United States Patent

Cullen et al.

[15] **3,673,785**

[45] **July 4, 1972**

[54] METHOD FOR WIRE-WRAPPING PIPE

[72] Inventors: **Roy H. Cullen; Charles H. Elliott,** both of Houston, Tex.

[73] Assignee: **Youngstown Sheet and Tube Company,** Youngstown, Ohio

[22] Filed: **Nov. 7, 1969**

[21] Appl. No.: **874,852**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 592,410, Nov. 7, 1966, Pat. No. 3,481,549.

[52] **U.S. Cl.** **57/161,** 57/13, 242/7.02

[51] **Int. Cl.** **D07b 1/06**

[58] **Field of Search** 242/7.02; 57/9, 11, 13, 3, 57/161

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[57] **ABSTRACT**

This patent discloses a method for wrapping a plurality of wires about an elongate member in a planetary lay. In one method the wires are permitted to turn as they are applied to obtain the planetary lay. In the other method the wires are pre-twisted and are held against rotation as they are applied so that they will untwist during application and provide a planetary lay.

3 Claims, 24 Drawing Figures

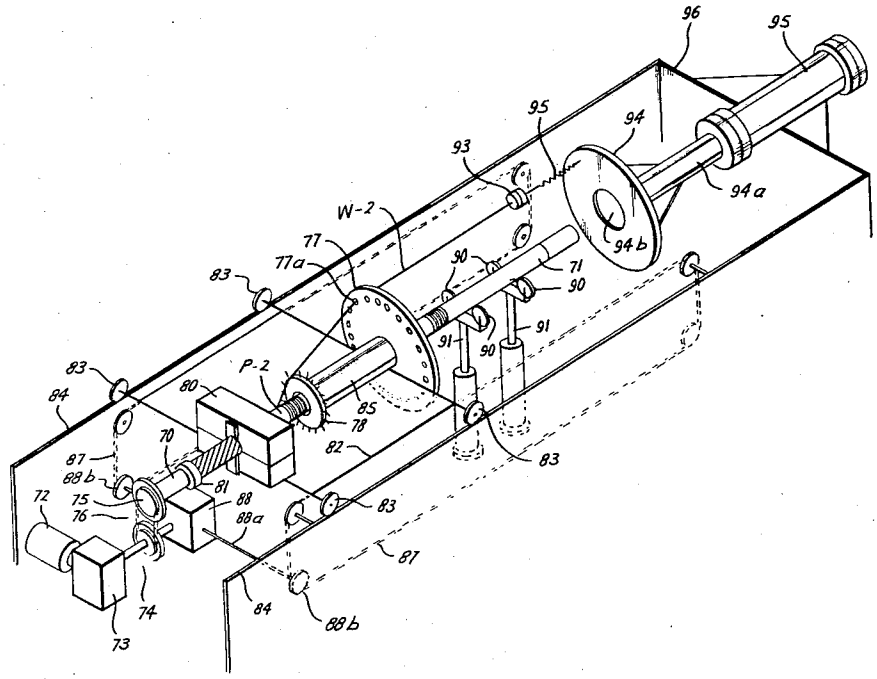


Fig. 1

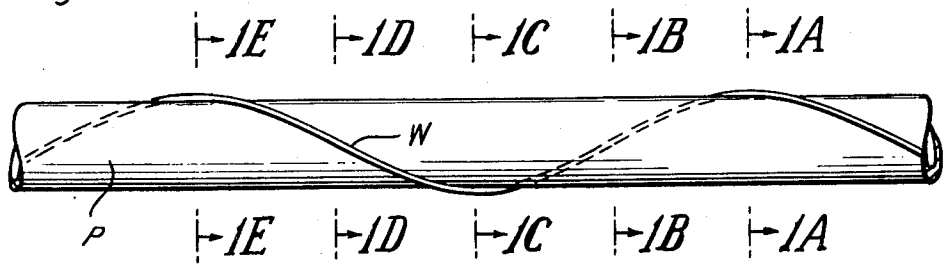
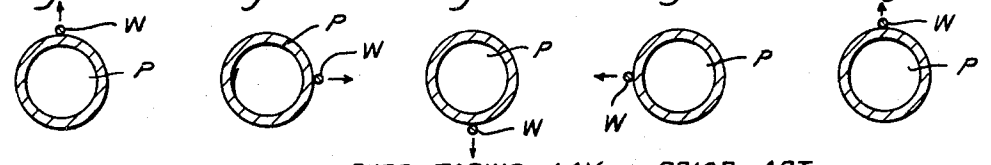
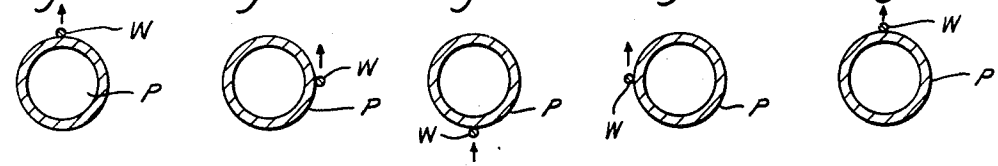


