United States Patent [19]

Steiner et al.

[11] **3,851,831**

[45] **Dec. 3, 1974**

[54] **METHOD AND APPARATUS FOR WRAPPING WIRE ABOUT A CONDUIT**

[75] Inventors: **John E. Steiner,** Edgewood Borough; **Donald N. Volk,** Irwin Borough, both of Pa.

[73] Assignee: **United States Steel Corporation,** Pittsburgh, Pa.

[22] Filed: **Apr. 27, 1972**

[21] Appl. No.: **248,061**

[52] **U.S. Cl.** **242/7.22,** 57/10, 57/160

[51] **Int. Cl.** **B65h 81/06**

[58] **Field of Search** 57/3, 10, 11, 156, 160; 242/7.21, 7.22, 7.23

[56] **References Cited**

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1,250,705	12/1917	Van Amburgh	242/7.22
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2,271,528	2/1942	Pfohl et al.	242/7.22
2,770,284	11/1956	Myrick	242/7.22 X
3,174,725	3/1965	Pfundt	57/10 X

Primary Examiner—John Petrakes
Attorney, Agent, or Firm—Ralph H. Dougherty

[57] **ABSTRACT**

A wire wrapping apparatus for and method of wrapping high strength wire (anchored at its free end to a predetermined point on a conduit) under a predetermined tension and pitch about the conduit are disclosed.

The apparatus has a spinning head disposed about the conduit in engagement with the conduit for relative rotating and longitudinal movement with respect to the conduit and for wrapping the wire on the conduit to the predetermined tension and pitch. Wire supply means are either disposed about the conduit in engagement with the conduit for relative rotating and longitudinal movement with respect to the conduit or are mounted on the spinning head, both for supplying the wire to the spinning head. Friction means are associated with the wire supply means to provide a friction drag on the wire supply means thereby preventing uncontrolled payoff of the wire from the wire supply means. Wire tensioning means are mounted on the spinning head and are adapted to receive the wire from the wire supply means at a low first tension to store a plurality of turns of the wire on the wire tensioning means, and to wrap the wire at a higher second tension on the conduit from the predetermined point thereon during the relative rotating and longitudinal movement of the spinning head with respect to the conduit. Drive means are connected to one member of the spinning head and the conduit for causing relative rotating and longitudinal movement of the one member with respect to the other member of the spinning head and conduit.

The method includes the steps of:

a. storing a quantity of the wire on a wire supply means;

b. supplying the wire to a wire tensioning means;

c. providing a friction drag on the wire supply means to prevent uncontrolled payoff of the wire from the wire supply means to the wire tensioning means;

d. receiving the wire from the wire supply means on the wire tensioning means at a low first tension, storing a plurality of turns of the wire on the wire tensioning means, and wrapping the wire at a higher second tension on the conduit from the predetermined point thereon during the relative rotating and longitudinal movement of the wire tensioning means and wire supply means with respect to the conduit; and

e. causing relative rotating and longitudinal movement of one member of said wire tensioning means and said conduit with respect to the other member of the wire tensioning means and the conduit.

24 Claims, 15 Drawing Figures

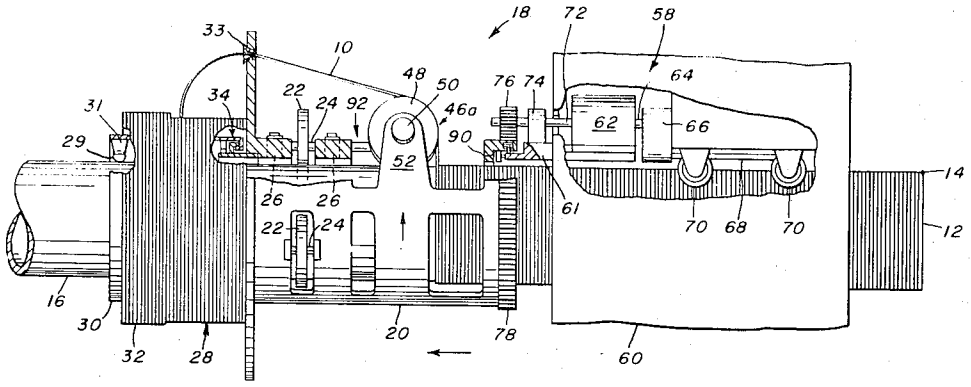

FIG. 1.

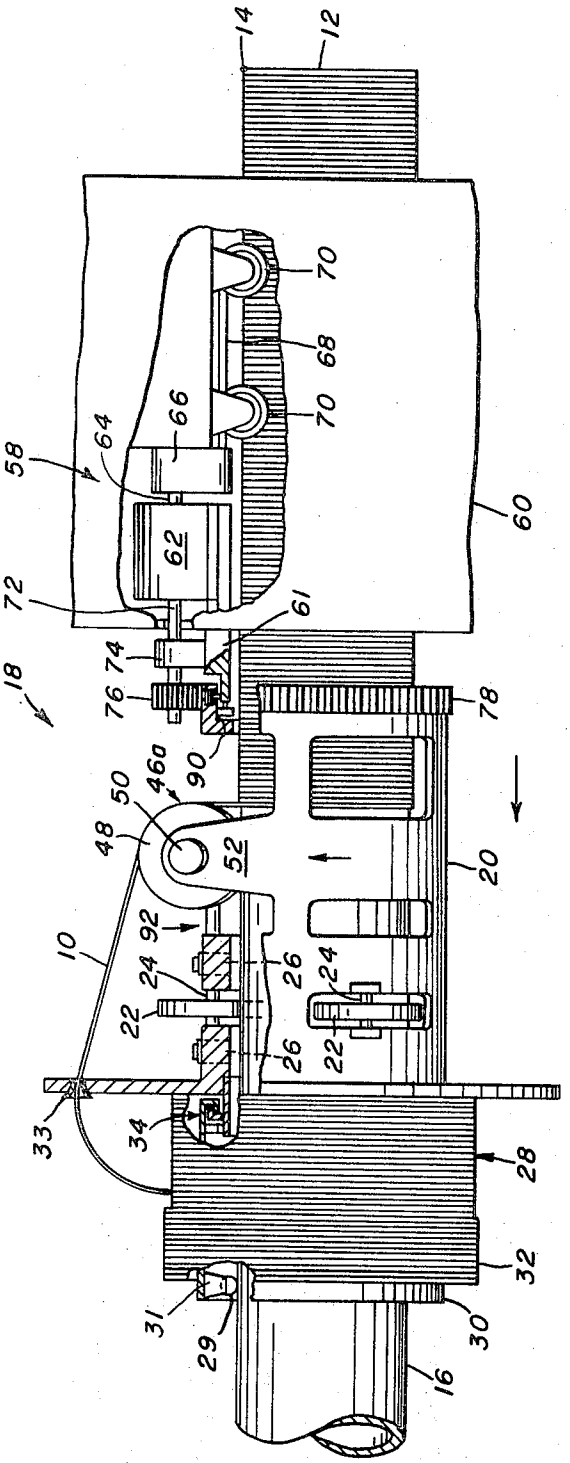
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FIG. 1A.

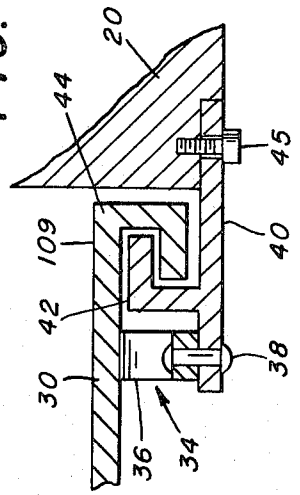
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FIG. 2.

