Nov. 15, 1932. M. E. EVANS 1,888,076

WIRE ROPE AND METHOD OF MANUFACTURE

Filed Aug. 29, 1930

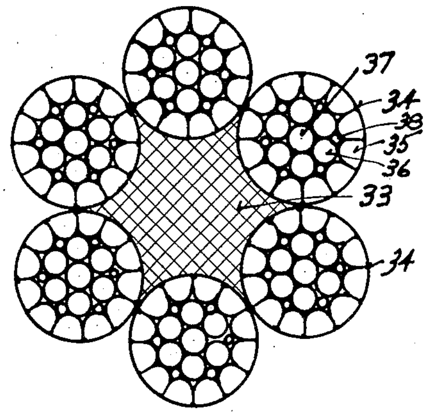

FIG. 7

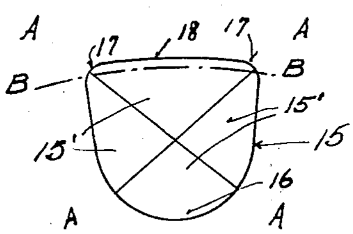

FIG. 3

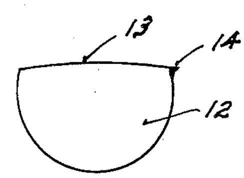

FIG. 2

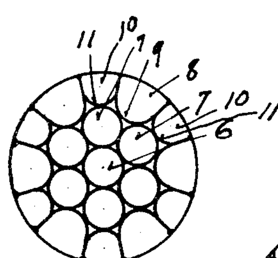

FIG. 6

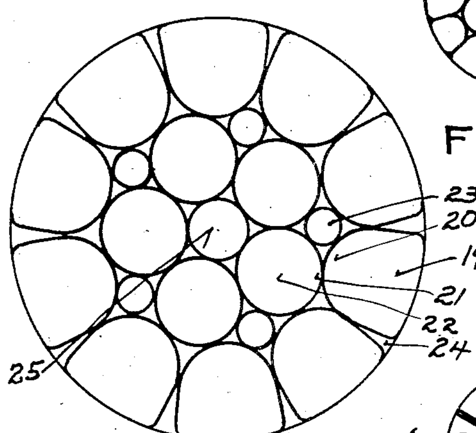

FIG. 4

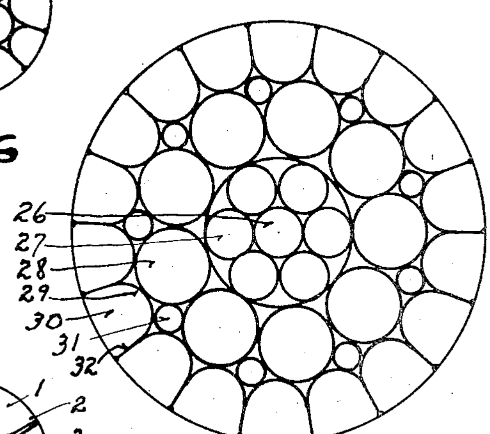

FIG. 5

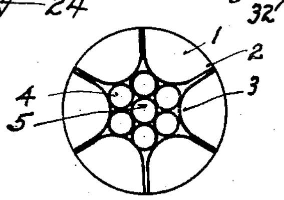

FIG. 1

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UNITED STATES PATENT OFFICE

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WIRE ROPE AND METHOD OF MANUFACTURE

Application filed August 29, 1930. Serial No. 478,687.

The main object of this invention is the provision of a compact flexible cable in which the outer series of wires of the strands making up the cable has an extended relatively smooth surface. Such a smooth surface is desirable for its wearing qualities and low abrasive action on equipment contacting therewith. To secure such an extended surface, a combination of wires of special shapes has been employed heretofore, but the stiffness or lack of flexibility has been so marked as to limit the use of rope with such wires. Flexibility, meaning the property of operating over sheaves without causing excessive bending stresses in the wires that compose the strand, is indispensible and is secured by employing a relatively large number of wires of suitable shape.

