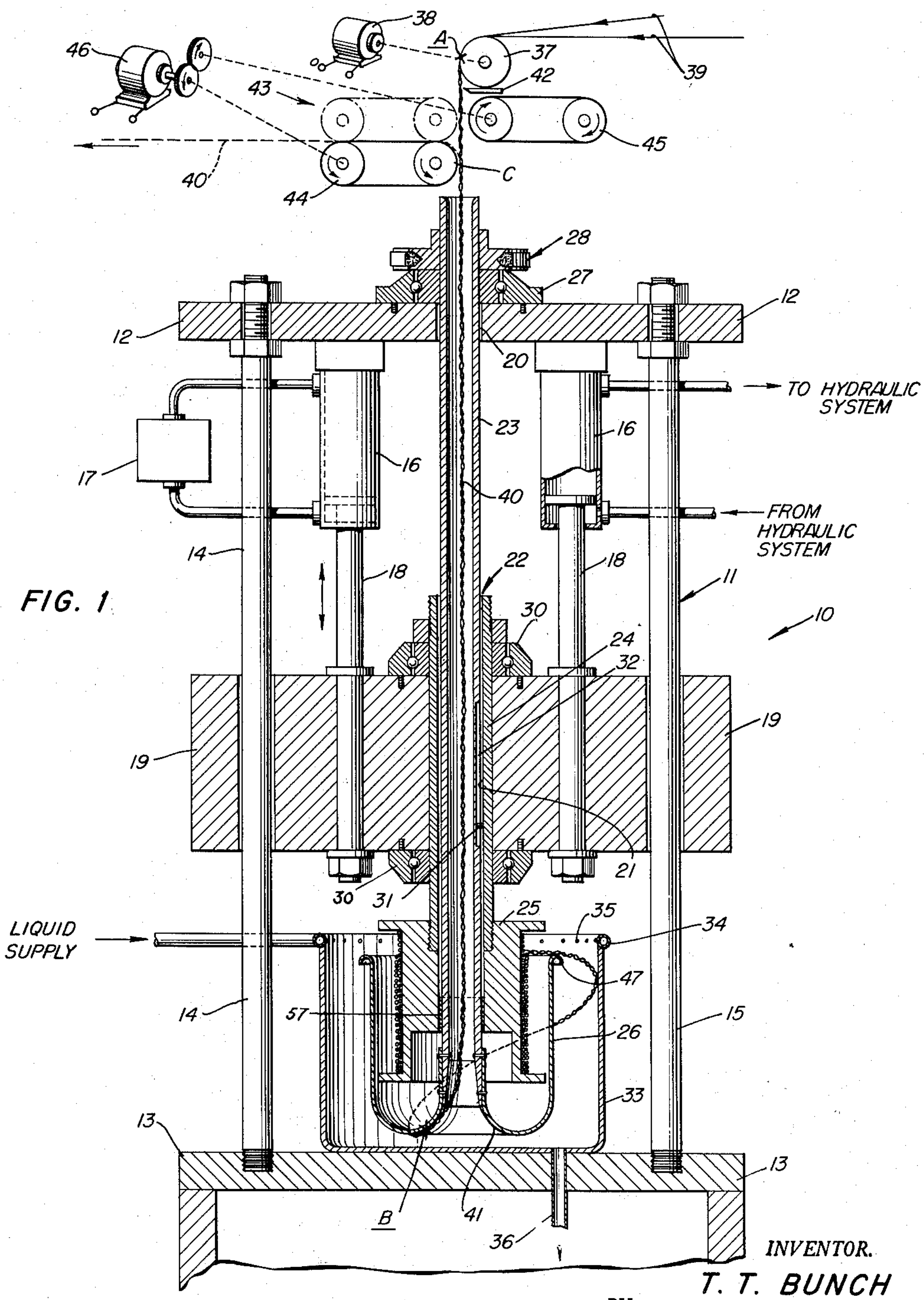



FIG. 1

INVENTOR.
T. T. BUNCH
BY H. J. Winegar
ATTORNEY

July 9, 1963 T. T. BUNCH 3,096,610

METHODS OF AND APPARATUS FOR MULTICYCLE TWISTING A WIRE-LIKE MEMBER

Filed Sept. 18, 1961



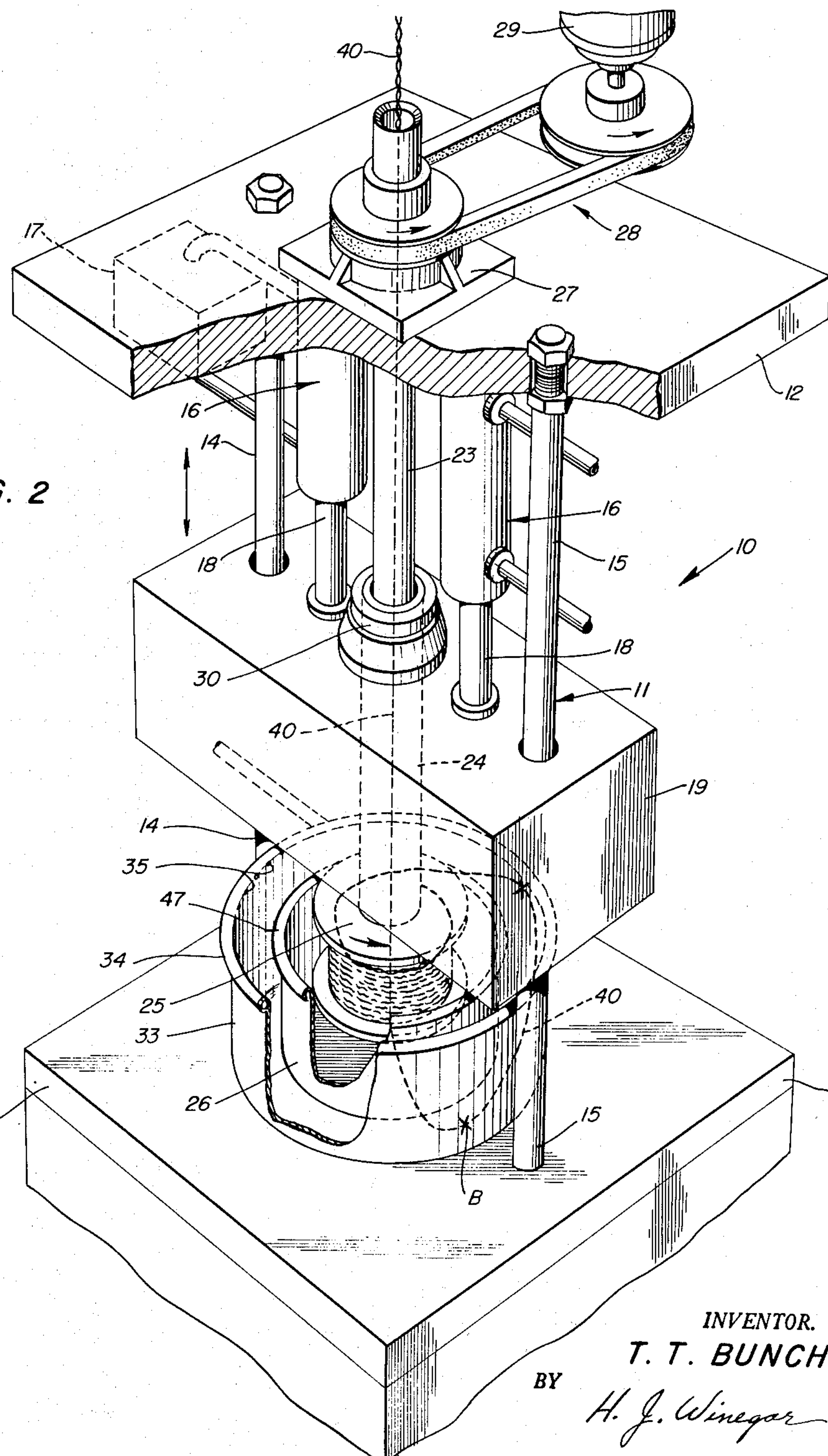



FIG. 2

INVENTOR.
T. T. BUNCH

BY H. J. Winegar

ATTORNEY

July 9, 1963

T. T. BUNCH

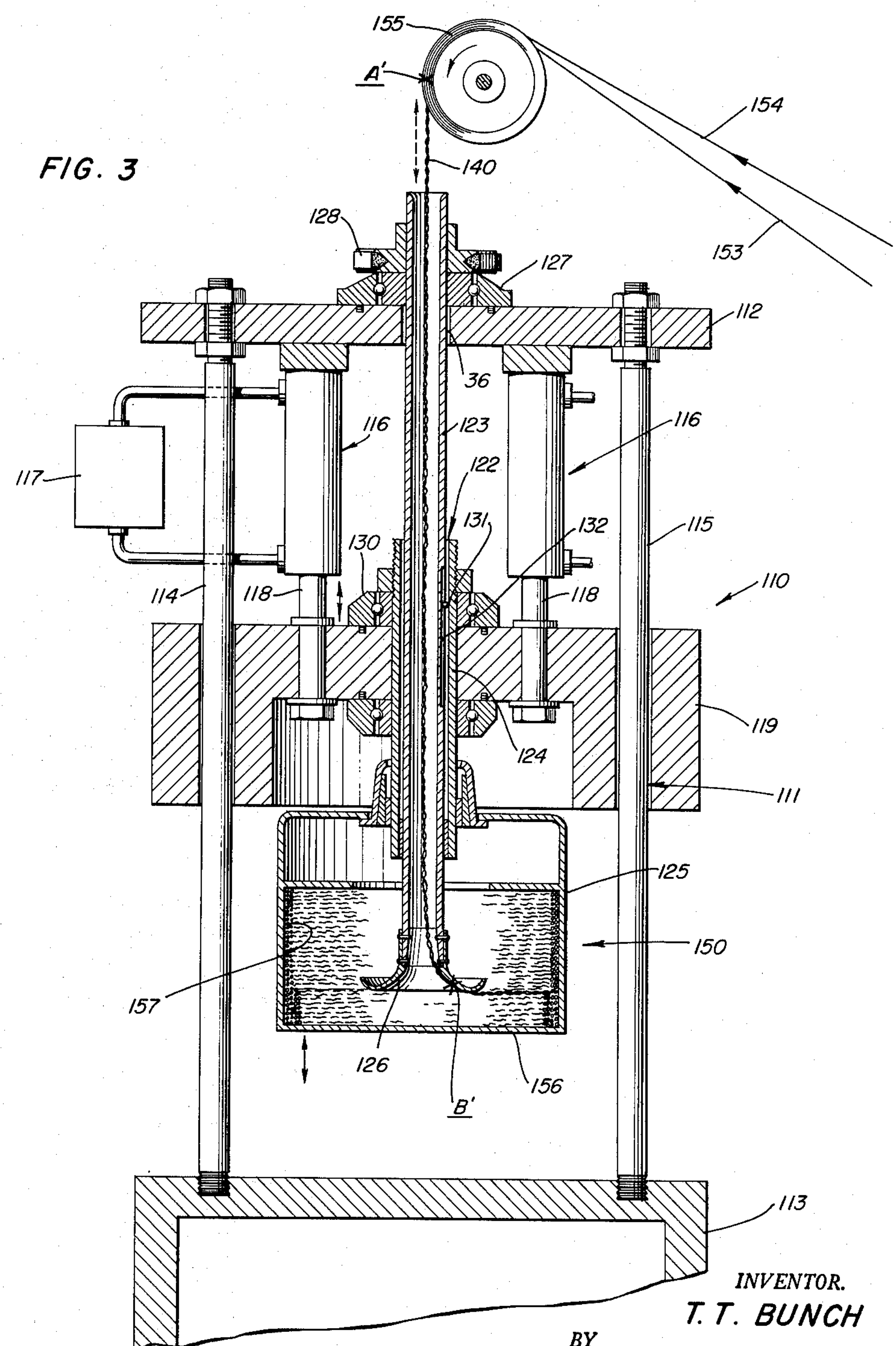
3,096,610

METHODS OF AND APPARATUS FOR MULTICYCLE TWISTING A WIRE-LIKE MEMBER

Filed Sept. 18, 1961

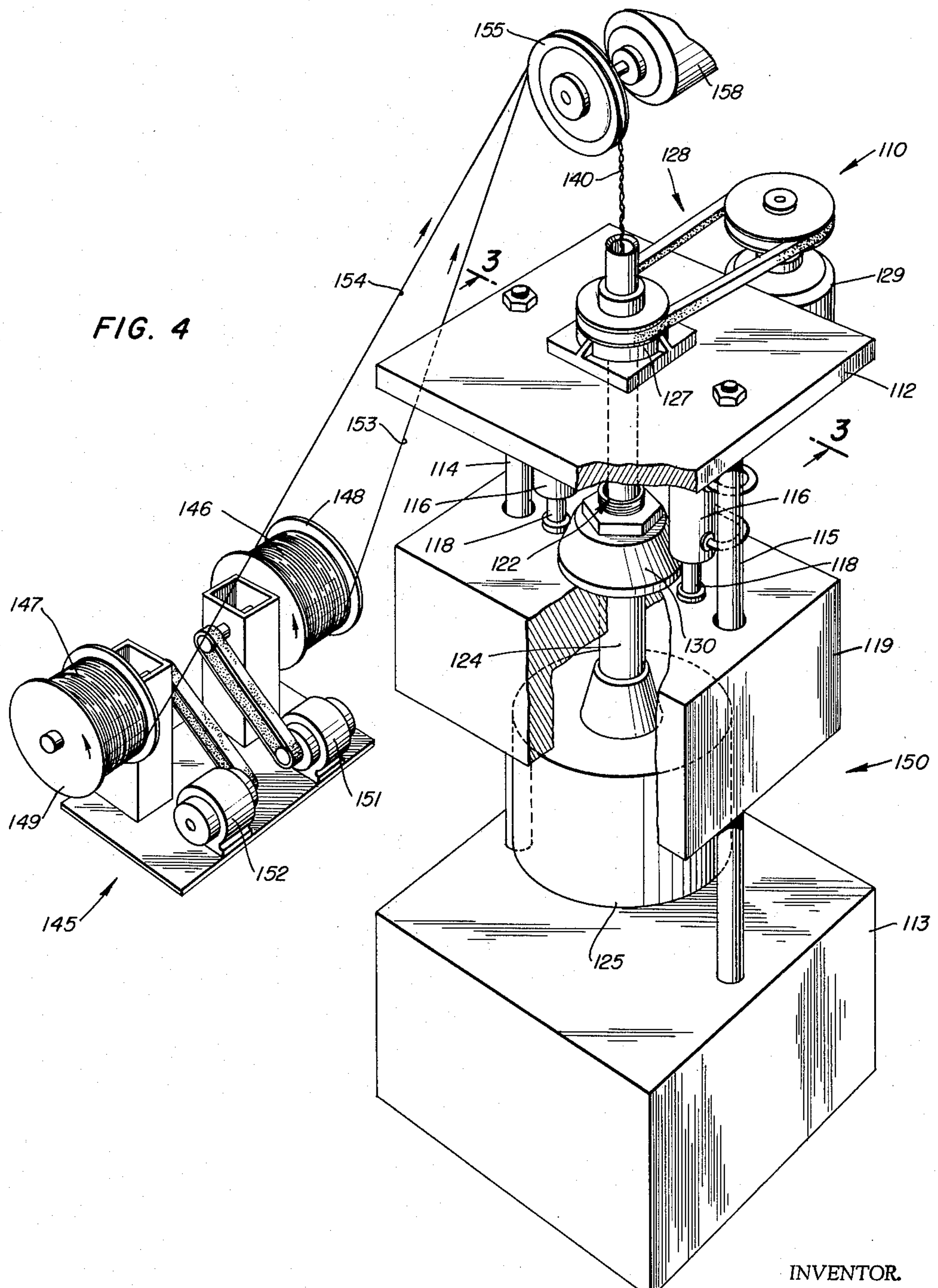
5 Sheets-Sheet 3

FIG. 3



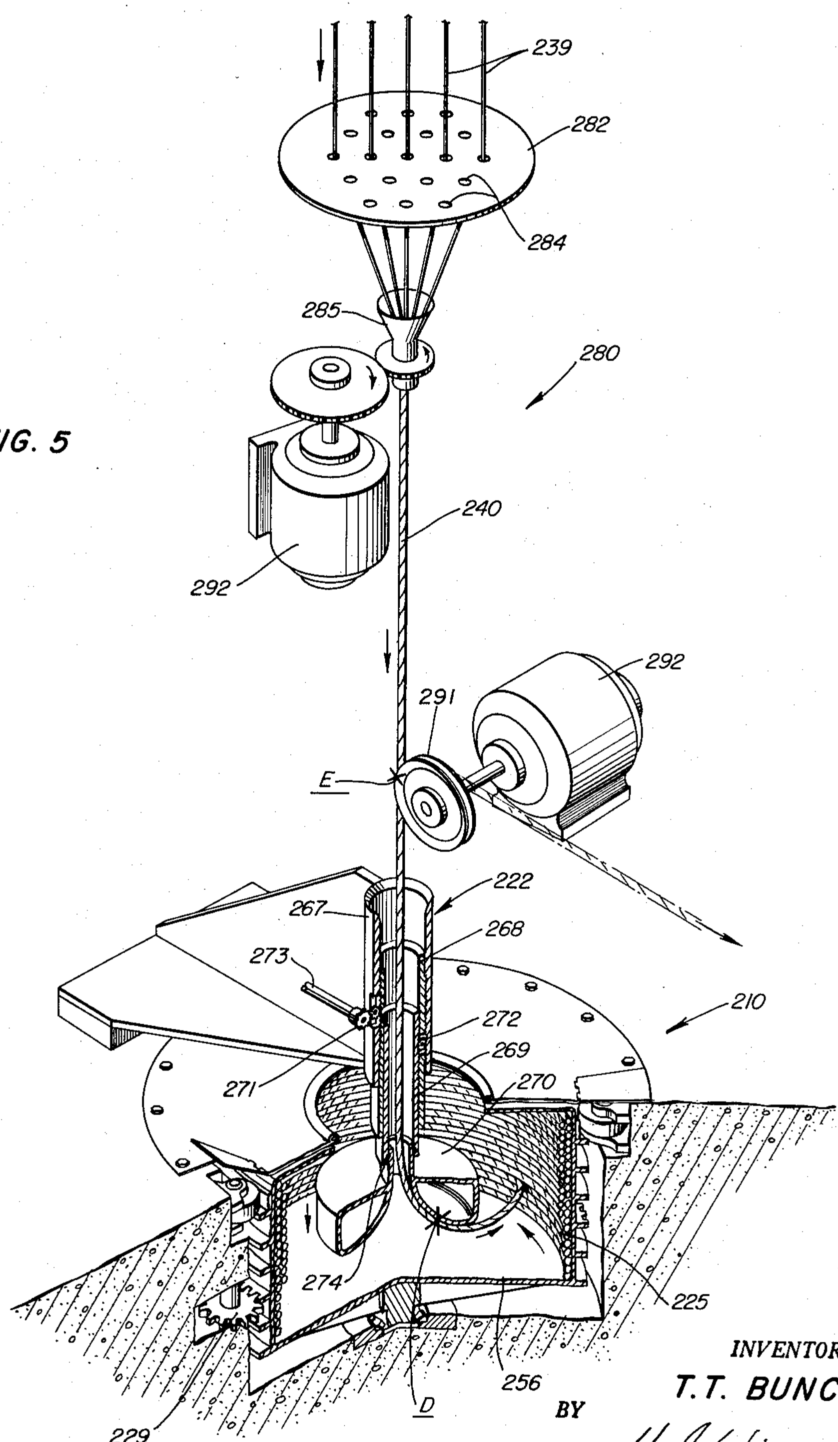

INVENTOR.
T. T. BUNCH
BY
H. J. Winegar
ATTORNEY

FIG. 4




INVENTOR.
T. T. BUNCH
BY
H. J. Winegar
ATTORNEY

FIG. 5




INVENTOR.
T. T. BUNCH
BY
H. J. Winegar
ATTORNEY

# United States Patent Office

3,096,610
Patented July 9, 1963




3,096,610

## METHODS OF AND APPARATUS FOR MULTI-CYCLE TWISTING A WIRE-LIKE MEMBER

**Tillman T. Bunch, Princeton, N.J., assignor to Western Electric Company, Incorporated, a corporation of New York**

**Filed Sept. 18, 1961, Ser. No. 138,854**
**14 Claims. (Cl. 57—34)**

This invention relates to methods of and apparatus for twisting a wire-like member and more particularly to methods of and apparatus for twisting together a plurality of electrical conductors.

One conventional line-type method of manufacturing twisted strands may comprise imparting to a plurality of separate wires continuous longitudinal movement while the wires are being twisted about each other. Such a method may be performed by means of a stationary die into which individual wires are fed from supply reels carried by rotatable supports. The resulting strand is in turn taken up on a reel so positioned as to have its axis transversely related to the feed. Priorly known apparatus for performing this manufacturing method have generally given satisfactory performance. However, their output rates have been limited because of the dynamic balance problems presented by their rotating components, such components including supply reels, reel support elements, rotary twisting frames, and the like. Accordingly, such twisting apparatus have been limited to relatively-low rotational speeds, i.e., generally not in excess of 1000 r.p.m., and, as a consequence thereof, their resulting production rates have been comparatively low.