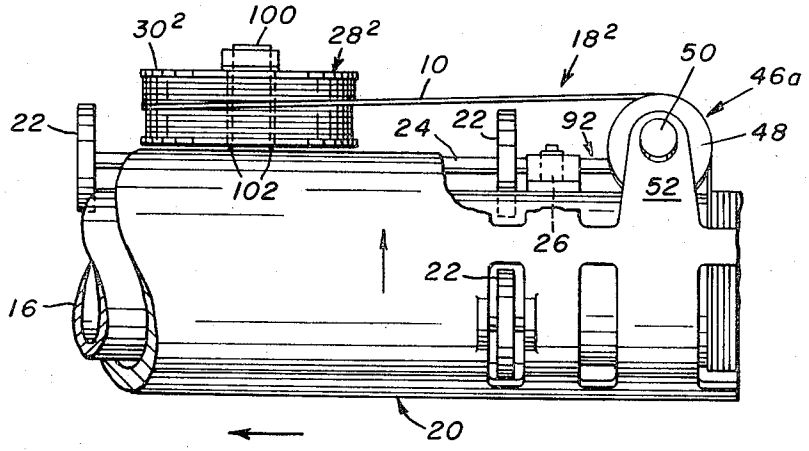


FIG. 2A.

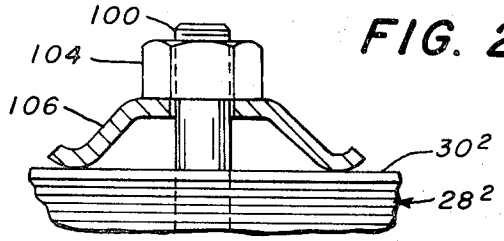
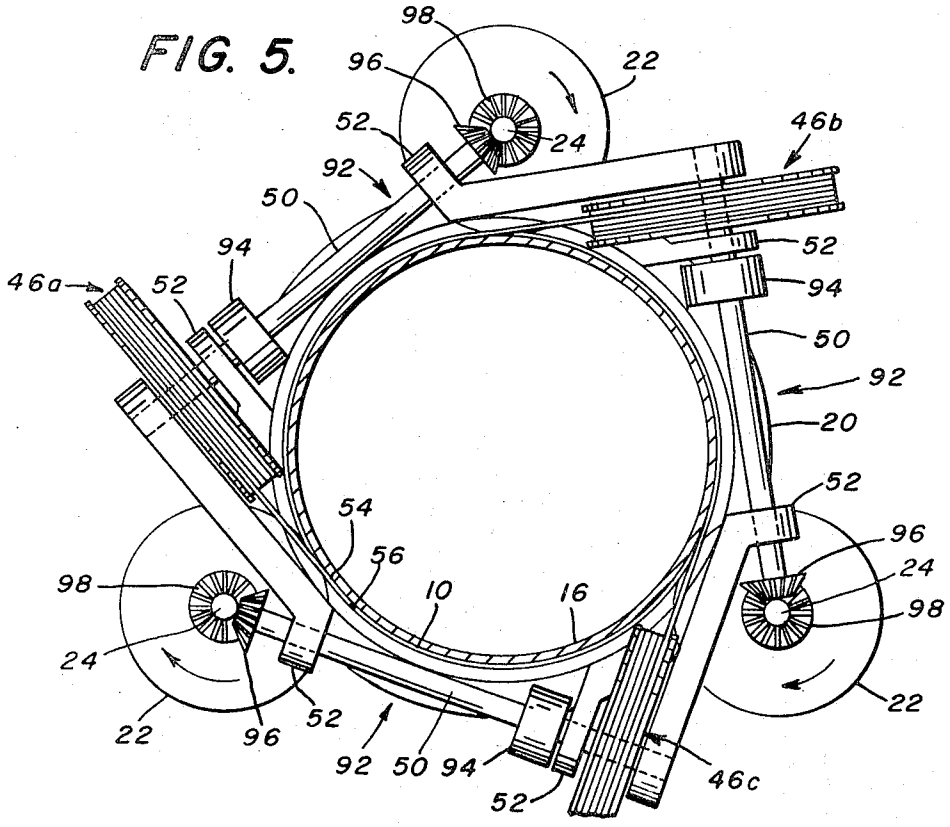


FIG. 5.



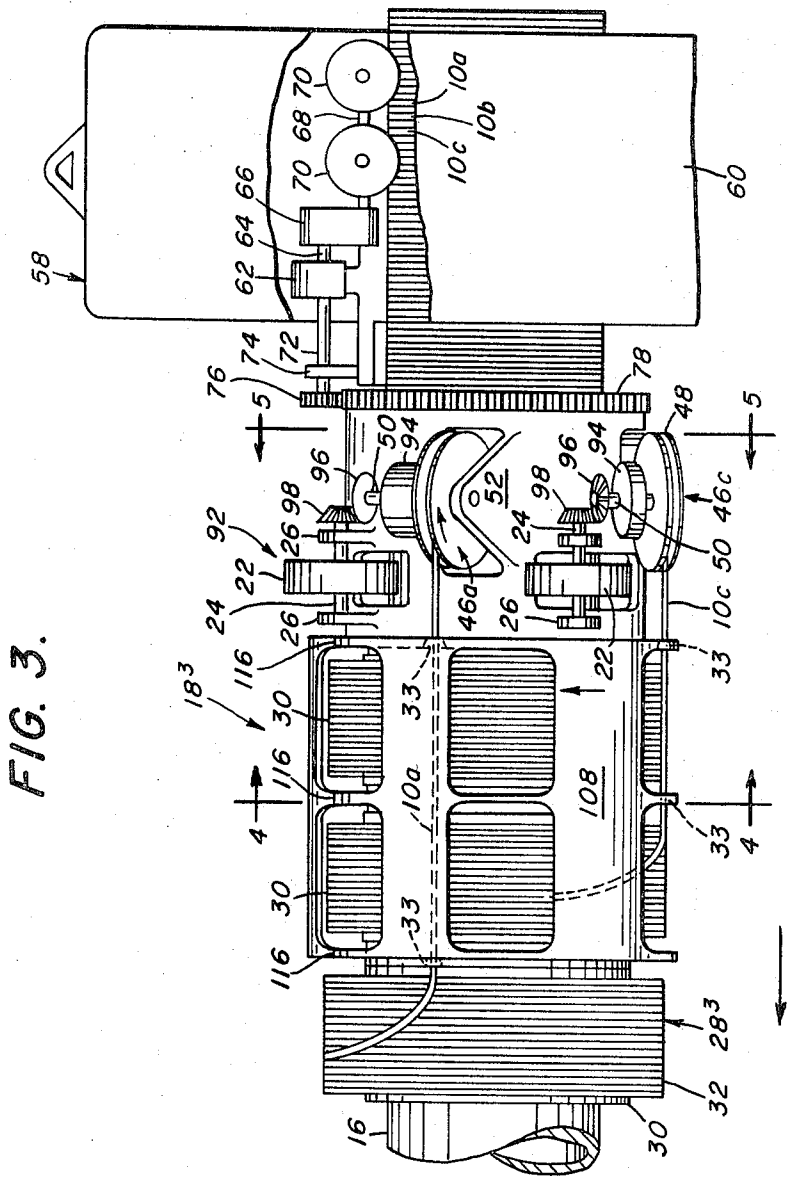

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FIG. 3.

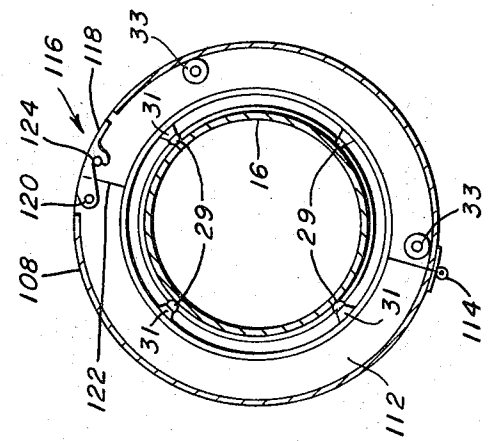
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FIG. 4.

FIG. 6.

