May 7, 1963 H. F. H. SHIELDS 3,088,269

WIRE ROPES

Filed Dec. 21, 1961 2 Sheets-Sheet 1

Fig.1.

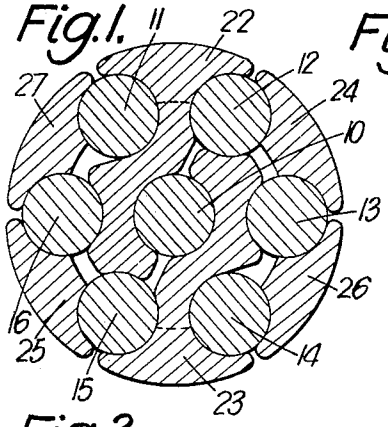

Fig.2.

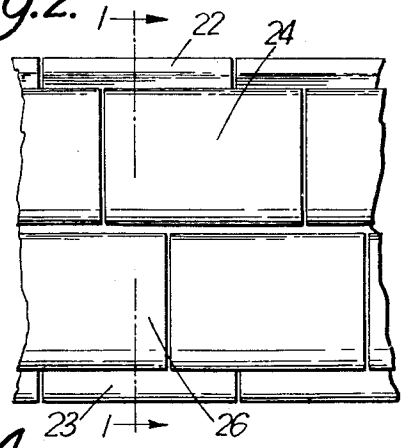

Fig.3.

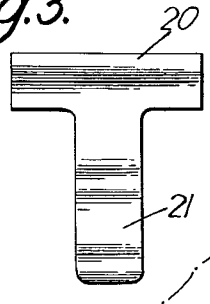

Fig.4.

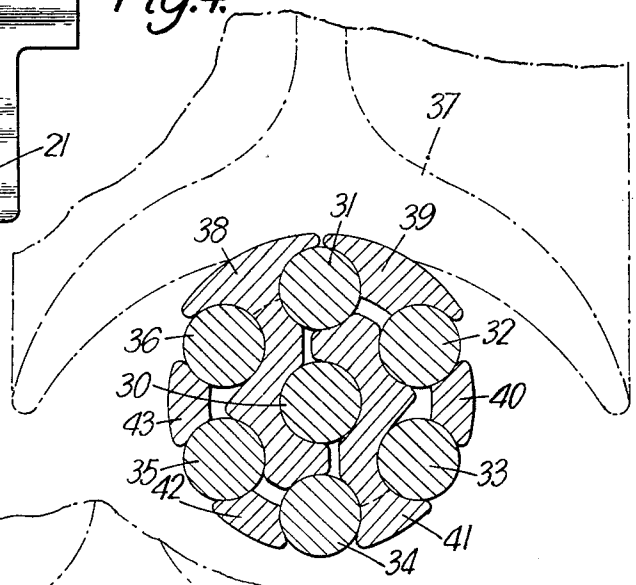

Fig.5.

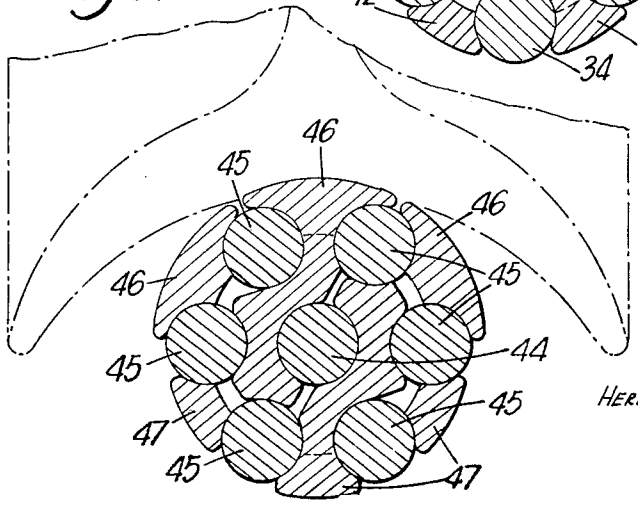

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Fig.6.

