Jan. 18, 1966 J. E. BALLMER 3,229,925

FIBER WINDING MACHINE

Filed June 27, 1963 2 Sheets-Sheet 1

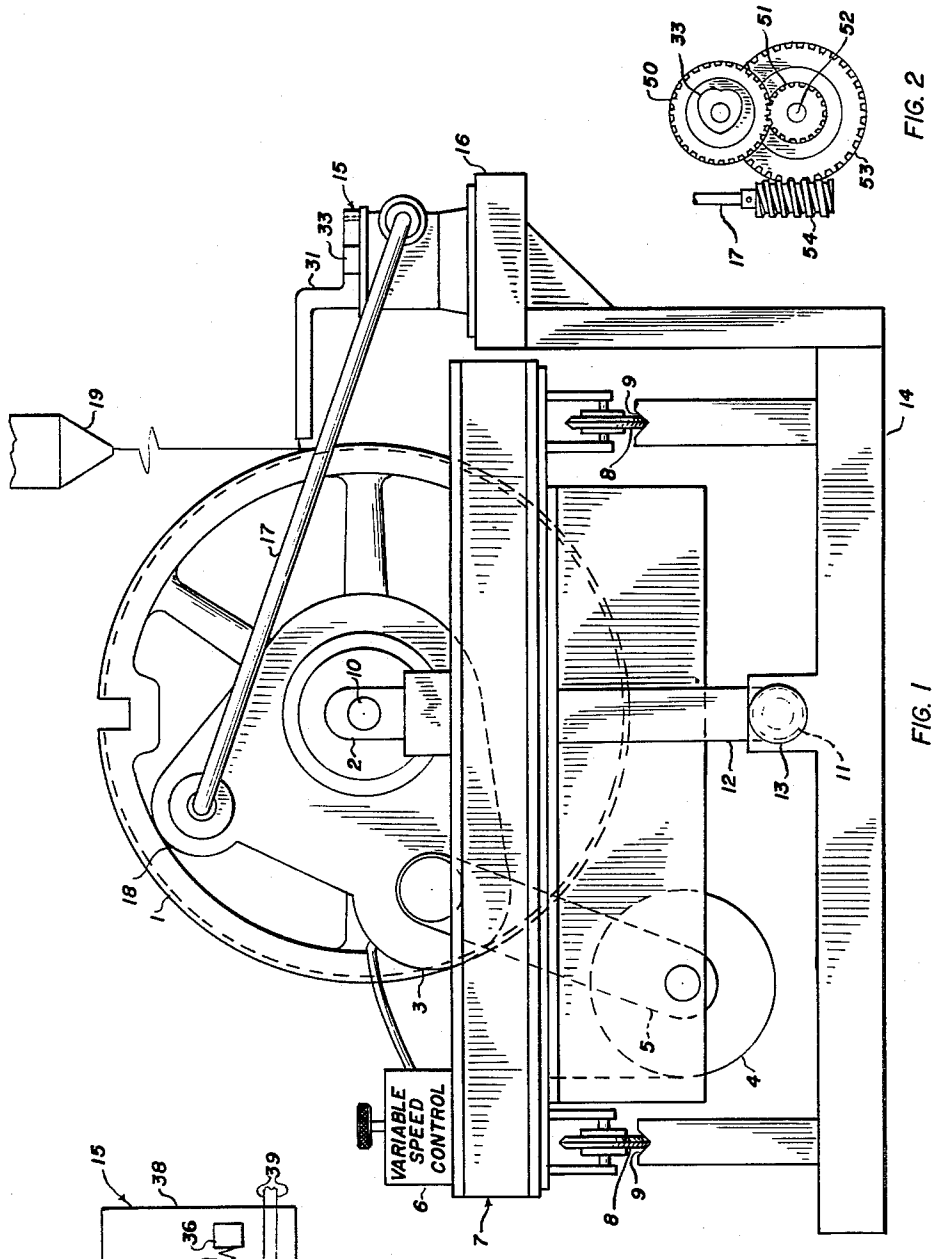


FIG. 1

FIG. 2

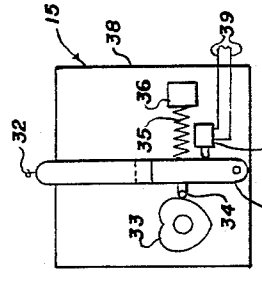


FIG. 4

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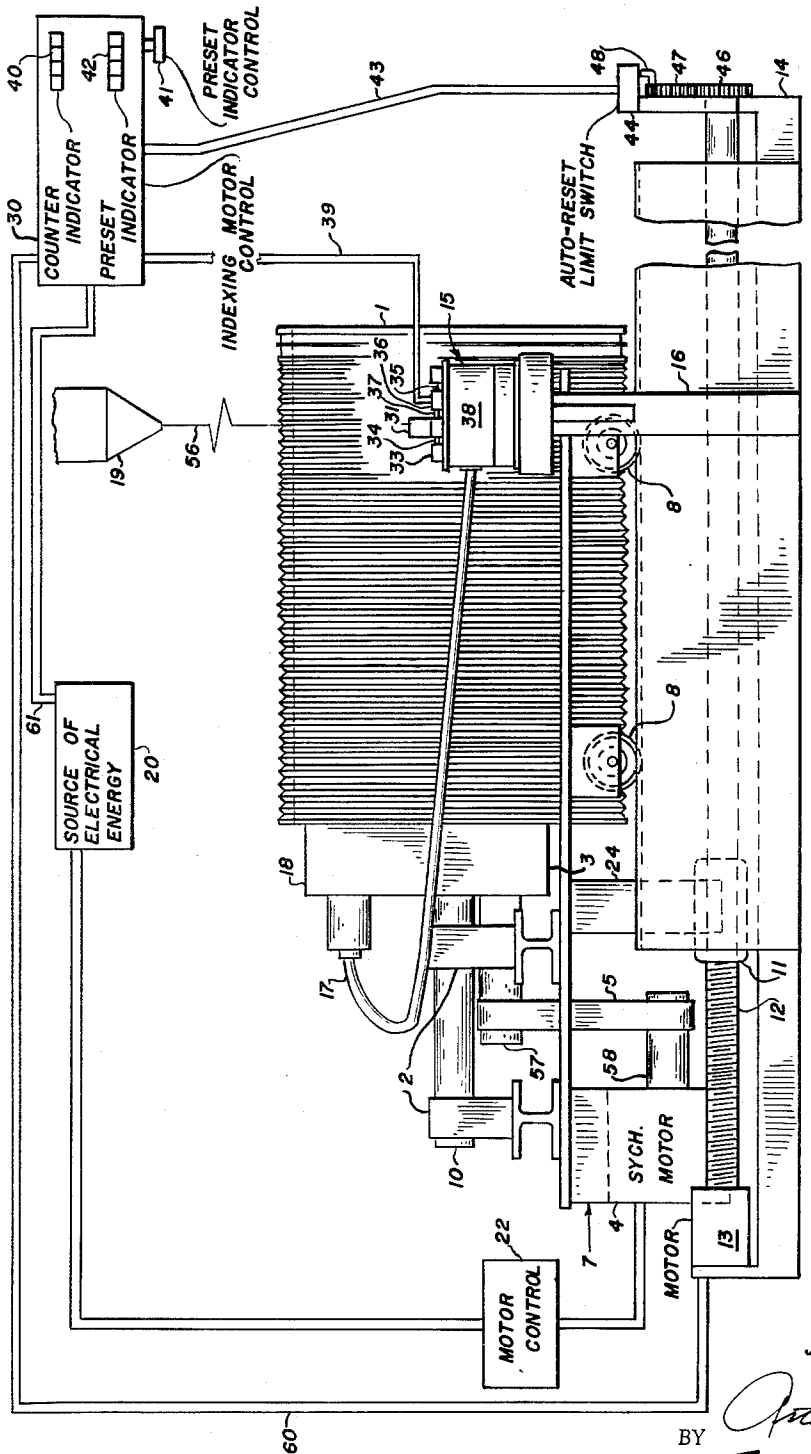


FIG. 3

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FIBER WINDING MACHINE

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This invention relates to winding of fibers and more particularly to a fiber winding apparatus.

