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Lovett, Jr.

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[45] **Jan. 2, 1973**

[54] **METHOD AND APPARATUS FOR ATTACHING FAIRING STRIPS TO CABLES**

[75] Inventor: **Stanley L. Lovett, Jr.**, Culpeper, Va.

[73] Assignee: **The Rochester Corporation**, Culpeper, Va.

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[52] **U.S. Cl.** .....**57/1 UN**, 57/156

[51] **Int. Cl.**.....**D07b 3/00**, D07b 1/14, D07b 7/18

[58] **Field of Search**....57/1 R, 25, 1 U, 2.3, 24, 34 R, 57/143, 145, 156, 160, 161, 166; 116/114

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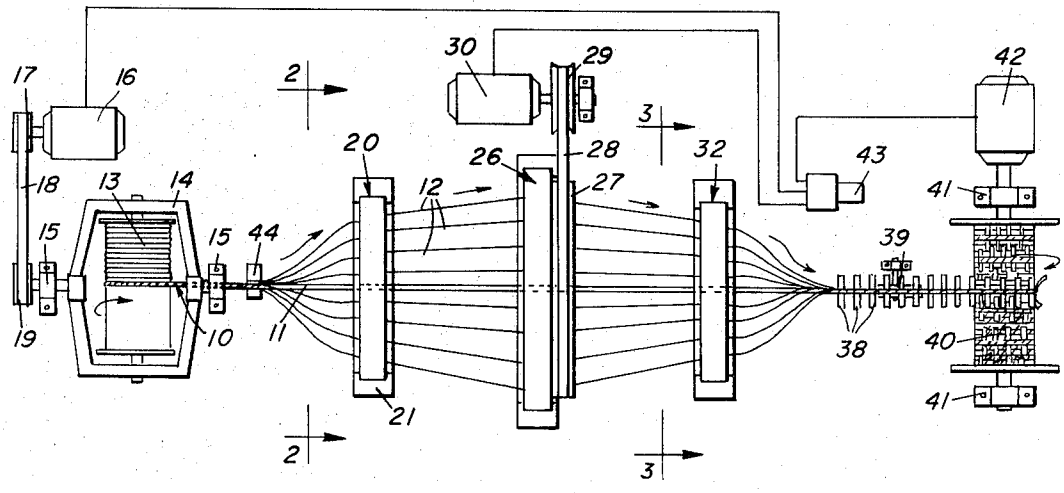
Primary Examiner—Donald E. Watkins

Attorney—Arnold B. Christen et al.

[57] **ABSTRACT**

A method of attaching flexible fairing strips to a conventional cable having a core portion surrounded by a layer of armor wires includes unlaying all of the armor wires, inserting the fairing strips under the unlayed armor wires and re-laying the armor wires around the core portion, so that the fairing strips are fixedly secured. An apparatus for performing this method includes a swivel frame supporting the let-off reel, three bearing disk units for guiding and rotating the grouped armor wires, a support for a driven take-up reel and a manual control for operating the apparatus.

