HIGH SPEED STRANDED CONDUCTOR PRODUCTION PROCESS

Inventor: Hisateru Akachi, Kanagawa-ken, Japan
Assignee: Oki Densen Kabushiki Kaisha, Kanagawa, Japan

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Primary Examiner—John Petrakes
Attorney—Kelman & Berman

ABSTRACT

A high speed stranded conductor production process in which individual strands are fed to and onto a reel through a concentric rotary twisting member having holes therein, said reel being mounted on a cantilevered rotary shaft and having a predetermined drum and flange diameter ratio selected for producing a predetermined variable pitch in a stranded conductor formed from said strands and after the passage through said twisting member, prior to being fed to and onto said reel, said strands are passed over grooved guide means mounted on a ring-shaped rotary member provided around said reel independently of the reel and adapted to be rotated relative to the reel in the same direction or the opposite direction to the reel at a different speed from the reel.

11 Claims, 5 Drawing Figures
HIGH SPEED STRANDED CONDUCTOR PRODUCTION PROCESS

This invention relates to a high speed stranded conductor production process and more particularly, to an application of the construction of a variable pitch stranded conductor for communication cables and the process for producing the conductor which makes it possible to employ a relatively large capacity reel thereby to produce a high rotational movement for strands as they are twisted together into a stranded conductor and is also applicable to the production of cores for communication cables having large diameters from strands in multi-pairs by twisting the strands together as they are being wound about the reel.

The constructions of variable pitch stranded conductors for communication cables and the process and apparatus for producing such stranded conductors have been found excellent and more advantageous over the prior arts, but the applicant has further developed an improved variable pitch stranded conductor production apparatus which is of the type in which strands are twisted together as they are being payed out of the reel drum (this type of apparatus will be referred to as "paying-out type" hereinafter) and details of such an apparatus are disclosed in co-pending Patent Application Ser. No. 78870, filed on Oct. 7, 1970, now U.S. Pat. No. 3,715,877. The apparatus can produce variable pitch stranded conductors with a high efficiency through efficient utilization of the principle of the process for producing variable pitch stranded conductors. However, the apparatus and process disclosed in the above-mentioned co-pending Patent Applications still have some defects. For example, when the process of the co-pending Patent Application is carried out in an apparatus in which no capstan is provided and strands are fed to the drum of a winding reel after they have passed along the outer rim of the flange at one or the leading end of the reel while rotating thereabout whereby to make it possible to reduce the size of a rotary frame or flyer can be rotated at a higher speed (this type of apparatus will be referred to as "take-up type" hereinafter). However, the size of the rotary frame or flyer can not be reduced to the extent that when small gage strands are twisted together at a high speed the inertia force of the rotary frame or flyer may be disregarded at the time of actuation, acceleration, deceleration, sudden stoppage or the like. And when the process of the co-pending Patent Application is carried out in a large size "take-up type" apparatus designed to twist strands in multi-pairs together, it is necessary to mount an arm on the flyer so that a stranded conductor or product produced by twisting the strands together may be uniformly distributed along the entire length of the reel drum between the flanges at the opposite ends of the reel and furthermore, it is also necessary to mount one or more grooved guide pulleys at the tip of the arm which pulleys have a large size sufficient to prevent the stranded conductor from being untwisted into individual strands. Still furthermore, such an arm must have a thickness sufficient to provide a strength to bear against the centrifugal force generated from the guide pulleys. In order to prevent the stranded conductor or cable core which has been formed by passing the individual strands through the rotary twisting member from contacting the flange at the leading end of the reel until the conductor reaches the above-mentioned guide pulleys, an additional grooved guide pulley or pulleys must be provided and the additional guide pulley or pulleys also must have a large diameter sufficient to prevent the stranded conductor from being untwisted into the individual strands.

Therefore, when a stranded conductor such as a variable pitch cable core is produced by twisting a plurality of individual strands together using a "take-up type" twisting apparatus, the size of the rotary frame or flyer is inevitably large to the extent that most of the advantageous effects which will be otherwise obtained by the process disclosed in the co-pending Application may be lost.