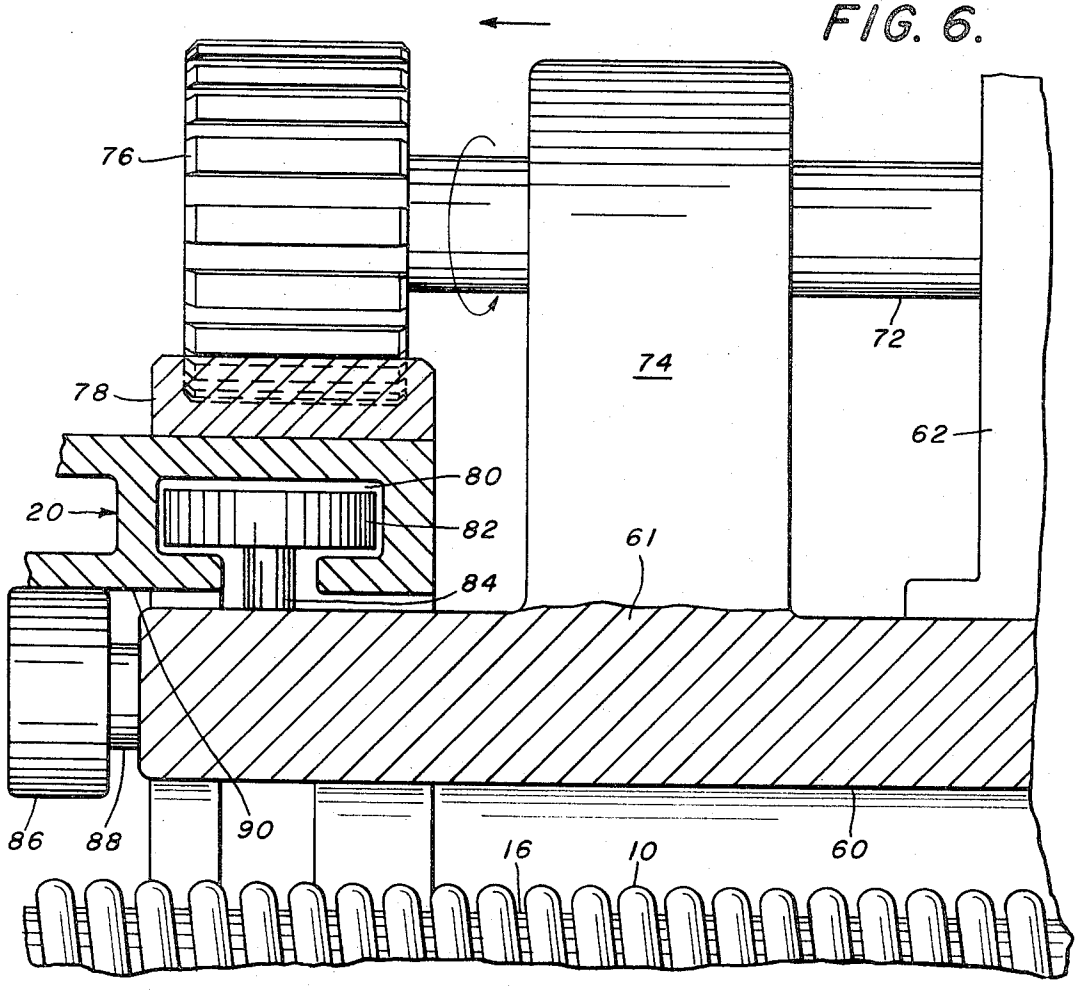
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FIG. 7.

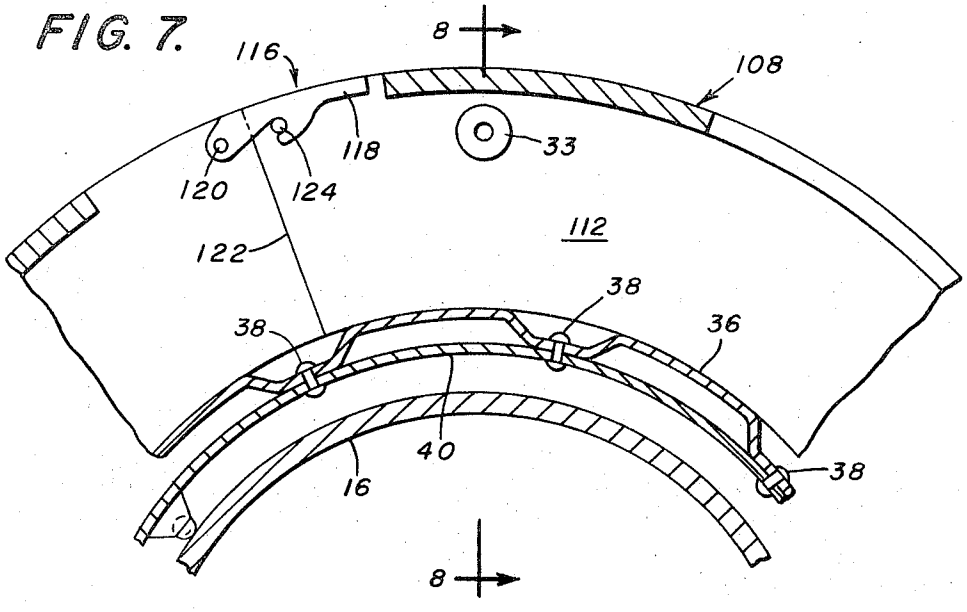
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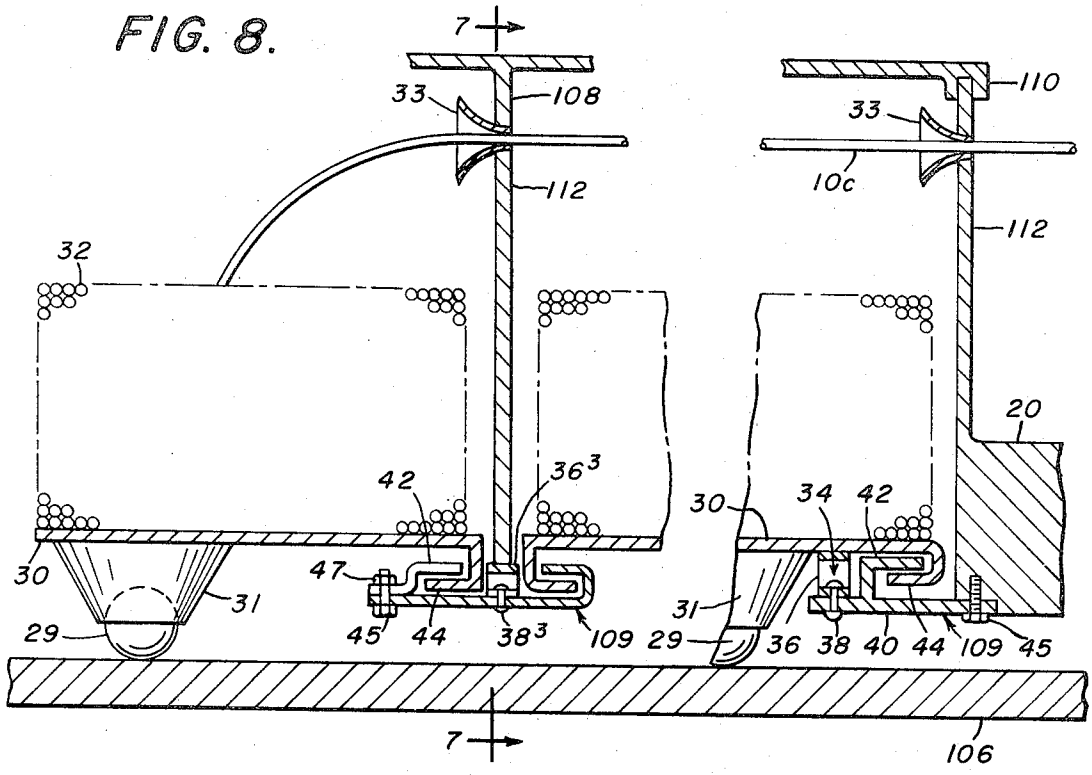
FIG. 8.



