Jan. 16, 1968 J. L. McLARTY 3,363,849

FILAMENT WINDING APPARATUS

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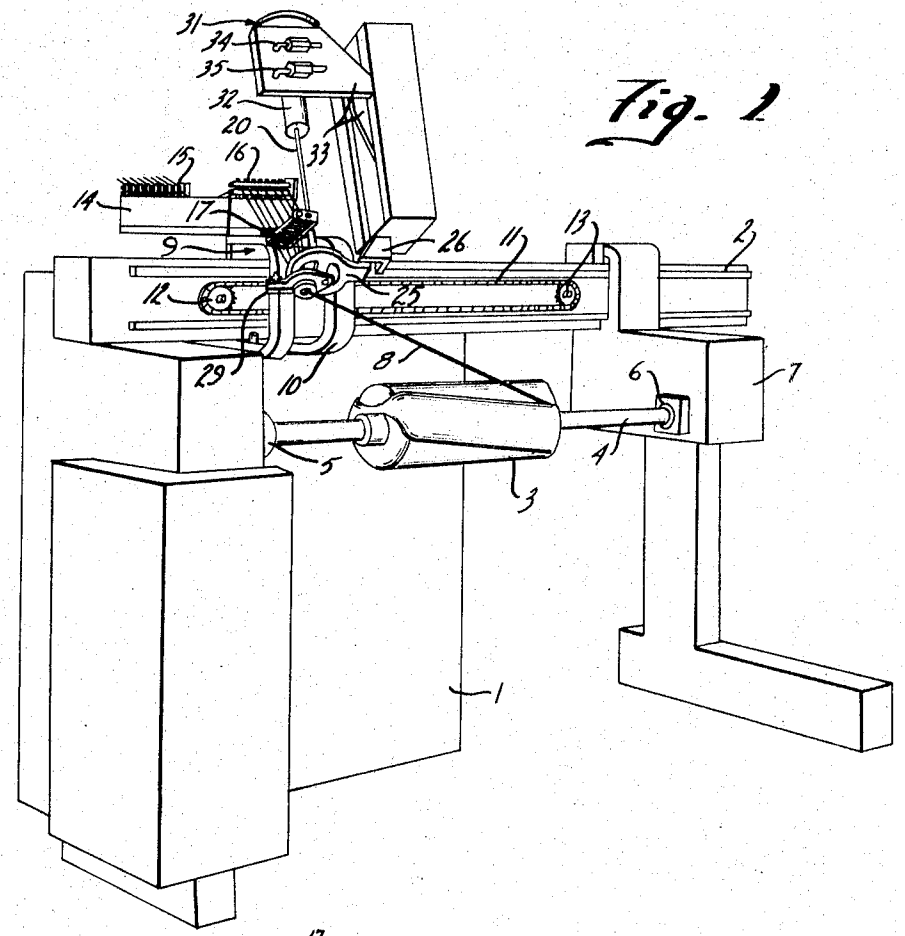


Fig. 1

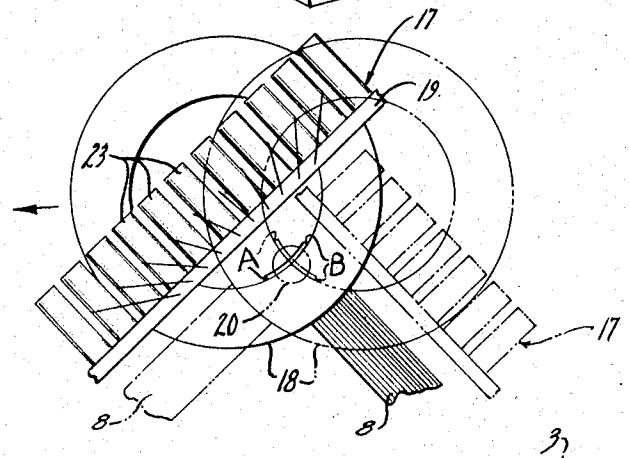
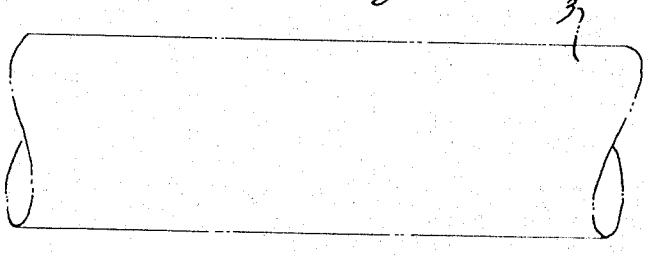


