United States Patent [19]

Miura

[11] **3,899,206**

[45] **Aug. 12, 1975**

[54] **ENDLESS ROPE SLING**

[76] Inventor: **Kitie Miura,** No. 51 Higashi-Oyashiki, Katahari-machi, Gamagoori, Japan

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[21] Appl. No.: **414,719**

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Nov. 14, 1972	Japan	47-114525
Nov. 14, 1972	Japan	47-114526
Nov. 14, 1972	Japan	47-114527

[52] **U.S. Cl.** **294/74**

[51] **Int. Cl.²** **B66C 1/12**

[58] **Field of Search** .... 294/74, 73; 24/735 A

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Primary Examiner—James B. Marbert
Attorney, Agent, or Firm—Bucknam and Archer

[57] **ABSTRACT**

Herein disclosed is a multi-layered endless rope sling made of continuous nylon filament yarns. The endless rope sling comprises a core including a plurality of substantially concentric layers, which are consecutively braided from the nylon filament yarns in a manner to cover one with another, and a sheath including at least one substantially concentric layer which is consecutively braided from the filament yarns in a manner to cover the outermost layer of said core. A method of braiding the filament yarns into the endless rope sling is also disclosed, which comprises the steps of braiding the filament yarns into a rope of a predetermined length, bringing the leading end of said rope into contact with the trailing end, which is being braided, so as to form an endless rope, and continuing the braiding operation so as to consecutively cover one layer, which has been braided, with another which is being braided, thereby forming the multi-layered endless rope sling. In order to put the method into practice, the apparatus disclosed includes a plate structure, which is formed with an opening for continuously allowing a running endless rope under the braiding operation to pass therethrough, and to which a structural member is removably attached for allowing the manufactured endless rope sling to be taken out from the opening, and a plurality of guide rollers for guiding the running endless rope under a predetermined tension.

