TAPE WRAPPING MACHINE WITH CONTROLLABLE TENSIONING

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ABSTRACT

A tape wrapping machine is provided for wrapping a moving length of tape onto a moving length of hose that is moving relative to the machine and the length of tape with controlled tape tension, and lay angle during wrapping. An adjustable guide arm supporting a moving length of tape is mounted on a rotating shuttle plate, and is adapted to pivot toward and away from a length of hose between a first position and at least one second position so as to provide a plurality of angular relationships between the guide arm and the moving length of hose. A first tension transducer is arranged so as to support the length of tape and a second, reference transducer is positioned in a spaced diametric relation to the first transducer. A reference signal from the second transducer is subtracted from a signal from the first representing the centripetal force plus the tape tension applied to the first transducer. The result of this subtraction yields a signal that represents the tension in the tape. This signal is communicated to a computing and control device where the speed of the tension controlling motor is dynamically altered to maintain a specified tension.
FIG. 1
(PRIOR ART)
FIG. 14
TAPE WRAPPING MACHINE WITH CONTROLLABLE TENSIONING

FIELD OF THE INVENTION

[0001] The present invention generally relates to winding machines, and more particularly to winding machines used in the fabrication of reinforced flexible hoses and the like.

BACKGROUND OF THE INVENTION

[0002] Flexible hoses having core tubes made of elastomeric or flexible plastic materials require reinforcement by one or more layers of wire, nylon, fiberglass or the like when the hoses are to be used for conveying fluids under high pressure. Each layer may comprise one or more sets of helically wound strands that may be either interwoven to form a braid or knit. In some cases, a second set of strands is wound over a first set to form what is sometimes referred to as a spiral wrap. In hydraulic service the pressure within the hose may be over 1000 psi. For example, in small diameter hoses having about a 0.250 inch inner diameter, one layer of reinforcement may be sufficient to give the hose a burst strength of more than 10,000 psi, depending upon the particular reinforcement material used and the amount of coverage provided by the reinforcement for the core tube. The strands may be of multiple filament or mono filament form.

[0003] Referring to FIG. 1, in a typical manufacturing process for a flexible reinforced tubular conduit 5, a flexible polymeric or fabric tape 6 is spirally wrapped completely about a reinforcement layer 7, e.g., a weave or braid of reinforcing filaments that have been previously wound onto an elastomeric length of hose 8. Tape 6 comprises an overlap seam that extends helically along length of hose 8. Tape 6 also preferably has a thickness of from about 1 to about 10 mils, but can often be as little as about 1 to 2 mils. The width of tape 6 depends upon the outer diameter of inner reinforcement layer 7, which in turn is determined largely by the bore diameter of length of hose 8. Once wrapped, the assembly is processed, e.g., by heating and curing, so as to force inner reinforcement layer 7 to become embedded in and chemically fixed to a portion of length of hose 8. At the end of the heating/curing step, tape 6 is unwound from length of hose 8 and reused.

[0004] For the foregoing process to be successful, it is critically important that tape 6 be wound onto reinforcement layer 7 with an even and flat lay, without appreciable camber (i.e., without an appreciable curvature or arch) and with a known tension. Heretofore, known tape wrapping machines have been less than adequate for accomplishing this process in a uniform, repeatable, and satisfactory manner. As a consequence, there has been a long felt need for a tape wrapping machine that is capable of reliably and repeatedly wrapping a flexible tape completely around a core tube covered with a reinforcement layer of woven or braided reinforcing filaments, with an even and flat lay, and with a known tension.

SUMMARY OF THE INVENTION

[0005] The present invention provides a machine for wrapping a moving length of tape onto a moving length of hose where the hose is moving relative to the machine and the length of tape. The machine includes a frame supporting a shuttle plate and a tension plate in parallel spaced relation to one another. The shuttle plate and the tension plate each have a central bore for receiving the moving length of hose, and the tension plate supports a supply of the tape. A first motor is supported by the frame and is operatively engaged with the shuttle plate so as to rotate the shuttle plate relative to the frame. A second motor is supported by the frame and is operatively engaged with the tension plate so as to rotate the tension plate relative to the shuttle plate. A spindle head is mounted adjacent to the shuttle plate. It includes a tube positioned in coaxial relation to the central bore so as to receive the moving length of hose, and a guide arm having a first end pivotally mounted on the tube so that the guide arm pivots relative to the tube between a first position and at least one second position. The moving length of tape continuously engages the guide arm prior to wrappingly engaging the length of hose so as to be guided at a preselected angular relation to the hose during the wrapping of the moving length of hose. A sensor may be positioned on the spindle head and adjacent to an edge of the moving length of tape and arranged to sense the position of the tape edge at the sensor.