42 Claims, 8 Drawing Figures



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SHEET 1 OF 2

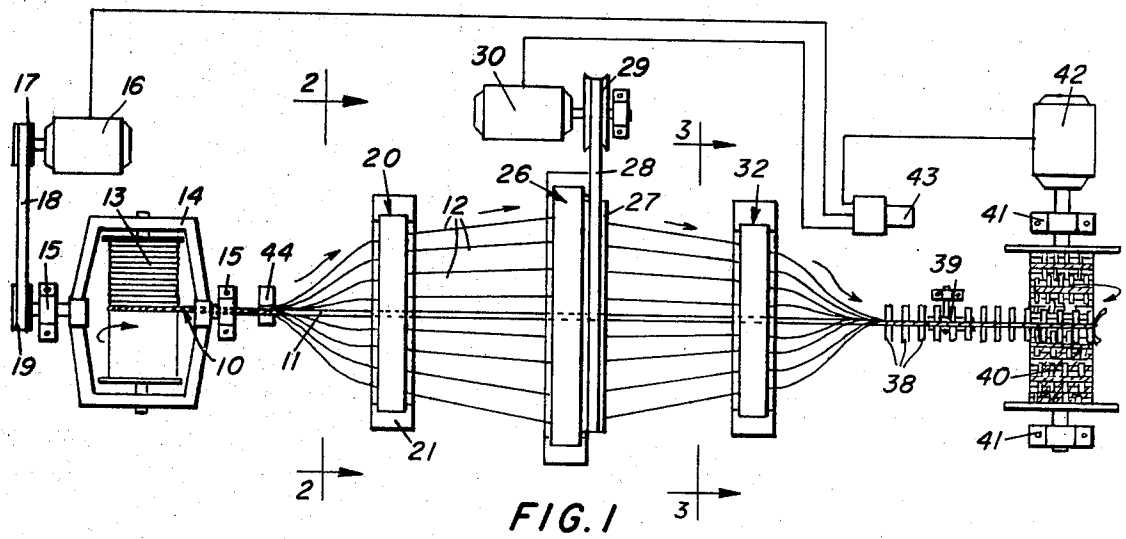


FIG. 1

FIG. 2

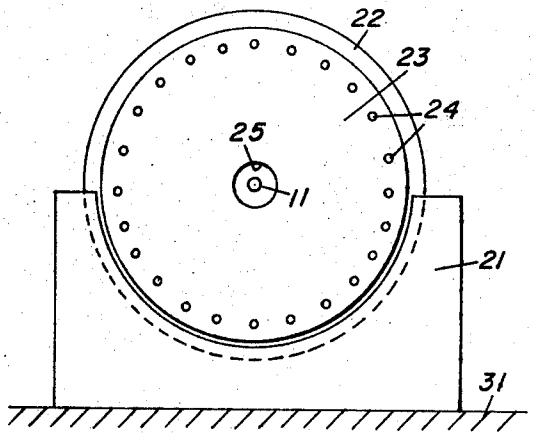


FIG. 3

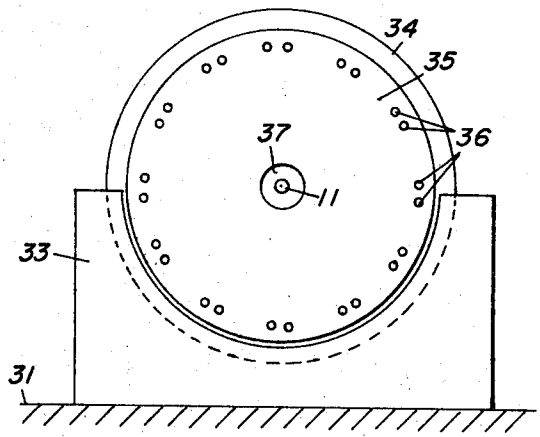
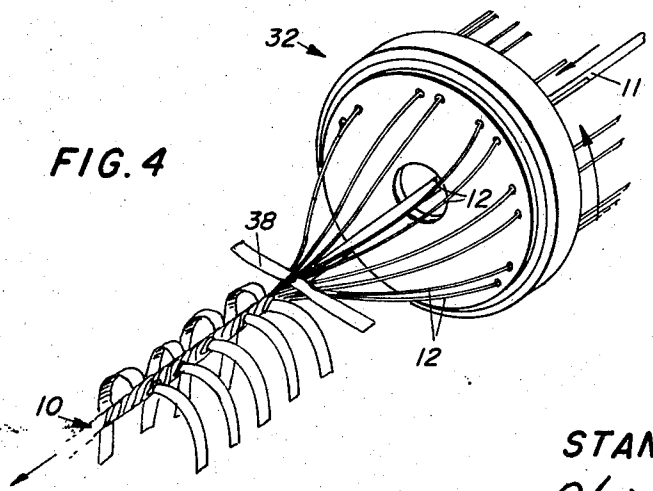
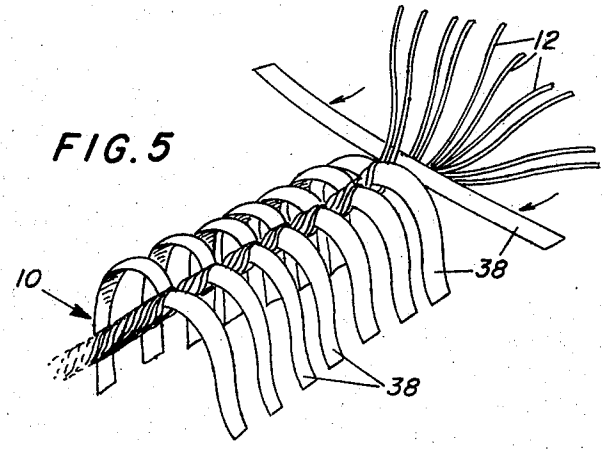


