United States Patent [19]

Pearson

[11] **3,809,802**

[45] **May 7, 1974**

[54] **ROUND ELECTRIC CABLE FOR SEVERE ENVIRONMENTAL OPERATION AND METHOD OF MANUFACTURE THEREOF**

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[73] Assignee: **Crescent Insulated Wire & Cable Company, Inc.,** Trenton, N.J.

[22] Filed: **Nov. 13, 1972**

[21] Appl. No.: **305,800**

[52] **U.S. Cl.** **174/103,** 156/50, 174/107

[51] **Int. Cl.** **H01b 7/20**

[58] **Field of Search**..... 174/102 R, 107, 103, 116, 174/110, 110 PM, 133 R, 120 SR; 57/7, 9; 156/47, 48, 50, 51

[56] **References Cited**

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Primary Examiner—E. A. Goldberg

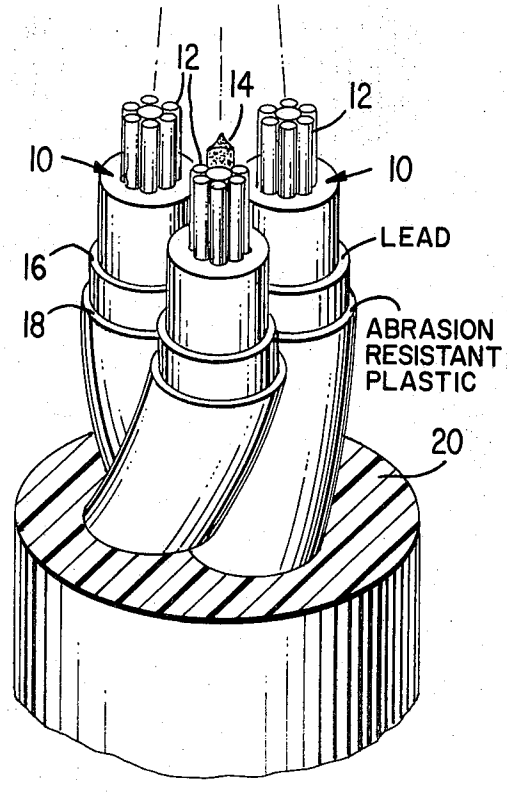
Attorney, Agent, or Firm—Sperry and Zode

[57] **ABSTRACT**

A method is herein provided for making round electrical cable for use under severe environmental conditions including the step of providing a conductor, coated with a layer of insulating material. A lead sheath is applied over the layer of insulating material and a layer of heat resistant, abrasive resistant, protective material, such as a nylon base substance, is extruded onto the outer surface of the lead sheath. The conductor is then twisted with other similar conductors, through a die, and the bundle of mutually twisted conductors is then encased in a nitrile-base jacketing material.

The disclosed round cable generally includes a plurality of mutually twisted, insulated conductors, encased in a nitrile-base jacket. Each insulated conductor generally comprises at least one strand of conductor wire, coated with an electrical insulating material and a lead sheath enclosing the insulating material. A layer of an abrasive resistant protective material is applied to the outer surface of the lead sheath. Preferably, the protective material consists of a nylon-based relatively pliable substance.

5 Claims, 4 Drawing Figures



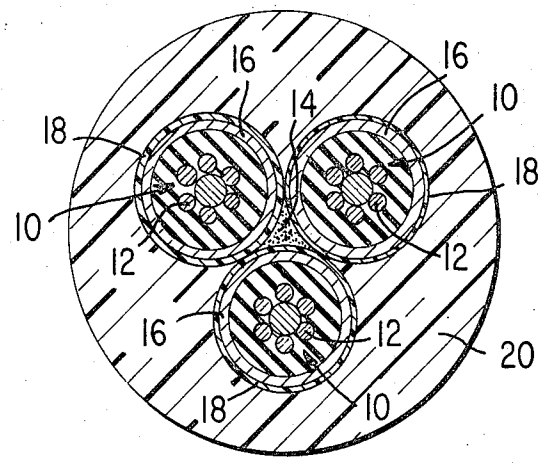


Fig. 1.