[0006] In another embodiment of the invention, a machine for wrapping a moving length of tape onto a moving length of hose is provided that includes a frame supporting a shuttle plate and a tension plate in parallel spaced relation to one another. The shuttle plate and the tension plate each include a central bore for receiving the moving length of hose, and the tension plate supports a supply of the tape. A first motor is supported by the frame and is operatively engaged with the shuttle plate so as to rotate the shuttle plate relative to the frame. A second motor is supported by the frame and is operatively engaged with the tension plate so as to rotate the tension plate relative to the shuttle plate. A spindle head is mounted to the shuttle plate, and includes a tube positioned in coaxial relation to the central bore so as to receive the moving length of hose. A tension measuring assembly is mounted on the shuttle plate and positioned so as to support and direct the moving length of tape from the supply of tape into engagement with the moving length of hose. The tension measuring assembly includes a first tension transducer arranged so as to support the length of tape and a second transducer positioned in spaced diametric relation to the first transducer.

[0007] In yet a further embodiment of the invention, a machine for wrapping a moving length of tape onto a moving length of hose is provided where the hose is moving relative to the machine and the moving length of tape. The machine includes a frame supporting a shuttle plate and a tension plate in parallel spaced relation to one another. The shuttle plate and the tension plate each have a central bore for receiving the moving length of hose, and the tension plate supports a supply of the tape. A first motor is supported by the frame and is operatively engaged with the shuttle plate so as to rotate the shuttle plate relative to the frame. A second motor is supported by the frame and is operatively engaged with the tension plate so as to rotate the tension plate relative to the shuttle plate. A spindle head is mounted to the shuttle plate, and includes a tube positioned in coaxial relation to the central bore so as to receive the moving length of hose. A guide arm having a first end is pivotally mounted on the tube so that the guide arm pivots relative to the tube between a first position and at least one second position. A tension measuring assembly is mounted on the shuttle plate.
and positioned so as to support and direct the moving length of tape from the supply to engagement with the moving length of hose. The moving length of tape continuously engages a portion of the guide arm. A sensor may be positioned on the spindle head and adjacent to an edge of the moving length of tape and arranged to sense the position of the tape edge at the sensor. The tension measuring assembly includes a first tension transducer arranged so as to support the moving length of tape and a second transducer positioned in spaced diametric relation to the first transducer. Means for computing a difference signal from respective output signals from the first and second transducers are provided such that the difference signal comprises a measure of tension in the moving length of tape. The measure of tension is communicated to the second motor by the computing and communicating means, and the second motor speed is continuously adjusted based on the measure of tension in the moving length of tape.

[0008] A method is provided for adjusting the lay angle of a length of tape as it is wrapped onto a length of hose. A movable guide arm is arranged so as to support a length of tape. The guide arm is pivotable toward and away from the length of hose between a first position and at least one second position so as to provide a plurality of angular relationships between the guide arm and the moving length of hose. The length of tape continuously engages a portion of the guide arm so that a lay angle of the tape on the moving length of hose may be adjusted by movement of the guide arm between the first position and the at least one second position.

[0009] A method is also provided for determining the tension in a length of tape as it is wrapped onto a moving length of hose. A first tension transducer is arranged so as to support a length of moving tape on a rotating plate. A second, reference transducer is positioned in spaced diametric relation to the first transducer on the rotating plate. A reference signal is transmitted by the second transducer that represents the centrifugal force generated by the second transducer as the shuttle plate rotates. A tension signal is transmitted by the first transducer that represents the centrifugal force plus the tape tension applied to the first transducer. The reference signal is subtracted from the tension signal to yield a resultant signal which, in the centrifugal environment of the rotating shuttle plate, represents the effect of the tape traversing the first transducer alone, i.e., the tension in the tape as it moves from its supply to the moving length of hose.

[0010] Of course the foregoing methods may be combined so as to be performed either in serial or parallel, as required by a particular application.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] These and other features and advantages of the present invention will be more fully disclosed in, or rendered obvious by, the following detailed description of the preferred embodiments of the invention, which are to be considered together with the accompanying drawings wherein like numbers refer to like parts and further wherein:

[0012] FIG. 1 is a side elevational view of a section of prior art hose used in connection with the present invention;

[0013] FIG. 2 is a perspective view of the present invention including a frame, cabinet, electronics control module, and reels of hose;

[0014] FIG. 3 is a broken-away, perspective view of a pair of opposed loop belt drives of the type used in one preferred embodiment of the invention;

[0015] FIG. 4 is a broken-away, side elevational view of the present invention showing a shuttle plate, nose assembly and spindle head assembly;

[0016] FIG. 5 is a cross-sectional view of the spindle assembly, as taken along lines 5-5 in FIG. 4;

[0017] FIG. 6 is a front elevational view of a shuttle plate;

[0018] FIG. 7 is a perspective view a nose assembly formed in accordance with the present invention;

[0019] FIG. 8 is a perspective view of a nose and nose hub formed in accordance with the present invention;