FIG. 4



INVENTOR
STANLEY L. LOVETT, Jr.
BY Christen and Sabol
ATTORNEYS

FIG. 5



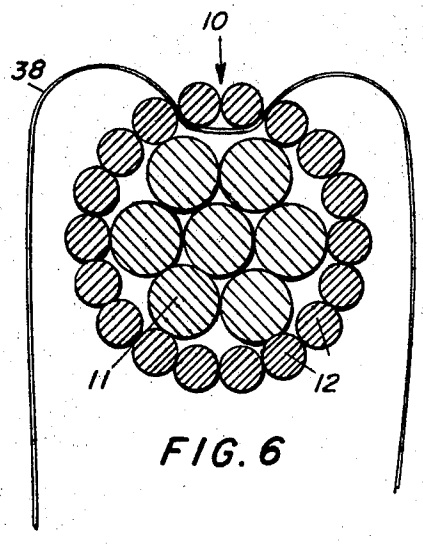


FIG. 6

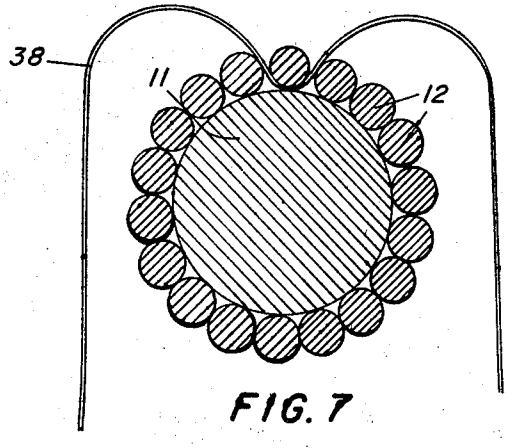


FIG. 7

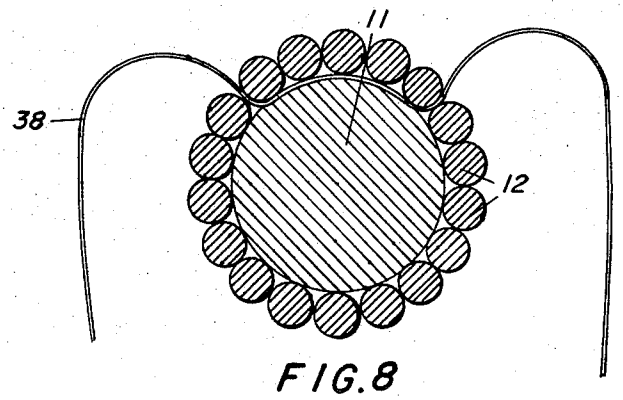


FIG. 8

INVENTOR
STANLEY L. LOVETT, Jr.
BY Christen and Sabol
ATTORNEYS

METHOD AND APPARATUS FOR ATTACHING FAIRING STRIPS TO CABLES

The present invention relates to a method and apparatus for attaching fairings to cables, and more particularly to a method and apparatus for attaching flexible fairing strips to a cable having a core portion surrounded by a single multi-strand layer of pre-formed, helically wound armor wires.