SUMMARY OF THE INVENTION

One object of the present invention is to provide a highly efficient stranded conductor production process which can effectively eliminate the above-mentioned problems inherent in the prior art process using a "take-up type" twisting apparatus.

Another object of the present invention is to provide a stranded conductor production process which can be also effectively carried out using a "paying-out type" twisting apparatus.

A further object of the present invention is to provide a process which can also be utilized in the production of a constant pitch conductor.

The above and other objects and attendant advantages of the present invention will be more readily apparent from a reading of the following detailed description in conjunction with the accompanying drawings wherein identical or similar parts are assigned thereto the same reference numerals throughout the several figures of the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of an apparatus suitably employed in carrying out the process according to the present invention;

FIG. 2 is a cross-sectional view taken substantially along the line A—A' in FIG. 1;

FIG. 3 is diagrammatic view showing the operation of said apparatus of FIGS. 1 and 2;

FIG. 4 is a diagrammatic view showing the operation of a modified form of apparatus suitably employed in carrying out the process of the invention; and

FIG. 5 is a diagrammatic view showing the operation of a still further modified form of apparatus suitably employed in carrying out the process of the invention.

PREFERRED EMBODIMENTS OF THE INVENTION

Prior to proceeding to description of the process of the invention, reference will be generally had to the figures of the accompanying drawings in which apparatus employed in the process of the invention and those employed in the conventional processes are illustrated in order to show the improvements of the process by the invention over the conventional processes. FIG. 1 shows a "take-up type" apparatus employed in producing a stranded conductor by the process of the invention, FIG. 2 is a front elevational view of the apparatus taken substantially along the line A—A' of FIG. 1, FIG. 3 is a diagrammatic view showing the operation on the apparatus of FIGS. 1 and 2, FIG. 4 is similar to FIG. 3, but shows the apparatus with the capstan shown in FIG. 3 removed therefrom, and FIG. 5 is a diagrammatic
view of an apparatus employed for preparing a constant pitch stranded conductor by the process of the invention. FIGS. 3 through 5 are on the same reduced scale. Throughout FIGS. 1 through 3, of the accompanying drawings reference numeral 1 denotes strands or cable core elements from which a stranded conductor or communication cable core is formed and in case of a communication cable core, the strands are arranged in pairs or quads. Each of the apparatus of FIGS. 1 through 3 and 5 comprises a capstan 6 which is adapted to feed the strands 1 to reel 18 or unwind the strands from the reel at a predetermined constant rate in either case. The capstan 6 is connected through a transmission mechanism 41, 42 and 43 (shown only in FIGS. 3 and 5) to a main drive shaft 12 rotated at a constant speed from an electric motor 46 through V-sheaves 44, 45. Reference numeral 7 denotes a guide plate which has guide holes formed therein in an arrangement depending upon a particular twisting pattern for the strands and after having passed through the guide holes in the guide plate 7, the strands 1 are fed into a rotary twisting member 8 which twists the strands together as they pass through its hole. The rotary twisting member 8 is rotated from the main drive shaft 12 through V-sheaves 10, 11 and an endless member trained over the V-sheaves. The rotation speed of the twisting member 8 is higher than that at which the strands 1 are actually twisted together so that wear may be evenly distributed around the entire circumference of the hole in the member 8. The hole in the twisting member 8 is adjacent to the reel so that the twisted strands 1 may not separate from each other as they leave the twisting member 8. The strands 1 issue from the twisting member 8 as a semi-stranded conductor or cable unit which will be subjected to further twisting to form a core for a communication cable, for example. Reference numeral 19 denotes a ring-shaped rotary member having the inner diameter larger than the outer diameter of the flanges of the reel 18 and the rotary member 19 is maintained in the concentric relationship to the reel 18 by means of four support rolls 24, 25, 26 and 27 mounted in equiangularly spaced relationship around a pedestal 