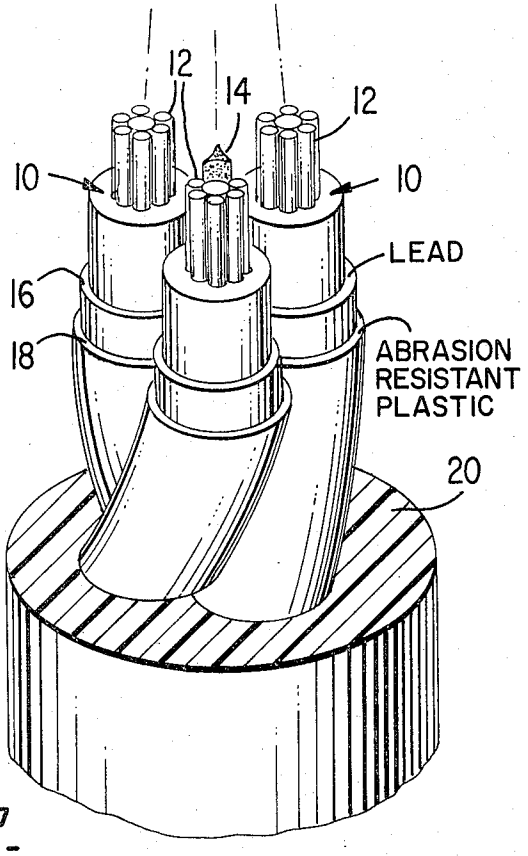


Fig. 2.

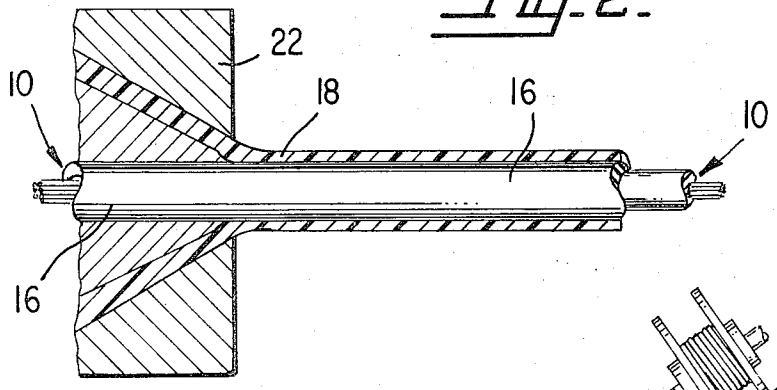


Fig. 3.

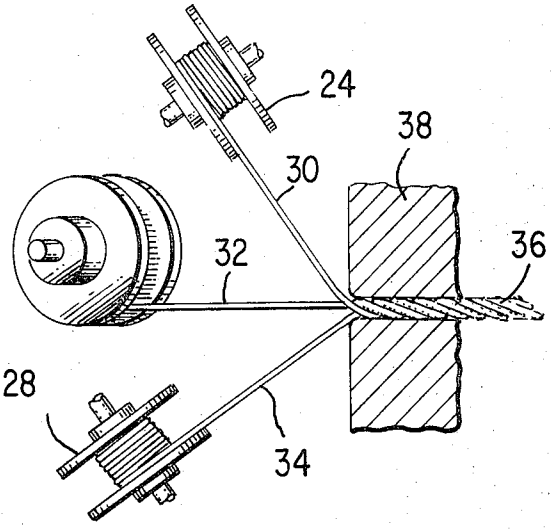


Fig. 4.

ROUND ELECTRIC CABLE FOR SEVERE ENVIRONMENTAL OPERATION AND METHOD OF MANUFACTURE THEREOF

BACKGROUND OF THE INVENTION

The present invention relates to a high temperature electric cable which is particularly suitable for down-hole, pumping operations, and the like.

In such cable configurations, it is common to have at least three conductors bound together as a conductor "bundle" in either a mutually twisted or in a side-by-side disposition. Examples of such high temperature electric cables are set forth in the disclosure of U.S. Pat. No. 3,413,408, issued to Robinson, on Nov. 26, 1968, and assigned to the assignee of the present invention.

Typically, it has been found that, when the conductors are bound together in a side-by-side, "flat cable," configuration, more installation damage is probable, due to crushing, catching, and abrasion in a borehole, than if the conductors were mutually twisted into a "round" cable.

