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Vogelsberg et al.

[11] **3,823,536**

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[54] **METHOD OF TWISTING ELEMENTS TO FORM AN ELECTRICAL CABLE HAVING A TWIST WHOSE DIRECTION ALTERNATES FROM SECTION TO SECTION**

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[51] **Int. Cl.** **H01b 13/04,** D07b 3/02
[58] **Field of Search** ..... 57/34 AT, 156, 59, 66

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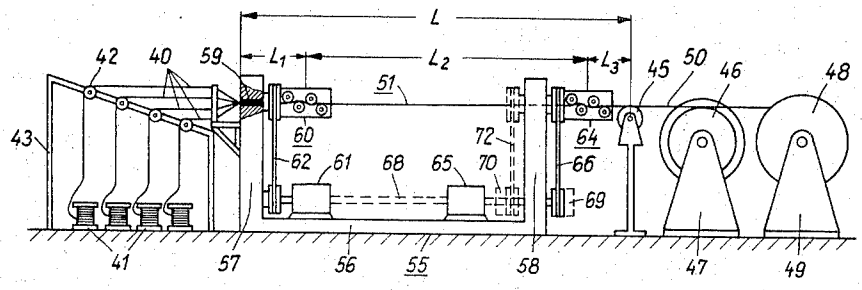
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Primary Examiner—John Petrakes
Attorney, Agent, or Firm—Kenyon & Kenyon Reilly Carr & Chapin

[57] **ABSTRACT**

A method of twisting cable elements to form a cable unit which has a twist which alternates from section to section in which the cable being twisted is held in a stretched manner between two twisting heads one arranged immediately behind a first twisting point and the second one immediately in front of a second twisting point, the twisting heads being rotated at a speed which can be varied with respect to each other to obtain variations in twist direction.

