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GLASS FILAMENT TENSIONING SYSTEM

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FIG.1.

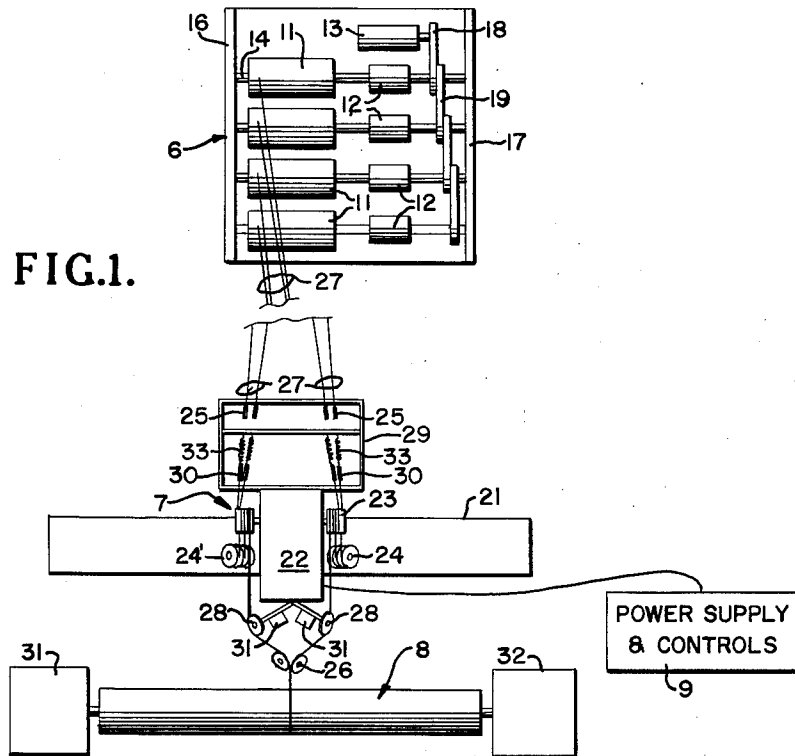
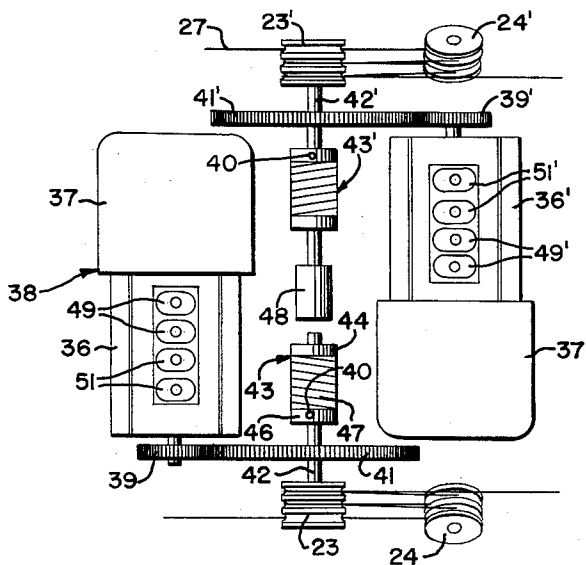


FIG.2.



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GLASS FILAMENT TENSIONING SYSTEM

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America as represented by the Secretary of the Navy
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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates generally to improvements in maintaining a constant tension on strand material and the like and more particularly to new and improved tensioning apparatus wherein an electric motor operating through a hysteresis brake produces a first coarse tension on a strand of glass filaments, and a second variable torque electric motor having the strand of glass filaments encircling the drive pulley and rotating the motor in the opposite direction of normal rotation thereby produces a fine or vernier tension on the strand of glass filaments immediately prior to its application on a rotating mandrel.