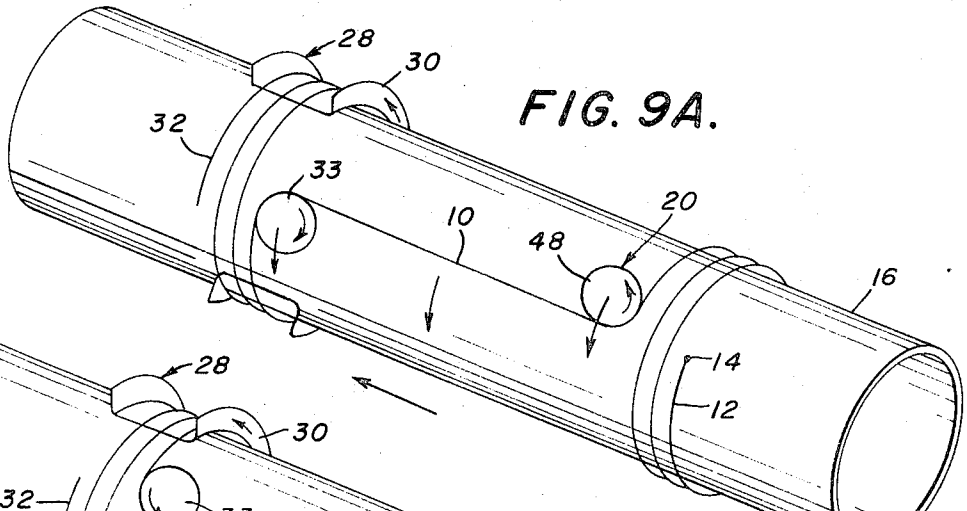


FIG. 9A.

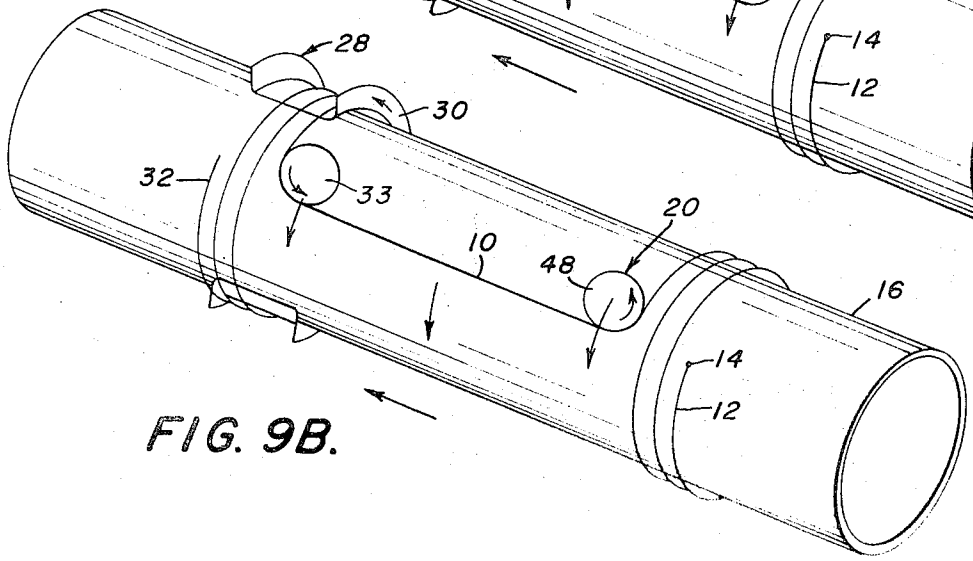


FIG. 9B.

FIG. 10.

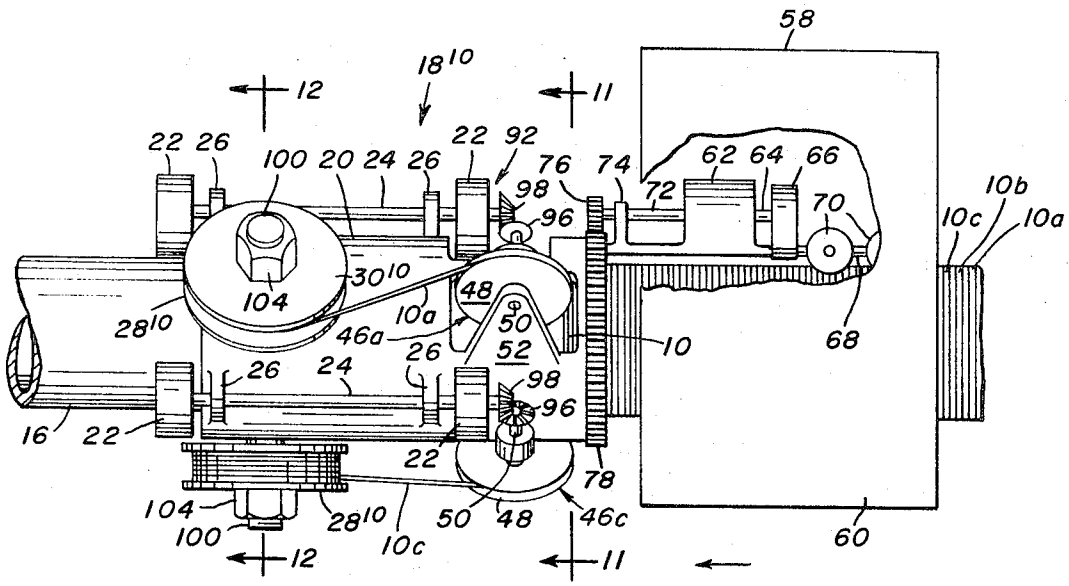


FIG. 11.

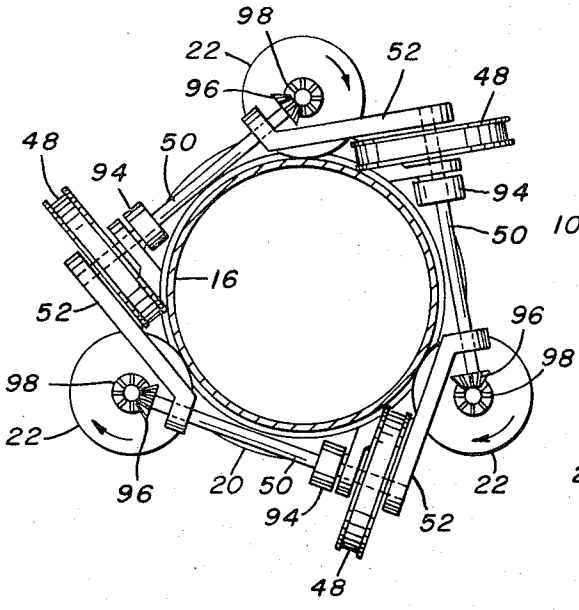
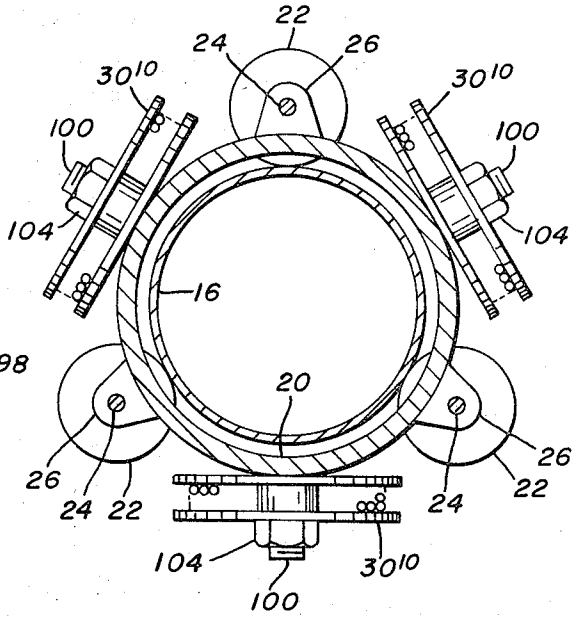


FIG. 12.



