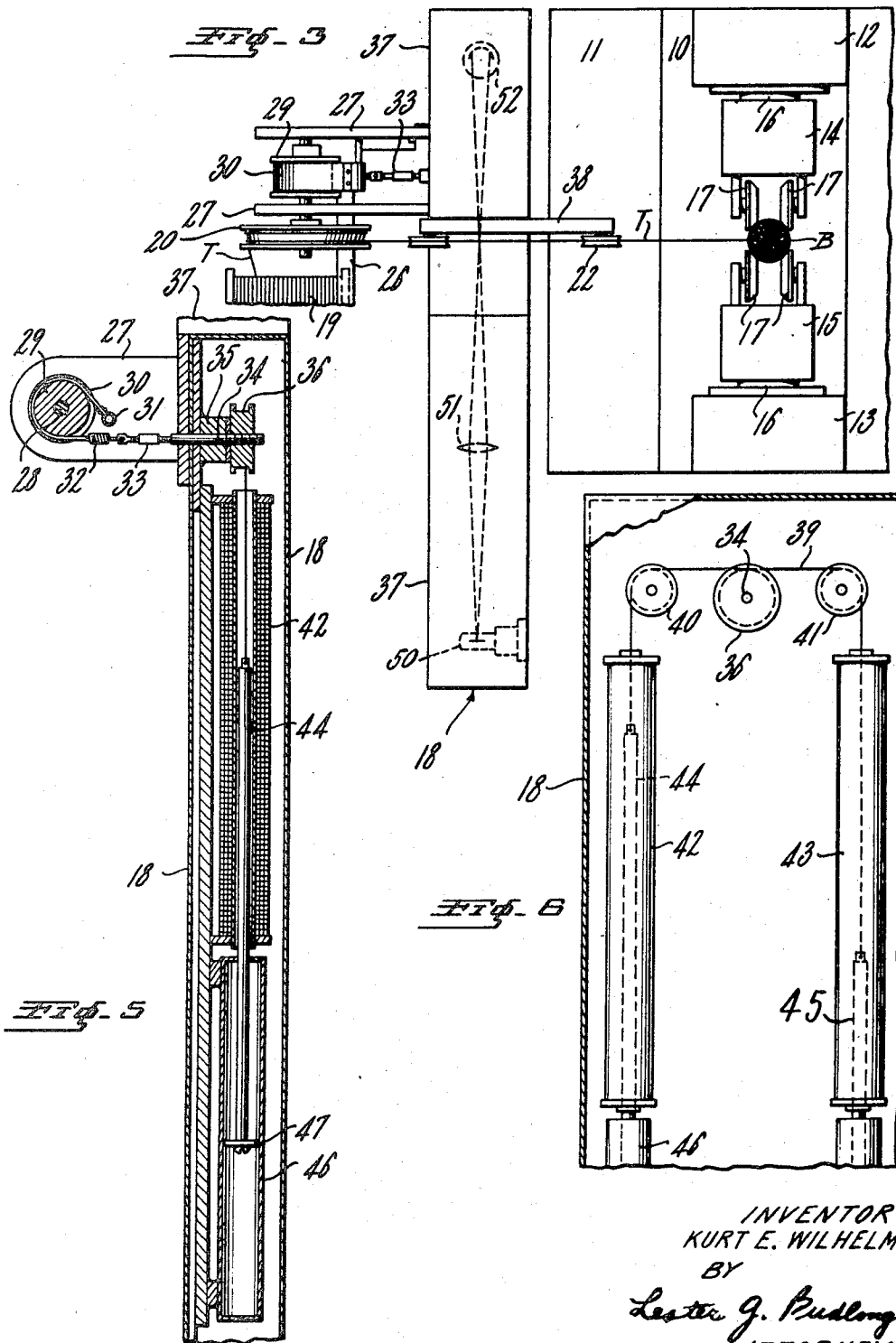
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3 Sheets-Sheet 2



