Feb. 22, 1966 H. W. FLETCHER, JR., ETAL 3,236,039

CONTINUOUS WINDER

Filed Aug. 27, 1962 3 Sheets-Sheet 1

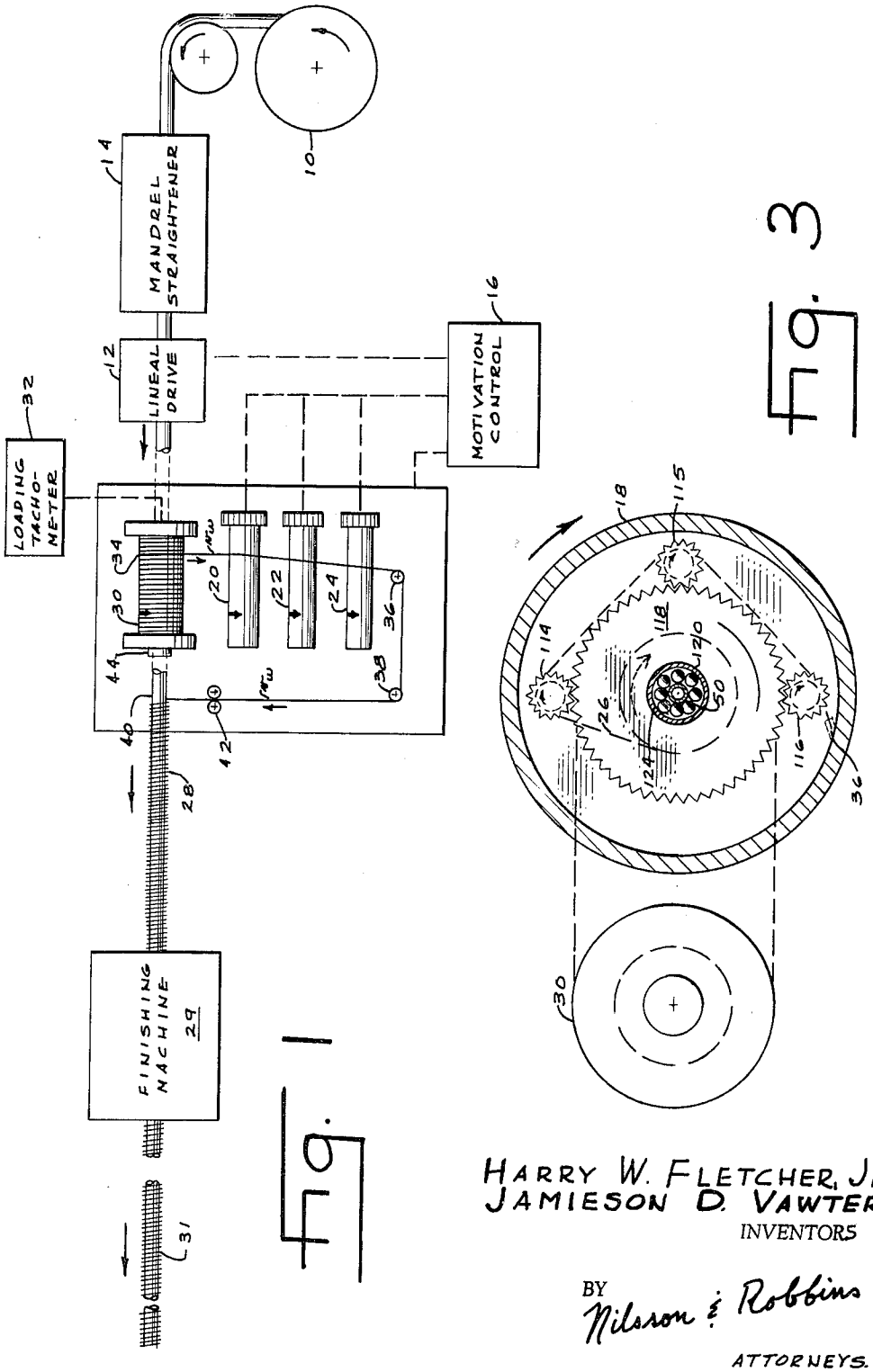


Fig. 1

Fig. 3

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CONTINUOUS WINDER

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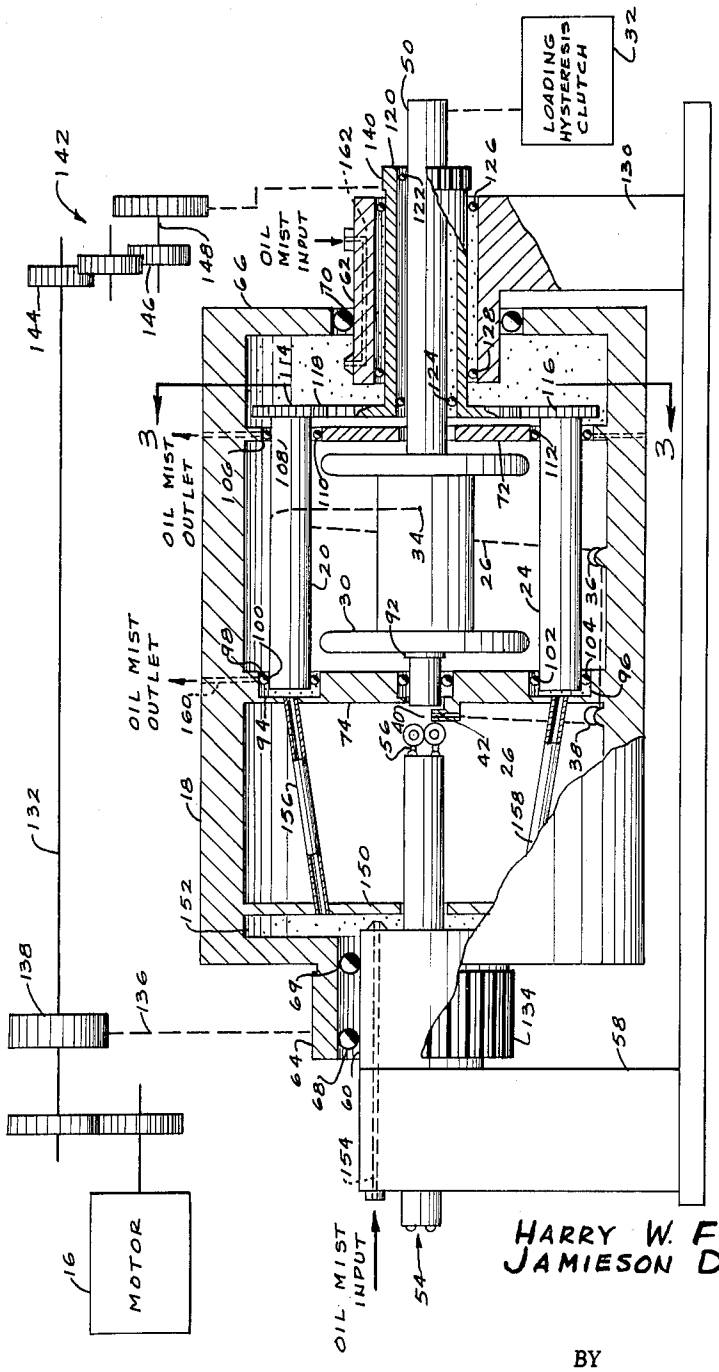


