This invention relates to apparatus for winding wire around objects, and more particularly for applying a tensioned wrapping of wire in the production of pre-stressed pipe.

Among the objects of the invention is to provide an apparatus for wrapping a rotating body with wire having a known tension and for maintaining the tension during the entire wire wrapping operation.

Another object is to provide a compact apparatus for tensioning a wire end for applying the tensioned wire as a helical winding about a rotating body.

Another object is to provide a winding apparatus with a closed system through which the torque required to rotate an object being wrapped is balanced by a restraining torque acting upon the supply portion of the wire so that only a relatively small amount of power is required for accomplishing a winding operation.

Another object is to provide a wire winding apparatus employing a floating sheave by which tension is applied to a loop of wire intermediate a source of supply and an object being wrapped with the wire and wherein control is effected to limit the extension of the loop and accompanying movement and displacement of the floating sheave during a wire winding operation.

Another object is to provide an apparatus capable of winding wire under tension without injuring the wire or causing damage to any coating that it may have.

Another object is to provide a device for rotationally supporting a hollow core and for transmitting a rotating torque to the core, said device including a rotatable member engaging the exterior of the core and centering the core and a flange extending from the member inwardly of the core and supporting an inflatable element in contact with the interior of the core.

Another object of the invention is to provide a machine whereby a pre-stressed pipe may be constructed which has been wrapped under an exact tension.

Further and other objects of the invention will be hereinafter set forth in the accompanying specification and claims and illustrated in the drawings which show by way of illustration a preferred embodiment incorporating the principle of the invention and the best form in which I have contemplated applying that principle.

Referring to the drawings, Fig. 1 is a plan of the left end of an apparatus embodying the principle of the invention;

Fig. 2 is a front elevation of the left end of the apparatus; Fig. 2B is a front elevation of the right end of the apparatus; Fig. 3 is a longitudinal section through a differential unit; Fig. 4 is a view on line 4-4 of Fig. 3; Fig. 5 is a longitudinal section through a portion of a supporting flange by which one end of a pipe core is rotated; Fig. 6 is a view similar to Fig. 5 showing a tube in inflated condition for engaging the interior of the core.

The principle of the present invention is useful in the production of pre-stressed pipe in which great strength is obtained and great economy effected by winding high tensile wire under high tension about a pipe core, thereby compressing the core. The wire must be wrapped evenly and uniformly around the core under a definite predetermined tension and in a manner that will assure no loss of tension at any stage of the winding operation. The machine of this invention accomplishes this result. It also has the advantages of a compact organization capable of efficiently applying a tensioned wrapping about any object.

All of the operating mechanisms and the object being wrapped are mounted and contained within an open box-like frame made up of structural steel elements, as shown in the drawings. In view of the fact that the object-supporting means is designed to accommodate a pipe core, such as a steel or concrete sleeve-like member, I shall refer herein to the object being wound as a core, it being understood that this term is used without limitation and to identify any object about which a tensioned winding is applied.

During a wire-winding operation a core 10 is mounted centrally of the right end of the box-like frame. The core is supported at its ends from a pair of vertically disposed circular plates 11, 12, which have flanges 13 and 14, respectively, engaging over the exterior end-portions of the core. Plate 11 is mounted upon and keyed to one end of shaft 15 for rotation therewith, and plate 12, at the other end of the core, is supported from a spindle 16 which is journaled for rotation in bearings 17 and 18. Bearings 17 and 18 are carried upon a carriage 19 having pairs of rollers 20, 21 which run on base I-beams 22 and 23 of the main frame.

For placing a core 10 in the machine the carriage 19 is displaced to the right of its position in Fig. 2B and the core is rolled over timber skids 24 and 25 to a central position between support-
ing plates 11 and 12. The core is then raised by an over-head chain hoist and its left end is inserted within flange 13 of the supporting plate 11. Core 19 is then advanced towards the other end of the core until flange 14 of plate 12 is brought into supporting registration with that end of the core. Movement of the carriage is accomplished by the use of a motor 20 having a sprocket and chain connection 27 with one of the wires supporting the carriage. The carriage is locked in the core-supporting position illustrated in Figs. 1B and 2B during a wire-winding operation.