METHOD AND APPARATUS FOR WRAPPING WIRE ABOUT A CONDUIT

BACKGROUND OF THE INVENTION

Heretofore, large-diameter steel line pipes, in the size range of 16 to 60 inches in outside diameter, have been commonly used for transmission of natural gas, petroleum products, and numerous other gaseous, liquid, and liquid-solid aggregates or the like. Such line pipes have, in the past, been made with a single wall of solid steel. However, recent experimental work has indicated that a pipe with a substantial decrease in wall thickness can be used when the pipe is prestressed and reinforced with a hard-drawn, high-strength wire, or that a conventional pipe can be operated at double or more its standard rated pressure with such reinforcement. The obvious advantage of the prestressed-steel wire-wrapped line pipe is expected to find wide acceptance in the liquid and gaseous-liquid transmission industry.

In fabricating prestressed-steel line pipe, two general approaches are open to the manufacturer; the first being a plant-wrapped approach, such as presently employed in the wire-wrapped prestressed-concrete pipe industry, and the second being the field wrapping of pipe just prior to final protective coating and lowering of the pipe into the ditch.

Prior to our invention, however, no machinery existed for a field wrapping operation. Although different methods and forms of apparatus have been devised for the wrapping of tar-impregnated paper and felt tapes around fully fabricated line pipe for the purpose of protective coating, they are not suitable to wrap wire around the line pipe because the necessary tension cannot be achieved. In each of these machines, the paper and felt product to be laid on the line pipe is held on a spool at a point about the outer periphery of the line pipe and the entire spool is rotated about the line pipe to effect the wrapping action.

A principal inadequacy of the adaptation of the simple tape wrapping machines to the wrapping of prestressed line pipe is the amount of tension that must be imparted to the wire. A tension of approximately 50 pounds is common for tape wrapping, while tensions on the order of about 2000 to 5000 pounds are necessary for the wire wrapping of prestressed pipe to gain the degree of prestress required for the structure. Accordingly, we have found that a simple redesign of existing tape wrapping machines used for the field coating of line pipe is inadequate for the purpose of wrapping prestressed line pipe.

We are aware of the following prior art patents:

U.S. Patent No.	Inventor	Issued
1,250,705	Van Amburgh	12/18/17
2,271,528	Pfohl et al.	2/3/48
2,770,284	Myrick	11/13/56
2,923,486	Betzel, Sr.	2/2/60

Pfohl et al. 2,271,528, Myrick 2,770,284 and Betzel 2,923,486 have means for applying a protective fabric to pipe and these methods are not capable of applying sufficient tension to wire wrapping to obtain the degree of prestress necessary for reinforcing pipe with wire. Furthermore, their methods of placing the supply spools of wrapping material substantially away from the pipe and rotating all the supply spools around the pipe would necessitate a structure of inordinate weight and physical dimensions if adapted to an apparatus for applying wire wrapping to line pipe in place. None of these references provides conservation of energy by reapplication of the wrapping torque to useful work.

Van Amburgh has no provision for reapplication of torque and his device requires at high speeds and high wire tension impractically high powered drives. The direction of unreeling shown in FIG. 2 of Van Amburgh would result in extremely high reel rotational speeds, which in turn, would require a higher power drive. The tensioning device described in Van Amburgh would not be adequate at high speed, high tension operation because of frictional heating.

OBJECTS OF THE INVENTION

It is the general object of this invention to avoid and overcome the foregoing and other difficulties of and objections to prior art practices by the provision of an improved wire wrapping apparatus for and method of wrapping high-strength wire under tension about prestressed large diameter metal line pipe, which improved wire wrapping apparatus and method:

a. apply a wire wrapping to fabricated line pipe in the field;

b. apply the wire wrapping to the line pipe under sufficient tension so as to provide the level of prestress (i.e., about 0 lbs. to 7000 lbs. tension in the wire) required for modern wire-wrapped line pipe;

c. apply the wire wrapping at a high speed of about 2 to 5 miles per day per machine;

d. are light weight and portable, simple and rugged, and have a long, maintenance free operational life;

e. are capable of applying a wire wrapping to infinite lengths of pipe;

f. are compact and are light in weight (i.e., about 7000–8000 lbs.);

g. maintain the clearance between the pipe being wrapped and the ground level at a maximum of about 30 inches;

h. utilize a simultaneously differential rotating spinning head and wire supply means for feeding the wire to a tensioning drum;

i. recover the bulk of the power consumed in tensioning the wire thereby utilizing the recovered power to rotate the spinning head; and

j. prevent entanglement of the wire being wound from the wire supply reel by the simultaneous differential rotation of the spinning head and wire supply reel.

BRIEF SUMMARY OF THE INVENTION

The aforesaid objects of this invention, and other objects which will become apparent as the description proceeds, are achieved by providing a wire wrapping apparatus for and method of wrapping high strength wire (anchored at its free end to a predetermined point on a conduit) under a predetermined tension and pitch about the conduit.

The apparatus has a spinning head disposed about the conduit in engagement with the conduit for relative rotating and longitudinal movement with respect to the conduit and for wrapping the wire on the conduit to the predetermined tension and pitch. Wire supply means are either disposed about the conduit in engagement with the conduit for relative rotating and longitudinal

movement with respect to the conduit or are mounted on the spinning head, both for supplying the wire to the spinning head. Friction means are associated with the wire supply means to provide a friction drag on the wire supply means thereby preventing uncontrolled payoff of the wire from the wire supply means. Wire tensioning means are mounted on the spinning head and are adapted to receive the wire from the wire supply means at a low first tension to store a plurality of turns of the wire on the wire tensioning means, and to wrap the wire at a higher second tension on the conduit from the predetermined point thereon during the relative rotating and longitudinal movement of the spinning head with respect to the conduit. Drive means are connected to one member of the spinning head and the conduit for causing relative rotating and longitudinal movement of the one member with respect to the other member of the spinning head and conduit.

The method includes the steps of:

a. storing a quantity of the wire on a wire supply means;

b. supplying the wire to a wire tensioning means;

c. providing a friction drag on the wire supply means to prevent uncontrolled payoff of the wire from the wire supply means to the wire tensioning means;

d. receiving the wire from the wire supply means on the wire tensioning means at a low first tension, storing a plurality of turns of the wire on the wire tensioning means, and wrapping the wire at a higher second tension on the conduit from the predetermined point thereon during the relative rotating and longitudinal movement of the wire tensioning means and wire supply means with respect to the conduit; and

e. causing relative rotating and longitudinal movement of one member of said wire tensioning means and said conduit with respect to the other member of the wire tensioning means and the conduit.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

For a better understanding of this invention, reference should be had to the accompanying drawings, wherein like numerals of reference indicate similar parts throughout the several views and wherein:

FIG. 1 is a side elevational view of the wire wrapping apparatus for wrapping a high-strength wire (anchored at its free end to a predetermined point on a conduit) on the conduit and having a spinning head for wrapping the wire about the conduit with a predetermined tension and pitch, a wire supply means for supplying the wire to the spinning head, wire tensioning means on the spinning head for receiving the wire from the wire supply means and wrapping one outlet end of the wire from the wire tensioning means about the conduit, friction means between the spinning head and the wire tensioning means to prevent uncontrolled payoff of the wire from the wire supply means, driving means connected to the spinning head for rotating the spinning head relative to the conduit and for longitudinally moving it with respect to the conduit; and the auxiliary drive means driven by the torque from the wire tensioning means to cause rotating and longitudinal movement of the spinning head with respect to the conduit;

FIG. 1A is a fragmentary side elevational view of the friction means between the wire supply means and the spinning head;

FIG. 2 is a fragmentary side elevational view, similar to FIG. 1, of an alternative embodiment of the wire wrapping apparatus wherein the wire supply means is mounted on the spinning head and the friction means is disposed on the wire supply means;

FIG. 2A is a fragmentary side elevational enlarged view of the friction drag washer, shaft and wire supply reel;

FIG. 3 is a fragmentary longitudinal side elevational view of an alternative embodiment of the wire wrapping apparatus shown in FIG. 1 and having three concentric wire supply means or reels and an individual wire tensioning means for each wire supply means and for winding three wires simultaneously in side-by-side relationship on the conduit;

FIG. 4 is a vertical sectional view taken along the line 4—4 of FIG. 3 taken in the direction of the arrows and showing the clamshell construction housing of the wire supply means whereby such housing can be opened and a new bundle of wires mounted on the wire supply means;