The particular shape of wire here employed is designated as Keystone shape with a rounded point. This shape has been used heretofore with the point resting in the valley between two round wires of the same size in the series of wires supporting the outer wires of a rope or strand. This arrangement necessitated the use of the same number of wires in both series, and because of the greater arc in the outer series, the width of wires therein is enough larger than the inner wires to cause a marked lack of flexibility. Since the maximum bending stresses, abrasion, and tendency to displacement occur in the outer wires of the strand it is necessary to give special attention to their proper support as well as to their size. The object of increasing the rope flexibility is attained by increasing the number of wires in the outer series and incident thereto special arrangements of supporting wires are introduced.

The further object of increasing the strength and durability of the rope is attained by increasing the metallic cross sectional area by reason of the interfitting of the wires in a manner to give support against displacement. The interfitting of the wires to a nicety new to the art is attained by reason of a compacting or preforming operation.

The strands embodying the invention are of such a construction that they may be used individually as a one-strand rope and such use is included within the invention. By reason of the interlocking of the Keystone wires with the supporting wires, a bridging effect by the outer Keystone wires that permits undue longitudinal movement of the core within the supporting wires is prevented.

Heretofore Keystone-shaped wires have been so rigidly supported that the sharp edge on the exterior surface has acted as a cutting edge upon surfaces contacting therewith and having movement there against. By reason of the pivot point of the Keystone wire and the rocking motion thereon, the wire may adjust itself, thereby avoiding the above mentioned cutting action when properly designed.

As a full understanding of the invention can best be given by a description of a construction embodying the various features, such a description will now be given in connection with the accompanying drawing showing some of the preferred forms of the embodiment of the invention. The features forming the invention will be specifically detailed in the claims.

In the drawing:

Figure 1 illustrates, in an end view, a construction of wire strand with relatively large exterior wires.

Figure 2 illustrates, in an end view, the spreading action of the metal in a rope wire.

Figure 3 illustrates, in an end view, a shaped wire adapted to the exterior of a rope strand.

Figure 4 illustrates, in an end view, a construction of wire strand embodying the invention.

Figure 5 illustrates another embodiment of the invention in an end view.

Figure 6 illustrates a modified construction embodying the invention.

Figure 7 illustrates, in an end view, the application of the invention to a stranded rope.

As ordinarily constructed, strands for wire rope employing shaped wires in the exterior layer, as contrasted to round wires, have a degree of stiffness or lack of flexibility that limits their application to travel over sheaves of relatively large diameter. This is particularly true of such ropes as have an exterior layer of shaped wires resting in the valley between the round wires in an adjacent supporting layer.

Referring to Figure 1, for instance, there is illustrated a strand consisting of six outer shaped wires (1) with acutely angled edges (2) and with rounded points (3) resting in the valleys between the six wires (4) supported on the core wire (5). The relative width of these shaped wires compared to their depth is due to the use of only two sizes of wires to form the exterior and adjacent layers of wires around the core wire (5). According to the present invention, at least three sizes of wires are introduced into the two layers of wires, being so disposed as to increase the number of tension wires in the outer layer as compared with the number of wires in the supporting or adjacent layer.

Referring to Figure 6, around a core wire (6) are disposed six round wires (7) similar to the core and adjacent layers illustrated in Figure 1. But by introducing large Keystone wire (8) with points (9) in the valleys between the round wires (7) and small Keystone wires (10) with points (11) on the crowns of the round wires (7) in alternation with the large Keystone wires, the relative width of the outer shaped wires compared with their depth is reduced. The consequent increase in flexibility permits the extended use of the shaped exterior wires in the strand. Also the acute angled edges (2) of wires shown in Figure 1 are increased, thereby giving more substantial support to the metal at the edges which is an important factor in increasing the life of the wire under flexure.