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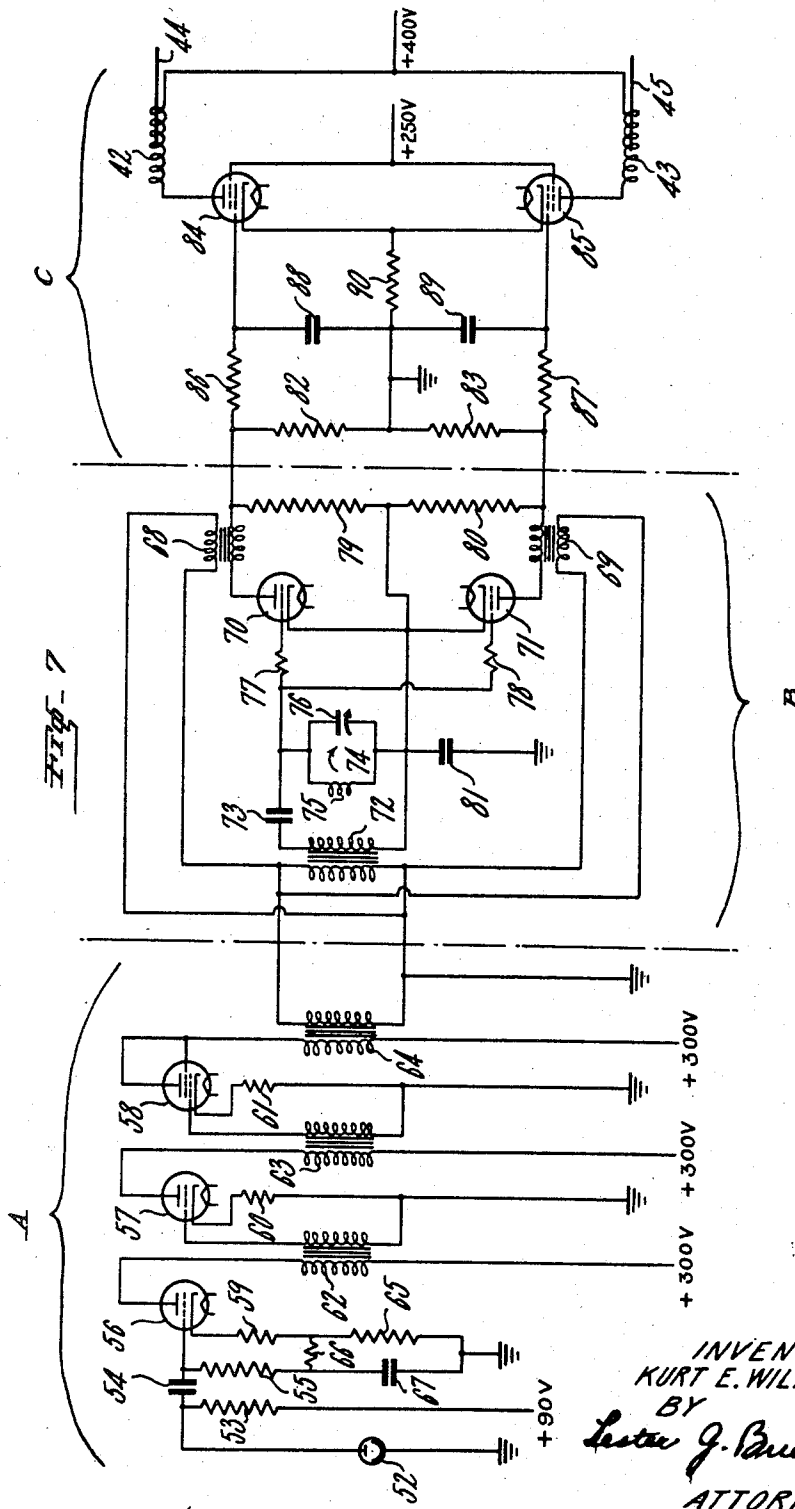
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METHOD OF CONTROLLING THREAD TENSION

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3 Sheets-Sheet 3



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2,425,909

METHOD OF CONTROLLING THREAD TENSION

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Application December 14, 1945, Serial No. 635,072

7 Claims. (Cl. 242—45)

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This invention relates to a novel method of controlling the tension of a thread or strand during a winding operation to thereby keep the pounds per square inch tension of the thread constant. The present method is particularly well adapted to control the tension of a rubber thread as it is wound on a golf ball, but may be used for tensioning threads for other purposes.

