United States Patent

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[54] **FIELD IMPREGNATED EXTRA HIGH VOLTAGE CABLE SYSTEM**
4 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** ..... **174/25,** 174/10, 174/108, 174/120 FP
[51] **Int. Cl.** **H01b 9/06**
[50] **Field of Search** ..... 174/25, 102, 102.2, 108, 13, 10, 113, 120, 25 R, 102 SC, 113 R, 120 FP

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ABSTRACT: This electric cable uses a polymeric insulation in place of impregnated paper insulation to make possible underground transmission lines for high voltage. The cable is constructed for impregnation in the field and is filled, usually with oil, after installation in a pipe. The cable insulation is a fibrous paperlike sheet material of high-density polyethylene. Low friction of the insulation, when dry, permits bending around smaller spools for shipping. The cable is free of cellulose material, or other substances that have a sponge effect when exposed to moisture, so that no high-temperature drying is required in the field prior to impregnating the cable.

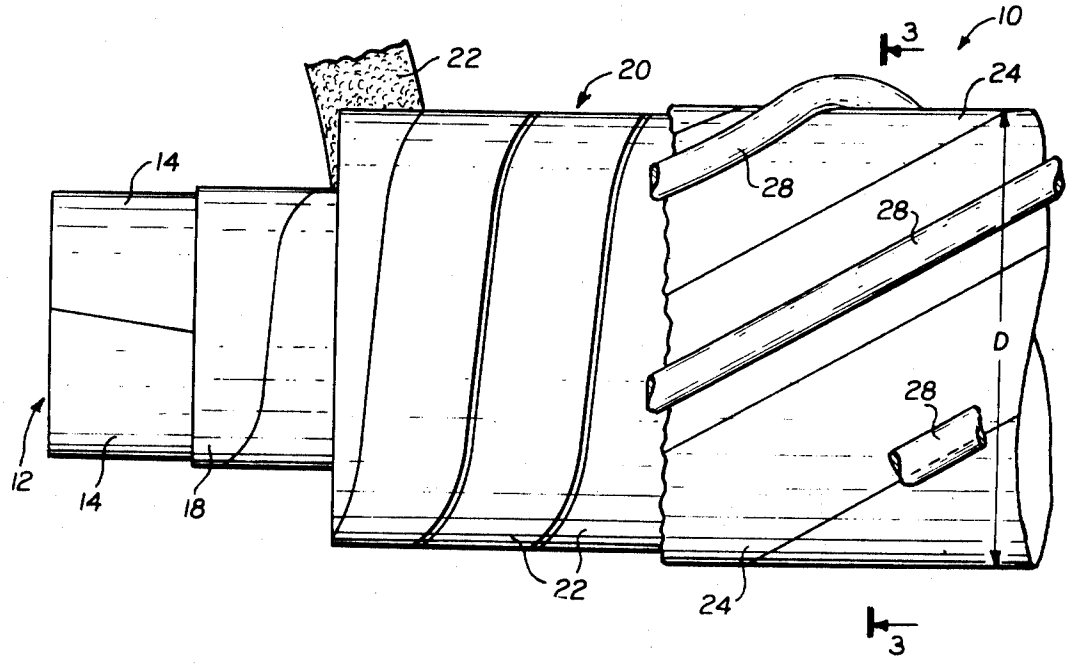


FIG. 1.