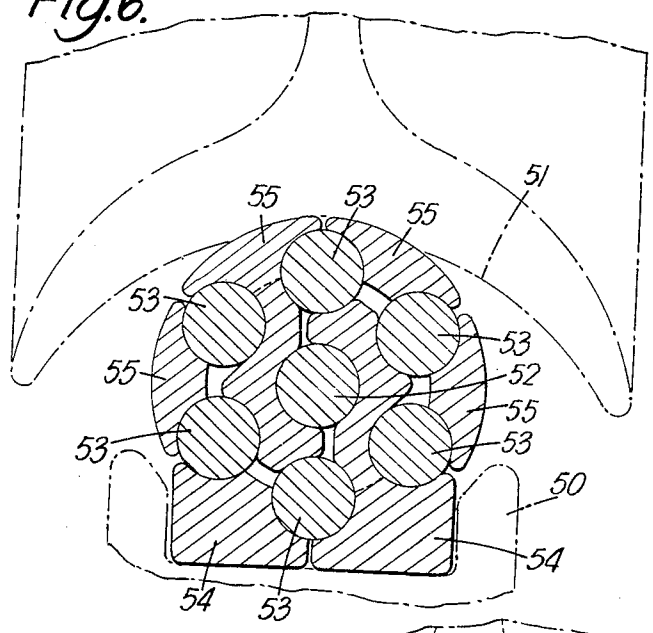


Fig.7.

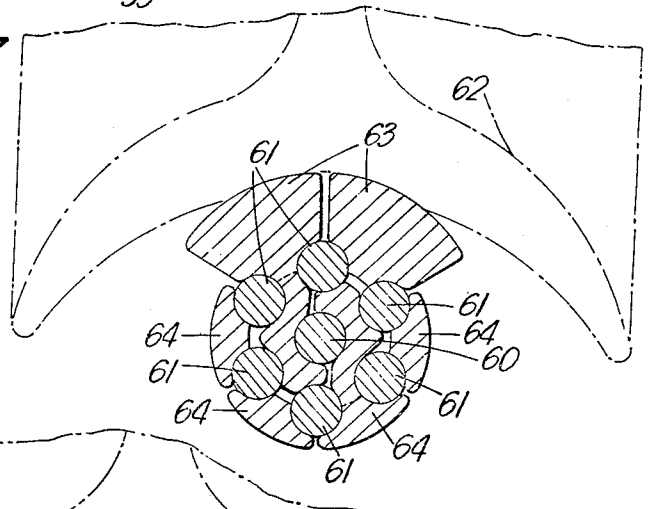
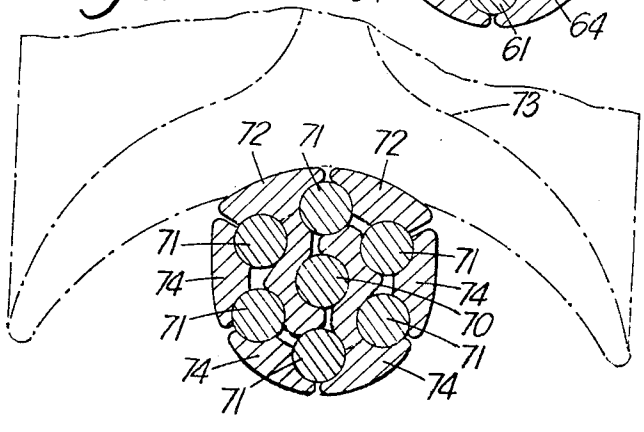


Fig.8.



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United States Patent Office

3,088,269
Patented May 7, 1963

3,088,269

WIRE ROPES

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Filed Dec. 21, 1961, Ser. No. 161,121
Claims priority, application Great Britain Dec. 29, 1960
17 Claims. (Cl. 57—146)

This invention relates to wire ropes, such as are used for example as track ropes in bi-cable ropeways, having a substantially smooth outer surface.

It is a common practice to employ, as track ropes in bi-cable ropeways, the type called locked coil. Such ropes are formed of a number of steel wires laid together and surrounded by a number of helically wound wire elements which are shaped in cross-section so that they abut and interlock circumferentially along their adjacent surfaces and form a substantially smooth outer surface to the cable. The smooth outer surface is desirable on a track rope for a ropeway to ensure smooth running. This type of locked coil rope, however, has the disadvantage that it is uneconomical to make the shaped interlocking wire elements of the highest tensile steel for strength and, at the same time, of a large size for wear. In practice, the interlocking shaped elements may have a tensile strength of the order of only 60 to 65 tons per square inch, as compared with a tensile strength of the order of 110 to 120 tons per square inch which may readily be obtained with circular section high tensile steel wire. Such a locked coil rope therefore has, for a given external cross-section, a substantially smaller breaking stress than would be possible with a simple rope of similar diameter formed of helically wound high tensile steel strands.