Another priorly known method for manufacturing strands comprises axially moving a plurality of wires into a rotating die with the resulting strand being received in a hollow receiver rotated coaxially with the die and the wires. Though apparatus for performing this method are, in contrast to the above first-mentioned priorly known apparatus, capable of operating at relatively-high rotational speeds, they are not appropriate for utilization as nonterminous components of cable manufacturing systems of the line type. The hollow receivers of such apparatus are contemplated as the final depositories of the twisted strands, there being no provision for withdrawing and further twisting the strands from such receivers.

It is the general object of this invention to provide new and improved methods of and apparatus for twisting a wire-like member.

It is another object of this invention to provide new and improved methods of and apparatus for twisting together a plurality of electrical conductors.

Further, it is an object of this invention to provide methods of and apparatus for twisting wire-like members of such character as to be suitable for utilization in both cable manufacturing systems of the line-type as well as in autonomous twisting units.

A specific object of the present invention is to achieve a high-speed twisting and correspondingly increased production rates, while minimizing the risk of strand injury by having the apparatus comprise relatively few sheaves and guides over which the elongated members are required to travel.

A method illustrating certain features of the present invention may include the steps of inserting one end of a wire-like member axially through a guide means and into engagement with a receiver means axially aligned with the guide means, applying during a first cycle of operation a first force to the wire-like member at a point preceding the guide means for controlling the axial and rotational movement of the member, rotating the receiver means in one direction during the first cycle and a second cycle of operation, and applying during the second cycle