10 Claims, 4 Drawing Figures



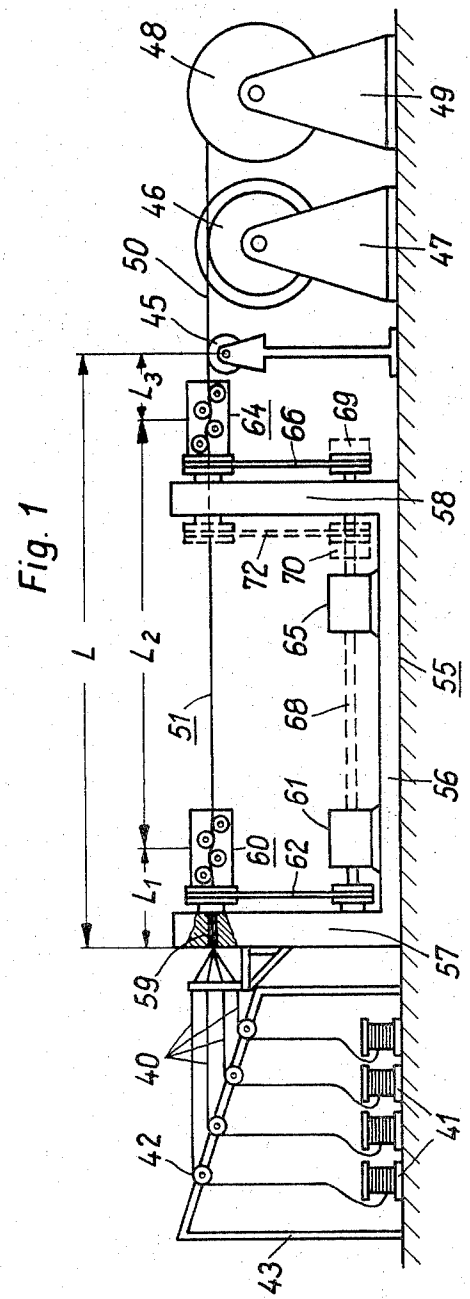

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Fig. 1

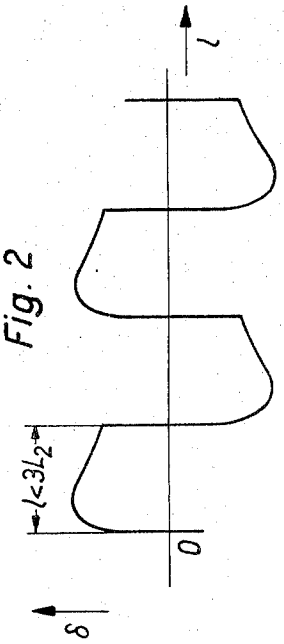

l
$l<3L_2$
0
δ

Fig. 2

Fig. 3

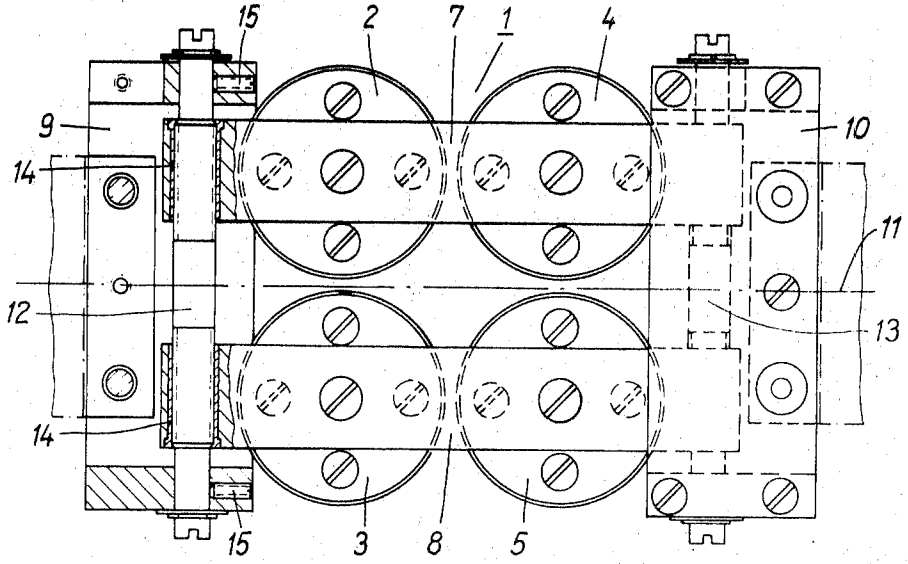
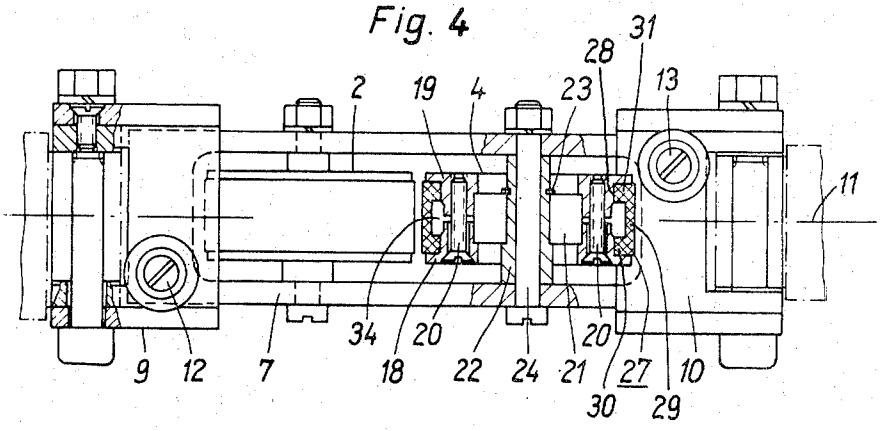

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1
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12
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14
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Fig. 4


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METHOD OF TWISTING ELEMENTS TO FORM AN ELECTRICAL CABLE HAVING A TWIST WHOSE DIRECTION ALTERNATES FROM SECTION TO SECTION

BACKGROUND OF THE INVENTION

Various methods and devices have recently been developed for twisting electrical cbles such as communication cables so that the cable elements forming a finished cable unit are alternately twisted with a left-hand twist and a right-hand twist. Left-hand twists are generally referred to as S-twists and right-hand twists as Z-twists. In general, the type of twisting wherein S and Z-twists alternate are called SZ-twists. These devices which have recently been developed have the advantage that the elements to be twisted can be unwound from stationary supply frames and that further processing of the SZ twisted units can follow in a single operation.

