PIE TYPE CABLES WITH IMPROVED SKID WIRE PROTECTION

Inventors: George S. Eager, Jr., Upper Montclair, N.J.; David A. Silver, Roslyn, N.Y.; Carlos Kata, Bayonne, N.J.

Assignee: General Cable Corporation, New York, N.Y.

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ABSTRACT

This specification discloses an electric cable with a skid wire that has a lower co-efficient of friction than metal skid wires and is made of synthetic material having electric resistance that is too high for the skid wire to maintain electric continuity between an electrostatic shield of the cable and a metal surface in a pipe or other conduit in which the cable is installed. Metal or other good electrical conducting means extends through the skid wire with exposed surfaces of the metal in position to maintain the desired electrical continuity between the electrostatic shield and the conduit. The skid wire has a perforated metal center strip with plastic extruded along both sides of the strip and locked together in a one piece extrusion by portions of the plastic extending through the perforations in the strip.

15 Claims, 17 Drawing Figures
This invention relates to cables installed in pipes and particularly to high voltage cables provided with an improved skid wire that protects the cable and minimizes abrasion of the enclosure in which the cable is installed, while maintaining the electric continuity between the cable electrostatic shield and this enclosure.

Skid wires are used on pipe type cables to provide mechanical protection to the cable core during shipment, installation and in service operation. Skid wires are generally half round or D shaped. The flat surface is applied bearing against the cable surface.

The enclosures in which pipe type cables are installed are generally of carbon steel having smooth surfaces. A considerable amount of abrasion occurs on both the pipe and the skid wire when long lengths of cable are installed in a pipe system. This abrasion is a consequence of the resistance the pipe surface offers to the motion of the cable(s) and is in direct relation to the pressure exercised by the cable(s) on the enclosure. The abrasion on the skid wires is most severe when the cable passes over sharp changes in direction of the enclosure.

Three basic types of skid wires are known to us:
1. Metallic skid wires made of conducting materials such as copper, bronze, brass, zinc, stainless steel and aluminum.
2. Skid wires made of mechanically strong synthetic materials such as linear polyethylene or nylon (U.S. Pat. No. 3,080,446).
3. In combination, a dielectric skid wire with a plurality of conducting means wrapped helically around the dielectric at spaced intervals (U.S. Pat. No. 3,080,446).

All of these skid wires have serious shortcomings, limiting the possibility of installation of present cables to a reduced number of types of enclosure. Some of the most outstanding shortcomings are:
1. Because of excessive abrasion, relatively heavy wall steel pipes (generally 0.25 inch thick), and large skid wires are required, specially for large cable pulls. The thickness of the pipe walls are additionally dependent on the pressure at which the system will operate. Also because of the excessive abrasion produced by metallic skid wires the use of aluminum pipes, providing lower losses and consequently higher conductor current carrying capacities, has been practically non-existing in pressure pipe type cables.
2. Skid wires made of synthetic materials are generally insulating or semi-conducting and can only be used in very specialized applications. Under normal cable operating conditions such skid wires are not acceptable because they do not provide the electric conducting pad required in a cable system between the electrostatic shield and the enclosure. The use of this type of skid wires is dangerous for the cable system and therefore has not found acceptance. In the case of lightning and switching surges and in the case of ground faults which cause over-voltages, the dielectric may break through causing arcing which may destroy the cable shield and subsequently the cable insulation.
3. The third type of skid wire mentioned above, although providing an electric connection between the electrostatic shield and the enclosure has the same weaknesses as the first type. Because a relatively thin metallic wrapping is used around such a skid wire its use has to be limited to relatively short lengths of cable.

Extruded synthetic type skid wires offer the lowest coefficient of friction but because of the shortcomings mentioned above they are not used in commercial installations. The following tabulation indicates the results of friction angle measurements performed in our laboratories using steel and aluminum pipes. In all cases the same cable, skid wire spacing, skid wire size and pipe size were used.