Due to the various electrical fields created by three phases of an electrical power supply being carried by three adjacent conductors, it has been found highly desirable to configure the conductor bundle in a mutually twisted arrangement so as to minimize and balance the effects of the electrical fields created thereby. When the conductors are aligned in a side-by-side configuration, electrical imbalances have resulted in phase shifts and other undesirable electrical phenomena.

Additionally, since many boreholes, in earth drilling operations, deviate from a normal "plumb line" to a substantial degree, the restricted flexibility of a flat cable, in the plane of flatness, presents a problem to those attempting to supply electrical power down hole.

Accordingly, it is advantageous, from both a physical and an electrical viewpoint, to be able to readily form conductor bundles in a mutually twisted configuration, as a "round cable." However, since such conductors are generally covered with a lead sheathing, and since the lead sheathing may become severely abraded, during a twisting operation, through a die, such twisting of lead sheathed high temperature conductors has heretofore been difficult.

Therefore, it would be a major contribution to the art, if a method and apparatus were provided for facilitating the mutual twisting of conductors, covered with lead sheaths, for the purpose of forming high temperature cable.

OBJECTS AND SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method and apparatus for facilitating the mutual twisting of conductors having lead sheaths disposed thereon.

It is another object of the present invention to facilitate the manufacture of round cable.

It is still another object of the present invention to provide a method and apparatus for manufacturing cable which tends to minimize the effect of the mutual interaction of electrical fields of a plurality of contiguous electrical conductors.

It is a major object of the present invention to solve at least some of the problems confronting those attempting to provide electrical power down-hole in pumping operations.

The above-cited objects are achieved by the provision of a method for making round, high temperature electrical cable including the step of providing a conductor, coated with a layer of electrical insulating material. A lead sheath is applied over the layer of electrical insulating material and a layer of heat resistant, abrasive resistant, relatively pliable protective material is applied to the outer surface of the lead sheath. The conductor is then mutually twisted with other similar conductors, through a die, and the resulting conductor bundle is encased in a nitrile base jacketing material.

The insulated conductor, according to the present invention, generally comprises at least one strand of conductor wire coated with an electrical insulating material and a lead sheath enclosing the overall conductor, so insulated. A layer of abrasive resistant protective material is applied onto the outer surface of the lead sheath to prevent abrasion of the lead sheath during mutual twisting of the conductor with other similar conductors, through a die.

BRIEF DESCRIPTION OF THE DRAWINGS

While the invention is particularly pointed out and distinctly claimed in a concluding portion of the specification, a preferred embodiment is set forth in the following detailed description, which may be best understood when read in conjunction with the accompanying drawings, in which:

FIG. 1 is a radial sectional view of a round cable according to present invention;

FIG. 2 is a perspective view of the round cable, set forth in FIG. 1, wherein various layers of material have been stripped away to illustrate the general components of the overall cable;

FIG. 3 is a diagrammatic view of protective material being extruded, in accordance with one method of the present invention; and

FIG. 4 is a diagrammatic view, illustrating the step of mutually twisting conductors, according to the present invention, to form a conductor bundle.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, in which like numerals are used to indicate like parts throughout the various views thereof, FIG. 1 shows a radial sectional view of a round cable according to the present invention.

Essentially, the cable comprises a plurality of insulated conductors **10**, which may each, in turn, comprise a plurality of conductor strands **12**. The strands **12** may be mutually twisted about a center strand and the overall conductor, formed thereby, may be embedded within an insulating material. Such material may generally comprise a thermo-setting material such as rubber or cross-linked polyethylene, or a thermoplastic insulation such as polyethylene, polypropylene or vinyl.

The insulated conductors **10** are then mutually twisted with the center interstice **14** filled with a rubber-like filler material. Since such cables are utilized for extreme environmental conditions, a lead sheath **16** is disposed about the insulated conductors **10.**

In accordance with the present invention, a heat resistant, abrasion resistant, protective, relatively pliable material **18** is extruded over the outer surface of the lead sheath **16.** The method of applying the material **18**

as well as the function thereof will be explained, in detail, with respect to FIGS. **3** and **4.**

The mutually twisted bundle of conductors **10** is then encased within an oil-resistant, gas-resistant, and water-resistant jacket material **20,** such as Acrylonitrile-butadiene (Nitrile). Sometimes, a flexible, interlocked galvanized steel or monel armor is applied over the nitrile jacket for additional mechanical protection. However, this is not always necessary.