Fig. 2A

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CONTINUOUS WINDER

Filed Aug. 27, 1962 3 Sheets-Sheet 3

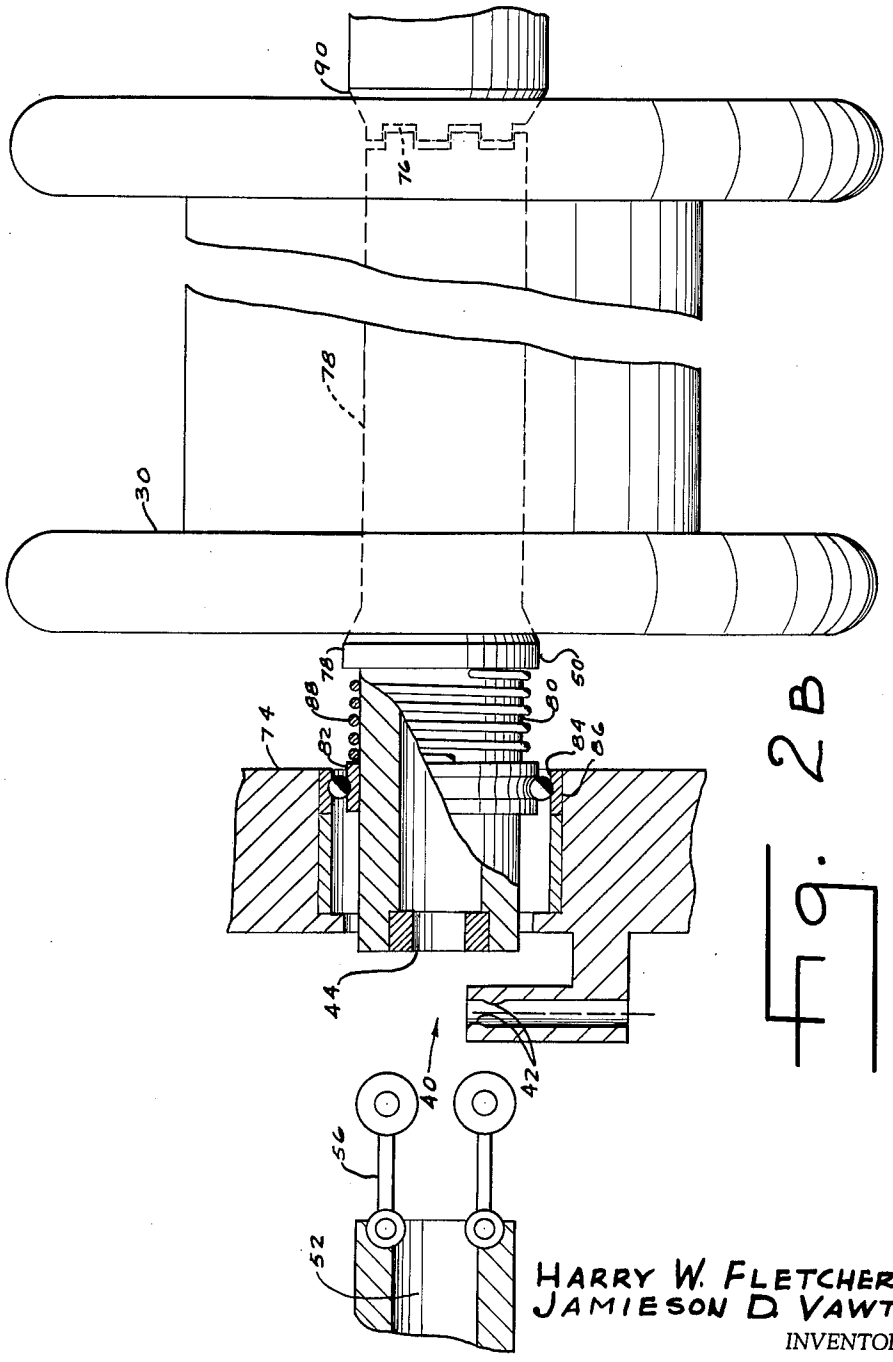


Fig. 2B

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United States Patent Office 3,236,039 Patented Feb. 22, 1966

3,236,039

CONTINUOUS WINDER

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Filed Aug. 27, 1962, Ser. No. 219,518
4 Claims. (Cl. 57—18)

This invention relates generally to the field of coil winding, and more particularly to a new apparatus and method for winding a coil of strand material upon a continuous mandrel.

In the field of providing devices which include a coil of strand material, such as conductive wire wound over a mandrel, for example, a resistance elements as for a variable resistor, it is highly desirable for their economic mass production that the coils be continuously wound over a very long or continuous mandrel. The long or continuous coil is then parted into the desired individual components. With such a general technique, it is hypothetically possible to manufacture at very high speed the resistance elements having precisely constant winding parameters over their entire length.

However, to wind a coil continuously over a mandrel requires either that the mandrel be rotated while a source of the strand material, such as a spool of resistance wire, is moved along the length of the mandrel in a manner to create and control the winding pitch while maintaining a predetermined tension in the wire, or that the winding mechanism itself, including the spool source, be rotated around the mandrel while one or the other is translated longitudinally to provide the pitch.

Prior art attempts to achieve such continuous winding have typically been directed toward a lathe type machine which spins the mandrel as a "workpiece" and carries a spool of resistance wire on the "tool holder" carriage at a fixed longitudinal rate with respect to the angular velocity of the mandrel thusly to determine the pitch of the coil. Such techniques can be made to provide relatively precise components. However, the process cannot be a truly continuous one unless a source of the mandrel material is also being spun and means is provided for axially propelling the mandrel past the spool of resistance wire. As a practical matter, such techniques can provide a length of coil which is no longer than the permissible travel of the tool holder carriage along the bed of the machine. A further disadvantage of spinning mandrel types machines is that at usefully high speeds of operation there is always some lateral whipping of the spinning elongated mandrel which deleteriously varies the tension in the winding wire, and consequently the diameter or pitch, or both, of the resultant coil.