Figs. 5 and 6 illustrate the manner in which the left end of the core is supported by plate 11 and flange 13. The core illustrated includes an outer steel cylinder with joint rings welded thereto and an interior body of concrete. The end of the core is seated against plate 11, and flange 13 engages the circumference of the bearing ring of the core. A ring 28 is fixedly mounted on plate 11, concentrically with flange 13. About this ring there is mounted a pneumatic tube 29 having a valve stem 30 by which it may be inflated. After the core is mounted in place between the plates 11 and 12, the pneumatic tube 29 is distended by inflation to provide a firm connection between the interior of the core and ring 28, as illustrated in Fig. 6. This manner of mounting and securing the core in the apparatus affords means for firmly gripping the core whereby the core-rotating torque is transmitted from flanged plate 11 to the core during a wire-winding operation. A gripping connection similar to the pneumatic tube and ring may be used with plate 12 at the other end of the core, but this is not indispensable since spindle 15 rests in its bearings and the core is adequately supported by flange 14.

The drive for rotating the core originates from a variable speed motor 31 which drives a speed reducer 32, a flexible coupling 33, and a shaft 34 which is mounted in bearings 35 and 36. Shaft 34 is affected by a torque substantially equal and opposite to the core-rotating torque as will be explained hereinafter. Shaft 34 carries a sprocket wheel 37 driving a sprocket chain 38, and a sprocket wheel 39 which is keyed to shaft 15 upon which core-supporting and driving plate 11 is mounted. Shaft 15 is journalled in bearings 40, 41.

The wire to be wound upon the core may be taken from a supply spool (not shown). It is threaded through a light restraining brake 42 from which it passes to a tapered drum 43. Several turns of the wire are placed about the tapered drum and only sufficient restraint is applied by brake 42 to cinch the wire about the drum. The drum is restrained against free rotation but rotates sufficiently to supply wire for application to the core. Wire-tensioning means is provided intermediate the drum and the core. As shown in Figs. 1A and 2A, the wire leaving the drum passes over an idler 44 which guides the wire to a floating sheave 45 from whence it is delivered to a travelling guide-sheave 46 and then through an opened adjustable clamping 47 and then through a housing 48. As shown in the drawings, the core has been rotated a few times, during which travelling sheave 46 has moved to the right from a left hand position.

The pitch of the winding on the core is controlled by the rate of movement of sheave 46. Sheave 46 is mounted upon a carriage consisting of a frame 49 supported at its ends by pairs of rollers 50, 51. These rollers are borne upon the inside flanges of a pair of I-beams 52, 53 and travel thereover. These I-beams are parallel to the core and extend lengthwise of the apparatus for guiding the sheave a sufficient distance to wrap the longest core that may be mounted in the apparatus.

The rate of movement of travelling sheave 46 and frame 49 is controlled by a variable speed motor reducer unit 54 which drives a speed reducing unit 55 and a sprocket and chain connection 56. The driven sprocket 57 of this drive is mounted upon a shaft 58 to which is keyed a sprocket wheel 59. Bearings 60 and 61, which support shaft 58, are adjustable lengthwise of the machine for controlling the tension in chain 62.

Travelling sheave 46 is moved by chain 62 which operates as an endless chain having its ends connected to carriage frame 49 at 63 and 64. The chain passes over a sprocket 65 at the right end of the apparatus. This sprocket is mounted on a shaft 66 journailed in adjustable bearings 67 and 68 by which the tension in chain 62 may be set. The upper reach of the chain between sprocket wheels 59 and 65 is supported against sagging on a web of a longitudinally extending I-beam 69.

The desired tension is applied to the loop of wire intermediate tapered drum 43 and the core by restraining force applied to floating sheave 45. This sheave is rotatably mounted upon a vertical shaft 70 which extends upwardly from a carriage frame 71 having pairs of rollers 72 and 73 engaging upper and lower flanges of channel members 74, 75. These channel members are part of the main frame and extend longitudinally thereof. A cable 76 is attached to the carriage by a yoke 77 fastened to shaft 70. Cable 78 passes over an idler sheave 78 and has attached to its other end a spring 79 from which a weight 80 is supported. The amount of mass represented by weight 80 may be varied, as desired, by placing or removing additional weights, it being understood that the total mass required must be such as to effect a pull upon the tension in cable 78 equal to twice the amount of the tension desired in the wire being wound about the core.