Referring to Figure 2 an originally round wire (12) is shown in a worn condition with the face (13) resulting from attrition. The edge (14) has been extended by the peening action of roughened supporting sheaves and because of its acute angle is readily ruptured under tension or reversal of bending stresses. To obviate any such condition arising in the rope, a wire construction or shape shown in Figure 3 is employed, wherein a Keystone wire (15) with rounded point (16) is given at its outer corners (17) a rounded form between which extends a wearing surface (18). The maximum stress in this wire occurs at the corners (17) when the wire is flexed in a plane (A—A) to place the corner (17) in tension. With the extended curved corner (17) present in place of the acute angled edge (2) shown in Figure 1 or of the edges shown in Figure 2, the formation of minute cracks that spread into cleavage planes across the wire is obviated. An area of metal in the wire (15) extending from the surface (18) to the line (B—B) may be removed before an appreciable angle appears at corners (17), and even then the angle is not acute so that continued wear is not likely to materially reduce the sectional area in advance of the wire failing by reason of fatigue of the metal.

The separate portions 15′ of the wire 15 are bonded together along the lines A—A thereby forming a laminated wire so that when the wire fails in consequence of fatigue the failure must start in each lamination. The portions 15′ may vary in shape and number, the division lines shown being diagrammatic only.

Keystone wire with rounded points have long been known in the art. However, their modification and application to wire rope usage has been extremely limited because of the lack of flexibility in the constructions using such wires. The use of three sizes of wire in the two exterior layers in a strand construction incorporating Keystone wires embodying this invention for the first time gives the Keystone wires to a wide variety of designs. The application of Keystone wires with rounded points to strand construction involves certain practical matters which require special attention. When a Keystone wire with a flat point is bent into position in a strand, the flat point bears directly and squarely upon the supporting wires, and there is no opportunity to twist out of its appointed position. Such a wire with a round point has a tendency to assume a position aside from its designed place both laterally and radially with respect to the strand into which it is being incorporated. A preferred method of overcoming this difficulty is to give the wire the helical shape it is to assume before it is positioned in the strand. This may be accomplished by wrapping the wire around a mandrel or drawing through a suitably shaped die or guides. The essential feature is that the wearing face of the Keystone wire shall remain in the surface described by the exterior outline of the strand. If the wear face projects beyond the said surface, the pressure of a supporting surface will induce torsional stresses in the strand which are most destructive and which are entirely absent from this cause in round wires. The preforming operation involves the shaping of a Keystone-shaped wire with a relatively flattened head and a relatively curved point by tensioning the head portion and compressing the point portion while simultaneously torsioning the intermediate portions to such an extent that when the operative forces are removed the helical shape of the wire closely approximates that required for the wire's position in the strand. It is desired that the wire shall tend to cling to its appointed position maintaining its point in continuous longitudinal contact with supporting wires. Heretofore, in spite of exercising all possible mechanical ingenuity to effect this condition, after the rope has been in service for a time the wires settle into working positions that develop slackness in the wires. This slackness causes flexing stresses in excess of those in wires not slackened and consequent earlier failure. By the present practice of preforming more power is made available at the point of assembling of the wires, giving greater compactness of the wires as they are assembled. Furthermore, because of the sectional area of metal being greater in the Keystone wire the residual spring stresses therein are proportionately greater unless the preforming operation is involved, and for the same reason the gripping action of the preformed Keystone wire is proportionately greater.