Each of the devices used for performing such twisting generally uses revolving twisting devices and often include an accumulator wherein a twist of one direction or the other may be stored. In some, accumulators of a fixed content are used and revolve with a speed or direction of rotation which changes from section to section with the velocity of the cable through the unit remaining constant. Such a device is shown in U.S. Pat. No. 3,169,360. It is also possible to have accumulators of fixed content which revolve at a constant speed and direction of rotation and in which the velocity of the cable elements through the accumulator is changed from section to section. Such a system is shown in French Pat. No. 1,468,382. Some twisting devices of this nature also include an accumulator which has a content which may be increased or decreased. In such devices the content is alternatingly increased and decreased while the rotary motion of the accumulator remains constant. This is shown in German Pat. No. 1,665,831 and in MTZ 1970, No. 9, pp. 472–80. Another type of twisting device uses a stationary accumulator around which flying, twisting yokes rotate. Such a device is shown in German Pat. No. 1,665,538.

Generally, the accumulators previously used for S-Z-twisting comprises two groups of rollers arranged on parallel axes. The stranding elements to be used in making the cable unit are led alternatingly around one roll of the one group of rollers and subsequently around a roll of the other group of rollers. Additionally, pulley-like designs may be used in an accumulator as shown in German Offenlegungsschrift No. 1,817,803. Further, accumulators having two twisting heads which are arranged at a fixed distance from each other and are rigidly coupled to each other in regard to their rotary motions have been used, for example, see Wire & Wire Products, 1/67, pp. 90–7 and 159–60. A practical embodiment of this which uses a caterpillar chain is shown in German Offenlegungsschrift No. 1,115,730.

Various methods may be used with the above described devices. In one twisting method using the above described accumulators, the elements are combined into a strand which is twisted between two fixed points in a stretched, torsionable condition. Twisting is done in sections having a multiple number of twist lays using a twisting device or twisting head which frictionally grips the strand perpendicular to its axis. In order to obtain high twisting efficiency using this method, provision is made so that the distance between the second fixed point, called the take-up point, and the point of attack of the twisting device is smaller than the distance between the point of attack of the twisting device and the first point called the entrance point. It is also provided that a longitudinal section of the stranded unit having the same twist direction is at least equal to the distance between the take-up point and the point of attack of the twisting device, and at most equal to three times the distance between the point of attack of the twisting device and the entrance point. This method is described in German Pat. No. 1,765,452. The twisting device or head used in this method will be, for example, comprised of two oppositely disposed rolls whose running surfaces press against the strand. In order to obtain a more homogenous twist between the point of entrance and the point of attack of the twisting device, additional twisting devices are arranged between the point of entrance and the twisting device. These additional twisting devices will have a speed of rotation which is adjusted to be equal to the speed of rotation of the twisting device providing the primary twisting of the cable.

In implementing this method above described a problem arises, particularly when manufacturing spiral guad due to the difficulty in obtaining homogenous twisting with simple means and preventing the scrambling of wires at the exit from the twisting device.

Very often SZ twisting is done in a two stage twisting process, i.e., the elements such as wires are first twisted into SZ twisted units, for example, pairs, triads or quads and then several of the SZ twisted units are then twisted to form a twisted group or finished cable. When such operation is carried out, two twisting operations are generally done in parallel. In order to ensure good mutual coupling of the SZ twisted units within the final cable, an attempt is generally made to have the lay of one set of twisted units different from that of the other units. In addition, it is helpful to arrange the reversal points of twist direction so that they do not coincide from one unit to the other.

In order to reduce electrical coupling it is also advisable to make the distance between the reversal points of twist direction as large as possible. In SZ twisting methods which use an accumulator, this means that the content of the accumulator should be as large as possible. This, of course, requires physically large and also very heavy accumulators. This requirement is in opposition to the requirement of having a production speed which is as high as possible. Such can be obtained only with accumulators of small size and therefore short spacing between the reversal points of twist direction. This problem is discussed in U.S. Application, Ser. No. 341,773, filed Mar. 15, 1973 and assigned to the same assignee as the present invention.

In SZ twisting methods in which the accumulators have groups of rollers and the stranding elements are sometimes led through the roller unsupported, parallel or nearly parallel to the axis of the rotation of the accumulator and at a distance from the axis which is up to about one-half the diameter of the rollers. During the twisting, as the accumulator rotates, forces are exerted on the stranding elements, which forces are proportional to the distance of the elements from the axis of rotation. This leads to high stressing of the stranding elements. Thus, the speed of rotation of the accumulator and thus the maximum speed at which the finished

unit can be drawn off is often limited by the allowable tensile stresses which may be placed on the individual elements.