[0020] FIG. 9 is a perspective view, partially in phantom, of an adjustable guide arm;

[0021] FIG. 10 is a perspective view of an angle indicator;

[0022] FIG. 11 is a perspective view of an angle gauge;

[0023] FIG. 12 is a side elevational view of a nose assembly, including a tape edge sensor, and showing a portion of tape being wrapped onto a section of hose;

[0024] FIG. 13 is a broken-away, perspective view of a spindle head assembly, a shuttle plate, and tension monitor assembly applying tape to a hose;

[0025] FIG. 14 is a transducer guide cage having a transducer shown in phantom mounted within it;

[0026] FIG. 15 is a perspective view of a tape shift guide;

[0027] FIG. 16 is a perspective view of a second guide;

[0028] FIG. 17 is a perspective view of a third guide and;

[0029] FIG. 18 is a front elevational view of a tension control assembly and nose assembly in position within the wrapping machine, with a tape threaded through the assemblies according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0030] This description of preferred embodiments is intended to be read in connection with the accompanying drawings, which are to be considered part of the entire written description of this invention. In the description, relative terms such as “horizontal,” “vertical,” “up,” “down,” “top” and “bottom” as well as derivatives thereof (e.g., “horizontally,” “downwardly,” “upwardly,” etc.) should be construed to refer to the orientation as then described or as shown in the drawing figure under discussion. These relative terms are for convenience of description and normally are not intended to require a particular orientation. Terms including “inwardly” versus “outwardly,” “longitudinal” versus “lateral” and the like are to be interpreted relative to one another or relative to an axis of elongation, or an axis or center of rotation, as appropriate. Terms concerning attachments, coupling and the like, such as “connected” and “interconnected,” refer to a relationship wherein structures are secured or attached to one another either directly or indirectly through intervening structures, as well as both movable or rigid attachments or relationships, unless expressly described otherwise. The term “operatively con-
is such an attachment, coupling or connection that allows the pertinent structures to operate as intended by virtue of that relationship. In the claims, means-plus-function clauses are intended to cover the structures described, suggested, or rendered obvious by the written description or drawings for performing the recited function, including not only structural equivalents but also equivalent structures.

Referring to FIGS. 2-3, a tape wrapping machine 20 is adapted for wrapping a flexible polymeric or fabric tape 6 in a spiral completely about a reinforcement layer of braided filaments 7 that surround a flexible reinforced length of hose 8. Tape wrapping machine 20 selectively, but continuously controls tape tension and lay angle during wrapping. In a preferred embodiment, tape wrapping machine 20 comprises a support frame 22, a spindle head assembly 24, a shuttle plate 26, and a tension monitor assembly 28.

More particularly, support frame 22 comprises a cabinet 30, a sliding panel door 32, a first end 34 and a second end 36. Cabinet 30 defines an interior space sized to contain spindle head assembly 24, shuttle plate 26, and tension monitor assembly 28, all of which may be accessed via sliding panel door 32. First end 34 is bounded by a main plate 38 having fixtures that are adapted for mounting drive means 51, 53 and electronic control and operation means 55 of the type known for use in the operation of high speed equipment. An opening 42 is defined through main plate 38, and is sized and shaped to receive a continuous moving length of hose 8. A second opening 44 is located in spaced relation to opening 42, and is sized and shaped to receive the continuous moving length of tubular conduit 5 after it has been wrapped with tape 6.

Tubular conduit 5 may be moved through tape wrapping machine 20 by various methods and apparatus that are well known to those skilled in the art, e.g., tubular conduit 5 may be pulled through tape wrapping machine 20 from one reel 47 located adjacent to first end 34 to another reel 49 located adjacent to second end 36, via a pair of opposed loop belt drives 48, as shown in FIG. 3. Belt drives 48 are spaced apart sufficiently to allow wrapped tubular conduit 5 to be evenly gripped between the opposed belts so that when the belts are driven, clockwise and counter-clockwise, respectively, wrapped tubular conduit 5 is pulled through wrapping machine 20 at a constant, known velocity.

Referring to FIGS. 4 and 5, spindle head assembly 24 comprises a shuttle drive hub 50 and a nose assembly 52. More particularly, shuttle drive hub 50 is mounted to main plate 38 so as to project into the interior chamber of cabinet 30 (FIGS. 2 and 4). Shuttle drive hub 50 comprises an open ended cylindrical support structure within which nose assembly 52 is mounted. A main stationary spindle 54 is arranged in coaxially aligned relation within the interior of shuttle drive 50, and is fixedly secured to main plate 38. A plurality of bearings 56 provide an interface between the interior surfaces of shuttle drive 50 and the exterior surfaces of main stationary spindle 50, such that shuttle drive 50 may rotate relative to main stationary spindle 54. A shuttle plate driver sprocket 58 is positioned in a rear portion of shuttle drive hub 50 and adapted for engagement with a motor (shown generally at 51 in FIG. 2) which provides rotational motive force to shuttle drive hub 50 via shuttle driver sprocket 58.

