Oct. 6, 1964 J. K. COCHRAN 3,151,963

APPARATUS FOR WINDING GLASS STRANDS

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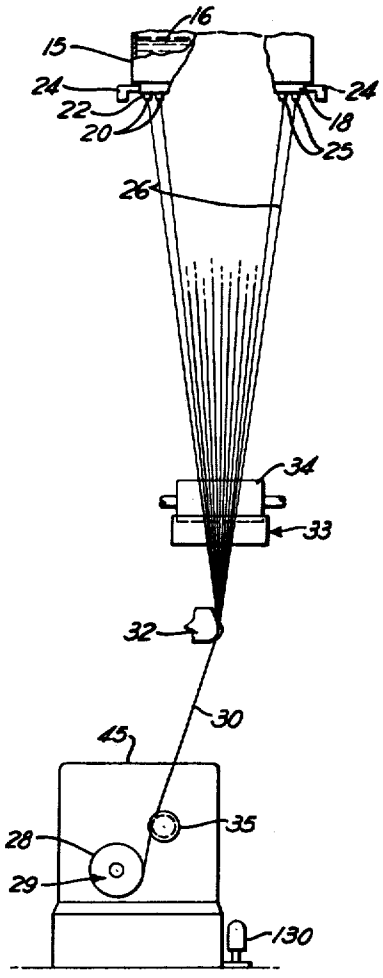


Fig. 1

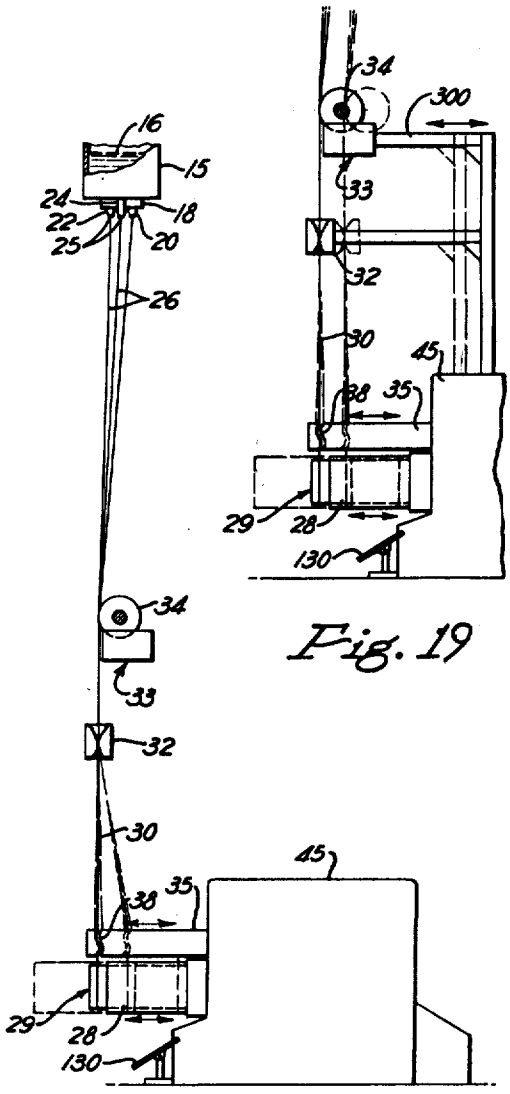


Fig. 19

Fig. 2

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Fig. 3

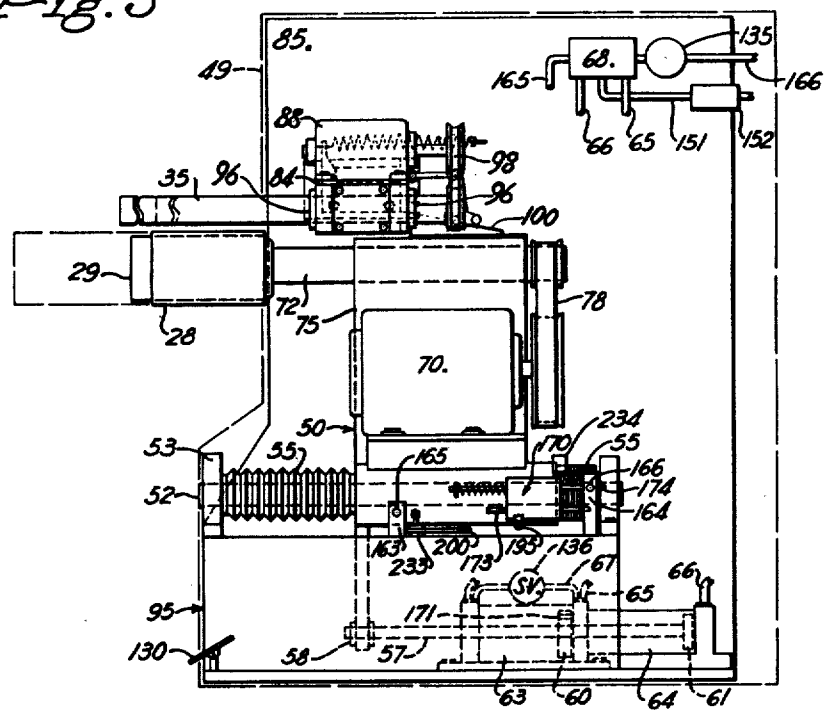
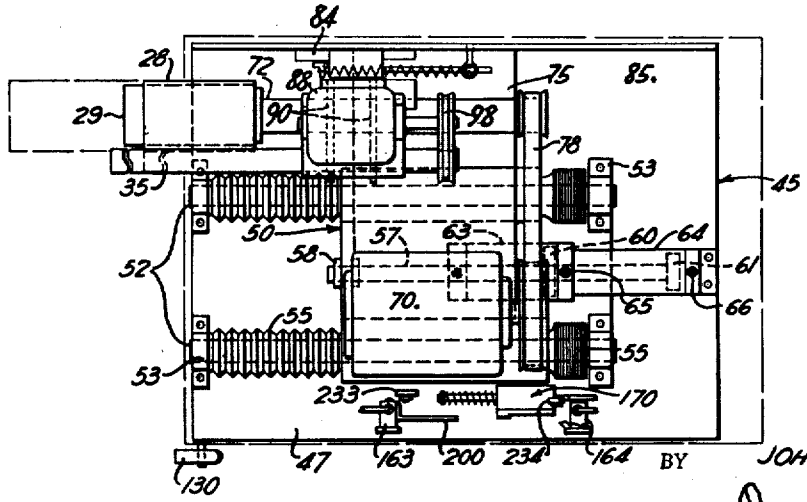


Fig. 4



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Fig. 5

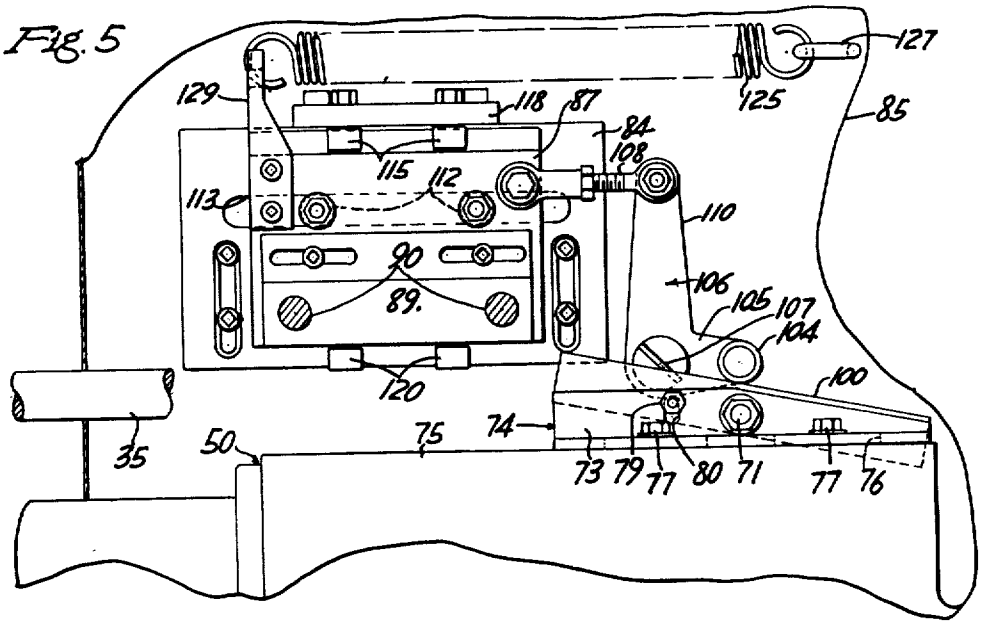


Fig. 7

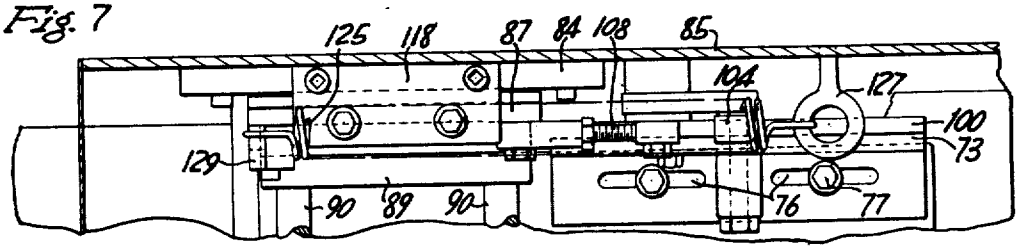
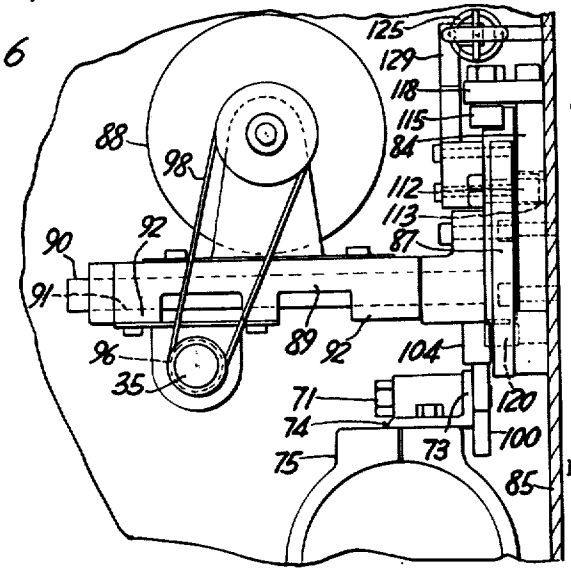