Fig. 1E Fig. 1D Fig. 1C Fig. 1B Fig. 1A



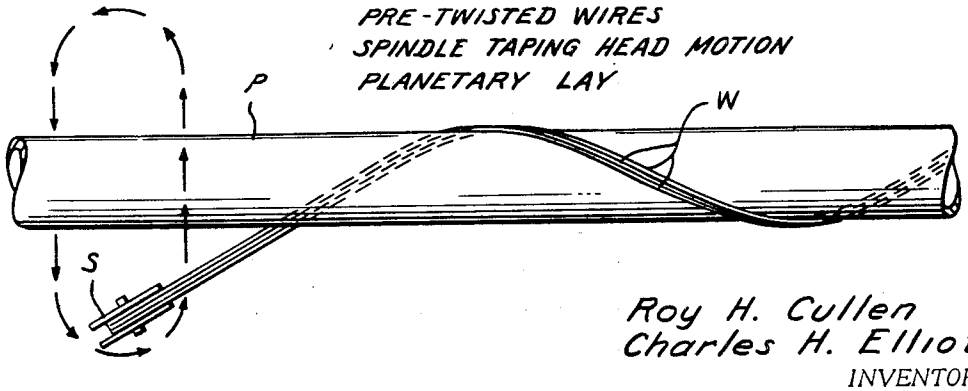
PURE TAPING LAY, PRIOR ART

Fig. 2E Fig. 2D Fig. 2C Fig. 2B Fig. 2A



PURE PLANETARY LAY, PRIOR ART

Fig. 3



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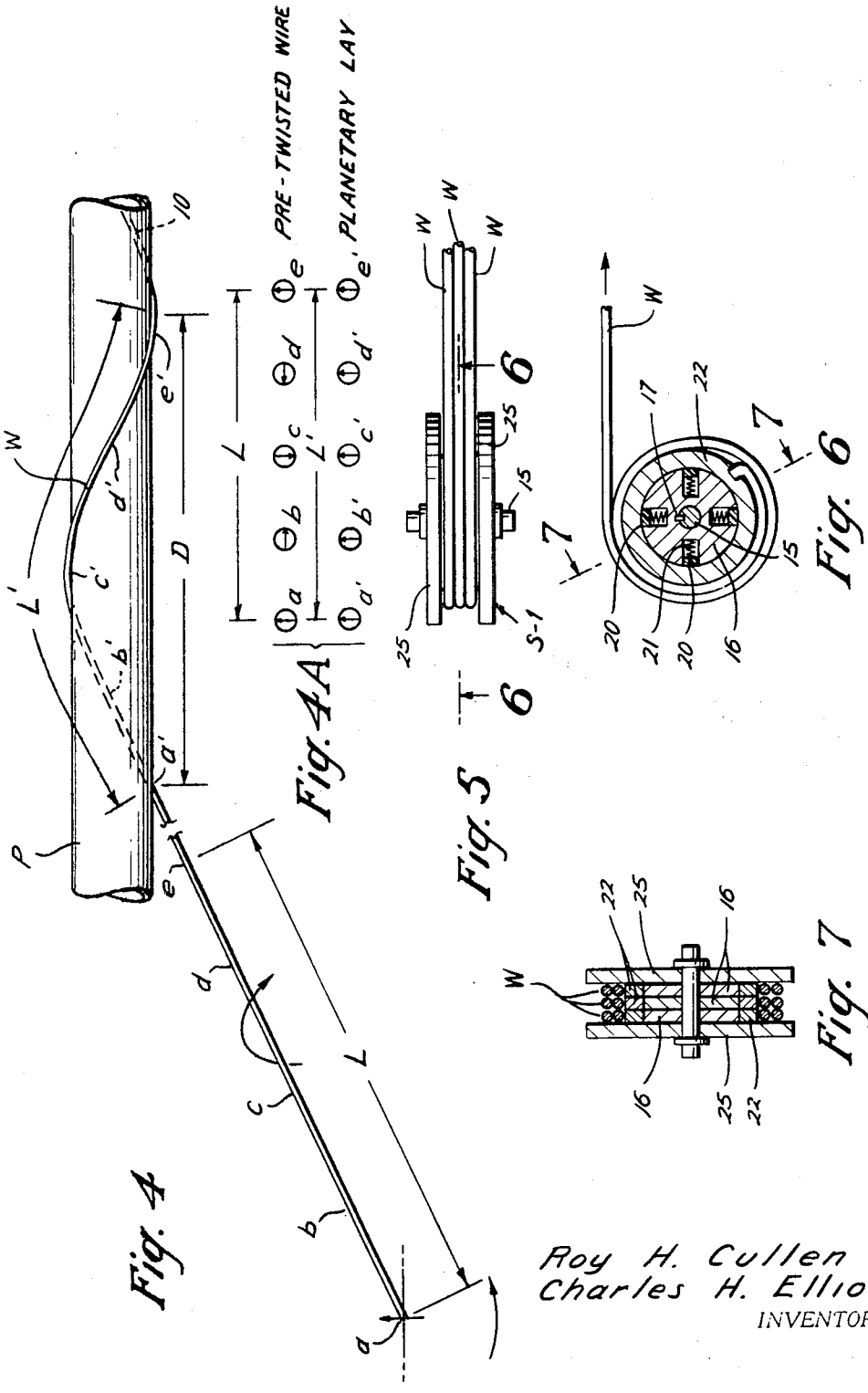
PRE-TWISTED WIRE
PLANETARY LAY
Fig. 4
Fig. 4A
Fig. 5
Fig. 6
Fig. 7
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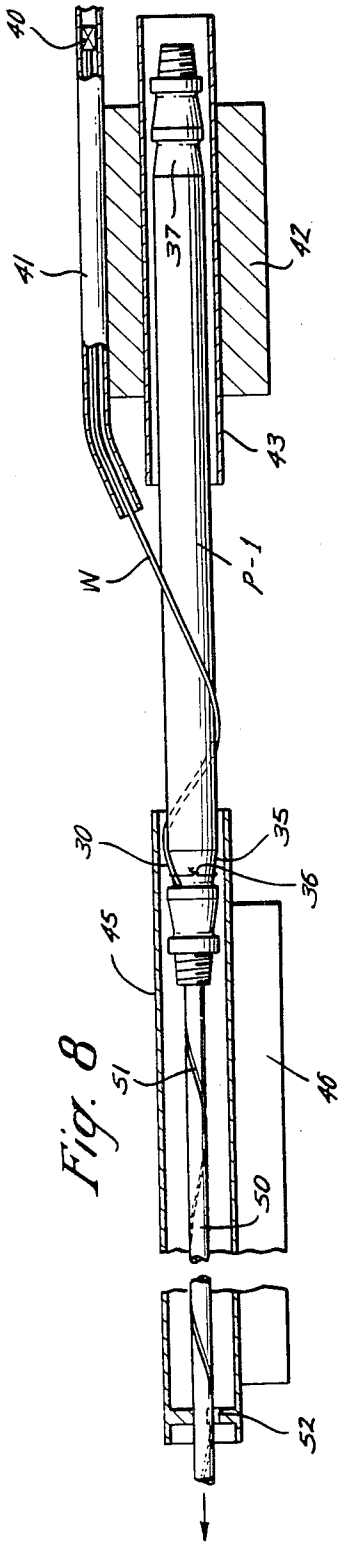