Golf balls as usually constructed consist of a core about which a rubber thread or tape is wound under considerable tension to form the ball body that is later provided with a protecting cover.

The better golf balls are wound under high tension since the higher the tension with which the rubber thread is wound the greater will be the flight of the ball.

Various types of tension devices have been employed heretofore to control the tension of the rubber thread as it is supplied to a golf ball and many of these tension devices operate automatically to maintain a constant pull upon the thread being wound on the ball.

That is such prior tension devices exert a constant pull on the running thread regardless of thread size variations, and as a result when the thread runs small the rubber forming the same will be stretched to a greater degree than normal and when the thread runs large it will be stretched to a less degree than normal.

The rubber threads available for winding golf balls do not run uniform as to size even when carefully manufactured, and when such a thread is subjected to a constant tensioning pull as heretofore, regardless of thread size variations, the rubber forming the portions of the thread that are undersize will be stretched to a much greater degree than the rubber forming the portions of the thread that are oversized. This results in a substantial variation in the degree of stretch of the rubber thread wound upon the ball and a corresponding variation in the density of the balls. It will therefore be seen that no matter how well a golf ball tension device may operate to exert a predetermined constant pull upon a thread, any variation in the size of the running thread will cause variations in the degree to which the thread is stretched as it lies on the ball. This in turn will produce variations in the density and flight properties of the balls.

Heretofore in winding the better grade golf balls it has been the usual practice to select the permissible thread gauge tolerance such as 10% variation in the size of the rubber thread and then measure the thread from time to time to see

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if its size is within the tolerance range. This involves considerable time and expense but was necessary to keep the density of the finished golf balls within a selected range. The present invention makes this prior practice unnecessary since wide variations in the size of the thread being wound will not affect the density of the finished ball as will now be explained.

The primary purpose of the present invention is to produce golf balls that will possess a high degree of uniformity as to density and flight properties. To accomplish this the present invention employs an entirely different principle from that used heretofore to control the tension of the thread for golf balls, in that in accordance with the present invention the thread is supplied to the golf ball under constant pounds per square inch winding tension and not under a constant pull as heretofore. Stated differently the aim of the present invention is to keep the pounds per square inch tension of the thread constant independently of size variations in the running thread.

The operation of the present invention is such that the actual tension exerted upon the thread at any instant is controlled in accordance with the cross sectional area of the particular portion of the thread being wound at that instant. If this portion of the thread is undersized the total pull being exerted on the thread at such instant will be reduced whereas if the cross sectional area of the thread is oversized the total pull will be increased, so that the pounds per square inch tension of the rubber thread will be maintained constant throughout a wide range of size variations in the thread.

The method contemplated by the present invention for controlling the pounds per square inch tension of a running thread operates quickly to make corrections for variations in the size of the thread. That is the electrical control used will make a correction in an extremely small fraction of a second and before the tensioned thread, when being wound at high speed, will travel one foot after a change in the rate of thread vibration occurs. This accurate control of the tension of the thread as its size varies produces golf balls of uniform playing properties, and reduces the likelihood of the thread breaking during the ball winding operation.

In carrying out the present invention the thread which is being wound upon a golf ball is drawn forward by the ball under tension so that it passes over two spaced points, and the length of thread extending between these points is kept

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vibrating continuously at right angles to its length like the string of a harp. This thread will vibrate in accordance with the known physical law that for a given length and volume the natural frequency of vibration is proportional to the square root of the pounds per square inch tension. In the present case since the length remains constant the rate of thread vibration will vary with changes of the size and tension of the thread.

In carrying out the present invention the first step employs means for keeping a fixed length of the running thread vibrating at its natural frequency. A second step employs means for detecting the frequency at which the thread is vibrating at each instance. A third step employs electronic means for automatically varying the total tension applied to the thread in accordance with the variations in such frequency, to thereby keep the frequency at which the thread vibrates practically constant irrespective of size variations in the running thread.

One good practical means for keeping the running thread vibrating resides in two small jets of air disposed at right angles to each other and to the thread so that they strike the thread and cause it to revolve or vibrate in a somewhat elliptical path.