a second force to the wire-like member at a point preceding the guide means for withdrawing the member from the guide means. The engagement of the wire-like member and the receiver means in combination with the first force cause that portion of the member extending from the guide means to rotate during the first cycle of operation at an angular velocity less than that of the receiver means. The difference in angular velocity between the extending portion of the member and the receiver means enables the latter to wind the member into a coil on a winding surface of the receiver. As the member is so wound, it is twisted as it is drawn axially through the guide means toward the receiver means. The second force applied during the second cycle, on the other hand, causes that portion of the member extending from the guide means to rotate at an angular velocity greater than that of the receiver means. Accordingly, during the second cycle, the member is caused to unwind from the winding surface of the receiver. Consequently, the member is drawn axially through the guide means in the opposite direction toward the point at which point the second force is applied and, as it is so drawn, acquires a further twist cumulatively related to the initial twist.

Apparatus illustrating certain features of the invention may include guide means, receiver means concentrically positioned with respect to the guide means, and means for controlling during a first cycle of operation the axial speed and rotational movement of a wire-like member insertable into the guide means, the control means being designed to apply during a second cycle of operation a withdrawing force to the wire-like member. Further, there is provided first drive means for continuously rotating the receiver means in one direction during the first and second cycles. In addition, a second drive means may be provided to cause continuous relative reciprocation between the guide and receiver means, thus providing controlled helical distribution and withdrawal of the member as it is successively deposited in and removed from the receiver during the first and second cycles.