Referring to Figure 4, for instance, strand structure is shown wherein an outer layer of Keystone shaped wires (19) with rounded points (20) rest upon the crowns (21) of an adjacent series of relatively large wires (22) and upon auxiliary wires (23) which cooperate to hold the Keystone wire in a position of equilibrium. The cooperation of three sizes of wires in the outer and adjacent layers secures the Keystone wires in greater number than heretofore in a state of equilibrium to function more efficiently than previous ropes. The greater efficiency of operation is due to the limited contact between the wires and the continuity of this contact. The three sizes of wire have practically line contact. The outer Keystone wires have practically line contact with supporting wires and intervening lateral spaces (24) available for lateral adjustment of position due to spreading action of metal or to a rocking action of the rounded point of the outer wires. The relatively large round wires (22) rest upon a single core wire (25). To increase the flexibility of the strand, it is necessary to increase the number of wires for a given size rope construction.

As compared with the construction shown in Figure 4, a more flexible arrangement is shown in Figure 5, wherein a single core wire (26) is surrounded by six wires (27) to form a seven wire core strand over which is wound a layer of relatively large wires (28). Rounded points (29) of Keystone wires (30) in an outer layer rest on the crowns of the wires (28) in which position they are supported by relatively smaller auxiliary wires (31). The adjacent sides (32) of the Keystone wires (30) are shown in surface contact, the pressure between which is regulated by the width of the Keystone wires (30) and by the size of the auxiliary wire (31) so as to have a minimum of friction therebetween. Probably this surface contact is established after the wires are in service. The single sized Keystone wires (30), the relatively large round wires (28) and the auxiliary round wires (31) cooperate to give an exterior layer and an adjacent supporting layer construction in the strand of relatively great flexibility. The Keystone wires and the supporting round wires shown in Figure 5 are relatively smaller than the same wires in Figure 4, but the relation between the Keystone wires and the supporting round wires in Figure 5 change in that in the latter the Keystone wires are relatively the smaller.

Referring to Figure 7, a complete rope structure is shown having a fiber core (33) around which six strands (34) are helically positioned. The strands are made up of an outer layer of twelve Keystone wires (35) with round points resting on the crowns of six wires (36) forming an adjacent supporting layer resting on a single core wire (37). Six auxiliary round wires (38) assist in maintaining the Keystone wires in position on the crowns of the supporting wires (35) and in regulating the position of the adjacent sides of the Keystone wires. By reason of the number of wires in the two outer layers of the strand design illustrated in Figure 7 being intermediate of those shown in Figures 4 and 5 the flexibility of the former is intermediate that of the two latter.

In all the strand designs illustrated the cooperation of three sizes of wires making up an outer Keystone layer and an inner adjacent supporting layer of wires is characteristic. The preforming of the wires in both layers accomplishes the relative positioning so that the efficiency of operation of the two layers is definitely increased since it obviates the difficulty of definitely positioning the shaped wire in the strand structure. With the compacted positioning of Keystone wires in the outer layer comes an increase of metallic area in the strand structure making available a rope of lesser diameter for a given strength.

The interlocking of the outer and supporting layers of wires in the various strand constructions is an important feature preventing relative longitudinal movement of a magnitude that is designated as a creeping of the supporting wires. As the number of wires in the outer layer of a strand structure increases, the width of the wires is relatively less as compared with the depth. In this connection it is contemplated that the rounded inner point may become the head of the Keystone wire. In this event side space for lateral adjustment of position as illustrated with the coarser Keystone wires of Figure 4 would become available.

As soon as the exterior round wires of a rope are exposed to wear, their shape is rapidly changed to the ultimate condition illustrated in Figure 2 with an elongated bearing surface so that the unit pressure over the bearing surface decreases as the wire changes shape. By providing initially an elongated bearing surface, the life of the wire is increased by reason of the lesser working of the surface metal and its consequent slower change of character.

By suitable attention to the character of the metal used for the so-called Keystone wires exceptional wearing qualities thereof are obtained. Failure of a Keystone wire comes from a fracture extending across its section and seldom from extreme attrition. By employing a number of laminations in the wire joined together by a bonding metal preferably of lower melting temperature than the wire a fracture must be newly started in each lamination. The laminating metal also may consist of metal of higher melting temperature, but more pliable and ductile than the metal of the body of the wire. Thus low carbon iron may be used as the bond metal with high carbon, high strength metal forming the body metal. This combination may be variously attained as during a casting operation, or by subsequent welding.