In the field of tensioning strand material, many devices both electrical and mechanical have been employed satisfactorily to produce the desired tension, however, with the increased use of strands of glass filaments wrapped upon a mandrel to produce a very strong light weight casing it has been found that the maintaining of a constant tension is of the utmost importance in order to enjoy the benefits of the high tensile strength and light weight of the glass filament material. Variations in tension in the application of the strand of glass filaments upon the mandrel produce non-uniformity in composition which creates a weakened area in the end product. The present invention overcomes this difficulty by employing a new combination of elements which cooperate together to produce a necessary constant tension which is required in the utilization of the strands of glass filaments.

The present invention utilizes an electric motor connected through a hysteresis brake and driven in the opposite direction from that necessary to unwind the strand of glass filaments and produces a first fairly constant tension. This tension is subsequently further controlled by passing this strand under tension over a drive pulley of a two-phase electric motor which is rotated in the opposite direction of its normal rotation to obtain benefit of the nearly linear torque curve obtainable thereby and from thence is put on the mandrel. As a result the tension of the strand applied to the mandrel is more constant than heretofore obtainable.

An object of the present invention is to produce a more uniform and constant tension on the glass filament strands which are wrapped upon a mandrel.

Another object of the present invention is to produce a stronger and lighter end product which is obtained by the use of better quality control in the tensioning of the strands of glass filaments.

A further object of the invention is to be able to vary and control the tension of the strands of glass filaments over a wide range of values.

A still further object of the invention is to place the vernier tension control close to the working area and thereby reduce some of the variations in the tension of the strand material.

Yet another object of the invention is to provide both a coarse and a vernier tension control for each strand of glass filaments and thereby dampen any oscillatory and sudden surges in the tension of the strand material.

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Another object of the present invention is to provide a brake for the vernier tension motor so that entanglement among the various strands upon the breakage of an individual strand is eliminated.

Another object of the present invention is to utilize the reverse linear torque characteristics of a motor being rotated in the direction opposite of normal rotation and thereby eliminate the effects of the non-linearity of the curve when the motor is rotated in a normal direction.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the figures thereof and wherein:

FIG. 1 is a schematic view of a preferred embodiment of the invention as viewed by looking down at the top of the invention; and

FIG. 2 is an enlarged top view of the carriage mounted tensioning system of the present invention.

Referring now to FIG. 1 there is generally shown the spool holder 6 holding a plurality of spools of glass strand material which are then connected to carriage mounted tensioning system 7 and from thence to the mandrel generally shown at 8. The power supplying controls generally shown at 9 provide the electrical energy and the control for the carriage mounted tensioning system. The spool holder 6 contains a plurality of spools 11 mounted on shafts 14 and maintained under constant tension by the hysteresis brakes 12 which are driven by electrical motor 13. The shafts 14 are suitably mounted in mounting means 16 and 17 and permit the free rotation for the spools 11, the hysteresis brakes 12 and the shafts 14. The electrical motor 13 is connected to the shafts 14 by means of a plurality of pulleys 18, and drive belts 19. Each spool 11 has up to several thousand yards of glass roving or strand material wrapped upon it. This glass roving is made up of a plurality of glass filaments up to several hundred which are combined to form a strand which is utilized in the production of an end product as will be described later. The hysteresis brakes 12 are of standard commercial construction. The hysteresis brakes 12 are a means to convert a continuous rotational motion on one side of the brake to a shaft on the other side of the brake while maintaining the shaft under a constant tension and in operation it acts as a slip clutch. The tension is maintained by the inner action of the magnetic field present in the brake due to the permanent magnets within the brake and a tensioning means is available to vary the tension within a certain range. Generally the tension is varied by varying the air space through which the magnetic lines of force produced by the permanent magnet must pass in order to complete a path. The glass strands of the spools 11 are unwound in one direction and the electric motor 13 tends to drive the spools in the opposite direction from that in which they are unwound. The hysteresis brakes 12 convert this constant rotation produced by electric motor 13 into a constant tension on the spools and the roving or strands emanating from the spools so that a nearly constant tension is always present on the strands when the strands are connected to the other parts of the apparatus of this invention, as will be described later.