A complete understanding of the invention may be obtained from the following detailed description of the apparatus forming specific embodiments thereof, when read in conjunction with the appended drawing, in which:

FIG. 1 is an elevation view illustrating a partial cross section of an inertial twister representing a first embodiment of the invention;

FIG. 2 is a perspective view of a portion of the apparatus illustrated in FIG. 1 with parts thereof broken away for clarity;

FIG. 3 is an elevation view illustrating a cross section of an inertial twister representing a second embodiment of the invention;

FIG. 4 is a partially cutaway, perspective view of the apparatus shown in FIG. 3 in combination with wire-feeding, strand-withdrawing apparatus; and

FIG. 5 is a partially cutaway, perspective view illustrating a third embodiment of the invention.

### *First Embodiment*

Referring to the drawings, FIGS. 1 and 2 illustrate an inertial twister **10** comprising a support frame **11** having a support plate **12**, a base plate **13**, and a pair of support rods **14** and **15** positioned between the plates. Supported by and extending down from the support plate **12** is a pair of hydraulic cylinder assemblies **16—16** operated by a conventional hydraulic drive system **17**. Pistons **18—18** of the cylinder assemblies **16—16** are fixedly connected to a carriage **19**, the latter being in turn slidably positioned about the rods **14** and **15** for vertical reciprocating movement. In operation, the flow of hydraulic fluid to the cylinder assemblies **16—16** is periodically reversed to impart the desired reciprocating movement to the carriage 19.

Extending through and axially aligned with an aperture 20 in the support plate 12 and an aperture 21 in the carriage 19, is a rotor assembly 22. The rotor assembly 22 comprises a strand-receiving shaft 23, a rotatable, reel support shaft 24, a hollow, strand-receiving reel 25, and a strand-distributing guide 26. The strand-receiving shaft 23 extends through a bearing block 27 positioned above the aperture 20 upon the plate 12, the plate supporting the block for permitting rotational movement of the shaft. Positioned above the bearing block 27 and coupled to the shaft 23 is a pulley drive arrangement 28 associated with a motor drive 29 for rotating the shaft 23. Slidably positioned about a portion of the shaft 23 and extending through the aperture 21 of the carriage 19, is the shaft 24. A pair of bearing blocks 30—30, each positioned at opposite ends of the aperture 21 and fixedly connected to the carriage 19, support the shaft 24 in a manner permitting rotational movement thereof. To insure the coaxial alignment of the shaft 23 with respect to the shaft 24, and to maintain a separation between these shafts, there is provided a bushing 57 positioned within the reel 25 and about the shaft 23. A key 31 on the inner surface of the shaft 24 extends into an elongated slot 32 in the outer surface of the shaft 23. This key-slot arrangement 31—32 permits the carriage 19 to carry the shaft 24 along with it as it is reciprocably moved by the pistons 18—18, as determined by the hydraulic drive system 17, along support rods 14 and 15 toward and away from base plate 13. Further, the key-slot arrangement 31—32 enables the shaft 23 to rotate the shaft 24 along with it as the shaft is rotated by the pulley drive arrangement 28.

Concentrically positioned and fixedly connected to the reel support shaft 24 and the strand-receiving shaft 23 are, respectively, the strand-receiving reel 25 and the strand-distributing guide 26. The reel 25 and the guide 26 are configurated to permit the former to be axially reciprocated into and out of the latter as they are simultaneously rotated by the shaft 24 and the shaft 23.

Axially aligned with the rotor assembly 22 and supported by the base plate 13, is a stationary tank structure 33 which is designed to receive therein a portion of assembly 22, viz., that portion comprising the reel 25 and the guide 26. Located in the vicinity of the upper periphery of the tank structure 33 is a toroidal spout 34 having a plurality of outlet ports 35—35, each communicating with the inner surface of structure for enabling a liquid, for example, water, passed through ports 35 to flow down the inner surface of the structure. A drain 36 extending through the base of the tank structure 33 and the base plate 13 is provided for enabling the liquid passed into the structure by the spout 34 to be removed therefrom.

Though inertial twister 10 is of such versatility as to be suitable for utilization in either a line-type cable manufacturing system or an autonomous strand twister, it is hereinafter described, in conjunction with ancillary strand-handling mechanisms, with respect to line-type operation.

For line-type operation of the twister 10, a capstan 37 coupled to a capstan drive 38 and operable at a predetermined speed may be fixedly positioned above strand-receiving shaft 23 for feeding a plurality of wires 39—39 into the twister 10. The wires 39—39 are passed, in the form of a strand 40, from a strand restraining point A on the capstan 37 down through shaft 23, out of a bell-shaped portion 41 of strand-distributing guide 26, and up between the inner wall of the tank structure 33 and the guide 26 to the reel 25. Preferably, a ball-chain (not shown) having one of its ends permanently connected to reel 25 and being of sufficient length to be extended up through guide 26 and shaft 23, is provided for initially drawing wires 39—39 connected thereto down through twister 10.

To start the strand-loading cycle of twister 10 the wires 39—39 may be connected to the above-mentioned ball-chain and the capstan drive 38, the motor drive 29 and the hydraulic drive system 17, are activated. The activated capstan drive 38 rotates capstan 37 so as to draw the wires 39—39 around its periphery and feed the wires 39—39 into the shaft 23, while the activated motor drive 29 causes the pulley drive arrangement 28 to rotate the shaft 23 which in turn rotates the guide 26 connected directly thereto and, by means of the key-slot arrangement 31—32, the shaft 24 and the reel 25. Concurrently, the activated hydraulic drive system 17 causes the pistons 18—18 to successively extend and retract so as to impart reciprocating motion to the carriage 19 and the shaft 24 supported thereby. Accordingly, since the shaft 23 merely rotates while the shaft 24 simultaneously rotates and reciprocates, the reel 25 connected to the shaft 24 is axially moved into and out of the guide 26 as the reel and the guide are rotated in synchronism. As the reel 25 rotates and reciprocates with regard to the rotating guide 26, the wires 39—39 are drawn, for the reason discussed hereinafter, from the capstan 37 into the shaft 23 by the ball-chain.

Upon the rotation of the reel 25, that portion of the ball-chain extending between the reel and bell-shaped portion 41 of the guide 26 is rotated at such an angular velocity that an inertial force causes this portion of the chain to balloon out toward the inner cylindrical surface of the tank structure 33. Preferably, liquid flowing down the inside wall of the tank structure 33 from the ports 35—35 of the spout 34 engages the ballooning portion of the chain and, thus, applies a drag force thereto. This drag force is a material factor in causing the ballooning portion of the chain to rotate at an angular velocity somewhat less than that of the reel 25. This difference in angular velocity causes the chain to be drawn and wrapped about the rotating reel 25, thus applying a tension force to the chain and the wires 39—39 connected thereto.

Alternatively, in the instance wherein the strand to be twisted comprises a surface which is not readily susceptible to damage due to abrasions, the liquid flow in the tank structure, and the features directing such flow, may be dispensed with. In the absence of liquid flow, the ball-chain and the wires 39—39 successively engage the inner surface of the tank structure 33. Such engagement causes a frictional drag force to be applied to the engaged portion of the chain or wires. This frictional drag force serves the same function as does the above-mentioned liquid applied drag force.

As a result of the ballooning of the ball-chain portion between the reel 25 and the bell-shaped portion 41 of the rotating guide 26, the chain is thrust against the periphery of the bell-shaped portion 41. The guide 26 tends to carry the chain at the point of engagement and, accordingly, such point of engagement defines a strand-restraining point B. However, since the ballooning portion of the chain is, due to the liquid or frictional drag force, rotating at an angular velocity less than that of the reel 25, restraining point B is a rotating point on the surface of the bell-shaped portion 41 which moves in the same direction, but lags behind the rotating guide 26.

As the chain is drawn about the rotating reel 25, the wires 39—39 connected to one end thereof are drawn from the capstan 37 to form the strand 40. From the capstan 37 the strand 40 is drawn through shaft 23, over the restraining point B, on the bell-shaped portion 41, and from the point B, in a path similar to that previously followed by the chain, to the reel 25. Accordingly, the strand 40 is drawn about the rotating reel 25 for the reasons mentioned in regard to the chain.