FIG. 5 is a vertical sectional view taken along the line 5—5 of FIG. 3 in the direction of the arrows and showing the auxiliary drive means whereby the torque from the wire tensioning means is transmitted through a clutch to drive wheel on the spinning head and engageable with the conduit for causing relative rotative movement between the spinning head and the conduit;

FIG. 6 is a fragmentary enlarged vertical sectional view showing the details of the coupling between the drive means for the wire wrapping apparatus and the spinning head;

FIG. 7 is a vertical sectional view taken along the line 7—7 of FIG. 8 in the direction of the arrows and showing the details of the latching means employed in the clamshell-type housing associated with the wire supply means and a frictional supply ring connection between the spinning head and wire supply means spool;

FIG. 8 is a vertical sectional view taken along the line 8—8 of FIG. 7 in the direction of the arrows and showing the details of the individual wire supply means and the spinning head;

FIG. 9A is a schematic perspective view showing the arrangement and direction of wire feed from the wire supply means to the wire tensioning means and the application of the wire to the conduit and showing also the direction of wrapping of the wire on the wire supply means as the same as the direction of wrapping of the wire on the conduit to produce a relatively low-speed motion of the wire supply means where the rotation of the spinning head is opposite to that shown in FIGS. 1,2,3;

FIG. 9B is a view similar to FIG. 9A of an alternative embodiment wherein the direction of wrapping of the wire on the wire supply means is opposite to that of the direction of wire applied to the conduit to produce a relatively high-speed relative rotation of the wire supply means, thus requiring greater energy consumption for driving the wire supply means;

FIG. 10 is a view similar to FIG. 1 of another alternative embodiment of the wire wrapping apparatus showing a plurality of wire supply means mounted on the spinning head and further showing an individual wire tensioning means for each wire supply means;

FIG. 11 is a vertical sectional view taken along the line 11—11 of FIG. 10 in the direction of the arrows

and showing the auxiliary drive means driven by the wire tensioning means; and

FIG. 12 is a vertical sectional view taken along the line 12—12 of FIG. 10 in the direction of the arrows and showing the details of the mounting of the wire supply means on the spinning head.

Although the principles of this invention are broadly applicable to a wire wrapping apparatus and a method of wrapping, this invention is particularly adapted for use in conjunction with an apparatus for and a method of wrapping wire about a conduit and hence it has been so illustrated and will be so described.

DETAILED DESCRIPTION

With specific reference to the form of this invention illustrated in the drawings, and referring particularly to FIG. 1, a wire wrapping apparatus for wrapping a high strength wire 10 (anchored at its free end 12 to a predetermined point 14 on a conduit or pipe 16) is indicated generally by the reference numeral 18. This apparatus 18 winds the wire 10 about the conduit 16 under a predetermined tension and pitch.

Apparatus 18

Spinning Head 20

As shown in FIG. 1, the wire wrapping apparatus 18 has a spinning head 20 disposed about the conduit 16 in engagement with the conduit 16 for relative rotating and longitudinal movement in the direction of the arrows shown in FIG. 1 with respect to the conduit 16. The spinning head 20 wraps the wire 10 on the conduit 16 with the required predetermined tension and pitch. The spinning head 20 is rotatable and moves longitudinally relative with respect to the conduit 16 by means of wheels 22 (FIG. 1). As shown particularly in FIG. 1, the wheels 22 are mounted on a shaft 24, which shaft 24 is mounted as shown in FIG. 1 in brackets 26 upstanding from the spinning head 20. Such shaft 24 is driven by an auxiliary drive means 92 (FIGS. 1,2,3,5,10) as hereinafter explained.

Wire Supply Means 28

A wire supply means 28 (FIG. 1) is disposed about the conduit 16 and is rotatable on the conduit 16 (by means of casters 29, (FIG. 1) mounted on brackets 31 depending from a wire supply reel 30) by relative rotating and longitudinal movement with respect to the conduit 16. The wire supply means 28 supplies the wire 10 to the spinning head 20 through a guide 33 (FIG. 1) in the spinning head 20. As shown in FIG. 1, the wire supply means 28 has the reel 30 adapted to receive a bundle 32 of the wire 10.

Friction Means 34

In order that the wire supply means 28 will rotate in the same direction but at a speed differential with respect to the spinning head 20, a friction ring 36 (FIG. 1A) of a friction means 34 (FIGS. 1,1A,7,8) is mounted by means of a rivet 38 (FIG. 1A) on a connecting ring 40 projecting from the spinning head 20. As shown in FIG. 1A, a threaded bolt 45 (FIG. 1A) secures the connecting ring 40 to the spinning head 20. The means utilized to connect the wire supply means 28 to the spinning head 20 consists of coupling means 109 (FIG. 1A) having interlocking C-connectors 42 and 44. The C-connector 42 is upstanding from the connecting ring 40 on the spinning head 20 and the C-connector ring 44 projects downwardly from the wire reel 30 into locking engagement with the ring 42. The friction means 34 (FIG. 1A) which is associated with the wire supply means 28 provides a friction drag on the wire supply means 28 thereby preventing uncontrolled payoff of the wire 10 from the wire supply means 28.

Wire Tensioning Means 46

Wire tensioning means 46a (FIG. 1) has a wire tensioning drum 48 mounted on a shaft 50, which shaft 50 is journalled in brackets 52 (FIG. 1) upstanding from the spinning head 20. As shown in FIG. 1, the wire 10 is received on the drum 48 from the wire supply reel 30 (through the guide 33) at a relatively low first tension. The drum 48 stores a plurality of turns, such as, for example, about seven turns of the wire 10 on the wire tensioning drum 48. The outlet end 54 (FIG. 5) of the wire 10 from the wire tensioning drum 48 is fed at a higher second tension to the point of tangency 56 (FIG. 5) on the conduit 16 during the relative rotating end longitudinal movement of the spinning head 20 with respect to the conduit 16.

Drive Means 58

As shown in FIGS. 1,3, and 6, a drive means 58 is connected to one member of either the spinning head 20 or the conduit 16 (in this case, the spinning head 20) for causing relative rotating and longitudinal movement of the one member (i.e., the spinning head 20) with respect to the other member of the spinning head 20 and the conduit 16 (in this case, the conduit 16). The drive means 58 has a housing 60 (FIGS. 1,3, and 6) in which are contained the moving parts of the drive means 58. For the purpose of providing longitudinal drive means for the wrapping apparatus 18, a motor 62 (FIGS. 1,3,6) has its drive shaft 64 (FIGS. 1,3) connected through a gear reduction unit or the like 66 (FIGS. 1,3) to a drive shaft 68 (FIGS. 1,3) carrying wheels 70 (FIGS. 1,3) which ride on the wrapped conduit 16.

The means utilized to rotate the spinning head 20 has a second drive shaft 72 (projecting from the motor 62, FIGS. 1,3,6) journalled in brackets 74 upstanding from an extension 61 (FIGS. 1,6) of the drive means housing 60 and terminating in a drive gear 76 (FIGS. 1,3,6). In order to transmit the rotating movement indicated by the arrow in FIG. 6 of the gear 76 to the spinning head 20, the gear 76 engages a girth gear 78 (FIGS. 1,3) affixed to the spinning head 20.

For the purpose of coupling the drive means 58 to the spinning head 20 while permitting relative rotational movement between the drive means 58 and the spinning head 20, the spinning head 20 is provided with a coupling cavity 80 (FIG. 6) of generally T-shaped cross section and an idler roller 82 (FIG. 6) on a stud shaft 84 (FIG. 6) projects from the extension 61 drive means frame 60 engages or rides in the cavity 80. In addition, a second idler roller 86 (FIG. 6) extends longitudinally on a stud shaft 88 (FIG. 6) from an extension 61 (FIGS. 1,6) on the drive means frame 60 and engages the under side of a projection 90 (FIGS. 1,6) of the spinning head 20 extending outwardly toward the drive means 58 from the spinning head 20.