In the manufacturing of winding fibers considerable effort is being made to increase the rate of winding the fiber bundles to reduce the unit cost per bundle. It is also necessary that the bundle be close packed to improve efficiency of light transmission.

Accordingly this invention provides for continuous winding of a fiber to provide a plurality of fiber bundles on a single drum. The device includes the necessary scanning mechanism to form each individual bundle and also the indexing mechanism to sequentially index the drum when the required number of fibers are wound in each of the plurality of grooves. Together with this mechanism is the speed changing device for controlling the speed of winding the fiber in accordance with the speed at which the fiber is supplied.

It is an object of this invention to provide a means for winding a plurality of fiber bundles in a continuous operation.

It is another object of this invention to provide a means for winding a plurality of close packed fiber bundles on a single drum from a continuous fiber.

It is a further object of this invention to provide a means for simultaneously controlling the fiber characteristics and the number of fibers in each bundle to thereby provide a plurality of fiber bundles produced in a single uninterrupted operation from an endless fiber.

It is a further object of this invention to provide a means for controlling the speed of winding of a fiber, the rate of scan of the fiber as it is laid down on the drum, and the number of fibers in each bundle on the drum during the fiber winding operation from a continuous fiber source.

The objects of this invention are accomplished by providing an infinitely variable speed winding drum, and a scanning mechanism to provide a variable scanning rate and sweep together with a counting mechanism to sequentially index the winding drum when a predetermined number of fibers are laid down in each of the plurality of bundles.

The variable speed winding drum is controlled by an infinitely variable speed transmission intermediate a synchronous motor and the winding drum. The variable transmission used might be of the conventional type manufactured which is known as a Graham variable speed transmission. By providing a synchronous motor as the source of power a constant initial speed is delivered. The variation of the transmission gives an accurate control of the speed in revolutions per minute for the winding drum. This is important because the speed of rotation of the drum is a factor in the control of certain characteristics of the fiber as the fiber is wound on the drum.

The indexing mechanism as illustrated is electrical, however, the inventor does not wish to limit the means of accomplishing this function to the specific disclosure. The indexing mechanism operates through a counter system having a preset counter to control the number of fibers wound in each bundle and the point upon which the drum indexes and winding of another bundle is initiated.

The scanning arrangement is operated through a speed reduction arrangement intermediate the synchronous motor and the scanning device. A mechanical arrangement

of the cam and cam follower is disclosed in the scanning device but the operation could also be accomplished in various ways to provide a variable amplitude of scan and rate of scan.

The indexing motor operates a switch which stops the motor when the indexing screw has moved the drum a distance equal to the center to center distance between adjacent grooves. The center to center distance between grooves would depend on the drum being used which is also interchangeable. Accordingly, the changing of the drum to a drum having different groove widths requires a change in the gear ratio operating the switch on the end of the indexing screw.

Although it is possible to wind a plurality of bundles on a single smooth drum with the machine as illustrated, the bundle is not as close packed when removed from the drum as the device shown. The 60° V slot has been proposed as the most optimum groove shape to provide the best bundle pack over a large range of numbers of fibers in each bundle. Although a semi-circular groove might provide an improved bundle pack for one specific bundle size, the flexibility in changing from different bundle sizes to provide the optimum pack would be lacking.

A transverse slot on the outer periphery of the winding drum is provided to permit the removal of the bundles in an easy manner. The bundle may be tied or clamped and then cut to easily remove the bundle from the drum. The transverse slot also provides a means to assist a fiber to changing from one groove to another subsequent to indexing of the drum by an indexing motor and indexing screw.

It will become apparent to those skilled in the art from the description and the attached drawings the advantages achieved in the fiber winding device and method as disclosed.

FIG. 1 illustrates a side elevation of the winding device.