Fig. 4



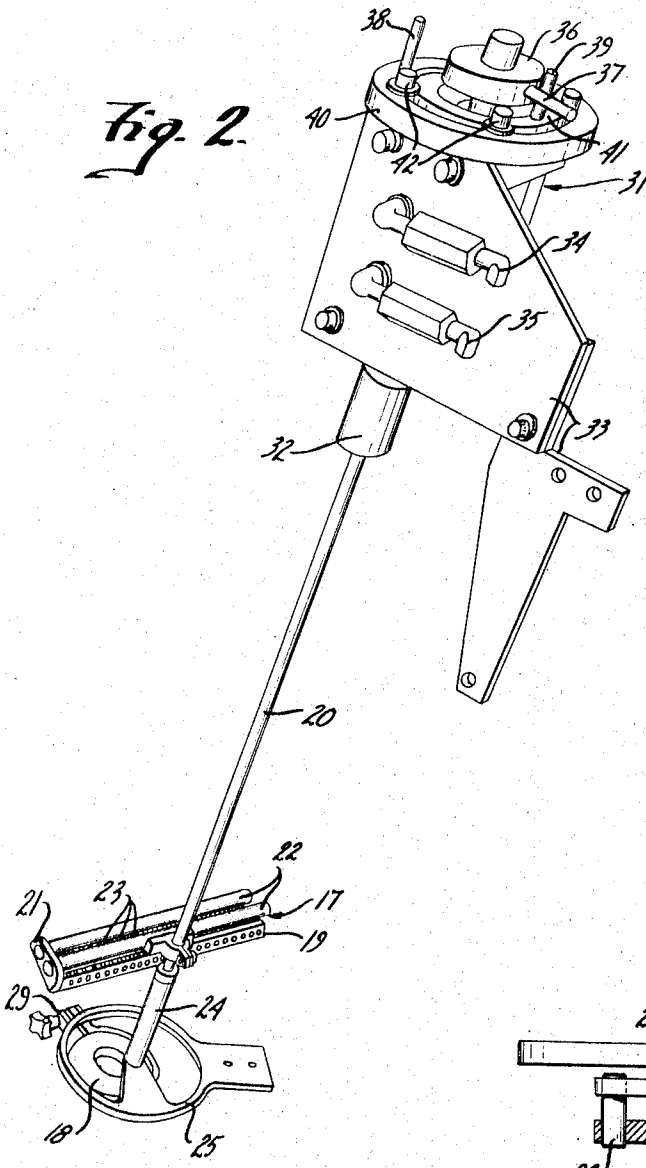
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Fig. 2.



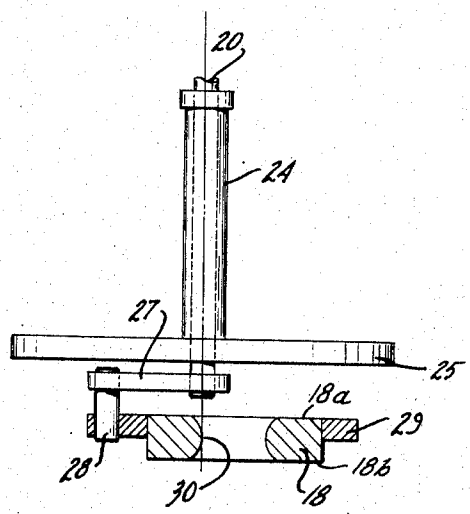


Fig. 3.