Fig. 6



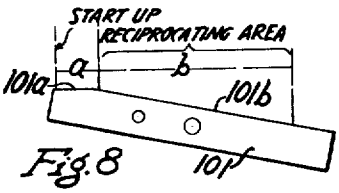


Fig. 8

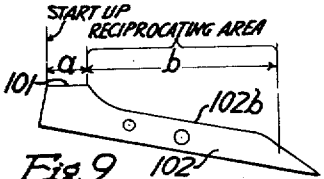


Fig. 9

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Fig. 11

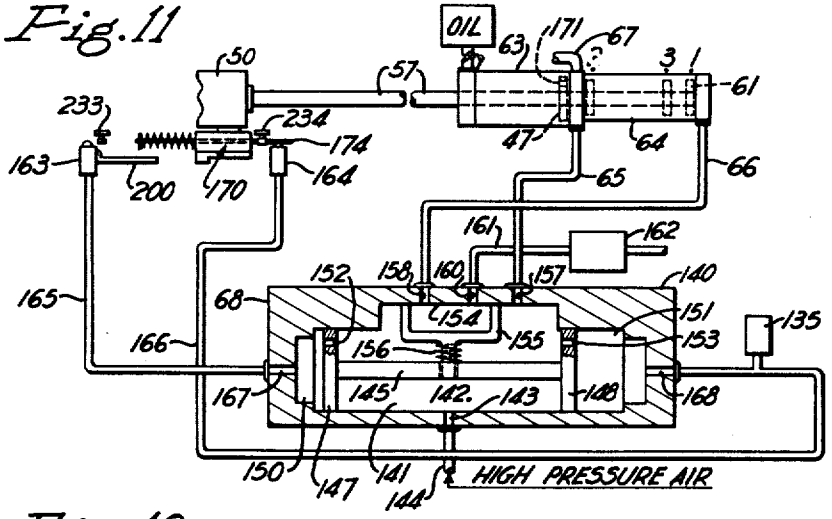
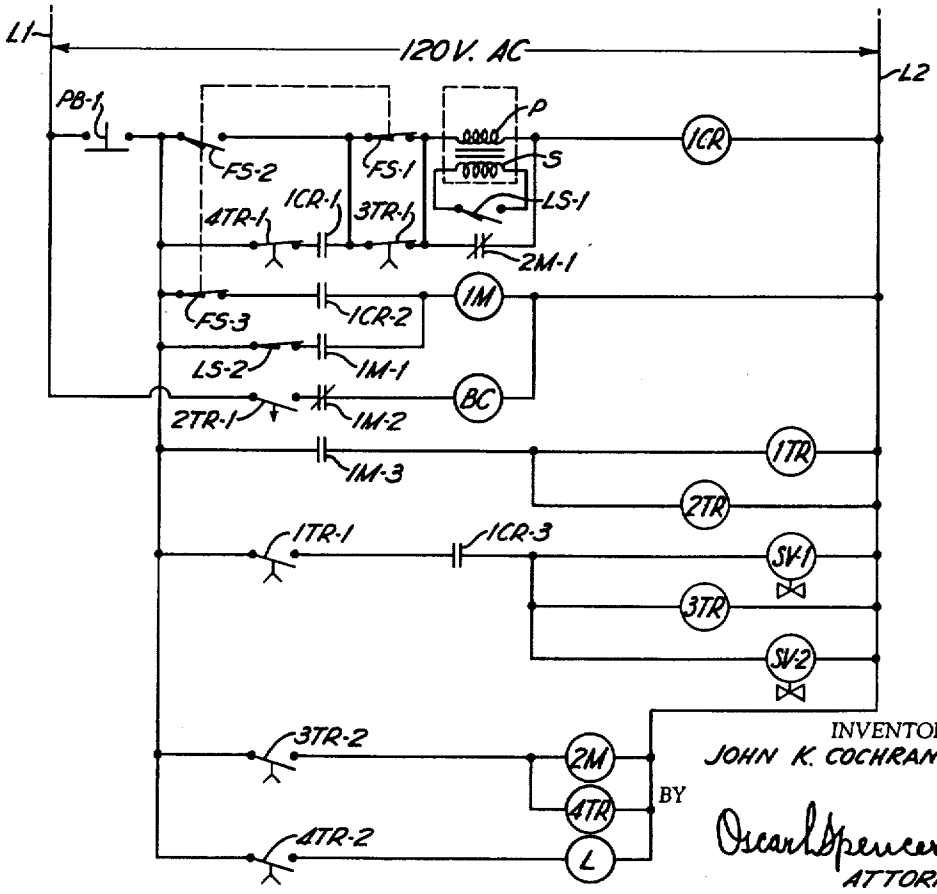


Fig. 10



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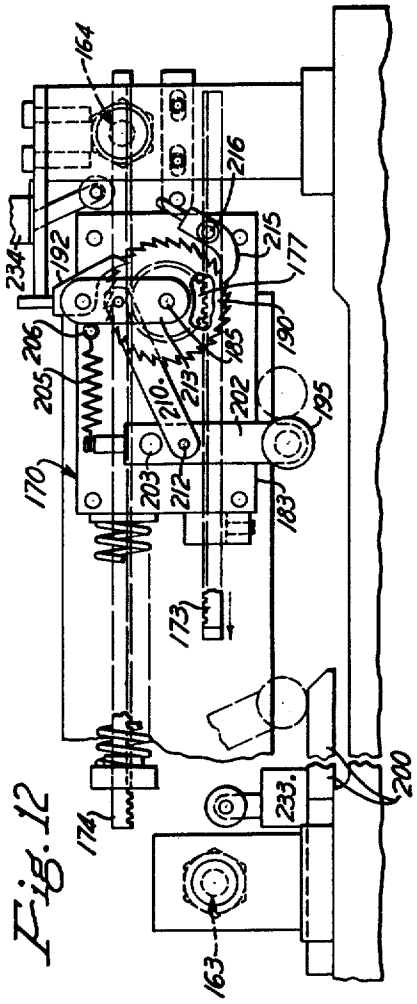


Fig. 12

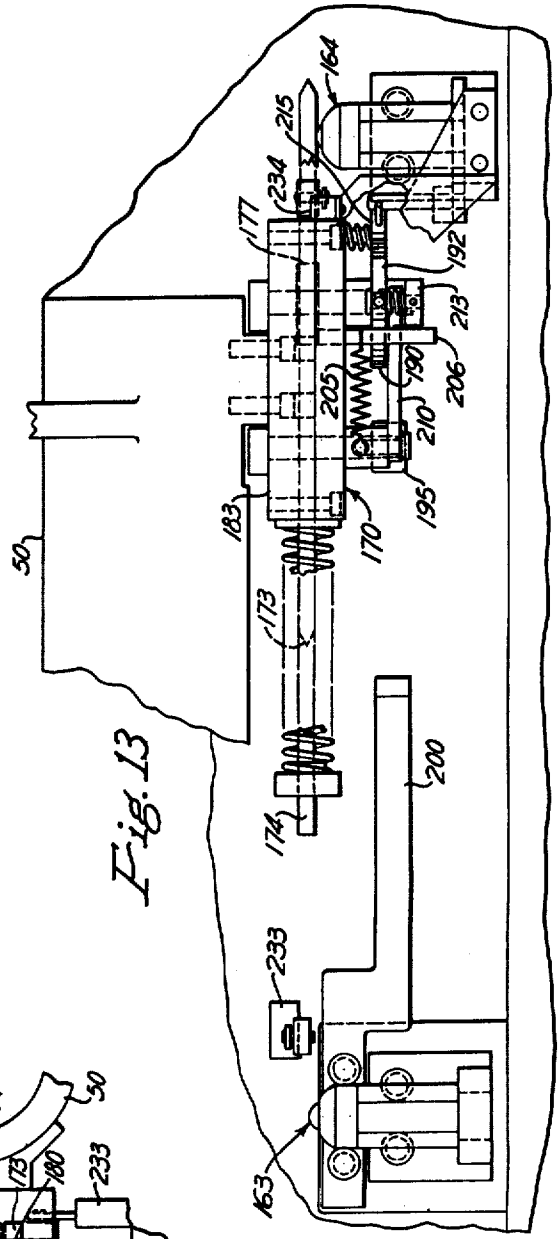


Fig. 13

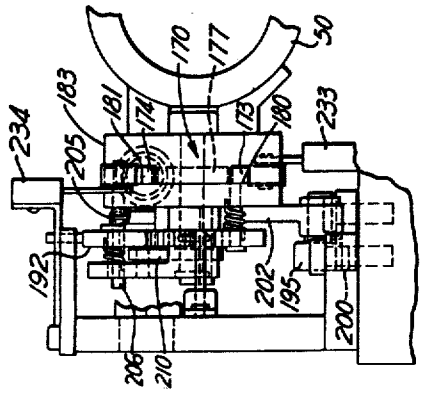


Fig. 14

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APPARATUS FOR WINDING GLASS STRANDS

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Fig. 15

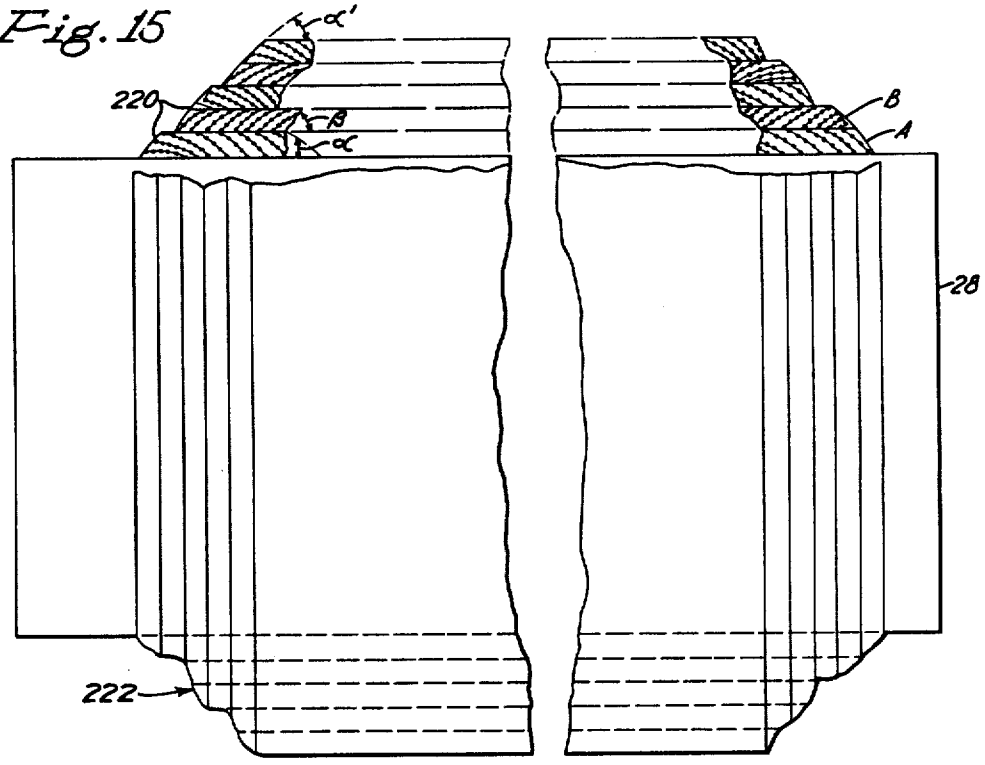
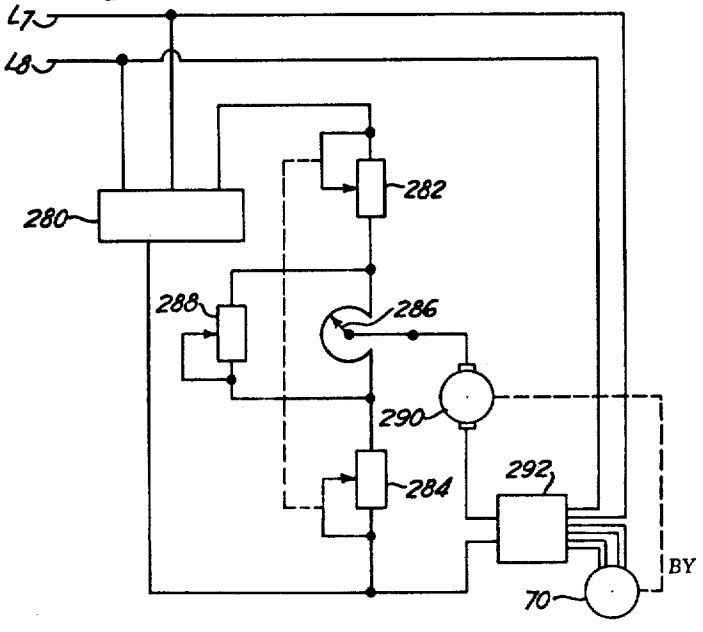


