United States Patent

Gilmore

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[54] **INTERLOCKED MULTI-WIRE MEMBER**

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[52] **U.S. Cl.** **57/139,** 57/145, 57/166

[51] **Int. Cl.** **D07b 1/06,** D02g 3/36, D07b 1/08

[58] **Field of Search**..................57/9, 55, 138, 139, 145, 149, 57/166

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[57] **ABSTRACT**

A multi-wire member in which the outer layer comprises alternate base and oversize wires wherein the oversize wires have been deformed into interlocking engagement with each other and with respect to the wires comprising the next underlying layer of the member to produce a smooth and substantially continuous outer surface.

8 Claims, 3 Drawing Figures

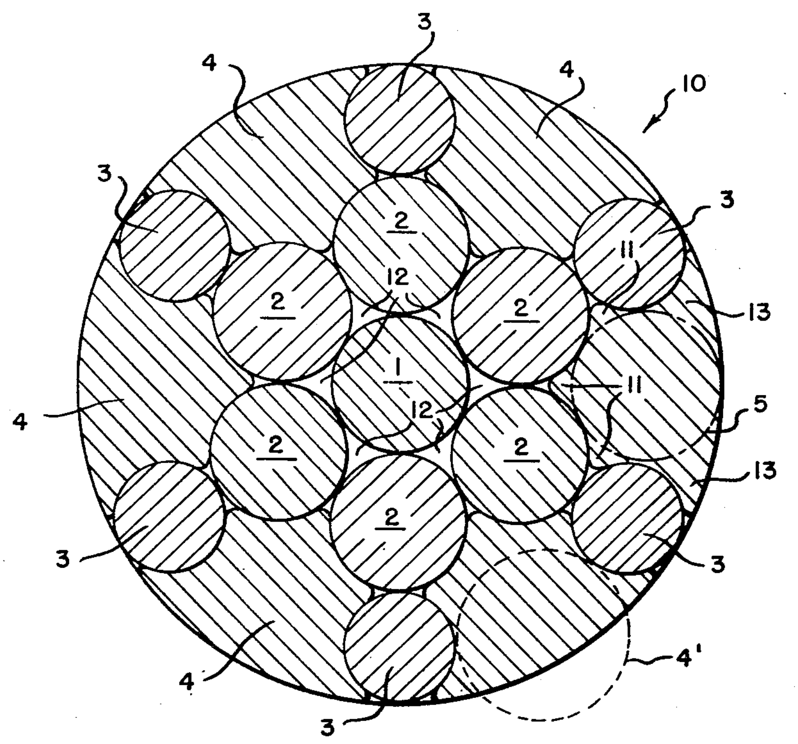


FIG. 1

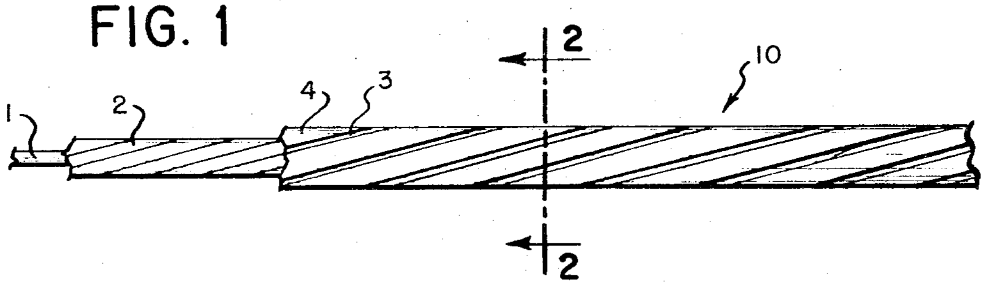
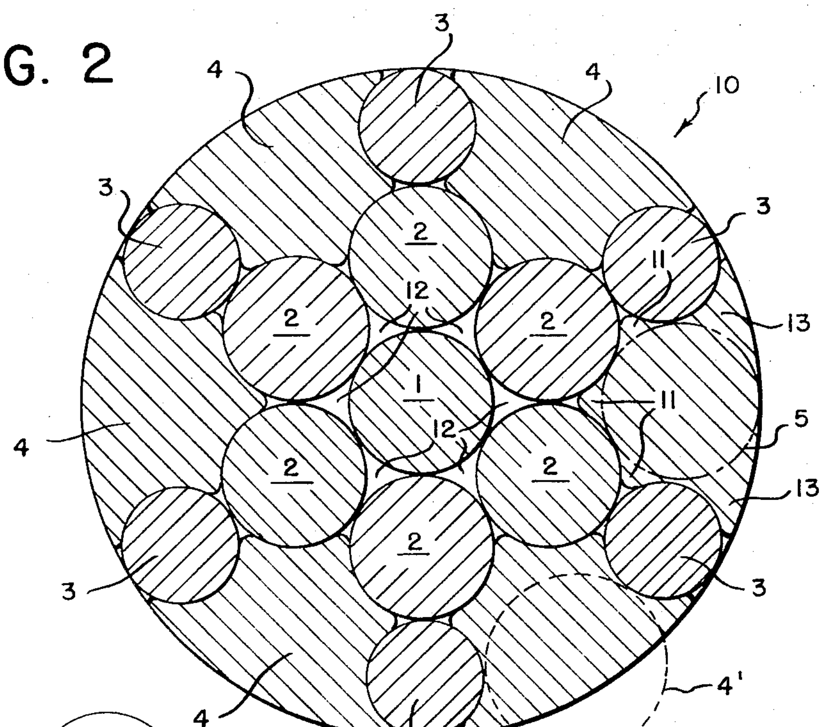