During a wire-winding operation the wire intermediate tapered spool 43 and the core is subjected to high tensile stress and, disregarding for the moment the effect of movement of guide-sheave 46, it is apparent that floating sheave 45 would change its position as wire delivered from the tapered drum becomes tensioned. If provision were not made for automatically controlling the position of floating sheave 45, a considerable length of track would have to be provided for the movement of the sheave. The mechanisms about to be described enable the movement of floating sheave 45 and the rise and fall of weight 80 to be restricted within narrow limits. These mechanisms include a differential unit capable of controlling the rate of rotation of drum 43 and gearing 32, 33 which is directly driven by shaft 34 and motor 31. The differential unit is supported by the shaft 15, but all members thereof can rotate with respect to the shaft.
Shaft 34 has keyed to it a gear 82 which meshes with a gear 83 which is keyed to sleeve 84 of a differential unit, as best illustrated in Figs. 3 and 4. Sleeve 84 carries a bevel gear 85 of a differential gearing. Since the shaft 15 and the shaft 34 are directly connected together by the sprocket chain 88, and the sleeve 84 is directly connected to the shaft 34 by the gears 82 and 83, the gear 85 of the differential gearing is driven at a speed proportional to the speed of the shaft 15 but in the opposite direction. Gear 86 is engaged by bevel pinions 88 which are individually secured on a suitable support and are meshed in turn by a spider worm gear 80. Four of these bevel pinions 86 are engaged by a bevel gear 89 which is fast to a sleeve 90 to which tapered drum 43 is keyed. Spider worm gear 80 is carried by a differential housing 31, 32, which is attached to sleeves 93, 94, and bears on bronze bushings for free rotation about sleeves 84 and 90. The differential unit is located on shaft 15 by a pair of collars 95 and 96 which are pinned to the shaft.

With the ratio of gears 82 and 83 equal to the ratio of sprockets 37 and 38, when shaft 34 is rotated, shaft 15, which operates the core, and drum 43 will be rotated in the same direction and the speed of rotation of the core and of the drum will be the same so long as spider worm gear 88 is held in a stationary position. However, as wire is taken from drum 43 and when it becomes subjected to elongation due to the applied tension, it is required that the rate of rotation of drum 43 be less than that of the core if the movement of floating sheave 45 is to be limited within a reasonable distance. Advantages of restricting the length of movement of sheave 45 include savings of time which otherwise would be required by stoppages of the apparatus for resetting the sheave periodically during a winding operation.

The rotation of spider worm gear 88 and its housing is controlled by a motor 97 which operates a worm 88 having engagement with the spider worm gear. With reference to the machine and relative size of core illustrated in the drawings, the differential of rotation of the motor 97 is such as to drive the spider worm gear 88 in a clockwise direction as viewed from the right of Figs. 2A. As the wire is wound about the core 10 from left to right, some of the elongation of the wire between the drum 43 and the core 10 is compensated for by the travel of the guide sheave 45 to the right, but the normal stretching of the wire is greater than the linear travel of the guide sheave 45. Therefore there remains an amount of stretch that can be compensated for by rotation of the drum 43 at such a rate as to provide an instantaneous speed of the drum less than that of the core 10. By driving the spider worm gear 88 clockwise (as viewed from the right of Fig. 2A) and at a speed less than that of the gear 85, the counterclockwise speed of rotation of the bevel gear 88 will be less than the clockwise speed of rotation of the bevel gear 85, and the core will run at a speed less than the counterclockwise speed of the core 10. As illustrated in the drawings, motor 97 is operated from a switch 99, Fig. 2A, which is controlled by a pair of spaced stops 100, 101. These stops may be carried by carriage 11 or any other suitable support that is free to move with the movement of the carriage as, for example, weight 80. As the wire leaving drum 43 elon-
sheave 46 adds to the corrective compensation required for the stretching of the wire, the speed of rotation of the drum 43 will have to be slower than its speed of rotation during winding of the core from left to right. Consequently, the spider worm gear 65 will be rotated slightly faster or more frequently (depending on whether the motor is a variable speed motor or a constant speed motor) in a clockwise direction, as viewed from the right of Fig. 2A, as compared to its operation when the winding is applied from left to right along the core.