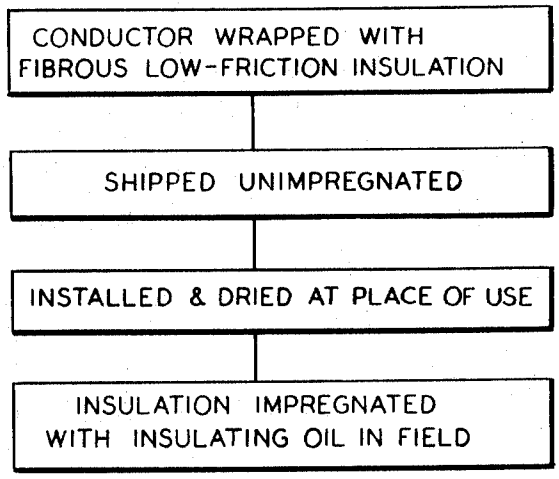
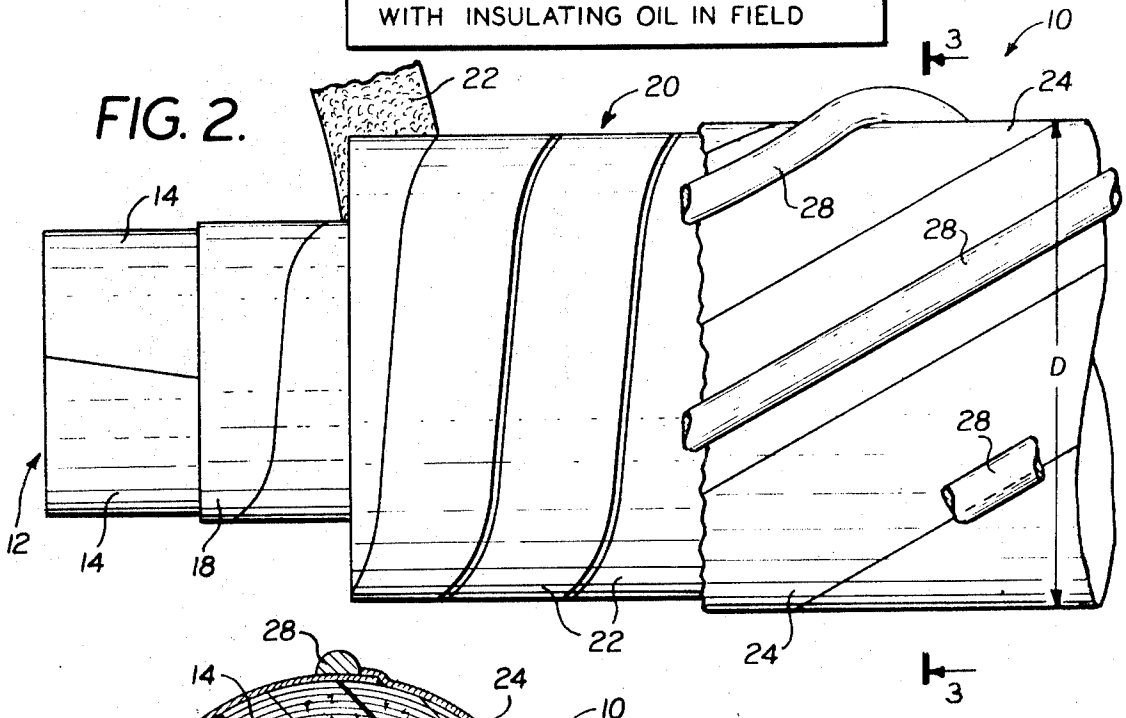


FIG. 2.



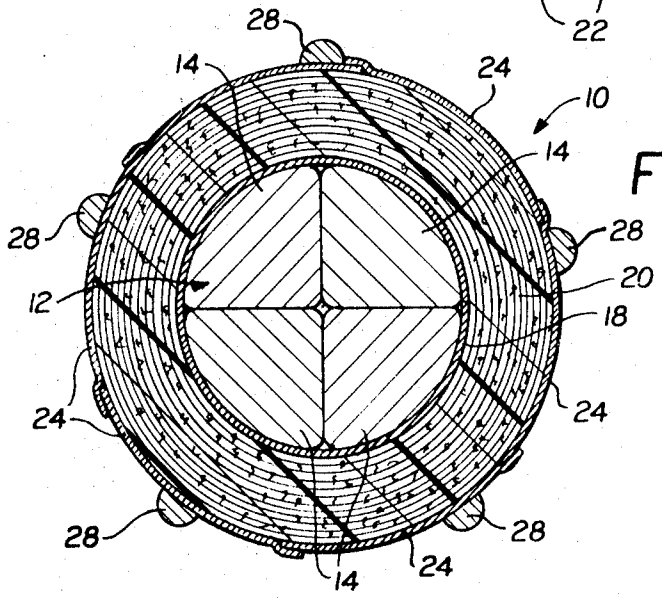


FIG. 3.

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FIELD IMPREGNATED EXTRA HIGH VOLTAGE CABLE SYSTEM

BACKGROUND AND SUMMARY OF THE INVENTION

One object of the invention is to provide an electric cable suitable for use for underground transmission at voltages of 500 kv. or 750 kv. and plus or minus 600 kv. AC. The invention is concerned more particularly with pipe-type cable.

Specific inductive capacity (dielectric constant) and the power factor of oil-impregnated cellulose paper are approximately 3.5 and 0.20 percent, respectively, and cables with this insulation have excessive dielectric loss.

The oil-impregnated synthetic film or tape-insulated cable of this invention has a specific inductive capacity of 2.3 and a power factor of less than 0.10 percent.

A commercially available "paper" made of linear polyethylene fibers is available in the form of fibrous tapes comprising webs of randomly arranged, highly dispersed, continuous filament fibers of the polymeric material bonded primarily at filament crossovers. This material is made by duPont and is known as "Spunbond". It has been found that this polymeric paper runs satisfactorily on the existing taping machines. Thus a dry cable with Spunbond insulation can be produced without special equipment. However, drying and impregnation by conventional procedures and with conventional saturants is not practical because of temperature limitations of the polyethylene fibers and because of a tendency of these fibers to swell to some degree when exposed to insulating oil.