Fig. 8

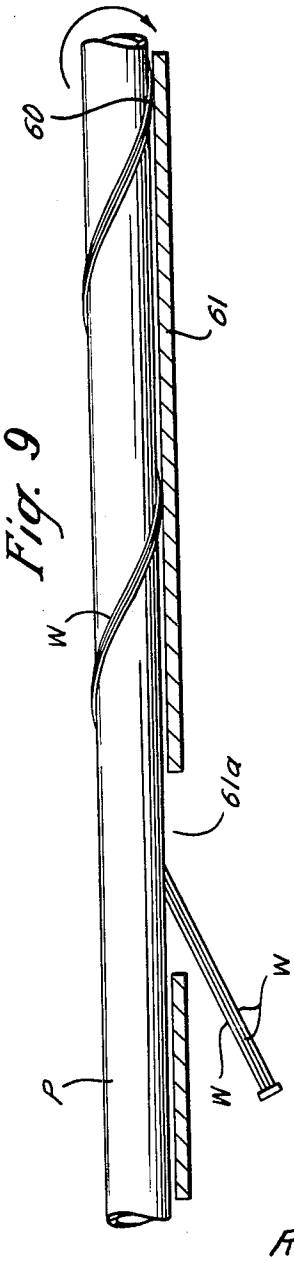

Fig. 9

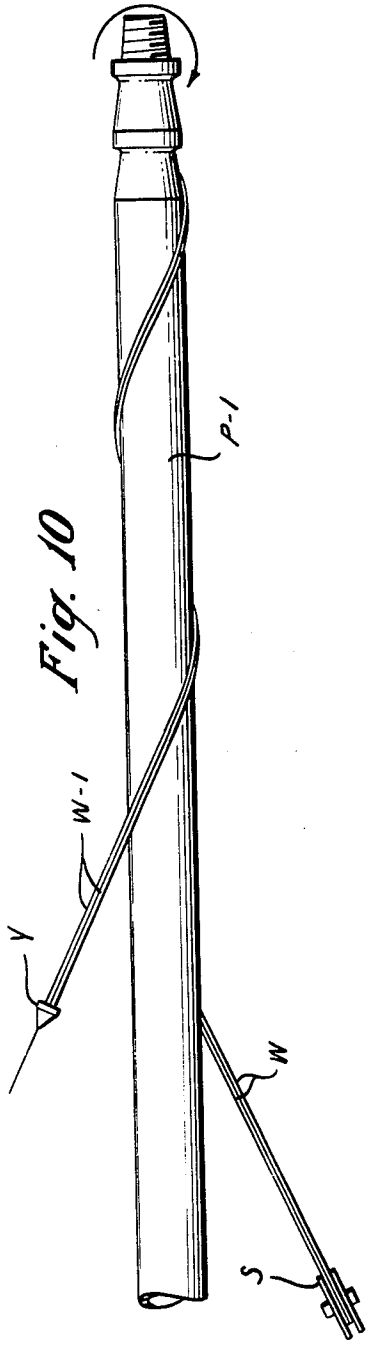

Fig. 10

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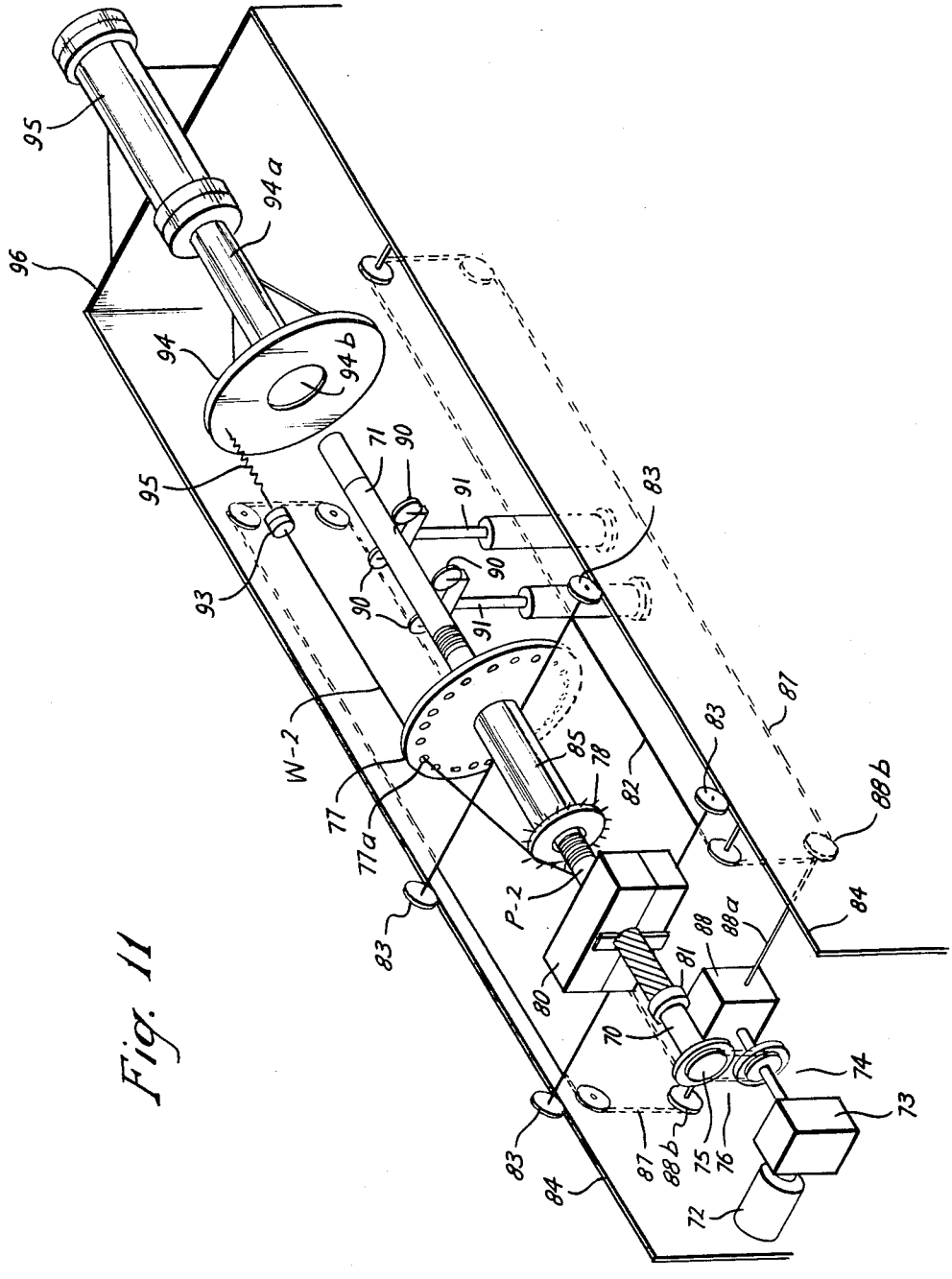