FIG. 2



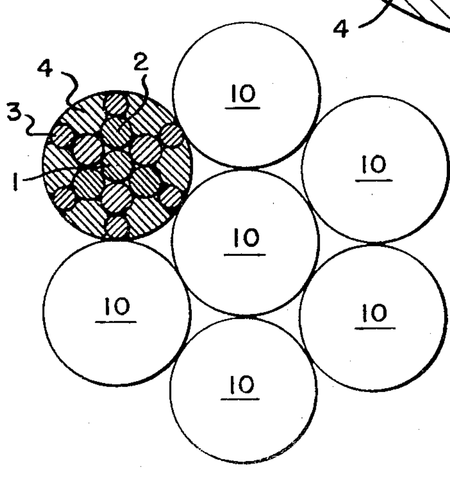


FIG. 3

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INTERLOCKED MULTI-WIRE MEMBER

BACKGROUND OF THE INVENTION

Wire ropes in the past have generally included multi-strand constructions wherein each strand comprises a plurality of round wires wrapped helically in side-by-side relationship about a central core wire. Typically, the round wires are disposed in multiple layers about the core wire.

One of the factors which is determinative of the tensile strength of the individual strands having the above construction and, hence, of the wire rope comprising such strands is the percentage of cross-sectional area which is occupied by the material comprising the individual wires. Unfortunately, however, with round wire strands a considerable amount of cross-sectional area of the strand is occupied by air filling the intrastrand spaces existing between the round wires of each layer and those of the adjacent layer. Thus, the tensile strength of the wire rope is undesirably less than optimum.

Heretofore, the most common way of dealing with the problem presented by the existence of the intrastrand air spaces was to provide multi-wire constructions of the type described with so called filler wires. These filler wires generally extend longitudinally throughout the strand structure within the intrastrand air spaces thereby at least partially filling up the air spaces and to some extent increasing the metallic cross-sectional area and, in turn, the ultimate tensile strength of the strand.

The individual strands of existing multi-strand wire ropes of the type described are also highly susceptible to becoming damaged by wear and tear in service. This drawback is due primarily to the nature of the surface area of the wire rope which is exposed to contact with foreign objects such as the sheaves and drums of the rope pay-out and retrieving system. This contact surface includes a series of smaller arcuate shaped surfaces each of which is defined by the exposed portion of an individual wire comprising the outer layer of the outer strands of the rope. Each line is, therefore, exposed to abrasion, nicking, and other forms of wear and tear. If an individual wire or strand should break during use, the structural cohesion and the internal stability of the entire structure is endangered resulting in premature failure of the entire rope.

SUMMARY OF THE INVENTION

In accordance with the teaching of the present invention, there is provided a multi-wire member as for example a multi-wire strand in which the individual wire structures comprising the outer layer of the strand are interlocking with respect to each other and with respect to the wire structures comprising the next underlying layer of the strand. The interlocking nature of the wires comprising the outer layer of the strand is such that they form a smooth and substantially continuous outer surface.

The outer layer of the strand includes a first group of base wires wrapped helically about the wires of the next underlying layer of the strand. A second group of oversize wires are disposed alternately between each two base wires to form therewith the outer layer of the strand.

To produce the interlocking relationship between the base and oversize wires and the wires of the underlying layer of the strand, radial compressive forces are applied about the circumference to the strand to thereby deform the oversize wires into the intrastrand air spaces normally existing between the wires of the strand. To facilitate plastic flow, the oversize wires are advantageously made of a relatively soft metallic material while the base wires are advantageously made of relatively hard metallic material; and these wires substantially retain their initial shape during the compacting operation.

With the multi-wire construction of the present invention, the effective outer surface contact area of the strand is advantageously increased thereby reducing the vulnerability of the individual wires to abuse in service. Also, the interlocking nature of the wires comprising the outer layer of the strand tend to hold the structure together even though an individual wire becomes broken during service. Moreover, this new construction provides the strand with greater cross-sectional metallic area than is possible with conventional filler wire constructions and, thus, the tensile load bearing ability of the strand is advantageously increased.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation view of the multi-wire strand of this invention.