The material designated by duPont as "Spunbond", Type 822, Series R" weighs two ounces per square yard and has a thickness of 6.5 mils. The fiber diameters are comparable to cellulose paper fibers in that they are in the micron range. On the other hand, the Spunbonded polyethylene paper consists of long, practically continuous fibers, in contrast to the short cellulose paper fibers. The fibers are spun and bonded together so as to produce a tape which has most of the mechanical properties of cellulose paper and behaves much like the latter.

This Spunbonded paper is made of linear polyethylene and has a softening point of about 110–125° C. To increase the resistance to high temperature of this tape, it may be chemically or electromagnetically cross-linked. Chemical cross-linking may be accomplished by treatment with a suitable organic peroxide. Electromagnetic cross-linking may be accomplished by subjecting the tape to electromagnetic radiation. In either case, the resistance to heat may be raised to a point from 110–125°C. softening point to 150° C. softening point.

With Spunbond paper the moisture content of the fibers is negligibly small. Absorbed noisture can be removed by applying vacuum at room temperature. Saturation can be effected by use of room temperature and a very thin oil such as dodecylbenzene. However, the low viscosity of the impregnant at room temperature produces another problem, namely that of serious drainage from the cable during shipment and storage prior to installation in the line pipe in the field.

In addition, the contact of the polyethylene fibers with the saturating oil may produce sufficient swelling to produce wrinkling or buckling of the insulation.

Thus there is a disadvantage in using impregnation in the factory. This invention makes practical impregnation in the field because only room temperature is needed for drying and saturation, and because there is no difficulty in obtaining room temperature in the field in a line buried some 4 feet below the surface of the ground. With this invention the cable is shipped to the field, wound on a spool in an unimpregnated state and the final drying and impregnation procedure is carried out in the field, preferably after the installation of the cable has been completed from pothead to pothead.

In the manufacture of paper tape insulated cables the paper tapes shrink slightly during the drying and evacuating process and this facilitates filling the insulation with oil. Until the tapes have shrunk and the cable has been filled with oil, it is important that the cable be not bent on a small radius, because the paper tapes do not slide readily one on top of the other and bending may damage the paper by tearing or by wrinkling. With Spunbond insulated cable there is less friction between tape layers and it is not necessary to use drums of as large size as for paper-insulated cable. However, when the Spunbond-insulated cable is impregnated with oil we have just the opposite situation that we do with paper-insulated cable, because the oil causes the Spunbond to swell slightly, making it more of a problem to bend the impregnated cable.

Another feature of the invention relates to the drying and shipping of the cable for subsequent impregnation in the field. Dry cables can be sent directly from the taping room on the shipping reel and a moisture seal blanket applied to the reel with an opening left in the blanket. The reel with the cable on it is placed in a tank and evacuated to effect removal of adsorbed moisture and to reduce the amount of drying time required in the field. On completion of the vacuum treatment, the vacuum is broken by admitting dry nitrogen to the tank and the slit in the blanket is then sealed when the reel is removed from the tank.

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 thereof, in which like reference characters indicate corresponding parts in all the views:

FIG. 1 is a flow diagram showing the successive steps in carrying out the method of this invention;

FIG. 2 is a diagrammatic fragmentary view with the parts broken away, showing a cable made in accordance with this invention; and

FIG. 3 is a sectional view taken on the line 3—3 of FIG. 2.

DESCRIPTION OF PREFERRED EMBODIMENT

A cable **10**, shown in FIGS. **2** and **3**, is preferably made with a conductor **12** having a plurality of segmental conductor elements **14**. The segmental conductor elements **14** are stranded and are shaped to give the outside of the conductor core a generally circular shape. Conductor shielding **18** is applied over the segmental elements **14** and this conductor shielding is shown as a helically wound tape.

Insulation **20** is applied over the conductor shielding **18**. This insulation is a polymeric material preferably made of linear polyethylene fibers in the form of fibrous tapes comprising webs of randomly arranged, highly dispersed, continuous filament fibers bonded primarily at filament crossovers and having the characteristics described above. The tapes **22** are helically wound in overlying layers to build up the radial thickness of the insulation to the thickness desired for the service for which the cable is intended.

Insulation shielding **24** is applied over the insulation **20**. This insulation shielding is preferably made of as assembly of semiconducting plastic shielding tape, metallized plastic tape supplemented by a metal tape intercalated with metallized or plain plastic tape wrapped around the insulation with a long lay, and with a plurality of overlapping tapes to cover the entire area of the insulation **20** in spite of the long lay of the shielding tapes. The expression "long lay" is used herein to designate a helical pitch greater than about 2½times the cable diameter; and in the construction illustrated the lay of the shielding tapes **24** is 4 D.