30. The rotary member 19 supports grooved guide pulleys 20, 21, 22 and 23 at angularly spaced points around the rotary member which serve to feed the twisted strands 1 to and onto the drum of the reel 18. The pulleys have a large diameter sufficient to prevent untwisting the twisted strands and the pulleys are formed from plastics so that any undue centrifugal force may not be generated. In preparing a stranded conductor by the process of the invention using a "take-up type" apparatus, one guide pulley is employed or two guide pulleys may be used in order to keep balance. However, in carrying out the process using a "paying-out type" apparatus, four guide pulleys are necessary corresponding to the number of strands to be twisted together which have been previously wound on the reel. Thus, in FIG. 2 of the drawings, four identical guide pulleys 20, 21, 22 and 23 are mounted on the ring-shaped rotary member 19 in equi-angularly spaced relationship along the circumference of the rotary member. Broken lines 2, 3, 4 and 5 in FIG. 2 denote strands as they are twisted together in a stranded conductor or cable core in a "paying-out type" apparatus. When the grooved guide pulleys 20, 21, 22 and 23 are employed in the "paying-out type" apparatus, they are preferably smaller and lighter. The ring-shaped rotary member 19 is then rotated by a torque motor 35 through V-sheaves 28, 29 and an endless member (shown with the dotted line) trained over the sheaves at a speed higher than that at which the reel 18 rotates or there is imparted thereto a reverse direction torque. In the example shown in FIGS. 1 and 2, as seen along the line A—A' of FIG. 1 and in the arrow direction therein, the reel 18 rotates in the counterclockwise direction while the torque motor 35 rotates the rotary member 19 in the clockwise direction. The reel 18 is fixedly secured at the opposite ends to the hollow shaft 16 by mean of an arm 31 and a set screw 17 for rotation together with the shaft 16. The shaft 16 is cantilevered at one end by a pedestal 32 which is in turn supported on the machine base and rotated by the main drive shaft 12 through V-sheaves 36, 37 and endless members trained over the sheaves (shown with the dotted lines). The rotation speed of the reel shaft 16 is maintained in predetermined ratio to the paying-out speed of the strands 1 by the capstan 6 so as to provide a basic pitch for a variable pitch stranded conductor to be formed from the strands. Reference numeral 13 denotes a detachable flyer which is fixedly secured by a nut 14 to a flyer shaft 15 which is in turn rotatably supported within the reel shaft 16 and also cantilevered at one end by the pedestal 32. The flyer shaft 15 is rotated by the main drive shaft 12 through V-sheaves 38, 39 and an endless member trained over the sheaves (shown with the dotted line). In carrying out the process of the invention using the apparatus of FIGS. 1, 2 and 3, the rotation of the ring-shaped rotary member 19 is in the same direction as the reel 18 and the rotation speed of the member 19 is delayed relative to that of the reel by a time period necessary for a turn of the stranded conductor to be placed about the entire diameter of the drum of the reel. The rotation of the flyer 13 is also in the same direction as that of the reel 18, but the rotation speed of the flyer is lower than that of the ring-shaped rotary member 19. A traverse shaft 33 is connected at one end to a reversible motor 34 and at the other end to a pedestal 30 supporting the rotary member 19 so as to reciprocally traverse the pedestal by a distance determined by the axial length between the flanges of the drum of the reel 18 thereby to uniformly distribute the stranded conductor along the drum of the reel 18. The flyer 13 has a ring-shaped outer peripheral rim having an inner diameter larger than the outer diameter of the flange at the leading end of the reel 18 and surrounding the reel flange and accordingly, the stranded conductor 2 can be effectively prevented from contacting the reel flange.

When the reel 18 and flyer 13 are desired to be detached from the shaft 16, the pedestal 9 of the rotary twisting member 8 is moved away from the reel and flyer assembly to a suitable position so that the reel and flyer can be easily detached from the shaft 16. Reference numeral 40 denotes a common bed on which the capstan 16 and pedestals 9, 30 and 32 are mounted. The high speed stranded conductor production process of the invention and effects derived from the process will be now described in connection with an operation to be performed using the apparatus shown in FIGS. 1, 2 and 3.