Cables provided with fairing strips are used in many marine operations. For example, marine oceanographic operations utilize submerged wire rope or cable to tow delicate instrument packages at various depths and speeds for experimental purposes. When bare unfaired cables are used to tow an instrument array or assembly, the tow vehicle must be operated at relatively slow speeds in order to maintain proper instrument depth and not exceed tolerable tow wire vibration. Cable fairing drastically reduces vibration and drag, thus permitting a deeper tow for a given instrument package, length of cable and speed.

Tow cables are also used for towing underwater vehicles, mine sweeping arrays utilizing diverters whereby the cable moves transversely through the water, anti-torpedo protective streamers for ships, and the like. Vibration and drag of power, tow and control cables are important limiting factors in the performance of many mine and torpedo countermeasure devices. Significant reduction of such vibration and drag makes possible the towing of more sensitive detection instrumentation as well as permitting higher speed towing or increasing the swept path of present mine sweeping gear utilizing cable diversion.

Moreover, the reduction in mechanical vibrations results in a reduction of the noise generated by such vibrations, which is a significant feature in sonar applications. Tow vibration, too, represents reduced cable fatigue and longer life.

At the present time several types of fairings are available. For example, the cable may be provided with fairing sections which are clamped or otherwise applied to the cable. However, these devices have not proved capable of conforming to the water flow under all conditions of cable angle or bend, due to a lack of flexibility, nor have these cable fairings proved suitable for reeling and storage on drums. To avoid these disadvantages fairings composed of hair-like strands or fringes comprising a plurality of thrums have been developed and have proved to be satisfactory.

The disadvantage of such fringe or strip like fairings, however, resides in their difficulty of being attached to the cable during manufacturing. The use of known securing methods, such as the fixation by means of special glues or the looping through the outer sleeve of the cable, is not always possible and represents a time consuming operation.

It is accordingly an object of the present invention to provide a method of attaching flexible fairing strips to a cable, which is time saving, which requires little skill by the part of the operator, and which provides a firm attachment of the fairing strips.

Another object of the present invention is to provide a method of attaching flexible fairing strips to a cable, whereby the separation between successive strips in axial direction of the cable can be predetermined and kept constant along a desired length of the cable.

Still another object of the invention is to provide a method of attaching flexible fairing strips to a cable, which permits the use of a conventional previously manufactured cable having a core portion surrounded by a single multi-strand layer of pre-formed, helically wound armor wires.

A further object of the invention is to provide an apparatus for attaching flexible fairing strips to a cable according to the method of the invention.

These objects can be realized, according to the invention, by unlaying all the armor wires of the cable for a predetermined distance, inserting a plurality of fairing strips under a succession of the armor wires, re-laying the armor wires on the core portion with the fairing strips looped thereunder, and compensating for the relative displacement in the positions of the armor wires with respect to the core portion caused by the addition of the fairing strips.

Other features and advantages of the present invention will become apparent from the following detailed description of a preferred embodiment of the invention, when read in connection with the accompanying drawings, in which:

FIG. 1 is a top view of a preferred form of apparatus to be used to perform the method of the present invention;

FIG. 2 is a cross-section taken on the line 2—2 of FIG. 1;

FIG. 3 is a cross-section taken on the line 3—3 of FIG. 1;

FIG. 4 shows a detail of the step of inserting the fairing strips, according to the invention;

FIG. 5 is a perspective view of a fairing cable produced with the method according to the invention;

FIG. 6 is a sectional view of the cable of FIG. 5; and

FIGS. 7 and 8 are two sectional views of different cables produced with the method of the present invention.