<table>
<thead>
<tr>
<th>Skid Wire</th>
<th>Friction Angle-Degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On Steel Pipe</td>
</tr>
<tr>
<td>High density polyethylene</td>
<td>7.0</td>
</tr>
<tr>
<td>Zinc-copper alloy</td>
<td>11.0</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>12.5</td>
</tr>
<tr>
<td>Brass</td>
<td>10.5</td>
</tr>
<tr>
<td>Bronze</td>
<td>10.5</td>
</tr>
</tbody>
</table>

It should be noted that, during installation of a three-phase pipe type cable system, where three cables are installed simultaneously in a pipe, if one of the skid wires should break it will be necessary to remove the three cables from the system and replace them with new cables. This is a very expensive procedure. Average lengths of pipe type cable are about 2,000 feet long, which means that about 6,000 feet of cable have to be replaced at once. Therefore, it is very important that skid wires offer absolute reliability.

We have invented a new, low cost skid wire which overcomes the weaknesses of the above mentioned skid wires and which allows metallic pipes of very thin wall or of relatively poor abrasion resistance to be used in cable systems.

The preferred construction of this invention has a metal strip that is a good conductor of electricity and that extends the length of the skid wire. The top and bottom edges of the strip are left exposed for contact of one edge with the cable and contact of the other edge with a metal surface in the pipe or other conduit in which the cable is installed. Synthetic plastic material extruded over both sides of the strip provides a skid surface better than the surface of the strip; and the plastic on opposite sides of the strip extends through openings in the strip to make the plastic a one piece extrusion secured to the metal.

In place of a simple strip, the metal can have cross-sections that increase for area of exposure on the side toward the cable and that decrease for area in contact with the metal surface of the pipe or other enclosure, this being the surface on which friction must be reduced in order to have the cable pull into the pipe or conduit with minimum resistance.

Other objects, features and advantages of the invention will appear or be pointed out as the description proceeds.

**BRIEF DESCRIPTION OF DRAWING**

In the drawing, forming a part hereof, in which like reference characters indicate corresponding parts in all the views;

**FIG. 1** is a fragmentary view with portions broken away and in section, showing a pipe type cable equipped with a skid wire made in accordance with this invention;

**FIG. 2** is a fragmentary view, partly in section, showing a portion of the skid wire, on a greatly enlarged scale, of the cable shown in FIG. 1;

**FIG. 3** is a sectional view through the skid wire shown in **FIG. 2**, the section being taken on the line 3—3 of **FIG. 4**;

**FIG. 4** is a longitudinal sectional view on the plane 4—4 of **FIG. 2** and **FIG. 4** also has the section line 2—2 which indicates where the sectional view is taken for **FIG. 2**;

**FIG. 5** is a view similar to **FIG. 2** but showing a modified form of the invention, the part of **FIG. 5** in section being taken on the line 5—5 of **FIG. 7**;

**FIG. 6** is a sectional view on the line 6—6 of **FIG. 7**;

**FIG. 7** is a sectional view taken on the plane 7—7 of **FIG. 5**;

**FIG. 8** is a view similar to **FIGS. 2** and 5 but showing still another modified form of the invention, the portion of **FIG. 8** that is in section being taken on the section line 8—8 of **FIG. 10**;

**FIG. 9** is a sectional view taken on the line 9—9 of **FIG. 10**;

**FIG. 10** is a longitudinal sectional view taken on the plane 10—10 of **FIG. 8**;

**FIG. 11** is a view similar to **FIGS. 2**, 5 and 8 but showing still another modified form of the invention, the portion of **FIG. 11** that is in section being taken on the line 11—11 of **FIG. 13**;

**FIG. 12** is a sectional view taken on the line 12—12 of **FIG. 13**;

**FIG. 13** is a longitudinal sectional view taken on the plane 13—13 of **FIG. 11**;
FIG. 14 is a view similar to FIGS. 2, 5 8 and 11 but showing still another modified form of the invention, the sectional 3 part of FIG. 14 being taken on the line 14—14 of FIG. 16; FIG. 15 is a sectional view taken on the line 15—15 of FIG. 16.