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FILAMENT WINDING APPARATUS

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5 Claims. (Cl. 242—7)

This invention relates to a filament winding apparatus and more particularly to a guide mechanism for guiding a strand of reinforcing material onto a rotating mandrel.

Fiber reinforced resin articles are fabricated by winding a strand of reinforcing material in a generally helical pattern in a number of superimposed layers on a rotating mandrel. The strand is guided onto the mandrel by a guide mechanism carried by a carriage which reciprocates along the length of the mandrel. In many cases, the guide mechanism includes a yoke or eye which serves to gather the individual fiber ends into a strand or band of substantial width and guide the strand onto the rotating mandrel. The guide surface of the yoke is generally curved and as the carriage moves in one direction, the strand trails off the curved support surface. When the carriage reverses its travel, the strand slides across the guide surface and trails off a second portion of the guide surface.

Because of this slippage of the strand across the guide surface, the drive mechanism in the conventional filament winding machine must be accurately programmed to prevent twisting of the strand and insure that each convolution or helical winding of the strand is in precise side-by-side relation. The programming requires accurate variation of the speed of the mandrel or the carriage at precise periods during the winding operation. Even with programming, the slippage of the strand over the guide surface is not entirely predictable and the strand at each reversal of the carriage may slip through a greater or lesser arc, depending on the viscosity of the resin, the tension on the strand, and the shape of the yoke. While this slippage and the resulting twisting or roping of the strand occurs when winding at both low and high winding angles, the result is more pronounced when winding at a low angle with a relatively wide strand. Also the width of the strand and distribution of its elements is changed undesirably because the guides do not retain their relative position with regard to the yoke.

The present invention is directed to an improved guide mechanism which eliminates slippage of the strand and prevents roping or twisting of the strand without programming of the mandrel or carriage drive and also retains the strand width and distribution of its elements at all winding angles. More specifically, the individual fiber ends pass through a guide comb to a yoke which gathers the ends into the form of a relatively wide strand. Both the guide comb and the yoke are mounted for oscillating movement about a shaft carried by the carriage. The axis of the shaft is located in alignment with the centerline or midpoint of the strand supporting surface of the yoke, so that when the yoke is pivoted through rotation of the shaft, the strand will be oscillated about the midpoint of its width.

When the carriage reaches the end point of its stroke of travel, or a position where the winding angle changes, the shaft will rotate through a predetermined arc which pivots the yoke and the strand about the midpoint of its width to thereby position the strand for the return stroke of travel of the carriage, or for a change in winding angle, maintain the strand width and distribution of elements. With this structure, the strand does not slip across the guide surface but maintains the same relative position on the guide surface during forward and

return movement of the carriage. As the strand does not slip on the guide surface, precise and accurate positioning of the strand is obtained on the mandrel without roping or twisting when winding at both high and low winding angles with a relatively wide strand.

Other objects and advantages will appear in the course of the following description.

The drawings illustrate the best mode presently contemplated of carrying out the invention.

In the drawings:

FIG. 1 is a perspective view of a filament winding apparatus employing the guide mechanism of the invention;

FIG. 2 is a fragmentary perspective view showing the rotatable guide mechanism of the invention;

FIG. 3 is an enlarged fragmentary longitudinal section of the yoke supporting mechanism; and

FIG. 4 is a transverse diagrammatic section showing the relative position of the guide comb, the guide yoke and the strand.

The drawings illustrate a filament winding apparatus which comprises a base cabinet or casing **1** and a generally horizontal beam **2** extends outwardly from the casing. A mandrel **3** is secured to a shaft **4** which is positioned generally parallel to the beam **2**. Secured to one end of shaft **4** is a spindle **5** which is operably connected to a drive mechanism located within the cabinet **1**. The other end of the shaft **4** is connected to a spindle **6** journalled within a tailstock **7** which is movable along the beam **2**.