By having a long lay for the shielding **24**, the shielding permits swelling of the fibrous polyethylene insulation **22** when the insulation is exposed to contact with insulating oil, and avoids wrinkling of the insulation such as would occur if the swelling were restrained.

A plurality of skid wires **28** surround the insulation shielding tapes **24** and these skid wires also have a long lay.

One important feature of the cable shown in FIG. 2 is that it is constructed of fibrous tape which has a low coefficient of friction on itself so that the layers of tape 22 can slide on top of one another when the cable is bent without damage to the tapes and without causing wrinkling of the insulation. As previously explained, this permits the cable to be wound on smaller reels and effects an economy in shipping.

FIG. 1 is a flow diagram showing the successive steps in carrying out the method of this invention. The conductor core, herein illustrated as the conductor 12 having segmental conductor elements 14 covered by conductor shielding 18, is wrapped with the fibrous low-friction insulating tapes 22, insulation shielding and skid wires 28, and then is shipped to the place of use with the insulation not impregnated.

After wrapping the cable on the shipping reel, a moisture seal blanket is applied over the cable and is sealed to the flanges of the reel with an opening left at one location in the blanket. The cable and any space around the cable is then evacuated by withdrawing air and moisture through the opening in the blanket. Then the vacuum within the cable and under the blanket is broken by admitting dry gas through the opening which is then sealed, all in accordance with the procedure disclosed in U.S. Pat. No. 2,616,780, issued Nov. 4, 1952.

At the place of use, the cable is pulled into a pipe, and pumps are used to draw a vacuum on the pipe. Dry nitrogen is then introduced into the pipe at substantially room temperature, and after splicing and terminating operations have been completed, the pipe is then evacuated again to remove any moisture from within the pipe. Insulating oil is then introduced into one end of the pipe while suction vacuum is maintained on the pipe by a vacuum pump at the other end and at one or more intermediate locations along the length of the cable when the cable length is very long. As the oil reaches any such intermediate locations, pumping at that location is stopped and the vacuum pump or pumps beyond that location continue to operate.

Any moisture present can be removed, without the use of heat, because of the cable construction which eliminates any soaking up of moisture that would require heat for removal. The fibrous tapes 22 have extremely low moisture content and any additional moisture which enters the insulation is not held by the fibrous tapes 22.

In connection with the moisture removal in the field without heat, it is important that the cable be free of any cellulose material such as cellulose paper fibers or fillers since cellulose holds moisture like a sponge and, in practice, the driving out of such moisture requires heat which would complicate the impregnation of the cable in the field.

The complete filling of the cable, including the conductor core and the insulation, is facilitated by the use of a low-viscosity insulating oil. The oil used is preferably dodecylbenzene, since this oil has low enough viscosity at room temperature to impregnate the cable promptly and thoroughly at temperatures encountered in a line pipe in the field. Other insulating oils of similar characteristics can be used if they are compatible with the insulating material. After the cable and pipe are filled with oil, a super atmospheric pressure is maintained on the oil. In practice, oil pressures of 200 p.s.i. are used. This value is given by way of illustration.

The preferred construction of the cable of this invention has been described, together with the improved method of this invention, and the invention is described in the appended claims.

What is claimed is:

1. A high-voltage electrical cable for installation in an unfilled state and subsequent fluid filling of the cable after installation including, in combination,

a conductor,

synthetic polymeric insulation of fibrous paperlike structure that swells when exposed to contact with insulating oil and that is insensitive to moisture and from which moisture can be expelled by a dry atmosphere at substantially room temperature,

the insulation material itself having a moisture content less than about 0.1 percent and being free of oil impregnation, and

overlapping conducting tapes wrapped around the outside of the insulation and constituting the insulation shielding of the cable and in contact with the insulation and having a long lay with a helical pitch greater than about 2½ times the cable diameter to increase the length of each convolution of the shielding tape and thereby reduce the stretch per unit of length of the shielding tape to accommodate swelling of the insulation when the cable is installed and filled with insulating oil.

2. The high-voltage electrical cable described in claim 1 characterized by the insulation shielding and all of the space enclosed within the insulation shielding being free of any cellulose material.

3. The high-voltage electrical cable described in claim 1 characterized by the insulation being high-density fibrous polyethylene comprising webs of randomly arranged, highly dispersed, continuous filament fibers bonded primarily at filament crossovers, and said insulation being successive helical layers of tape over one another, the insulation shielding assembly fitting closely around the cable.

4. The high-voltage electrical cable described in claim 3 characterized by the insulation shielding assembly including a plurality of semiconducting plastic tapes in overlapping helixes, and skid wires wrapped around the tapes of the insulation shielding in contact with the insulation shielding and having a long lay.

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