SUMMARY OF THE INVENTION

The present invention provides a method for the manufacture of SZ twisted units, particularly such units which are to be subsequently twisted to form a twisted group or finished cable, in such a manner that good decoupling of the units is obtained while at the same time a high production speed is maintained. To accomplish this, the stranding elements which are to be twisted into a cable unit are provided to a first stationary twisting point and a second stationary twisting point. The strand is torsioned or twisted immediately behind the first twisting point and immediately ahead of the second twisting point. To obtain different directions of twist the twisting of the strand is changed at intervals. The twisting which occurs behind the first twisting point is always in the same direction. The twisting which occurs immediately ahead of the twisting point is accomplished by twisting device which maintains the same direction of rotation as that of the first twisting device. Variation of twist direction is controlled by varying the relative speed of rotation and thereby the twisting which occurs between the two twisting devices. The strand being twisted is thus divided into three sections, the first section is that between the first twisting point and the first twisting device. The second is the distance between the first twisting device and the second twisting device and the third that between the second twisting device and the second twisting point. The amount of twisting imparted by the two twisting devices is controlled such that the ratio and/or difference between the twist acting on the strand immediately behind the first twisting point and the twisting action on the strand immediately ahead of the second twisting point is periodically changed at intervals which correspond to the time required for length element of the strand to move between the first and second twisting points.

In essence then the new twisting method requires that the stranding elements be brought together to form a strand which is in a stretched condition between two twisting points. Additionally, the torsion or twist applied at the twisting points is always applied with the same direction but such that the torsion acting on the strand differs from in magnitude from section to section. Because of the stretched disposition, no centrifugal forces are exerted on the strand elements when they travel through the accumulator between the twisting points. In addition, mechanical stresses when running over the deflection rolls are avoided. This allows the production speed, i.e., both the speed of rotation of the twisting devices used and the drawing off speed, to be substantially increased.

In addition, the manner in which the torsioning or twisting is applied assures that the stranding elements are always sufficiently twisted as they run through the twisting devices and that the reversal points of twist direction are developed only after passing the second twisting points thereby preventing scrambling of the wires.

The required decoupling of the twisted cable made from the SZ twisted units is obtained by providing a twisted unit which has a length of twist in each direction which is not constant over the length but varies continuously within predetermined limits. Thus, even if the same mean twist length is provided for each of the units which are being twisted into the finished cable, this variation about the mean results in a supression of coupling of adjacent quads. The transients which can develop in such situations can be taken into account when twisting these cables in the manner described in German Pat. No. 1,765,452. In addition, the modulation of the length of twist of the SZ twisted units which are being formed makes it possible to make the distance between the reversal points of the twist direction relatively short, for example, shorter than 5 meters so that the distance between the first and second twisting head does not become excessively large.

In implementing this new SZ twisting method, it is advisable that the torsion acting on the strands at the first twisting point and at the second twisting point be of the same order of magnitude. In implementing the twisitng method, a type of twisting head which frictionally grips the strand perpendicular to its axis is perferably used. As noted above, one such twisting head would be located immediately behind the first twisting point and a second twisting head immediately ahead of the second twisting point. Such twisitng heads are described in the journal "Draht," Volume 22, [1971] No. 9, T. 619–625. The two twisitng heads revolve with a direction of rotation which is constant and always the same for both and where the ratio of speed of rotation of the first twisting head to the speed of the second twisting head is always greater than the ratio of the distance of the first twisting head from the first twisting point to the distance of the second twisting head from the first twisting point. In addition, it is essential that the ratio and/or the difference between the rational speeds of the twisting heads be varied at intervals which correspond to at most three time the travel time for an element of the strand to travel from the first to the second twisting point. In one embodiment, the torsion acting on the strand immediately behind the first twisting point is chosen to always be the same both in direction and magnitude with the torsioning acting on the strand immediately ahead of the second twisting point varying at intervals. For example, the torsioning or twisting acting on the strand at the second twisting point may be selected so that its magnitude varies at predefined intervals by a plus or minus 50 percent of the torsion acting on the strand immediately behind the first twisting point.