A strand of reinforcing material **8** is guided onto the mandrel **3** by a winding head **9** supported on a carriage **10** which is mounted for reciprocating movement on the beam **2**. The strand **8** can be in the form of substantially continuous unidirectional fibers, woven fabric, braided tubing, matting, or the like. The fibrous material can be mineral fibers such as glass or asbestos; vegetable fibers such as cotton; animal fibers such as wool; synthetic fibers such as nylon, rayon or Dacron; or metal fibers such as steel wire.

To reciprocate the carriage **10** along the beam **2**, the carriage **10** is connected to an endless chain **11** which is trained over a drive sprocket **12** and an idler sprocket **13**. The connection of the carriage **10** to the chain **11** and the drive for the chain is similar to that described in the copending application, Ser. No. 401,571, filed Oct. 5, 1964, and entitled Filament Winding Apparatus.

The strand **8** is coated or impregnated with a liquid binder such as a thermosetting resin. It has been found that glass fibers impregnated with an epoxide resin formed by the reaction of epichlorohydrin and bisphenol-A, as disclosed in Patent No. 2,801,227, provides a very satisfactory material to be used in the winding operation.

The winding head **9** includes a trough **14** which contains the liquid binder or resin. The individual fiber ends pass through a guide comb **15** and then downwardly into the trough **14** where the fiber ends pass over a series of rollers, not shown, to impregnate the fibers with resin. On emerging from the trough **14** the fiber ends pass through a pair of guide combs **16** and **17** and then over an annular guide yoke **18**. Yoke **18** serves to gather the fiber ends together in the form of a relatively wide strand or band and guide the strand onto the rotating mandrel **3**.

The guide comb **17** includes a support bar **19** which is adjustably mounted on a shaft **20**. An end bar **21** is secured to one end of bar **19** and a pair of guide bars **22** extends outwardly from the end bar **2** and are generally parallel to the support bar **19**. In addition, a series of pins **23** extend outwardly in spaced relation from support bar **19** and are located beneath the bars **22**. The fiber ends travelling from the guide comb **16** pass between the guide bars **22** and then between the pins **23**.

The lower end of shaft **20** is journalled for rotation in a bushing **24** which extends upwardly from a support ring **25**. Support ring **25** is secured to the lower end of a reciprocating arm **26** which is adapted to be moved toward and away from the mandrel during predetermined periods in the winding cycle. With this connection the supporting ring **25** cannot rotate, but can move toward and away from the mandrel with the arm **26**.

The lower end of the shaft **20** is secured to one end of a link **27** and the opposite end of the link is connected by pin **28** to a split ring clamp **29**. The annular guide yoke **18** is removably attached within the clamp **29**. The guide yoke **18** is provided with an internal, generally curved or convex guide surface **30** and the strand **8** passes in a direction from end **18***a* of the yoke to end **18***b* as it moves to the mandrel. As shown in FIG. 3, an extension of the axis of shaft **20** extends tangentially of the surface **30** so that the midpoint of the width of the strand passing over surface **30** is in alignment with the axis of shaft **20**. In order to reduce the frictional resistance of the strand **8** passing over the guide surface **30**, the guide surface is usually formed of a material such as graphite, Teflon or other self-lubricating materials.

As the clamp **29** and guide yoke **18** are rigidly secured to the lower end of the shaft **20**, the yoke will rotate or pivot around the axis of the shaft in accordance with rotation of the shaft.

Shaft **20** is rotated by a conventional pneumatic motor **31** which is connected to the upper end of shaft **20** by a coupling **32**. The motor **31** is supported by a bracket assembly **33** which is connected by bolts to the arm **26** so that the motor **31** and shaft **20** will be moved toward and away from the mandrel in accordance with movement of arm **26**. Air, or other gas under pressure, is supplied to motor **31** through lines **34** and **35**.