7 Claims, 14 Drawing Figures

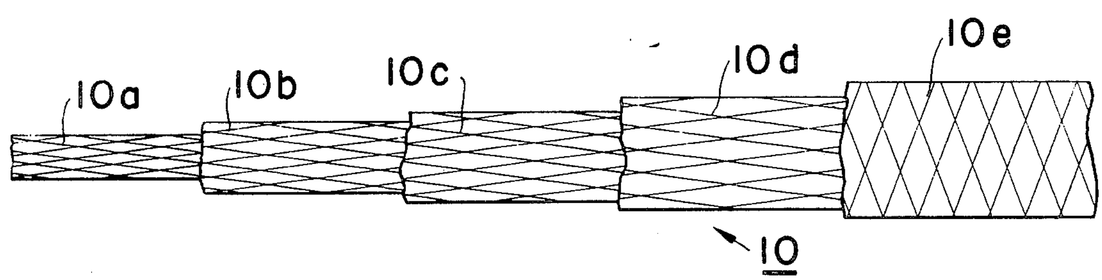


FIG.1

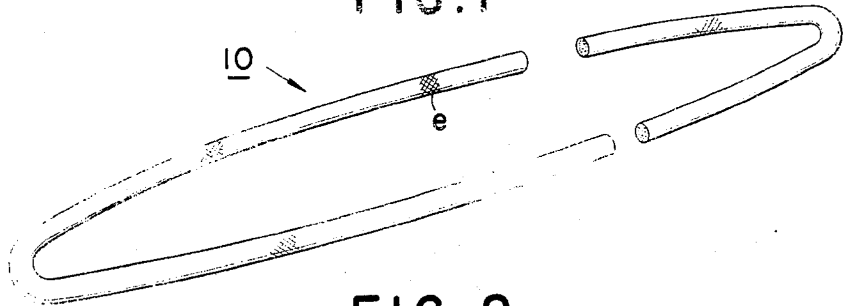


FIG.2

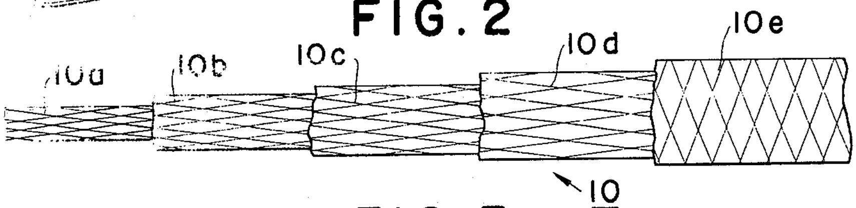


FIG.3

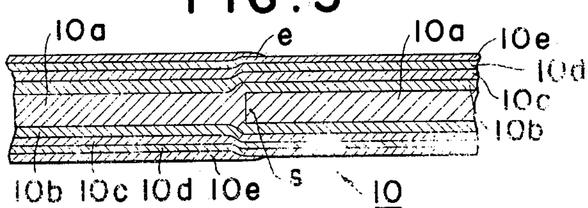


FIG.4

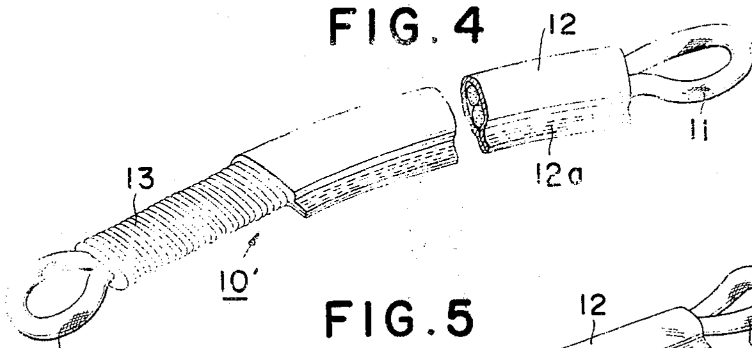


FIG.5

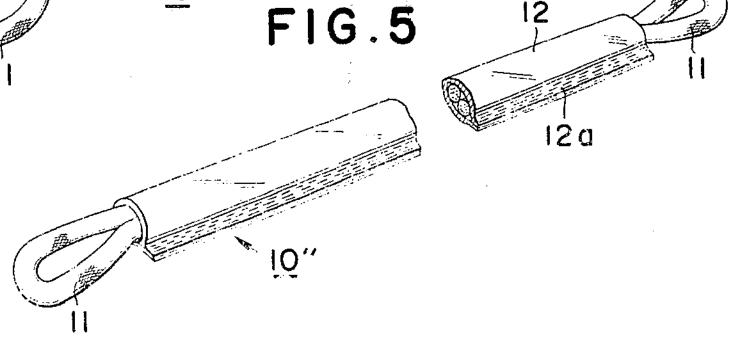


FIG. 6

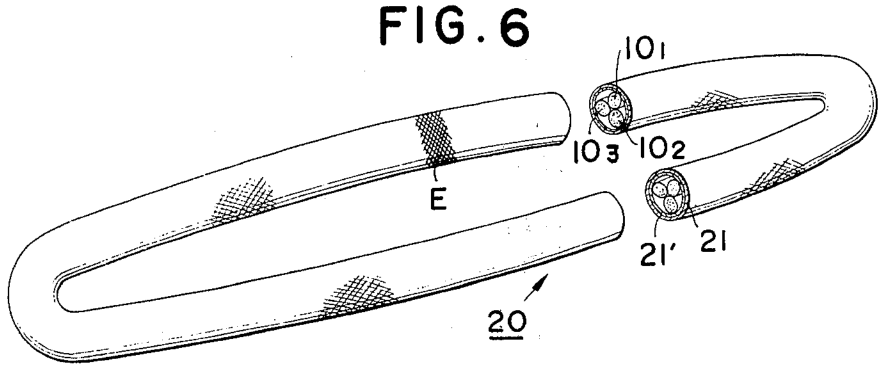
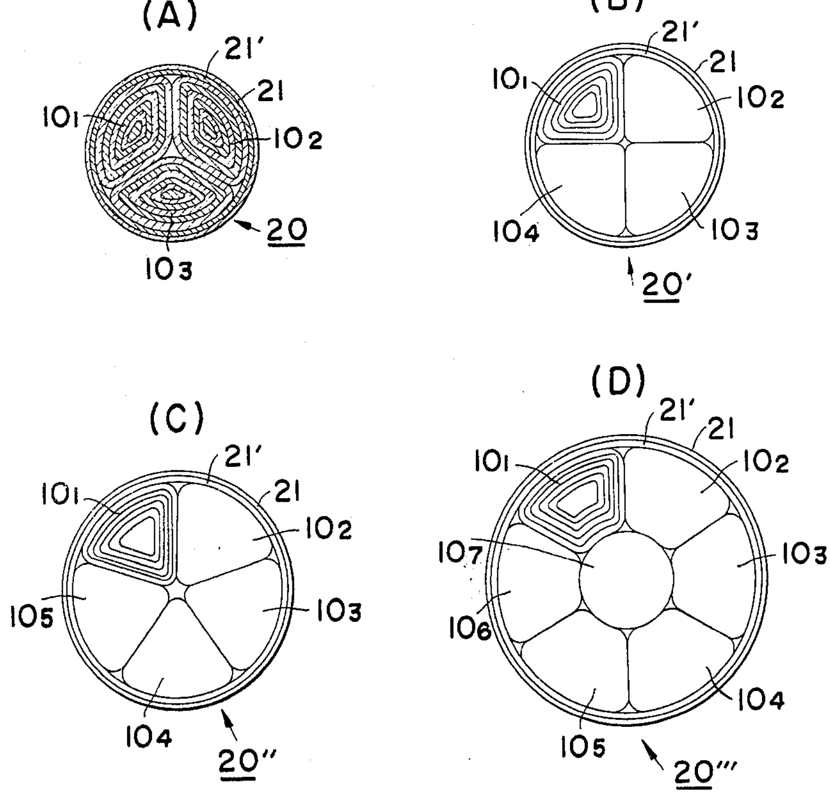

10₁
10₃
10₂
E
21'
21
20

FIG. 7


(A)
21'
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(B)
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10₃
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FIG. 8

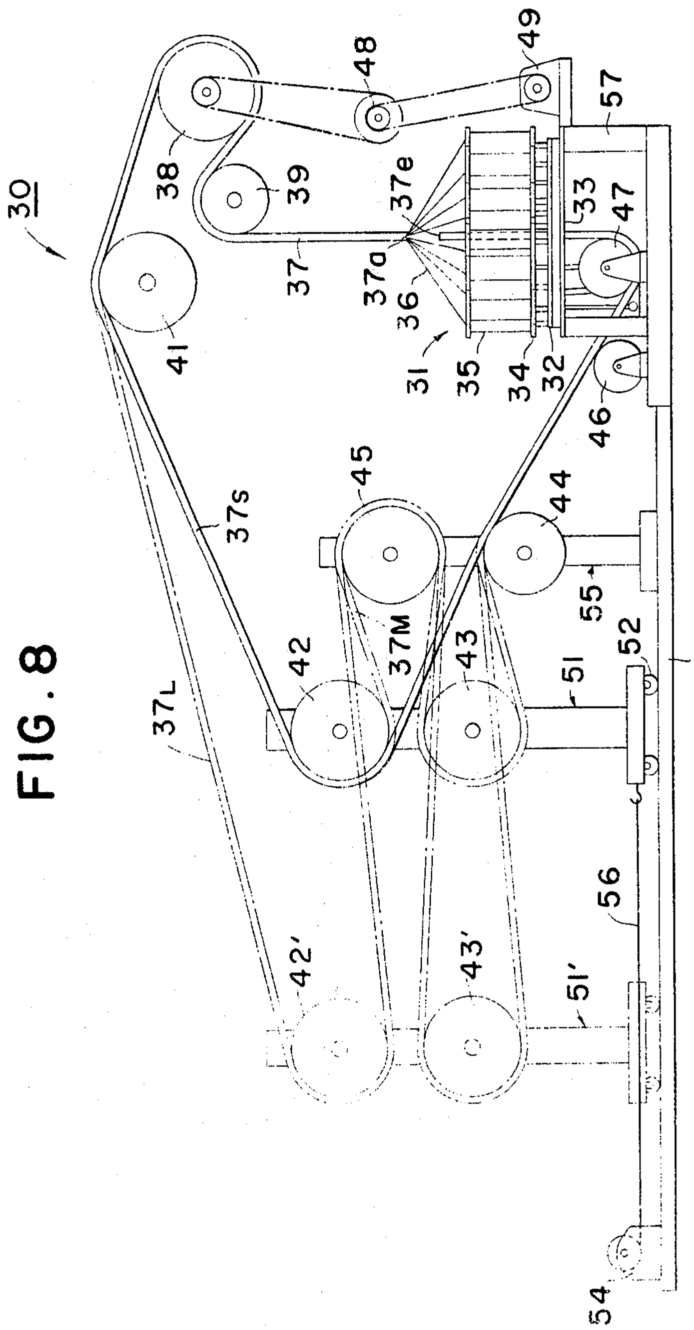
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FIG. 9