In a further embodiment of the invention the torsion exerted on the strand can be varied such that the torsion acting on the strand immediately behind the first twisting point and that acting ahead of the second twisting point can be changed at intervals. Such intervals can be equal to the travel time of a length of element of the strand from the first to the second twisting point. In addition, the torsioning acting on the strand may also be changed, for example, in a proportional manner. If the rotational speed of the two twisting heads is changed proportionally, they can be driven by the same drive using different transmission ratios, for example, the speed difference between the two twisting heads in such a case can always be maintained at 20 percent.

A particular advantageous twisting head which comprises essentially one or several pairs of rollers arranged on parallel axes and facing each other and in which the strand elements run between the running surfaces of the rollers and are frictionally gripped thereby is shown. In such an embodiment the elements are held

between the two rollers which are pressed together and thus maintained in a stretched condition. The design of the rollers is such that the strands are firmly held but that the pulling through of the strand is not impeded. This is accomplished by forming the rollers so that there is a groove in the running surface running in the direction of the circumference and extending approximately over the entire width of the running surface. In particular, a friction lining of rubber-elastic material is embedded in such a manner that a hollow space remains between the elastic surface and the bottom of the groove of the roller in which it is inserted. Thus, the portion of the roller which grips the strands can flex down providing the needed groove to firmly grip the strands but still permit ease of pulling through. In the preferred embodiment, this friction winding is made in a U-shaped cross section and with the ends of the legs of the U firmly connected to the roller and the bottom of the U forming the friction member which contacts the strands and forms the running surface of the roll.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevation view of a twisting machine according to the present invention;

FIG. **2** is a diagram illustrating the change of twist direction obtained through the method of the present invention;

FIG. **3** is an elevation view partially cut-away illustrating the preferred type of twisting head for use with the present invention;

FIG. **4** is a plan view partially in cut-away section of the twisting head of FIG. **3.**

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The twisting machine of FIG. **1** will provide a spiral quad cable which has alternating twists of left and right direction. The four wires **40** which go to make up the spiral quad are fed from stationary rolls **41** over pulleys **42,** supported by a bracket **43,** to a twisting machine indicated generally as **55.** After passing through the twisting machine, the spiral quad **50** is looped around a drawing pulley **46** supported by a base **47** and provided to a winding drum **48** supported by base **49.** Within the twisting device **55** are mounted two twisting heads **60** and **64.** These are rotatably supported on stands **57, 58** respectively and driven by motors **61** and **65** through appropriate drive belts **62** and **65.**

The wires **40** enter the twisting machine at the laying top **59** which comprises the first twisting point and form a strand **51.** The strand **51** is first twisted or torsioned between the twisting head **60** and the first twisting point **59.** The twisitng head **60** and the twisting head **64** will both be rotated with the same direction of rotation. Thus, as the strand **51** moves continuously through the twisting device **55,** the strands will tend to stay twisted together as they move from one twisting head to the other. After passing through the second twisting head **64** a twisting or torsioning in the opposite direction will take place. This twisting occurs between a fixed roller or deflection pulley **45** forming the second twisting point and the twisting head **64.** As shown, three distinct sections of the strand **51** may be identified. The first L_1 is the portion between the first twisting point **59** and the first twisting head **60.** The second, L_2 is the distance between the first and second twisting heads. The third, L_3 is the distance between the second twisting head **64** and the second twisting point **45.** As will be described more fully below, a different state of twisting or torsion exists in each section. The ultimate twist of the wire which is wound onto the drum **48** is controlled by changing the speed of rotation of the twisting head **64,** or by changing the speed of rotation of both twisting heads **60** and **64** at predetermined intervals. Consider, for example, the case where the speed of rotation of the twisting head **60** remains constant while that of the twisting head **64** is changed. Assume that the speed of rotation of the twisting head **64** is 50 percent less than the speed of rotation of the twisitng head **60.** The wires **40** will be twisted by the twisting head **60** in one direction and will leave twisting head **60** with a certain amount of twist. In the distance between the twisting head **60** and twisting head **64,** because of the difference in the speed of rotation, they will be subjected to a twisting in the opposite direction, (i.e., an untwisting). After passing through the twisting head **64** between the twisting head and twisting point **45** they will be subjected to additional twist in this opposite direction, thus producing a twisted cable unit which has a twist opposite to that initially imposed by twisting head **60.** The long length L_2 over which the strand **51** passes allows sufficient time to obtain the required twist even though the relative rate is smaller than that at which the twist was put into the strand at twisting head **60.** Thus, after passing the second twist point a twist of the opposite direction will result. Consider now the case where the speed of rotation of the second twisting head **64** is 50 percent greater than that of the twisting head **60.** Now, between the twisting head **60** and the twisting head **64,** additional twisting in the same direction as that imposed by twisting head **60** will be added to strand **51.** Thus, when it is twisted in the opposite direction by the twisting head **64** over the short length L_3 it will still, after being partially untwisted, have a twist in the direction initially provided by the first twisting device **60.** Thus, by varying the speed of rotation of the second twisting head **64** by 50 percent or the like about the speed of the twisting head **60,** twists of opposite direction may be obtained.

