Sept. 10, 1968 A. R. PARILLA ETAL 3,400,901

WINDING APPARATUS FOR FORMING FILAMENT WOUND OBJECTS

Filed Nov. 8, 1965 2 Sheets-Sheet 1

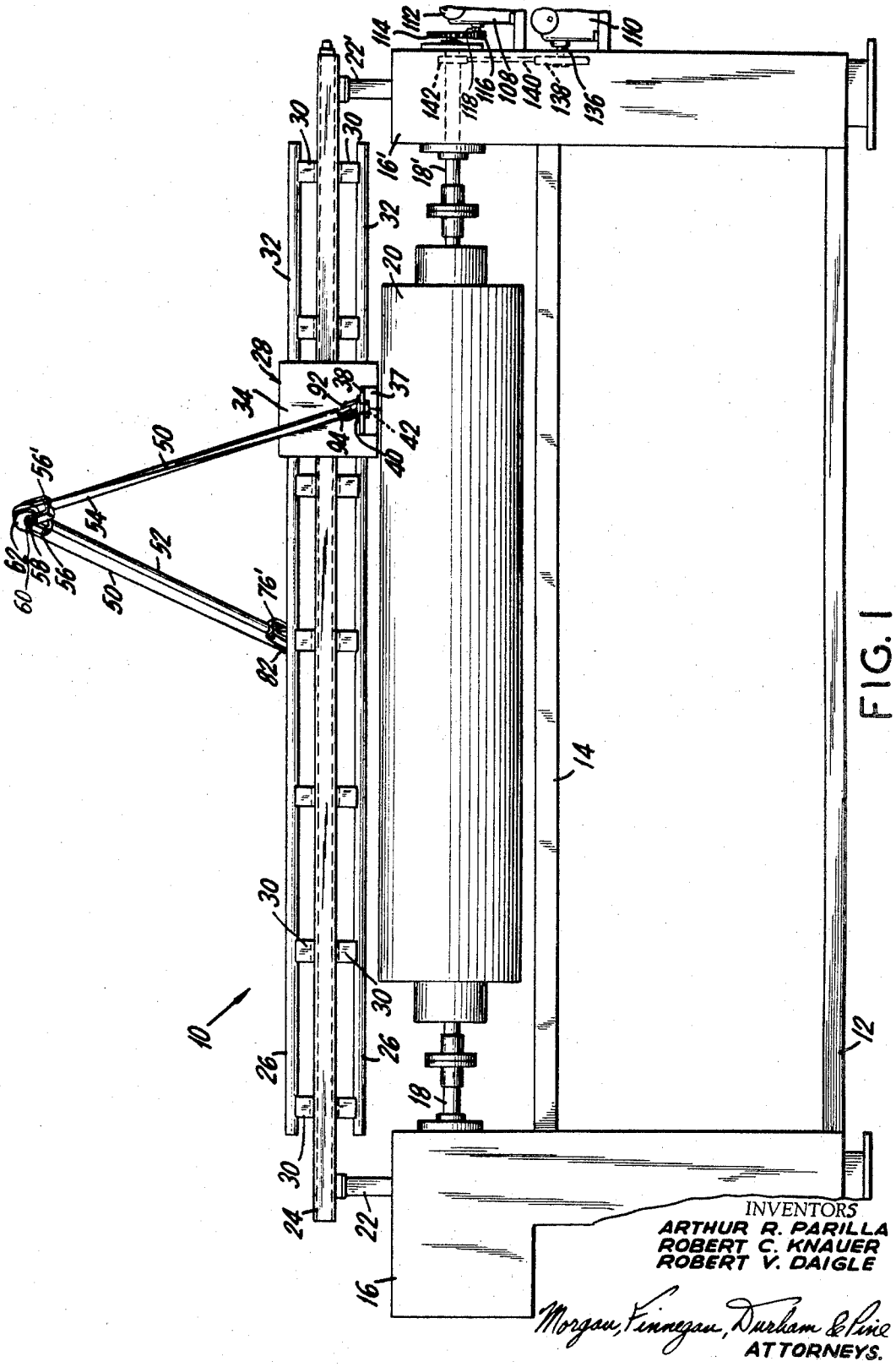

FIG. 1

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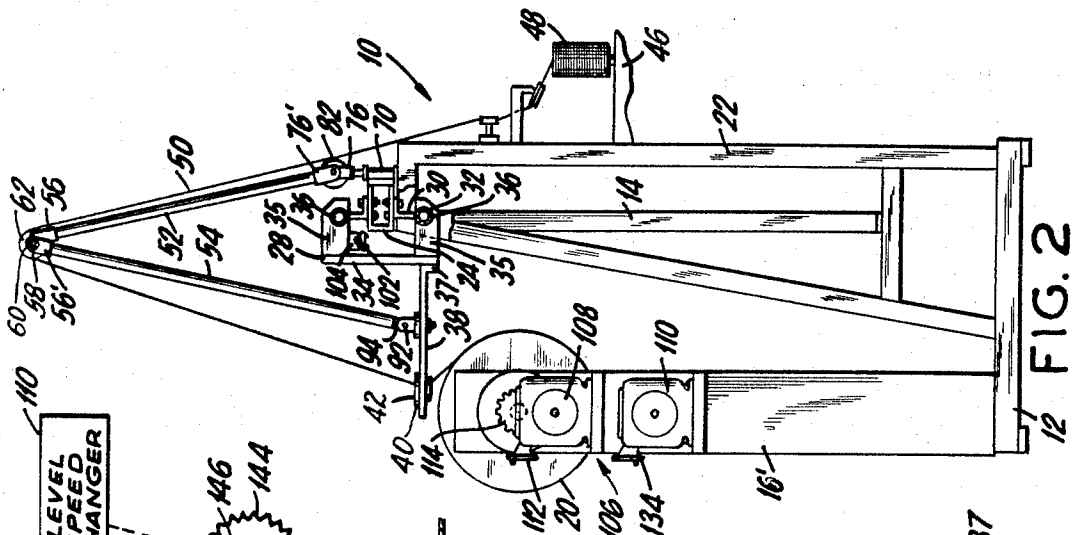

FIG. 2

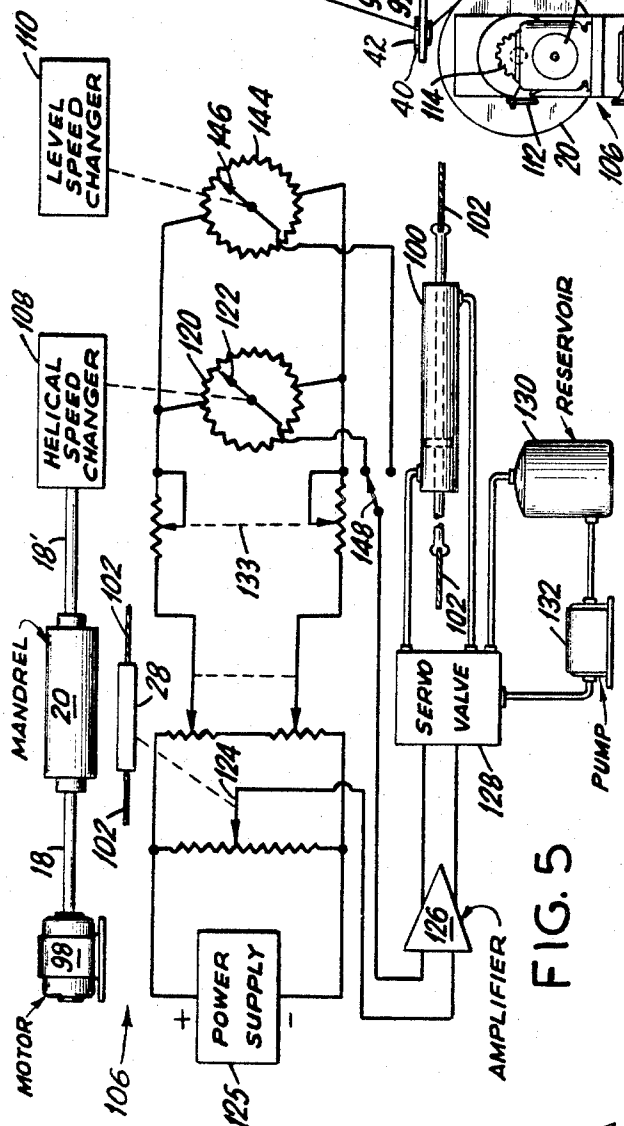

FIG. 5

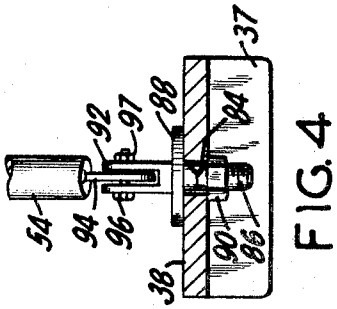

FIG. 4

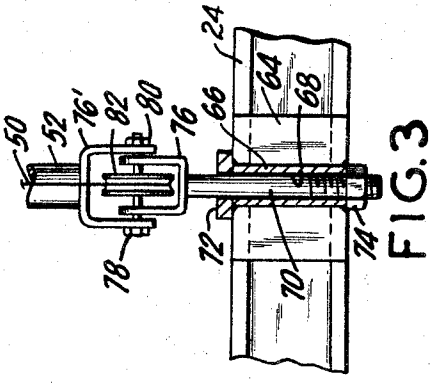

FIG. 3

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3,400,901

WINDING APPARATUS FOR FORMING FILAMENT WOUND OBJECTS

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15 Claims. (Cl. 242—158)