FIG. 16 is a longitudinal sectional view taken on the plane 16—16 of FIG. 14; and FIG. 17 is a sectional view showing the cable of FIG. 1 and enclosed in a pipe.

DESCRIPTION OF PREFERRED EMBODIMENT

FIG. 1 shows a cable 20 which includes a stranded center conductor 22 surrounded by a conductor shield 24 and with insulation 28 around the conductor shield 24. The cable has a conventional insulation shield 28 which is formed by a metallic shielding tape wrapped helically around the insulation and there are two skid wires 30 and 32 wrapped around the electrostatic shield 28 in helical formation which is also in accordance with conventional practice. Both of the skid wires 30 and 32 may be the same in construction or they can be of different construction, that is, the skid wire 30 may be made in accordance with this invention and skid wire 32 may be a conventional skid wire which has no electrical conductive feature of this invention.

The skid wire 30 may be of the construction shown in FIG. 2. This Figure shows a skid wire designated by the reference character 30a with a metal strip 34a which extends from a top surface 36a of the skid wire to a center bottom location 38a which represents the portion of the skid wire which is furthest from the electrostatic shield and which is the part of the skid wire which touches the pipe into which the cable is pulled.

The metal strip 34a has a top edge 40a which provides a surface for contact with the electrostatic shield 28 of the cable shown in FIG. 1, and since the strip 34a extends through the full height of the skid wire 30a, provides electrical continuity between the electrostatic shield and the pipe with which the skid wire is in contact.

In order to give the skid wire 30a low friction, the strip 34a is tapered so that the edge at the location 38a has a narrow width and most of the skid wire is formed of synthetic plastic material 42a which is preferably extruded over the strip 34a to provide the conventional semi-circular contour for the skid wire. The plastic extruded material 42a is preferably of one piece construction and this result is obtained by having openings 44a extending through the strip 34a as shown in FIGS. 3 and 4. When the plastic material 42a is extruded, it fills the openings 44a and connects the portions of the plastic material together which are on opposite sides of the metal strip 34a.

The plastic material 42a bonds to the metal strip 34a and if the plastic material 42a is a material which does not bond tenaciously to the metal of the strip 34a when extruded over the strip, then an adhesion promoting coating can be applied to the sides of the strip 34a but not to the top and bottom edges of the strip since it is important to maintain metal to metal contact between these edges and the electrostatic shield of the cable and the metal surface of the pipe in which the skid wire is used.

The electrically conductive material 34a is preferably from the group consisting of copper, aluminum, zinc, lead, steel and their alloys; and the plastic material 42a used as the protective covering is preferably from the group consisting of ethylene propylene copolymer (EPC), polyethylene oxide, high density polyethylene, polyesters, polyamides and their respective commercial variations.

FIG. 5 shows a modified form of the invention in which a skid wire 30b is provided with a metal strip 34b corresponding parts of the skid wire 34b are indicated by the same reference characters as in FIGS. 2-4 but with a letter "b" appended in place of the letter "a" of FIGS. 2, 3 and 4.

There are two differences in the construction shown in FIGS. 5-7 as compared to that shown in FIGS. 2-4. One difference is that the metal strip 34b is of uniform thickness in stead of being tapered as in FIG. 2 and another difference is that the openings 44b through the metal strip 34b are of a diamond shape instead of being round. It will be apparent that the openings through the metal strip can be of the desired shape provided that they do not extend so close together that they are likely to break into one another and destroy the longitudinal continuity of the metal strip.

FIG. 8 shows another form of the invention in which a skid wire 30c is made with a metal strip 34c, the parts being again identified by the same reference numerals as in the other drawings but with the letter "c" applied in place of the letters "a" and "b.