In particular, it has been found that, while such armor is necessary when the conductors **10** are aligned side-by-side, as a flat bundle, which is subject to crushing and abrasion within a borehole, a round cable, such as shown in FIG. **1,** is less susceptible to crushing and abrasion so as to permit the cable to be effectively utilized without the addition of such armor.

FIG. **2** shows the components set forth in FIG. **1,** in a stripped-away perspective view.

Referring now to FIG. **3,** a conductor **10,** having a lead sheath **16** enclosing the conductor, is passed through an extruding apparatus **22.** The conductor may pass through a central portion of the extruding apparatus **22** and the protective material **18** may be applied to the outer surface of the lead sheath **16** so as to provide an abrasion-resistant, relatively pliable, high temperature, protective coating for the lead sheath **16.** One example of a substance which has been found to work entirely satisfactorily is plasticized nylon material, sold by Rilsan Corporation of 139 Harristown Road, Glen Rock, N.J., and identified as Rilsan Nylon 11, BESNO-P40. The lubricity of nylon makes this substance especially effective. Additionally, the nylon is compatible with the nitrile jacket material **20.**

Referring now to FIG. **4,** it can be seen that three reels **24, 26,** and **28** carrying the protectively coated conductors (individually lead-sheathed and coated with the plastic covering **18**) are disposed to rotate so as to mutually twist the protectively coated conductors **30, 32,** and **34.** Since the conductors must be twisted into a tight bundle **36,** a mechanical die **38** is provided for guiding the conductors into a proper bundle configuration.

Heretofore, it had been found that the lead sheath **16** may become distorted and severely abraded, during this mutual twisting operation, as the conductors **30, 32,** and **34** are forced through the die **38.**

I have discovered that, by applying a substance having the requisite properties of pliability, resistance to abrasion, and ability to withstand high temperatures, such as the plasticized nylon identified above, to the outer surface of the lead sheath **16,** the distortion and abrasion of the lead could be prevented. This, in turn, was found to prevent electrical and mechanical failures caused when cable, utilizing distorted and abraded lead sheathed conductors, is subjected to the severe, environmental conditions of down hole operations.

The coating **18** applied about each lead sheath protectively encases the same in a manner that is of particular importance during the manufacture of the cable, in that first of all it permits the making of a round cable having mutually twisted conductors that are lead sheathed; secondly, accomplishes this by utilizing a protective coating for the conductors applied to the lead-sheathed conductors by an extrusion process or by an equally inexpensive method; and third, in the completed cable is fully compatible with the nitrile jacket thereof and has other important physical properties that assure against deterioration, malfunction or shortening of the life span of the cable during its employment in typically severe environments.

The substance identified above, which I find well suited to meet these rigorous requirements, has the following physical properties:

Water absorption:		
saturation at 73°F. and 65% RH		0.3%
24 hr. at 73°F		1.1%
Tensile strength:		
at −40° F		9,500 psi
at +68° F		7,500 psi
at +176° F		5,000 psi
Elongation:		
at −40° F		50%
at +68° F		300%
at +176° F		310%
Taber Abrasion:		
C17 wheel, 1,000 G. Wt.		loss in mg, 1000 cycles-2
Flexural Modulus:		
at −40° F		2.70 psi×10^5
at +68° F		0.50 psi×10^5
at +176° F		0.24 psi×10^5
Compressive strength		7,100 psi
Deflection Temperature	66 psi	284° F.
	264 psi	118° F.
Melting point		367° F.
Thermal Expansion Coefficient-Linear:		
between −22° F. and +104° F		9.1 10–5
Volume resistivity:		
at 68° F. and 65% RH		9.1 10^{10}
Dielectric Strength:		
short time, dry		17,500 KV/mm
Resistance to salt solutions, salt water, marine atmospheres, oils, greases and petroleum products		good
Compatibility with nitrile-base jackets		excellent
Resistance to electrolytic corrosion		excellent

It is entirely possible that other materials, having physical and electrical properties equal or in general close to those tabulated above, may be employed. For example, those extrusion-grade products classed as thermoplastic polyurethane compounds would be usable as the coating **18** selected of course to incorporate the requisite heat resistance, the toughness, and the pliability possessed by the nylon product hereinbefore identified. Typical among these, the polyester polymer sold under the trademark ESTANE 5710 by the B.F. Goodrich Chemical Company, 3135 Euclid Ave., Cleveland, Ohio 44115 may be advantageously employed.