Auxiliary Drive Means 92

The reaction torque produced in the wire tensioning

drum 48 (FIGS. 1,3,5,10) by the tensioning of the wire 10 is utilized to drive an auxiliary drive means 92 (FIGS. 1,3,5,10). For the purpose of providing a predetermined tension in the wire 10 on the outlet end 54 (FIG. 5) of the wire 10 from the wire tensioning means 46a (FIGS. 1,3,5,10) so that a predetermined reaction torque is developed in the wire tensioning drum 48, a clutch or partial brake means 94 (FIGS. 3,5,10) is mounted on a shaft 50 (FIGS. 3,5,10) journalled in brackets 52 (FIGS. 3,5,10) upstanding from the spinning head 20. Such shaft 50 carries a bevel gear 96 (FIGS. 3,5,10) engaging another bevel gear 98 (FIGS. 3,5,10) on a second shaft 24 (FIGS. 1,3,5,10) journalled (as mentioned before) in the brackets 26 (FIGS. 1,3,5,10) upstanding from the spinning head 20. It will be remembered from the earlier description of the spinning head 20 that the drive wheels 22 are driven by the auxiliary drive means 92 as they ride on the conduit 16.

Although the wheels 22 (three are shown in FIG. 5) are indicated as being substantially perpendicular to the shaft 24, they are of the friction type, suitably covered with a friction type material such as rubber or the like, and may be positioned at a skew angle to the shaft 24 to provide both relative rotational and longitudinal movement of the spinning head 20 with respect to the conduit 16. It will be understood by those skilled in the art that the torque demand of the drive wheel or wheels 22 of the auxiliary drive means 92 may equal the torque available from the wire tensioning drum 48 if the relationship of the sizes of the wire tensioning drum 48 and the wheels 22 and the relation of the ratio of the bevel gears 96,98 are properly adjusted and in this case, the clutch 94 may be eliminated.

ALTERNATIVE EMBODIMENTS

It will be understood by those skilled in the art that alternatively, the wire supply means 28^2 (shown in FIGS. 2,2A) may be moutned on the spinning head 20 by means of a bolt 100 (FIGS. 2,2A) secured to the spinning head 20 as by welds 102 (FIG. 2). A wire supply reed 30^2 is slipped over the upstanding bolt 100 and secured thereon as shown in FIG. 2A by means of a nut 104 (FIG. 2A) and a spring loaded friction washer 106 (FIG. 2A) to provide the required friction drag on the wire supply reel 30^2 thereby preventing the uncontrolled payoff of the wire 10 from the wire supply reel 30^2.

As shown in FIG. 3, a plurality of bundles 32 of wire 10 may be mounted on individual reels 30 of the wire wrapping apparatus 18^3 to wind three wires 10*a*,10*b*, 10*c* simultaneously in side by side relationship on the conduit 16. In this embodiment, as shown particularly in FIGS. 3,4,7, and 8, the wire supply means 28^3 is provided with a clam shell type housing 108 (FIGS. 3,4,7,8) adapted to cover the three loaded wire supply reels 30. Upon utilization of the wire 10*a*, 10*b*, etc. contained on such reels 30, the housing 108 can be readily opened to permit the quick and easy replacement of the bundles 32 on the reels 30. This clam shell housing 108 has (adjacent the spinning head 20) a friction clamp connection 109 (FIGS. 1A,8) which connection 109 is engageable with a flange 112 (FIG. 8) upstanding from the spinning head 20 adjacent a wire guide 33. As shown particularly in FIG. 8, the clam shell type housing 108 carries another wire guide 33 between the middle and interior reels 30 and has a depending flange 112 (FIGS. 7 and 8) which engages a friction ring 36 secured by rivets 38 to a connecting ring 40 (FIGS. 7 and 8) so that rotation of the spinning head 20 causes differential speed rotation of the wire supply means 28^3 in the same direction with the spinning head 20. In order to connect the reels 30 together in guided aligned rotational movement, C-connectors 42 and 44 (FIG. 8) are employed to couple the reels 30 to the spinning head 20, thereby permitting the ready assembly and disassembly of the coupling means 109 (FIGS. 1A,8) between the reels 30 and the spinning head 20 by bolts 45 (FIGS. 1A,8) which are threaded into the spinning head 20 from connecting ring 40 (as shown in the right hand portion of FIG. 8) or extend through the connecting ring 40 and the C-clamp 42 and are secured by nuts 47 as shown in the left hand portions of FIG. 8.

As shown particularly in FIGS. 4 and 7, the clam shell type housing 108 is of split construction, is hinged at 114 (FIG. 4) and is provided with a latching means 116 (FIGS. 4 and 7) approximately diametrically opposite to the hinge 114. This latching means 116 has a latch 118 (FIGS. 4,7) pivoting at 120 on the extension or flange 112 of the clam shell housing 108 on the left hand side of the split 122 between the halves of the housing 108 (FIGS. 4,7). The latch 118 extends across the split or division line 122 between the halves of the clam shell type housing 108 and engages a latch pin 124 on the right hand side (FIG. 7) of such division line 122 to lock the two halves of the clam shell type housing 108 together. When the reels 30 (FIGS. 3 and 8) are emptied, the latch 118 is moved from the closed position shown in FIG. 7 to the open position (not shown) to permit the halves of the clam shell type housing 108 to pivot outwardly on the hinge 114 (FIG. 4) so that replacement of the bundles 32 of wire 10 may be easily made upon the reels 30.

Referring to the schematic arrangement of the FIG. 1 type embodiment of the apparatus 18 shown in FIG. 9A, the wire bundle 32 is placed on the wire supply reel 30 so that the direction of wire payoff in relation to the direction of rotation of the spinning head 20 is opposite to the direction of the relative rotation of the wire supply reel 30 with respect to the conduit 16 thereby producing a relatively low speed motion of the wire supply means 28.

If, as shown in FIG. 9B (which also shows the FIG. 1 type embodiment of the wire wrapping apparatus 18) the wire 10 is fed from the wire supply reel 30 to the wire tensioning drum 48 in the same direction as the relative rotation of the wire supply reel 30, a relatively high speed rotation of the wire supply reel 30 is produced thereby requiring a greater energy comsumption (than the arrangement shown in FIG. 9A) for the movement of the wire supply means 28.

FIGS. 10–12 show a plurality of, for example, three loaded wire supply reels 30^{10} (FIGS. 1,12) mounted on the spinning head 20 for winding simultaneously the wires 10*a*,10*b*, 10*c* in side by side relationship on the conduit 16. It will also be appreciated from a consideration of FIG. 10 that in this embodiment each set of drive wheels 22 comprise a pair of wheels 22 in engagement with the conduit 16.

It will be understood that the improved wrapping apparatus and method can be employed with pressure vessels or containers.

Method

It will be understood from the above description of the various embodiments of the wire wrapping apparatus **18** (FIG. 1), **18²** (FIG. 2), **18³** (FIG. 3), and **18¹⁰** (FIG. 10) that an improved method is provided for wrapping a high strength wire **10** (anchored at its free end **12** to a predetermined point **14** (FIG. 1) on a conduit **16**) is provided for wrapping such wire **10** about the conduit **16** under a predetermined tension and pitch. This method includes the steps of:

a. storing a quantity of the wire **10** on a wire supply means **28** (FIG. 1), etc.;

b. supplying the wire **10** to a wire tensioning means **46*a***, **46*b***, etc.;

c. providing a friction drag on the wire supply means **28** (FIG. 1, etc.) to prevent the uncontrolled payoff of the wire **10** from the wire supply means **28** (FIG. 1, etc.) to the wire tensioning means **46a**,**46b**, etc.;

d. receiving the wire **10** from the wire supply means **28** (FIG. 1, etc.) on the wire tensioning means **46*a***,**46*b***, etc. at a low first tension, storing a plurality of turns of the wire **10** on the wire tensioning means **46*a***,**46*b***, etc., and wrapping the wire **10** at a higher second tension on the conduit **16** from the predetermined point **14** on such conduit **16** during the relative rotating and longitudinal movement of the wire tensioning means **46*a***,**46*b***, etc. and the wire supply means **28** (FIG. 1, etc.) with respect to the conduit **10**; and

e. causing relative rotating and longitudinal movement of one member of the wire tensioning means **46*a***,**46*b***, etc. and the wire supply means **28** (FIG. 1, etc.) and the conduit **16** with respect of the other member of the wire tensioning means **46*a***,**46*b***, etc. and the wire supply means **28** (FIG. 1, etc.) and the conduit **16.**