Other typical prior art attempts to achieve continuous coil winding have been directed toward the development of machines in which the mandrel is rotationally stationary while a winding mechanism carriyng the spool of resistance wire is rotated thereabout. The mandrel may in such cases be truly continuously fed past the winding mechanism. However, the centrifugal forces for the revolving winding mechanism, even when dynamically balanced, generally limit the process to a relatively low speed.

Typically in such systems, the reservoir spool of resistance wire is made to have a small diameter so that the system may have a minimum effective moment of rotational inertia and will require a minimum of centripital forces to hold the mechanism together. However, this necessitates making the spool longer in order to provide it with a practical capacity for the strand of material. Making the spool longer seriously aggravates another problem in this type of machine: that of removing the strand from the spool at high speeds. There must effectively be a single output point for the strand to leave the reservoir assembly. This output point generally must have a fixed axial relationship with the winding point where the strand is applied to the mandrel. As the strand is pulled from the spool and conveyed to the output point, it is pulled from a wide range of directions; that is, from the different ends of the spool. This range of directions is measured by the angles subtended at the output point by the opposite effective ends of the spool.

Since the lineal velocity of the strand between the reservoir spool and the mandrel is constant, and since the distance the strand must travel to arrive at the output point from the spool, varies due to the axial motion of the point of unwinding along the length of the spool, it follows that the angular velocity of the unwinding spool must oscillate as the point of unwinding moves from one end of the spool to the other. It may be considered that the longitudinal motion of the point of unwinding adds or subtracts a component of velocity to the lineal motion of the strand. The relative magnitude of this component compared to the total lineal strand velocity determines the amplitude of oscillation of the angular velocity of the unwinding spool and is proportional to the magnitude of the range of directions between the spool and the output point. In other words, the greater the change of direction suffered by the strand in reaching the output point from various points on the spool, the greater is the required variation in the rotational velocity of the spool.