Referring also to FIG. 6, shuttle plate 26 projects radially outwardly from an outer surface of shuttle drive hub 50. A tension plate 60 also projects radially outwardly from the outer surface of shuttle drive hub 50, and in substantially parallel relation to shuttle drive plate 26. Tension plate 60 supplies a support 67 of tape 6 that is arranged in coaxial relation to spindle head assembly 24. Preferably, shuttle plate 26 has a larger diameter than tension plate 60. Tension plate sprocket 62 is interconnected with tension plate 60, and provides for an operative interconnection between tension plate 60 and a motor (shown generally at 53 in FIG. 2). Tension plate 60 is arranged in operative cooperation with tension plate sprocket 62 and motor 53 so as to be caused to rotate at a controlled and selected rate that is normally less than the rotation rate of shuttle plate 26, during operation of wrapping machine 20. In this way, tape 6 is paid out from supply 67 as both shuttle plate 26 and tension plate 60 rotate. The rate of pay-out of tape 6 is directly proportional to the differential in rotational speed of tension plate 60 relative to shuttle plate 26. A nose hub 64 covers an inner front end of shuttle drive hub 50, and provides a support for a portion of nose assembly 52. A slip ring assembly 63 is located adjacent to nose hub 64 and provides for electrical interconnection between tension monitor assembly 28 and operational means 54. Referring to FIG. 6, shuttle plate 26 comprises a plurality of through bores 61 that are sized and arranged to support portions of tension monitor assembly 28. A spindle head mounting bore 66 is centrally located in shuttle plate 26 with a jack shaft bore 68 positioned adjacent to it. A disk brake system 65 comprises two discs 71 mounted to the drive pulleys of motors 51 and 53. Disk brake system 65 is provided adjacent to a rear side of shuttle plate 26, for controllably reducing the rotation of shuttle plate 26 and tension plate 60, respectively. Disk brake system 65 includes a pair of calipers 69 that are each arranged so as to controllably grip a disk 71 in order to separately slow shuttle plate 26 and tension plate 60.

Referring to FIGS. 2 and 7-12, nose assembly 52 projects outwardly from nose hub 64, and in coaxially aligned relation to openings 42 and 44. Nose assembly 52 comprises a nose 70, an adaptable guide arm 72, and an actuator subassembly 74. More particularly, nose 70 projects outwardly from nose hub 64, and comprises a semi-cylindrical tube having an upwardly opening longitudinal slot 77 extending along a portion of its length which provides access for tape 6 to be wrapped onto length of hose 8 as it moves through nose 70. A pivot yoke 79 is formed on a top portion of nose 70, adjacent to the end of slot 77 and to nose hub 64. A pivot shaft 80 is positioned through pivot yoke 79. Adjustable guide arm 72 comprises a hollow cylindrical rod having a central passageway 83 opening at one end 84, and a pivot lug 87 positioned at a second end 89. (FIG. 9) Pivot lug 87 includes a through-bore 88 that is sized so as to accept the end of pivot shaft 80 when guide arm 72 is mounted on nose 70.

Actuator assembly 74 comprises a DC motor 110, a clevis 100, a lever arm 102, and an angle pointer 105. More particularly, DC motor 110 is mounted on nose 70 via support mounts 105, 106 (FIG. 8). A motor gear reduction unit 98, of the type well known in the art, is mounted adjacent to motor 110. Motor 110 may be operatively controlled via electrical connection through slip ring 63 to electronic control and operational means 55 (FIGS. 2 and 5).
Clevis 100 is coupled to DC motor 110 and engages a pivot pin 107 positioned in a lower portion of lever arm 102. The upper portion of lever arm 102 comprises a through-bore that is mounted on pivot shaft 80 in spaced relation to pivot lug 87 of adjustable guide arm 72. Angle pointer 105 (FIGS. 7 and 10) comprises a through-bore 111 that accepts pivot shaft 80 and is held in place by a fastener 112. Angle scale 115 (FIGS. 7 and 11) is mounted to support mount 106 so as to be adjacent to angle pointer 105, and includes graduation lines 117 that are related to the angular orientation of adjustable guide arm 72. Of course, actuator assembly 74 may comprise various other known means for selectively pivoting adjustable guide arm 72.