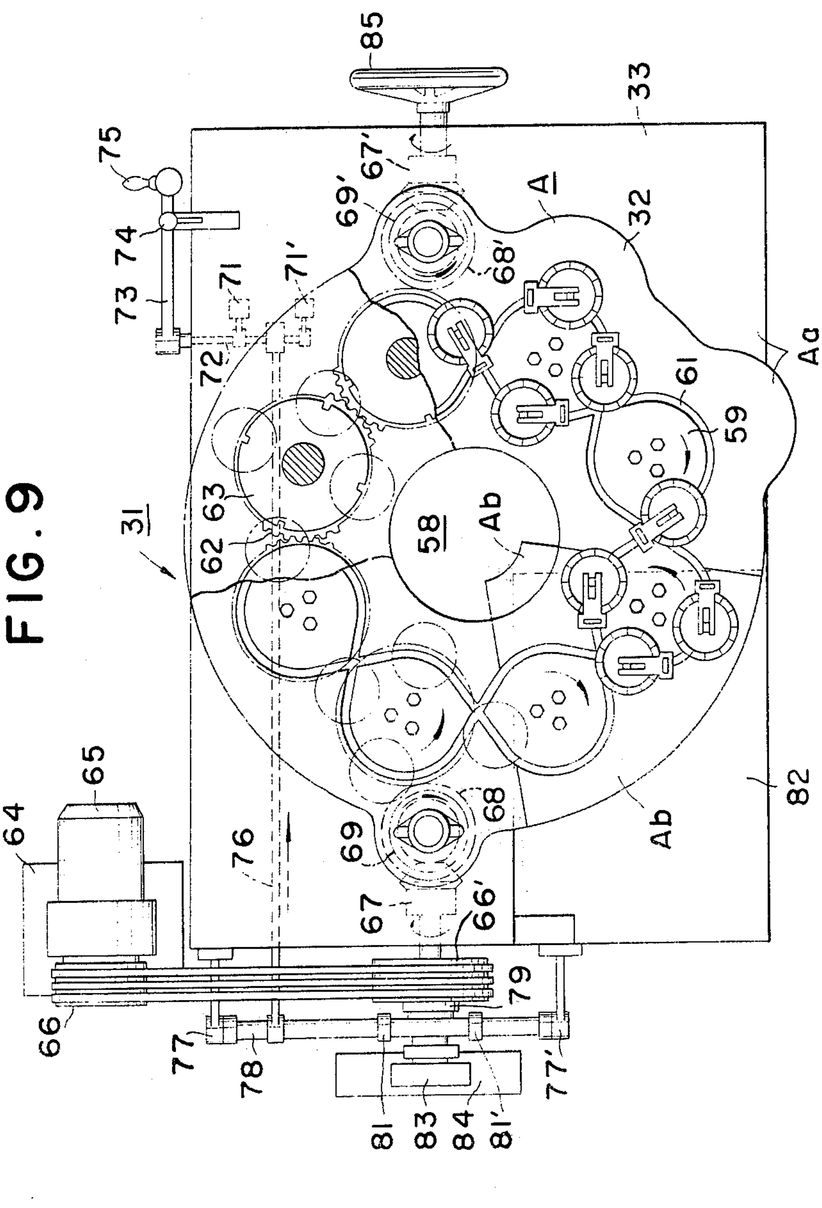
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FIG. 10

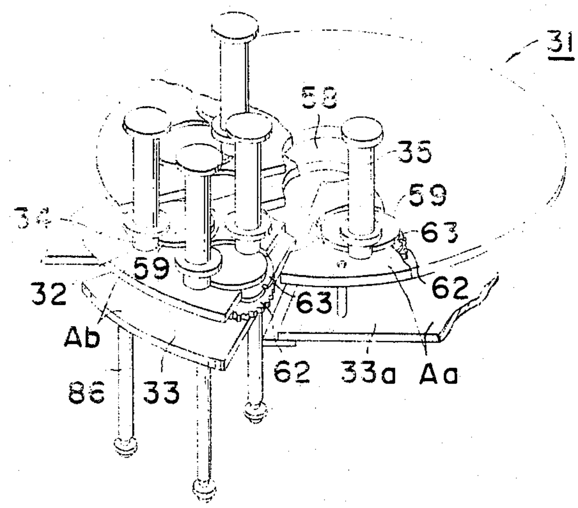
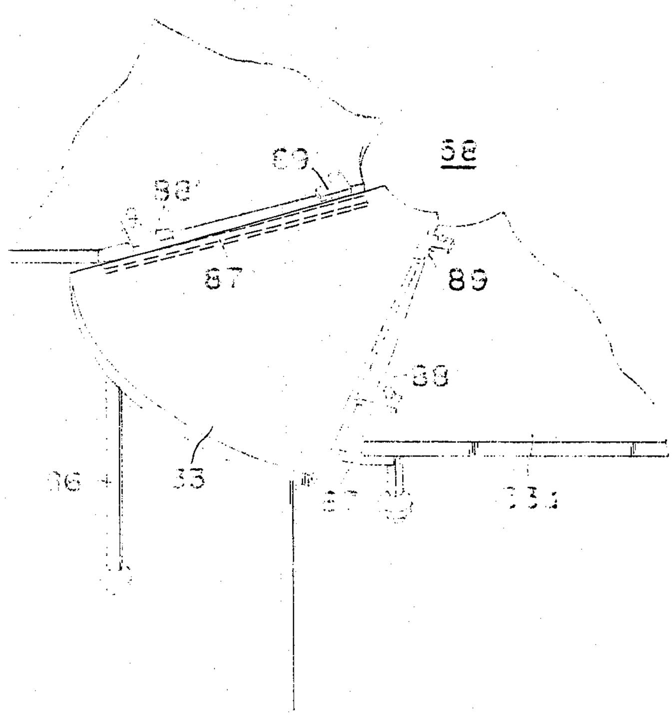


FIG 11



ENDLESS ROPE SLING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a rope sling, and more particularly to a multi-layered endless rope sling which has its layers successively braided from continuous filament yarns. The present invention further relates to a method of and an apparatus for successively braiding continuous filament yarns into the multilayered endless rope.