It is to be understood that the invention is susceptible of use for applying a winding or wrapping of practically any kind of flexible tension element about a body and that various changes and modifications in construction, form and relative arrangement of parts, which will now appear to those skilled in the art, may be made within the scope of the Invention. Reference is, therefore, to be had to the appended claims for a definition of the limits of the Invention.

I. Claim 1. In apparatus for winding wire on an object, the combination of means for rotatably supporting an object, a rotatably supported drum, means for rotating said object-supporting means, differential gearing having one gear driven by said last-named means, a driving gear for said drum, and a differential member geared to engage both of said gears, means controlling the rotation of said differential member to control the speed of rotation of said drum, and means acting on the wire intermediate said drum and object to apply and maintain constant tension to the wire leaving said drum and passing to said object even though the length of wire between said drum and said object changes during a wire-winding operation.

2. In apparatus for winding wire on an object, the combination of means for rotatably supporting an object, a rotatably supported drum, means acting on the wire leaving said drum and being applied to said object to maintain a constant tension on the wire irrespective of change in length of the wire between the drum and said object during a winding operation, means for rotating said object-supporting means to wind wire on said object carried thereby, differential gearing having one gear driven by said last-named means, a driving gear for said drum, and a differential member geared to engage both of said gears, and means for controlling the rotation of said differential member to control the speed of rotation of said drum relative to the speed of said object-supporting means.

3. In apparatus for winding wire on an object, the combination comprising means for rotating an object, a drum mounted for rotation on an axis coaxial with the axis of rotation of said object, means for applying tension in a loop of wire having reaches extending to said drum and to the object, means controlling the rotation of said drum as wire is drawn therefrom, said last-named means including differential gearing having one gear driven by said means for rotating said object, a driving gear for said drum, and a differential member geared to engage both of said gears, and means controlling the rotation of said differential member to vary the rate of rotation of said drum.

4. In apparatus for winding a wire on an object, the combination comprising means for mounting an object for rotation, means for rotating said object, a driving gear for said object, a drum mounted for rotation on an axis coaxial with the axis of rotation of said object, means for applying tension in a loop of wire having reaches extending to said drum and to the object, means controlling the rotation of said drum, and means for applying a helical winding of tensioned wire about said object.

5. In apparatus for winding wire on an object, the combination comprising means for mounting an object for rotation, a drum, means rotatably mounting said drum, common power means for rotating said object and said drum, gearing deriving power from said common power means and disposed intermediate said object and said drum whereby said object and said drum may be rotated at different instantaneous speeds, a movable sheave for engaging a loop of wire having one portion frictionally engaged by said drum and another portion extending to said object, weight means secured to said movable sheave for applying a constant load on said loop, means for controlling a carriage mounted for travel in a direction parallel to the axis of rotation of said object, a sheave on said carriage adapted for receiving wire from said loop of wire and directing the wire to said object, and means independent of said power means for traversing said carriage lengthwise of said object for applying a helical winding of tensioned wire about said object.

6. In apparatus for winding wire on an object, the combination comprising means for mounting an object for rotation, a drum, means rotatably mounting said drum coaxially with respect to the axis of rotation of said object, power means common to said object-mounting means and to said drum-mounting means for rotating said object and for applying a retarding torque to said drum, differential mechanism deriving power from said common power means and disposed intermediate said object and said drum whereby said object and said drum may be rotated at different instantaneous speeds, motor means independent of said power means and having connection with said differential mechanism for changing the relative angular velocities of said object and said drum, and means for traversing said carriage lengthwise of said object for applying a helical winding of tensioned wire about said object, and means controlled by the movement of said mov...
able sheave for controlling said first-named motor means to effect changes in the relative rates of rotation of said drum and said object.

7. In apparatus for winding wire on an object, the combination comprising means for mounting an object for rotation, a drum, means rotatably mounting said drum, power means common to said object-mounting means and to said drum-mounting means for rotating said object and for applying a retarding torque to said drum, differential mechanism deriving power from said common power means and disposed intermediate said object and said drum whereby said object and said drum may be rotated at different instantaneous speeds, motor means independent of said power means and having connection with said differential mechanism for changing the relative instantaneous speeds of said object and said drum, means for training the length of wire between said drum and said object including a movable sheave mounted for travel lengthwise of the axis of rotation of said object and a sheave mounted upon a carriage arranged to travel lengthwise of said object for delivering wire to said object, means attached to said movable sheave for imparting tension to said length of wire, means for traversing said carriage and said wire-delivering sheave lengthwise of the axis of rotation of said object at a linear velocity different from the linear velocity of said movable sheave, and electric circuit control means controlled by the movement of said movable sheave for controlling said motor means to change the instantaneous speeds of said drum and said object.