Fig. 18



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Fig. 16

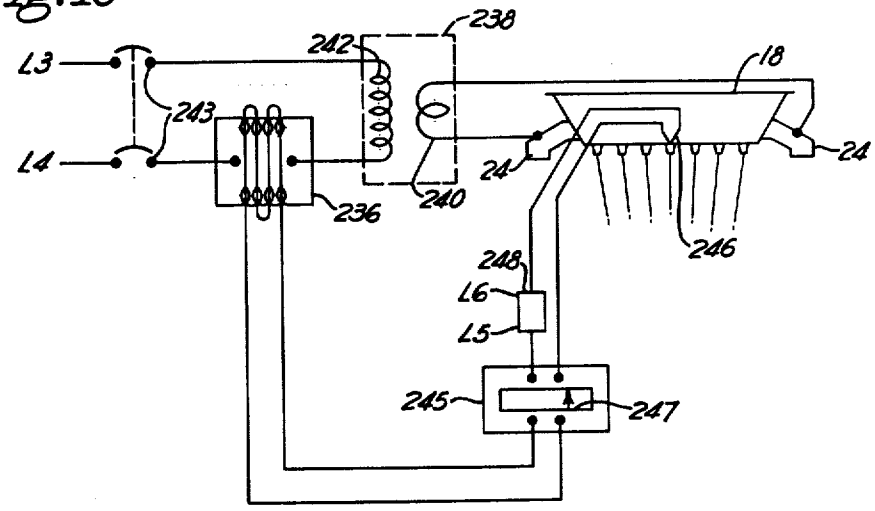
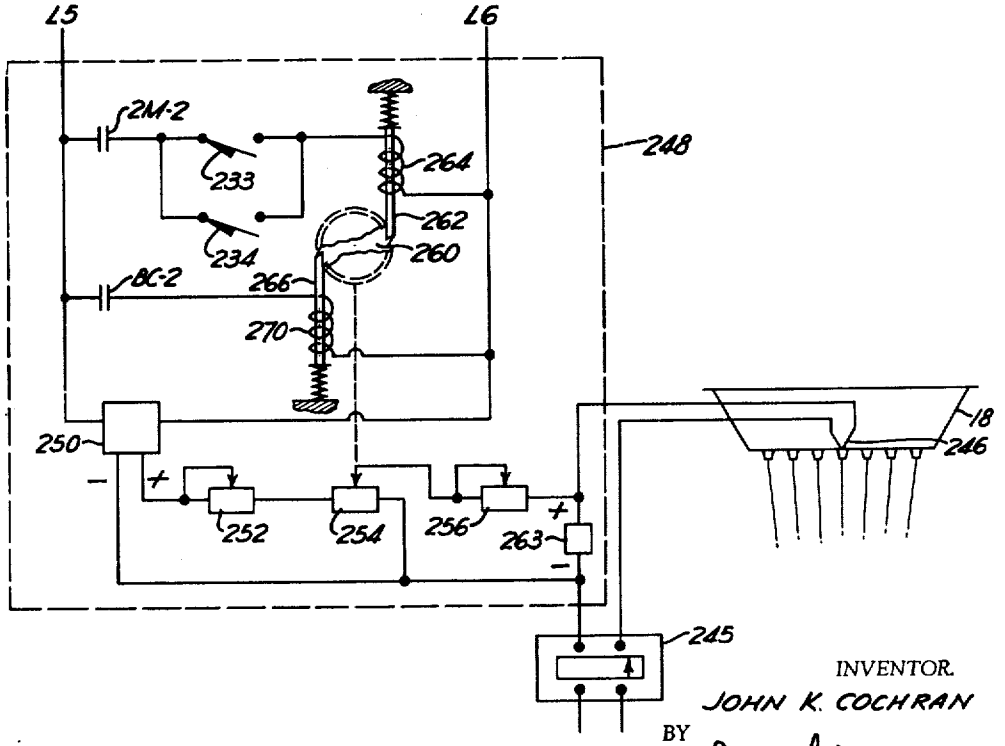


Fig. 17



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Fig. 20

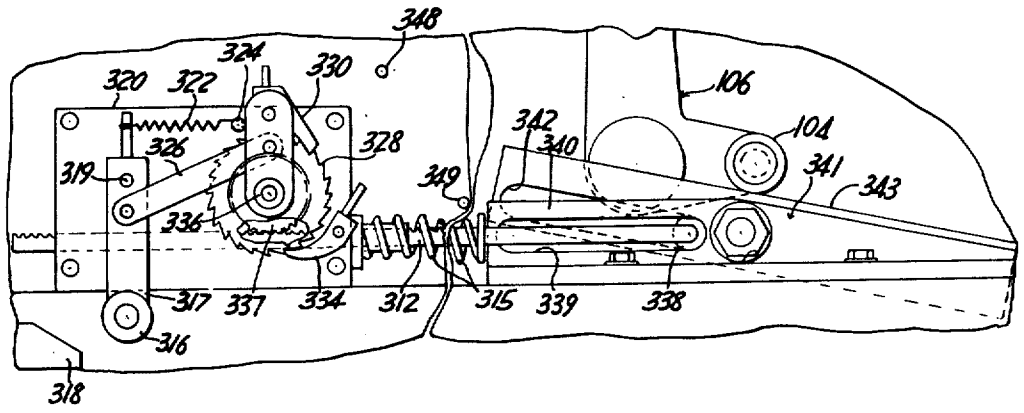
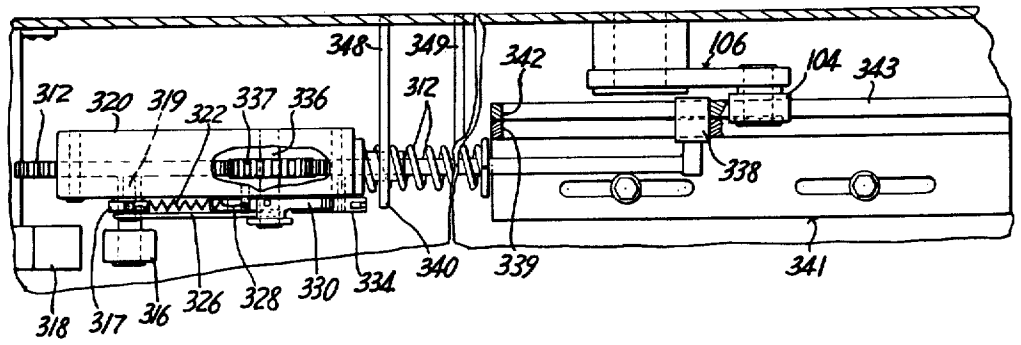


Fig. 21



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United States Patent Office 3,151,963 Patented Oct. 6, 1964

3,151,963

APPARATUS FOR WINDING GLASS STRANDS

John K. Cochran, Pine Township, Wexford, Pa., assignor to Pittsburgh Plate Glass Company, Pittsburgh, Pa., a corporation of Pennsylvania

Filed May 25, 1961, Ser. No. 112,632
8 Claims. (Cl. 65—11)

The present invention relates to an apparatus for winding strand, and it has particular relation to an apparatus for forming glass fiber strand and winding it on a cylindrical tube.

In one process for forming glass fibers, a plurality of individual fibers are drawn continuously from cones of glass suspended from tips defining orifices in an electrically heated, platinum alloy feeder known as a bushing. The fibers are passed through a gathering guide to group them together in the form of a strand and the strand is wound around a rotating, cylindrical forming tube which is mounted on a rotating cylinder known as a collet. The rotation of the forming tube supplies the drawing force to attenuate and form the individual fibers.

There is no twist in the strand as it is thus formed. A size is applied to the individual fibers prior to the winding of the strand on the forming tube in order to bond them together and maintain the integrity of the strand. An open wind, rather than a parallel wind, is desired in the winding of the strand on the tube. If a parallel wind is used, the individual fibers of one turn of strand tend to bind to the individual fibers of an adjacent turn of strand. These bound fibers from different turns of strand cling to each other and break when the strand is unwound from the tube. In this event, successive turns of the strand become entangled, and it soon becomes impossible to unwind the strand and remove it from the tube. If an open wind is employed, the turns of strand cross each other at an angle and do not tend to bind to each other. An open wind is therefore preferred.

An open wind is provided to the strand by means of a traverse which is located closely adjacent the forming tube. The traverse may move the strand back and forth through a two- or three-inch throw as it is wound on the forming tube. A much smaller throw, i.e., 1/16 to 1/2 inch, may be employed when a filling wind is desired. The length of the throw can be varied by varying the length of the cams in the traverse.

The process as above described is practiced as a single level and a double level process. In the double level process, the bushing and fiber gathering guide are on one level and the traverse and forming tube are on a floor level below them, and the traverse and fiber gathering guide are quite far apart, for example, about 80 inches apart. In the single level process, the bushing, fiber gathering guide, traverse and winder are all within reach of one operator on one level, and the distance between the traverse and fiber gathering guide is much less than in the double level process, for example, about 35 inches.

It is preferred, particularly in the single level process, to maintain the guide and traverse stationary with respect to each other and reciprocate the forming tube in order to distribute the strand along the length of the forming tube. This is because it is desired that the angle which the strand describes in its passage from the guide to the traverse be kept as small as possible. The reason for this is that as the angle increases, the tension and friction on the strand increases as it passes over the guide. The greater the tension and friction on the strand, the greater the tendency for an individual fiber in the strand to break and thereby break out the whole strand and discontinue the fiber forming operation. If the forming tube is axially reciprocated in order to distribute the strand along the length of the forming tube, this permits the angle which the strand makes on its passage from the guide to the traverse to be kept at a minimum and be no more than necessary to permit the throw imparted to the strand by the traverse.