The variation in angular unwinding velocity of the strand spool results in variations in tension of the strand as it is wound upon the mandrel and causes fouling in the spool at high speeds. In addition, the variation in tension and the longitudinal pulling of the strand at the point of unwinding, particularly at points axially most remote from the output point causes rotational fouling as adjacent loops of the strand are rolled over each other.

If the output point is removed from the vicinity of the spool, the range of angle or direction change of the strand is reduced; however, attempts in the prior art so to remove the output point have resulted in increased rotational inertia or unbalance or both.

Another attempted solution has been to provide longitudinal oscillation of the spool with respect to the output point, either by moving the spool or by mechanically moving the output point, so that the unwinding point remains axially fixed with respect to the output point. However, the resultant mechanisms developed toward that end have been impractically bulky and complex and have required sophisticated controls because the frequency of the longitudinal oscillation of the spool must vary with the varying effective diameter of the spool as well as with the strand size itself.

It is, therefore, an object of the present invention to provide a continuous coil winding machine and method which are not subject to these and other disadvantages of the prior art.

It is another object to provide such apparatus in which the mandrel does not rotate and may be truly continuous.

It is another object to provide such a coil winding machine in which the strand always leaves the reservoir spool substantially at right angles thereto.

It is another object to provide such a machine in which the reservoir unwinding point continually moves back and forth axially without axial motion of any apparatus.

It is another object to provide such an apparatus in which the output point of the reservoir assembly is radially adjacent to the spool.

It is another object to provide such a coil winding machine which may wind with high precision and repeatability at angular rates of several thousands of revolutions per minute without submitting the winding strand to appreciable tension.

It is another object to provide such a continuous coil winding machine which is mechanically rugged and stable.

It is another object to provide such apparatus in which an emptied reservoir spool may be readily replaced with a full one and the winding operation continued with only a few minutes down time.

Briefly, these and other objects and advantages are achieved in accordance with one example of the invention which includes means for positively driving a continuous mandrel along an axial path from its source, such as a large spool or an extrusion machine, toward a device for parting the continuous coil into separate elements and finishing them. Disposed concentrically about the axial path of the mandrel is a reservoir spool for the resistance wire. Disposed about the spool is a winding cage which supports a plurality of axially disposed wire directing cylinders. The cylinders are angularly spaced about the spool and have a length at least equal to the effective length of the spool.

The wire directing cylinders are driven to rotate about their own axes.

The resistance wire is fed from the spool over the wire directing cylinders, which are supported on the rotating winding cage, and through an output point which may be a pulley or other low friction wire direction change device affixed to the winding cage approximately midway between the ends of the spool. The wire is then carried axially to a point beyond the spool to a second pulley and thence radially inwardly toward a winding point which is also supported by the winding cage and which is revolved closely about the mandrel.

The angular velocity of the winding cage about the mandrel, the diameter of the mandrel, and the size of the wire determine the lineal velocity of the resistance wire. The wire directing cylinders are driven at a tangential velocity equal to, slightly less than, or greater than the lineal velocity of the unwinding wire.

Such a routing of the wire over the wire directing cylinders removes the output point from the unwinding point while the driven rollers provide a substantially constant tension in the wire between the unwinding point on the spool and the first wire directing cylinder. The tension in this segment of the wire is sufficient to assure that the wire is always substantially at right angles to the spool independently of the instantaneous position of the unwinding point along the length of the spool.

Similarly, the tension in the wire between the winding point near the mandrel and the second point is substantially constant, the variation in tension being absorbed and averaged in the wire over the driven wire directing cylinders and the output point pulley.

The angular velocities of the winding cage and of the wire directing cylinders may be independently determined or may be directly related by a mechanical coupling of their driving means which may additionally be coupled to the mandrel propelling means. The latter relationship may be used to vary the tension of the resistance wire.

Further details of these and other novel features and their principles of operation, as well as additional objects and advantages will become apparent and be best understood from a consideration of the following description taken in connection with the accompanying drawings which are presented by way of an illustrative example only, and in which:

FIG. 1 is an over-all schematic view of one example of a continuous coil winding system constructed in accordance with the principles of the present invention;

FIG. 2A is a mechanically simplified, partially cut away, partially longitudinally sectioned view of a continuous coil winding system constructed in accordance with the principles of the present invention;

FIG. 2B is an enlarged, partially broken away view of a portion of the overall structure illustrated in FIG. 2A; and

FIG. 3 is a cross-section view of a portion of the structure of FIG. 2A taken along the lines 3—3 thereof.

Referring to the particular figures in more detail, it is stressed that the details shown are by way of example only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles of the invention. The detailed showing is not to be taken as a limitation upon the scope of the invention which is defined by the appended claims forming a part of this specification. In an addition, it is to be noted that further in the cause of clarity a number of mechanical details which are considered to be obvious to the ordinary skilled artisan have been deliberately deleted from the drawings. For example, oil seals and details for constraining axial thrust have been removed from the drawings of the journals and bearings in order to facilitate a conceptual understanding of the principles of the invention.