Still referring to FIG. 1, the strands of glass filaments or roving 27 from the spools 11 lead to the resin pot or bath 29, wherein the strands of glass filaments are covered and saturated with a suitable resin bonding substance. Suitable pulleys guide the strands into the resin pot 29, and other suitable guide means (not shown) within the resin bath guide the strands through the resin bath. Upon emerging from the resin bath the strands pass over

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pulleys 30. Attached to each pulley 30 is a coiled spring 33 which helps maintain the coarse tension on the strands 27. The coiled springs 33 are required since in some winding operations the strands 27 actually move in the reverse direction of the normal movement and the hysteresis brakes 12 do not overcome the inertia of the spools 11 as rapidly as required in order to always maintain the proper tension on the strands 27. This requirement for constant tension will be more fully explained in relation to the drive pulleys 23. The position of the resin bath 29 between the coarse tension produced by the hysteresis brakes 12 and the vernier tension of tensioning system 22 allows the resin to coat and more completely impregnate the strands 27 since the tension is less at this point than it would be after tensioning system 22. From the pulleys 30 the strands lead to the carriage mounting tensioning system generally shown at 7. The tensioning system generally shown at 22 is mounted on a carriage which allows the tensioning system 22 to reciprocate back and forth along the carriage 21 by means of a suitable drive (not shown). In some applications the carriage 21 remains stationary and the mandrel performs the necessary movement to obtain the proper lay of the strands on the mandrel. Details of the tensioning system 22 will be described later in connection with FIG. 2. The roving or strands 27 emanating from the spools 11 pass over a drive pulley 23 and from thence to the idler pulley 24 and back again to the drive pulley and through the idler pulley and back to the drive pulley and from thence they go to a pulley 28 which has a strain gage tension measuring system 31 mounted thereon. From thence they go through guide pulleys 26 which are attached to the tensioning system 22 and the strands 27 then pass immediately to the mandrel shown generally at 8. The drive pulley 23 tends to rotate in an opposite direction from the direction in which the glass filament strands 27 are normally moving. The drive pulleys are driven by a two-phase electric motor as will be described in connection with FIG. 2. The plane which is normal to the axis of the drive pulley 23 forms an acute angle with the plane which is normal to the axis of the idler pulley 24, if they were extended to intersect. The purpose of this idler pulley is to guide the strand from the drive pulley so that the strand upon returning from the idler pulley to the drive pulley does not become entwined with the oncoming glass filament strand from the roving spools 11. A further purpose of the combination of drive pulley and idler pulley is to allow the strand 27 to be in contact with more area of the drive pulley to obtain a more constant tension on the strand. The pulley 24 being at a slight angle to pulley 23 allows the strand 27 to follow a predetermined path across the pulleys 23 and 24. The tension produced by the cooperation of the spool holder 6 and the hysteresis brake 12 together with the tension applied by the tensioning system 22 is measured by a suitable strain gage 31 which measures the tension of the strands 27 by determining the amount of flexure within the supporting structure for the pulley 23. A suitable strain gage means 31 may be of the well known type which is elongated or compressed in response to the flexure of the supporting member. This type of a strain gage is old and well known in the art. The strain gage is normally placed in a Wheatstone bridge type arrangement wherein the strain gage forms one leg of the bridge. The output of the bridge may be used to drive a recorder means or may be used to give the operator a visual indication of the amount of tension on the roving or strands 27. The guide pulleys 26 which are attached to the tensioning system 22 serve to guide the strand down onto the mandrel 8. The mandrel 8 is preformed to the desired shape of the end product placed between the mandrel drive motor 31 and the tailstock 32. The mandrel drive motor rotates the mandrel in a direction so that the roving is wrapped upon the preformed mandrel 8. Mandrel drive motor 31, the mandrel 8 and the tailstock

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32 have the appearance of a lathe. In a similar manner the carriage mounted tensioning system 22 is synchronized or driven by suitable drive gear means from the mandrel motor 31 in a well known manner such as that utilized in coordinating the carriage movement of the lathe with the rotation of the piece worked upon.