A desideratum of the glass fiber forming art has been to produce larger forming packages on larger forming tubes. This has been desired so that the amount of strand in a forming package is some even multiple of the amount of strand which is unwound from the forming tube, twisted and rewound on a twister tube. This enables the glass fiber yarn producer to supply splice-free yarn to the weavers. It is desired to produce these larger forming packages by means of apparatus which does not take up any more space than winding equipment now being employed, thereby eliminating the necessity to enlarge present production facilities or reduce the number of fiber forming stations within existing production facilities.

In accordance with this invention, apparatus is provided whereby this may be accomplished. This apparatus comprises a cylindrical winding or forming tube, means for rotating the tube, means for continuously reciprocating the tube axially during the winding, a traverse located adjacent the tube, means for actuating the traverse and means for reciprocating the traverse continuously during the winding in a line parallel to the axis of the tube, the means for reciprocating the tube and the means for reciprocating the traverse being adjusted so that the tube and traverse are reciprocating continuously in opposite directions. The tube reciprocating means and traverse reciprocating means may be independently operated; however, in a preferred embodiment of the invention the traverse reciprocating means is actuated by and is directly responsive to the tube reciprocating means. In a further embodiment of the invention, the fiber gathering guide may be reciprocated with the traverse, preferably in unison therewith.

For a more detailed description of the winding apparatus and its mode of operation in the winding and forming of a glass fiber strand, reference may be made to the drawings in which:

FIG. 1 is a diagrammatic elevation of a fiber forming apparatus;

FIG. 2 is a side view of the apparatus shown in FIG. 1;

FIG. 3 is an elevation of the winder which forms part of the apparatus illustrated in FIGS. 1 and 2;

FIG. 4 is a plan view of the winder shown in FIG. 3;

FIG. 5 is an enlarged partial elevation of a portion of the winder shown in FIG. 3 illustrating means for reciprocating the traverse which forms part of the winder;

FIG. 6 is a side view of the traverse reciprocating means shown in FIG. 5;

FIG. 7 is a top view of the traverse reciprocating means shown in FIG. 5;

FIGS. 8 and 9 are modified forms of cams which are useful and operable in the traverse reciprocating means shown in FIGS. 5, 6 and 7;

FIG. 10 is a schematic drawing of the electrical system of the winder;

FIG. 11 is a schematic drawing of the pneumatic system of the winder;

FIG. 12 is an elevation of the means for controlling and varying the axial movement of the forming tube;

FIG. 13 is a plan view of the control means shown in FIG. 12;

FIG. 14 is a side view of the control means shown in FIG. 12;

FIG. 15 is a diagrammatic elevation, partly in section, of a forming package produced by use of the winding apparatus;

FIGS. 16 and 17 are diagrammatic views of a means for controlling the bushing temperature during the run in response to the control means shown in FIGS. 12, 13 and 14;

FIG. 18 is a diagrammatic view of means for controlling the speed of the collet in response to the control means shown in FIGS. 12, 13 and 14;

FIG. 19 is a view similar to FIG. 2 showing another embodiment of the invention wherein the fiber gathering guide and size applicator are reciprocated in unison with the traverse;

FIG. 20 is an elevation similar to FIG. 5 illustrating a modification of the traverse reciprocating means shown in FIGS. 5, 6 and 7; and

FIG. 21 is a plan view of the modification shown in FIG. 20.

In FIGS. 1 and 2 of the drawing, there is shown a glass melting container **15** or forehearth thereof containing a supply of molten glass **16** and having an electrically heated feeder or bushing **18** attached to the bottom of the container. The bushing **18** is trough-like in shape and is provided with a series of orifices **20**, which orifices are defined by tips **22** suspended from the bottom portion of the bushing. The bushing is composed of an alloy containing about 90 percent platinum and 10 percent rhodium and is heated by passing through it electric current from a suitable source. The current is received by the bushing from the source by means of terminals or lugs **24** attached to opposite ends of the bushing along the vertical end walls of the bushing.

The molten glass **16** within the bushing is maintained at a temperature suitable for fiberizing by means of heat transferred by conduction from the bushing to the glass contained therein. The molten glass flows through the tips **22** and forms in small cones **25** suspended from the tips. The tips are aligned in four or more rows having a great many tips in each row so that the total number of tips may be about 200 to 400 or more. A smaller or greater number of rows and/or tips may be present in the bushing.

Glass filaments or fibers **26** are pulled from the cones **25** at a very high rate of speed, for example, 5,000 to 20,000 feet per minute, usually about 10,000 to 15,000 feet per minute and wound on a rapidly rotating forming tube **28** mounted on a rotating collet **29**. The collet may be approximately 6 to 8 inches in outside diameter and may rotate at approximately 6,000 to 8,000 r.p.m., depending upon the size of the fiber to be produced and other operating conditions such as temperature of the glass in the cones **25**. The glass fibers **26** are grouped into a a strand **30** as they pass over a fiber gathering guide **32** prior to being wound on the forming tube **28**.

Usually an aqueous size containing a liquid binder and a lubricant, such as a combination of starch and a vegetable oil, is applied to the individual fibers **26** of the strand **30** as they pass over a size applicator **33** which is mounted just above the guide **32**. The size transfer surface in the applicator **33** may be in the form of a rotating roller **34** or moving belt having a film of the size applied to it. The fibers **26** pass over the roller or belt at some tangential point for momentary contact with the sizing solution to transfer the solution from the applicator to the fibers. An example of a suitable size applicator is shown in U.S. Patent No. 2,873,718.

As the strand **30** is wound on the tube, it is given a traversing motion by means of cam **35**. The cam **35** is in the form of a cylindrical spindle having a sinusoidal, peripheral groove **38** around its surface. The walls **40** of the groove **38** are sloped inwardly at an angle of about 45 to 90 degrees to the axis of the spindle so as to reciprocate the strand **30** in the axial direction of the cam and collet very rapidly as the cam is rotated rapidly. The amplitude of the traversing movement may vary depending upon the axial distance covered by the high and low points of the sinusoidal groove **38** on the periphery of the cam. The amplitude may be very slight, for example, 1/16 to ½ inch or it may be much greater, for example, 3 to 5 inches. The frequency of the traversing movement is controlled by the speed at which the cam is rotated and the number of reverses in the direction of the groove **38** as it travels around the periphery of the cam **35**. All of these variables can be controlled within the skill of the art. The cam **35** may have a diameter at the bottom of the groove of about 2 inches and a diameter at the top of the groove of about 2½ inches and may have about 2 to 8 reversals in the groove. The cam **35** may rotate at about 1,000 to 25,000 r.p.m. with a cam of the above dimensions with 2 reversals in the groove being preferably rotated at about 18,000 r.p.m. when the amplitude of the traverse is about ½ inch and about 3,000 r.p.m. when the amplitude of the traverse is about 3 inches.

The strand is distributed along the length of the forming tube by the relative motion of the forming tube **28** with respect to the cam **35** as created by slowly reciprocating the forming tube and cam continuously in opposite directions during the fiber forming run. With each axial movement of the forming tube with respect to the cam **35**, a separate layer is wound on the forming tube so that the forming tube has a plurality of layers of strand wound in superposed relation on the forming tube **28**. Each succeeding layer may be substantially the same length as the preceding layer or may be of shorter length than the preceding layer. In the latter case, the end of each succeeding layer terminates short of the end of each preceding layer. Both of such methods of producing a forming package are described hereinafter in greater detail.

The winder, including the cam **35**, forming tube **28** and means for providing the reciprocatory movement between the two, is generally indicated at **45** in FIGS. 1 and 2. The winder **45** is shown in greater detail in FIGS. 3 and 4. It is composed of a base **47** and a sheet metal framing enclosure **49** mounted on the base. A carriage **50** is mounted on the base on a pair of lubricated slides **52** which are mounted on supports **53** rigidly fastened to the base. Accordion-like sleeves **55** are attached to the supports **53** and carriage **50** so as to protect the lubricated slides **52** from any dirt or other foreign substances.

The supports **53** act as mechanical stops for the reciprocating straight line motion of the carriage **50** on the slides **52**. The carriage **50** is reciprocated by means of a piston rod **57** which is rigidly attached to the carriage **50** at **58** and whose pistons **60** and **61** are mounted respectively in an oil cylinder **63** and air cylinder **64** mounted in tandem. The oil cylinder serves as a dashpot for smoothing out the movement of the pistons **60** and **61** caused by alternating air pressures on opposite sides of piston **61** in the air cylinder **64**. Air is supplied to opposite ends of the cylinder **64** by line **65** and **66** which are connected to a four-way, two-position, bleeder actuated, balanced air valve **68**. The details of the valve **68** and its method of controlling the air flow to the cylinder **64** are discussed in further detail in conjunction with the description of the operation of the winder **45**. The oil in the cylinder **63** passes from one side of the piston **60** to the other side by means of line **67** connected to each end of the cylinder **63**.

The drive for the collet **29** is motor **70** which is adjustably mounted on the carriage **50**. The collet **29** is mounted on a spindle **72** which is supported in a cylindrical bearing for rotation but limited to movement in an axial direction in an upright portion **75** of the carriage **50**. Spindle **72** is rotated by means of a belt **78** which is connected to and driven by the motor **70**. The motor **70** is equipped so direct current can be applied to the motor windings to reduce its speed.

The structure of the cam **35** has been discussed above

with respect to FIGS. 1 and 2 and its mounting and drive are now discussed in detail with respect to its showing in general in FIGS. 3 and 4 and in detail in FIGS. 5 to 7. A vertical stationary plate **84** is rigidly attached to an upright support **85** mounted on base **47**. The plate **84** serves as a fixed support for vertical reciprocating plate **87** which serves as a movable support for the cam **35** and its motor drive **88**. The motor **88** is supported on a platform **89** that is mounted on two horizontal rods **90** extending horizontally from and rigidly fastened to the bottom portion of plate **87**. The cam **35** extends through two hollow cylindrical bearings **91** in projections **92** extending downwardly from and forming a part of the platform **89**. A pair of collars **96** mounted on the cam **35** prevent avial movement of the cam **35** in the bearings **91**. The alignment of the cam **35** is such that the axis of the cam is parallel to the axis of the collet spindle **72**. The cam **35** is slightly above and to one side of the collet **29** so that it applies a traversing movement to the strand just before, i.e., 3¾ inches in distance, the strand is deposited on the forming tube. The cam **35** is driven by means of a belt **98** which is connected to and driven by the motor **88**.