Controlled distribution of the chain and strand 40 axially along the reel 25 is achieved by having the chain and the strand 40 successively guided by a curved peripheral lip portion **47** of the guide **26** onto reel **25** as the reel **25** axially reciprocates at a rate, as determined by the hydraulic drive systems **17—17**, into and out of the guide **26**.

The strand-loading cycle of the twister **10** may be terminated and its strand-withdrawing cycle commenced after the reel **25** has been loaded by simultaneously severing the strand **40** and reversing the direction of movement of the strand **40**, preferably by means of a cutting device **42** located in the vicinity of the capstan **37** and a strand-withdrawing mechanism **43** also located in the vicinity of the capstan **37**. The strand-withdrawing mechanism **43** may comprise a pair of endless belt capstans **44** and **45** each of which is coupled to a drive means **46** and one of which may be moved transversely in relation to the other across the path of the strand **40** so as to engage the strand near its severed end. The cutting device **42** and the strand-withdrawing mechanism **43** may be activated manually or by a conventional relay-controlled, drive arrangement responsive to the load condition of the reel **25**.

A significant characteristic of the twister **10** is that the transition from its strand-loading cycle to its strand-withdrawing cycle (initiated by reversing the direction of movement of the strand **40** by means of strand-withdrawing mechanism **43**) does not require a reversal or variation in the rotation of the rotor assembly **22**, or its component parts. More specifically, the reel **25** will continue to reciprocate in the same manner during the strand-withdrawing cycle, and the reel **25** and the guide **26** may synchronously rotate at substantially the same speed and direction during both of such cycles. Preferably, to withdraw the strand **40** and the chain in a manner which retraces the prior controlled distribution of the strand and chain about the reel **25**, the direction of reciprocation of the reel **25** is reversed by the hydraulic drive system **17** when the direction of movement of the strand **40** is reversed.

Upon the activation of strand-withdrawing mechanism **43** which initiates the strand-withdrawing cycle of twister **10**, the strand-withdrawing mechanism **43** applies a tensioning force to the strand **40** that is of sufficient magnitude to draw the strand up through the guide **26** and shaft **23**, at preferably a predetermined linear speed as determined by the capstan drive means **46**. Though, as in the strand-loading cycle, a drag force still is applied to the strand **40** by the liquid flowing down the inner surface of the tank structure **33**, the withdrawing force provided by the strand-withdrawing mechanism **43** is sufficient to overcome such drag force and to cause the ballooning portion of the strand **40** to rotate in the same direction as, but at a greater angular velocity than the reel **25** and the guide **26**. Consequently, because the ballooning portion of the strand **40** now leads the reel **25** and the guide **26**, the strand is unwound from the reel **25** and the restraining point B rotates in the same direction, but at an angular velocity greater than that of the reel **25**.

Now that the forces applied to and the relative velocities achieved by various portions of the strand **40** during the strand-loading and strand-withdrawing cycles have been discussed, the character of the twists provided during such cycles may be considered.

The strand **40** passes over the restraining points A and B during the strand-loading cycle, and restraining points B and C during the strand-withdrawing cycle. The restraining point A located on the surface of the capstan **37** is preferably fixed during the entire strand-loading cycle, while the restraining point B located on the periphery of the bell-shaped portion **41** rotates about the common axis of the reel **25** and the guide **26** and along such periphery. As discussed above, the point B rotates during the strand-loading cycle at an angular velocity less than that of the rotating guide **26**, but in the same direction, and during the strand-withdrawing cycle at an angular velocity greater than that of the guide **26**, but also



in the same direction. The restraining point C is located on the periphery of the caterpillar capstan **44** and is preferably fixed during the strand-withdrawing cycle.

Since the restraining point B rotates in the same direction during both cycles, but at different angular velocities, and the restraining point A and the restraining point B are preferably fixed, the twists provided in the strand **40** due to the relative angular velocities of the restraining point B with respect to the restraining points A and C, are cumulative. Further, since A is remotely positioned from B, and B is remotely positioned from C, the distribution of such twists along the strand **40** is affected by the mechanical characteristics of the strand **40** and the longitudinal velocity of the strand as the strand moves between such restraining points.

In addition to the above-mentioned twists, there is further provided an additional twist in the strand **40** as it is wound about the reel **25**. However, during the withdrawing cycle the strand **40** is unwound from the reel **25** and, consequently, this last-mentioned twist is removed.

An important characteristic of the inertial twister **10** is that it applies a substantially constant tension force to the strand **40** for given conditions of angular velocity of the rotor assembly **22**, unit weight of the strand **40**, and maximum radius which the strand **40** swings, viz., the inner radius of the tank structure **33**. Accordingly, the capstan **37** and the strand-withdrawing mechanism **43** may be operated successively to apply a constant-restraining force to the strand **40** at the restraining point A, and a constant-withdrawing force at the restraining point C so as to enable the strand **40** to be drawn into the twister **10** at a longitudinal velocity whose magnitude is equal to that of the velocity at which the strand is withdrawn. As a consequence of the constant tension force characteristic of the inertial twister **10**, the tension force applied by the twister to the strand **40** may readily be controlled by adjusting the angular velocity of the rotor assembly **22**. Also, since the tension forces applied to the strand **40** by the arrangement illustrated in FIGS. 1 and 2 during either the strand-loading cycle or the strand-withdrawing cycle may be maintained constant as the strand is drawn into or withdrawn from the twister **10** at a constant longitudinal velocity, a predetermined, relatively uniform twist lay in the strand may be acquired.

Further, under those conditions wherein the strand **40** is drawn into and out of the twister **10** at the same velocity, it is of particular interest to note that the angular velocity of the restraining point B during the strand-loading cycle may be expressed as

$$W_r - w \tag{1}$$

and during the strand-withdrawing cycle as

$$W_r + w \tag{2}$$

wherein:

$W_r$=The angular velocity of the rotor assembly **22** which is equal to the angular velocity of the strand-distributing guide **26** due to the direct coupling provided by key-slot arrangement **31—32**; and

$w$=The difference in angular velocity between the restraining point B and the rotor assembly **22**. From (1) and (2) it follows that for each passage of the strand **40** into and out of the twister **10**, the twist lay acquired by the strand **40** satisfies the following relationship:

$$L = \frac{6V}{W_r} \tag{3}$$

wherein:

$L$=The twist lay in units of inches per twist;

$V$=The longitudinal velocity of the strand **40** as it is drawn into and withdrawn from the twister **10** in units of feet per minute; and

$W_r$=The angular velocity of the rotor assembly **22** in units of revolutions per minute.

In view of the continuous rotation of the rotor assembly **22** during the strand-loading and strand-withdrawing cycles and the relatively compact, symmetrical configuration of the assembly, the twister **10** may be designed to operate at comparatively high rotational speeds, being limited in the main only by the amount of tension and twist that the strand **40** may withstand. Exemplary parameters acquired while twisting a pair of #19 gauge copper wires by means of a specific inertial twister of the type illustrated in FIGS. 1 and 2 are as follows:

$V$=2800 ft. per minute;
$W_r$=3000 revolutions per minute; and
$L$=5.6 inches per twist.

*Second Embodiment*

FIGS. 3 and 4 depict a second embodiment of the present invention comprising an inertial twister **110** of the internal-feed type, i.e., one in which the strand is passed directly through a guide to a receiver. The twister **110** is similar to the previously-described twister **10** in that it comprises a support frame **111**, a pair of hydraulic cylinder assemblies **116—116**, a hydraulic drive mechanism **117** coupled to the assemblies **116—116**, a carriage **119**, a rotor assembly **122**, a pulley drive arrangement **128**, and a motor drive **129** coupled to such arrangement, which cooperate with each other in the same general manner as do the corresponding components **11**, **16—16**, **17**, **19**, **22**, **28** and **29**, respectively, of the twister **10**. However, the rotor assembly **122** of the twister **110** differs from that of the twister **10** in that it includes a strand receiver **125** coaxially mounted about the lower portion of a receiver support shaft **124** and a bellmouthed guide **126** coaxially mounted on a portion of a strand-receiving shaft **123** within the receiver **125**. The twister **110** is also similar to the twister **10** in that it comprises a key-slot arrangement **131—132** of the type described previously in regard to the twister **10**, such arrangement permitting the strand-receiving shaft **123** to rotate the receiver support shaft **124** upon the former being rotated by the pulley drive arrangement **128**.