[0038] As a result of this construction, adjustable guide arm 72 is pivotable toward and away from nose 70 and length of hose 8, between a first position and at least one second position so as to provide a plurality of angular relationships between adjustable guide arm 72 and length of hose 8. Tape 6 continuously engages a portion of adjustable guide arm 72 so that a lay angle \( \alpha \) (FIG. 12) on moving length of hose 8 may be adjusted by movement of adjustable guide arm 72 between its first position and a plurality of other angularly spaced positions from moving length of hose 8. During set-up and adjustment of wrapping machine 20, adjustable guide arm 72 may be caused to move toward or away from nose 70, via actuator assembly 74 so as to change lay angle \( \alpha \) based upon several parameters including the width of tape 6, the outer diameter of tubular conduit 5, and the percentage of overlap required for a particular application. For example, lay angle \( \alpha \) may be approximately 56° for a tape width of two and a half inches, a tubular conduit outer diameter of one inch, and a desired overlap of about fifty percent. The angular relationship of adjustable guide arm 72 to nose 70 and therethrough length of hose 8 is displayed at the intersection between the tip of angle pointer 105 and graduation lines 117 on angle scale 115. In order to adjust the degree and overlap of tape 6 upon itself as it is wound upon length of hose 8, the operator of wrapping machine 20 merely adjusts the angular relationship of adjustable guide arm 72 relative to length of hose 8.

[0039] Lay angle \( \alpha \) may increase or decrease during operation of wrapping machine 20 due to slippage of tape 6 along the outer surface of adjustable guide arm 72. This slippage of tape 6 along guide arm 72 may be caused by changes in surface finish of guide arm 72 and/or changes in the moisture content or surface texture of tape 6. In order to alert the operator of wrapping machine 20 to an undesirable movement of tape 6 along adjustable guide arm 72, a sensor 118 is positioned adjacent to an inner edge 119 of tape 6. Sensor 118 may comprise an optical, acoustic, or sonic sensor that is capable of detecting the position, presence, or absence of tape 6 as it proceeds from supply 67 over adjustable guide arm 72 and on to conduit 5. Sensor 118 may be mounted on to nose 70 by a suitable bracket 120 (FIG. 12). Thus, when angle \( \alpha \) has been established through adjustment of guide arm 72, and wrapping machine 20 has begun to operate, sensor 118 will monitor the position of edge 119 of tape 6 so as to sense translational movement of said edge of said tape, i.e., movement along the length of hose 8. If tape 6 begins to move along adjustable guide arm 72, that movement is identified by sensor 118, an alarm or other suitable notification will be presented to the operator so that wrapping machine 20 may be stopped. The operator can then reposition adjustable guide arm 72 and tape 6 in a proper orientation to maintain angle \( \alpha \) at a desired value.

[0040] Referring to FIGS. 13-18, tension control assembly 28 includes a transducer guide cage 120, a shift guide 121, a second guide 122, a third guide 124, and a pair of transducers 126, 127. Guides 120, 121, 122, 124 and transducers 126, 127 are positioned on the circumferential edge of shuttle plate 26. Transducers 126, 127, are positioned in diametric opposition to one another, i.e., spaced at about 180 degrees apart on the peripheral edge of shuttle plate 26, with transducer 126 providing a reference signal and transducer 127 having a portion of tape 6 engaged around a portion of its outer surface (FIG. 18). Transducers 126, 127, are preferably Dover Flexo-FLRA-0-100-R6-6-SPR ribbon filament tension transducers connected to a Dover Flexo differential amplifier 129.

[0041] Referring to FIGS. 14-17, transducer guide cage 120 comprises three columns 131, 132, and 133, held together between a base plate 136 and a cover plate 138. Tension transducer 127 is mounted to base plate 136. Shift guide 121 comprises a push bar 137 mounted in a channel bracket 135. Channel bracket 135 is rotationally supported upon a plate stand 139 that is mounted to the outer surface of shuttle plate 26. Channel bracket 135 may be rotated so that push bar 137 may be oriented at a plurality of angles relative to shuttle plate 26 and tape 6. In this way, tape 6 may be pushed outwardly and away from tension plate 60.

[0042] Second guide 122 comprises a base plate 140 and an angled column 142 that projects outwardly from base plate 140. Column 142 is angled to aid in directing tape 6 outwardly toward nose assembly 52 and to orient tape 6 so as to engage nose assembly 52 at a proper angle. Third guide 124 comprises a base plate 146 having an angled column 148 projecting outwardly from base plate 146. A plurality of support members 149 are positioned adjacent to angled columns 142 and 148, so as to provide support for and resistance to the forces imposed on them by rotation of shuttle plate 26 and the passing of tape 6 during operation of tape wrapping machine 20.