2. Description of the Prior Art

When it is intended to hoist or lower heavy weights with use of a crane or hoist, it is a current practice to employ a steel wire rope. With the recent increase in the weight and volume of the article or object to be hung, the diameter and length of the wire rope has accordingly increased to invite not only considerable reduction in the fastening efficiency of the wire rope around the article but also augmentation of the operator's fatigue. With such increase, moreover, it is sometimes requested to hang an article weighing more than 100 tons. It is, however, above the present level of technology to manufacture a wire rope which can meet sufficiently the particular requirement. Because the present technology can hardly form an eye piece for a steel wire rope having a diameter exceeding about 50 mm or 60 mm. Even with the larger diameter of about 60 mm, however, the wire rope can hang at the heaviest about 100 tons when the handing angle is 0° with four hanging points and with a safety factor of seven. On the other hand, the latest crane can hoist an article weighing about 600 tons, and as such being the case a demand for hanging an article of more than 100 tons does exist actually, which demand cannot be satisfied in the least in respect of the hanging wire rope.

Recently, a nylon belt sling has been developed as a promissing rival of the steel wire rope. This nylon belt sling is made of nylon filament yarns having a highly breaking or tensile strength, and can be appreciated in its easy handling without resorting to formation of the eye splice, which is concomitant with the steel wire rope. The nylon belt sling can also be appreciated in its excellent properties including excellencies in resistance to wear, flexibility, stability and shock absorbability. One of the strongest nylon belt sling available has dimensions of 200 mm width and 12 mm thickness and a breaking strength of 80 tons. Thus, the nylon belt sling of the strongest type can hoist an article of about 40 tons, if the article is hung at four points and if a safety factor of eight is assumed. When, therefore, it is intended to hoist an article of about 100 tons, then the width of the belt sling has to be about 500 mm or the thickness of the same has to be about 30 mm. The belt sling of such enlarged cross-section is not available, because the present industrial sewing machine can barely manufacture a belt of about 300 mm width or of about 20 mm thickness.

SUMMARY OF THE INVENTION

It is, therefore, a primary object of the present invention to provide a rope sling which can hang a highly heavy article.

Another object of the present invention is to provide a multi-layered endless rope sling which has its layers successively braided from continuous filament yarns.

Still another object is to provide a multi-layered endless rope sling of the above type, in which the inside layers forming a core are braided from continuous nylon filament yarns at a small braiding angle.

A further object is to provide a composite endless rope sling which includes a plurality of tightly bundled endless ropes of the above type and a sheath braided from the filament yarns to tightly cover the bundled endless ropes.

A further object is to provide a method of consecutively braiding the filament yarns into the multi-layered endless rope of the above type.

A further object is to provide an apparatus for consecutively braiding the filament yarns into the multilayered endless rope of the above type.

According a major aspect of the present invention, an endless rope sling is provided, which comprises a core including a plurality of substantially concentric layers consecutively braided from continuous filament yarns in a manner to cover one with another, and a sheath including at least one substantially concentric layer consecutively braided from the continuous filament yarns in a manner to cover the outermost layer of the core.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a perspective view showing a multi-layered endless rope sling according to the present invention;

FIG. **2** is a cut-away view showing a portion of the multi-layered endless rope sling of FIG. **1** with its layeres being stepwise cut away;

FIG. **3** is a partial section taken along the axis of the multi-layered endless rope sling of FIG. **1**;

FIGS. **4** and **5** are similar to FIG. **1** but show modifications of the multi-layered endless rope sling of FIG. **1**;

FIG. **6** is similar to FIG. **1** but shows a composite endless rope sling including a plurality of the multi-layered endless ropes of FIG. **1**;

FIG. **7**(A) is a cross-sectional view showing the composite endless rope sling of FIG. **6**;

FIGS. 7(B) to 7(D) are similar to FIG. 7(A) but show the modifications of the composite endless rope sling of FIGS. **6** and **7**(A);

FIG. **8** is a diagrammatical view showing the overall construction of an apparatus suitable for manufacturing the multi-layered endless rope sling of FIG. **1**;

FIG. **9** is a partially cut-away top plan view showing a main body of the apparatus of FIG. **8**;

FIG. **10** is a perspective view showing such a portion of the main body of FIG. **9** as is removable according to the present invention to allow the endless rope sling of FIG. **1** from an opening; and

FIG. **11** a simplified but enlarged view showing the removable portion of FIG. **10**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made to FIGS. **1** to **3**, in which an endless rope sling according to the present invention is shown. Generally indicated at reference numeral **10** is one embodiment of the endless rope sling, which has its sheath terminating at such a portion as indicated at reference letter *e*. This termination *e* is fixed in position to a multi-layered core by a suitable heat treatment.

The endless rope sling **10** may be made of ten or more layers including the sheath, but, in the present embodiment, it is composed of a core having four layers **10***a*, 10*b*, 10*c* and **10***d*, and of the outermost layer or sheath **10***e*, for illustrative purposes only, as seen from FIGS. **2** and **3**. These core-constituent layers **10***a* to **10***d* and the sheath **10***e* are manufactured by braiding a desired number of continuous filament yarns, which are made of a thermoplastic resin such as nylon. This braiding operation is carried out such that the layers **10***e*, 10*d*, 10*c* and **10***b* cover, respectively, the layers **10***d*, 10*c*, 10*b* and **10***a*. As shown in FIG. **2**, the braiding angle of angles of inclination of the filament yarns, which constitute themselves into the inner layers **10***a* to **10***d* of the core, with respect to the axis of the rope sling **10** is much smaller than that of the filament yarns of the sheath **10***e*. More specifically, the former angle or angles is desirably preset about 5° to 20°, whereas the latter about 45° to 60°.