The means disclosed for continuously determining the rate at which such thread is vibrating resides in a beam of light which is positioned so that the vibrating thread will move across and interrupt this light beam, and at the opposite side of the thread from the light source is placed a light sensitive device capable of detecting the interruption of the light beam each time it is cut by the vibrating thread. In this way the beam is modulated at twice the frequency of thread vibration.

This modulated light beam is used to control electronic means which operates to increase or decrease the applied tension upon the thread in accordance with the rate at which the thread is vibrating, to thereby keep the frequency at which the thread vibrates as nearly constant as possible. By keeping this rate of vibration constant as variations in the size of the thread occur the pounds per square inch tension of the thread will be kept constant and this will produce balls of uniform density.

The various features of the method of the present invention will be more fully understood from the following description when read in connection with the accompanying drawings wherein:

Fig. 1 is an end view, with parts broken away, of a golf ball winding machine having associated therewith the tension control mechanism contemplated by 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 on a larger scale shows mechanism for vibrating the thread traveling between space points.

Fig. 5 is a sectional view taken on 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 electrical diagram of mechanism for varying the tension upon the thread when its rate of vibration changes.

The present invention may be employed to control automatically the tension of a thread,

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strand or filament that is being wound upon a spool or other package, but is particularly well adapted for use in controlling the tension of a rubber or elastic thread which is being wound. The thread tensioning mechanism contemplated by the present invention may be used upon various types of golf ball winding machines and is shown as associated with a golf ball winding machine of the general type disclosed in the Cobb Patent No. 1,270,009.

The winding machine shown in the drawings 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 to provide therebetween the opening in which the ball supporting heads 14 and 15 operate. These heads are supported and rotated by axially aligned shafts 16 that are mounted for limited longitudinal movement to facilitate the introduction of a ball B between the heads and an 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 said longitudinal axis. The ball is actually supported by the discs 17 provided upon the heads 14 and 15 and 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 said patent.

In the construction shown a cabinet 18 adapted to support or house the thread tension means is secured in front of the golf ball winding machine. The rubber thread T is supplied to the golf ball B under tension from a spool 19 supported in front of the cabinet 18, as will be apparent from Fig. 1. This thread is led upwardly from a supply spool 19 to and around a thread tension drum 20 and then upwardly over a first grooved wheel 21, where it travels horizontally to a second grooved wheel 22 to pass downwardly therefrom in an inclined direction to the ball B.

The parts 19 to 22 inclusive are shown in the drawings as supported by the metal cabinet 18 which is rigidly secured in front of the winding machine casing 10 and serves to house electrical and mechanical apparatus to be described.

The thread spool 19 is supported by a bracket 23 attached to the front of the cabinet 18 and having the spaced laterally extending arms 24 which rotatably support the spool 19 and also support the roller 25 about which the thread T passes before it travels upwardly to the drum 20. The bracket 23 preferably has pivotally secured thereto a weight 26 adapter to rest upon a flange of the spool 19 to apply an initial tension to the thread T and prevent the spool from over-running when the winding machine is stopped.

The thread tensioning drum 20 is shown as supported by spaced brackets 27 secured to the front of the cabinet 18 and adapted rotably to support the shaft 28 to which the drum 20 is rigidly secured. This shaft also has rigidly secured thereto a brake drum 29 which is engaged by the brake band 30. One end of this band is anchored to a pin 31 secured to the bracket 27 and the other end has secured thereto a spring 32, turn buckle 33 and threaded bolt 34. This bolt extends into the cabinet 18 and through a hole in the block 35 and has mounted on its protruding end a threaded pulley 36. The arrange-

ment is such that rotation of this pulley in one direction will tighten the brake band 30 about its drum 29 and rotation of this pulley in the opposite direction will lessen the tension upon this brake band. The cabinet 18 has mounted upon its upper end the boxes 37 that are spaced from each other to provide an opening in which there is mounted a horizontally extending beam 38 adapted rotatably to support at its opposite end the grooved wheels 21 and 22.