When separate strands are fed at a constant speed by the capstan 16 through the stationary hole guide plate 7 and then the rotary twisting member 8 to and onto the drum of the reel 18 fixedly mounted on the
canted reel shaft 16 as shown in FIG. 3 with the reel shaft maintained stationary, since the ring-shaped rotary member 19 and grooved guide pulley 20 (only one guide pulley is employed in the example of FIGS. 1, 2 and 3) are at all the times urged to rotate in the clockwise direction as seen in FIG. 2 by the torque motor 35, the rotary member 19 and pulley 20 rotates in the direction by an angular distance corresponding to the length in the the strands 1 to be fed into the apparatus and in this case, the strands 1 are twisted in the left-hand direction by an amount corresponding to the rotational movement of the ring-shaped rotary member 19. When the diameter of the stranded conductor 2 at the time each turn of the stranded conductor is wound around the drum of the reel 18 is expressed by \( d \), since the stranded conductor is imparted thereto one twist per complete rotation of the rotary member 19, the twisting pitch of the stranded conductor will be \( \pi d \). Thus, when the diameter of the reel drum is expressed by \( d_m \) and the maximum diameter of the stranded conductor wound on the reel drum is expressed by \( d_m \), then the twisting pitch will change stepwise from \( d_1 \) to \( d_m \). In other words, the number of twists in the left-hand twisting per meter of the stranded conductor will change from \( 1/\pi d_1 \) to \( 1/\pi d_m \).

Now, when the reel shaft 16 and accordingly, the reel thereon is rotated in the counter-clock direction in a constant speed ratio to the paying-out or feeding speed of the strands 1 by the capstan 16 while maintaining the rotary member 19 in its rotational movement, then the rotary member 19 is forced to rotate in the same direction as the reel due to the tension on the strands 1 against the torque of the torque motor and the rotation speed of the ring-shaped rotary member 19 is delayed from that of the reel by a time period necessary to wind a turn of the stranded conductor about the entire circumference of the reel drum. When the rotation speed of the reel 18 per minute is expressed by \( N \) r.p.m. while the paying-out speed of the capstan 16 per minute is expressed by \( V_m \), then the number of twists in the stranded conductor to be twisted by the rotational movement of the reel 18 will be \( N/V \) in the right-hand twisting per meter of the length of the conductor.

Thus, the variable pitch twisting in which the number of twists per meter of the stranded conductor in the right-hand twisting changes from \( N/V - (1/\pi d_1) \) to \( N/V - 1/\pi d_2 \) will be obtained.

In such a case, it will be apparent to those skilled in the art that the twisting pitch is determined depending upon the rotation speed of the ring-shaped rotary member and the paying-out speed of the strands by the capstan and that the stranded conductor is wound about the reel drum by the difference in rotation speed between the reel and ring-shaped rotary member.

FIG. 4 shows another type of apparatus employed in carrying out the process of the invention in a somewhat different manner. The apparatus of FIG. 4 is different from the apparatus shown in FIGS. 1 through 3 in that the capstan 6, the transmission mechanism 42, 41 and 43 associated with the capstan and the torque motor 35 employed in the apparatus of FIGS. 1 through 3 are eliminated and instead the V-sheaves 28 is fixedly mounted on the main drive shaft 12. Therefore, in the apparatus of FIG. 4, the ring-shaped rotary member 19 is rotated in the same direction as the reel 18 in the forward or reverse direction by two pairs of V-sheaves 36, 37 and 28, 29 and endless members trained thereover maintaining a constant rotation speed ratio to the rotation speed of the reel. The flyer 13 is rotated in the same direction and substantially at the same speed as the ring-shaped rotary member or the flyer is rotated in the same direction as the ring-shaped rotary member at a different speed from that of the rotary member having a greater difference speed than that which the rotation speed of the ring-shaped member has with respect to that of the reel. In such case, since the feeding speed of the strands is determined depending upon the speed at which the stranded conductor is wound about the reel drum, the variation range of twisting pitch will be wider than that obtainable in the apparatus of FIGS. 1 through 3. When the diameter of each turn of the stranded conductor on the reel drum is expressed by \( d \) and the rotation speed ratio of the ring-shaped rotary member to that of the reel is expressed by \( k \), since the feeding speed of the strands is determined by the difference in rotation speeds between the ring-shaped rotary member and reel, \( (KN-N)d = N(k-1)d \) per minute. and thus, the number of twists per meter of the stranded conductor per minute will be:

\[
\frac{KN}{N(k-1)} \pi d = \frac{K(k-1)}{\pi d}
\]

Thus, when the diameter of the reel drum is expressed by \( d \), and the maximum diameter of the stranded conductor on the reel drum is expressed by \( d_m \), the feeding speed of the strands per minute will change from \( N(k-1)d_1 \) to \( N(k-1)d_2 \) and the number of twists in the stranded conductor per minute will change from \( k(k-1)d_1 \) to \( k(k-1)d_2 \). Thus, the twisting pitch variation range in the apparatus of FIG. 4 will be wider than that in the apparatus of FIGS. 1 through 3.

Thus, it will be understood that the apparatus of FIG. 4 is simplified with respect to that shown in the preceding figures and accordingly, the process using the simplified apparatus can be performed at less expenses than those by the apparatus of FIGS. 1 through 3. And in the apparatus of FIG. 4, since the rotating parts are simultaneously driven from the common drive shaft, as compared with the apparatus of the preceding figures, abrupt stoppage and rapid acceleration of the apparatus of FIG. 4 can be done with greater easiness.

FIG. 5 shows another type of apparatus employed in carrying out the process of the invention for producing a constant pitch stranded conductor. In the apparatus of FIG. 5, the separate strands 1 are paid out at a constant speed by the capstan 6 to pass through the holed guide plate 7 and then through the rotary twisting member 8 where the separate strands are twisted together. The strands issue from the stranded member 8 in the form of a stranded conductor 2 and the conductor then passes in contact with the outer rim of the rotating flyer 13 which prevents the conductor from contacting the flange at the leading end of the rotating reel 18 and onto the drum of the reel to be wound thereabout in the same manner as mentioned in connection with the operation using the apparatus of FIG. 3. While the ring-shaped rotary member 19 is rotated by the main shaft 12 through the V-sheaves 28, 29 and the endless member trained thereover with the reel rotating in a constant ratio to the feeding speed of the strands in the apparatus of FIGS. 1 through 3, in the apparatus of FIG. 5, the ring-shaped rotary member 19 is rotated by the main drive shaft 12 through the V-sheaves 28, 29 and the endless member trained thereover in a constant ratio to the feeding speed of the
strands to feed the strands to and onto the reel drum while twisting them together into a constant pitch stranded conductor and the reel 18 is rotated from the torque motor 35 through the V-sheaves 36, 37 and the endless member trained thereover to wind the stranded conductor about the reel drum while being pulled toward the ring-shaped rotary member under the tension on the stranded conductor. Furthermore, in the apparatus of FIG. 5, the rotation speed of the ring-shaped rotary member relative to that of the reel varies in proportion to increase in the diameter of the stranded conductor on the reel drum and accordingly, in the operation using the apparatus of FIG. 5, when the feeding speed of the strands per minute is expressed by \( V \) m/min. and the rotation speed of the ring-shaped rotary member per minute is expressed by N. r.p.m., the number of twists per meter of the stranded conductor will be \( N/V \).