[0043] Tape wrapping machine 20 operates to wrap tape 6 around braided filament 7 and length of hose 8 with a controlled tension in the following manner. Length of hose 8 is pulled through nose assembly 52 by belt drive 48, as tape 6 from tape supply 67 is paid-out from tension plate 60 due to the differential in rotational speed between shuttle plate 26 and tension plate 60. As tape 6 is paid-out from supply 67, its inner edge 119 is substantially parallel with the surface of tension plate 60. Tape 6 is then wound through transducer guide cage 120 so as to loop around transducer 127. Tape 6 then engages push bar 137 of shift guide 121. Push bar 137 is oriented relative to plate stand 139 so as to shift or push tape 6 outwardly, away from tension plate 60. Tape 6 then engages second guide 122 and third guide 124. Second guide 122 and third guide 124 further adjust the outward movement of tape 6 so as to control the approach of tape 6 toward adjustable guide arm 72. From third guide 124, tape 6 is wrapped over a top surface of adjustable guide arm 72 and into engagement with length of hose 8 at a preselected lay angle \( \alpha \). It should be noted, however, that adjustable guide arm 72 is not a necessary element of tension monitor assembly 28.

[0044] As shuttle plate 26 rotates at approximately 1200 rpm, the signal generated by reference transducer 126 rep-
resents the centrifugal force exerted upon it as a result of rotation with shuttle plate 26. Transducer 127 is arranged so as to support a length of moving tape 6 and is positioned in spaced diametric relation to transducer 126. A tension signal is generated by transducer 127 that represents the centrifugal force plus the force exerted by tape 6 on transducer 127. The signal from reference transducer 126 is subtracted from the tension signal from transducer 127 to yield a resultant signal which, in the centrifugal environment of spinning shuttle plate 26, represents the force exerted by tape 6 as it traverses transducer 127 alone, i.e., the magnitude of the tension in tape 6 as it moves from tape supply 67 to the outer surface of length of hose 8.

[0045] The system is calibrated when shuttle plate 26 is at rest such that the output of differential amplifier 129 is about 10.0 VDC for a tape tension of 50 pounds, where the output signal is linear with tape tension. The output signal is utilized as a control signal which, when compared with a set point, instructs motor 53 to increase or decrease in speed to maintain the output at set point. Thus, a measure, feedback, and responsive control technique is implemented as a means for maintaining a known and constant tape tension during both wrap and unwrap modes of operation. Power and signal communications between transducers 126, 127 and differential amplifier 129 are accomplished via a slip-ring assembly 63, or alternatively by a battery and an RF transmitter. Thus, both the lay angle and tension of tape 6 may be adjusted and controlled by the present invention.

[0046] It is to be understood that the present invention is by no means limited only to the particular constructions herein disclosed and shown in the drawings, but also comprises any modifications or equivalents within the scope of the claims.

What is claimed is:

1. A machine for wrapping a moving length of tape onto a moving length of hose that is moving relative to said machine and said length of tape, said machine comprising:
   a frame supporting a shuttle plate and a tension plate in parallel spaced relation to one another, said shuttle plate and said tension plate comprising a central bore for receiving said moving length of hose, and said tension plate supporting a supply of said tape;
   a first motor supported by said frame and operatively engaging said shuttle plate so as to rotate said shuttle plate relative to said frame, and a second motor supported by said frame and operatively engaging said tension plate so as to rotate said tension plate relative to said shuttle plate;
   a spindle head mounted adjacent to said shuttle plate having a tube positioned in coaxial relation to said central bore so as to receive said length of hose, and a guide arm having a first end pivotally mounted on said tube so that said guide arm pivots relative to said tube between a first position and at least one second position wherein said moving length of tape continuously engages said guide arm prior to wrapping engaging said length of hose so as to be guided at a preselected angular relation to said hose during said wrapping of said moving length of hose.

2. A machine according to claim 1 comprising a tension measuring assembly mounted on said shuttle plate and positioned so as to support and direct said moving length of tape from said supply of said tape into wrapping engagement with said moving length of hose, said tension measuring assembly comprising at least two transducers wherein at least one transducer is engaged by said moving length of tape so as to provide a measure of tension in said moving length of tape, and wherein said second motor is continuously adjusted based on said measure of tension in said moving length of tape.

3. A machine according to claim 1 comprising a nose assembly projecting outwardly from a nose hub supported by said frame, and arranged in coaxially aligned relation to said central bore, said nose assembly including said tube, said guide arm, and means for pivoting said guide arm.

4. A machine according to claim 1 wherein said tube comprises a semi-cylindrical cross-section having an upwardly opening longitudinal slot extending along a portion of its length so as to provide access to said length of tape.

5. A machine according to claim 4 wherein said tube comprises a pivot yoke formed on a top portion thereof, adjacent to said slot and a pivot shaft positioned through said pivot yoke, said guide arm comprising a cylindrical rod having a pivot lug positioned at an end wherein said pivot lug includes a through-bore that is sized so as to accept a portion of said pivot shaft.

6. A machine according to claim 5 including an actuator assembly comprising a DC motor driven linear actuator interconnected with a clevis and lever arm that are operatively engaged with said pivot shaft for selected pivotal movement of said guide arm between said first position and said at least one second position.

7. A machine according to claim 5 wherein said actuator assembly includes an angle pointer mounted to an end of said pivot shaft and an angle scale mounted adjacent to said angle pointer, and including graduation lines that are related to the angular orientation of said guide arm relative to said moving length of hose.