FIG. 2 is a cross-sectional view taken along the lines **2—2** of FIG. 1.

FIG. 3 is a cross-sectional view of a plurality of the multi-wire strands of the present invention laid together to form a wire rope.

DETAILED DESCRIPTION OF THE INVENTION

With reference to the drawings, there is shown one embodiment of the multi-wire strand of the present invention. As shown most clearly in FIG. 2, the strand, indicated generally by reference numeral **10**, includes a core wire **1** surrounded by an intermediate layer of helically wrapped wires **2** which are in tight surface contact with the core wire. Surrounding the intermediate layer is an outer layer comprising a plurality of helically wrapped base wires **3** and a plurality of helically wrapped oversize wires **4** which are arranged alternately with respect to the base wires **3** so that each oversize wire **4** lies between each two base wires **3**. The base wires **3** are substantially circular in cross-sectional shape while the oversize wires **4**, originally of circular or other cross section, have been deformed into interlocking engagement with the base wires **3** and the wires **2** of the underlying layer.

The wires **4** are oversize in the sense that they have a larger than normal cross-sectional area. That is, the oversize wires **4** are larger in cross-sectional area than normal size wires which would have a cross-sectional area such that they could be readily placed between each two base wires **3** without being deformed or otherwise losing their original roundness and without disturbing the initial separation between the base wires **3**. Normal size wires are indicated by dot-dash lines **5** in FIG. 2 while the oversize wires of the present invention are indicated as they appear before deformation by dotted lines **4'** in FIG. 2.

In the construction shown in the drawings, the teachings of the present invention are applied to 1 × 19 multi-wire construction or what is commonly referred to in the industry as a basic Warrington construction. As shown, this construction includes a single core wire, a single intermediate layer consisting of six wires **2** and an outer layer consisting of six base wires **3** and six oversize wires **4** arranged alternately with with respect to the base wires as described above.

Although the drawing specifically shows the preferred embodiment of the invention as being applied to a strand member of the basic Warrington construction, it is to be understood that it is equally applicable to other strand structures having the same or even opposite lays. Also, the invention is applicable to other multi-wire members such as cables or ropes wherein the outer layer includes a plurality of base wire structures themselves constructed as multi-wire strands.

In the construction shown in the drawings, each base wire **3** is advantageously positioned so that it contacts the crown of one of the wires **2**. In other words, each base wire **3** is positioned in relation to the layer wires **2** of the underlying layer so that its longitudinal axis and the longitudinal axis of one of the wires **2** intersect a common line extending radially from the longitudinal axis of the core wire **1**. With this arrangement, there are no inter-wire air spaces between the outer layer and next underlying layer which are not substantially filled when the oversize wires **4** are later deformed. This arrangement also has the advantage of providing the greatest amount of interlocking surface area between the oversize wires **4** and the base wires **3**.

Each oversize wire 4 is, before deformation, supported by two base wires 3 in radially spaced relationship with the wires 2 of the underlying layer in the manner shown in FIG. 2. The lay of the oversize wires 4 and base wires 3 of the outer layer is in the same direction as the lay of the wires 2 of the underlying layer. Conventional stranding equipment may be used for wrapping the oversized wires 4 and base wires 3 about the next underlying layer in this manner. Such stranding equipment is well known in the art, and, therefore, in the interest of brevity further elaboration will be omitted.

Deformation of the oversize wires 4 is accomplished by conventional compacting operations wherein radial compressive forces are applied to the oversize wires to cause them to plastic flow into the interlocking configuration shown in FIG. 2. For example, these compressive forces may be applied by rotary swaging, rolling, or by a suitable die through which the entire structure is longitudinally drawn. Advantageously, these compressive forces are applied to the oversize wires 4 concurrently with the stranding operation so as to accommodate the different relative elongation of the oversize wires 4 and base wires 3 which normally occurs during the compacting operation.

To facilitate deformation of the oversize wires 4 into the interlocking arrangement shown in FIG. 2, these wires are relatively soft as compared to the base wires 3. The oversize wires 4 are soft in the sense that they are of somewhat lesser tensile strength than are the base wires 3 of the strand. For example, the base wires 3 may be made of carbon steel having a tensile strength of about 400,000 psi while the oversize wires 4 may be made of a material having a tensile strength of about 200,000 to 220,000 psi, such as galvanized plow steel. Advantageously, the oversize wires 4 may also be softer than the wires 2 which, for example, may be made of carbon steel having a tensile strength of 375,000 psi. This facilitates deformation of the oversize wires 4 into interlocking engagement with wires 2 as well as with the base wires 3. Also, the oversized wires may be made of material such as aluminum softer than the base wires and located in the electromotive series at an inferior position relative to the base wires to provide some corrosion resistant benefits of the wire ropes of the type disclosed in U.S. Pat. No. 3,307,343.