Referring to Fig. 3, the portions 15′ of the wire 15 between the lines A—A may be regarded as laminating elements bonded together along the lines A—A to form a solid wire. In operation, when one of these laminations is broken the other laminations sustain the load and four separate cracks must necessarily be started across the wire before it is ruptured.

Again referring to Figure 4, in connection with the requirement that a rope structure should be compact, the auxiliary wires (23) by reason of their limited contact with the adjacent wires soon change their shape sufficiently to let the Keystone wires (19) bear against each other more than is desired and tend to let them develop a looseness that is detrimental. It is rather difficult to handle a shaped wire and to work it into proper position as a substitute for the round wire; therefore, in place of auxiliary shaped wire, a round wire is made somewhat over size and subjected to a compacting pressure by the Keystone wire as placed thereon sufficient to establish an intimate surface relationship changing the cross-sectional shape sufficiently to bring the Keystone wire into its proper position. When a rope is placed in service, the wires thereof slide upon one another and make radial as well as longitudinal adjustments. Frequently these adjustments are of such a degree as to tension some wires more than others and even to develop a looseness that shortens the life of the rope. The looseness or extra length of some of the wires was present in the wire from the time of the laying of the wires in the strand, but no means of removing this looseness has heretofore been suggested. A way the looseness can be avoided is by taking out the extra length of wire as the laying progresses. To this end, the strand is subjected to repeated compacting and stretching operations in close vicinity to the die in which the wires are being assembled at rates that cause a given unit length of wire to be subjected to such action before a succeeding unit length is wound into position sufficiently to prevent the taking up of the slack incident to compacting. The pressure of the split die in which the wires are assembled is ordinarily limited by the friction between the wires and the die. To secure a die pressure independent of the friction element, it is proposed to divide the die longitudinally into two parts. The part into which the wires first enter during the laying operation being stationary and relatively short in length, and the part into which the wires subsequently pass, being reciprocated along the axis of the rope or strand. The second part of the die is provided with compression means of sufficient power to deform the wire if desired in the compacting of such apparatus. During the compacting by this part of the die, the die and wire move together as a unit and after the compacting of a given unit length, this moving portion of the die is returned to the vicinity of the first die section to engage a succeeding section of wires. The return of the compacting section to the stationary section takes place before a full wrap of wire or lay of a wire occurs so that there is direct tension on the wire available to take up slack expressed by the compacting operation.

If a tensioning operation is also desired in connection with the compacting operation, a third die section like the second one already mentioned is provided with an appreciable length of rope or strand between the two sections. When both these sections grip the strand or rope, they travel with the rope. A means such as a toggle applying definite forces tending to separate the two die sections as they travel is effective to stretch the strand or rope between the moving die sections to a predetermined point. Thus, with the rope takeup progressing at a uniform rate and an intermittent stretching taking place between the takeup and the first die section the passage of the strand or rope through the first die section varies. It is one value while the reciprocating die sections are returning to the stationary die section, and another varying value while the reciprocating sections are stretching the engaged section. These variations, however, are not detrimental to the rope structure since they are of small value per unit of length. The method of effecting the removal of slackness from a strand during the assembly of wires is dependent upon the timing of the successive steps so that a continuity of operation of the rope takeup is not disturbed. The final product of the various steps outlined is superior because of the special manipulation of a special metal precisely shaped and tensioned as wire in the process of assembly.

I claim:

1. A wire rope or strand comprising a core and a plurality of layers of wires upon said core including an outer layer of Keystone shaped wire resting on an adjacent layer of

wires so that two sizes of Keystone wire and one size of round wire cooperate to form said outer and adjacent layers of wire.