According to this invention, a rope comprises a central wire or strand of circular section, a plurality of outer wires or strands of circular section surrounding the inner wire or strand, and locking elements, each locking element having an arm passing radially between two of the outer wires or strands and hooking over the inner wire or strand and having an outer portion shaped to extend around only part of the periphery of the rope but at least partly extending over said two of the outer wires or strands to lock these two outer wires or strands to the inner wire or strand. The outer portions of the various locking elements may be shaped and positioned so as to provide a substantially smooth outer surface for the rope over at least a selected part of the periphery of the rope. The whole of the outer surface of the rope may be made smooth but commonly this is not necessary. For example, in a ropeway the carriages run on the top surface of the rope and only this part may be made as a smooth outer surface. For this purpose the locking elements having their outer portions on the upper part of the periphery of the rope may have larger outer portions than the other locking elements and these outer portions may be shaped to provide a smooth outer surface over the upper part of the periphery of the rope. With this construction the inner and outer wires or strands can be made of high tensile steel if so desired. The locking elements need, however, occupy only a much smaller fraction of the cross-sectional area compared with the shaped wire elements in the above described known type of locked coil ropes. The tensile loads on the rope will be carried solely by the inner and outer wires or strands but this type of construction enables a rope to be constructed having less weight for the same strength compared with a conventional type of locked coil rope, particularly as the locking elements, if desired, may be formed of a light alloy or plastic.

Hitherto all locked coil ropes have been manufactured

with their shaped wires locking circumferentially. This arrangement is uneconomical because of the cost of producing shaped wires, and also because such wires are uneconomical to produce in higher ranges of tensile strength viz. 100–110 or 110–120 tons per square inch. The arrangement of the present invention eliminates any necessity for wires of special shape for locking the load bearing wires radially. The material of the locking elements is not subjected to tensile stresses but forms a protective cover for the rope, becoming, in the case of a track rope, the medium over which rolling wheel loads would traverse. The wear caused by rolling loads over the rope is confined to the protective cover and the life of the load bearing wires or strands is prolonged appreciably.

A further advantage of the construction of the present invention over ordinary locked coil ropes is that special couplings, which are of large size, are necessary for joining locked coil ropes and these special couplings may become too big for the tread of the carriage wheels in a ropeway. With the construction of the present invention, such couplings are unnecessary; the various strands, for a large diameter rope, would each be a stranded helically wound rope and these strands may be joined by ordinary splicing with the splices staggered along the length of the rope. This eliminates the heavy expense of the locked coil coupling and the difficulty and risk of fitting these couplings with the ordinary white metal or wedge type fixings.

In a construction having a central wire or strand directly surrounded by n parallel outer wires or strands most conveniently locking elements are arranged between each pair of outer wires or strands, with the locking elements in pairs having radial arms of the two elements of each pair lying on opposite sides of the central strand, the outer portion of each locking element extending around $1/n$ of the periphery of the rope and the outer portions having an axial length at least $\frac{1}{2}n$ times the axial length of said arms. With this construction very conveniently the locking elements may be arranged in pairs in succession along the rope with their respective arms extending in turn between each successive pair of wires or strands and with the outer portions of the locking elements abutting one another. Thus the locking elements may be considered as being arranged in a helical path around the rope with each successive locking element displaced along the cable $2/n$ of the length of this outer portion and displaced around the periphery $1/n$ of a revolution. Preferably the axial length of the arms is made exactly $2/n$ of the axial length of the outer portions so that, where the arms hook over the central wire or strand they will abut one another to form the continuous assembly along the length of the rope. If the central and outer wires or strands are made of the same diameter, most conveniently six outer wires or strands will be employed.

The outer wires or strands most conveniently are laid straight. The use of straight wires or strands is particularly advantageous in facilitating the assembly of a rope on the site where it is required, as is sometimes necessary to avoid the difficulties of transporting long lengths of heavy rope such as might be required for a ropeway or a suspension bridge.

This advantage also arises in applying the invention to electric power cables. In a long overhead span, such as for example may be necessary for crossing a wide river, an electric power cable may be assembled on site by putting a plurality of strands separately across the span and then locking them together. The invention thus also includes within its scope an electric power cable comprising a plurality of strands arranged as outer strands around a central strand, at least some of which strands are formed of electrically conductive material and a plurality of lock-

ing elements arranged each to hold two of the outer strands in position with respect to the inner strand.