Fig. 11

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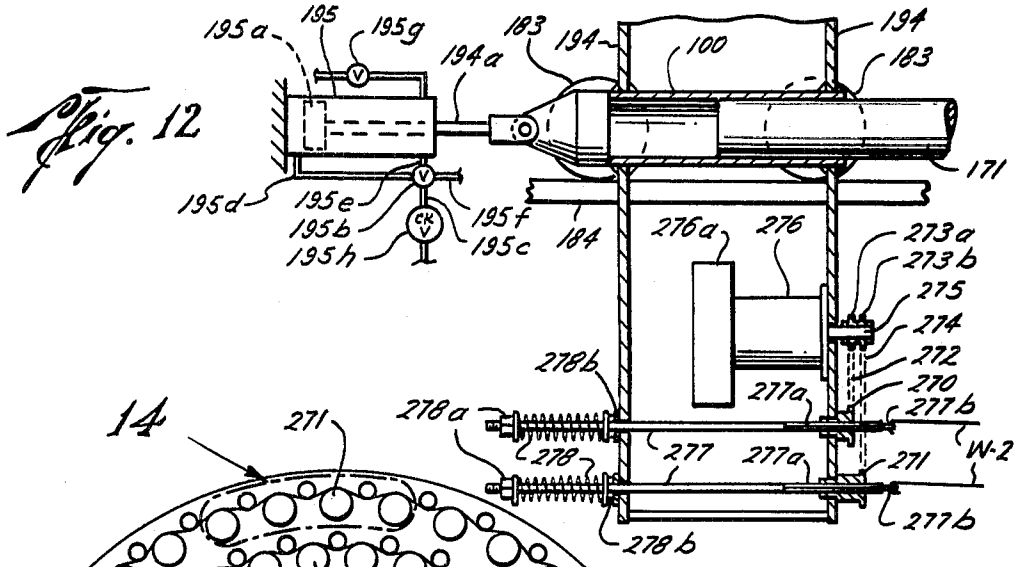


Fig. 12

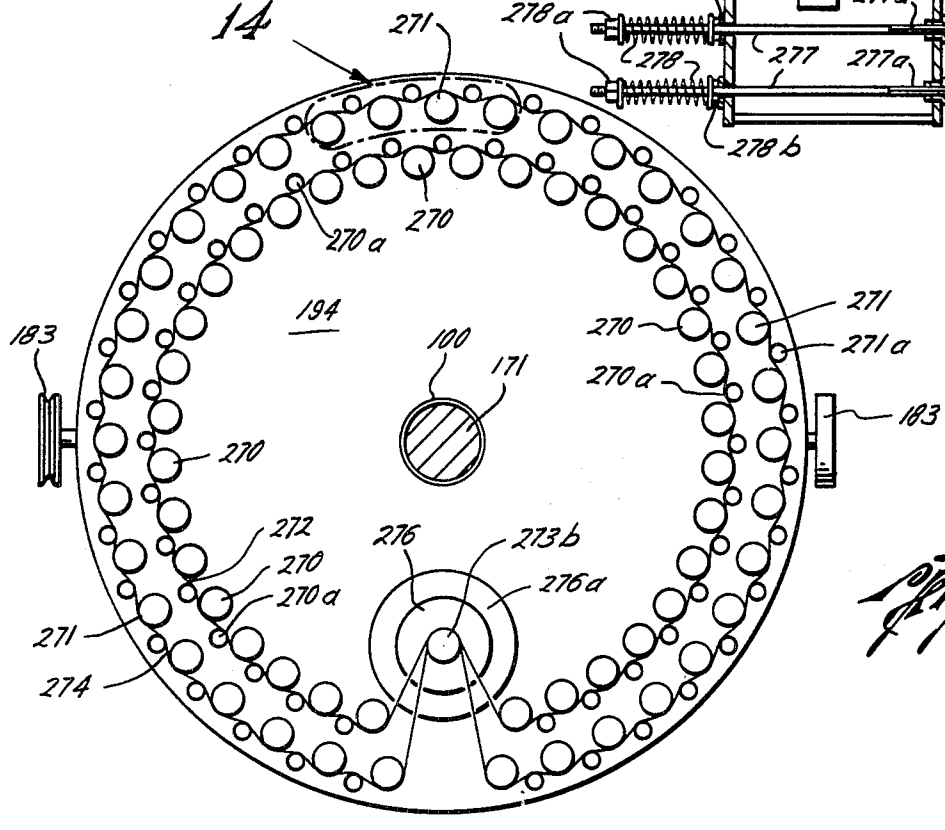
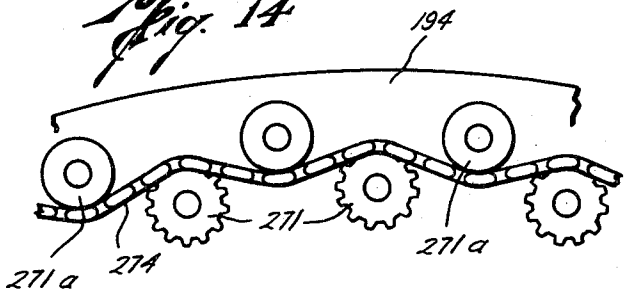


Fig. 13

Fig. 14



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METHOD FOR WIRE-WRAPPING PIPE

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U.S. application Ser. No. 592,410, filed Nov. 7, 1966, now U.S. Pat. No. 3,481,549.

This invention relates to new and useful methods for wire-wrapping pipe, and particularly for helically wrapping armor wire on flexible pipe.

In the manufacture of flexible pipe of the type disclosed in U.S. Pat. No. 3,004,779, and other elongate members, it is often necessary or desirable to wrap one or more layers of wire around the pipe or other elongate member. Heretofore, such wrapping was accomplished with either a planetary lay or a taping lay, or modified forms thereof. When wires are wrapped on a flexible pipe with a taping lay, the wires tend to spring away from the core of the pipe or elongate member which is especially bad when the armored or wire-wrapped pipe is run through a series of grippers of the type disclosed in U.S. Pat. No. 2,892,535 since any looseness of the wires is forced to collect at the end of the pipe, or section thereof, which results in damage to the wires when they are squeezed by the grippers.

When wires are wrapped with the planetary lay, they tend to hug the core of the pipe or tubular member instead of springing away, but to produce the planetary lay by previously known apparatus and methods results in further problems. For example, the prior art employed a separate spindle for each wire together with special mechanisms to keep the axes of the spindles parallel to a given plane as the spindles rotate relative to the base or core being wrapped with the wires from the spindles.

Although it might be thought that such prior art apparatus could be simplified by rotating the hose or core relative to stationary spindles for the armoring wire, such reversal of procedure does not produce the desired planetary lay, but instead it produces the undesirable taping lay.

The present invention relates to methods which solve the problems of the prior art by obtaining the desired planetary lay using either pre-twisted wires applied with a taping lay motion from reels or using a plurality of wires which are mounted without reels and are applied by rotating the hose or core relative to the wires. In the latter case, one end of each of the wires is secured to the hose or core and the wires are wrapped thereon with the unsecured ends of the wires turning or being turned. Alternatively, the wires may be pre-twisted and the unsecured ends of the wires may be held to prevent them from turning during the wrapping operation. The resulting product is a wire-wrapped hose or core wherein the wires hug or tightly grip the hose or core.

It is therefore an object of the present invention to provide new and improved methods for wire-wrapping flexible pipe or other elongate member wherein the wires are wrapped so as to hug the core of such pipe or elongate member as with the planetary lay but without the disadvantages of the prior planetary lay methods and apparatus.