The nature of the interlocking relationship between the wires 2, 3 and 4 can be best understood by reference to FIG. 2. There, it will be seen that the interior surface region of each oversize wire 4 is in intimate contact with those portions of the surrounding base wires 3 and wires 2 facing the oversize wire 4. Also, a portion of each oversize wire 4 extends into and substantially fills the interwire air spaces existing between the two layers. For example, the interwire triangularly shaped air spaces 11 present with normal size wires 5 have been substantially eliminated leaving only air spaces 12 between wires 2 and the core wire 1. Thus, the total amount of intrastrand air space is advantageously reduced.

In addition to the above, the present invention provides a construction in which the valleys 13 previously formed on the exterior of the strand between the normal size wires 5 and adjacent base wires 3 are eliminated by the deformed oversize wires 4. These valleys 13 have been eliminated in such a manner that the strand of the present invention is provided with a smooth and substantially continuous outer surface with the outermost surfaces of the oversize wires 4 and base wires 3 together forming a tangent with a circumscribed circle at substantially all points therealong. That is, the outer surface of the structure is substantially contiguous with an imaginary circle circumscribed about the strand.

With round wire constructions of the prior art, the effective contact radius of the strand varies considerably about its circumference. This is due to the fact that, with conventional multi-wire strands, the radius of the outer surface of the strand is, in effect, defined by the much smaller radii of the individual round wires comprising the outer layer. In contradistinction, the effective contact radius of the interlocked multi-wire strand member of the present invention is substantially identical to the radius of the entire strand. The result is a strand in which the individual wires are less susceptible to abrasion and other forms of wear and tear.

The anti-abrasion feature of the present invention is particularly advantageous when a plurality of interlocked multi-wire strands formed according to the present invention are wound together to form a wire rope as shown in FIG. 3. In this application, each multi-wire strand contacts the adjacent strand along a substantially smooth and continuous surface. Thus, intrastrand nicking and other forms of abrasive wear and tear, as for example when the wire rope is subjected to loading in a sheave or drum system, are advantageously reduced.

In addition to the advantages mentioned above, the internal stability of the interlocked multi-wire member of the present invention is considerably improved over conventional round wire constructions; even those in which filler wires are incorporated. In this connection, the interlocking relationship between the oversize wires 4 and the wires 2 and 3 tend to hold the entire structure together even though an individual wire becomes broken during use in the field.

As mentioned above, the interlocked multi-wire member of this invention may be fabricated simply and inexpensively by the use of conventional stranding machines and compacting equipment. Apparatus constructed specifically for this purpose is not required and hence very little time is lost in setting up a production run and tooling costs are virtually nil.

I claim:

1. In a multi-wire member, the improvement wherein the outer layer of the member comprises:
   a. a plurality of helically wrapped base wire structures;
   b. a plurality of oversize wires disposed alternately between each two base wire structures, each oversize wire having a normal undeformed shape extending radially outwardly of said base wires and being deformed into interlocking engagement with the base wire structures on either side thereof, each oversize wire is deformed with the outer surface regions of the base wires defining a relatively smooth and substantially continuous outer surface of the member.
2. The improvement according to claim 1 wherein:
   a. the multi-wire member is a strand with each base wire structure defined by a single wire.
3. The improvement according to claim 2 wherein:
   a. the multi-wire strand has a plurality of layers; and
   b. each oversize wire is deformed by radial compressive forces applied thereto such that it at least partially surrounds in intimate surface-to-surface relationship each base wire on either side thereof and each wire of the next underlying layer of the strand facing said oversize wire.
4. The improvement according to claim 3 wherein:
   a. each oversize wire is deformed such that the outer surface regions of the oversize wires together with the outer surface regions of the base wires define a relatively smooth and substantially continuous outer surface of the strand.
5. The improvement according to claim 4 wherein:
   a. the base wires are made of relatively hard material; and
   b. the oversize wires are made of relatively soft material.
6. The improvement according to claim 5 wherein:
   a. each base wire and one of the wires comprising the next underlying layer of the strand are positioned with respect to each other such that the longitudinal axis of each intersects a common line extending outwardly in a radial direction from the center axis of the strand.
7. The improvement according to claim 5 wherein:
   a. each base wire is substantially round in cross-sectional shape both before and after said redially compressive forces are applied to the oversize wires; and
   b. each oversize wire is initially round in cross-sectional shape before said radially compressive forces are applied thereto.
8. The improvement according to claim 5 wherein a plurality of said strands are wrapped together to form a wire rope.

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