ABSTRACT OF THE DISCLOSURE

This invention relates to a winding machine for forming filament wound objects comprising a rotatable mandrel adapted to receive filament which forms the object and a reciprocating carriage for movement along the mandrel to deliver filament thereto. First circuit means are provided to generate a first electrical signal as a function of the mandrel position and second circuit means for generating a second electrical signal as a function of the carriage position. The electrical signals are combined to produce a resultant control signal which operates means for controlling the movement of the carriage to achieve the relative movement between the carriage and mandrel which produce the desired filament wound object.

This invention relates to a method of and apparatus for winding filament and, more specifically, to an improved control system for depositing filament upon a mandrel in a highly selective and controlled pattern, and which provides an improved filament feeding system that maintains controlled tension upon the filament as it is being wound to form various objects.

Many varied types of objects or articles, such as containers and missile components, are now formed by wound filaments. In a common type of filament winding machine used for this purpose, a mandrel having the desired shape of the article is held between two spindles and rotated. At the same time a carriage having a filament feed eye reciprocates along the length of the machine parallel to the axis of rotation of the mandrel, delivering filament or roving that is wrapped around the mandrel either helically or circumferentially or a combination of both.

The filament, usually fiberglass yarn or roving, is supplied as a wrapped package in cylindrical form, called a "ball" or "spool." It is common practice to use several spools, thus laying down multiple filaments in one operation.

To insure that each roving is properly wound upon the mandrel, the tension during this operation must be carefully maintained and controlled. One apparent way of accomplishing this is to place each spool adjacent the carriage and reciprocate the combination together. The weight of each spool and associated tension, however, have been found to add considerable mass to that which must already be reciprocated. The added mass, in turn, has increased the inertia loads which are incurred upon reversing the carriage, to such an extent, that this method has been found to be generally unsatisfactory. Its only remaining use is possibly on very large machines. Moreover, space limitations further restrict this type of filament delivering system.

On the other hand, when the spools are positioned at a point spaced from the carriage and fixed relative to the reciprocating movement other problems have arisen. In particular, the rate at which the filament is paid out is due to two variables: (1) the velocity at which the filament is deposited on the mandrel; and (2) the carriage position. When the carriage position is directly opposite the fixed point from which this filament is supplied, the distance to the feed eye of the carriage is a minimum. As the carriage traverses the machine in a direction away from the fixed point, this distance increases, adding to the velocity of the filament pay-out. When the carriage reverses and moves back toward the fixed point, the velocity decreases, thereby creating an excess of filament which is relatively slack. With the desired tension thusly lacking, the filament is not laid upon the mandrel in the desired manner necessary to properly form the article.

In winding the filament upon the mandrel under controlled tension, the movement of the mandrel and carriage must also be coordinated to lay down the proper filament pattern. For this purpose previous machines for filament winding have employed mechanical drives, as illustrated for instance in Patent No. 2,837,456. This comprises an electric motor which drives the mandrel, and by means of a bevel gear drive, transmits power to a jack shaft. A chain and sprocket drive then reciprocates the carriage through a scotch yoke on the carriage. A double planetary gear system is also required between the bevel gear and the chain and sprocket drive to provide a speed ratio only slightly different from unity so as to displace the winding pattern one band width to provide uniform coverage of the mandrel.

It is necessary to perform tedious engineering calculations for the required gear ratios, and to provide new gears, sprockets, etc. each time a mandrel of different geometry is to be wound. This greatly increases cost and set-up time. Also, fixed gearing cannot readily correct for small discrepancies in mandrel fabrication.