It will be understood from the mechanism so far described that when the golf ball winding machine is operated by driving the heads 14 and 15 to rotate the ball B the thread T will be unwound from the spool 19 to pass around the roller 25 and then upwardly to the drum 20 about which it is looped one or more times, and then passes over the spaced grooved wheels 21 and 22 and to the golf ball. It will also be understood that the amount of tension placed upon this thread can be controlled by rotating the threaded pulley 36 to thereby control the tension of the brake band 30. Rotation of the pulley 36 is secured in the construction shown by looping around this pulley several times a fine wire 39 so that one end portion of this wire extends laterally and then downwardly about a grooved pulley 40, and the other end portion extends laterally in the opposite direction and then downwardly about the grooved pulley 41. The arrangement is such that a downward pull upon one end of this wire will rotate the pulley 36 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 39 and for operating this wire to rotate the pulley 36 and thereby control the tension of the thread T comprises the solenoids 42 and 43 mounted within the cabinet 18. One of these solenoids has mounted therein the sliding iron core 44 secured to one end of the wire 39 and the other solenoid has the core 45 secured to the other end of this wire. Both solenoids are made relatively long so that each core may travel a substantial distance within its solenoid under the influence of the magnetic field produced by the solenoid, to thereby turn the threaded pulley 36 through a sufficient number of revolutions to control the tension upon the brake band 30 throughout the desired range. The cores 44 and 45 extend downwardly a substantial distance beyond the lower ends of their respective solenoids to enter the dash pots 46 containing a liquid, or a gas such as air, to act upon the disc 47 at the lower end of each core to prevent these cores from moving too rapidly. The arrangement is such that the weight of these cores will keep the wire 39 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 29.

In carrying out the method of the present invention that portion of the thread T which is advancing between the spaced rollers 21, 22 is caused to vibrate at its natural frequency, and means is provided for automatically detecting the rate at which this thread is vibrating, and also for automatically controlling the tension upon the thread T so as to keep its frequency of vibration practically constant as variations in the size of the thread occur. The solenoids 42 and 43 and associated mechanism above described

will automatically control the tension upon the thread T provided the operating current supplied to these solenoids is properly controlled. The length of the thread T extending between the spaced rollers 21, 22 is conveniently kept vibrating by pipes 48 and 49 disposed at right angles to each other as shown in Fig. 4 and adapted to direct jets of air against the tensioned thread so that the jet of air from the pipe 48 will force the stretched thread upwardly, whereupon the jet from the pipe 49 will force the thread laterally slightly out of the path of the jet 48 so that the thread may vibrate more easily in a downward direction. In this manner the thread is kept vibrating by revolving in a somewhat elliptical path.

In order to determine the rate at which the thread is vibrating without disturbing its vibrating operation a beam of light is employed which is so disposed that the vibrating thread will interrupt this beam upon each up and down stroke of its vibration.

This is accomplished in the construction shown by mounting above the cabinet 18 in one of the boxes 37 an electric light 50 which preferably contains a single straight line filament, and mounted within this same box half way between the vibrating rubber thread T and light 50 a lens 51 positioned so that the image of the filament 50 will fall upon the thread when the latter occupies a mid stroke straight line position. The effect of this is to cause the thread T to interrupt the beam of light on each up and down stroke of its vibration, and at the instant such light beam is interrupted it will fail to fall upon the phototube 52 mounted in the other box 37 at the opposite side of the thread from the light 50. The construction of the boxes 37 is such that all external light is excluded therefrom except the small amount that may enter through small holes formed in the adjacent vertical walls of these boxes to clear the light beam.

The light 50 may be supplied with an operating current from any suitable source. The phototube 52 is included in the electric circuit shown in Fig. 7 wherein there is illustrated an electrical assembly diagram that is formed of the three separate diagrams marked A, B and C. The operation of this electrical apparatus will now be described.

The light falling on the photo-tube 52 will be interrupted at twice the frequency of the thread vibration. This will cause a varying current through this tube, and hence a varying voltage drop across the resistor 53 is generated. This varying voltage, which may be called the signal voltage, is applied through the blocking condenser 54, and across the grid resistor 55, to the grid of the triode 56.