Also shown in FIG. 1 is a power supply and controls 9 which supply the necessary power and control for the tensioning system 22. The power supply supplies a two-phase voltage which is necessary to drive the motor contained in the tensioning system 22 as will be described later in conjunction with FIG. 2. This power supply can be a motor generator or any well known system or converting three-phase power to two-phase power. The controls are means placed in each of the two phases of the power supply and consist of means to regulate the magnitude of the voltage such as by suitable resistors. Since there are two phases, two such resistors are required and a third control allows the regulation of the phase angle between the two phases such as by well known means as inductors, capacitors, or an impedance dividing network placed between the two phases.

FIG. 2 is an expanded top view of the contents of the tensioning system 22 of FIG. 1. The two-phase A.C. control motor 33 contains a blower 37 which supplies a constant flow of cooling air to the servo-control motor 36. The blower 37 is necessary to insure that the servo motor 36 will not become overheated due to the fact that the servo motor is generally being rotated in a direction opposite of normal rotation. Connected to the shaft output of the servo motor 36 are two spur gears 39 and 41 which transmit the power of the servo motor to the shaft 42 which has the main drive pulley 23 and a one-way mechanical clutch 43 mounted thereon. The one-way mechanical clutch 43 has two face plates, face plate 44 which is connected to the stationary portion of the carriage and face plate 46 which is connected to the drive shaft 42 by a suitable screw 40 with a coiled spring 47 inserted therebetween. The coiled spring 47 allows rotation in one direction and prevents rotation in the other direction. The servo motor 36 normally under its own power tends to drive the shaft 42 in the direction which is prohibited by the one-way clutch 43 while the roving 27, FIG. 1, encircles the drive pulley 23 and the idler pulley 24 in such a manner as to turn the drive pulley 23 and its associated shaft and one-way clutch 43 in the direction that is permitted by the one-way clutch. In some applications the one-way clutch 43 is not desired since the roving 27 will of necessity have a retrograde or reverse movement from that which is normal. In those applications the screw 40 is loosened or removed to disengage the one-way clutch 43 from the shaft 42. One such example is in the winding of a generally cylindrical shaped form in which the end is rounded and in which the radius of curvature changes rapidly so that the rapid change of radius plus the movement of the carriage causes a slack in the roving 27. As stated earlier the hysteresis brakes 12 do not always respond as quickly as necessary and the coiled springs 33 absorb this slack so that the tension produced by the hysteresis brakes 12 is constantly maintained on the drive pulley 23 thereby insuring the constant tension on strands 27 is maintained even in these cases in which the roving 27 moves in the opposite direction of its normal movement. FIG. 2 also shows a second two-phase A.C. control motor with the associated parts and are generally denoted by the primes of the number of the reference numerals and indicate like parts of the first portion. The shafts 42 and 42' have a suitable coupling 43 placed between them so that if it be desirable to have one motor drive two drive pulleys or to have two motors drive one drive pulley this may be accomplished by connecting the coupling 43 to both the shafts 42 and 42'. The drive pulley 23 and the idler pulley 24 are shown with different rotational axes and as described in relation to FIG. 1 the idler pulley co-

operates with the strand emanating or passing over the drive pulley 23 to guide the strand along a predetermined path across both the guide pulley and the idler pulley. The four terminals, designated as 49 and 51, are the input power connections from the power supply and controls 9, FIG. 1. One phase, such as illustrated by terminals 49, is generally maintained at a constant reference voltage and the second phase, illustrated by input terminals 51, is varied by the controls on the power supply and controls 9, FIG. 1, to obtain the proper tension as desired on the drive pulley 23.