The cam reciprocates in an axial direction in addition to the rotating movement supplied to the cam **35** by the motor **88**. The cam **35** reciprocates in an axial direction which is opposite to the axial reciprocation of the forming tube **28**. The driving force for the axial reciprocation of the cam is supplied by the axial reciprocation of the forming tube **28** as provided by the movement of the carriage **50**. It is to be understood, of course, that the axial reciprocation of the cam can be independently provided by independent driving means (not shown); however, the method and apparatus for axially reciprocating the cam in response to the movement of the carriage **50** as hereinafter described is preferred since it is a simple and efficient method for accomplishing the axial reciprocating movement of the cam **35**.

The apparatus for and the manner of axially reciprocating the cam **35** is now described. A cam **100** in the form of an inclined plane is rigidly but adjustably fastened at about its midpoint upon a bolt **71** that extends through an upright flange **73** of an angle iron **74**. The angle iron **74** is adjustable horizontally upon the upper portion **75** of the carriage **50**. Slots **76** are formed in the angle iron **74** to receive bolts **77** threaded into the top of the carriage **50** and thereby to provide proper adjustment of the angle iron and the cam carried thereby. This adjustment permits control of the positioning of the end-points of the forming package on the forming tube. An additional bolt **79** disposed in a slot **80** formed in the upright flange **73** is threaded into the cam **100** and provides for adjustment of the cam **100** in various positions about the horizontal bolt **71** in order to vary the slope of the cam and the amount of the extension of the length of the forming package.

As shown in the drawing, the highest point of the inclined plane is toward the front of the winder, i.e., the end where the cam **35** is located. The guiding surface of the inclined plane is aligned with the travel of the carriage **50** so as to provide a continually changing surface to a roller **104** as the carriage **50** moves back and forth. The roller **104** is mounted at the end of a generally horizontal arm **105** of a bell crank lever **106** which is pivotally mounted at **107** to the upright support **85**. A generally horizontal connecting rod **108** is pivotally mounted at its one end to the upper end of a generally vertical arm **110** of the bell crank lever **106**. The rod **108** is pivotally connected at its other end to the movable support plate **87**. It can be seen that as the carriage **50** moves in and out, the roller **104** moves up and down the inclined plane cam **100**, and this in turn causes the rod **108** through the bell crank lever **106** to move horizontally out and in the direction of its length, thereby transmitting a reciprocating motion to the plate **87** which is directly opposite to the reciprocating motion of the carriage **50**.

The movement of the plate **87** in response to the action of the bell crank lever **106** is accomplished in the following manner. A pair of rollers **112** are mounted for rotation on the back of plate **87** in horizontal alignment with each other so as to ride in a horizontal slot **113** provided in plate **84**. The plate **87** is guided on the plate **84** at the top of plate **87** by means of a pair of rollers **115** which are mounted for rotation about vertical axes to a horizontal plate **118** which extends from upright support **85** and is bolted to the top of plate **84**. The plate **87** is held away from plate **84** by means of a pair of rollers **120** which are fastened to the bottom of plate **87** for rotation about vertical axes in contact with the exposed face of plate **84** along its bottom edge. The diameter of the rollers **120** is sufficiently larger than the thickness of the plate **87** so that the plate **87** is held a short distance, i.e., $\frac{1}{32}$ of an inch, away from plate **84**.

The plate **87** (and the motor **88** and cam **35** supported by it) are urged inwardly or held to the rear of the winder by means of a horizontal spring **125** which is connected at one end to a support **127** in the form of an eye which is rigidly connected to the plate **87** and is connected at the other end to an upright extension **129** having an opening in it to permit attachment of the end of the spring. The extension **129** is rigidly connected to the upright, movable support **87**. As the carriage **50** moves in (towards the rear of the winder), the inclined plane moves the roller **102** up, and through the bell crank lever **106** the connecting rod **108** urges the plate **87** forward (towards the front of the winder) against the retaining action of the spring **125**. As the carriage **50** moves out (towards the front of the winder), the spring **125** pulls the plate **87** back to the rear of the winder and the roller **104** moves down the inclined plane. Thus, it can be seen that the reciprocating action of the cam **35** is directly opposite to the reciprocating action of the forming tube **28** and is directly responsive to the reciprocating movement of the forming tube.

As shown in FIG. 2, the cam **35** is mounted so that when the cam is at the midpoint of its travel its groove **38** is in a vertical plane with the guide **32** and the center of the bushing **18**, said plane being perpendicular to the axes of the cam **35** and the forming tube **28**. The guide **32** is located approximately under the center of the bushing **18**, but, as shown in FIG. 1, the axis of the cam groove **38** is offset in the aforementioned vertical plane approximately 10 to 15 degrees from a vertical line drawn through the center of the bushing and the guide **32**. This angle is just slightly larger than the angle formed by the outside or end fibers **26** with the vertical line.

The forming tube **28** is mounted below the guide **32**. The strand **30** passes over the cam **35** under slight tension as it moves between the guide **32** and the forming tube **28**. As shown in FIG. 1, the cam **35** intercepts an imaginary line drawn from the guide **32** to the point on the periphery of the forming tube **28** where the strand first contacts the tube. This positioning of the cam **35** is required so that the cam **35** is able to engage the strand positively and move it back and forth as it is wound upon the forming tube. When the cam **35** is at its midpoint of reciprocating travel, the groove **38** is in line with the midpoint of the forming tube **28** at the midpoint of its reciprocating travel, i.e., the groove **38** and the midpoint of the forming tube are in the same vertical plane when the cam **35** and forming tube **28** are at the midpoint of their reciprocating movement.

The advantage of the reciprocating actions of the cam **35** and the forming tube **28** as above described can best be explained by means of an example. Assume that the winder is designed and has been built to provide a carriage movement (and forming tube movement) of a maximum of 7 inches, and the throw of the traverse is about ½ inch. This would mean that the maximum length of forming package on the forming tube would be 7½

inches. Assume next that a forming package 11½ inches long with a strand lay requiring the ½ inch traverse throw is desired. Theoretically, it would be necessary to increase the maximum length of the carriage reciprocation, and this would require a rebuilding of the winder. In accordance with the present invention, however, the same winder with a longer collet can be employed with the addition of the inclined plane cam **100** so as to provide a reciprocating movement of the cam **35** through a 4-inch stroke, i.e., 2 inches to either side of its central position. Since this reciprocating movement of the cam is opposite to the reciprocating movement of the forming tube as described above, a forming package of 11½ inches rather than 7½ inches can be produced.

The above conditions of manufacture are exemplary only and it can be understood that the apparatus of the invention can be modified to produce forming packages of various lengths. The addition of the means which provides a reciprocating motion to the cam **35**, which motion is oppoiste to the reciprocating motion of the forming tube, provides a versatility to the winder which is not present in any of the winders now employed in the glass fiber art.

Modifications of the inclined plane cam **100** to provide slightly modified operation of the winder are illustrated in FIGS. 8 and 9. Cam **101** is similar to cam **100** except that the forward guide surface **101***a* which is contacted by the roller **104** during the movement of the collet **29** through the distance *a* between the innermost reciprocating point and the startup position is horizontal so that the roller **104** has no vertical movement but merely rides on surface **101***a* without rotating the bell crank lever **106** and moving the cam **35** axially during this portion of the collet's travel. The remaining portion **101***b* of the guiding surface of cam **101**, which is contacted by roller **104** during the reciprocating movement of the collet **29**, has the same slope as cam **100** and provides the same axial reciprocating motion to the cam **35** during the fiber forming run as described above with respect to cam **100**.

Cam **102** shown in FIG. 9 is similar to cam **101**, however, the slope of the cam surface varies through the distance *b* representing the reciprocating area of the collet **29** during the fiber forming run. The slope of the cam **102** is greater at each end than it is in the middle of this distance so that axial speed of cam **35** is faster while depositing strand at the ends of the forming package than in the center. This prevents the buildup of ridges at the end of the forming package. Other modifications of the surface of the cams **100**, **101** and **102** can be made to achieve differently shaped forming packages.

The operation of the winder **45** during the glass fiber forming process can best be described in conjunction with the description of the schematic drawing of the electrical system in FIG. 10 and the schematic drawing of the pneumatic system in FIG. 11. In starting the fiber forming process, the operator pulls the strand **30** across the guide **32** and wraps it around the end of the collet **29** which extends beyond the forming tube **28**. The collet **29** is at its innermost position at the start of the run. While doing this the operator has his foot on a foot switch **130** having normally closed contacts FS–1 and FS–3 and normally open contact FS–2 located in a 120 volt alternating current circuit generally designated **132** in FIG. 10.

Contacts FS–1 and FS–2 are in a circuit in series with a normally closed push-button switch PB–1, the primary winding P of a transformer **134**, normally closed contact **2M–1** and a coil **1CR** of a relay having normally open contacts 1CR–1, 1CR–2, 1CR–3, 1CR–4 and 1CR–5. The winding P and contact **2M–1** are in parallel with each other. A normally closed contact 3TR–1 is in another circuit in parallel with contact FS–1 and in series with push-button PB–1, contact FS–2, normally closed contact **4TR–1**, normaly open contact 1CR–1, primary winding P, contact **2M–1** and coil **1CR**. The contacts **4TR–1** and **1CR–1** are in series with each other and in parallel with contact FS–2. The various contacts PB–1, FS–1, FS–2, 3TR–1, 1CR–1, 2M–1 and 4TR–1 together with primary winding P form in combination with coil 1CR a plurality of circuits through which coil 1CR can be energized or deenergized.

Depression of the foot switch **130** by the operator as he starts the winding process opens contacts FS–1 and FS–3 and closes contact FS–2. Current is then able to flow through the circuit containing contacts PB–1, FS–2, 3TR–1, 2M–1 and coil 1CR to energize the coil 1CR and close the normally open contacts 1CR–1 and 1CR–2. When contact 1CR–1 is closed a holding circuit is completed having in series contacts PB–1, 4TR–1, 1CR–1, 3TR–1, 2M–1 and coil 1CR to maintain coil 1CR energized upon release of the foot switch **130**.

Release of the foot switch **130** closes contacts FS–1 and FS–3. Contact FS–3 is located in another circuit in series with normally open, now closed, contact 1CR–2, normally closed contact BC–1 and coil **1M** of a starter for the collet motor **70**. This energizes coil 1M of the starter and starts the collet **70**. Coil 1M has normally closed contacts 1M–2 and 1M–4 and normally open contacts 1M–1 and 1M–3. When coil 1M is energized, interlock contact 1M–3 is closed in another circuit to energize a collet oscillating timer 1TR and a collet motor braking timer 2TR in parallel with each other and in series with contact 1M–3. The timer 1TR, of the on delay type, is set, e.g., for about 4 to 6 seconds to permit the collet motor **70** to attain sufficient speed to rotate the collet at about 7,650 r.p.m. When 1TR times out, its normally open contact 1TR–1 closes. The contact 1TR–1 is in series with normally open contact 1CR–3, now closed, and with a solenoid SV–1 of a normally closed, spring biased, solenoid valve **135**, timer 3TR of the on delay type and solenoid SV–2 of a normally open solenoid valve **136** in line **67** connected to the oil cylinder **63**. The solenoids SV–1 and SV–2 and coil 3TR are in parallel with each other. The solenoid valve **135** controls the oscillation of the collet. The timer 3TR, through its normally open contact 3TR–2 of the on delay type, initiates the rotation of the cam **35**. The solenoid valve **136** allows slow reciprocation of the collet when it is closed and permits a rapid return of the collet to the home or starting position at the end of the run when it is open.