Though the inertial twister **110** is suitable, as is the twister **10**, for utilization in a line-type cable manufacturing system, it is depicted in FIG. 4 in combination with a wire-feeding, strand-withdrawing apparatus **145** to illustrate that it may also be utilized to form an autonomous strand-twisting unit **150**. In such a combination, the wire-feeding, strand-withdrawing apparatus **145** may comprise a plurality of wire supplies **146** and **147**, each having a reel **148**, or **149**, coupled to a drive mechanism **151**, or **152**. Wound about reels **148** and **149** are, respectively, wires **153** and **154**. The wire **153** is preferably of greater length than wire **154** and has its internally located end fixedly connected to the reel **148**. Further, the apparatus **145** may comprise a reversible constant-speed capstan **155** fixedly positioned above the strand-receiving shaft **123** of twister **110** and coupled to a speed control mechanism **158**.

The operation of strand-twisting unit **150**, more particularly twister **110**, is also of the multicycle type, i.e., it has a strand-loading cycle and a strand-withdrawing cycle. However, in contrast to the operation of the twister **10** described previously, the wires **153** and **154** of strand-twisting unit **150** need not be connected directly, or by means of a chain, to the strand receiver **125** prior to the commencement of the strand-loading cycle. Rather, the free ends of the wires **153** and **154** need only be inserted into the twister **110** subsequent to the activation of the rotor assembly **122** to initiate the strand-loading cycle of twister **110**. This characteristic and the general manner in which the twister **110** functions are briefly described hereinafter.

Operation of the strand-twisting unit **150** commences upon the motor drive **129** associated with pulley drive arrangement **128** and the hydraulic drive mechanism **117** associated with the cylinder pistons **116—116**, being activated. Upon such activations the strand-receiving shaft **123** and the bellmouthed guide **126** connected thereto, and the support shaft **124** and the strand receiver **125** connected thereto, are synchronously rotated at a relatively-high angular velocity. Simultaneously, the receiver support shaft **124** and the receiver **125** are reciprocated by the carriage **119**, the latter moving along support rods **114** and **115** in response to the movement of pistons **118—118** of the hydraulic cylinder assemblies **116**.

Upon the strand receiver **125** achieving a high angular velocity, the strand-loading cycle of the twister **110** is commenced by, for example, manually drawing the wires **153** and **154** from the reels **148** and **149**, over the capstan **155** to form a strand **140**, and from the capstan through the strand-receiving shaft **123** and the bellmouthed guide **126** into engagement with a base portion **156** of the strand receiver **125**. Due to the angular velocity of receiver **125**, the base portion **156** tends to carry the engaged portion of strand **140** along with it as it rotates and, consequently, imparts rotational movement thereto. This rotational movement of the strand **140** imparts an inertial force to the strand **140** which is of sufficient magnitude to direct that portion of the strand between the bellmouthed guide **126** and the strand receiver **125** toward and into engagement with an internal cylindrical surface **157** of the receiver. Also, as a result of such inertial force, the strand **140** is thrust against bellmouthed guide **126**, the frictional forces at the point of such engagement tending to cause the guide to carry the strand along with it as it rotates. Accordingly, such point of engagement defines a rotating, strand-restraining point which has been designated B′.

Upon the engagement of the strand **140** with the internal cylindrical surface **157** of the rotating receiver **125**, the receiver tends to carry along with it the engaged portion of the stand and, consequently, that portion of the strand immediately adjacent thereto. However, since the constant-speed capstan **155** provides a strand-restraining point A′, which is preferably fixed in relation to the restraining point B′ and, also, controls the speed at which the strand **140** may be drawn into the strand-receiving shaft **123**, a tension force is applied to the strand which partially offsets the effect of the rotating receiver **125** upon the strand. This tension force, the frictional force applied to the strand **140** by guide **126** at the restraining point B′, and the inherent mechanical resistance of the strand **140** against being twisted (i.e., its resilience), are the principal factors in causing that portion of the strand between restraining point B′ and surface **157** to have an angular velocity less than that of the receiver **125** during the strand-loading cycle. Accordingly, the strand-restraining point B′ is a rotating point which moves about the periphery of the bellmouthed guide **126** in the same rotational direction as does guide **126**, but at a lower angular velocity. As a consequence of this difference in angular velocity, the strand **140** comprising the wires **153** and **154** is drawn through the shaft **123** and guide **126** and wound internally in the receiver **125**, the reciprocating movement of the receiver providing axial distribution of the strand therein.

After the shorter wire, viz., the wire **154**, has been drawn from reel **149** and over the strand-restraining point A′ of the capstan **155**, the strand-loading cycle of the twister **110** is terminated by sustaining the rotation of the reel **148** in the same direction by means of the drive mechanism **151**. At the instant the wire **153** has been completely withdrawn from the reel **148**, the continued rotation of this reel causes that end of the wire **153**, fixedly connected to the reel, to be wound thereabout in a direction opposite to that in which it was originally wound. Consequently, such winding of wire **153** about the reel **148** applies a tension force to the strand 140 which causes it to be withdrawn from the twister 110, thus commencing the strand-withdrawing cycle of the twister 110.

During the strand-withdrawing cycle of the twister 110, as in the strand-loading cycle, the strand 140 experiences an inertial force tending to move it toward the internal cylindrical surface 157 and a frictional force at the restraining point B'. However, the withdrawing force provided by the reel 148 is sufficient to overcome the effects of such forces and to cause that portion of the strand 140 engaging the bellmouthed guide 126 to rotate about the periphery of the latter in the same direction as before, but at a greater angular velocity than the guide 126 and receiver 125. Accordingly, during the withdrawing cycle the restraining point B' rotates in the same direction as in the loading cycle, but at a greater angular velocity than the guide 126. Consequently, the strand 140 is unwound from within the receiver 125.

In the strand-twisting unit 150 the strand 140 passes over the remotely positioned restraining points A' and B' in opposite directions during the strand-loading cycle and during the strand-withdrawing cycle. Since the restraining point B' rotates at different velocities but in the same direction during both cycles, while the restraining point A' is preferably fixed, the twists acquired by the strand 140 due to the relative angular velocities of the restraining point B' with respect to the restraining point A' during the loading and withdrawing cycles, are cumulative. In addition to these cumulative twists, as in the previously-described twister 10, the strand 140 acquires a further twist as it is wound within the strand receiver 125. However, during the strand-withdrawing cycle the unwinding of the strand 140 from within the receiver 125 removes this last-mentioned twist.

A basic distinction between this second embodiment and the previously-described first embodiment is that the strand tension provided by the first embodiment remains constant for given conditions of rotative speed, unit weight of the strand, and the maximum radius which the strand loop swings, whereas for the second embodiment the radius which the strand swings diminishes as the material processed is deposited directly in the strand receiver 125, thus causing the tension applied to the strand 140 by the twister 110 to diminish approximately as the square of this radius. Accordingly, the first embodiment develops a constant strand pull-in tension, whereas the second embodiment develops a varying pull-in tension.

Notwithstanding the above-mentioned distinction, under those conditions wherein the drive mechanisms 151 and 152 are so arranged as to maintain the longitudinal velocity of the strand 140 constant as it is drawn into and withdrawn from the twister 110, the above-defined Equation (3) is equally applicable to the second embodiment.

As in the first embodiment, the unaltered, continuous rotation of the rotor assembly 122 and the relatively-compact, symmetrical configuration of the assembly, enable the twister 110 to operate at exceptionally high rotational speeds. Exemplary parameters realized while separately twisting pairs of #19 and #26 gauge copper wires by means of an inertial twister of the type illustrated in FIGS. 3 and 4 are as follows:

$V$=2800 feet per minute;
$W_r$=5000 revolutions per minute; and
$L$=3.36 inches per twist.