8. A machine according to claim 1 wherein said guide arm is pivotally adjustable toward and away from said tube, between said first position and said at least one second position so as to provide a plurality of angular relationships between said guide arm and said hose.

9. A machine according to claim 1 wherein said moving length of tape continuously engages a portion of said guide arm so that a lay angle of said length of tape on said moving length of hose may be selectively adjusted by movement of said guide arm between said first position and a plurality of angularly spaced positions relative to said hose.

10. A machine according to claim 7 wherein an angular relationship of said guide arm to said moving length of hose is displayed at the intersection between said angle pointer and said graduation lines.

11. A machine for wrapping a moving length of tape onto a moving length of hose that is moving relative to said machine and said length of tape, said machine comprising:
   a frame supporting a shuttle plate and a tension plate in parallel spaced relation to one another, said shuttle plate and said tension plate comprising a central bore for receiving said moving length of hose, and said tension plate supporting a supply of said tape;
   a first motor supported by said frame and operatively engaging said shuttle plate so as to rotate said shuttle
plate relative to said frame, and a second motor supported by said frame and operatively engaging said tension plate so as to rotate said tension plate relative to said shuttle plate;

a spindle head mounted to said shuttle plate having a tube positioned in coaxial relation to said central bore so as to receive said moving length of hose; and

a tension measuring assembly mounted on said shuttle plate and positioned so as to support and direct said moving length of tape from said supply of tape into engagement with said moving length of hose wherein said tension measuring assembly includes a first tension transducer arranged so as to support said length of tape and a second transducer positioned in spaced diametric relation to said first transducer.

12. A machine according to claim 11 wherein said first transducer is engaged by said moving length of tape so as to provide a measure of tension in said moving length of tape, and wherein said second motor is continuously adjusted based on said measure of tension in said moving length of tape.

13. A machine according to claim 11 wherein said tension control assembly includes a transducer guide cage arranged in surrounding relation to said first transducer and at least one tape guide positioned on a peripheral edge of said shuttle plate and circumferentially spaced from said transducer guide cage.

14. A machine according to claim 11 wherein said first and second transducers are positioned at about 180 degrees apart from one another on the peripheral edge of said shuttle plate.

15. A machine according to claim 11 wherein a guide arm having a first end pivotally mounted on said tube of said spindle head so that said guide arm pivots relative to said tube between a first position and at least one second position wherein said moving length of tape continuously engages said guide arm prior to wrapping said length of hose so as to be guided at a preselected angular relation to said hose during said wrapping of said moving length of hose.

16. A machine for wrapping a moving length of tape onto a moving length of hose that is moving relative to said machine and said moving length of tape, said machine comprising:

a frame supporting a shuttle plate and a tension plate in parallel spaced relation to one another, said shuttle plate and said tension plate comprising a central bore for receiving said moving length of hose, and said tension plate supporting a supply of said tape;

a first motor supported by said frame and operatively engaging said shuttle plate so as to rotate said shuttle plate relative to said frame, and a second motor supported by said frame and operatively engaging said tension plate so as to rotate said tension plate relative to said shuttle plate;

a spindle head mounted to said shuttle plate having a tube positioned in coaxial relation to said central bore so as to receive said moving length of hose, a guide arm having a first end pivotally mounted on said tube so that said guide arm pivots relative to said tube between a first position and at least one second position; and

a tension control assembly mounted on said shuttle plate and positioned so as to support and direct said moving length of tape from said supply to engagement with said moving length of hose wherein said moving length of tape continuously engages a portion of said guide arm and wherein said tension control assembly includes;

a first tension transducer arranged so as to support said moving length of tape and a second transducer positioned in spaced diametric relation to said first transducer,

means for computing a difference signal from respective output signals from said first and second transducers;

wherein said difference signal comprises a measure of tension in said moving length of tape that is communicated to said second motor by said computing and communicating means, and wherein said second motor speed is continuously adjusted to control said measure of tension in said moving length of tape.

17. A machine for wrapping a moving length of tape onto a moving length of hose that is moving relative to said machine and said length of tape wherein said moving length of tape comprises at least one edge, said machine comprising:

a frame supporting a shuttle plate and a tension plate in parallel spaced relation to one another, said shuttle plate and said tension plate comprising a central bore for receiving said moving length of hose, and said tension plate supporting a supply of said tape;

a first motor supported by said frame and operatively engaging said shuttle plate so as to rotate said shuttle plate relative to said frame, and a second motor supported by said frame and operatively engaging said tension plate so as to rotate said tension plate relative to said shuttle plate;

a spindle head mounted adjacent to said shuttle plate having a tube positioned in coaxial relation to said central bore so as to receive said length of hose, and a guide arm having a first end pivotally mounted on said tube so that said guide arm pivots relative to said tube between a first position and at least one second position wherein said moving length of tape continuously engages said guide arm prior to wrapping said length of hose so as to be guided at a preselected angular relation to said hose during said wrapping of said moving length of hose; and

a sensor positioned on said spindle head and adjacent to said edge of said moving length of tape and arranged to sense a plurality of angular relationships between said guide arm and said moving length of hose and thereby adjust the lay angle of the tape on the hose.