Also usable is the **90** Shore A polytetramethylene — etherglycol (PTMG) based thermoplastic, polyurethane material known as ROYLAR E-9 and sold by Uniroyal Chemical Division of Uniroyal, Inc., Naugatuck, Connecticut 06770.

It can therefore be seen that a conductor configuration has been herein provided which facilitates the mutual twisting of conductors for the manufacture of round cable. Furthermore, it can be seen that a method for manufacturing round cable has been herein disclosed which method permits the formation of conductor bundles in a tight, mutually twisted configuration, so as to minimize the mutual interaction of fields, created by current flowing through mutually adjacent conductors.

It can also be seen that, since cable for severe environmental conditions may now be made in a round configuration, without the difficulty heretofore experienced, the flat type of cable configuration, need not be used. This, in turn, permits effective use of deviated boreholes. Also, the severe crushing of flat cable and the abrading thereof, caused by the rather cumbersome configuration of the flat cable, may now be obviated by the use of round cables.

In sum, the invention produces, at a competitive production cost, a cable that has lead-sheathed conductors to withstand extreme environmental conditions; that has desirable electrical properties through the provision of spirally twisted conductors; has desirable mechanical properties as regards withstanding crushing and distortion in use; has good flexibility to facilitate insertion and withdrawal from the hole; and has compatible components all of which can withstand severe environmental conditions. To my knowledge, all of these characteristics have heretofore not been combined in a single cable.

Accordingly, the present invention is a technical advance and a contribution to the field of electrical cables especially adapted for manufacture of a round cable having a multiplicity of spirally twisted lead-sheathed conductors, and for use in the severe environmental conditions associated with down hole pumping operations.

SCOPE OF THE INVENTION

While what has been described is a preferred embodiment of the present invention, it is of course to be understood that various modifications and changes may be made therein without departing from the invention.

Accordingly, it is intended to cover in the following claims all such modifications and changes as may fall within the true spirit and scope of the present invention.

What I claim is:

1. A method for making round electrical cable comprising the steps of:

first, providing a conductor, coated with a layer of electrical insulating material;

then, applying to said conductor a lead sheath over the layer of electrical insulating material;

after application of said lead sheath, applying a layer of heat resistant, abrasive resistant, relatively pliable, protective material onto an outer surface of the sheath whereby to prevent distortion and abrasion of said sheath normally likely to occur on twisting of a plurality of lead-sheathed conductors together;

then, mutually twisting the conductor with the lead sheath and said layer of pliable material thereon, with other similar conductors to which lead sheaths and pliable material have also been applied, through

a die; and as a final step,

encasing the twisted conductors in a jacketing material.

2. A round electrical cable comprising:

a bundle of mutually twisted insulated conductors encased in a jacket, each said insulated conductor comprising at least one strand of conductor wire coated with an electrical insulating material and a lead sheath enclosing the insulated conductor wire; and

a now impregnated covering of an abrasive resistant, heat resistant, relatively pliable, protective material, completely enclosing the lead sheath of each of the mutually twisted conductors of said bundle, the several lead-sheath-enclosing coverings of the bundle extending in longitudinally contacting relation in the twisted relationship of the conductors whereby to prevent distortion and abrasion of the lead sheaths normally likely to occur on twisting of a plurality of conductors together when they are so sheathed.

3. The combination according to claim **2**, wherein said abrasive resistant, heat resistant, relatively pliable, protective material comprises a nylon base.

4. The combination, according to claim No. **2**, wherein said abrasive resistant, heat resistant, relatively pliable, protective material exhibits a high degree of lubricity.

5. The combination according to claim **2**, wherein said abrasive resistant, heat resistant, relatively pliable, protective material comprises a polyurethane base.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,809,802 Dated May 7, 1974

Inventor(s) Stanley Pearson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 19 change "now" to --non--

Signed and sealed this 1st day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.

UNITED STATES PATENT OFFICE

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