This invention overcomes the difficulties previously mentioned by providing a filament winding machine comprising a moveable mandrel upon which is wound filament, a carriage for delivering the filament to said mandrel, and drive means operatively connected to the mandrel and the carriage for maintaining the necessary speed ratio therebetween for forming the filament wound object as well as for adjusting the speed ratio at any time during the operation without causing any delay in the winding of the filament. Moreover, the same drive means is used irrespective of the mandrel employed in forming the object. In addition, the filament is maintained under the desired tension as it is being wound upon the mandrel by feeding the filament from a source to the carriage which moves relative to said source, and maintaining the distance the filament must travel from the source to the mandrel constant irrespective of the movement of the carriage. By so doing the tension of the filament is always constant, even when the carriage is reversed. Accordingly, no excess filament accumulates and the desired tension is therefore maintained throughout the cycle.

Thus, the present invention provides an instantaneous, infinitely variable drive means for the mandrel and the carriage, and at the same time, maintains the filament under the desired tension.

In the preferred embodiment of the invention, a filament winding machine having a rotatable mandrel, a carriage having a filament feed eye and reciprocating along the length of the machine parallel to the axis of rotation of the mandrel, is provided with drive means comprising a variable speed motor for rotating the mandrel, first circuit means connected to the mandrel providing a first electrical signal as a function of the mandrel position, a hydraulically operated double acting piston for reciprocating the carriage, second circuit means connected to the carriage providing a second electrical signal as a function of the carriage position, and servo means connected to the hydraulically operated piston and responsive to said electrical signals for controlling the movement of said carriage to achieve the relative motion between said carriage and mandrel required to form the desired filament wound object.

The accompanying drawings referred to herein and constituting a part hereof, illustrate one embodiment of the invention, and together with the description, serve to explain the principles thereof.

FIGURE 1 is a front elevation of a filament winding machine including the filament delivering system of the present invention;

FIGURE 2 is a side elevation of the filament winding machine including the filament delivering system of the present invention shown in FIGURE 1;

FIGURE 3 is a detailed view, partially in section, of the connection between the filament winding machine frame and the articulated linked assembly of the present invention;

FIGURE 4 is a detailed view, partially in section, of the connection between the carriage and the articulated linked assembly of the present invention;

FIGURE 5 schematically shows the infinitely variable speed drive of the present invention.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and are not restrictive of the invention.

In accordance with the present invention there is shown in the drawings a filament winding machine **10** including a base **12**, an upright frame **14**, secured to the base **12**, and a pair of upright pedestals **16** secured to the base **12** spaced from opposite ends of the frame **14**. Extending from each pedestal **16** and **16'** are rotatable spindles **18** and **18'** adapted to engage one end of a mandrel **20** for rotation in a conventional manner therewith. The mandrel **20** has the shape of the product to be formed and is preferably collapsible or dissolvable.

The frame **14** includes a pair of supports **22** and **22'** at its opposite ends which are welded to the base **12**. Welded to the supports **22** and **22'** is a channel **24** positioned slightly above and spaced from the mandrel **20**.

Welded to the top and bottom of the channel **24** are a pair of tracks **26** upon which a carriage **28** is slidably mounted. Each track **26** includes a plurality of L-shaped brackets **30** bolted to the channel **24** and a pair of shafts **32** bolted to the vertical leg of the brackets **30**.

The carriage **28** includes a vertical plate **34** from which laterally and rearwardly depend support members **35**. The members **35** each have a groove **36** therein which cooperates with a track shaft **32** for reciprocating the carriage **28** therealong. Bolted to the front face of the carriage **28** is an L-shaped bracket **37** with an elongated leg **38** extending partially over the mandrel **20**. At the forward end of the leg **38** is a carriage feed eye **40** having a bore **42** therethrough over the mandrel **20**.

Extending from the rear of the machine **10** is a shelf **46** having an upright shaft (not shown) upon which a spool **48** of roving or filament **50** is rotatably mounted. In practice as the carriage reciprocates on the tracks **26**, the spool **48** rotates about the shaft (not shown), delivering filament **50** to the mandrel **20** through the carriage feed eye **40**. Thus, the position of the spool **48** is fixed relative to the reciprocating movement of the carriage **20**. However, the distance the roving **50** travels is maintained constant by feeding it from the spool **48** over a pair of articulated linked tubes **52** and **54** which will be presently described. Although for simplicity only one spool is shown, it is to be understood that several spools can be similarly mounted on the shelf **46** and simultaneously fed over the linked tubes **52** and **54**. In such case multiple rovings are wound upon the mandrel **20** at the same time.

The linked tubes **52** and **54** are pivotally connected to each other above the frame **14** by overlapping U-shaped brackets **56**, **56'** secured to adjacent ends of the tubes. The brackets **56**, **56'** articulate about a bolt **58** which extends through bores (not shown) in the legs of the brackets **56**, **56'** and which is threaded at one end to receive a nut **60**. To facilitate movement of the filament **50** over the tubes **52** and **54**, a pulley **62** for each spool **48** is rotatably mounted on the bolt **58** within the brackets **56**, **56'**.