Although the process of the invention has been described in connection with various operations using the various types of apparatus as shown in the several figures, the process is also applicable to many other operations. In the examples described referring to FIGS. 1 through 3, although the ring-shaped rotary member is rotates at a lower speed with respect to the rotation speed of the reel, when the rotational direction of the reel shaft 16 and accordingly, the reel 18 thereon is reversed from that as described hereinabove while the direction in which the torque of the torque motor 35 is applied is maintained the same as described hereinabove, the hand of the twisting is reversed and the rotation speed of the ring-shaped rotary member will be higher that than of the reel. The difference in rotation speed between the reel and ring-shaped rotary member will vary depending upon a particular strand feeding speed and variation in the diameter of the stranded conductor as the conductor is wound about the reel drum in the same manner as mentioned hereinabove. In such a case, the number of twists per meter of the stranded conductor will be as follows:

- Initial stage of winding: \( N/V + (1/\pi d_1) \)
- Final stage of winding: \( N/V + 1/\pi d_2 \)

In the process to be carried out using the apparatus of FIG. 4 description has been made of the instance in which the rotation speed of the reel is lower than that of the ring-shaped rotary member, but the rotation speed relation-ship between the two rotating parts can be reversed within the scope of the invention and in the reversed rotation speed relationship the above-mentioned relationship will be as follows:

- Feeding speed of strands at initial stage: \( N(1-K) d_1 \)
- Feeding speed of strands at final stage of winding: \( 18N(1-K) d_2 \)

The number of twists per meter of the stranded conductor will be as follows:

- Initial stage of winding: \( [K/(1-K)]\pi d_1 \)
- Final stage of winding: \( [k/(1-K)]\pi d_2 \)

In the process using the apparatus of FIG. 5 it is also possible that the reel is not rotated by the strands and instead the reel is rotated at a higher rotation speed than that of the ring-shaped rotary member depending upon a particular feeding speed of the strands, the direction in which the torque of the torque motor is applied being the same as the rotational direction of the ring-shaped rotary member.

When the torque of the motor of FIGS. 2 and 5 is employed as a brake, the torque motor may be replaced by a mechanical or electromagnetic brake.

The stranded conductor production operations described hereinabove are examples of the process of the invention wherein the process of the invention is conducted in a "take-up type" apparatus, but the process of the invention can be equally applied to the production of a stranded conductor in a "paying-out type" apparatus. In such a case, a plurality of strands having the same length are previously wound about the reel drum in a predetermined parallel relationship and the reel having the strands wound thereon is fixedly mounted on the reel shaft. Then, the wound strands are payed out or unwound from the reel and passed through the twisting member provided in a plane of an extension line of the axis of the shaft of the reel while being rotated along the flange at one end of or the leading end of the reel and twisted together thereby to provide a stranded conductor.

In carrying out the process of the invention in the "paying-out type" apparatus, the grooved guide pulleys on the ring-shaped rotary member must be employed in the number corresponding to that of the strands employed and these guide pulleys must be arranged in substantially a symmetrical relationship about the shaft of the reel so that they can serve as mean which arrange the strands in a predetermined pattern. These guide pulleys also serve as means which keep the strands in a separated relationship. Since the guide pulleys serve to guide the individual strands respectively, they may be of smaller size and lighter weight as compared with the corresponding single guide pulley employed in carrying out the process in the "take-up type" apparatus.

The arrangement of the guide pulleys 20, 21, 22 and 23 shown in FIG. 2 is that for the paying-out application and the broken lines 2, 3, 4 and 5 in FIG. 2 show the individual strands as being payed out of the reel drum.

In either case, the flyer is rotated in the same direction as the ring-shaped rotary member and at the same speed as or a speed higher than that of the ring-shaped rotary member. The outer rim of the flyer not only prevents the strands from contacting the flange at the leading end of the reel, but also assists the individual strands in rotating or allows the strands to automatically rotate under the tension on these strands.

In the application of the process as shown in FIGS. 4 and 5, the flyer serves for the former purpose while in the application of FIG. 3, the same flyer serves for the latter purpose.