An important object of this invention is to provide a new and improved method of wrapping wires on a core wherein the wires are pre-twisted in such a direction that when the wires are wrapped with a taping lay motion they will nevertheless lay on the core in a final position which is the same as that which the wires would have if applied with a planetary lay motion.

Another object of this invention is to provide a new and improved method of wrapping wires on a core wherein a plurality of wires may be wrapped from a single spindle or support with a taping head motion while laying the wires in a planetary lay, whereby the wires closely hug the core but are applied without the drawbacks of the conventional planetary lay method.

A further object of this invention is to provide a new and improved method of wrapping wires on a core wherein one end of each of a plurality of wires is secured to the core and the other ends are not secured thereto so that upon a rotation of the core the wires are wrapped thereon while the unsecured ends of the wires untwist, or are driven to positively untwist same, to thereby obtain a planetary lay of the wires on the core.

The preferred embodiment of this invention will be described hereinafter, together with other features thereof, and additional objects will become evident from such description.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

FIG. 1 is an elevation illustrating a wire wrapped on a tube or rod with a typical prior art taping lay;

FIGS. 1A through 1E are sectional views taken on lines 1A—1A through 1E—1E of FIG. 1 to indicate the rotational movement of the wires as applied to the elongate member using the prior art taping lay motion;

FIGS. 2A through 2E are views corresponding to FIGS. 1A through 1E, respectively, but illustrating the prior art planetary lay;

FIG. 3 is an elevation illustrating the method and one form of the apparatus of the present invention wherein the individual wires are pre-twisted so that a plurality of wires are applied with a common spindle using the taping lay motion and obtaining a planetary lay wrap;

FIG. 4 is a schematic view illustrating the present invention;

FIG. 4A is a schematic view wherein the upper row indicates the condition of the pre-twisted wire and the lower row indicates the condition of the wire after it has been wrapped on the pipe or other elongate member;

FIG. 5 is a plan view of one type of tensioning spindle which may be used in carrying out the method of this invention for maintaining a tension on the ends of the wires during the wrapping thereof on a pipe or other elongate member;

FIG. 6 is a sectional view taken on line 6—6 of FIG. 5 and further illustrates the tension spindle of FIG. 5;

FIG. 7 is a sectional view taken on line 7—7 of FIG. 6 to further illustrate the construction of the tension spindle of FIG. 5;

FIG. 8 is a view, partly in elevation and partly in section, illustrating a simplified apparatus for use in carrying out the method of this invention;

FIG. 9 is a schematic view illustrating the application of a plurality of wires on a pipe or tube by rotating the pipe or tube over pre-twisted wires;

FIG. 10 is a further illustration illustrating two different types of apparatus which may be used for applying the wires to the tube or elongate member in accordance with the present invention;

FIG. 11 is a schematic view of an apparatus for performing the method of this invention wherein wires are wrapped on the core by rotating the core relative to the wires while the free ends of the wires untwist to obtain a planetary lay;

FIG. 12 is a fragmentary view partially in elevation and partially in section of a modified form of the apparatus of FIG. 11 which may be used for pre-twisting the individual wires and then holding them against rotation as they are wrapped on the core to obtain a planetary lay;

FIG. 13 is a view taken from the right-hand end of FIG. 12 and showing the complete disc and drive means for the modified form of the invention; and

FIG. 14 is a partial view showing in detail a portion taken from FIG. 13 as indicated thereon.

Briefly, the present invention relates to a method for applying wire in a helical wrap on pipe or other elongate members. The term "wire" as used herein includes not only the conventional steel and other metal wires, but may also include any similar type of element. Preferably, the pipe which is wrapped with the wire in the present invention is of the type disclosed in U.S. Pat. No. 3,004,779, but the invention is not limited thereto.

To provide a background for an understanding of the present invention, the prior art has been illustrated in FIG. 1, FIGS. 1A through 1E and FIGS. 2A through 2E. In FIG. 1, a wire W is illustrated as being disposed in a helical wrap on a pipe, rod or other elongate member P. Sectional views taken on lines 1A—1A through 1E—1E of FIG. 1 have been provided to illustrate the pure taping lay of the prior art, using the small arrows as shown in FIGS. 1A–1E for such purpose. Thus, a single pitch of the wire W extends from 1A to 1E of FIG. 1. When the wire W is laid on the pipe or other elongate member P with the pure taping lay of the prior art, the wire W is actually rotated about its longitudinal axis 360° from the point 1A to the point 1E of FIG. 1. The rotation is illustrated by the arrows in FIGS. 1–A through 1–E. Such rotation of the wire W with the taping lay results in a wire which tends to spring away from the pipe P and become loose in use. Such construction is particularly detrimental if the wire W is wrapped with a plurality of parallel wires to form an armor on a flexible hose core or flexible pipe of the type disclosed in said U.S. Pat. No. 3,004,779. For example, if such looseness develops in the wires, the looseness will be forced to collect and accumulate when such wires are passed through gripping devices of the type disclosed in U.S. Pat No. 2,892,535. When the loose wires thus collected or accumulated are gripped or squeezed, they will be damaged, sometimes to the point of fracture.

The pure planetary lay of the prior art is illustrated in FIGS. 2A through 2E and it is assumed that such positions correspond with the cut lines 1A—1A through 1E—1E, respectively of FIG. 1. With the planetary lay, the wire W is held during the laying operation so that it does not rotate with respect to the pipe or other elongate object, as indicated by the small arrows in FIGS. 2A–2E. By reason of the planetary lay wrap, the wire W tends to hug and fit closely to the external surface of the pipe P or other elongate object which prevents it from becoming loose during operation. However, the planetary lay has a number of drawbacks or disadvantages as explained heretofore.

With the present invention, one embodiment of which is illustrated in FIG. 3, a plurality of wires W are wrapped on a pipe or other elongate member P from a common spindle S with a taping head motion while obtaining the planetary lay wrap. Thus, as will be more evident hereinafter, the method of the present invention has all of the advantages of both the taping lay technique and the planetary lay technique of the prior art, while eliminating the disadvantages of same.

To understand how the results of the present invention are accomplished, reference is made to FIGS. 4 and 4A. As illustrated in FIG. 4, the letter P indicates a pipe, rod or other elongate member, or the core of a flexible pipe or hose of the type shown in said U.S. Pat. No. 3,004,779. A single wire W is shown, with a portion L extended therefrom prior to wrapping on the pipe or elongate member P, and with another portion L′ already wrapped on the pipe or elongate member P. It is assumed that one end such as indicated at **10** of the wire W is secured either permanently or temporarily to the pipe or elongate member P. Normally, the end **10** of the wire W is secured at a coupling (not shown) for the core of the flexible pipe P.