The difference in construction between the skid wire 30c and the skid wires shown in the other Figures is that the metal strip 34c has openings 44c which are notches in both the upper and lower edges of the metal strip as is most clearly shown in FIG. 10. When the plastic material 42c is extruded over the strip 34c, the plastic material on opposite sides of the strip merges across the notches forming the openings 44c and thus makes the plastic material 42c of one piece construction with the strip 34c imbedded in it.

FIG. 8 shows the upper discontinuous edge 40c of the strip 34c extending slightly above the top surface 36c of the skid wire material 42c; and also shows the lower edge at the location 38c extending somewhat below the surface of the plastic material 42c.

This result can be obtained by shrinkage of the plastic material 42c as it cools after extrusion, or by the way in which it is molded on the metal strip 34c if molding is used instead of extrusion. It should be understood that the other modifications of the invention herein described, including what is shown in FIGS. 2 and 5, can be made with the edges of the metal strip extending slightly above the wide surface of the skid wire that contacts with the cable and extending slightly below the center of the arcuate surface of the skid wire.

FIG. 11 shows a skid wire 30d with a metal strip 34d which has its upper edge broadened out so as to cover the entire top surface of the plastic material 42d. The portion of the metal strip 34d which extends downwardly toward the arcuate surface of the strip is shown tapered in FIG. 11 but can be of uniform width as in FIGS. 5 and 8. The downwardly extending portion of the metal strip 34d has large openings 44d which are notches in the bottom edge of the strip 34d. The plastic material 42d on both sides of the strip 34d merges to form a piece of plastic mass secured together by the portions of the plastic which extend through these openings 44d. The deep notches forming the openings 44d in the skid wire 30d and extending for somewhat more than half the total depth of the metal strip 34d increase the flexibility of this metal strip as compared with the strips shown in FIGS. 2-4 because these notches are at the outside of the bend which is imparted to the skid wire when it is wrapped around the cable.

FIG. 14 shows a skid wire 30e with a metal strip 34e having openings 44e formed by deep notches in the bottom edge of the strip 34e as in FIG. 13 and also formed with notches in the upper edge providing somewhat smaller openings 44e. The plastic material 42e on opposite sides of the strip 34e merges to form a piece of extrusion flow by through the openings 44e and also through the openings 44e. The metal strip 34e tapers to a narrow edge at its lower end as in the strips shown in FIGS. 2 and 11.

FIGS. 2-16 illustrate a number of different ways in which the skid wire of this invention can be constructed but other combinations are possible and will be suggested by those illustrated.

FIG. 17 shows the cable 20 enclosed in a pipe 50 filled with dielectric fluid under pressure, such as oil 52.

The skid wire 30 is in contact with the inside wall of the pipe 50 and it will be apparent that with the skid wire 30 constructed as shown in any of the FIGS. 2 through 16, there may be electric continuity between the electrostatic shield 28 of the cable and the inside surface of the metal pipe 50. The skid wire can be used in pipes which are not made of metal or in
other conduits which are not made of metal if a metal lining or sheathing is used along the length of the pipe or conduit to obtain the effect of a metal pipe.

The preferred embodiments of the invention have been illustrated and described, but changes and modifications can be made and some features can be used in different combinations without departing from the invention as defined in the claims.

What is claimed is:

1. The combination of an electric cable and a skid wire helically wrapped around the cable, the skid wire having a surface for contact with the circumference of the cable and a skid surface for contact with a conduit into which the cable is intended to be pulled, the skid wire being made partly of electrically conductive material that extends from the surface that contacts with the circumference of the cable and through the skid wire to an area of the skid portion that contacts with the conduit after the cable is introduced into the conduit, and the skid wire being made partly of protective covering material that has a low coefficient of friction than the electrically conductive material and that covers said electrically conductive material to protect substantial areas of said electrically conductive material from contact with the conduit when the cable is being pulled into the conduit.