The tube **52** is swivelly connected to the frame **14** adjacent the spool **48** as shown in FIGURE 3. A plate **64** is welded to the rearwardly extending legs of the channel **24** adjacent the spool **48**. Welded to the plate **64** is a bearing member **66** having a bore **68** therethrough. Journaled in the bore **68** is a rotatable shaft **70** that also extend above the frame **14**. To maintain the shaft **70** within the bore **68**, a collar **72** on the shaft **70** rests atop the member **66**. In addition, the lower end of the shaft **70** extends through the bore **68** and is threaded to receive a nut **74**.

Secured to the upper end of the shaft **70** above the frame **14** is a U-shaped bracket **76**. Secured to the lower end of the tube **52** is a corresponding U-shaped bracket **76'** that overlaps the shaft bracket **76**. As before, a bolt **78** extends through bores (not shown) in the legs of the brackets **76**, **76'** and is threaded to receive a nut **80**. Moreover, a pulley **82** for each spool **48** is rotatably mounted on the bolt **78** within the brackets **76**, **76'**.

The lower end of the tube **54** is connected to the carriage **28** as shown in FIGURE 4. Extending through the carriage bracket leg **38** adjacent the feed eye **40** is a bore **84**. Journaled in the bore **84** is a rotatable shaft **86** which extends above the carriage leg **38**. To maintain the shaft within the bore **82** a collar **88** on the shaft **86** rests atop the carriage leg **38**. In addition, the lower end of the shaft **86** extends through the bore **84** and is threaded to receive a nut **90**. The end **92** of the shaft **84** above the carriage leg **38** is bifurcated. Slidably fitted within the bifurcated end **90** is a reduced end portion **94** of the lower end of the tube **54**. A bolt **96** extends through bores (not shown) in the interconnecting ends **90**, and is threaded to receive a nut **97**.

Referring now to FIGURES 1 and 2 for the operation of the machine **10**, the filament **50** is fed from the spool **48** to the mandrel **20** over the articulated tubes **52**, **54** and pulleys **62**, **82** and through the carriage feed eye **40**. The height of the tubes **52** and **54** above the carriage **28** will be at its maximum when the carriage **28** is directly opposite the spool **48**, which in this embodiment is the middle of the mandrel **20**. Correspondingly, this height will be at a minimum whenever the carriage is at the ends of the mandrel **20**.

The starting position of the carriage **28** may be at any point along the mandrel **20**. In the position shown in FIGURE 1, the carriage is moving away from the spool **48**, delivering filament **50** to the mandrel **20** through the feed eye **40**. In so doing the linked tubes **52** and **54** are lowered, pivoting about their brackets **56**, **56'** and swiveling as a unit with their shafts **70** and **86**.

The carriage **28** will continue to be moved away from the spool **48** until it reaches the end of the mandrel **20**, and will then be reversed, moving back toward the spool **48** and finally to the opposite end of the mandrel **20**. In moving back the lowered linked tubes **52** and **54** are raised until the carriage **28** is opposite the spool **48** and then they are again lowered as the carriage **28** moves to the opposite end of the mandrel **20**. In so doing, the linked tubes **52** and **54** pivot about their brackets **56**, **56'** and swivel as a unit with their shafts **70** and **86**, respectively.

This operation is then repeated until the desired object is formed upon the mandrel **20**. During the entire operation, the filament **50** is fed over the links **52** and **54** and therefore will always travel a constant distance despite the constantly changing distance between the spool **48** and carriage **20**. Inasmuch as the distance the filament **50** must travel is always constant, its velocity remains constant throughout the cycle. Accordingly, there is no slack in the filament **50** at any point in the cycle that will cause it to be improperly wound upon the mandrel **20**.

The drives for the mandrel **20** and carriage **28** are schematically shown in FIGURE 5. The mandrel **20** is

rotated by a variable speed motor **98** housed in the pedestal **16** adjacent the spindle **18**. The carriage **28** is reciprocated by a hydraulically operated double acting piston **100** connected thereto by a cable **102**. The piston **100** is suitably mounted within the frame **14**. The cable **102** is secured to the carriage by a jig **104** bolted to the upper member **36**, as shown in FIGURE 2.

For properly synchronizing the reciprocation of the carriage **28** with the rotation of the mandrel **20**, an infinitely variable speed drive **106** is connected therebetween as shown in FIGURES 1 and 5.