As illustrated by FIG. **2** the time at which the twisting head **64** rotates at 50 percent below and 50 percent above the speed of twisting head **60** should be at a maximum three times the time it takes a length element of the strand **51** to travel from point **59** to point **45.**

When operating in this manner a single motor **61** may be used which drives the twisting head **64** via shaft **68** and a first magnetic clutch **70** or a second magnetic clutch **69** each having different transmission ratios. Thus, clutch **70** can be arranged to provide a ratio which will cause twisting heads **64** to rotate at a speed 50 percent less than twisting head **60.** This clutch is coupled to the twisting head through belt **72.** Similarly magnetic clutch **69** can be arranged to drive twisting head **64** (through belt **65**) at a speed which is 50 percent greater than the speed of twisting head **60.**

When operating in a mode where the speed of rotation of both twisting heads is changed simultaneously, it is advisable to change over at intervals which correspond to the travel time of a length element of the strand **51** from point **59** to point **45.** The speed change can be chosen such that the speed of each twisting head is always in proportional relationship to the other. In a manner similar to that described above, through the use of different transmission ratios and magnetic

clutches, it is also possible to drive both twisting heads using the same motor.

In the new SZ twisting device, the two twisting heads **60** and **64** form an accumulator. It is essential for the formation of this accumulator that the two twisting heads **60** and **64** rotate, at least during different intervals simultaneously at different speeds of rotation. As described above, this results in the section between the two twisting heads, i.e., within the accumulator, having a continuous change of state of torsion of the spiral quad travelling therethrough. Thus, the final twisting of the spiral quad will have continuously changing length of lay to thereby improve the electrical decoupling when several such spiral quads are twisted together. The pattern of the resulting twist is illustrated by FIG. **2.**

FIGS. **3** and **4** illustrate a particular useful twisting head which may be used as the twisting head **60** and **64** of FIG. **1.** The twisting head, designated generally as **1,** and which will be called a roller twister comprises essentially the two pairs of rollers **2** and **3** and **4** and **5.** The two rollers of each pair are arranged on parallel axes and disposed with their running surfaces opposite each other. The rollers **2** and **4** are supported by an upper roll carrier **7** and the lower rolls **3** and **5** by a lower roll carrier **8.** The roll carriers **7** and **8** are attached at one end to a left-hand frame **9** and at the other to a right-hand frame **10.** The entire twisting head is rotatably supported in conventional fashion about the axis of rotation **11.** Although two pairs of rollers are shown herein, a single pair may be used as may a plurality of pairs greater than two. To adjust the spacing of the upper and lower rollers so that they may handle different sizes of strand **51,** spindles **12** and **13** which are provided with a left-handed thread at one end and a right-handed thread at the other end are provided in frames **9** and **10.** The upper and lower frames **7** and **8** are guided by respective threaded sleeves **14** engaging the threaded portion of the spindles **12** and **13.** A set screw **15** is provided to hold the spindles in place once the desired setting has been made.