In any of the above constructions, the central and outer wires or strands preferably are each formed of a single circular section wire but they might, if desired, be formed each as a stranded helically wound rope.

The aforementioned arms of the locking elements are preferably of square or rectangular section extending inwardly from the centre of the outer portion of the locking element. The outer portions of the locking elements most conveniently are of generally rectangular form with two edges parallel to the axis of the rope. These outer portions may on their inner surfaces be shaped to fit closely over the outer wires or strands to ensure a firm grip. The outer portions preferably abut one another longitudinally but, for many purposes, they need not abut one another circumferentially.

In the following description reference will be made to the accompanying drawings in which:

FIGURE 1 is a cross section through a rope;

FIGURE 2 is a side elevation of part of the rope of FIGURE 1;

FIGURE 3 is a side elevation of one of the locking elements of the rope of FIGURE 1; and

FIGURES 4, 5, 6, 7 and 8 are cross sections of ropes showing how they may be employed in a ropeway.

Referring to FIGURES 1 to 3 there is shown a rope for use, for example, as a track rope on a ropeway and which is formed of seven strands **10** to **16** which are locked together by locking elements **22–27**. The strands **10** to **16** may each be formed for example of a single circular wire or may each be formed of stranded helical wound rope. The strand **10** is located centrally and the strands **11** to **16** are spaced evenly around strand **10** at a uniform radius. The locking elements **22–27** which hold the strands together are all similar. One such locking element is shown in side elevation in FIGURE 3 and comprises an outer portion **20** which extends along the axial length of the rope and an inwardly extended arm **21** having a width, in the axial direction of the rope, one-third of the length of the outer portion **20**. The inwardly extending arm **21** is located at the centre of the outer portion **20**. As is most clearly seen in FIGURE 1, by considering the locking element **22**, the outer portion extends around the periphery of the rope assembly over an arc of about 60° and the inwardly extending arm is shaped so that it may pass between two adjacent strands **11**, **12** and then hook around the central strand **10**. Two locking elements **22**, **23** in FIGURE 1 are arranged with their arm portions hooking round the central strand **10** on opposite sides thereof so that these two locking elements may be positioned at the same position along the length of the rope on opposite sides of the rope. The next pair of locking elements **24**, **25** are spaced along the length of the rope so that their two radial arm portions are also hooked around the central strand **10** at a point further along the length of the rope. Normally the locking elements would be assembled on the rope with the arm portions of one pair of locking elements closely adjacent the arm portions of the next. The third pair of locking elements **26**, **27** are spaced still further along the length of the rope. The rope is assembled on the site where it is to be used by putting the various strands **10** to **16** separately across the span to lie parallel to one another and then, conveniently starting at one end, putting in a first pair of locking elements and then the next adjacent pair and so on along the length of rope to lock the various strands together.

It will be seen that by this form of construction it is possible to make up the complete rope assembly on the site where the rope is to be used. For example, for a ropeway the various strands may be carried on separate drums and put separately into position and then the locking elements put in along the length of the rope to assemble the strands together. The weight of the individual strands on their drums is very much less than the weight of the completed assembly, thereby facilitating the handling of the material. Since the individual strands can be of circular section they may readily be made of high tensile steel wire if a rope of high breaking strength is required. The individual locking elements may be made of metal or plastic material. Very conveniently they are molded of a light alloy. The material of the locking elements is not subjected to any tensile stresses but forms a protective cover for the rope. In the case of a track rope for a ropeway the locking elements form the medium over which the rolling wheel loads traverse and they would be made of a suitable material to resist wear. The wear caused by the rolling loads however is confined to these locking elements and the life of the load bearing wires or strands is prolonged appreciably compared with conventional rope assemblies.

In general the various strands in the rope would all be laid straight and this is advantageous in facilitating the assembly of the load on site.