Energizing of the solenoid SV–1 by closing contact 1TR–1 opens the solenoid valve **135**. This opens a portion of the pneumatic system for controlling the oscillation of the collet **29** and permits the collet to move outward from its home position. Also, when contact 1TR–1 closes, the timer 3TR is energized. The timer 3TR times out and closes the normally open contact 3TR–2 which is in series in another circuit with the coil 2M of the starter for the cam motor **88**. The closing of contact 3TR–2 (after a delay of about 1 to 3 seconds) starts the rotation of the cam **35**. With this arrangement the cam **35** does not begin to rotate until after the collet comes up to speed and has moved outwardly from the innermost or home position in response to the energization of the solenoid SV–1.

At the same time that the cam motor **88** is started, a synchronous motor timer 4TR is energized. The timer 4TR is in parallel with coil 2M and in series with contact 3TR–2. The timer 4TR is set for the length of the run, for example 10 minutes. At the end of the run timer 4TR times out to close its normally open contact 4TR–2 so that a light L in series with contact 4TR–2 in another circuit is lit to indicate to the operator that the run is complete.

Normally closed contact 4TR–1 in series with the 1CR holding circuit described above times open at the end of the run and since contact FS–2 is open, the coil 1CR is deenergized. When coil 1CR is deenergized, its contact 1CR–2 is opened, but this does not deenergize collet motor starter 1M and stop the collet motor because the

holding circuit containing limit switch LS–2 and normally open, now closed, contact 1M–1 continues to energize the starter 1M.

When coil 1CR is deenergized, its contact 1CR–3 is opened, solenoid SV–1 closes and solenoid SV–2 opens to cause the carriage 50 to return rapidly to its innermost position. The solenoid SC–2 opens line 67 to permit oil in cylinder 63 to move rapidly from one side of piston 60 to the other and permit rapid return of the carriage to its home position. When timer 3TR is deenergized, its contacts 3TR–2 are opened and cam motor 88 is stopped. Contacts 3TR–1, which opened after a delay of about 3 seconds when timer 3TR was initially energized is closed when timer 3TR is deenergized and this permits coil 1CR to be energized when the foot switch 130 is depressed.

When the carriage returns to the innermost position, limit switch LS–2 is opened and the holding circuit for the starter 1M is broken. This deenergizes starter 1M which disconnects collet motor 70 from its power lines and closes contacts 1M–2. With the closing of contacts 1M–2, the collet motor brake contactor BC is energized. This applies direct current to the motor windings which dynamically brakes the motor to bring it quickly to a stop. The deenergizing of starter 1M also opens contact 1M–3 which in turn deenergizes timers 1TR and 2TR.

When 2TR was initially energized contact 2TR–1 in series with normally closed contact 1M–2 and brake contact BC was instantaneously closed; however, since 1M–2 was open the brake contactor was not energized. When 2TR is deenergized as just described above, its contacts 2TR–1 will remain closed for approximately six seconds to allow sufficient time for the collet motor to be stopped. Thereafter it will open and the brake contactor is deenergized to remove the direct current from the motor.

If for some reason it is desired to stop the winder before the normal length of time set for a run, the operator can depress the foot switch 130 to open contact FS–1. Since contact 3TR–1 is also open, the coil 1CR is deenergized, the winder returns to its innermost position and starter 1M is deenergized. The winder may be restarted as described by release of the foot switch if the foot switch is held depressed until the winder returns to its home position and starter 1M is deenergized.

The winder is automatically stopped if the strand breaks. When the strand 30 is passing over the spring loaded guide 32, the tension of the strand moves the guide against a normally open limit switch LS–1 to close a circuit containing the limit switch LS–1 and the secondary winding S of the transformer. When limit switch LS–1 is closed thereby short circuiting the secondary winding S of the transformer a small impedance is reflected to the primary winding P of the transformer. In this situation, there is only a small voltage drop, i.e., 20 volts, across the primary winding and there is sufficient voltage left in the circuit in which the primary winding P is located to maintain coil 1CR energized. When the strand breaks, the pressure on the guide 32 is released and limit switch LS–1 is opened. The secondary winding of the transformer is opened and this reflects a very high impedance to the primary winding P of the transformer. This produces a high voltage drop across the primary winding P and there is insufficient voltage left in the circuit in which the primary winding P is located to maintain the coil 1CR energized. The coil 1CR becomes deenergized because of this and because contact 2M–1 is open while the cam motor 86 is running. The normally closed contact 2M–1 permits bypassing of the transformer circuit during the start-up of the winder. The transformer is used with limit switch LS–1 so that switch LS–1 is in a low voltage circuit and the operator will not be subjected to a high voltage line in case he touches the circuit in which the limit switch is located.

The pneumatic system is shown schematically in FIG. 11. Air valve 68 as previously mentioned controls the air supplied to each side of the piston 61 mounted in air cylinder 64. The air valve 68 is of the balanced type, for example, as shown in U.S. Patent No. 2,607,197. The air valve 68 is composed of a casing 140 providing a chamber 142 to which air under high pressure is constantly supplied through an inlet port 143 connected by pipe 144 to an air pressure source. A spool or plunger 145 is mounted within the chamber 142 for movement lengthwise of the chamber. The spool 145 is provided with pistons 147 and 148 at each end which in combination with the walls of the chamber 142 act to separate the chamber into three sections, a central section 149 into which the air under pressure is continuously provided, and sections 150 and 151 at the ends of the chamber. The central section of the chamber is connected to the end sections 150 and 151 by small ports 152 and 153 in the pistons 147 and 148 to provide for eventual equalization of the pressure in the three sections of the chamber. This permits the spool 145 to be in a balanced position within the chamber 142. The spool is moved lengthwise in the chamber by exhausting the air from either end sections 150 or 151 to temporarily unbalance the air pressure within the sections of the chamber and cause the spool to move toward the end of the valve from which the air has been exhausted.

One wall of the central portion of the chamber 142 provides a seat 154 for a slide valve 155 connected with the spool and normally urged by spring 156 against the seat. The inlet port 143 is located beyond the range of movement of the slide valve 155 so that air under pressure is constantly supplied to the chamber 142. The casing 140 has three passages opening into it through the wall forming the valve seat 154. Two of the passages 157 and 158 are connected respectively by lines 65 and 66 to opposite ends of the air cylinder 64. The third passage 160 is connected by a suitable line 161 to the atmosphere through muffler 162 and serves as an exhaust. In one position of the slide valve 155, the passage 157 communicates with the central section 149 of the chamber and it causes air under pressure to be directed toward one side of the piston 61 in air cylinder 64. In this position the passage 158 is connected through valve 155 and passge 160 to the atmosphere and thus serves as an exhaust for the air from the other side of the piston 61 in air cylinder 64. In the other position of the slide valve 155, the passage 158 communicates with the central section 149 of the chamber 142 and the passage 157 communicates with the atmosphere through valve 155 and passage 160.

The sliding of valve 155 is accomplished by alternately bleeding air from the end sections 150 and 151. This is accomplished by means of poppet valves 163 and 164 which are connected to end sections 150 and 151 respectively through air lines 165 and 166 connected to passages in the end walls of the casing 140.

The poppet valves 163 and 164 are mounted on the base 47 of the winder 45 in a line parallel to the travel of the carriage 50 and the collet 29. An automatically adjustable poppet valve engaging means 170 is rigidly attached to the side of the carriage 50 and as the carriage moves back and forth, the engaging means 170 alternately contacts the poppet valves to open them and cause the end sections 150 and 151 of the chamber 142 of valve 68 to be exhausted alternately to the atmosphere. The oil cylinder 63 connected to the air cylinder 64 causes the movement of the carriage to be smooth rather than abrupt. The cylinder 63 contains oil and this oil bleeds through an opening 171 in the piston 60 mounted on the piston rod 57 which extends through the oil cylinder to the air cylinder, and on which piston 61 is also mounted.

The extent of movement of carriage 50 is determined by the engagement of the means 170 alternately with the poppet valves 163 and 164. The engaging means 170 shown in greater detail in FIGS. 12, 13 and 14, is

composed of racks **173** and **174** which engage poppet valves **163** and **164** respectively. The effective lengths of the racks **173** and **174** are determined by pinion **177**. When the pinion rotates counter-clockwise as viewed in FIG. 12, the rack **174** is caused to move to the left and thereby increase its effective length as a cam for engaging poppet valve **163** and rack **174** is caused to move to the right and thereby increase its effective length as a cam for engaging poppet valve **164**. The racks **173** and **174** move respectively in channels **180** and **181** in support **183** which is rigidly attached to the side of the carriage **50**.

The pinion **177** is mounted on an axle **185** which is mounted for rotation in bearings in the support **183**. The pinion **177** is driven by means of a ratchet **190** which is also mounted on axle **185** and the ratchet **190** is in turn given rotational movement by means of pawl **192**. The pawl **192** is caused to move by movement of the carriage **50**. As the carriage moves to the left as shown in FIG. 12, roller **195** comes into contact with stationary cam **200** mounted on the base **47**. The roller **195** is mounted for free rotation on the end of link **202** which is pivotally mounted at **203** on support **183**. The link **202** is normally held in an upright position by means of spring **205** attached at one end to fixed pin **206** extending from support **183** and at the other end to the end of the link **202** opposite from the roller.

Engagement of the roller **195** with the cam **200** causes the link **202** to rotate. This in turn causes link **210** to move. Link **210** is connected at one end to a pin **212** mounted on link **202** between the pivotal mounting of the link and the end of the link containing the roller **195** and mounted at the other end to the central portion of a link **213**. Link **213** is mounted for free rotation at one end on a bearing integral with the axle **185** and carrying on its other end pawl **192** which is spring biased thereon to hold the pawl in engagement with the teeth of the ratchet **190**. Another pawl **215** is pivotally mounted on pin **216** extending from support **183** and is spring loaded so that the engaging end of the pawl is held in position against the teeth of the ratchet **190**. The pawl **215** serves to hold the ratchet in its new position each time the pawl **192** returns to its original position when the carriage moves to the right and the roller **195** becomes disengaged with the cam **200**. Thus, for each movement of the carriage to the left and return the ratchet is moved one notch and the racks **173** and **174** are moved outwardly a short distance, for example, 1/16 to 1/4 inch.