FIG. 2 illustrates a simplified version of a gear change mechanism for providing the desired speed of scanning on the scanning device.

FIG. 3 illustrates the front view of the winding device and a schematic illustration of the control system.

FIG. 4 is a plan view of the scanning device.

Referring to the drawings a method and an apparatus for winding a continuous fiber is illustrated. Although this device adapts itself well to winding a glass fiber, it is also adaptable to winding fibers of other materials. The device could be used in a combination for rewinding fibers or a device operating simultaneously with drawing of a fiber. This device is directed primarily toward the winding although it operates with a fiber drawing device to advantage in that it has an infinite variable speed winding drum which inherently assists in controlling the fiber diameter as it is being drawn.

FIG. 1 illustrates a fiber winding drum **1** rotatably mounted on a plurality of bearings **2** and driven through a variable speed transmission **3** by a synchronous motor **4**. The power transmitting element as illustrated may be chain belt **5** or any positive drive means connected to the output of the synchronous motor **4** and driving into the transmission **3**. The transmission **3** is variable through infinite speeds by the variable speed control **6**.

The plurality of bearings **2** are supported on the carriage. The carriage **7** supports the drum **1** and the variable speed drive transmission **3** and a synchronous motor **4**. This whole assembly is supported on a plurality of rollers **8** rolling within the tracks **9**. The tracks **9** are parallel with the axis of the shaft **10** on the drum **1**. The carriage **7** is integral with the nut **11** which is threaded on its inner periphery to receive the indexing screw **12**. The indexing screw **12** is driven by the indexing motor **13**. The indexing motor **13** is mounted on the base frame **14** and rotates in response to energization through the con-

trol system. The rotation of the indexing motor **13** is at a slow rate and is controlled by a limit switch **44** on the opposite end of the indexing screw **12**.

The scanning device **15** is supported on the bracket **16** and driven through a flexible cable **17**. The flexible cable **17** is connected to the drive shaft **10** through the transmission **18** which is primarily a speed reduction transmission. The variation in the speed may be controlled in the transmission **3** as illustrated in FIG. 2.

The scanning device includes gear change mechanism to vary the speed of scan, and a cam mechanism with a variable can throw to vary the amplitude of sweep of scanning the arm. This operation will be described more specifically in the subsequent paragraphs.

The fiber source **19** supplies a continuous fiber and requires that the speed of the fiber delivered from the source be accurately controlled. Any predetermined speed may be used to provide the desired fiber characteristics but the speed must be held constant for a given requirement of the fiber characteristics.

Referring to FIG. 3 the front view of the winding device is illustrated together with the schematic diagram of the control system. The fiber source **19** is illustrated above the winding mechanism and is fixed relative to the frame **14**. The bracket **16** is also fixed relative to the base frame **14**. The scanning device **15** is fixed on the bracket **16** and scans at the desired rate. The scanning device **15** is driven by the flexible cable **17** and receives its driving power from the transmission **18**.

The drum **1** is removable by sliding axially away from the plurality of bearings **2**. The synchronous motor **4** drives through the chain belt **5** to the transmission **3**. A suitable motor control **22** is connected to a source of electrical energy and provides a starting means for the synchronous motor **4**.

The indexing motor **13** drives through the indexing shaft **12** in response to the control system. The arm **24** is connected to the nut **11** and moves the drum **1** axially in response to actuation of the motor **13**. The control system rotates the motor the desired degree of rotation to provide the indexing of the drum a distance equal to the distance between centers of adjacent grooves. The indexing motor is of a conventional type more commonly known as a slosyn motor and available from Superior Electric Company.

Referring to the schematic portion of FIG. 3 the control panel **30** includes circuitry together with the necessary switches and controls as indicated suitable for performing the operations subsequently described. The control panel **30** includes a counter indicator operating in response to the oscillating movement of the scanning bar **31** as the fiber is guided by the guide **32**. The cam **33** is operated in response to the movement of the mechanism within the scanner **15**. The cam follower **34** is connected to the scanning bar **31** and is biased to a contacting position on the cam **33** by means of the spring **35**. The abutment **36** supports the spring **35** and maintains its position against the scanning bar **31**.