In the arrangement of FIGURES 1 to 3 the locking elements are all similar and, with the seven-strand construction, that is to say an inner strand and six outer strands, the outer portion of each locking element extends over substantially an arc of 60° and the radial arms are of a length in the axial direction of the rope one-third of the length of the outer portion. A seven-strand construction is very conveniently employed but obviously it would be possible to use other numbers of strands. In general there will be an inner strand surrounded by an even number of outer strands and, if there are n outer strands, then each locking element using an assembly containing identical locking elements would extend over $1/n$ of the periphery of the rope. Provided the locking elements are arranged so that they may be put in pairs as shown in FIGURE 1, then the axial length of the arm **21** would be made $2/n$ of the axial length of the outer portion **20**. If the radial arms are arranged so that two cannot lie on opposite sides of the central strand, then the radial arms should be made $1/n$ of the length of the outer portion so that the various arms can be made to abut one another the locking elements then being arranged helically around the rope assembly with each successive locking element displaced along the cable $1/n$ of the length of the outer portion of the locking element and displaced around the periphery $1/n$ of a revolution.

As shown in FIGURE 1 the central strand is conveniently made the same diameter as the outer strand but this is not essential.

The form of construction described above may readily be modified to provide ropes of different sections or properties for specific purposes. FIGURE 4, for example, shows one construction of rope for use in a ropeway as a track rope. The rope is formed of a central strand **30** and six outer strands **31** to **36**. The wheel of a ropeway carriage, which wheel is indicated diagrammatically by the chain lines **37**, bears only on the upper surface of the track rope. The locking elements **38**, **39** at the upper part of the track rope are shaped to extend over an angle of about 120° around the periphery of the rope. Since there is no wear or load on the outer portions of the remaining locking elements, these, as shown at **40** to **43**, may be made of different section, the outer portions being smaller than the outer portions of elements **38**, **39** and merely made to extend circumferentially sufficiently far to grip the strands on either side but not extending over the whole periphery, thereby not only saving material but reducing the weight of the complete rope assembly.

FIGURE 5 shows a construction also with an inner strand **44** and six outer strands **45**. In FIGURE 5 there are three locking elements **46** shaped to provide outer portions extending over substantially 180° of the rope circumference whilst the remaining three locking elements **47** are similar to the locking elements **40–43** of FIGURE 4.

In a ropeway the track rope may have to extend over saddle supports and FIGURE 6 illustrates a rope assembly passing over a saddle support indicated by the chain lines **50** and arranged for carrying a carriage one of the wheels of which is indicated by the chain lines **51**. In the arrangement of FIGURE 6 there is shown a central strand **52** and six outer strands **53**. The locking elements at the bottom of the rope, as shown at **54**, are shaped to provide a flattened surface fitting into the saddle **50** so that the rope is supported firmly thereby. In the particular arrangement of FIGURE 6 the remaining locking elements **55** are similar and have outer portions each extending over about 60° of the circumference of the rope. It will be appreciated that the specially shaped elements **54** need only to be put in the rope at the point where it passes over the saddle support and that, along the other stretches of the rope, locking elements similar to elements **55** may be employed.

In many ropeways hte carriages carry a load in one direction along the ropeway and return empty in the opposite direction along a parallel track rope. The arrangement of the present invention facilitates the provision of a lighter weight rope for the return track where the carriages are empty. In FIGURE 7 there is shown such a rope with a central strand **60** and six outer strands **61**. The carriage wheel is indicated by the chain line **62** and the shape of this wheel will determine the minimum radius of curvature of the periphery of the rope section at the point where the carriage wheel engages the rope. Specially shaped locking elements **63** having outer portions of suitably large curvature are provided on the upper part of the rope where it engages the carriage wheel. The various strands however may be made much smaller than might be the case for example in the arrangement of FIGURE 1 or FIGURE 4 and the remaining locking elements **64** are made of the appropriate size to hold these strands together in the rope assembly.

FIGURE 8 illustrates another form of rope assembly with shaped locking elements to provide a relatively large radius of curvature compared with the radial dimensions of the rope and which may be used for a track rope for the returning empty carriages on a ropeway. In FIGURE 8 the rope assembly has a central strand **70** with six outer strands **71**. The two locking elements **72** around the upper part of the rope are shaped to have an appropriate radius of curvature for engaging a carriage wheel as indicated at **73**, whilst the remaining locking elements **74** are shaped to lock the rope assembly together.

In the above constructions, the locking elements conveniently are formed of a light metal alloy or of plastic material. For example, the elements in the lower part of the rope might be made of polyvinyl chloride whilst those on the upper part which come into contact with the carriage wheels might be made of nylon.