The operation of the winder with respect to the oscillation of the carriage **50** and collet **29** is now described. The solenoid valve **135** controls the operation of air valve **68** to control whether or not the carriage **50** returns to and remains in its innermost starting position or whether it oscillates between positions spaced outwardly from the innermost starting position. When the solenoid valve **135** is closed, the line **166** connecting passage **168** to poppet valve **164** is closed and no air can escape from end section **151** whether the poppet valve **164** is open or not. If the carriage **50** is in its innermost position and the solenoid valve **135** is closed, the carriage will stay in that position. When the carriage is in the innermost position, the rack **174** holds the poppet valve **164** open; however, the carriage **50** cannot move forward until the solenoid valve **135** is open so as to connect the end section **151** with the poppet valve **164** through line **166**. The various valves and pistons in the pneumatic system are shown in FIG. 6 in their position at start-up with the piston **61** in the cylinder **64** being in the first or innermost position indicated adjacent the cylinder **64**.

As established in the above description of the electrical diagram in FIG. 10, the collet starts to rotate and the stand initially formed is wound at the end of the collet for a time interval until the collet gets up to the desired winding speed. After this interval, the normally open contact **1TR-1** closes to energize solenoid **SV-1** of the solenoid valve **135**. The solenoid valve **135** opens and exhaust line **166** is now open to poppet valve **164**. The balanced condition of air valve **68** is upset and the spool **145** and slide valve **155** move to reverse the flow of air through lines **65** and **66** to the cylinder **64** and cause the piston **61** and carriage **50** to move forward.

As the carriage **50** approaches its outermost position, the rack **173** engages poppet valve **163** to exhaust air through line **165** from end section **150** of chamber **142** and unbalance the valve **68**. The spool **145** and slide valve **155** are moved to their alternate positions and the flow of air in lines **65** and **66** to the cylinder **64** is again reversed to stop the carriage at the outermost position and reverse its movement. A similar procedure is followed when the rack **174** engages poppet valve **164** on the return motion of the carriage and the carriage is stopped and reversed at a third position intermediate the first (innermost) and second (outermost) positions.

The balancing and unbalancing of the air valve **68** causes the carriage **50** and collet **29** to move automatically slowly back and forth through distances as determined by the engagement of the racks **173** and **174** with the poppet valves **163** and **164** respectively. Since the racks are extended with each movement of the carriage back and forth on the base, they strike the poppet valves **163** and **164** sooner with each pass than in the preceding pass. This results in each succeeding layer of strand wound on the forming package terminating slightly inwardly in an axial direction from the end of the preceding layer. The buildup of the layers **220** of strand is shown in FIG. 15.

FIG. 15 is an elevation partly in section showing diagrammatically how a strand, such as a 400 filament, 150 strand, is built up in superposed layers **220** on the forming tube **28**. Each layer **220** is deposited in the form of a filling wind with the strand being laid down with a very slight traverse from cam **35** and with the layer being first formed at one end of the tube and progressing slowly to the other end by virtue of the relatively slow axial movement, i.e., about 50 to 150 inches per minute, of the collet with respect to the cam **35**. The strand is wound around the forming tube in small helixes so that generally each turn of the strand is parallel to the preceding turn with the exception that the strand describes a very flat sine wave, i.e., 1 to 10 degrees at the point of crossover, as imposed by the low amplitude, high frequency action of cam **35**. The axial movement of the collet is slow enough with respect to the rotation of the collet that the strand is deposited upon itself in each layer to a thickness of about 4 to 8 strand diameters.

The movement of the collet causes the leading edge of the layer A to be built up at an angle α to the surface of the forming tube, i.e., about 10 to 20 degrees as measured in a plane parallel to and containing the axis of the collet. At the end of a layer this angle α is steeper as the collet pauses prior to starting on the return trip. As the strand transfers from one layer (A) to the next (B), it passes several times around the tube in first the end of layer A and then in the beginning of the next layer B. As the collet starts back in the opposite direction, the leading edge of the next layer (B) is sloped in the opposite direction at the same angle β to the surface of the forming tube as the preceding layer. Each layer at the end where the last strand is laid down as contrasted to the end where the new layer begins terminates short of the end of the preceding layer.

It is desired that the diameter of the fibers in the strand formed in each of the succeeding layers **220** in the forming package be the same. It can be seen that in forming package **222** each succeeding layer increases the diameter of the package and thus increases the attenuating speed of the fibers if the r.p.m. of the collet is maintained constant. This increase in diameter in the forming package can

be compensated for by increasing the temperature of the bushing during the fiber forming run and/or reducing the r.p.m. of the collet. Both of these methods will be discussed.

In FIGS. 16 and 17 a means for increasing the bushing temperature stepwise with the formation of each layer is shown. This means is described in conjunction with FIG. 12. Mounted on the base **47** are two limit switches **233** and **234**. These limit switches are mounted in line with the poppet valves **163** and **164** with limit switch **233** being mounted on the base just inboard of poppet valve **163** so that rack **173** strikes the limit switch **233** shortly before it strikes the poppet valve **163** and with limit switch **234** being mounted on the base just inboard of poppet valve **164** so that rack **174** strikes the limit switch **234** just before it strikes the poppet valve **164**. The limit switches **233** and **234** are located in suitable circuits for either changing the bushing temperature or the r.p.m. of the collet motor.

FIGS. 16 and 17 show circuits for increasing the bushing temperature with the completion of each longitudinal movement of the carriage so that each succeeding layer on the forming package will be wound at the same effective attenuating speed so as to produce the same diameter fiber. An electrical power circuit containing suitable controls for supplying energy to the bushing **18** is shown in FIG. 16. The power circuit includes a saturable core reactor **236** in series with a power transformer **238** for the bushing **18**. The bushing terminals **24** connect the bushing **18** in series with the secondary winding **240** of the transformer **238**. The primary winding **242** of the transformer **238** is connected in series with the saturable core reactor **236** and the series circuit is connected through contacts **243** of a line circuit breaker to a suitable power line source, L_3, L_4, such for example as a 440 volt, 60 cycle line.

The current regulating controls for the power circuit may be provided by a conventional temperature measuring and regulating unit **245** which is arranged to operate in conjunction with a thermocouple **246** which is in thermal contact with the bushing **18**. The unit **245** measures the temperature of the bushing **18** by means of the thermocouple **246** and indicates the temperature signal at a meter **247** provided with means for presetting the temperature desired. As the temperature signal fed to the unit **245** varies from a preset value, the unit functions to supply a corrected signal to the power circuit by way of the saturable reactor to establish the heating current flow to the bushing for the temperature desired.

The unit **245** receives in addition to the signal from the thermocouple **246** an auxiliary signal from a variable resistance unit **248** which in effect causes a false signal to be supplied to the temperature regulating unit **245**. The increase in temperature of the bushing is accomplished by supplying a false temperature signal to the temperature regulating unit **245** from the variable resistance unit **248** along with the actual temperature signal supplied by the thermocouple **246**. The variable resistance unit **248** is connected to the regulating unit **245** in series with the thermocouple **246** and is so arranged that an increase in the signal from the unit **248** causes a decrease in the total signal so as to indicate falsely to the temperature regulating unit **245** that the temperature of the bushing **18** is falling. The temperature regulator unit **245** then sends an increased current signal to the saturable core reactor which reduces the inductive reactance of the reactor and permits more current to be supplied to the transformer **238** and consequently more current to the bushing **18**.

The variable resistance unit **248** is shown in FIG. 17 in more detail in combination with the temperature regulating unit **245**, thermocouple **246** and bushing **18**. Electrical energy for the false signal generated by the resistance unit **248** is supplied over suitable power lines of an alternating current source L_5, L_6. This energy is supplied to a rectifier **250** which provides a constant direct current reference voltage for the false signal circuit. The direct current portion of the variable resistance unit circuit contains rheostats **252**, **254** and **256** from the positive side of the rectifier. Rheostat **252** is used to control the current supplied to potentiometer connected rheostat **254** and rheostat **256** is used to control the rate of temperature change. The rheostat **254** is mechanically changed by a spring biased ratchet **260** which is driven by pawl **262** in stepwise fashion so as to derive a variable voltage which can be used to pass current through a resistance **263** which is in series with the thermocouple **246** and temperature regulating unit **245**.

The pawl **262** is spring loaded so as to be normally out of contact with ratchet **260**. The pawl **262** is actuated by coil **264** to move against the teeth of ratchet **260** to rotate it. The coil **264** is in series with limit switches **233** and **234** (which are in parallel with each other) and with normally open contact **2M–2**. Contact **2M–2** is closed as solenoid valve **135** is opened and the collet begins to move out from the home position. Thereafter, each time either of the limit switches is closed by racks **173** and **174**, the pawl **262** steps up ratchet **260** and the rheostat **254** is changed stepwise for each axial movement of the collet. A spring biased pawl **266** is normally engaged with ratchet **260** to keep the ratchet from returning to its original position as pawl **262** retracts each time. The pawl **266** is disengaged from the ratchet by coil **270** which is in series with normally open contact BC–2. Contact BC–2 is normally open but is closed when brake contactor BC is energized to stop the collet motor **70**. When contact BC–2 is closed, coil **270** is energized, pawl **266** is retracted and ratchet **260** returns to its original position. Ratchet **260** is ready for another fiber-forming run when coil **270** is deenergized and pawl **266** again engages the ratchet.

The circuit just described produces a stepwise varied current through a low value resistance **263** connected in series with the bushing thermocouple. The current flowing through the resistance **263** produces the false temperature supplied to the temperature regulating unit. It can be readily understood that a conventional stepping switch and a series of fixed resistors can be employed in place of the ratchet **260**, pawls **264** and **266** and potentiometer connected rheostat **254**.

In FIG. 18 there is shown a diagrammatic view of an electrical control means for varying the speed of the collet motor while maintaining the bushing temperature constant in order to compensate for the increase in diameter of the forming package. This is an alternative to the control means shown in FIGS. 16 and 17. In the control means shown in FIG. 18 there is a reference signal generating unit which supplies a speed command signal to a conventional adjustable speed drive power and control unit which in turn controls the speed of the collet motor. The speed of the motor is modified by the power and control unit to be directly proportional to the reference signal. The reference signal generating unit is adjusted to produce a signal and determines the speed of the collet motor at the beginning of the fiber forming run. This signal is decreased stepwise during the run in response to the limit switches **233** and **234**.

A direct current reference source **280** produces a constant voltage from power lines L_7, L_8. The reference voltage causes a current to flow through a voltage divider network composed of rheostats **282** and **284** and pawl driven potentiometer rheostat **286** in series with each other. A rheostat **288** is in parallel with rheostat **286** and in series with rheostats **282** and **284**. Rheostats **282** and **284** are positioned in tandem with a common adjustment shaft so that as the resistance of one is increased, the resistance of the other is decreased, and vice versa, so that their total resistance remains constant. These rheostats fix the speed of the motor at the beginning of the run. Rheostat **288** controls the extent to which the

speed of the collet can be reduced during the run. Rheostat **286** controls the actual speed of the motor and is driven by a ratchet and pawl arrangement (not shown) in combination with limit switches **233** and **234** in the same manner as described above with respect to ratchet **260** and pawls **262** and **270** in FIG. 17.