The counter switch **37** is supported on the scanner housing **38** and transmits an electrical signal through suitable electrical conductors **39** to the control panel **30**. Each complete cycle of scan of the scanning bar **31** is indicated on the counter indicator **40**.

The preset counter control **41** on the control panel **30** permits setting of the number of the predetermined count in cycles to be completed by the scanner bar **31** in accordance with preset indicator **42**. The scanner bar **31** sweeps through a scanning distance controlled by the cam throw of cam **33**. The preset number on the preset indicator **42** controls the cycles of sweep completed by the scanning bar. When the counter indicator equals the preset indicator, the panel control circuit initiates an electrical impulse. The impulse is conducted through connectors **43** and the limit switch **44** and the panel control circuit to connect the source of electrical energy **20** through conductors **61** and **60** and energize the indexing motor **13** which causes the indexing motor to rotate the indexing screw **12**. The indexing screw rotates the gear **46** which in turn counter rotates the gear **47**. The indexing cam **48** which is connected to the gear **47** rotates a complete revolution and opens the limit switch **44** to deenergize the motor **13**. The limit switch **44** resets and closes after a short interval of time and is again ready to transmit an energizing pulse when the preset count is again equalled on the counter indicator.

The gears **46** and **47** control the degree of rotation of the indexing screw **12** which is equal to the center to center distance of adjacent grooves on the winding drum. The two gears **46** and **47** are removable and replaceable by similar gears having the same center to center dimension but different gear ratios. This change of gear ratios permits the desired degree of rotation of indexing screw to accommodate a different groove width of adjacent peripheral grooves on the winding drum.

The synchronous motor **4** is also connected to a source of electrical energy **20** which may be the same source as operates the indexing motor. A suitable control unit **22** which is conventional in its operation is connected intermediate the source of electrical energy **20** and the synchronous motor **4**.

Referring to FIG. 2 the cam **33** is illustrated connected to the gear **50**. The cam **33** and gear **50** may be integral and removable as a unit. The gear **50** is driven by the pinion **51** which is nonrotatably fixed to the shaft **52**. The shaft **52** is driven by the helical gear **53**. The flexible cable **17** drives the worm gear **54** which supplies the power input for the scanning mechanism **15**. Although the illustration in FIG. 2 is a limited disclosure it is merely illustrative and not limiting in its scope. Other reduction gear means and cam throws or cam contours might be devised to give a suitable operation.

The operation of this device will be described in the following paragraphs. Referring to FIG. 3 a suitable fiber source is illustrated for supplying a continuous fiber **56**. The drum **1** winds the fiber at the rate determined by the speed of the driving means in accordance with the supply rate. The shaft **10** connected to the drum **1** is connected through the Graham transmission **3** to the shaft **57**. The shafts **57** and **58** are provided with a sprocket to accommodate a link belt arrangement to transmit power from the synchronous motor **4** to the shaft **57**. Any suitable positive drive is satisfactory. The synchronous motor **4** is brought to speed by the motor control **22** connected to a source of electrical energy **20**. The Graham transmission **3** then is set to provide the proper shaft speed on the drum shaft **10** through the use of the variable speed control **6**. The speed at which the motor operates is constant, however, the drum speed may be varied to provide a control of the fiber characteristic which is being received from the source **19**. It is understood that control of the fiber characteristics is not solely dependent on the speed of the winding drum, however, control of the speed of the winding drum is necessary.

It is pointed out that the source **19** may be used for supplying fibers of coated glass, metallic, ceramic, plastic and other materials.