Referring now particularly to FIG. 1, a pre-formed cable **10** comprising a core portion **11** and armor wires **12** which has been made in the usual way is wound on a let-off reel **13**. This coil **13** is rotatably mounted within a swivel frame **14** and is provided with well-known braking means, such as a band brake (not shown), to provide tension in the cable being payed out. The swivel frame **14** is rotatably mounted on supports **15** and can be rotated by means of a motor **16** and conventional driving means, such as a variable ratio drive comprising two variable pulleys **17** and **19** and a V-belt **18**, or can be turned manually, if desired.

The cable which is payed out from reel **13** is unlayed before it reaches a first bearing disk unit **20**, shown in FIG. 2. A bearing housing **22** is fixedly mounted on a support **21** which stands on the floor **31**. A bearing disk **23** can freely rotate within said bearing housing **22**, and is provided with a plurality of equally spaced apertures **24** which are circularly located around the center of the disk **23**, and with a central bore **25**. The armor wires **12** of the unlayed cable **10** are lead through said apertures **24**, whereas the core portion **11** passes through said central bore **25**.

Subsequently, the armor wires **12** and the core portion **11** are lead through a second bearing disk unit **26** of an essentially analogous structure as disk unit **20**. The differences consist only in that preferably disk unit

26 is of larger size than disk unit 20 and in that the bearing disk of disk unit 26 is provided with drive means, such as a concentrically attached pulley 27 which can be rotated by means of a motor 30 and conventional connection means, such as a variable ratio drive comprising a variable pulley 29 and a V-belt 28.

The armor wires 12 and the core portion 11 are then lead to a third bearing disk unit 32, better shown in FIG. 3, and comprising support 33, a bearing housing 34 and a bearing disk 35. Said disk 35 can freely rotate within housing 34, and is provided with a plurality of equally spaced groups of apertures 36 which are circularly located around the center of the disk 35, and with a central bore 37. Thus, the armor wires are grouped in predetermined numbers, for example, in groups of two wires, while the core portion 11 passes through bore 37.

After the armor wires and the core portion have passed through the disk 35, fairing strips 38 of a flexible material, for example of polyurethane, and of a length which is approximately 12 times the width of the strips, are manually inserted under alternative groups of armor wires formed by disk 35, as shown in FIG. 4. Subsequently, the armor wires are re-layed on the core portion so that the fairing strips 38 are looped under the armor wires and held between them and the core portions. The formed fairing cable is then guided over a guide pulley 39 and wound at a second location on a take-up reel 40 which is rotatably mounted on support 41 and driven by a motor 42.

The motors 42, 30 and 16 can be commonly actuated by the operator who inserts the fairing strips by means of a foot-pedal 43. Each motor is provided with a conventional gear means to produce predetermined amounts of rotation which are synchronized with each other.

Further, a length counter device 44 can be provided to indicate the processed length of cable.

FIGS. 5 and 6 show a conventional cable 10 provided with fairing strips 38. Preferably, the core portion 11 comprises a multi-strand wire layer and the armor layer comprises an even number of wires. However, the method of the present invention is not limited to any special number of wires. Also, the core portion may comprise a tubular conduct or any other kind of generally cylindrical body, as well as a solid wire.

According to the method of the invention the fairing strips 38 are inserted under the armor wires in succession at the same angular position in the periphery of the cable, so that all fairing strips extend along the length of the cable in a straight line. This is automatically accomplished by longitudinally pulling the cable and simultaneously rotating the disks, which conducts the groups of armor wires, around the axis of the cable, so that each successive fairing strip can always be inserted at the same point under the respective armor wires.

According to a further feature of the method of the invention each successive fairing strip 38 is inserted under a group of armor wires and, particularly, in an alternative way. That is, for one revolution of the disk 35 every other group of armor wires is skipped, so that a predetermined securing angular pattern of insertions of the fairing strips is obtained. On the following revolution of the disk 35 the fairing strips are inserted under the alternate groups of armor wires which were omitted in the previous revolution, this alternation taking place with every revolution of the disk 35. This offers the advantages that the increase in diameter caused by the addition of the fairing strips and, consequently, the increase in bulkiness of the cable can be kept to a minimum, and that the axial displacement of the armor wires with respect to the core portion can be compensated by circumferentially shifting the positions of the re-layed wires compared to their positions before being unlayed. Further, a predetermined and regular spacing of the fairing strips can be achieved along the cable.