It will be noted that diagram A employs the three stage transformer coupled amplifier using the triodes 56, 57 and 58. The purpose in providing this construction is to amplify the signal voltage and provide sufficient power to operate the remainder of the apparatus. Also this three stage amplifier is designed to change the signal voltage into a sinusoidal form. This is accomplished sufficiently well, for applicant's purpose, by the use of unbypassed cathode resistors 59, 60 and 61 and transformers 62, 63 and 64 in the plate circuits. In the case of the first stage which employs the triode 56, the effect is enhanced by the use of the additional resistor 65 in the cathode circuits. The resistor 66 and condenser 67 are used in order to maintain the proper grid bias.

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The detector circuit is shown in diagram B, wherein by employing the transformers 68 and 69 the amplified and modified signal voltage is applied to the plates of the triodes 70 and 71 respectively. The polarities of these triodes are such that the phase difference between the voltages applied is 180°.

The transformer 72 of this diagram B feeds the signal voltage to the grids of the triodes 70 and 71. A condenser 73 is provided to shift the phase 90°. In order to accomplish this its impedance at the operating frequencies is made large compared to the impedance of the resonant circuit 74 which includes the coil 75 and condenser 76. It is important to understand that the circuit 74 has a selected or established resonance frequency, such as 1000 vibrations per second, built into the circuit. Thus, if the frequency of the signal voltage is equal to the selected resonance frequency of the circuit 74 the voltage applied to the grids 70 and 71 will be 90° out of phase with the signal voltage. At the selected resonance frequency, there will be no phase shift across the resonant circuit 74. Under these conditions, the plate voltage of one tube will lead the voltage upon the grid by 90° while the plate voltage of the other tube will lag the grid voltage by 90°. The magnitude of the grid voltage is made so large that the voltage at the grid is essentially either negative beyond the cut-off value or else slightly positive. The resistors 77 and 78 serve to keep the positive values small. Therefore, if the frequency of the signal voltage is equal to the resonant frequency of circuit 74, the average current through 70 and 71 will be equal to each other. It will be understood that the actual magnitude of the grid voltage, provided it is made large enough, will not materially affect the results.

If in this diagram B the signal frequency is larger or smaller than the resonance frequency of the circuit 74 the phase across such circuit will change in one direction or the other, so that the grid voltage will get more into phase with the plate voltage of one tube and more out of phase with the plate voltage of the other tube. Thus the average current through one of these tubes will increase and that through the other will decrease. The voltage drop across resistors 79 and 80 will, as a result, be correspondingly different, it being understood that the effect of changes in the magnitude of the grid voltage is negligible. A condenser 81 serves to keep the detecting circuit at ground potential as far as alternating currents are concerned.

Resistors 82 and 83 of Diagram C are employed so that whatever difference in voltage is developed across resistors 79 and 80 it will be applied in an equal, though opposite in sign, manner to the grids of the beam power tetrodes 84 and 85. Resistors 86 and 87, and condensers 88 and 89 comprise the filter network that prevents voltage variations at the frequency of the signal voltage from reaching the grids of tetrodes 84 and 85, while at the same time they still permit corrections to take place in a small fraction of a second. Resistor 90 is a cathode bias resistor for tetrodes 84 and 85.

As long as the voltages of the grids of tetrodes 84 and 85 are equal, which is the case when the signal frequency is the same as a resonant frequency of circuit 74 or when there is no signal voltage at all, the plate currents of tetrodes 84 and 85 and hence the pulls on the movable iron cores 44 and 45 in the solenoids 42 and 43 will be equal. If the signal frequency is different

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from the resonant frequency, the grid voltages on the tetrodes 84 and 85 will not be equal, and the pull on the iron cores 44 and 45 will not be the same. Under these conditions the cores will move in such a way as to adjust the tension on the thread T so as to cause it to vibrate at the selected frequency, and thereby produce the desired pounds per square inch tension in the thread. It will be understood that the movement of the iron cores takes place until the desired pounds per square inch tension is obtained. When the pulls exerted by the solenoids on the cores are equal no motion will take place.

The resistors 53 and 55, where the signal voltage is slight, may be of the order of one or two megohms, and as the signal voltage is built up as it advances to diagrams B and C resistors of greater current carrying capacity will be used. The electrical or electronic mechanism of Fig. 7 may be housed in the metal cabinet 18 and the grounds shown in Fig. 7 may be formed by grounding these points to this metal cabinet. Operating current is supplied to the diagrams A, B and C at the points indicated.