Referring first to FIGURE 1, the infinitely variable drive **106** includes a pair of manually adjustable variable speed changers **108** and **110** connected to the mandrel spindle **18'** which extends through the pedestal **16'** for this purpose.

The upper variable speed changer **108** is for varying the helix angle of the filament windings, preferably from about 3° to 80°, by selective movement of a manual adjuster **112**. This changer **108** is connected to the spindle **18'** by intermeshing gears **114** and **116** secured to the ends of the spindle **18'** and the changer shaft **118**, respectively.

Referring to FIGURE 5, the motor **98** drives the spindle **18**, **18'** and the mandrel **20**. This rotation is transmitted to the movable arm of an endless circular potentiometer **120** through the manually adjustable helical variable speed changer **108**. Impressed across the diameter of the potentiometer **120** is a DC voltage produced by a power supply **125** that preferably is a constant voltage source of low voltage.

At the same time the linear reciprocating movement of the carriage **28** is transmitted to the movable arm of a potentiometer **124** that is also connected to a power supply **125**. The potentials at the movable contacts of potentiometers **120** and **124** are then compared in the amplifier **126** which responds to the difference potential. The amplifier **126** in turn operates a servo-valve **128** which meters hydraulic fluid from a reservoir **130** and a pump **132** to either side of the double acting piston **100**.

The direction the piston **100** is moved depends on the polarity of the output signal developed by amplifier **126**. The system thus comprises a "servo loop" and the carriage **28** is made to reciprocate across the mandrel **20** by the rotation of the spindle **18**, **18'** as will now be explained.

The potentiometer **120** has a continuous winding around its circumference. A voltage from the supply **125** is then applied across its diameter. When this voltage is sensed by the arm of the potentiometer **120**, this voltage will be a linear function of the angular position of the arm. If this arm is driven at a constant rate of speed, as it is in this machine, the voltage on the arm will change from the maximum at the top terminal, to the minimum at the bottom terminal, and will then rise as the arm sweeps upward. The resulting voltage is therefore triangular in wave form having a period equal in time to one revolution of the potentiometer **120** and having an amplitude equal to the voltage applied across the input terminals of the potentiometer **120**.

Since a servo system embodies a command signal, and a follower signal, the voltage output from the carriage potentiometer **124** follows the voltage output from the mandrel potentiometer **120**. Each time the command signal reverses (as the arm reaches the extremities of the mandrel potentiometer **120**) the carriage travel must also reverse to follow.

In operation the servo-device continually moves the carriage **28** in an attempt to minimize the differential potential being fed to the amplifier **126**. Accordingly, the potentiometer arms will move across their respective potentiometers **120** and **124** in synchronism. The difference potential, or error signal, which determines the output signal provided to the servo valve **128** by the amplifier **126**, is caused by a slight lag by the arm of potentiometer **124** as it attempts to follow the arm of potentiometer **120**. When the carriage **28** begins to fall behind, there will be an increase in the differential voltage supplied to the amplifier **126**. This will cause the servo valve **128** to feed fluid from the reservoir **130** to the piston **100** thereby moving the carriage **28** at a greater rate until the desired relative speed is established. Correspondingly, when the carriage **28** begins to move too fast there will be a decrease in the differential voltage to the amplifier **126**. This will cause the servo-valve **128** to decrease the amount of fluid being fed to the piston **100**, thereby decreasing the rate of carriage movement until the desired relative speed is once again established.

In the embodiment shown in the drawings, the carriage **28** travels one complete cycle for each revolution of the potentiometer **120**. This occurs because the potentiometer **124** follows the potentiometer **120**. However, the desired speed ratio between the mandrel **20** and the carriage **28** is determined from the mandrel geometry. Thus, the number of revolutions of the mandrel **20** for one traverse (half cycle) of the carriage **28** depends upon the length of the mandrel **20**. For example, if the length of the mandrel **20** is doubled while maintaining its diameter and helix angle constant, the mandrel **20** must make more revolutions before the carriage **28** reverses. Therefore, the ratio between revolutions of the mandrel **20** and revolutions of the potentiometer **120** must also be doubled.

Since the potentiometer **120** is driven by an infinitely variable speed drive, it can accommodate any mandrel geometry within the machine specifications.

The variable speed drive **106** also serves another important function. When the winding pattern repeats, successive layers of the roving must be slightly displaced, i.e. one filament width, so as to provide uniform coverage over the circumference of the mandrel **20**. This incremental change in position of the roving with each successive filament winding requires changing the speed ratio either slightly more or slightly less than the ratio which would cause the roving to pile up on itself. With the present variable speed drive **106**, this can be done experimentally very conveniently, greatly reducing machine setup time for developing the pattern for a new mandrel geometry.