As to these angles of inclination, it is well known in the art that the breaking strength of a rope sling depends remarkably upon the twisting pitch of the constituent filament yarns. For example, let is be assumed that the breaking strength of steel wires assumes 100 when they are just bundled, and then the strength will be reduced to 80 to 90 when they are twisted and braided into a single steel wire rope. For a rope made of a thermoplastic synthetic resin filaments, on the other hand, the reduced strength is about 50. Taking such material reduction in the breaking strength due to the fact that the filament yarns are subjected to twisting, it is desirable that they should be inclined with respect to the axis of the rope sling as slightly as possible.

In the present invention, therefore, the filament yarns of the core-constituent layers **10***a* to **10***d* are arranged almost in parallel with the sling axis, because the breaking strength of the rope sling **10** is wholly given by the core. The braiding angle of the sheath **10***e* is, however, at a normal value of about 45° to 60° so that the undesirable sliding of the filament yarns and accordingly the resultant deformation of the rope sling **10**, both of which are otherwise experienced frequently, can be prevented. With such large braiding angle, therefore, the sheath **10***e* cannot give rise to the tensile strength of the rope sling **10** as a whole, but can tightly retain the inner core layers **10***a* to **10***d* and is contributable to stability in shape of the rope sling **10**. Although this sheath **10***e* may have one layer in the case where the total number of layers of the rope sling **10** is less than five as in the present embodiment, it is preferable that the sheath **10***e* has two layers in the case where the total number of layers exceeds five.

Indicated at reference letter *s* in FIG. **3** is an initial portion of the innermost layer **10***a* of the core, at which portion *s* the braiding of the present endless rope sling **10** is initiated. In more detail, the filament yarns are braided at a slight angle with each other to form the innermost layer **10***a*. After the braiding action has proceeded to a predetermined extent, the initial portion *s* is suitably inserted into and fixed to the braided portion of the innermost layer **10***a* to afford the same a predetermined length to the finally obtainable rope sling **10.** The braiding action is then further continued with use of the continuous filament yarns so that the layer **10***a* may be covered with the second layer **10***b*. This second layer **10***b* is then covered with the third layer **10***c*, and on and on. The fourth layer **10***d* is finally covered with the outermost layer or sheath **10***e* which is braided at a relatively large angle from the continuous filament yarns. Although, in this instance, the sheath **10***e* has its termination *e* axially at the same position as the initial portion *s* so as to give a uniform tensile strength to the obtainable rope sling **10,** it should be understood that the location of the termination *e* can be varied. Since, in either event, the present rope sling **10** is different from the conventional belt sling, in which two or more sheets of cloth of a thermoplastic synthetic resin filaments are placed one upon another to have their ends sewed to each other, the rope sling **10** can have a substantially uniform tensile strength.

In order to augment the tensile strength and to attain an increased frictional effect, which is important to secure hanging of a load by means of the rope sling **10,** it is preferable that the rope sling **10** is subjected by the dipping method to a coating process of a synthetic resin or rubber, after the braiding action has been finished.

The endless rope sling **10** thus manufactured can be used as a sling as it is, but may be modified for strengthening purposes in a manner as shown in FIGS. **4** or **5.** In a modification of FIG. **5**, the rope sling **10''** is made to have its central portions arranged in contact with each other such that the end portions are left in the form of eyes or hanging loops **11.** The central portions are tightly covered with a thick woven fabric **12** which is adhered to each other at its edges **12***a*, thus forming an annular sheath **12.** In another modification of FIG. **4**, moreover, the rope sling **10'** has its central portions tightly wound with a rope **13,** which may be made of a similar material, before they are covered with the annular sheath **12.**

In the following, the tensile strength of the present endless rope sling will be tabulated in respect of the results which are obtained with use of the Amsler tensile testing machine or by the actual test using a crane.

TABLE

Endless Rope Constituent Filament Yarns	Calculated Strength	Breaking Strength	1/8/Safety Hanging	Two Point Hanging	Four Point Hanging	Diameter (mm)	m/Weight (Kg)
1260D × 10 × (10.08 Kg) 3 × 2 × 8 = (480 Yarns) 4.83 (tons) 6 Core Layers + 2 Sheath Layers 2880 Yarns / 29.0(tons)	58.0(tons)	43.5(tons)	5.4(tons)	about 10 (tons)	about 20 (tons)	30	0.73
1260D × 10 × 5 × 2 × 8 = 8.04(tons) 7 C.L. × 1 S.L.	116.2(tons)	87.15(tons)	10.89(tons)	about 20 (tons)	about 40 (tons)	38	1.3

TABLE -Continued

Endless Rope Constituent Filament Yarns	Calculated Strength	Breaking Strength	1/8/Safety Hanging	Two Point Hanging	Four Point Hanging	Diameter (mm)	m/Weight (Kg)
2520D × 10 × 5 × 2 × 8 = 16.128(tons) 5 C.L. + 1 S.L.	161.28(tons)	120.96(tons)	15.12(tons)	about 30 (tons)	about 60 (tons)	45	1.8
1260D × 10 × 3 × 2 × 8 = 4.83(tons) 23 C.L. + 2 S.L.	222.6(tons)	166.95(tons)	20.8(tons)	about 40 (tons)	about 80 (tons)	58	2.2
2520D × 10 × 5 × 2 × 8 = 16.128(tons) 9 C.L. + 2 S.L.	290.3(tons)	217.7(tons)	27.2(tons)	about 50 (tons)	about 100 (tons)	62	2.6
2520D × 10 × 5 × 2 × 8 = 16.128(tons) 14 C.L. + 2 S.L.	451.4(tons)	338.5(tons)	42.3(tons)	about 80 (tons)	about 160 (tons)	70	4.5
2520D × 10 × 5 × 2 × 8 = 16.128(tons)	580.6(tons)	435.4(tons)	54.4(tons)	about 100 (tons)	about 200 (tons)	80	6.0

Note:
1. The breaking strength is at 75% efficiency.
2. The strength calculation is based on the relation D/8 g, that is, the yarn has a strength of 8 g per D (denier).
3. The strength of the sheath layer or layers is not introduced into the calculation.
4. The Equation "1260D × 10 × 3 × 2 × 8 = 4.83(tons) means that ten filament yarns of 1260D are doubled, three of which are arranged together with for braiding operation with use of eight pairs of paired bobbines.
5. The two or four point hanging is carried out at a hanging angle of 0 degrees.