*Third Embodiment*

Illustrated in FIG. 5 is an inertial twister 210 especially suitable for twisting a plurality of twisted strands 239—239 to form a cable 240. Twister 210 comprises a cylindrical cable receiver 225, preferably located below floor level because of space considerations, mounted in such a manner as to permit the rotation thereof upon the activation of a gear drive mechanism 229. Axially aligned with and extending partially into the receiver 225 is a telescoping assembly 222 comprising a plurality of concentrically related, tubular members 267, 268 and 269, and a bell-mouthed guide 270. Between the tubular members 267 and 268, and the tubular members 268 and 269, there are provided, respectively, gear mechanisms 271 and 272 for imparting relative axial movement to the respective tubular members upon the activation of a drive shaft means 273 coupled to the gear mechanism 271. Accordingly, such activation varies the length of the telescoping assembly 222 so as to reciprocate the bellmouthed guide 270. The bellmouthed guide 270 is axially aligned with and supported by the tubular member 269 by means of, for example, a ball bearing coupling 274 so as to permit free rotational movement of the bellmouthed guide.

The operation of twister 210 is analogous to that of the previously-described operation of the twister 110, except that a restraining point D does not rotate at different velocities about the periphery of the bellmouthed guide 270. Rather, in this embodiment, the restraining point D is a relatively fixed point on the periphery of the freely rotating bellmouthed guide 270, the guide itself being carried at the point of engagement with the cable 240 by the latter at different angular velocities during the cable-loading and the cable-withdrawing cycles.

As indicated in FIG. 5, the inertial twister 210 may be arranged to be operated in conjunction with a strand-feeding mechanism 280 and a cable-withdrawing capstan 291 coupled to a motor drive 292. The strand-feeding mechanism 280 preferably comprises a fixed guide plate 282 having a plurality of strand-guiding apertures 284—284, and a rotating die 285 axially aligned with telescoping assembly 222 of the twister 210 and coupled to a drive mechanism 292.

During the loading cycle of such an arrangement, the strands 239 are passed through the apertures 284 and through the rotating die 285 to form the cable 240. From the rotating die 285 the cable 240 is passed axially through the telescoping assembly 222 and into engagement with a base portion 256 of the rotating cable receiver 225. Rotational movement is imparted to the portion of the cable 240 in the vicinity of such engagement which gives rise to an inertial force that directs that portion of the cable 240 experiencing such force toward and into engagement with the rotating receiver 225. The cylindrical cable receiver 225 tends to carry that portion of the cable 240 with which it engages along with it as it rotates. However, since the fixed guide plate 282 limits the rotation of the strands 239—239, and rotating die 285 controls the axial and rotational movement of the cable 240, the angular velocity of that portion of the cable 240 between the bellmouthed guide 270 and receiver 225 is less than that of the receiver during the loading cycle. As a consequence of such cable velocity being less than the receiver velocity, the cable 240 is drawn into and internally wound in the cylindrical cable receiver 225, the reciprocating movement of the bell-mouthed guide 270 controlling the axial distribution of the cable 240 within the receiver. x

The loading cycle of the twister 210 may be terminated and the withdrawing cycle commenced by severing the cable 240 and then placing the former in engagement with the withdrawing capstan 291. Upon such engagement and the activation of a motor drive 292 associated with the capstan 291, the capstan applies a tension force to the cable 240 which causes the bellmouthed guide 270 and that portion of the cable 240 between the guide 270 and the cable receiver 225 to rotate at an angular velocity greater than that of the receiver. Consequently, because of such cable velocity being greater than the receiver velocity, the cable 240 is unwound from within the receiver 225 as the cable is withdrawn by the capstan 291 from the twister 210 through the telescoping assembly 222.

In the arrangement depicted by FIG. 5, the cable 240 is twisted during the loading and withdrawing cycles as the strands 239—239 pass from the fixed guide plate 282 to the rotating die 285, as the cable 240 passes through the rotating die 285 to the restraining point D on the periphery of the bellmouthed guide 270, and as the cable 240 passes from the restraining point D to a fixed restraining point E on the periphery of the withdrawing capstan 291. The twists acquired are cumulative since the rotating die 285 and the bellmouthed guide 270, the latter being carried by the cable 240 at a different velocity during each of the cycles, rotate in the same direction during both cycles, and since the guide plate 282 and the capstan 291 are, respectively, fixed in relation to the rotating die 285 and the restraining point D. As in the previously-described twister 110, a further twist is also acquired by the cable 240 as it is wound within the cylindrical cable receiver 225 during the loading cycle. However, this last-mentioned twist is removed as the cable 240 is unwound from the receiver 225 during the cable-withdrawing cycle.

It is to be understood that the terms "strand" and "wire-like member" as used herein and in the appended claims are intended to include solid wires, stranded wires, tubing, tapes, ribbons and all types of members of relatively small cross section and of indefinite length.

It will be appreciated that the above-described methods of and apparatus for twisting wire-like members are merely illustrative of the principles of the invention. Numerous other methods and arrangements may be devised by one skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A multicycle apparatus for twisting a wire-like member, which comprises hollow guide means, said guide means including a structure having a hollow cylindrical portion and a hollow bell-shaped portion, said cylindrical portion having a diameter larger than that of a reel so as to permit the reel to be moved axially into and out of the guide means, a rotatable reel receiver having a winding surface positioned concentrically with respect to said guide means, means operable to control the movement of the wire-like member in a longitudinal direction while restraining axial rotation of the engaged portions relative thereto, means for operating said control means to limit the rate of advance of the wire-like member during a first cycle of operation in the direction of its length through the hollow guide means to the winding surface of the receiver, and drive means for rotating the receiver about a common axis of the guide means and the receiver during the first cycle and a second cycle of operation at a rotational speed such that an inertial force is imparted to a portion of the wire-like member extending from the guide means to the winding surface, such inertial force tending to advance the wire-like member through the guide means to the winding surface, said extending portion of the wire-like member rotating during said first cycle about the common axis at a speed less than the rotational speed of the receiver and causing a twisting of the member between the control means and the guide means, said means for operating said control means causing the latter to move the twisted wire-like member in the reverse longitudinal direction during the second cycle of operation while the receiver continues to rotate in the same direction, such reversal of longitudinal direction of the wire-like member causing that portion of the wire-like member extending from the guide means to the winding surface to rotate in its original direction about the common axis at a speed greater than that of the receiver, thus causing it to be unwound from the winding surface and further twisted as it moves between the control means and the guide means.

2. A multicycle apparatus for twisting a wire-like member, which comprises hollow guide means, a hollow rotatable receiver having a winding surface positioned concentrically with respect to said guide means, means operable to control the movement of the wire-like member in a longitudinal direction while simultaneously engaging successive portions relative thereto, means for operating said control means to limit the rate of advance of the wire-like member during a first cycle of operation in the direction of its length through the hollow guide means to the winding surface of the receiver, drive means for rotating the receiver about a common axis of the guide means and the receiver during the first cycle and a second cycle of operation at a rotational speed such that an inertial force is imparted to a portion of the wire-like member extending from the guide means to the winding surface, such inertial force tending to advance the wire-like member through the guide means to the winding surface, said extending portion of the wire-like member rotating during said first cycle about the common axis at a speed less than the rotational speed of the receiver and causing a twisting of the wire-like member between the control means and the guide means, said means for operating said control means causing the latter to move the twisted wire-like member in the reverse longitudinal direction during the second cycle of operation while the receiver continues to rotate in the same direction, such reversal of longitudinal direction of the wire-like member causing that portion of the wire-like member extending from the guide means to the winding surface to rotate in its original direction about the common axis at a speed greater than that of the receiver, thus causing it to be unwound from the winding surface and further twisted as it moves between the control means and the guide means, second drive means arranged to provide continuous relative axial movement between said hollow guide means and said hollow rotatable receiver during said first and second cycles, said guide means insuring controlled uniform helical distribution and withdrawal of said wire-like member as it is passed to the winding surface of said receiver and as it is withdrawn therefrom, and a tank structure means positioned coaxially about said guide means and aligned axially with said receiver for applying a drag force to the rotating portion of the wire-like member extending from the guide means which tends to decrease the angular velocity of said portion below that of said receiver during at least the first cycle.