The relationship between the frequency of thread vibration and pounds per square inch tension is shown by the following formula:

$$f = k \frac{1}{L} \sqrt{\frac{T}{M}}$$

where

f=frequency

k=constant

L=length between fixed points

T=tension (total)

M=mass per unit length

But

$$M = Ad$$

where

A=cross-sectional area of thread

d=volume density

Substituting in the first formula above

$$f = k \frac{1}{L} \sqrt{\frac{T}{Ad}} \quad \text{or} \quad f = k \frac{1}{L} \sqrt{\frac{S}{d}}$$

where

S=pounds per square inch tension

Stating this in words we have, for a given distance L and a given volume density d the natural frequency of vibration is proportional to the square root of the pounds per square inch tension. Applying this information to the problem at hand is found that a selected number of thread vibrations per second will produce a ball of a particular density. The apparatus disclosed operates to change the thread tension as necessary to keep its rate of vibration constant.

The present method makes permissible variations in the size of the rubber thread being wound on a golf ball through a range of 25% or more, since such variations in the size of the running thread will not vary the density of the wound ball, and by securing uniform density all balls of a particular grade will play the same.

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

1. The method of controlling the tension of a thread, which consists in advancing the thread under tension past two fixed points and vibrating the portion of the thread traveling between these points at its natural frequency, automatically detecting the rate of thread vibration, and

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automatically varying the tension upon the thread so as to keep its frequency of vibration practically constant as variations in the size of the thread occur, to thereby keep the pounds per square inch tension of the thread constant.

2. The method of controlling the tension of a thread, which consists in advancing the thread under tension past two fixed points and vibrating the portion of the thread traveling between these points at its natural frequency, electrically detecting the rate of thread vibration, and automatically varying the tension upon the thread so as to keep its frequency of vibration practically constant as variations in the size of the thread occur, to thereby keep the pounds per square inch tension of the thread constant.

3. The method of controlling the tension of a thread, which consists in advancing the thread under tension past two fixed points, vibrating by means of air the portion of the thread traveling between these points at its natural frequency, automatically detecting the rate of thread vibration, and automatically varying the tension upon the thread so as to keep its frequency of vibration practically constant as variations in the size of the thread occur, to thereby keep the pounds per square inch tension of the thread constant.

4. The method of controlling the tension of a thread, which consists in advancing the thread under tension past two fixed points and vibrating the portion of the thread traveling between these points at its natural frequency, producing an electrical signal frequency that bears a definite relation to the frequency of thread vibration and utilizing said signal frequency to control the tension on the thread so as to keep its frequency of vibration practically constant as variations in the size of the thread occur, to thereby keep the pounds per square inch tension of the thread constant.

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5. The method of controlling the tension of a thread, which consists in advancing the thread under tension past two fixed points and vibrating the portion of the thread traveling between these points at its natural frequency, utilizing a beam of light to detect the rate of thread vibration and produce signals of a corresponding frequency, and varying the tension upon the thread in accordance with the signal frequency so as to keep the frequency of thread vibration practically constant as variations in the size of the thread occur, to thereby keep the pounds per square inch tension of the thread constant.

6. The method of controlling the tension of a thread, which consists in advancing the thread under tension past two fixed points and vibrating the portion of the thread traveling between these points at its natural frequency, automatically detecting the rate of thread vibration and producing a corresponding electrical signal, establishing a related circuit having a fixed resonant frequency, and automatically varying the thread tension to keep the signal frequency the same as that of the resonant frequency, to thereby keep the pounds per square inch tension of the thread constant.

7. The method of producing golf balls of uniform density, which consists in winding each ball with an elastic thread under tension past two fixed points, keeping the portion of the thread traveling between these points vibrating at its natural frequency, electrically detecting the rate of thread vibration and controlling by electrical means the tension upon the thread so as to keep its frequency of vibration practically constant as variations in the size of the thread occur, to thereby wind a ball so that its density is uniform although the size of the thread varies.

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