18. A method for adjusting the lay angle of a moving length of tape being wrapped onto a moving length of hose comprising:

positioning a pivotable guide arm so as to support a length of tape wherein said length of tape continuously engages a portion of said guide arm; and

pivoting said guide arm toward and away from said length of hose between a first position and at least one second position so as to provide a plurality of angular relationships between said guide arm and said length of hose and thereby adjust the lay angle of the tape on the hose.
19. A method for determining the tension in a moving length of tape being wrapped onto a moving length of hose comprising:

mounting a first tension transducer on a rotating plate so as to support a length of said moving tape;

mounting a second transducer on said rotating plate in spaced diametric relation to said first transducer;

reading and storing a reference signal transmitted by said second transducer that represents the centrifugal force generated by said second transducer as said plate rotates;

reading and storing a tension signal transmitted by said first transducer that represents the centrifugal force plus the tape tension applied to said first transducer;

subtracting said reference signal from said tension signal and storing a resultant signal which is representative of the tension in said tape.

20. A method for adjusting the lay angle of a moving length of tape being wrapped onto a moving length of hose comprising:

positioning a pivotable guide arm so as to support a length of tape wherein said length of tape continuously engages a portion of said guide arm; and

pivot said guide arm toward and away from said length of hose between a first position and at least one second position so as to provide a plurality of angular relationships between said guide arm and said length of hose and thereby adjust the lay angle of the tape on the hose;

monitoring an edge of said moving length of tape so as to sense translational position of said edge of said tape.

21. A machine for wrapping a moving length of tape onto a moving length of hose that is moving relative to said machine and said length of tape, said machine comprising:

a frame supporting a shuttle plate and a tension plate in parallel spaced relation to one another, said shuttle plate and said tension plate comprising a central bore for receiving said moving length of hose, and said tension plate supporting a supply of said tape;

a first motor supported by said frame and operatively engaging said shuttle plate so as to rotate said shuttle plate relative to said frame, and a second motor supported by said frame and operatively engaging said tension plate so as to rotate said tension plate relative to said shuttle plate;

a spindle head mounted adjacent to said shuttle plate having a tube positioned in coaxial relation to said central bore so as to receive said length of hose, and a guide arm having a first end pivotally mounted on said tube so that said guide arm pivots relative to said tube between a first position and at least one second position wherein said moving length of tape continuously engages said guide arm prior to wrapping said length of hose so as to be guided at a preselected angular relation to said hose during said wrapping of said moving length of hose; and

a tension measuring assembly mounted on said shuttle plate and positioned so as to support and direct said moving length of tape from said supply of said tape into wrapping engagement with said moving length of hose, said tension measuring assembly comprising two transducers wherein one transducer is engaged by said moving length of tape so as to provide a measure of tension in said moving length of tape, and wherein said second motor is continuously adjusted based on said measure of tension in said moving length of tape.

22. A machine for wrapping a moving length of tape onto a moving length of hose that is moving relative to said machine and said length of tape, said machine comprising:

a frame supporting a shuttle plate and a tension plate in parallel spaced relation to one another, said shuttle plate and said tension plate comprising a central bore for receiving said moving length of hose, and said tension plate supporting a supply of said tape;

a first motor supported by said frame and operatively engaging said shuttle plate so as to rotate said shuttle plate relative to said frame, and a second motor supported by said frame and operatively engaging said tension plate so as to rotate said tension plate relative to said shuttle plate;

a spindle head mounted adjacent to said shuttle plate having a tube positioned in coaxial relation to said central bore so as to receive said length of hose, said tube comprising a semi-cylindrical cross-section having an upwardly opening longitudinal slot extending along a portion of its length so as to provide access to said length of tape and a pivot yoke formed on a top portion, adjacent to said slot and a pivot shaft positioned through said pivot yoke; and a guide arm having a first end pivotally mounted on said tube so that said guide arm pivots relative to said tube between a first position and at least one second position, said guide arm comprising a cylindrical rod having a pivot lug positioned at an end wherein said pivot lug includes a through-bore that is sized so as to accept a portion of said pivot shaft wherein said moving length of tape continuously engages said guide arm prior to wrapping said length of hose so as to be guided at a preselected angular relation to said hose during said wrapping of said moving length of hose; and

an actuator assembly comprising a DC motor driven linear actuator interconnected with a clevis and lever arm that are operatively engaged with said pivot shaft for selected pivotal movement of said guide arm between said first position and said at least one second position.