3. Multicycle twisting apparatus in accordance with claim 2, wherein said tank structure means comprises a liquid directing means for providing liquid flow along an inside surface of said structure means, which applies said drag force to said wire-like member portion, and means for removing the liquid from within said structure means.

4. Multicycle twisting apparatus in accordance with claim 2, wherein said control means comprises a capstan means fixedly positioned above said receiver for directing said wire-like member axially into said guide means, and a plurality of wire supplies, each including a reel having a wire wound thereabout and an associated drive mechanism, each of the wires wound on said supplies being passed over said capstan to form said wire-like member, one of said reels being fixedly connected to one end of the wire wound thereon so that upon said last-mentioned wire being completely unwound from said one reel, the continued rotation of the said one reel causes said last-mentioned wire to wind about said one reel in the opposite direction by its associated drive mechanism, thus drawing said wire-like member from said guide means and about said one reel during said second cycle.

5. Multicycle twisting apparatus in accordance with claim 2, wherein said control means comprises a strand-feeding mechanism positioned above and axially aligned with said receiver, said strand-feeding mechanism including a rotating die and a fixed guide plate having a plurality of apertures for passing therethrough during said first cycle a plurality of strands for forming said wire-like member, and a capstan means positioned between said guide means and said feeding mechanism for withdrawing said wire-like member through said guide means during said second cycle.

6. Multicycle twisting apparatus in accordance with claim 2, wherein said guide means comprises a support member and a telescoping assembly fixedly connected to said support member and axially aligned with and partially extending into said receiver, said telescoping assembly including a plurality of concentric tubular members and a rotatable guide, said rotatable guide being coupled to one of said tubular members in a manner enabling the former to rotate freely with respect to the latter.

7. Multicycle apparatus for twisting a strand of wires, comprising a frame structure; a rotor assembly supported by said frame structure in a manner permitting rotational movement of the former, said rotor assembly comprising a hollow guide means, and a hollow receiver means coaxially related to said guide means; means for controlling during a first cycle of operation the speed and rotational movement of a strand insertable into said guide means, said controlling means applying during a second cycle of operation a withdrawing force to said strand; first drive means coupled to said rotor assembly for rotating said guide means and said receiver means in the same direction during said first and second cycles; and second drive means coupled to said rotor assembly for providing axial movement between said guide means and receiver means; whereby, upon the insertion of one end of the strand axially through said guide means, a portion of the strand extending from said guide means is rotated during said first cycle at an angular velocity less than that of said receiver means, such difference in angular velocity enabling said receiver means to wind the strand within said apparatus, thus drawing the strand from said controlling means through said guide means in a first direction so as to provide a first twist in the strand; and during said second cycle said controlling means causing the portion of the strand extending from said guide means to rotate at an angular velocity greater than that of said receiver means so as to unwind said strand and to draw it from said guide means to said controlling means in a direction opposite to that of said first drawing direction so as to provide a second twist in the strand cumulatively related to said first twist.

8. Multicycle twisting apparatus in accordance with claim 11, wherein said receiver means comprises a first tubular member coupled to said second drive means for axial movement thereof and a hollow reel concentrically positioned about said first tubular member, and said guide means comprises a second tubular member supported by said frame structure in a manner enabling rotational movement thereof, and a guide structure including a first hollow cylindrical portion and a second hollow bell-shaped portion, said cylindrical portion being of such configuration as to enable said reel to be axially moved into and out of said guide structure.

9. Multicycle apparatus for twisting a strand comprising a frame structure; a rotor assembly supported by said frame structure in a manner permitting rotational movement thereof, said rotor assembly comprising first and second hollow concentric members coupled to each other in a manner permitting relative axial movement therebetween, and receiver means and guide means each axially aligned with and supported from one of said concentric members; means for controlling during a first cycle of operation the speed and rotational movement of a strand insertable into said rotor assembly; means for applying during a second cycle of operation a withdrawing force to said strand; first drive means coupled to said rotor assembly for rotating said receiver and guide means in one direction during said first and second cycles; and second drive means coupled to one of said concentric members for providing relative axial movement between said guide means and receiver means during said first and second cycles.

10. Apparatus for twisting a strand of wires, comprising a frame structure; a carriage means slidably mounted within said frame structure; telescoping drive means supported by said frame structure and fixedly connected to said carriage means for driving the latter toward and away from a base portion of said frame structure; a rotor assembly extending through said carriage means and supported by said frame structure in a manner permitting rotational movement thereof, said rotor assembly comprising first and second concentrically related members having a coupling means therebetween, said coupling means enabling said second member to move axially with respect to said first member; receiver means supported by one of said concentric members; guide means axially aligned with said receiver means and supported by the other of said concentric members; means for controlling during a first cycle of operation the speed and rotational movement of a strand insertable into said rotor assembly; means for applying during a subsequent second cycle of operation a withdrawing force to the strand; first drive means coupled to said rotor assembly for rotating said guide means and receiver means in one direction during said first and second cycles, and second drive means coupled to said rotor assembly for providing axial movement between said receiver means and guide means.

11. Multicycle apparatus for twisting a plurality of strands to form a cable, comprising a support member; a telescoping assembly fixedly connected to said support member, said telescoping assembly including a plurality of concentric tubular members and a rotatable guide; a cylindrical receiver having one open end axially aligned with and positioned about a portion of said telescoping assembly; means for controlling during a first cycle of operation the speed and rotational movement of a cable insertable into said telescoping assembly, and for applying during a second cycle of operation a withdrawing force to said cable, said control means comprising a fixed plate having a plurality of apertures, a rotating die means and a withdrawing mechanism; first drive means coupled to said cylindrical receiver for rotating the latter in one direction during said first and second cycles; and second drive means coupled to said tubular members to provide axial movement therebetween.

12. Multicycle twisting apparatus in accordance with claim 11, wherein said rotatable guide comprises a bell-mouthed device coupled to and supported by one of said tubular members in a manner permitting unrestricted rotation of said bellmouthed device.

13. Multicycle apparatus for twisting a wirelike member comprising a hollow guide means; a hollow receiver means axially aligned with and insertable into said guide means; a tank structure concentrically positioned about said guide means; means for connecting the wire-like member axially through said guide means to said receiver means; means for applying during a first cycle of operation a first force to said wire-like member at a point preceding said guide means for controlling the axial and rotational movement of said wire-like member, said last-mentioned means applying during a second cycle of operation a second force to said wire-like member at a point preceding said guide means for withdrawing said wire-like member; means for rotating said receiver means and guide means in one direction during said first and second cycles; and means for providing axial movement between said guide means and receiver means, said connection of said wire-like member to said receiver means in combination with first force causing a portion of said wire-like member extendng from said guide means to rotate during said first cycle at an angular velocity less than that of said receiver means so as to wind said wire-like member within said apparatus and to draw said wire-like member in a first direction during said first cycle, said second force causing the portion of said wire-like member extending from said guide means to rotate at an angular velocity greater than that of said receiver means so as to unwind said wire-like member and to draw it through said guide

means in a direction opposite to said first drawing direction during said second cycle.

14. Method of twisting a strand of wires comprising the steps of extending one end of a strand axially through a guide means and into engagement with a receiver means axially aligned with said guide means; rotating said receiver means in one direction during a first and second cycle of operation at such velocity as to impart an inertial force to the strand tending to advance it through the guide means; moving one of said receiver and guide means so as to provide axial movement therebetween during said first and second cycles; applying during said first cycle a first force to said strand at a point preceding said guide means for controlling the axial and rotational movement of said strand; applying a drag force during at least said first cycle to a portion of said strand extending from said guide means and into engagement with said receiver means, said portion of said strand extending from said guide means rotating during said first cycle at an angular ve-



locity less than that of said receiver means and thus enabling said receiver means to wind said strand about its periphery and to draw said member in a first direction; and applying during said second cycle a second force to said strand at a point preceding said guide means, said portion of said strand extending from said guide means rotating at an angular velocity greater than that of said receiver means during said second cycle so as to unwind said strand from said receiver means and to draw it through said guide means in a direction opposite to said first drawing direction.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,941,348 | Biche | June 21, 1960 |
| 2,998,694 | Haugwitz | Sept. 5, 1961 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 1,185,950 | France | Feb. 16, 1959 |