SUMMARY OF THE ACHIEVEMENTS OF THE OBJECTS OF THE INVENTION

It will be recognized by those skilled in the art that the objects of this invention have been achieved by providing an improved wire wrapping apparatus **18** (FIG. 1), **18²** (FIG. 2), **18³** (FIG. 3), **18¹⁰** (FIG. 10) and an improved method of wrapping high strength wire **16** (anchored at its free end **12** to a predetermined point **14** on a conduit **16**) under a predetermined tension and pitch about the conduit **16.** The apparatus and method apply a wrapping of wire **10** to fabricated line pipe **16** in the field; apply the wrapping of wire **10** to the line pipe under sufficient tension so as to provide a prestress level (of from about 0 pounds to about 7000 pounds of tension in the wire) required for modern wire wrapped line pipe; apply the wrapping of wire **10** at a high speed of from about 2 to about 5 miles per day per machine; are lightweight and portable, simple and rugged, and have a long, maintenance-free operational life; are capable of applying a wrapping of wire **10** to infinite lengths of pipe **16**; are compact and light in weight (i.e., about 7000 to about 8000 pounds, maintain the clearance between the pipe **16** being wrapped with the wire **10** and the ground level at a maximum of about 30 inches, utilize a simultaneous differential rotating spinning head **20** and a wire supply means **28** (FIG. 1, etc.) for feeding the wire **10** to a tensioning drum **48**; recover the bulk of the power consumed in tensioning the wire **10** thereby utilizing the recovered power to rotate and longitudinally move the spinning head **20** by means of an auxiliary drive means **92**; and prevent entanglement of the wire **10** from the wire supply reel **30** (FIG. 1, etc.) by the simultaneous differential rotation of the spinning head **20** and the wire supply reel **30** or the utilization of a friction means associated with the wire supply means **28** (FIG. 1, etc.).

While in accordance with the patent statutes, preferred and alternative embodiments of this invention have been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

We claim:

1. A wire wrapping apparatus for wrapping high-strength wire, anchored at its free end to a predetermined point on a conduit, under a predetermined tension and pitch about said conduit, said apparatus having:

a. a spinning head disposed about said conduit in engagement with said conduit for relative rotating and longitudinal movement with respect to said conduit and for wrapping said wire on said conduit with said predetermined tension and pitch;

b. wire supply means either disposed about said conduit in engagement with said conduit for relative rotating and longitudinal movement with respect to said conduit, or mounted on said spinning head and for supplying said wire to said spinning head;

c. friction means associated with said wire supply means for providing a friction drag on said wire supply means to prevent uncontrolled payoff of said wire from said wire supply means;

d. wire tensioning means mounted on said spinning head and adapted to receive said wire from said wire supply means at a low first tension, to store a plurality of turns of said wire on said wire tensioning means, and to wrap said wire predetermined a higher second tension on said conduit from said redetermined point during the relative rotating and longitudinal movement of said spinning head with respect to said conduit; and

e. drive means connected to one member of said spinning head and said conduit for causing relative rotating and longitudinal movement of said one member with respect to the other member of said spinning head and said conduit.

2. The wire wrapping apparatus recited in claim **1** and having auxiliary drive means on said spinning head and connected to said wire tensioning means so that the reaction torque in said wire tensioning means drives said auxiliary drive means.

3. The wire wrapping apparatus recited in claim **2** wherein said auxiliary drive means rotates said spinning head with respect to said conduit.

4. The wire wrapping apparatus recited in claim **2** wherein said auxiliary drive means moves said spinning head longitudinally with respect to said conduit.

5. The wire wrapping apparatus recited in claim **1** and having clutch or partial brake means associated with said wire tensioning means to provide a predetermined tension in said wire on the outlet end of said wire from said wire tensioning means so that a predetermined reaction torque is developed in said wire tensioning means.

6. The wire wrapping apparatus recited in claim **5** and having auxiliary drive means on said spinning head and connected to said wire tensioning means so that

said predetermined reaction torque drives said auxiliary drive means.

7. The wire wrapping apparatus recited in claim 1 wherein said wire supply means is disposed about said conduit in engagement with said conduit for relative and longitudinal movement of said wire supply means with respect to said conduit.

8. The wire wrapping apparatus recited in claim 1 wherein said wire supply means is mounted on said spinning head.

9. The wire wrapping apparatus recited in claim 8 wherein said wire supply means is a reel mounted on a shaft and said friction means is disposed between said reel and said shaft.

10. The wire wrapping apparatus recited in claim 1 wherein said friction means is disposed between said spinning head and said wire supply means.

11. The wire wrapping apparatus recited in claim 1 wherein said wire is fed from said wire supply means to said wire tensioning means in a direction opposite to the direction of relative rotation of said wire supply means with respect to said conduit to produce a relatively low-speed motion of the wire supply means.

12. The wire wrapping apparatus recited in claim 1 wherein said wire is fed from the said wire supply means to said wire tensioning means in the same direction as the relative rotation of said wire supply means with respect to said conduit to produce a relatively high speed relative rotation of said wire supply means thereby requiring greater energy consumption for the movement of said wire supply means.

13. A method for wrapping a high strength wire anchored at its free end to a predetermined point on a conduit, about said conduit under a predetermined tension and pitch, said method including the steps of:

a. storing a quantity of said wire on a wire supply means;

b. supplying said wire to a wire tensioning means;

c. providing a friction drag on said wire supply means to prevent uncontrolled payoff of said wire from said wire supply means to said wire tensioning means;

d. receiving said wire from said wire supply means on said wire tensioning means at a first low tension, storing a plurality of turns of said wire on said wire tensioning means, and wrapping said wire at a second higher tension on said conduit from said predetermined point during the relative rotating and longitudinal movement of said wire tensioning means and wire supply means with respect to said conduit; and

e. causing relative rotating and longitudinal movement of one member of said wire tensioning means and said wire supply means and said conduit with respect to the other member of said wire tensioning means and said wire supply means and said conduit.

14. The method recited in claim 13 and including the step of utilizing the torque developed in said wire tensioning means to drive an auxiliary drive means associated with said wire tensioning means.

15. The method recited in claim 14 wherein the torque from said wire tensioning means rotates said wire tensioning means with respect to said conduit.

16. The method recited in claim 14 wherein the torque in said wire tensioning means moves said wire tensioning means longitudinally with respect to said conduit.

17. The method recited in claim 13 and including the step of either clutching or partially braking said wire tensioning means to provide a predetermined tension in said wire on the outlet end of said wire from said wire tensioning means so that a predetermined torque is developed in said wire tensioning means.

18. The method recited in claim 17 and including the step of utilizing the predetermined torque from said wire tensioning means to drive an auxiliary drive means associated with said wire tensioning means.

19. The method recited in claim 13 including the step of disposing said wire supply means about said conduit in engagement with said conduit for relative and longitudinal movement of said wire supply means with respect to said conduit.

20. The method recited in claim 13 including the step of mounting said wire supply means adjacent said wire tensioning means and relatively stationary with respect to said wire tensioning means.

21. The method recited in claim 20 including the step of providing a friction drag for the wire supply means between a reel of said wire supply means and a shaft of said wire supply means on which said reel is rotatably mounted.

22. The method recited in claim 13 including the step of providing a friction drag between said wire supply means and said wire tensioning means.

23. The method recited in claim 13 including the step of feeding the wire from said wire supply means to said wire tensioning means in a direction opposite to the relative rotative movement of said wire supply means with respect to said conduit to produce a relative low-speed motion of said wire supply means.

24. The method recited in claim 13 and including the step of feeding the wire from said wire supply means to said wire tensioning means in the same direction as the relative rotation of said wire supply means with respect to said conduit to produce a relative high speed motion of said wire supply means.

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