Turning now to FIGS. **6** and **7**(A) to **7**(D), generally indicated at reference numeral **20, 20', 20''** and **20'''** are endless rope slings of composite type, each of which includes a plurality of bundled rope slings **10** of the first embodiment and a sheath covering them. As shown in FIGS. **6** and **7**(A), the composite endless rope sling **20** is composed of three bundled rope slings 10_1, 10_2 and 10_3 and of two sheath-constituent layers **21** and **21'**.

These sheath layers **21** and **21'** are formed by the later-described braider according to the present invention, in which the bundled rope slings 10_1 to 10_3 are tightly covered with braided filament yarns to form a unitary structure. Since, in this instance, the sheath layers **21** and **21'** will not aid in increase in the tensile strength of the composite rope sling **20**, the braiding angle may have a normal or relatively large value. Although, moreover, the inner sheath layer **21'** may desirably be dispensed with, two-layer construction is preferable with a view to ensuring tightening the rope slings 10_1 to 10_3 as well as maintaining the desired shape.

Then, the termination E of the outer sheath layer **21** thus braided is also fixed in position by the heat treatment. Moreover, the obtained rope sling **20** as a whole is dipped into a bath so that it is coated with a synthetic resin or rubber.

The filament yarns to be braided into the sheath may be made not only of nylon but also of such a variety of materials as are used in the filament yarns of the rope slings 10_1 to 10_3. In other words, the cutting strength of the sheath can be so preset by selecting a suitable material that its wear or cut can be a measure of disposal of the rope sling **20** as a whole.

In a modification, moreover, the sheath layers **21** and **21'** may also be made of wound nylon ropes, that is, the three rope slings 10_1 to 10_3 are gathered to form a bundle, on which a nylon rope is tightly wound and then is subjected to the coating treatment.

In a still another modification, the sheath layers **21** and **21'** may further include an annular sheath of thick woven fabric covering the wound rope.

With close reference to FIG. **7**(A), the rope slings 10_1 to 10_3 are shown to be considerably separated from each other, but actually they are so closely tightened as to have their boundaries merging into each other. The composite rope sling **20'** is composed of four rope slings 10_1 to 10_4, as shown in FIG. **7**(B). The other rope slings **20''** and **20'''** are, on the other hand, composed of five and seven rope slings 10_1 to 10_5 and 10_1 and 10_7, respectively, as shown in FIGS. **7**(C) and **7**(D).

The testing results regarding the breaking strength of the present rope sling, which were conducted with use of the testing machine No. T - **687** by the Industrial Association of Cloth Rope of Aichi Prefecture in Japan, will be presented in the following.

(1)

Sling-Constituent Rope **10**

Number of Rope-Constituent Yarns

1260(denier) × 10(doubling) × 3(doubling) × 2(paired bobbins) × 8(pairs) × 5(core layers) = 2400(yarns)

Calculated Strength of Core

24.2(ton) (where strength per denier is 8 g and strength per yarn is 10.08 kg)

Calculated Strength of Rope

48.4(ton)

Standard Strength (for Efficiency of 75%)

36.3(ton)

Diameter of Rope

29(mm)

Weight of Rope

0.64(kg)

Length of Rope

9.5(m)

Testing Results

Actual Strength: 39.4(ton) (Efficiency of 81.4%)

Elongation (for ⅓ cut):9.0(%)

(for total cut):14.5(%)

(2)

Rope Sling **20** with Three Ropes 10_1 to 10_3

Calculated Strength of Core

72.6(ton)

Calculated Strength of Rope Sling

145.2(ton)

Diameter of Rope Sling

54(mm)

Weight of Rope Sling
1.81(kg)
Length of Rope Sling
9.4(m)
Testing Results
Actual Strength: 112.5(ton) (Efficiency of 77.5%)
Elongation(for 1/3 cut):10.8(%)
(for total cut):16.0(%)

As is apparent from the above testing results, the actual strength of the rope having five-layer core is as high as 81.4 percent of its calculated strength, and the actual strength of the rope sling **20** having three ropes $\mathbf{10}_1$ to $\mathbf{10}_3$ is also as high as 77.5 percent of its calculated strength. It can also be appreciated that the elongation is considerably small for the rope **10** and the rope sling **20.** Taking the progressive reduction in the strength efficiency with increase in number of the core layers into consideration, therefore, a rope sling having three or four ropes which respectively has about five core-layers is more efficient than a simple rope sling of larger diameter, which is made of much more core-layers, for a load of the same weight.

The endless rope sling **20** can hang a load of about 56 tons, if the hanging is carried out at four points and if the safety factor of **8** is adopted. This limit weight of hanging can be increased more if the filament yarns of about 2560 deniers, if the sling-constituent ropes are more than three as is shown in FIGS. 7(B) to 7(D), and/or if the rope itself has more core-layers than four.

Turning now to FIG. **8,** the method of manufacturing the endless rope sling according to the present invention will be described with reference to FIG. **8,** in which a braiding apparatus is generally indicated at reference numeral **30.** A main body **31** of the braiding apparatus **30** includes a plate structure composed of upper and lower stationary plates **32** and **33,** which are horizontally disposed at a spacing from each other. This upper plate **32** is formed with a plurality of openings which are positioned along a periphery of a circle. A plurality of specially shaped plate members are disposed in the openings of the upper plate **32** for defining inbetween two passages which are undulating radially of the circle. In the undulating passages are movably mounted a plurality of upright spindles **34,** on which a plurality of bobbins **35** are mounted for feeding continuous filament yarns **36.** These filament yarns **36** are braided at a braiding point **37***a* into an endless rope **37,** as shown. For this purpose, a spindle transfer mechanism (which will be detailed later) is interposed between the upper and lower plates **32** and **33** and is engaged with the spindles **34** for successively moving the latter in the passages. In addition, a power transmission mechanism is also interposed between the upper and lower plates **32** and **33** and connected with the spindle transfer mechanism for actuating the latter.