The speed reference signal between the brush contact of the rheostat **286** and the negative reference source line is compared to the speed feed-back signal from a tachometer generator **290** that is driven from the collet motor **70** and the difference or error signal is fed to a conventional adjustable speed drive power unit **292** to control the speed of the motor.

The winder as above described automatically produces longer and larger forming packages for a given size winder than heretofore possible. These packages can be formed with a maximum degree of fiber forming efficiency, i.e., a minimum number of break-outs or discontinuances during a plurality of fiber forming runs. The larger forming packages permit more economic fiber forming operations since the winders run for longer periods of time, thereby reducing the total amount of down time between fiber formnig runs during a given period of time, such as an eight-hour shift period. The forming packages are composed of continuous strand made up of fibers of substantially uniform diameter throughout the package. The end of the strand can be easily found at that point in the outermost layer of strand where the fiber forming operation ended. The strand can be unwound over end from the longer forming package without undue creation of fuzz or strand breakage. A plurality of splice-free twisted yarn packages can be produced from the larger forming packages. For example, two 4½ pound packages of twisted yarn can be produced from a 9 pound forming package.

Various additions or modifications to the winder as described in FIGS. 1 to 18 above can be made. For example, when the winder is employed in a single-level process, it is desirable as described above that the angle which the strand **30** describes in its passage from the guide **32** to the cam **35** be kept as small as possible. The reasons for this is that as the angle ϕ increases, the tension and friction on the strand **30** increases as it passes through the guide **32**. This is illustrated in FIG. 19. The greater the tension and friction on the strand **30**, the greater the tendency for an individual fiber **26** in the strand to break and thereby break out the whole strand and discontinue the fiber drawing operation. In order to keep the angle ϕ at a minimum therefore, the guide **32** (and the coating applicator **33** when employed) can be mounted on a support **300** which is rigidly attached to the reciprocating plate **87** which supports the cam **35**. This causes the guide **32** and the applicator **33** to reciprocate in a line parallel to the axis of cam **35** and in unison with the cam **35**. If no size is applied to the individual fibers **26**, or if the size is applied by means of a saturated felt pad which is mounted in the guide **32**, it is necessary only to reciprocate the guide **32** in conjunction with the cam **35**. The reciprocation of the guide **32** (and applicator **33** when employed) is desirable in a one-level process but may be omitted in a two-level process where the angle ϕ is usually much smaller due to the greater distance between the guide **32** and cam **35** than in the one-level process.

The winder as described may also be modified by omitting the rack and pinion arrangement shown in FIGS. 12 to 14 for progressively shortening the length of travel of the carriage **50** and forming tube **28**. In such case the rack and pinion elements are replaced by a single bar of fixed length so that the ends of the bar strike the poppet valves **163** and **164** at the same point for each reciprocation of the carriage **50** and thereby cause the carriage to move the same distance on each reciprocation. In such case the cam **35** can be modified so that the groove **38** covers a longer distance along the surface of the cam in an axial direction, thereby increasing the throw of the traverse to say, for example, 3 inches. In such case the package formed on the forming tube resembles the outline of a barrel with the package gradually tapering from a minimum thickness at the ends to a maximum thickness toward the center. The forming package produced by this modification of the winder differs from that shown in FIG. 15 in that it has a much shorter flat outer surface in its central portion, said surface being parallel to the surface of the forming tube, and the taper at the ends of the package is more gradual.

In FIG. 20 there is shown another embodiment of the invention wherein the forming package such as shown in FIG. 13 can be produced. In this embodiment of the invention, the rack and pinion device shown in FIGS. 10, 11 and 12 for progressively shortening the reciprocating distance of the carriage **50** is omitted so that the carriage travels through the same distance with each reciprocation. Instead, the inclined plane cam **100** is adapted with a similar rack and pinion device so that its angle with the horizontal is gradually decreased with each succeeding reciprocation of the carriage until the inclined plane is horizontal. As the inclined plane decreases in its angle to the horizontal, it can be seen that the axial distance through which the cam **35** reciprocates is progressively lessened. This achieves the same effect as shortening the distance of reciprocation of the carriage **50** while maintaining the angle of the inclined plane cam **100** constant as shown in FIGS. 1 to 12.

As shown in FIG. 20 the inclined plane is pivotally mounted to the upright portion **75** of the carriage **50** at point **310**. The inclined plane is urged upwardly to its maximum angle as permitted by the rack **312** by means of rack spring **315**. With each forward travel of the carriage **50**, a cam follower **316** on the lower end of a lever **317** is contacted by a ratchet cam **318** mounted rigidly on the upright support **85**. The lever **317** is pivotally mounted near its center on a rotatable, horizontal shaft **319** which is mounted for rotation in a block **320** mounted on the upright support **75**. The lever **317** is held in a generally vertical position by spring **322** which is fastened at one end to the upper end of the lever **316** and at its other end to a pin **324** rigidly attached to the block **320**. As the lower end of the lever **316** hits the ratchet cam **318**, a rod **326** is moved by the rearward movement of the lower end of the lever **316** so as to move the ratchet **328** in a counter-clockwise manner by means of pawl **330**. As the carriage **50** starts its rearward movement and the lower end of lever **317** disengages the ratchet cam **318** and returns to a normally vertical position, the pawl **334** holds the ratchet in the new position while the pawl **330** slides back to the next indentation in the ratchet.

The ratchet **328** is mounted on a shaft **336** which also has a pinion **337** mounted on it. The pinion **337** engages rack **312** to move the rack horizontally in the direction of its length. A roller **338** is mounted on the rear end of the rack **312** so that it projects horizontally from the rack through a slot **339** in upright flange **340** of an angle iron **341** into a slot **342** in cam **343**. The slot **342** extends along the length of the cam in a direction which is parallel to the guiding surface of the cam **343**. The slot **339** guides the roller **338** on the end of the rack **312** through a fixed horizontal path.

As the shaft **336** is rotated by the rotation of the ratchet **328**, the pinion **337** rotates thereby moving the rack **312** forward (to the left in the drawing) which in turn pivots the forward end of the inclined plane downwardly to reduce the angle of the inclined plane guiding surface with a horizontal plane. The angle of the inclined plane guiding surface with a horizontal plane can be reduced to zero for the last reciprocating movement of the carriage **50** during the fiber forming run. As the rack **312** moves forward during the run, the rack spring **315** is compressed. At the end of the run when the carriage returns to its innermost, starting position, the pawls **330** and **334** are

engaged at their ends away from the projections of the ratchet respectively by means of stops **348** and **349** thereby disengaging the pawls from the ratchet. When the pawls are disengaged from the ratchet, the compressed rack spring **315** expands to move the rack rearwardly. As the rack moves rearwardly, the shaft **336** rotates back to its original position and the inclined plane cam **343** is raised to its original position.

Although the present invention has been described with respect to specific details of certain embodiments thereof, such details are not to be considered as limitations upon the scope of the invention except insofar as set forth in the accompanying claims.

This application is a continuation-in-part of my copending application Serial No. 35,643 filed June 13, 1960, now abandoned.

I claim:

1. Apparatus for winding a strand which comprises a cylindrical winding tube, means for rotating the tube about its axis, means for reciprocating the tube in an axial direction, a strand traverse positioned adjacent the tube, means for actuating the traverse, and means for reciprocating the traverse in a line which is parallel to the axis of the tube and in a direction which is opposite to the direction of movement of the tube during its reciprocation.

2. Apparatus for winding a strand which comprises a cylindrical winding tube, means for rotating the tube about its axis, means for reciprocating the tube in an axial direction, a strand traverse positioned adjacent the tube, means for actuating the traverse, and means for reciprocating the traverse in a line which is parallel to the axis of the tube in a direction which is opposite to the direction of movement of the tube during its reciprocation, said traverse reciprocating means being responsive to the reciprocating movement of the tube reciprocating means.

3. Apparatus for winding a strand which comprises a cylindrical winding tube, means for rotating the tube about its axis, means for reciprocating the tube in an axial direction, a strand traverse positioned adjacent the tube, means for actuating the traverse, means for reciprocating the traverse in a line which is parallel to the axis of the tube and in a direction which is opposite to the reciprocating movement of the rotating tube and means for progressively shortening the distance of the reciprocatory movement of the tube during the winding process.

4. Apparatus for winding a strand which comprises a cylindrical winding tube, means for rotating the tube about its axis, means for reciprocating the tube in an axial direction, a strand traverse positioned adjacent the tube, means for actuating the traverse, means for reciprocating the traverse in a line which is parallel to the axis of the tube and in a direction which is opposite to the reciprocating movement of the rotating tube and means for progressively shortening the distance of the reciprocatory movement of the travers during the winding process.

5. Apparatus for winding a strand which comprises a strand guide, a cylindrical winding tube, means for rotating the tube about its axis, means for reciprocating the tube in an axial direction, a strand traverse positioned adjacent the tube, means for actuating the traverse, means

for reciprocating the traverse in a line which is parallel to the axis of the tube and in a direction which is opposite to the reciprocating movement of the rotating tube, and means for reciprocating the guide in a line which is parallel to the axis of the tube in a direction and through a distance which is similar to the reciprocating movement of the traverse.

6. Apparatus for forming a strand of glass fibers which comprises a container for holding a supply of molten glass and means for drawing a plurality of glass fibers from the container including a guide for grouping the fibers into a strand, a cylindrical winding tube, means for rotating the tube about its axis, means for reciprocating the tube in an axial direction, a strand traverse mechanism positioned adjacent the tube, means for actuating the traverse, and means for reciprocating the traverse in a line which is parallel to the axis of the tube and in a direction which is opposite to the reciprocating movement of the rotating tube.

7. Apparatus for forming a strand of glass fibers which comprises a container for holding a supply of molten glass and means for drawing a plurality of glass fibers from the container including a guide for grouping the fibers into a strand, a cylindrical winding tube, means for rotating the tube about its axis, means for reciprocating the tube in an axial direction, a strand traverse mechanism positioned adjacent the tube, means for actuating the traverse, and means for reciprocating the traverse in a line which is parallel to the axis of the tube and in a direction which is opposite to the reciprocating movement of the rotating tube, said traverse reciprocating means being responsive to the tube reciprocating means.

8. Apparatus for forming a strand of glass fibers which comprises a container for holding a supply of molten glass and means for drawing a plurality of glass fibers from the container including the guide for grouping the fibers into a strand, a cylindrical winding tube, means for rotating the tube about its axis, means for reciprocating the tube in an axial direction, a strand traverse positioned adjacent the tube, means for actuating the traverse, means for reciprocating the traverse in a line which is parallel to the axis of the tube and in a direction which is opposite to the reciprocating movement of the rotating tube, and means for progressively shortening the relative reciprocating motion between the tube and the traverse during the winding process.

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