In FIG. 1 there is illustrated a source **10** of continuous mandrel material which may be metallic or plastic tubing or solid filament having a circular or a rectangular cross-section and supplied on a relatively large capacity spool. Alternatively, the source **10** may be a fabrication source, such as an extrusion presss for the mandrel material. In either event, the capacity of the source **10** is sufficient to be, for all practical purposes, encompassed by the term "continuous" as used here. The continuous mandrel is pulled from the source **10** by a lineal drive **12** which may be a positively driven conveyor of the type utilizing geared rubber belts between which the mandrel is pressed. Although the lineal drive **12** is illustrated as pushing the mandrel through the spool **30**, it should be understood that it may also pull the mandrel or be arranged to both push and pull. Interposed between the lineal drive **12** and the source **10** is a mandrel straightener **14** which may be a series of rollers which remove bends and relieve stresses in the mandrel material as it is pulled or driven therethrough.

The lineal velocity imparted to the mandrel by the lineal drive **12** is positively controlled by a motivation control **16** which also motivates and controls the angular velocities of the winding cage **18** and the wire directing cylinders **20, 22, 24.**

In operation, the winding cage **18**, carrying with it the wire directing cylinders **20, 22, 24,** is rotated about the mandrel causing the resistance wire **26** to be wrapped into a continuous coil **28** with a pitch determined by the relationship between the operating velocities of the lineal drive **12** and the winding cage **18**; such relationship being determined by the motivation control **16**. The continuous coil **28** is then fed through a finishing machine **29** which, among other functions, coats, bonds, scrapes a side free of insulation when desired, and cuts the continuous coil into appropriate lengths **31** for individual components when desired.

As the winding cage **18** is revolved about the mandrel the resistance wire **26** is pulled from the reservoir spool **30** at a lineal wire velocity v_w. The wire then progresses to the first wire directing cylinder **20** which, because it is rotating with a tangential velocity of the order of and in general at approximately v_w minimizes tension in the segment of the wire between the wire directing cylinder **20** and the spool **30**. The magnitude of this tension is controlled in part, by the loading of a hysteresis clutch **32** and is maintained at a level such that the wire is always pulled from the unwinding point **34** on the spool substantially at right angles to the length of the spool.

The wire **26** then progresses over the other wire directing cylinders **22, 24** to the output point pulley **36** which

is a fixed point with respect to and supported on the winding cage 18. From the output point 36 the wire 26 is conveyed to a second pulley 38 and thence radially inwardly to a winding point 40 associated with the mandrel. The wire is guided at a winding point 40 by wire guides 42 supported on the winding cage 18 and which may comprise a pair of smooth hard surfaces of diamond or other low friction, wear resistant materials. The mandrel is stabilized against any lateral motion by a stabilizing bushing 44 which may be selected to pass, closely, the desired mandrel diameter.

As described above, the wire velocity is v_w and is substantially constant everywhere along the wire path from the unwinding point 34 on the spool 30 to the winding point 40 at the mandrel.

Although the angular velocity of the spool 30 is permitted to be relatively constant due to the removal of the output point 36 from the unwinding point 34 by the distance over and between the wire directing cylinders, there remains a slight variation in the rotational velocity of the spool. This variation, it may be noted, is due to the axial motion of the unwinding point which varies the distance which the wire must travel in going from the spool 30 to the output point 36 and furnishes a component of velocity which must be algebraically added to the tangential velocity of the spool to equal v_w. It is also to be noted that in accordance with the principles of operation of the system disclosed, the unwinding point, and the effective output point as viewed from the spool oscillate axially without the axial motion of any physical apparatus.

As noted previously, the resistance characteristic along the coil 28 may be altered from a constantly linear one to any desired variation therefrom as for the purpose for example, of making wire wound resistance elements for rheostats having an exponentially tapered characteristic. The coupling relationship between the lineal device 12 and the winding cage motivation controls may be varied as by a cam mechanism to provide periodically the desired variation of winding pitch along the mandrel.

FIG. 2A and FIG. 2B illustrates the invention in more detail but deletes conventional mechanical details wherever possible in order to facilitate a clear understanding of the principles and operation of the invention. To the same end, the reference numerals which were applied to the elements of the purely schematic FIG. 1 have been used again to denote actual structure in the subsequent figures.

The path of the continuous mandrel, itself not shown, is seen to enter the machine at its right hand end, as viewed in the figure, along the center of a spool supporting spindle 50. At the opposite end of the spindle 50 the mandrel passes between the mandrel stabilizing bushing 44, progresses past the winding point 40, enters an output bore 52 and leaves the machine at its output end 54 at the left hand end of the drawing. As the mandrel is wound with resistance wire at the winding point 40 and enters the output bore 52 it passes between a set of coil receiving, stabilizing rollers 56 which provide additional lateral stabilization to the wound coil. Thus the mandrel is stabilized by means disposed closely to the winding point from both axial directions.

The winding cage 18 is supported by a base assembly 58 which has a pair of spaced journal portions 60 and 62 upon which the opposite ends 64, 66 of the winding cage 18 are rotationally supported through anti-friction bearing members 68, 69 and 70. As stated previously, the thrust restraining portions of these bearing members are not shown in the figures.