A provision is made for adjusting the amount of rotational movement of the shaft **20**. In this regard a cap **36** is secured to the upper end of the drive shaft of motor **31** and the cap is provided with an outwardly extending pin **37** which is mounted to engage stops **38** and **39**. Engagement of the pin **37** with the stop **38** limits the rotational movement of the motor in one direction, while engagement of the pin **37** with the other stop **39** limits the rotational movement in the opposite direction.

The location of the stops **38** and **39** can be conveniently varied in order to change the degree of rotational movement of the shaft **20**. Stop **38** is mounted on an outer ring **40** while stop **39** is mounted on an inner ring **41**. The rings **40** and **41** are secured against relative rotation by a series of the tie bolts **42**. By loosening the tie bolts **42**, the rings **40** and **41** can be rotated to thereby vary or change the relative position of stops **38** and **39**.

While the drawings illustrate a pneumatic motor being employed to provide the rotational movement for the shaft **20**, it is contemplated that any other conventional mechanism can be employed to rotate the shaft **20**.

The mandrel **3**, carriage **10** and the arm **26** are driven in programmed sequence in the manner set forth in the copending application Ser. No. 401,571, filed Oct. 5, 1964, and entitled Filament Winding Apparatus. As the carriage **10** and winding head **9** move in the direction of the arrow in FIG. 4, the strand **8** will trail off from the arc AB on yoke **18**. When the carriage approaches the end point in its stroke of travel, air will be introduced through one of the lines **34** and **35** to rotate the shaft **20** and the yoke **18** to the position of the phantom lines in FIG. 4.

As the axis of the shaft **20** is in direct alignment with the surface **30** at the midpoint of the width of the portion of the strand **8** which is passing over the surface **30**, the strand **8** will be pivoted about the midpoint of its width so that the strand will not slip or move its relative position on the surface **30** during the pivotal movement. As shown in the phantom lines in FIG. 4, the strand **8** still trails off the arc AB of yoke **18** after the pivotal movement of the yoke. As the guide comb **17** is also attached to the shaft, the guide comb will also pivot or rotate with the yoke **18**.

It the vessel to be wound has curved ends or beads along with a cylindrical shell, the yoke **18** will be rotated before the carriage **10** reaches the end of its stroke of travel and will continue to be rotated for a short period after the carriage begins its return stroke. In this case the rotational movement of the yoke or guide member is programmed with the carriage movement so that the strand will be maintained relatively flat against the curved end surface of the mandrel at all times. However, if the winding pattern is such that only a cylindrical surface is being wound, the guide or yoke **18** will then be pivoted after the carriage has reached its end point of travel and before the carriage begins its return stroke.

As the strand does not slide across the supporting surface **30**, precise and accurate positioning of the strand on the mandrel is obtained without roping or twisting even when winding with a relatively wide strand at low helix angles. Moreover, as the strand pivots about the midpoint of its width and does not slide relatively to the guide surface, the guide surface need only be as wide as the strand **8** and does not have to be annular as shown in the drawings or U-shaped. It is also contemplated that the guide member shown by the yoke **18** can be a roller which will reduce the frictional resistance of the strand moving over the guide surface. With the structure of the invention the roller guide will pivot around the midpoint of its length and there will be no sliding or lateral movement of the strand with respect to the roller.

The present invention provides a predictable winding pattern in that the strand will not slide or move laterally with respect to the guide mechanism. This insures that the fibrous strand will be deposited without a change in strand width and without roping, thereby resulting in a more even distribution of fibers throughout the wall thickness of the article being wound.