Referring again to FIG. 1 the motor 13 by its constant rotation of the hysteresis brakes 12 produces a predetermined tension, according to the variable settings on the hysteresis brakes 12, which holds or maintains the roving or strands 27 under a certain predetermined tension since the motor tends to rotate the spools 11 in the opposite direction from that which they are unwound by the mandrel 8. This is known as a coarse tension adjusting means produced by hysteresis brake. The fine tensioning adjustment or vernier adjustment on the roving or strands is produced by the tensioning system 22 driving the drive pulley and the idler pulley 24 in the opposite direction from that in which the strand 27 is being pulled through the pulley by the rotating mandrel 8, which tension is measured by strain gage 31. Resin is deposited on the strand before the strand is applied to the tensioning system 22. The vernier tension produced by the tensioning system 22 is maintained, monitored and controlled by an operator through the power supply and controls 9 and thus the resultant tension on the strands 27 as they are applied to the mandrel is a summation of the tension produced due to the hysteresis brakes 12 and the two-phase motors driving the drive pulley 23 within the tensioning system 22. After the preformed mandrel has been completely wound it is removed and properly cured by well known methods to obtain the completed end product. Although only two tensioning drive pulleys 23 and 23' are shown in conjunction with tensioning system 22 any suitable number may be employed by merely duplicating the parts and placing them one on top of the other and similarly the number of spools 11 may be increased or decreased according to the needs of the specific end product. As shown in the FIG. 1 one strand may be controlled by joining two tension motors by the coupling 48, FIG. 2, or as many as four strands may be controlled by tensioning two strands simultaneously one set of drive pulley 23 and idler pulley 24. Upon the breakage of a tension strand 27 between the drive pulley and the mandrel 8, FIG. 1, the one-way clutch 43, FIG. 2, prevents the servo motor from rotating and entangling the broken strand among the various pulleys and spools. By the novel combination of the tensioning systems of this invention a more accurate reliable and constant tension is produced on the individual strands as they are applied to the mandrel and thereby resulting in a stronger end product having a greater tensile strength than was normally heretofore attainable.

It should be understood, of course, that the foregoing disclosure relates to only a preferred embodiment of the invention and that numerous modifications or alterations may be made therein without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. Apparatus for applying uniform tension to roving of glass filaments upon a winding machine comprising, in combination,

- (a) a first dynamic coarse tensioning means having,
 - (1) at least one spool having roving of glass filaments wound in one direction thereon,
 - (2) an electric motor means,

- (3) and a magnetic hysteresis brake means having a driving shaft connected to each spool and a driven shaft connected to said motor means for converting a torque output of said motor means and applying to the driving shaft a uniform predetermined torque in the direction necessary for winding the roving on said spool,
- (b) a winding machine having,
 - (1) a mandrel,
 - (2) rotating means connected to said mandrel for rotating said mandrel about its longitudinal axis in a predetermined direction,
 - (3) and a carriage mounted on said winding machine,
- (c) a carriage mounted dynamic vernier tensioning means having,
 - (1) at least one variable torque electrical driving motor,
 - (2) a drive pulley connected to said driving motor,
 - (3) and an idler pulley, forming a first plane perpendicular to a shaft connected to said idler pulley, mounted in close proximity to said drive pulley, said drive pulley forming a second plane perpendicular to a shaft connected to said drive pulley, the first and second planes upon extension intersect to form an acute angle for prescribing a predetermined path for the roving emanating from said spool to said mandrel and partially encircling said drive pulley and said idler pulley to rotate said drive pulley in a direction opposite the normal direction of rotation by said driving motor for substantially reducing variations in tension on the roving emanating from said coarse tensioning means and for maintaining a relatively constant tension on the roving as applied to said mandrel,
 - (d) and a resin impregnating means positioned in the path of roving from said spool to said drive and said idler pulleys for coating and impregnating the roving with a resinous material,
 - (e) whereby constant tension is maintained on the roving being wound on the mandrel by the coaction of the coarse and vernier tensioning means.
2. Apparatus as recited in claim 1 wherein a one-way mechanical clutch is connected to said drive pulley and the carriage for permitting rotation of the drive pulley in the direction of the roving being drawn onto the mandrel and for preventing rotation of the drive pulley in the direction determined by the normal rotation of the driving motor.
3. Apparatus as recited in claim 1 wherein a tension measuring strain gage is positioned in the path of the roving between the drive pulley and the mandrel.
4. Apparatus as recited in claim 1 wherein a spring means is positioned between said spool of roving and said drive pulley for maintaining tension on the roving by absorbing slack in the roving when the roving is moving in the direction opposite to the normal direction utilized in applying roving to said mandrel.

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