Downstream of the braiding point **37***a* is a pulling pulley **38** which is operative to pull the braided rope **37** in synchronism with the angular speed of the spindles **34.** The rope **37** thus pulled is guided in the form of an endless rope by guide means which is also disposed downstream of the braiding point **37***a*. This guide means includes a plurality of guide pulleys **39, 41, 42,** 43, **44,** 45, **46** and **47.** More specifically, the pulling pulley **38** has a relatively large diameter and is rotatably supported by a bracket bearing which is mounted on a frame. To the end of a shaft of the pulling pulley **38** is secured a gear which is driven through a chain by

a gear of a reduction gear mechanism **48.** This reduction gear mechanism **48** is driven through an endless belt by a prime mover or electric motor **49.**

With closer reference to FIG. **8,** the method of braiding the continuous filament yarns **36** into a multilayered endless rope sling in accordance with the present invention will be described in the following. First of all, location of the guide pulleys **42** and **43** is accomplished in dependence upon a desired length of the endless rope **37.** These pulleys **42** and **43** are rotatably supported by a movable stand **51,** on the bottom of which rollers **52** are rotatably mounted. These rollers **53** can run on two parallel rails **53** which extend toward the main body **31** of the braiding apparatus **30.** The running operation of the stand **51** is carried out by a winch **54,** which is disposed in the vicinity of the end of the rails **53,** as shown at the lefthand side of FIG. **8.** The guide pulleys **44** and **45** are, on the other hand, rotatably supported by a stationary stand **55.** Thus, the endless rope **37** coming from the pulling pulley **38** is led through the stationary guide pulley **41** to the guide pulleys **42** and **44,** as shown by a solid line **37***s*. The tension to be applied to the endless rope **37***s* can be maintained at a constant level by moving the movable stand **51** and accordingly the guide pulley **42** toward and away from a frame **57** of the main body **31.**

At the next stage, the bobbins **35,** on which the filament yarns **36** made of nylon and having a suitable denier selected in accordance with the desired diameter of the final rope and with the desired number of the layers are wounded, are attached to the spindles **34.** Then, the leading ends of the filament yarns **36** are extracted from the respective bobbins **35** and are bundled to be tied to the trailing end of a flexible guide member or leading wire (not shown). This wire has the same length as that of the final endless rope. Then, the leading end of the wire is guided along some of the pulleys **39, 38,** 41, 42 and, **44** and is fed to a suitable take-up mechanism (not shown). This take-up mechanism may preferably be disposed in the vicinity of the main body **31.** The leading wire may also be manually taken up at the same speed as the pulling speed of the pulling pulley **38.**

After the above preparatory steps have been completed, the main body **31** and the pulling pulley **38** are brought into operating conditions, and the take-up mechanism is concurrently started at the same speed of the pulling pulley **38.** Thus, the filament yarns **36** are braided at the braiding point **37***a* at a predetermined braiding angle into the innermost layer of the endless rope **37,** by the cooperation between the radially undulating horizontal movements of the bobbins **35** and the upward pulling operation of the pulling pulley **38,** the detail of which will be described later. The rope layer thus braided is led through the guide rollers to the take-up mechanism.

When, moreover, the trailing end of the leading wire comes close to the take-up mechanism, the operations of the main body **31** and the take-up mechanism are discontinued to untie or cut the tied portion between the leading wire and the ends of the filament yarns. Then, the leading end **37***e* of the rope **37** is inserted into the braiding point **37***a* through an opening, which is formed in the plate structure of the main body **31,** although not shown. After that, the braiding operation is started again to cover the innermost layer with an outer second layer of the braided filament yarns. More specifically, the braided single layer is successively subjected to the braiding action at the braiding point **37***a*, and is pulled by the pulling pulley **38** through the guide pulley **39**. Then, the single layer is further guided to the guide pulley **47** by way of the guide pulleys **42, 44** and **46,** successively in this order. The final guide pulley **47** is so disposed in the frame **57** as to guide the rope **37** upwardly to the braiding point **37***a* through the opening. Thus, a desired number of layers can be consecutively braided from the filament yarns **36** in a fashion to cover one with another.

In order to obtain a uniform braiding angle, it is necessary to increase the pulling speed of the pulling pulley **38** for the outer layer. As has been described, moreover, the tensile strength of a braided rope is known to depend inversely proportionately upon the inclination of the constituent filament yarns with respect to the axis of the rope. With this in mind, the braiding angle of the core layers should be as small as possible. Since, in this respect, the braiding angle is known to be determined mainly by the relation between the pulling speed of the rope and the running angular speed of the bobbines, the former speed is increased and the latter speed is decreased when the core layers are being braided. This control of speed can be automatically accomplished in the present invention by resorting to the reduction gear mechanism **48.**

After a predetermined layers including at least one sheath layer have been formed, the operations of the main body **31** and the pulling pulley **38** are stopped. Then, the ends of the filament yarns **36** are cut at the braiding point **37***a*, and the winch **54** is actuated to move the stand **51** toward the main body **31** so as to loose the rope **37***s*. Then, a portion of the plate structure of the main body 4 **31** is removed to allow the rope **37***s* to be taken out from the opening of the main body **31.** After that, the rope **37***s* is also taken out from the pulleys **38, 39, 41, 42, 44, 46** and **47.** The cut end of the outermost sheath layer is fixed in position to the next inner layer by a suitable heat treatment or the like. The endless rope thus manufactured is usually coated with a synthetic resin or rubber so as to improve its fatigue allowance and to increase its frictional force.

When it is intended to obtain a longer endless rope, on the other hand, the guide pulleys **41, 42, 45, 43** and **44** are used in this order in addition to the pulleys **38,** 39, 46 and 47, as shown at two chain lines 37_M. For a longer endless rope 37_L, the stand **51** is moved apart from the main body **31** to a position as shown at **51′**, and the rope 37_L being braided is made to run along the guide pulleys **41, 42′, 45, 43′** and **44.**

The details of the present braiding apparatus, especially, the construction of the main body **31** will now be described with reference to FIGS. **9** to **11.** As better seen from FIGS. **9** and **10**, the plate structure is composed of two portions A*a* and A*b*, the latter of which can be removed from the former. The upper plate **32** of the plate structure has a generally circular shape, whereas the lower plate **33** has a generally rectangular shape excepting its removable fan-shaped portion A*a*. The plate structure is formed substantially at its center with an opening **58**, through which the endless rope being braided is allowed to pass. With the portion A*b* being removed, the rope in the opening **58** can be taken out.