The letter D in FIG. 4 designates the pitch or one helical revolution of the wire W with respect to the pipe P. Such pitch D extends from *a′* to *e′*. The physical length of the wire W is indicated by L′ for the unit of pitch D and therefore the length of the wire L′ may be referred to as a unit length of the wire W. The extended portion of the wire W may be of any length and for purpose of illustration is indicated as having a unit length L which is equal to the unit length L′. There may of course by a number of such unit lengths, each of which is ultimately wrapped or laid helically on the pipe or other elongate member P.

In accordance with one embodiment of the present invention, each, unit length L is pre-twisted so as to compensate for the rotation or twisting which would otherwise occur when using the prior art taping lay motion. In FIG. 4, various points along the unit length L of the wire W have been marked with the letters *a*, *b*, *c*, *d*, and *e*, and corresponding positions of rotation of such unit length of the wire are indicated in the top row of FIG. 4A, with the short arrows indicating the direction of twist at the particular point marked by such letters *a* through *e*, respectively. Thus, if the unit length L is viewed from the left-hand end at *a* and looking towards *e*, the pre-twisting of such unit length A is for a full 360° and in a clockwise direction. The unit length L is wrapped on the core, pipe or other elongate member P by the taping lay motion which involves a rotation of core P relative to the wire W, or vice versa, to produce the helical wrap indicated at L′ in FIG. 4. During such relative rotation, the the free or unsecured end of the wire W, such as the end *a* (FIG. 4), is held to prevent turning or twisting, whereby the pre-twisting is relieved as the wrapping progresses to obtain the planetary lay wrap as indicated by the arrows in the lower row of FIG. 4A. The relative motion between the core P and the wire W is also schematically illustrated in FIG. 3 of the drawings by the arrows and dotted lines in connection with the spindle S. It will be seen from FIG. 3 that the ends of the wires W on the spindle S correspond to the free or unsecured end *a* of the wire W in FIG. 4, in that such ends on the spindle S are likewise prevented from untwisting except to the extent such untwisting occurs during wrapping to produce the planetary lay.

For purposes of explanation, it is assumed that the unit length L′ was initially pre-twisted in the same manner as the unit length L and then was wrapped with the taping lay motion, using a spindle S or other suitable means. The resulting condition of the unit length L′ is illustrated in the lower row of FIG. 4A, with *a′*, *b′*, *c′*, *d′*, and *e′* indicating the direction of twist of the wire at each of those points so marked in FIGS. 4 and 4A. The small arrows in the bottom row of FIG. 4A thus illustrate that the wire W is actually laid in its final wrap with the wire in the same condition as if it had been laid by the planetary lay motion, as can be seen by comparing the arrows in the bottom row of FIG. 4A with the arrows for the wire W in FIGS. 2A–2E.

When a plurality of wires W are wrapped simultaneously from a common spindle S using the taping lay motion indicated in FIG. 3, each of the wires W is pre-twisted in the same manner as described in connection with FIG. 4 above so that each of such wires W is finally wrapped or laid into position on the pipe or other elongate member P as if it had been laid by the planetary lay motion. Thus, all of the wires W are readily applied with the relatively simple apparatus and the operation of the taping lay motion and apparatus, but the wires W actually hug and fit closely on the external surface of the pipe P or other elongate member instead of being loosely mounted thereon as would occur with the normal taping lay motion.

In some instances, it may be desirable to over-twist the wire prior to applying same using the present method, in which case an increased hugging or tendency to remain in close contact with the external surface of the pipe or other elongate member P will be produced. Such additional pre-twisting may be effected to the extent of the elastic limit of the wire, since such elastic limit of the wire cannot be exceeded in torsion. It will be understood that only three wires W are illustrated in FIG. 3 for simplicity of illustration, but the number of wires may be increased or decreased as desired, preferably applying all of the wires for each layer of armor on the hose or other flexible member P in a single operation.

Various types of apparatus may be employed in carrying out the method of this invention. For example, a modified spindle S–1 is illustrated in FIGS. 5–7 for three of the wires W, it being understood that the spindle S–1 may be enlarged to accommodate more wires W if so desired. The spindle S–1 has a central shaft **15** which is fixed and which is connected to a friction slip disk **16** with a key **17** or other suitable connector. The friction slip disk has friction shoes made of rubber, asbestos or similar brake type material indicated at **20** for engaging with the internal surface of a spindle ring **22**. A spindle ring **22** is

provided for each of the wires W as best seen in FIG. 7 so that tension may be maintained on each of the wires W independently of the others. The wires W are confined between side plates 25 which are secured to the fixed shaft 15 by keys or other suitable connecting means. Friction shoes 20 are urged outwardly by springs 21 to assure frictional contact of the shoes 20 with the inner surface of the ring 22 even when wear occurs.

A simplified form of apparatus for carrying out the method of this invention is illustrated in FIG. 8, wherein a section of flexible pipe P–1 of the type illustrated in said U.S. Pat. No. 3,004,779 is shown. Such pipe P–1 is illustrated in FIG. 8 prior to the application of the armor wire layers, which are applied with the method of this invention to the core of such flexible pipe P–1. One end of the wire W is indicated at 30 on the left-hand end coupling 35 of the flexible pipe P–1. Such end 30 is secured by any suitable means such as a tightly wrapped wire or clamp 36. The wire W is pre-twisted in the same manner as explained in connection with FIGS. 4 and 4A, such the pre-twist being maintained by a frictional lock or key schematically shown at 40 in FIG. 8 within a tube 41. The tube 41 is shown as disposed on a support 42 which has a feed-off guide 43 for the pipe P–1. A sleeve forming a post armor guide 45 supports the flexible pipe P–1 at the left-hand end of FIG. 8 and it in turn is mounted on a base or support 46. A guide rod or bar 50 is disposed within the guide sleeve 45 and one end thereof is temporarily threaded or otherwise connected to the coupling 35. Such rod 50 has a helical groove 51 formed therein which has the helical configuration desired for the wrapping of the wire W on the pipe P–1. A pawl 52 is formed internally of the sleeve 45 and extends into the groove 51. Suitable means (not shown) is provided for moving the rod 50 longitudinally to the left as viewed in FIG. 8 and as indicated by the arrow so as to cause the rod 50 to rotate during such longitudinal movement as the pawl 50 follows the groove 51. As the rod 50 is thus moved in a helical path, the pipe P–1, is moved in the same helical motion and the wire W is pulled from the tube 41 while being maintained under tension by the friction lock 40 so as to wrap the wire W in the helical wrap corresponding to the helical groove 51. Since the wire W is pre-twisted, it assumes a final condition corresponding to the planetary lay illustrated by the bottom row of FIG. 4A as previously explained.