The scanning device **15** operates to scan a limited width on the longitudinal surface of the winding drum **1**. The scanning is an oscillating operation in which layers of fibers are laid down on the drum as the scanning arm **31** moves back and forth in response to the driving of the cable **17**. The transmission **18** receives its input power from the shaft **10** and is intermediate the shaft **10** and the flexible cable **17**. Any suitable reduction gear arrangement intermediate the shaft **10** and the cam **33** may be devised. The reduction gear mechanism as illustrated in FIG. 2 together with the transmission **18** control the rate of scan relative to the speed of rotation of the drum **1**. As the flexible cable **17** rotates the worm gear **54**, the

gears 53 and 50 rotate to drive the cam 33. The cam follower 34 engages the cam 33 in response to the spring 35. The guide 32 receives the fiber and causes a scanning action of the fiber on the surface of the drum 1.

The V slots forming the plurality of grooves on the drum 1 as illustrated are approximately 60°. The 60° groove is considered to be the best groove to provide a close packed fiber bundle over a wide range of fibers per bundle. It is understood that the drum 1 might be formed with a flat peripheral surface and any number of fibers could be wound in each bundle. The closeness of pack of the fiber bundles which affects the total efficiency of light transmission, or transmission of energy is affected if the closeness of pack is reduced. It is also understood that a semi-circular groove might be more suitable if one size of bundle were used and only a predetermined number were wound in each of the bundles.

The indexing mechanism operates in response to the control system. The preset number is set on the preset indicator which indicates the total number of cycles through which the scanning bar 31 completes. When the counter indicator equals the preset indicator number which is controlled by the cam switch 37 then the indexing operation is initiated. The indexing motor is energized by a signal passing through the limit switch 44 through the indexing motor control in panel 30 which connects the motor 13 to the source of electrical energy 20 and energizes the indexing motor 13. The indexing motor 13 rotates the indexing shaft 14 to rotate the gears 46 and 47 and the limit switch cam 48. As the limit switch cam 48 opens the limit switch 44 the indexing motor is deenergized. The drum is rotated until the fiber transfers to the adjacent groove in the transverse slot. The lateral component of force causes the fiber to align itself in the adjacent groove when the drum is indexed. The counter indicator resets at zero and initiates a new cycle of counting. The preset indicator remains at the preset number unless reset to some other number. The number of revolutions of the winding drum per cycle at the scanning arm is controlled by the gear ratio between shaft 10 and cam 33. The gear ratio in the scanner 15 is changeable to accomplish this change in ratio of drum rotations per scan. The fiber characteristic may also be varied by a variable speed control 6 of transmission 3.

In this manner the total fibers in each of the bundles which are wound in each of the plurality of grooves is controlled. The process is automatic to provide a plurality of bundles wound in the plurality of grooves on the drum. The process set forth in this invention includes the steps operated as described in previous paragraphs by the apparatus as shown. A fiber is supplied by a suitable source and may be simultaneously drawn, or supplied from a previously wound bundle. The fiber is wound on a plurality of grooves on a winding drum. A scanning device simultaneously scans a limited longitudinal portion of the surface on the drum to provide a close packed bundle of fibers as the drum rotates. The indexing of the drum continuously controls the number of fibers in each bundle. The driving means for the winding drum provides the speed of rotation of the drum to simultaneously control the fiber characteristic.

The device as illustrated and described sets forth the preferred embodiment of this invention. It is understood that variations of this embodiment might be devised which fall within the scope of the invention which are covered by the attached claims.

I claim:

1. A fiber winding device comprising, a source of fiber forming material providing a deformable fiber, a fiber winding drum rotatably mounted on a supporting means and constructed and arranged with a plurality of peripheral grooves for receiving a fiber from said source, a variable speed driving means mounted on said supporting means and connected to said drum for driving said drum at a speed to provide a predetermined characteristic thickness of fiber drawn from said source, scanning means mounted on said supporting means driven by said driving means guiding said fiber to repetitively scan at least a portion of one of said grooves on said winding drum for a predetermined number of cycles, a control system including a counter means connected to said scanning means for counting the cycles of scan of said scanning means and an adjustable preset indicator connected to said counter means for adjustably presetting the number of cycles said scanning means will scan each groove of said drum, an indexing means mounted on said supporting means connected to said control system for changing the relative axial position between said drum relative to said scanning means when the preset number of scanning cycles have been completed for one of said grooves to thereby subsequently scan another groove on said winding drum.