While the above description has been directed to the yoke or guide being pivoted at the end points of the reciprocating stroke of travel of the carriage, it is contemplated that the yoke can be pivoted at any given point in the winding pattern, as for example, in situations where the winding angle is changed or when winding over odd contours. Similarly, the yoke or guide can be progressively pivoted during a given period of the winding cycle, or it can be pivoted quickly through its arc of travel, depending on the programming desired.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims, particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. In a filament winding apparatus, a rotatable mandrel, a carriage disposed to move in a reciprocating path of travel along the mandrel, a guide member mounted on the carriage and disposed to guide a strand onto the mandrel as the carriage moves in the reciprocating path, said guide member having a smooth strand guiding surface and including means directing said strand along a length of said surface and initially contacting said surface along a line of contact, means for pivotally mounting the guide member about an axis extending in a direction generally parallel to the direction of travel of said strand on said surface, said axis extending generally tangentially of said line of contact and located at the midpoint of said length of the surface, and means for pivoting said guide mechanism about said axis at predetermined times during the winding cycle to thereby pivot the strand about the midpoint of its width and prevent slippage of the strand along said surface.

2. In a filament winding apparatus, a rotatable mandrel, a carriage disposed to move in a reciprocating path of travel along the mandrel, a guide member mounted on the carriage and disposed to guide a strand onto the mandrel as the carriage moves in the reciprocating path, said

guide member having a strand guiding surface and having a first end and a second end located on opposite sides of the strand guiding surface, said guide member including means to direct said strand in the form of a band of greater width than thickness along said surface in substantial line contact therewith in a direction from said first end to said second end, the width of the strand extending along a length of said strand guiding surface, means for pivotally mounting the guide member about an axis extending in a direction from the first end to the second end, said axis being generally normal to said ends and extending tangentially of said surface and located approximately at the midpoint of said length of said surface, and means for pivoting said guide mechanism about said axis at predetermined times during the winding cycle to thereby pivot the strand about the midpoint of its width and prevent slippage of the strand along said surface.

3. In a filament winding apparatus, a rotatable mandrel, a carriage disposed to move in a reciprocating path of travel along the mandrel, a guide member mounted on the carriage and disposed to guide a strand onto the mandrel as the carriage moves in the reciprocating path, said guide member having a strand guiding surface and having a first end and a second end located on opposite sides of the strand guiding surface, said surface being generally convex in a first direction from said first end to said second end and the strand disposed to ride over said surface in said direction, said surface being generally concave in a second direction normal to said first direction, said guide member including means to direct said strand along a length of said surface in said second direction and in substantial line contact therewith, means for mounting said guide member for oscillating movement about an axis extending in said first direction and extending tangentially of said surface and located approximately at the midpoint of said length of said surface, and means for pivoting said guide mechanism about said axis at predetermined times during the winding cycle to thereby pivot the strand about the midpoint of its width and prevent slippage of the strand along said surface.

4. In a filament winding apparatus, a rotatable mandrel, a carriage disposed to move in a reciprocating path of travel along the mandrel, a guide member mounted on the carriage and disposed to guide a strand onto the

mandrel as the carriage moves in the reciprocating path, said guide member having a strand supporting surface and including means directing said strand in the form of a band of greater width than thickness to pass along a length of said surface and initially contacting said surface along a line of contact, a shaft connected to the guide member with the axis of the shaft extending in the direction of travel of said strand over said surface and said axis extending tangentially of said line of contact and intersecting the midpoint of said length of the strand supporting surface, drive means connected to the shaft for rotating said shaft about its axis at predetermined periods during the winding cycle, and means for limiting the degree of rotation of said shaft.

5. In a filament winding machine, a rotatable mandrel, a carriage disposed to move in a reciprocating path of travel along the mandrel, a guide ring mounted on the carriage and disposed to guide a strand onto the mandrel as the carriage moves in the reciprocating path, means for preventing movement of the guide ring with respect to the carriage in the direction of said reciprocating path, said ring having an inner annular guide surface, means associated with said guide ring for directing said strand to pass along said surface in line contact therewith, the width of the strand extending circumferentially along a portion of said surface, means for pivotally mounting the guide ring about a line extending generally parallel to the axis of said ring, said line extending tangentially of said guide surface and intersecting the mid point of the length of said portion of the surface, and means for pivoting said ring about said line at predetermined times during the winding cycle to thereby pivot the strand about the mid point of its width and prevent slippage of the strand along said guide surface.

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