It will be understood that a plurality of the wires W may be wrapped in a single operation to fully armor each layer of wires on the core of the pipe P–1 at one time if so desired. When the full length of the wire W has been wrapped on the length of the pipe P–1, the end of the wire W is severed and is secured to the other end coupling 37, using the methods for effecting such coupling disclosed in the prior art.

In FIG. 9 of the drawings, a further modification of the method of this invention is illustrated. The illustration of FIG. 9 includes a pipe P or other elongate member with a plurality of wires W which have been pre-twisted in the manner explained above in connection with FIG. 4. Such wires W are secured in parallel relationship, the number of which may vary. The wires W may be laid out on a plane such as a floor, one end of the pipe P may be secured to one end of the plurality of parallel wires W, such ends being designated at 60 in FIG. 9, and then the pipe P may be rolled along the floor to roll the parallel wires W onto the pipe P. Alternatively, and as specifically illustrated in FIG. 9, the ends 60 may be initially attached or temporarily secured to the pipe P at the desired point, the pipe P may be fixed in a location for rotation with a backup plate 61 having an opening 61*a* through which the plurality of wires W extend. As the pipe P is rotated, the wires W are pulled onto the rotating pipe or tube T to thus cover such pipe or tube P with the wires W. The number of wires are illustrated in FIG. 9 as being three for simplicity, but the number may be increased or decreased as previously explained, using the same procedure.

In FIG. 10, the pipe P–1 preferably corresponds with the core of the pipe illustrated in U.S. Pat. No. 3,004,779. The pipe P–1 may be rotated and advanced longitudinally to the right as viewed in FIG. 10 with the spindle S for the wires W in a fixed position. Alternatively, the pipe P–1 may be fixed and the spindle rotated as explained in connection with FIG. 3 of the drawings.

Also, in FIG. 10 another procedure is illustrated wherein a yoke Y is illustrated for the ends of the wires W–1. Such yoke Y is connected to the ends of the wires which have been pre-twisted so that as the pipe P–1 is rotated, the wires W–1 are wrapped as illustrated so as to obtain the same results and condition heretofore explained in connection with FIG. 4.

In FIG. 11, still another embodiment of the present invention is illustrated, wherein wires are applied to the hose core without the use of reels and normally without any pre-twisting of the wires. One type of apparatus which may be used for carrying out such method is schematically illustrated in FIG. 11. Thus, as illustrated in FIG. 11, a predetermined length of hose P–2 which is to be wrapped by a plurality of armor wires such as wires W–2 are mounted on the apparatus for the wrapping operation. The hose core P–2 is threaded at one end to a rotatable mandrel 70 and it is secured at its other end to a guide mandrel or pilot 71. The mandrel 70 is rotated by any suitable drive means such as an electric motor 72 which drives through a gear box 73 and sprockets or gears 74 and 75, to which are connected a pulley or chain 76. The wire W–2 illustrated in FIG. 11 is merely representative of a plurality of wires which are disposed through the openings 77*a* in a wire guide plate 77. Each of the wires W–2 passes through the opening 77*a* and through a space between the jaws of a closing die 80 which is disposed around the hose core P–2. The ends of the wires W–2 adjacent the mandrel 70 are secured to the hose core P–2 by a holding nut 81 or similar retaining device. At the start of the wrapping operation, the closing die 80 is disposed adjacent the nut 81 and all of the wires W–2 are extended substantially longitudinally and parallel with the axis of the hose P–2, but spaced outwardly therefrom so as to completely surround such hose core P–2. The closing dies 80, the comb 78 and the wire guide plate 77 are all preferably mounted together on a frame 82 which has rollers 83 so that such components move as a unit longitudinally on a track or frame support indicated by the rails 84. It is to be noted that the comb 78 is connected to the wire guide plate 77 by a connector tube 85 through which the core P–2 initially extends. The framework 82 is operably moved longitudinally by any suitable means so as to move the wheels or rollers 83 on the track 84 to the right as viewed in FIG. 11 when wrapping the wires W–2 on the hose core P–2. As illustrated in FIG. 11, such operating means includes an endless chain 87 on each side of the frame 82, each of which is driven by the motor 72 through a gear box 88, shafts 88*a* and sprockets 88*b* engaging the endless chains 87. The direction of rotation of the sprockets 88*b* determines the direction in which the closing dies 80 and the wire guide plate 77 are moved longitudinally with respect to the hose core P–2, as will be more evident hereinafter.

The guide mandrel or pilot 71 is supported on any suitable support such as support rollers 90 which are mounted on a retractable base 91.

The unsecured or free end of each of the wires W–2 is attached to a swivel 93 which is resiliently connected to a carriage plate 94 by a spring 95. The carriage plate 94 is mounted in any suitable means for limited longitudinal travel to compenstate for the movement of the ends of the wires W–2 during the wrapping operation, as will be explained. Thus, the carriage plate 94 is mounted on a stem 94*a* which has a piston disposed inwardly of a cylinder 95 so that hydraulic fluid provides a cushion to limit the amount of the movement of the ends of the wire connected to the swivel 93, while allowing enough movement to permit the wrapping of the wires W–2 helically on the core P–2. The cylinder 95 is connected to a suitable frame or support that is indicated at 96.

In carrying out the methods as illustrated in FIG. 11, the plurality of wires W–2 are secured to the hose core P–2 at the

mandrel end with a nut **81** and with the closing dies **80** over the wires W–2 adjacent such nut **81**. Each of the wires W–2 extends through one of the openings **77***a* in the guide plate **77** and through the spaces between the teeth of the comb **78**. Also, each of the wires W–2 is maintained under tension and is connected with a swivel **93** or other suitable means for allowing the wire W–2 to turn or untwist during the wrapping operation. Also, instead of simply allowing the ends of the wire to turn at the swivels **93**, each of the wires W–2 may be forced to untwist or rotate about its own longitudinal axis during the wrapping operation to obtain the close-fitting planetary lay of such wires on the core P–2.

When it is desired to begin the wrapping, the mandrel **70** is rotated and the endless chains **87** are actuated to move the closing die **80** together with the guide plate **77** and the comb **78** longitudinally away from the mandrel **70**. Since the wrapping of each of the wires W–2 on the hose core P–2 occurs helically, it requires a greater length of the wires W–2 than the actual length of the hose core P–2. For this reason, the ends **93** of the wires W–2 tend to move towards the forward end of the hose core P–2 during the wrapping operation and such movement is permitted by the travel of the piston on the piston stem **94***a* within the cylinder **95**, maintaining tension on the wires W–2 at all times. The pilot **71** enters the opening **94***b* and actually moves within the bore of the stem **94***a* during the travel of the equipment longitudinally during the wrapping operation. The rollers **90** may be moved downwardly out of the way of the guide plate **77** by any suitable mechanism so that the predetermined length of the hose core P–2 may be wrapped by continuous movement in one direction of the guide plate **77** and the closing dies **80** with respect to the hose core P–2.