2. A fiber winding device comprising, a source of an endless fiber, a fiber winding drum rotatably mounted on a supporting means defining a plurality of V-shaped peripheral grooves about its outer periphery, driving means connected to said drum for driving said drum at a predetermined rate of speed, scanning means mounted on said supporting means driven by said driving means and guiding said fiber from said source of fiber and repetitively scanning at least a portion of the width of one of said grooves on said drum for a predetermined number of cycles, a control system including a counter means connected to said scanning means to count the number of scanning cycles made by said scanning means with relation to one of said grooves and an adjustable preset indicator connected to said counter for indicating the number of scanning cycles to be completed for each groove, an indexing means supported on said supporting means and connected to said control system and mechanically connected to said drum for changing the axial position of said winding drum relative to said scanning means a dimension equal to the distance between groove centers on said winding drum to thereby cause said scanning means to subsequently scan an adjacent groove when the preset number of scanning cycles have been completed for one of said grooves.

3. A fiber winding device comprising in combination, a source of deformable material for forming an endless fiber, a fiber winding drum having a grooved periphery rotatably mounted on a supporting means for receiving said fiber on its outer periphery, a motor connected through a variable speed transmission to said drum and mounted on said supporting means for driving said drum at the desired speed to control the fiber characteristic, a scanning means mounted on said supporting means guiding said fiber and repetitively scanning a groove of said drum a predetermined number of cycles during winding of a fiber bundle on said drum, a control system including a counter indicator indicating the number of cycles of scan completed by said scanning means for each fiber bundle being wound in each groove of said drum and an adjustable preset indicator connected to said counter indicator for presetting the number of cycles said scanning means will scan in winding a bundle, indexing means on said supporting means connected to said winding drum to shift the relative position between said winding drum and said scanning means, a control circuit connected to said control system and to said indexing means to initiate a signal when said two indicators are equal and initiate indexing of said indexing means to thereby control the number of cycles of scan of said scanning means per each bundle wound on said winding drum.

4. A fiber winding device for automatically winding more than two fiber bundles comprising, a source of an endless fiber, a fiber winding drum rotatably mounted on a supporting means adjacent to said source, a motor driving a variable speed transmission mounted on the supporting means and drivingly connected to said drum

to drive said drum at the desired speed, a scanning means mounted on said supporting means guiding said fiber and repetitively axially scanning a limited portion of the periphery of said drum for a predetermined number of cycles for winding a fiber bundle, a control system including a counter indicator connected to said scanning means for counting the cycles of scan of said scanning means for each bundle wound and an adjustable preset indicator connected to said counter indicator for presetting the number of cycles said scanning means will scan for each bundle, indexing means on said supporting means connected to said control system and connected to said drum for indexing the relative position between said scanning means and said drum when the preset number of cycles on said preset indicator is equal to the cycles indicated on the counter indicator to thereby terminate winding of one bundle and initiate winding of another bundle at a point axially spaced on the periphery of said winding drum.

5. A fiber winding device comprising, a source of an endless fiber, a winding drum rotatably mounted on a supporting means defining a plurality of peripheral grooves for receiving a plurality of fiber bundles, a variable speed driving means mounted on said supporting means and drivingly connected to the drive shaft of said winding drum, scanning means on said supporting means repetitively scanning at least a portion of one of said grooves a predetermined number of cycles, a transmission connecting the drive shaft of said winding drum to the scanning means to provide a predetermined gear ratio between said drive shaft and said scanning means, a control system including a counter indicator connected to said scanning means for indicating the number of cycles of scans completed by said scanning means in winding each bundle and an adjustable preset indicator for adjustably setting the number of scanning cycles to be completed by said scanning means during winding of the bundle in each groove, an indexing means mounted on said supporting means connected to said control system for indexing the relative position of said winding drum with respect to said scanning means upon completion by said scanning means the preset number of cycles indicated by said preset indicator to thereby continuously wind a predetermined number of windings to form a fiber bundle in each of the plurality of grooves of said winding drum.

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