2. In a wire rope or strand comprising a core and a plurality of layers of wires upon said core, an outer layer of Keystone shaped wires with rounded points resting on an adjacent layer of wires so that at least three sizes of wires cooperate to form the said outer and adjacent layers of wires, the point of a Keystone wire resting upon the crown of a relatively large round wire, while an adjacent Keystone wire forming the third size of the three mentioned gives support to the said Keystone wire on the said crown.

3. In a wire rope or strand comprising a core and a plurality of layers of wires upon said core, an outer layer of Keystone shaped wires with rounded points resting on an adjacent layer of wires so that three sizes of wires cooperate to form the said outer and adjacent layers by reason of round wires forming said adjacent layer supporting on their crowns small Keystone wires and in their valleys larger Keystone wires, said sizes of Keystone wires occupying alternate positions in said outer layer.

4. A strand for wire rope comprising a plurality of layers of helically wound wires, and at least one of said wires being formed of a plurality of longitudinal elements bonded together to form a single wire whereby when flexed in said strand and cracked in consequence thereof said crack is confined to the element in which said crack starts thereby prolonging the life of said rope.

5. A strand for wire rope comprising a plurality of layers of helically wound wires, each wire formed of a plurality of longitudinal elements bonded together to form a single wire whereby when flexed in said strand and cracked in consequence thereof said crack is confined to the element in which said crack starts thereby prolonging the life of said strand.

6. A strand for wire rope comprising a plurality of layers of helically wound wires, the exterior layer of wires being of Keystone shape with rounded points supported by a layer of round wires, said Keystone wires being each formed of a plurality of longitudinal elements bonded together to form a single wire whereby when flexed and cracked in consequence thereof said crack is confined to the element in which said crack starts thereby prolonging the life of said strand.

7. A strand for wire rope comprising a plurality of layers of helically wound strand wires, the exterior layer of strand wires being of Keystone shape supported by a layer of round wires so arranged that three of said Keystone wires continuously contact with one of said round wires whereby said Keystone wires are maintained in position.

8. A strand for wire rope comprising a plurality of layers of helically wound strand wires, the exterior layer of strand wires being of Keystone shape and the head of which has rounded corners, supported by a layer of round wires so arranged that three of said Keystone wires continuously contact with one of said round wires whereby said Keystone wires are maintained in position.

9. A strand for wire rope comprising a plurality of layers of helically wound wires, the exterior layer of strand wires being Keystone in shape with round points, the supporting layer for said Keystone wires being of round wires, and the points of said Keystone wires being positioned alternately in the valleys between said round wires and on the crowns of said round wires whereby said Keystone wires are maintained in position.

10. A strand for wire rope comprising a plurality of layers of helically wound wires, the exterior layer of strand wires being Keystone in shape with round points supported by a layer of round wires, said Keystone wires being so arranged that three are continuously supported in contact with one of said round wires.

11. A strand for wire rope comprising a plurality of layers of helically wound wires, and at least one of said wires being formed of a plurality of longitudinal elements bonded together to form a single wire of non-circular cross-section whereby, when flexed in said strand and cracked in consequence thereof, said crack is confined temporarily to the element in which said crack starts, thereby prolonging the life of the rope.

12. A strand for wire rope comprising a plurality of layers of helically wound wires, and with said wires being formed of a plurality of longitudinal elements bonded together to form a single wire of non-circular cross-section whereby, when flexed in said strand and cracked in consequence thereof, said crack is confined temporarily to the element in which said crack starts, thereby prolonging the life of the rope.

13. A strand for wire rope comprising a plurality of layers of helically wound wires, and with said wires formed of a plurality of longitudinal elements bonded together to form a single wire of Keystone cross-section whereby, when flexed in said strand and cracked in consequence thereof, said crack is confined temporarily to the element in which said crack starts, thereby prolonging the life of the rope.

Signed at Pittsburgh, in the county of Allegheny and State of Pennsylvania, this 26th day of August, A. D. 1930.

MARTIN E. EVANS.