Axially spaced within the winding cage 18 is a pair of bulkheads 72, 74; see FIG. 2B. These bulkheads are parallel and are axially spaced by a distance slightly greater than the length over-all of the spool 30. The bulkhead 72 is centrally relieved about the spool supporting spindle 50. The bulkhead 74 is similarly relieved but is constructed to support the inner end of the spindle 50. In order to remove and replace the spool 30 when empty, the spindle 50 is provided with parting means 76 which when parted permits the removal of the segment 78 of the spindle within the spool 30 to be withdrawn from the assembly to permit longitudinal displacement of the segment 78 from the remainder of the spindle 50. The left hand end of the spindle segment 78 is relieved to form a smaller diameter portion 80 which is free to slide within the inner race 82 of the bearing member 84 which is restrained against longitudinal displacement by its outer race 86 which is secured to the bulkhead 74. A spring 88 under axial compression continuously urges a spindle segment 78 toward the parting means 76 which may be actuated by further compressing the spring 88 and axially sliding the reduced diameter end portion 80 of the spindle 50 through the centrally relieved bulkhead 74. When the parting means 76 is thus operated, the spool 30 may be removed from its position between the bulkheads 72, 74 and replace the full reservoir spool. The spool 30 while in place between the bulkheads 72, 74 is constrained axially at a desired location by a pair of sloping retaining shoulders 90, 92. The retaining shoulders are continually pressed against the ends of the spool 30 by virtue of the compression of the spring 88 and a slight axial tolerance in the parting means 76. Thus the spool is axially constrained and is frictionally rotationally coupled to the spool supporting spindle 50.

The bulkhead 74 is relieved for the purpose of defining a plurality of bearing housings 94, 96. Within the bearing housing 94 is disposed a bearing 98 which supports a journal portion 100 of the wire directing cylinder 20. Similarly, a journal portion 102 of the wire directing cylinder 24 is supported within a bearing 104 within the bearing housing 96. Axially in register with the bearing housing 94 the bulkhead 72 is relieved to form a bearing housing 106 within which is supported a journal portion 108 of the wire directing cylinder 20. An appropriate anti-friction bearing 110 is provided within the bearing housing 106 for engagement with the journal portion 108. The bulkhead 72 is similarly relieved to rotationally support the journal portion 112 of the wire directing cylinder 24.

The ends of each of the wire directing cylinders which project through the bulkhead 72 are fitted with a gear 114, 115, 116. A larger gear 118 is in this example centrally disposed about the spindle 50 and is fitted with gear teeth which mesh with the gears 114, 115, 116. The larger gear 118 is affixed to the end of a gear support spindle 120 which is centrally relieved and fitted with bearings 122, 124 for rotational support of the spindle 120 about the outer journalling surfaces of the inner spindle 50. The gear support spindle 120 is in turn supported by a set of bearings 126, 128 with rotational freedom within the end portion 130 of the base assembly 58. The gear support spindle 120 extends effectively externally of the relieved end portions 130 for purposes of mechanical coupling thereto for driving the gears 118 and consequently the gears 114, 116 on the ends of the wire directing cylinders 20, 24. Similarly, the spool supporting spindle 50 extends externally of the interior of the gear support spindle 120 for purposes of the mechanical coupling thereto of the magnetic loading hysteresis clutch 32.

The source of motivation power and motivation control 16 may, by conventional means, drive a motivating shaft 132. The shaft 132 may be mechanically directly coupled to a gear or geared pulley portion 134 of the winding cage 18 by means of a chain or geared belt 136 which is power engaged by a gear or geared pulley 138 affixed to the shaft 132. The shaft 132 is similarly mechanically coupled to a gear or geared pulley portion 140 of the exposed end of the gear support spindle 120 through an adjustable idling gear arrangement 142. The relatively effective diameters of a removable gear 144 on the shaft

132 and the removable gear 146 on the secondary shaft 148 determines the angular velocity relationship between the wire directing cylinders and the winding cage 18. The indicated adjustment is typically achieved by selecting the removable gears 144, 146 to provide the desired rotational velocity relationship between their respective shafts. The idler gear shown permits such adjustment without lateral displacement of the shafts 132, 148.

The system and particularly the supporting bearings for the wire directing cylinders which rotate at a very high angular velocity are in this example lubricated by an oil mist method. It is essential to provide such lubrication without exposing the reservoir spool 30 or the mandrel in the region of the winding point 40 to an oil bath. To this end, a third bulkhead 150 is provided within the winding cage 18 to form an isolated chamber between it and the bulkhead 74 within which the mandrel is exposed as it is wound with the resistance wire. The bulkhead 150 also defines a chamber 152 at the left hand of the winding cage 18 as viewed in the drawing and to which the oil mist is injected through an input 154. Communication from the oil mist from the chamber 152 to the bearings 100, 102 in the bearing houses of the bulkhead 74 is provided by an oil tube 156, 158 respectively. An oil mist output 160 may be provided to remove excess condensed oil from the bearings through the outer wall of the winding cage 18. Conventional oil seals, not shown, are provided to preclude the oil from entering either of the major chambers on either side of the bulkhead 74.

In like manner, the bearings 108, 112 as well as the gears 114, 116, 118 are lubricated with oil mist supplied through an input 162.