The construction of each of the rollers **2, 3, 4** and **5** is illustrated by FIG. **4** which is a plan view of the assembly of FIG. **3.** In FIG. **4,** the roller **4** is shown in a cut-away cross section. Essentially, it is made up of two roll halves **18** and **19,** which are of symmetrical design and bolted together by bolts **20.** The two halves are pressed against the outer race of a ball bearing which is axially secured to a sleeve **22** by means of a snap ring **23.** The roller shaft **24** is led through the sleeve **22** and holds the roller between the upper roll carrier **7.** The two halves of the roll **18** and **19** contain a grooved portion around their circumference. Into this groove **28** is fitted a friction lining **27** which is a rubber-elastic material. The friction lining **29** is of a U-shaped cross section with its legs **30** and **31** abutting the inner surface of the groove **28.** The bottom and base **29** of the U forms the running surface which grips the strand **51** of FIG. **1.** The hollow space **34** results in the ability to flex and thus to firmly grip the strand **51** preventing any motion which would cause it to slip out from between the roller but still permitting ease of pulling through the rollers. Ideally, the friction lining **27** will be a closed ring which can be inserted into one of the sides **18** or **19** prior to assembly. In addition, the bottom of the groove should be painted with an adhesive prior to assembly so that the legs **30** and **31** will be firmly bonded to the bottom of the groove **28.**

Particularly useful as a friction lining is a material having a basis of polyurethane such as that marketed by the firm Bayer-Leverkusen under the tradename "Vulkollan".

Thus an improved method for the SZ twisting of wires and a device for performing that method has been illustrated. Although specific embodiments have been illustrated and described, it will be obvious to those skilled in the art that various modifications may be made without departing from the spirit of the invention which is intended to be limited solely by the appended claims.

What is claimed is:

1. A method of twisting cable elements to form a cable unit having a twist direction which changes from section to section comprising:

a. providing a plurality of cable elements at a constant velocity to a first stationary twisting point and forming said elements into a strand at said first twisting point;

b. stretching said strand between said first twisting point and a second stationary twisting point;

c. twisting said strand immediately behind said first twisting point with a torsion always in one direction and immediately ahead of said second twisting point with a torsion which is always in the same direction thereby forming three strand subsections each having a different twist; and

d. changing one of the ratio, difference and ratio and difference of the torsion acting immediately behind said first twisting point and that acting immediately before said second twisting point at intervals which correspond to at most three times the travel time of a length element of the strand between said first and second twisting points.

2. The invention according to claim **1,** wherein the magnitude of the torsion acting behind said first twisting point is constant.

3. The invention according to claim **1,** wherein the torsions acting at said first and second twisting points are changed simultaneously at intervals corresponding to the travel time of a length element between said first and second twisting points.

4. The invention according to claim **3,** wherein said torsions are changed proportionally.

5. Apparatus for twisting cable elements to form a cable unit having a twist direction which changes from section to section comprising:

a. means acting as a first twisting point at which a plurality of elements may be formed into a strand, from which the cable units are to be formed;

b. a first twisting head immediately behind said first twisting point to grip the strand perpendicular to its axis;

c. a second twisting point;

d. a second twisting head immediately before said second twisting point adapted to grip the strand in a manner similar to said first twisting head;

e. means to hold the strand stretched between said first and second twisting points; and

f. means to rotate said first and second twisting heads so that both rotate in the same direction but with a speed ratio such that ratio of the speed of the first twisting head to that of the second is always greater than the ratio of the distance between the first

twisting point and the first twisting head to the distance between the first twisting point and the second twisting head, and to change the relative rotational speeds of said first and second twisting heads at intervals corresponding at most to three times the travel time of a length element of the strand between said first and second twisting points.

6. The invention according to claim **5**, wherein said first twisting head is rotated at a constant speed.

7. The invention according to claim **5**, wherein said means to change simultaneously changes the speed of both twisting heads at intervals corresponding to the travel time of a length element between said first and second twisting points.

8. The invention according to claim **7**, wherein said means to rotate comprises a single source of drive power coupled to said first and second twisting heads through means having different transmission ratios.

9. The invention according to claim **5**, wherein each of said first and second twisting heads comprise:

a. at least one pair of rollers;

b. means supporting said rollers on parallel axes disposed opposite each other such that a strand may be gripped between said rollers and wherein each roller includes;

c. a groove running about the circumference of the roller over the major portion of the roller running surface width; and

d. a friction lining made of an elastic material embedded in said groove and bonded to the bottom thereof in a manner such that a hollow space is formed between the bottom of the groove and the portion of said lining forming the roller running surface.

10. The invention according to claim **9**, wherein said friction lining has a U-shape with the legs of the U bonded to the bottom of said groove and with the base of the U forming the running surface.

* * * * *