2. The combination described in claim 1 characterized by the electrically conductive material being exposed across part of the length and breadth of the surface of the skid wire that contacts with the cable and said electrically conductive material extending through the low friction material to the opposite side thereof, and the protective covering material being on both sides of the electrically conductive material with said protective covering material on the different sides connected together for portions thereof that extend through transverse openings in the electrically conductive material.

3. The combination described in claim 1 characterized by the electrically conductive material being a metal and the protective covering material being a mechanically strong synthetic plastic material.

4. The combination described in claim 3 characterized by the electrically conductive material being from the group consisting of copper, aluminum, zinc, lead, steel, and their alloys, and the protective covering material being from the group consisting of ethylene propylene copolymer (EPC), polyphenylene oxide, high density polyethylene, polyesters, polyamides and the respective commercial variations.

5. The combination described in claim 1 characterized by the skid wire being wrapped helically around an electric cable that has insulation and an electrostatic shield over the insulation, a metal surface in a conduit in which the cable is enclosed, the electrically conductive material of the skid wire maintaining electric continuity between the cable electrostatic shield and said metal surface in the conduit.

6. The combination described in claim 1 characterized by there being a second skid wire helically wrapped around the cable with convolutions that are located between the convolutions of the first skid wire, the second skid wire being made throughout of low friction material that is an electrical insulator.

7. The combination described in claim 1 characterized by the skid wire being of generally semi-circular cross-section with the flat side of the skid wire in contact with the circumference of the cable, the electrically conductive material being exposed over at least the middle portion of the flat side of the skid wire, and said electrically conductive material extending radially through the semi-circular cross-section and opening through the semi-circular surface of the skid wire at substantially the mid-region of said semi-circular surface.

8. The combination described in claim 7 characterized by the electrically conductive material having a larger surface on the flat side of the skid wire than on the semi-circular side of the skid wire.

9. The combination described in claim 7 characterized by the electrically conductive material extending somewhat above the flat surface and radius in claim 1 characterized by the electrically conductive material being continuous lengthwise of the skid wire, and a low friction material being located on both sides of the electrically conductive material and also extending continuously lengthwise of the skid wire and having the portions on opposite sides of the electrically conductive material connected by sections of said low friction material that extend through openings in the electrically conductive material.

10. The combination described in claim 10 characterized by the low friction material being a piece which extends through the openings in the electrically conductive material to secure the portions of the low friction material on opposite sides of the skid wire together and to hold them in contact with opposite sides of the electrically conductive material.

11. The combination described in claim 10 characterized by the electrically conductive material being a metal strip with an opening thereto substantially spaced lengthwise of the strip.

12. The combination described in claim 11 characterized by the electrically conductive material being a metal strip with an opening thereto substantially spaced lengthwise of the strip.

13. The combination described in claim 11 characterized by the electrically conductive material being a metal strip with an opening thereto substantially spaced lengthwise of the strip.

14. The combination described in claim 11 characterized by the metal strip being the conduit for the cable, an electrostatic shield around the cable, a conductive moisture barrier around the cable, a fluid dielectric that floods the cable and space in the pipe around the cable, said electrically conductive material of the skid wire maintaining electric continuity between the electrostatic shield and the metal of the pipe, the electrically conductive material and the low friction material of the skid wire being compatible with the fluid dielectric in the pipe.

15. The combination comprising an electric cable, a skid wire extending helically around the circumference of the cable, the cable having insulation and an electrostatic shield covering the insulation, a conduit in which the cable is enclosed, the conduit having a metal surface for grounding the electrostatic shield, the skid wire being made of material having electrical resistance too high for the skid wire to maintain an electrical continuity between the electrostatic shield and the metal surface in the conduit, and means for maintaining electric continuity between the electrostatic shield and said metal surface including material of good electrical conductivity extending through the skid wire from a mid-portion of the surface of the skid wire that contacts with the cable to the surface of the skid wire that contacts with said metal surface.