8. In apparatus for winding wire on an object, the combination comprising means for supporting an object for rotation, a rotatably mounting drum, a movable sheave for engaging a loop of wire having reach extends to said object and to said drum, force applying means attached to said sheave for maintaining a constant tension in the wire intermediate said drum and said object, track means parallel to the axis of rotation of said object, a carriage mounted for travel along said track means and carrying a second sheave engaging said tensioned wire between said drum and said object for guiding it onto said object, a sheave engaging and forming a loop in the wire between said drum and said object, a weight carried by said sheave, said weight and said sheave being free to move except for the restraining effect of the tensioned wire travelling from said drum to said object, means for applying a retarding torque against the free rotation of the drum-supporting means under the action of the tension in said loop of wire, said last-named means including differential mechanism between said drum-supporting means and said object-supporting means with connections at opposite sides thereof with said object-rotating means and with said drum-supporting means, respectively, motor means for controlling the operation of said differential mechanism to cause the drum-supporting means to be rotated at a speed slower than the given velocity of the object-supporting means, and means responsive to the length of wire between said drum and said object for alternately changing and restoring the velocity ratio of said differential mechanism to vary the speed of rotation of said drum-supporting means, periodically to change the length of wire between said drum and said object during a wire wrapping operation.

HUGH FOSTER KENNISON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,816,909</td>
<td>Larsen</td>
<td>Aug. 4, 1931</td>
</tr>
<tr>
<td>2,012,208</td>
<td>Willy</td>
<td>Aug. 10, 1935</td>
</tr>
<tr>
<td>2,243,785</td>
<td>Eaddy</td>
<td>May 27, 1941</td>
</tr>
<tr>
<td>2,313,618</td>
<td>Bridges</td>
<td>Mar. 9, 1943</td>
</tr>
<tr>
<td>2,389,047</td>
<td>Heins</td>
<td>Nov. 3, 1945</td>
</tr>
</tbody>
</table>

2,573,793

10

accompanying movement of said sheave during the wrapping of wire about said object, a differential mechanism having one member connected to turn with said object-supporting means and another member connected to turn with said drum-supporting means, and a third member in geared engagement with said first and second members, means for rotating said object-supporting means and said first-named member, the retarding torque transmitted by said last-named rotating means being balanced by the retarding torque of said drum acting on said wire as transmitted through said second-named member and differential mechanism, means for controlling the rotation of said third member of said differential unit to thereby control the speed of said drum with respect to the speed of said object and the rate of change in length of the wire between said drum and said object, a motor for operating said last-named means, and a controlling circuit for said motor for changing the rate of operation of said motor to thereby limit the travel of said movable sheave away from and towards said drum and said object.

10. In apparatus for applying a wrapping of tensioned wire about a pipe or other object to which one end of the wire is fastened, and the object is rotated as the wire is wrapped thereon, the combination comprising rotatable means for supporting the object, power means having direct connection with said object-supporting means for rotating the object at a given velocity to wrap wire about said object, a drum for receiving relatively untensioned wire which is snubbed around the drum and tensioned for delivery to said object, rotatable means for supporting said drum, means for guiding the wire onto said object, a sheave engaging and forming a loop in the wire between said drum and said object, a weight carried by said sheave, said weight and said sheave being free to move except for the restraining effect of the tensioned wire travelling from said drum to said object, means for applying a retarding torque against the free rotation of the drum-supporting means under the action of the tension in said loop of wire, said last-named means including differential mechanism between said drum-supporting means and said object-supporting means with connections at opposite sides thereof with said object-rotating means and with said drum-supporting means, respectively, motor means for controlling the operation of said differential mechanism to cause the drum-supporting means to be rotated at a speed slower than the given velocity of the object-supporting means, and means responsive to the length of wire between said drum and said object for alternately changing and restoring the velocity ratio of said differential mechanism to vary the speed of rotation of said drum-supporting means, periodically to change the length of wire between said drum and said object during a wire wrapping operation.