The method thus described with respect to FIG. **11** produces a wrap which has the wires W–2 disposed thereon with the planetary lay as illustrated in the bottom row of FIG. **4A**.

A modified form of the apparatus of FIG. **11** may be used to pre-twist the individual wires W–2 and then hold them against rotation as they are wrapped on the hose core P–2 so that a planetary lay wrap is produced. This modified form of the apparatus of FIG. **11** is illustrated in FIGS. **12** through **14** wherein the spring or tension assembly and the swivel assembly are modified as compared to FIG. **11**. Thus the ring **94** is replaced by the rings or plates **194** which have a central pipe or tube **100** welded or otherwise connected to the two plates or rings **194**. Suitable rollers **183** are mounted with the plates **194** for limited rolling movement on the track or bar **184** corresponding to bar **84** of FIG. **11**.

The plates **194** are moved in any suitable manner to the same extent as explained heretofore in connection with the plate **94** of FIG. **11** to thereby compensate for the lengthwise movement of the ends of the wires W–2 as they are wrapped on the hose core P–2. In the FIG. **12** form the pipe **100** is connected to a piston rod or shaft **194***a* which extends to a fluid cylinder **195** so that a piston **195***a* therein is adapted to be moved backwards or forwardly for controlling the tension on the wires W–2. A four-way valve **195***a* is preferably used with the cylinder **195** for controlling the inlet pressure fluid through an inlet line **195***c* to either the inlet tube **195***d* or the inlet tube **195***e*. Line **195***f* is provided for a return to the tank of the pressure source. By introducing fluid through the line **195***e*, it will be appreciated that the piston **195***a* will be moved to the left so as to thereby move the pipe **100** and the plates **194** to the left as viewed in FIG. **12**. It should be noted that such movement of the pipe **100** is relative to the pilot **171** (corresponding to pilot **71** of FIG. **11**) which does not move but slides internally of the pipe **100** for thereby supporting the forward end of hose core P–2 during the wrapping operation. A relief valve **195***g* is provided on the cylinder **195** in FIG. **12**, and it may be set to relieve pressure on the right-hand side of the piston **195***a* when the pressure reaches a predetermined amount so as to permit the piston **195***a* to move to the right without developing an excessive tension in the wires W–2. Also, such valve **195***g* may be manually or automatically operated as desired. A check valve **195***h* in the inlet line **195***c* prevents fluid from escaping from the right-hand side of piston **195***a* through line **195***c*.

With the apparatus illustrated in FIGS. **12** through **14**, the wires W–2 may be positively pre-twisted an effective amount to assure the desired planetary lay. To accomplish such positive pre-twisting of the wires W–2, two sets of circumferentially disposed sprockets **270** and **271** are provided. The sprockets **270** are disposed internally of the sprockets **271** and are circumferentially staggered so that alternate wires W–2 are positioned on the sprockets **271** and the other alternate wires W–2 are positioned on the sprockets **270** as will be more fully explained. The inner sprockets **270** are interconnected by drive chain **272** which extends over a drive sprocket **273***a* (FIG. **12**) while the outer sprockets **271** are driven by a chain **274** which fits over a drive sprocket **273***b* (FIGS. **12** and **13**). The sprockets **270** and **271** preferably have corresponding idler rollers **270***a* and **271***a* engaging their respective drive chains (FIGS. **13** and **14**).

The sprockets **273***a* and **273***b* are preferably on a common drive shaft **275** which is driven by a suitable motor **276** having a brake **276***a* associated therewith (FIG. **12**). Each of the sprockets **270** and **271** has a splined rod **277** extending therethrough with splines at **277***a* within the bore of each of the sprockets **270** and **271** to thereby provide rotation to the rod **277** in accordance with the rotation of the sprockets **270** and **271**, while also permitting a sliding relative movement therebetween. The rods **277** are resiliently urged forwardly by springs **278** which are disposed between thrust bearings **278***b* adjacent the rings or plates **194** and suitable adjustable nuts **278***a* so that a predetermined tension may be maintained in the wires W–2 when the wires are connected to the rearward end of the rods **277** as indicated at **277***b*. After the wires are connected, the splines may be adjusted by rotation of nuts **278***a* to apply approximately equal tension on each of the wires. The simultaneous rotation of all the sprockets **270** and **271** may be accomplished by operation of the motor **276**. Thus the motor **276** may be operated to impart to each of the wires W–2 the desired amount of pre-twist and then the brake **276***a* engaged to hold the wires W–2 against rotation as they are helically wrapped on the pipe core P–2 in the manner previously explained in connection with the apparatus of FIG. **11**.

In operation, the modified apparatus of FIGS. **12–14** may be used as follows: the individual wires W–2 are attached to the splined rods **277**. Valve **195***b* is operated to admit fluid to cylinder **195** through line **195***e* and to vent through line **195***d* to move piston **195***a* to the left; after which the pressure source to line **195***c* is turned off, a check valve **195***h* preventing the escape of pressurizing fluid through line **195***c*. As the piston **195***a* and the plates **194** move to the left, the wires W–2 are placed under tension. Nuts **278***a* on rods **277** may be adjusted to place each of the wires under approximately equal tension. Motor **276** is operated to pre-twist the wires W–2 the desired amount and then brake **276***a* is engaged to prevent the wires from untwisting. The wires are now pre-twisted and ready to be wrapped on the pipe core P–2 in the manner previously described. During the wrapping process, as the wires W–2 exert pull on the plates **194** the plates **194** will tend to move away from fluid cylinder **195**. The piston **195***a* will increase pressure on relief valve **195***g* which bleeds fluid out of the cylinder to maintain the wire W–2 under a tension which is preferably constant.

It is preferred that the wires be pre-twisted one revolution for each wrap of the wires on the core P–2. Additional pre-twist may be used, if desired, up to the elastic limit of the wire.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A method of wrapping a plurality of wires on an elongate member comprising,

securing one end of each wire in proximity to one end of an elongate member,

positioning the wires substantially longitudinally with respect to the elongate member and pre-twisting said wires about their longitudinal axes,

applying tension to the other end of each wire while holding the other end of each wire against rotation about its longitudinal axis,

relatively rotating the elongate member and wires and helically wrapping the wires on the elongate member;

said wires untwisting as they wrap about the elongate member and returning to substantially their axial orientation prior to being pre-twisted;

and moving the other ends of the wires toward said secured ends during said wrapping step while continuing to apply said tension.

2. The method of claim 1 wherein each of said wires is pre-twisted approximately 360° for each length of wire corresponding to each pitch of the wrapped wire.

3. The method of claim 1 wherein each of said wires is pre-twisted more than 360° for each length of the wires corresponding to each pitch of the wrapped wire.

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