Preferably, each of said recurring groups of armor wires comprises two armor wires 12, as shown in FIGS. 5 and 6. But it can also comprise one or five wires, as shown in FIGS. 7 and 8, respectively, or any other number of wires, depending upon the total number and the thickness of the armor wires.

A second way of compensating for the relative axial displacement in the positions of the armor wires with respect to the core portion which would result in slackness of said core portion comprises, according to the invention, a relative twisting of the cable between the let-off coil 13 and the take-up coil 40. This twisting is achieved by rotating the swivel frame 14, for example by means of motor 16, in the same direction as the rotation of disk unit 26. This rotation will increase the action of unlaying the armor wires, which is mainly effected by the disk unit 26, whilst the core portion will remain essentially unchanged, so that an increase in the length of the armor wires will be available to compensate for the increase in diameter caused by the inserted fairing strips, and the core portion will not become slack. This compensating effect can be improved by using a cable, the core portion of which is wound in the direction opposite to the twist direction of the armor wires, so that the unlaying of the armor wires will be accompanied by a twisting and contraction of the inner core portion, due to the rotation of the swivel frame 14.

The main unlaying action, however, is effected by the disk units 20, 27 and 32. Theoretically, one driven disk unit alone, such as 27, would be sufficient, since the purpose of the rotating disk is to confer a rotation to the armor wires 12 around the non-rotating core portion 11 while the cable with the fairing strips 38 is pulled by the take-up reel 40. At the same time, however, a certain separation of the armor wires from the core portion must be maintained in order to keep the armor wires under tension. This apparent increase in length is due to the temporary suppression of the twist of the armor wires around the core portion, so that the armor wires are angularly displaced with respect to their usual position on the core portion. Therefore, the unlayed wires are initially radially diverging to the location comprising the disk units, and are converged thereafter. The use of two disk units permits an easier passage of the wires through the apertures because said separation of the wires from the core portion can be kept smaller and the changes of direction of the wire are also less pronounced. The use of three disk units improves that effect and, in addition, the last disk unit can be provided with groups of apertures, so that the desired group formation for the insertion of the fairing strips can be obtained. A change in the desired number of wires per group will require a change of the last disk unit or of its bearing disk 35, respectively.

When the operator actuates the foot-pedal **43** the motor **42** is actuated and causes the take-up coil to pull the prepared fairing cable. At the same time the motor **30** is also actuated and causes the ring **27** to turn, thus also rotating the corresponding bearing disk. The free rotating disks **23** and **35** will be taken along by the rotating armor wires **12**. The amount of rotation for each step of operating the foot-pedal **43** is predetermined by the formula:

$$A = 360°/n/G$$

whereby

A = angle of rotation

n = total number of armor wires per cable

G = number of armor wires per group

The amount of advance of the cable depends upon the twist of the cable and must be synchronized with the rotation of the bearing disk. It is therefore apparent that both movements are intermittent and can completely be controlled by the operator, who has to insert the fairing strips in the time period between successive steps of rotating and simultaneously advancing the armor wires.

It will be apparent that, an automatic insertion device could be used, and that the intermittent actuation of these motors could be coordinated with such an insertion device.

The motor **16** for the swivel frame is also operated by the foot-pedal **43** and its rotation depends mainly upon the twist of the cable **10**, and can be predetermined by one skilled in the art. However, the amount of rotation is considerably smaller compared with the rotation of the bearing disks.

An advantage of the method according to the present invention resides in the fact that by using pre-formed cable and unlaying it, the twist remains inherent in the armor wires and produces a very regular cable after the fairing strips have been inserted.