The potentiometer **133** is a manual control and together with the adjustment of the mechanical ratio of the changer **108** provides adjustment of the machine for the helix angle and for the span of the carriage motion. In practice the potentiometer **133** varies the applied voltage to the command poentiometer **120** while the voltage to the follower potentiometer **124** is held constant. In this way, if the command voltage span is small, the resulting carriage travel will be small, and if the command voltage span is made larger, the carriage span will be correspondingly increased.

When level (circumferential) windings are desired, the mandrel **20** must make many revolutions with a very slow advance of the carriage **28**. The speed ratio for level winding must then be very large compared to helical winding. While theoretically the same unit could be adjusted to provide the ratios, to obtain longer life and reliable operation it is preferred to provide a second speed changer **110** for level winding, as shown in FIGURES 1 and 5.

The lower variable speed changer **110** also has a manual adjuster **134** (FIG. 2), but this is for varying the circumferential filament windings, preferably from a lead of 0 inch per revolution of the mandrel to about 2 inches per revolution of the mandrel **20**. The changer **108** is connected to the spindle **18'** through its shaft **136** which extends into the pedestal **16'** and has a pulley **138** thereon for receiving a belt **140** that also goes about the pulley **142** mounted on the spindle **18'**. In the embodiment shown in the drawings, the step down ratio between the pulleys **138** and **142** is 20:1.

Rotation is transmitted through the level speed changer **110** to a potentiometer **144** in parallel with the potentiometer **120** used for helical windings which may range

from a helix angle of about 3° to 80°. As before, the potentiometer **144** has a DC voltage impressed across its diameter, and since it is a linear device, the output voltage appearing at the wiper contact **146** is an oscillating voltage of triangular shape.

The remaining portion of the servo device is the same as before, and it is connected to potentiometer **144** by a switch **148**. In practice, when a level winding is desired the switch **146** is moved out of contact with the wiper contact of potentiometer **120** for helical windings and into contact with the wiper contact of potentiometer **144** for level windings.

In some cases, it is desired to wind with alternating layers of helical and level windings. This can readily be done with the dual variable speed changers **108** and **110**, by just switching from a helical winding potentiometer **120** to the level winding potentiometer **144** through the switch **148**. In such instance the setting for each variable speed changer **108** and **110** is maintained throughout the winding operation, eliminating errors due to improper resetting of a single variable speed drive.

As before the manually adjustable potentiometer **133** can be used to vary the carriage span of the machine **10**.

The invention in its broader aspects is not limited to the specific embodiment herein shown and described but departures may be made therefrom within the scope of the accompanying claims, without departing from the principles of the invention and without sacrificing its chief advantages.

What is claimed is:

1. A winding machine for forming filament wound objects, comprising a rotatable mandrel adapted to receive filament which forms the object, a reciprocating carriage, means for delivering the filament to said mandrel wherein said carriage moves relative to said filament delivering means, means operatively connected between said delivering means and said carriage for feeding the filament from said delivering means to said carriage and for maintaining the filament length therebetween constant irrespective of the carriage position, first circuit means providing a first electrical signal as a function of the mandrel position, second circuit means providing a second electrical signal as a function of the carriage position, and, servo means responsive to said electrical signals for controlling said carriage to achieve the relative motion between said carriage and mandrel required to form the desired filament wound object.

2. A winding machine for forming filament wound objects, comprising a rotatable mandrel adapted to receive the filament forming the objects, a reciprocating carriage adjacent to said mandrel and moveable along an axis parallel to the axis of rotation of said mandrel, means for supplying the filament to said mandrel through said reciprocating carriage, a motor connected to said mandrel for rotation thereof, first circuit means operatively connected to said rotating mandrel providing a first electrical signal as a function of the mandrel position, drive means connected to said carriage for reciprocation thereof, second circuit means operatively connected to said reciprocating carriage providing a second electrical signal as a function of the carriage position, and servo means connected to said drive means and responsive to said electrical signals for controlling said carriage to achieve the relative motion between said carriage and mandrel required to form the desired filament wound object.

3. The filament winding machine recited in claim **2** wherein said servo means relatively moves said carriage in relation to said mandrel so that the filament can be wound upon the mandrel in a helical pattern having a helix angle from about 3° to 80°.

4. The filament winding machine recited in claim **2** wherein said servo means relatively moves said carriage in relation to said mandrel so that the filament can be wound upon the mandrel in circumferential pattern with a lead between filaments of about 0 inch per revolution of the mandrel to about 2 inches per revolution of the mandrel.