Referring to FIG. 3, the relationship of the central larger gear 18 to the gears 114 and 116 as well as gear 115 (not shown in FIG. 2) is illustrated. A gear support spindle 120 is shown in section as benig rotationally supported by the bearing 124 upon the inner spool supporting spindle 50, also shown in section. Access for the spool 30 through the otherwise solid wall of the winding cage 18 is provided by the openings, not shown, in the cylindrical walls of the winding cage 18.

In operation, the resistance wire 26 is pulled from the reservoir spool 30 causing it to rotate in a clockwise direction as viewed in the drawing with respect to the direction of rotation of the winding cage 18 which in this example may be considered as also rotating clockwise. In order to pull the resistance wire 28 from the spool 30 under tension, the wire directing cylinders 114, 115, 116 are driven in a clockwise sense of rotation by the central gear 118 which is accordingly driven in a counterclockwise direction.

There has thus been disclosed a continuous coil winding machine which exhibits all of the advantages and achieves all the objects enumerated above. It is stressed that the drawings and the discussion are presented for the purpose of example only and do not define the limits of the invention. Many modifications to and changes in the apparatus shown may be made by skilled artisans without deviating from the scope of the invention. For example, additional wire directing cylinders may be utilized in order further to remove the output point 36 from the unwinding point 34; and it may prove desirable in some instances to have the reservoir spool 30 fixed permanently in place within the winding cage with its wire supply replenished when empty by rewinding without removing it from its position on the spindle 50.

What is claimed is:

1. A continuous coil winding machine comprising: means for advancing a continuous core mandrel along a predetermined axis at a predetermined longitudinal velocity; a rotatable winding cage disposed substantially concentrically about said axis and having axially spaced end portions; stationary supporting means having centrally relieved, cage journals disposed coaxially within and in friction minimizing rotational relationship with each of said end portions of said cage; a pair of axially spaced bulkheads affixed to the inner periphery of said cage and extending radially inwardly therefrom; a spool supporting hollow shaft disposed concentrically about said axis and extending from a first one of said bulkheads through the second one and thence concentrically through one of said centrally relieved cage journals; a plurality of elongated wire driving cylinders disposed parallel to said axis and displaced radially approximately equally therefrom and extending between said bulkheads, said first bulkhead being centrally relieved to form a bearing housing about said spool supporting shaft, said first and second bulkheads being relieved to form a plurality of sets of bearing housings for said wire driving cylinders which are thereby effectively journalled therewithin with rotational freedom with respect to said cage; first cylinder driving means concentrically affixed to each of said cylinders; a centrally relieved second cylinder driving means motivationally coupled to said first driving means of said wire driving cylinders; an elongated hollow driving shaft affixed in supporting relationship to said centrally relieved cylinder driving means and disposed concentrically between said spool supporting shaft and said centrally relieved cage journals and extending axially effectively externally thereof; wire directing means affixed to the interior of said cage and including a first anti-friction wire direction change element disposed axially between the ends of said spool for directing wire therefrom axially toward said first bulkhead after said wire has traversed said wire driving cylinders; a second anti-friction wire direction change element disposed axially on the opposite side of said first bulkhead for directing said wire radially towards said mandrel; wire guide means affixed to said cage and interposed radially between said mandrel and said second wire direction changing element; adjustable inter-coupled rotational motivation means coupled to said driving shaft for said centrally relieved driving means and to said rotatable winding cage whereby both are simultaneously angularly driven and said cage is rotated at an angular velocity having a predetermined instantaneously fixed realtionship with respect to the angular veloicty of said elongated wire driving cylinders.

2. A continuous coil winding machine comprising: means for advancing a continuous core mandrel along a predetermined axis at a predetermined longitudinal velocity; a rotatable winding cage disposed substantially concentrically about said axis and having axially spaced end portions; stationary supporting means having centrally relieved, cage journals disposed coaxially within and in friction minimizing rotational relationship with each of said end portions of said cage; a pair of axially spaced bulkheads affixed to the inner periphery of said cage and extending radially inwardly therefrom; a spool supporting hollow shaft disposed concentrically about said axis and extending from a first one of said bulkheads through the second one and thence concentrically through one of said centrally relieved cage journals; at least three elongated wire driving cylinders disposed parallel to and within approximately a 180° arc about said axis and displaced radially approximately equally therefrom and extending between said bulkheads, said first bulkhead being centrally relieved to form a bearing housing about said spool supporting shaft, said first and second bulkheads being relieved to form a plurality of sets of bearing housings for said wire driving cylinders which are thereby effectively journalled therewithin with rotational freedom with respect to said cage; a wire driving cylinder gear concentrically affixed to that end portion of each of said cylinders nearest to said second bulkhead; a centrally relieved driving gear having gear teeth disposed concentrically about said axis in meshed relationship with those of said wire driving cylinder gears; an elongated hollow driving shaft affixed in supporting relationship to said

centrally relieved driving gear and disposed concentrically between said spool supporting shaft and said centrally relieved cage journals and extending axially effectively externally thereof; wire directing means affixed to the interior of said cage and including a first anti-friction wire direction change element disposed axially in between the ends of said spool for directing wire therefrom axially toward said first bulkhead after said wire has traversed said wire driving cylinders; a second anti-friction wire direction change element disposed axially on the opposite side of said first bulkhead for directing said wire radially towards said core mandrel; wire guide means affixed to said cage and interposed radially between said mandrel and said second wire direction changing element; and inter-coupled rotational motivation means coupled to said driving shaft for said centrally relieved driving gear and to said rotatable winding cage whereby both are simultaneously angularly driven and said cage is rotated at an angular velocity having a predetermined instantaneously fixed relationship with respect to the angular velocity of said elongated wire driving cylinders, said angular velocity of each of said cylinders on its axis being such that its wire driving tangential velocity is approximately the same as the lineal velocity of said wire.