Other objects and advantages will be apparent from the following claims. Also, it is understood that many variations in the realization of the method and the apparatus according to the invention can be made by those skilled in the art without departing from the scope of the invention, which is defined in the appended claims.

The claims are:

1. Method of attaching flexible fairing strips to a cable having a core portion surrounded by a single multi-strand layer of pre-formed, helically wound armor wires comprising the steps of unlaying all of said armor wires for a predetermined distance, inserting a plurality of fairing strips under a succession of the armor wires, re-laying the armor wires on the core portion with the fairing strips looped thereunder, and compensating for the relative displacement in the positions of the armor wires with respect to the core portion caused by the addition of the fairing strips.

2. The method of claim **1**, wherein said compensation for the relative displacement comprises the step of circumferentially shifting the positions of the re-layed wires compared to their positions before being unlayed.

3. The method of claim **1**, wherein said core portion comprises a generally cylindrical body.

4. The method of claim **1**, which includes the steps of paying out unprepared pre-formed cable at a first location while restricting rotation of the cable, taking up prepared cable at a second location, confining the respective armor wires to a plurality of paths concentrically disposed about the core portion, each of said paths being initially radially diverging to a third location spaced between the first and second locations, and being converged thereafter, the radial distance of each armor wire from the core portion at said third location for each said confined path being uniform, and inserting said fairing strips under selected armor wires between said third and second locations.

5. The method of claim **4**, wherein said third locations for each said path lie in a common plane normal to the core portion.

6. The method of claim **4**, wherein the core portion of the cable includes a multi-strand wire layer helically wound in the direction opposite to the armor wires and said compensation includes the step of relative twisting of the cable between said first and second locations to unlay the armor wires and to twist said wires of the inner core portion.

7. The method of claim **4**, which includes the step of imparting a predetermined amount of rotation to the armor wires of the unprepared cable around the core portion in response to taking up of a predetermined amount of prepared cable.

8. The method of claim **4**, which includes the step of advancing the armor wires in a longitudinal direction between the insertion of each fairing strip.

9. The method of claim **8**, which includes the steps of inserting successive fairing strips under different wires in succession at the same angular position in the periphery of the cable.

10. The method of claim **5**, wherein the armor wires are angularly displaced at said third location with respect to their usual position on the core portion.

11. The method of claim **10**, which includes the step of confining the armor wires to a path which also passes another series of points concentrically arranged in a common transverse plane at a fourth location between the third location and one of the first two locations.

12. The method of claim **10**, which includes the step of confining the armor wires to a path which also passes through two series of points concentrically arranged, respectively in two common transverse planes at locations on respective opposite sides of the third location.

13. The method of claim **9**, wherein certain of the armor wires are skipped in a predetermined recurring angular pattern of insertions of fairing strips.

14. The method of claim **13**, wherein said recurring pattern of skipped wires is followed by a recurring similar pattern in which fairing strips are inserted under the wires which were skipped during the first pattern of insertions.

15. The method of claim **14**, wherein said fairing strips are inserted under recurring groups of adjacent wires.

16. The method of claim **15**, wherein each group comprises the same number of wires.

17. The method of claim **16**, wherein the total number of armor wires is even and the number of wires in each group is the same as the number of wires skipped between each insertion and comprises at least one wire.

18. The method of claim **17**, wherein each of said groups comprises two wires.

19. The method of claim 17, wherein each of said groups comprises five wires.

20. Apparatus for attaching a series of fairing strips to an armored marine cable of the type in which a longitudinally extending core is surrounded by a plurality of helically wound pre-formed armor wires, the combination including means to progressively unlay the armor wires corresponding to a length of the core sufficient to insert successive fairing strips under at least one of the armor wires at a predetermined station and to re-lay the armor wires around the core after successive fairing strips have been inserted, means to retain the armor wires in their corresponding relative angular positions while being unlayed and re-layed, means to progressively change the relative angular relationship between the core and the armor wires to compensate for the increase in diameter of the cable resulting from the insertion of the fairing strips, means to feed unlayed cable to said predetermined station, and means to remove faired cable from said station.