Before entering into the detailed discussion on the removable portion A*b* of the plate structure, the spindle transfer mechanism and the power transmission mechanism will be described at first with reference to FIG. **9.** The upper plate **32** is formed with eight openings which are positioned along a periphery of a circle (not shown). As shown, peach-shaped plate members **59** are disposed in the eight openings of the upper plate **32,** thus defining inbetween two passages **61** which are undulating radially of the circle. Eight pairs of the spindles **34** carrying the bobbines **35** are arranged to run in the undulating passages **61.** As shown with a portion of the upper plate **32** being removed, the power transmission mechanism includes eight spur gears **62,** to which eight circular plates **63** are coaxially attached. Each of these circular plates **63** is formed with four notches, in which the feet of the spindles **34** are retained so that the spindles **34** can move in the passages **61.** These paired spindles **34** can be transferred from the notches of one of the circular plates **63** to those of the other which is positioned adjacent to said one of the circular plates **63.** As is well known in the art, the spur gears **62** and the circular plates **63** are driven by a prime mover or an electric motor **65** which is mounted on a platform **64.** The driving power is transmitted by way of a pair of belt pulleys **66** and **66′**, two pairs of meshing bevel gears **67** and **68** and **67′** and **68′**, and a pair of spur gears **69** and **69′**.

To the lower plate **33,** on the other hand, is fastened by means of bolts a pair of bracket bearings **71** and **71′**, to which a shaft **72** is journaled. This shaft **72** is connected through an arm **73** and a vertical shaft **74** to a handle **75.** A lever **76** is made movable in the direction of an arrow by the action of the handle **75,** and has its one end secured to the shaft **72** and the other secured to a shaft **78,** which is rotatably supported by two bracket bearings **77** and **77′**. To this shaft **78** is secured a pair of rocking arms **81** and **81′** which can bring a clutch **79** into frictional engagement by the movement of the lever **76** so that the driving shaft (not shown) may rotate.

Indicated at reference numeral **82** is an auxiliary rectangular table which lies on the frame **57.** The fan-shaped removable portion A*b* can slide on the table **82** to be removed. Indicated at numeral **83** is a bracket bearing which is mounted on a table **84** for rotatably supporting the not-shown driving shaft. Indicated at numeral **85** is, on the other hand, a handle, by which the main body **31** can be manually brought into operation when the filament yarns are broken or when it is intended to repair the mechanism of the main body **31.**

Turning now to FIG. **10**, the removable portion A*b* can be removed from the plate structure or separated from the portion A*a* such that two of the peach-shaped plate members **59** are taken out integrally with the spur gears **62** and the circular plates **63.** At this instant, some of the spindles **34** retained by the plate members **59** are taken out together with the removable portion A*b*. Although, in this embodiment, the removable portion A*b* is formed to have a fan-shape, the shape itself should not be limited to the fan shape if it can be separated with ease together with the plate members **59,** the gears **62** and the circular plates **63.** If desired, such a removable portion as above can be formed additionally in the portion A*a*. Indicated at reference numeral **86** are feet which are fastened to the removable fan-shaped portion A*b* of the lower plate **33** by means of bolts or the like.

The removable construction of the portion A*b* of FIG. **10** will be described in more detail with reference to FIG. **11.** To the lower edges of the stationary portion **33***a* of the lower plate **33,** are secured a pair of plates **87** and **87'** which have their facing edges left free to provide guide surfaces for the removable fan-shaped portion **33.** To the upper edges of the portion **33***a*, on the other hand, are fastened two pairs of "L"-shaped retaining members **88** and **88'** and **89** and **89'** which have their free ends facing each other, as shown. The fastening of the retaining members **88, 88', 89** and **89'** is performed in a removable manner with use of bolts. Since the retaining members **88, 88', 89** and **89'** have their extensions free and juxtaposed to the guide plates **87** and **87'**, two guide passages for the removable portion **33** are formed, so that, when it is intended to take out the endless rope from the central opening **58,** the portion **33** can be removed with the retaining members **88, 88', 89** and **89'** being removed. The removable construction should not be limited to the above, and a modification is conceivable, in which the open edges of the stationary portion are formed with radially extending grooves whereas the free edges of the removable portion are formed with such radial protrusions as can be slidably fitted in the grooves.

What is claimed is:

1. An endless rope sling comprising:

a core including a plurality of substantially concentric layers which are consecutively braided from continuous filament yarns in a manner to cover one with another; and

a sheath including at least one substantially concentric layer which is consecutively braided from said continuous filament yarns in a manner to cover the outermost layer of said core.

2. An endless rope sling according to claim **1,**

wherein said at least one layer has its trailing end fixed in position to the outermost layer of said core.

3. An endless rope sling according to claim **1,** wherein the braiding angle of the layers of said core with respect to the axis of the endless rope sling is so determined at a small value as to prevent material reduction in the tensile strength of the endless rope sling as a whole.

4. An endless rope sling according to claim **1,** wherein the braiding angle of said at least one layer of said sheath is so determined at a considerable value as to prevent sliding of said filament yarns and deformation of the endless rope sling as a whole.

5. An endless rope sling according to claim **1,** wherein said continuous filament yarns are made of a thermoplastic synthetic resin.

6. An endless rope sling according to claim **5,** wherein said thermoplastic synthetic resin is selected from the group consisting of nylon, polyester synthetic resin and polyvinyl alcohol resin.

7. A composite endless rope sling comprising:

a plurality of tightly bundled endless ropes each comprising a core including a plurality of substantially concentric layers, which are consecutively braied from continuous filament yarns in a manner to cover one with another, and a sheath including at least one substantially concentric layer which is consecutively braided from said continuous filament yarns in a manner to cover the outermost layer of said core;, and

a sheath including at least one layer which is braided from continuous filament yarns in a manner to cover said tightly bundled endless ropes and which has its trailing end fixed in position to its outer surface.

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