3. A continuous coil winding machine comprising: means for advancing a continuous core mandrel along a predetermined axis at a predetermined longitudinal velocity; a rotatable winding cage disposed substantially concentrically about said axis and having axially spaced end portions; stationary supporting means having centrally relieved, cage journals disposed coaxially within and in friction minimizing rotational relationship with each of said end portions of said cage; first and second axially spaced bulkheads affixed to the inner periphery of said cage and extending radially inwardly therefrom; a spool supporting hollow shaft disposed concentrically about said axis and extending from said first bulkhead through said second bulkhead and thence concentrically through one of said centrally relieved cage journals; at least three elongated wire driving cylinders disposed parallel to and within approximately a 180° arc about said axis and displaced radially approximately equally therefrom and extending between said bulkheads, said first bulkhead being centrally relieved to form a bearing housing about said spool supporting shaft, said first and second bulkheads being relieved to form a plurality of sets of bearing housings for said wire driving cylinders which are thereby effectively journalled therewithin with rotational freedom with respect to said cage; a wire driving cylinder gear concentrically affixed to that end portion of each of said cylinders nearest to said second bulkhead; a centrally relieved driving gear having gear teeth disposed concentrically about said axis in meshed relationship with those of said wire driving cylinder gears; an elongated hollow driving shaft affixed in supporting relationship to said centrally relieved driving gear and disposed concentrically between said spool supporting shaft and said centrally relieved cage journals and extending axially effectively externally thereof; wire directing means affixed to the interior of said cage and including a first anti-friction wire direction change element disposed axially in between the ends of said spool for directing wire therefrom axially toward said first bulkhead after said wire has traversed said wire driving cylinders; a second anti-friction wire direction change element disposed axially on the opposite side of said first bulkhead for directing said wire radially towards said core mandrel; wire guide means affixed to said cage and interposed radially between said mandrel and said second wire direction changing element; adjustable inter-coupled rotational motivation means coupled to said driving shaft for said centrally relieved driving gear and to said rotatable winding cage whereby both are simultaneously angularly driven and said cage is rotated at an angular velocity having a predetermined instantaneously fixed relationship with respect to the angular velocity of said elongated wire driving cylinders, said angular velocity of each of said cylinders on its axis being such that its wire driving tangential velocity is at least equal to the lineal velocity of said wire; and an oil mist inlet and outlet network for mist lubrication of regions within said rotatable cage.

4. A continuous coil winding machine comprising:

means for advancing a continuous core mandrel along a predetermined axis at a predetermined longitudinal velocity;

a rotatable winding cage disposed substantially concentrically about said axis and having axially spaced end portions;

stationary supporting means having cage journals disposed in friction minimizing rotational relationship with each of said end portions of said cage;

a hollow shaft disposed concentrically about said axis and extending therealong through one of said end portions concentrically with one of said cage journals;

a segment of said shaft within said cage being removable and adapted to support a spool for retaining wire,

parting means at one end of said segment for engagement with the remainder of said shaft, and

spring means at the other end of said segment continuously urging said parting means into engagement with the remainder of said shaft, said segment being removable from said cage by disengagement of said parting means from said shaft;

at least three elongated wire driving cylinders disposed parallel to said axis and displaced radially approximately equally therefrom, the distance between at least two immediately adjacent cylinders being greater than the diameter of a spool for containing wire;

means carried by said cage for rotatably supporting said cylinders therewithin with rotational freedom with respect to said cage;

first cylinder driving means concentrically affixed to each of said cylinders;

a second driving means coupled to said first driving means of said wire driving cylinders;

an elongated driving shaft affixed in driving relationship to said second driving means;

wire direction changing means affixed to the interior of said cage and supported thereby for directing wire, after said wire has traversed said wire driving cylinders, radially towards said mandrel;

wire guide means affixed to said cage and interposed between said mandrel and said wire direction changing means; and

inter-coupled rotational motivation means coupled to said driving shaft and to said rotatable winding cage whereby both are simultaneously angularly driven and said cage is rotated at an angular velocity having a predetermined relationship with respect to the angular velocity of said elongated wire driving cylinders.

References Cited by the Examiner

UNITED STATES PATENTS

970,098	9/1910	Noble	57—18
1,632,884	6/1927	Carter	57—18
2,253,740	8/1941	Van Hook	57—18
2,430,358	11/1947	Merwin et al.	57—18
2,519,882	8/1950	Bullard et al.	310—93
2,527,662	10/1950	Stevens	242—53
2,905,401	9/1959	Ewald	242—7
3,034,744	5/1962	Bancroft	242—155 M

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