21. The apparatus of claim 20, wherein said means to progressively unlay the armor wires includes means to support said wires concentrically spaced away from the core and in angularly displaced relation thereto.

22. The apparatus of claim 21, wherein said means to support the armor wires includes at least one rotatably mounted bearing disk means, and power operated means for rotating said bearing disk means.

23. The apparatus of claim 22, wherein said means to remove faired cable from said station includes power operated take-up means, and means for actuating said take-up means and bearing disk means in synchronism with each other at correlated rates of speed.

24. The apparatus of claim 23, wherein said means for actuating the take-up means and bearing disk means includes manually actuated switch means for intermittent actuation by an operator at said predetermined station.

25. The apparatus of claim 23, wherein said means for feeding unlayed cable includes let-off reel means.

26. The apparatus of claim 25, wherein said let-off reel means includes a mounting for a reel of cable and means for rotating said reel about an axis normal to the axis of the reel.

27. The apparatus of claim 26, wherein said means for rotating a reel includes power operated rotating means.

28. The apparatus of claim 27, wherein said means for actuating the take-up means and bearing disk means includes means for actuating said rotating the let-off reel in synchronism and at a correlated rate of speed.

29. The apparatus of claim 28, wherein said means for actuating the take-up means, bearing disk means and let-off means includes switch means for intermittent actuation by an operator at said predetermined station.

30. The apparatus of claim 22, wherein said bearing disk means includes a plate provided with a circularly arranged series of apertures to receive said armor wires and a central opening for the core, and means to support the plate for rotation abut its central axis parallel to the direction of movement of a cable.

31. The apparatus of claim 30, wherein said apertures are arranged in groups, each group being circumferentially spaced from the adjacent groups.

32. The apparatus of claim 30, wherein the bearing disk means includes electric motor means and means connecting the motor means for rotating said plate.

33. The apparatus of claim 32, wherein said means connecting the motor means and plate includes variable ratio drive means.

34. The apparatus of claim 32, wherein said means to remove faired cable includes a take-up reel and electric motor means to drive said take-up reel, said electric motor means including variable speed control means for rotating the plate at an angular rate of speed proportional to the linear rate of speed of movement of the faired cable.

35. The apparatus of claim 34, wherein said variable speed means includes variable ratio drive means connecting the plate and an electric motor means.

36. The apparatus of claim 35, wherein said variable speed means includes manually operable actuating means for intermittent operation of said electric motor means.

37. The apparatus of claim 36, wherein said variable speed means includes variable ratio drive means connecting an electric motor means and said plate and manually operable switch means for controlling said electric motor means.

38. The apparatus of claim 34, wherein said means to feed cable includes a let-off reel supported for rotation about both the axis of rotation of the reel and a second axis normal to the axis of rotation of the reel, and electric motor means including variable speed means to control rotation about said second axis at an angular rate of speed proportional to the linear rate of movement of the faired cable.

39. The apparatus of claim 38, wherein said variable speed means includes manually operable switch means for controlling said electric motor means.

40. The apparatus of claim 30, wherein said bearing disk means includes at least two plates, each of the plates being provided with a circularly arranged series of apertures to receive said armor wires and a central opening for the core, and means to mount said plates in spaced parallel relationship for rotation about their respective central axes parallel to the direction of movement of a cable.

41. The apparatus of claim 40, wherein said bearing disk means includes electric motor means including variable speed drive means for rotating one of said plates.

42. The apparatus of claim 41, wherein said bearing disk means includes a third plate provided with a circularly arranged series of apertures to receive said armor wires and a central opening for the core, and means to mount the third plate in spaced parallel relationship to the first mentioned two plates for rotation about its central axis parallel to the direction of movement of the cable.

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