5. A filament winding machine, comprising a rotatable mandrel upon which is wound the filament to form the desired object, a carriage for delivering filament to the mandrel which reciprocates along the length of the machine parallel to the axis of rotation of the mandrel, a variable speed motor connected to said mandrel for rotation thereof, a hydraulically operated double acting piston connected to said carriage for reciprocation thereof, a reservoir of fluid for said piston, and servo means operatively connected to said carriage and piston for regulating the amount of hydraulic fluid that is fed to said piston for controlling the relative movement between said carriage and said mandrel to thereby obtain the desired filament pattern that is to be wound upon said mandrel.

6. In a filament winding machine having a rotatable mandrel, a housing adjacent said mandrel, a carriage mounted on said housing which reciprocates along the length of said mandrel parallel to the axis of rotation thereof and wherein said carriage has a filament feed eye through which is fed said filament onto the mandrel, and a stationary spool spaced from the carriage, the impovement which comprises a plurality of rigid articulately connected linked members over which the filament is fed from said stationary spool and through said carriage feed eye onto said mandrel, the links being pivotally connected to one another above the filament winding machine and having the lower end of one link adjacent the machine housing swivelly connected thereto and the lower end of the link adjacent the carriage swivelly connected thereto such that the links are raised and lowered with the movement of the carriage to maintain the length of the filament between said spool and carriage feed eye constant, irrespective of the reciprocating movement of said carriage.

7. A winding machine for forming filament wound objects in accordance with claim **1** wherein:

the carriage includes a feed-eye extending therethrough for feeding the filament from the carriage to the mandrel and means are provided for horizontally displacing the carriage in a predetermined manner during its reciprocating movement.

8. A winding machine for forming filament wound objects comprising:

a rotatable mandrel adapted to receive filament which forms the object,

a reciprocating carriage,

a filament supply for delivering filament from said supply through the carriage to the mandrel,

first circuit means providing a first electrical signal as a function of the mandrel position,

second circuit means providing a second electrical signal as a function of the carriage position, and,

servo means responsive to said electrical signals for controlling said carriage to achieve the relative motion between said carriage and mandrel required to form the desired filament wound object.

9. A winding machine for forming filament wound objects comprising:

a movable mandrel adapted to receive the filament that forms the objects,

a movable carriage,

means for delivering the filament to said mandrel through said carriage,

first circuit means providing a first electrical signal as a function of the mandrel movement,

second circuit means providing a second electrical signal as a function of the carriage position,

means for combining the first and second electrical signals to produce a resultant control signal, and,

control means responsibe to said control signal for controlling the relative movement of the carriage and mandrel to form the desired filament wound object.

10. A winding machine for forming filament wound objects in accordance with claim 9 wherein:

the first circuit means includes a power supply, at least one variable speed drive connected to the movable mandrel, a potentiometer operatively connected to the variable speed drive, and circuit means connecting the power supply to the potentiometer to produce a first electrical signal as a function of the mandrel movement.

11. A winding machine for forming filament wound objects in accordance with claim 10 further including:

first and second variable speed drives, and,

means for switching between the variable speed drives to produce a predetermined filament wound object.

12. A winding machine for producing filament wound objects in accordance with claim 10 wherein:

the variable speed drive operates the potentiometer at a lesser rotational speed than the mandrel to produce a predetermined helically wound filament object.

13. A winding machine for forming filament wound objects in accordance with claim 9 wherein:

the second circuit means comprises a power supply, a potentiometer coupled to the movable carriage and to the power supply to produce a second electrical signal as a function of the carriage position.

14. A winding machine for forming filament wound articles in accordance with claim 9 wherein:

the first circuit means includes a first and a second variable speed drive, a potentiometer operatively connected to each of said drives, a power supply, and means for connecting either the first or the second variable speed drive to the power supply to produce a first electrical signal as a function of mandrel movement, one of said potentiometers being operated at a relatively low rotational speed to produce a signal resulting in a predetermined circumferentially wound filament.

15. A filament winding machine comprising:

a rotatable mandrel upon which is wound the filament to form the desired object,

a carriage for delivering filament to said mandrel which reciprocates along the length of said mandrel parallel to the axis of rotation thereof,

a pair of tracks positioned adjacent the top and bottom of said carriage, said carriage having means extending therefrom which are mounted for movement along said tracks,

a stationary spool of filament spaced from the carriage, and,

a plurality of articulated rigid links between said mandrel and spool over which the roving is fed from the spool to the carriage, said articulated links having one end connected to the carriage for movement therewith.

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