In any of the applications shown in the various figures, the purpose for subjecting the individual strands to a tension sufficient to positively twist them together can be attained by the rotation torque to be imparted to the ring-shaped rotary member by the torque motor of FIG. 3 or braking force to be imparted to the rotary member by a brake device (not shown) and in the application of FIG. 4, the same purpose can be attained by tension to be imparted to the individual strands when they are twisted together. And furthermore, in the application of FIG. 5, the rotation force or braking force to be imparted to the reel by the torque motor of that figure or braking force to be applied to the reel by a brake device (not shown) can attain the same purpose.
In carrying out the process of the invention, if the stranded conductor or individual strands are rotated in a circular path far away outwardly from the outer rim of the flyer due to centrifugal force generated as they are rotated at a high speed thereby to render the flyer to fail to serve its intended function or the conductor or strands are forced out of the guide pulley or pulleys, a restraining member having a ring-shaped or cylindrical outer periphery is provided in a suitable position in the path of the conductor or strands between the guide pulleys and twisting member thereby to enhance the effects of the process of the invention.

Although the best mode contemplated for carrying out the present invention has been herein shown and described, it will be apparent that modification and variation may be made without departing from what is regarded to be the subject matter of the invention.

What is claimed is:

1. A method of manufacturing a cable from a plurality of cable elements which comprises:
   a. twisting said cable elements at constant pitch to form an elongated cable unit;
   b. continuously and longitudinally feeding said unit to a guide member mounted for movement in a circular path about an axis extending approximately in the direction of elongation of the unit being fed to said guide member;
   c. withdrawing said unit from said guide member and winding the same on a reel in a helix extending about said axis, said path spacedly enveloping said reel; and
   d. moving said guide member in said path and rotating said reel about said axis in respective directions at respective different angular speeds to further twist said cable elements in said cable unit while simultaneously axially reciprocating said guide member.

2. A method as set forth in claim 1, wherein said guide member is moved in said path by the tension of said cable unit, said guide member being moved about said axis in the direction of rotation of said reel.

3. A method as set forth in claim 2, wherein said cable elements are fed to said guide member at an instantaneous rate, and said reel is rotated at an angular speed proportional to said rate, whereby the pitch of the cable unit being wound on said reel varies as the effective diameter of the reel is increased by successive layers of said cable unit wound on said reel.

4. A method as set forth in claim 1, wherein said guide member is moved in said path in the direction of rotation of said reel, the difference between the angular rate of movement of said guide member and the angular speed of said reel being constant, whereby the pitch of said cable unit is varied as the effective diameter of the reel is increased by successive layers of said cable unit wound on said reel.

5. A method as set forth in claim 1, wherein said reel is rotated in the direction of movement of said guide member in response to the tension of the cable unit being wound on said reel.

6. A method as set forth in claim 5, wherein said cable unit is fed to said guide member at a rate substantially proportional to the speed of said movement of the guide member, said reel being driven in response to the tension of said cable unit for rotation at a speed varying with the effective diameter of said reel, said diameter changing with the number of layers of said cable unit wound in said reel, whereby said cable unit has a substantially constant pitch.

7. A method as set forth in claim 5, wherein said reel is being biased to rotate in a direction opposite to the direction of movement of said guide member for applying a braking force to said reel sufficient to cause rotation of said reel at an angular speed smaller than the angular speed of said guide member.

8. A method as set forth in claim 5, wherein said reel is being biased to rotate in the direction of movement of said guide member at an angular speed higher than the angular speed of said guide member.

9. A method as set forth in claim 1, wherein said guide member is being biased to move in a direction opposite to the direction of rotation of said reel for thereby applying a braking force to said guide member, whereby the angular speed of said reel is higher than the angular speed of said guide member.

10. A method as set forth in claim 1, wherein said guide member is being biased to move in the same direction as said reel for movement at an angular speed higher than the angular speed of said reel.

11. A method as set forth in claim 1, wherein said cable unit is fed to said guide member through a flier while said flier and said reel rotate about said axis in the direction of movement of said guide member.

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