It will be seen that, by enabling separate strands to be put across a span and then locked together to form a single rope assembly, the present invention facilitates the construction of rope assemblies to cross a long span particularly in that the strands individually are much lighter and more readily handled than the complete assembly. Because of this, the invention also finds application for the construction of electric power cables particularly for long spans such as for crossing a wide river. A number of separate strands, some or all of which may comprise the electrical conductors, may be put in position and then locked together with locking elements. In this case the locking elements may conveniently be spaced apart along the length of the cable. The various strands of the cable may be made of different sizes and/or materials, for example, it may be required to have some of material which is a good electrical conductor whilst one or more than one strand may be of material of high tensile strength to take the tensile load.

I claim:

1. A rope comprising an inner wire or strand of circular section, a plurality of outer wires or strands of circular section surrounding the inner wire or strand, and locking elements, each locking element having an arm passing radially between two of the outer wires or strands and hooking over the inner wire or strand and having an outer portion shaped to extend around only part of the periphery of the rope but at least partly extending over said two of the outer wires or strands to lock these two outer wires or strands to the inner wire or strand.

2. A rope as claimed in claim 1 wherein the outer portions of the various locking elements are shaped and positioned so as to provide a substantially smooth outer surface for the rope at least over a selected part of the periphery of the rope.

3. A rope comprising an inner wire or strand of circular seution, n parallel outer wires or strands of circular section directly surrounding the inner wire or strand, and locking elements, each locking element having an arm passing radially between two of the outer wires or strands and hooking over the inner wire or strand and having an outer portion shaped to extend around only part of the periphery of the rope but at least partly extending over said two of the outer wires or strands to lock these two outer wires or strands to the inner wire or strand, the locking elements being arranged between each pair of outer wires or strands with the outer portion of each locking element extending around $1/n$ of the periphery of the rope.

4. A rope comprising an inner wire or strand of circular section and n parallel outer wires or strands of circular section directly surrounding the inner wire or strand, and locking elements, each locking element having an arm passing radially between two of the outer wires or strands and hooking over the inner wire or strand and having an outer portion shaped to extend around only part of the periphery of the rope but at least partly extending over said two of the outer wires or strands to lock these two outer wires or strands to the inner wire or strand, the locking elements being arranged between each pair of outer wires or strands with the locking elements in pairs having radial arms of the two elements of each pair lying on opposite sides of the central strand and the outer portions of the locking elements having an axial length at least $\frac{1}{2}n$ times the axial length of said arms.

5. A rope as claimed in claim 4 wherein the axial length of the arms of the locking elements is exactly $2/n$ of the axial length of the outer portions so that, when the arms hook over the central wire or strand, they will abut one another to form a continuous assembly along the length of the rope.

6. A rope as claimed in claim 1 wherein the central and outer wires or strands are of the same diameter and wherein six outer wires or strands are employed.

7. A rope as claimed in claim 1 wherein the outer wires or strands are laid straight.

8. A rope as claimed in claim 1 wherein the central and outer wires or strands are each formed of a single circular section wire.

9. A rope as claimed in claim 1 wherein the central and outer wires or strands are each formed as a stranded helically wound rope.

10. A rope as claimed in claim 1 wherein the aforesaid arms of the locking elements are of square or rectangular section extending inwardly from the centre of the outer portion of the locking element.

11. A rope as claimed in claim 1 wherein the outer portions of the locking elements are of generally rectangular form with two edges parallel to the axis of the rope.

12. A rope as claimed in claim 1 wherein the outer portions of the locking elements, on their inner surfaces, are shaped to fit closely over the outer wires or strands to ensure a firm grip.

13. A rope as claimed in claim 1 wherein the outer portions of the locking elements abut one another longitudinally.

14. A rope as claimed in claim 1 and arranged for use

in a ropeway wherein the locking elements having their outer portions on the upper part of the periphery of the rope have larger outer portions than the other locking elements.

15. A rope as claimed in claim 14 wherein the locking elements are arranged to provide a smooth outer surface over the upper part of the periphery of the rope.

16. A rope as claimed in claim 1 and arranged for suspension in spans between saddles wherein, over the parts of the rope to seat in the saddles, the locking elements on the undersurface the rope are shaped to provide a flattened surface for sitting in the saddles.

17. An electric power cable comprising a plurality of strands arranged as outer strands around an inner strand,

at least some of which strands are formed of electrically conductive material, and a plurality of locking elements, each locking element having an arm passing radially between two of the outer strands and hooking over the inner strand and having an outer portion shaped to extend around part of the periphery of the cable and at least partly extending over said two of the outer strands to hold these two strands in position with respect to said inner strand.

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