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ELECTRIC CABLE

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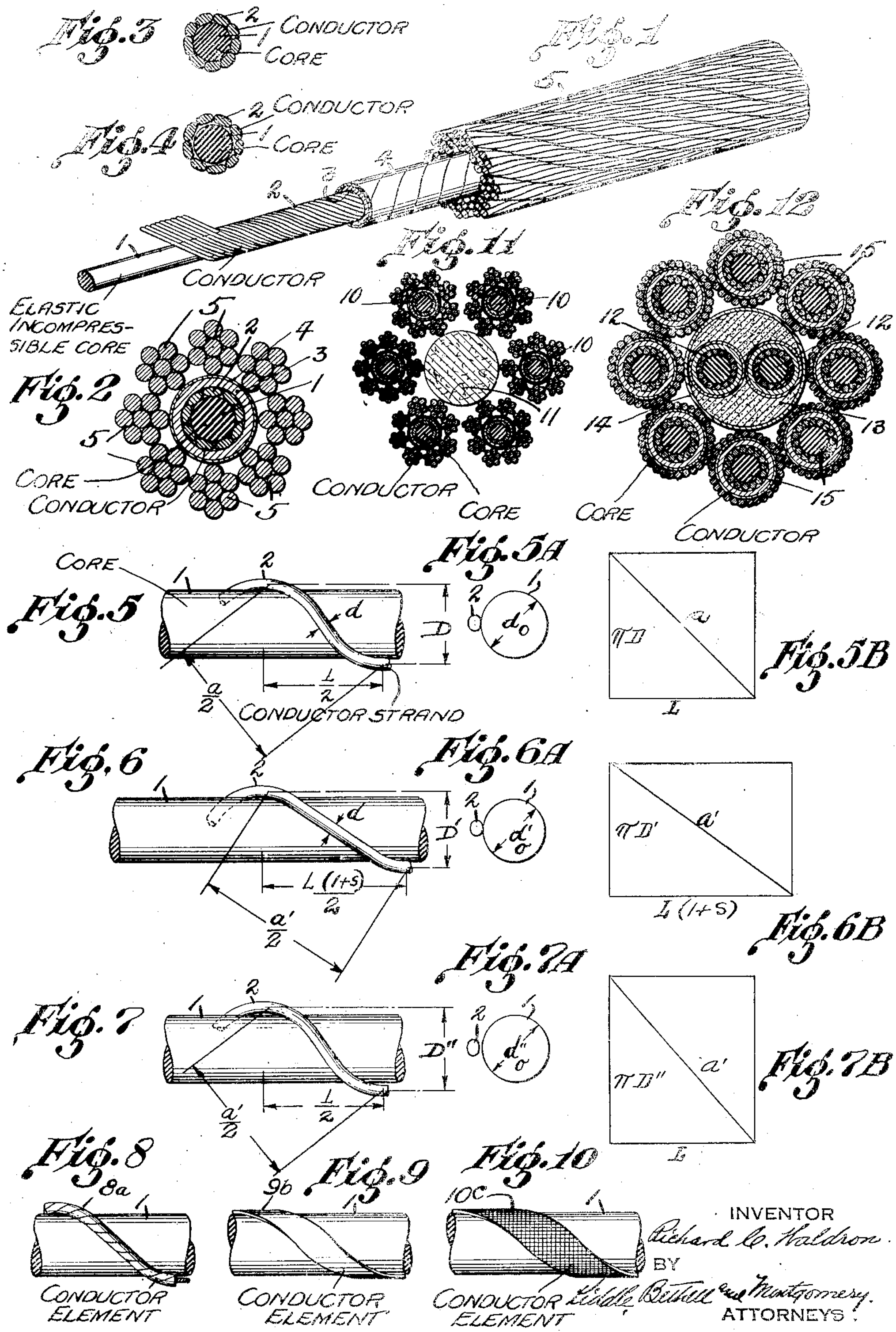

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ELECTRIC CABLE

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4 Claims. (Cl. 173—266)

This invention relates to an improvement in electric cables particularly adapted for vertical suspension as for example in the exploration of oil wells, and has for one of its objects the provision of a cable which is so constructed as to limit or restrict the elongation of the cable conductors. In previous cables for vertical suspension difficulty is experienced with elongation of the conductor of the cable to such an extent that upon contraction of the cable, i. e., restoration of the cable to its original length, the conductor buckles, repetition causing the conductor to break. This difficulty is eliminated in the present construction.

One of the objects of the present invention is the provision of an electric cable construction in which stretching of the conductor is so controlled that the cable can be elongated and restored to its original length without buckling and breaking of the conductor, my copending application Serial No. 58,475, filed January 10, 1936, showing a construction in which the conductor will stretch and contract with the cable without deformation.

More specifically the present invention provides a cable construction in which the conductor is applied helically about an extensible, incompressible core at a critical lay, the lay of the conductor about the core being such that upon initial elongation of the cable the conductor is elongated to a predetermined degree, elongation of the conductor being so controlled and restricted by the core and the lay of the conductor about the core that upon the tension being removed from the cable the cable can be restored to its original length without buckling of the conductor.

Comparing the cable of my invention with prior cables, and assuming the same certain desired percentage elongation of the cable in both instances, in prior cable structures the conductor is stretched to such an extent that upon return of the cable to its original length the conductor buckles, repetition resulting in breaking of the conductor; with my improved cable the conductor is so laid up about the core that the stretch or elongation of the conductor is materially reduced, and as a consequence, although the percentage of elongation of the cable is the same in both instances, my cable can be elongated and contracted repeatedly without buckling and breaking of the conductor.

In addition to all of the foregoing in my improved construction the lay of the conductor is sufficiently long so that the cable cannot be stretched without the conductors pulling down on the core and being deformed. As a consequence my construction adds the full strength of the conductor to the core due to the conductor pulling down on the core. It will be appreciated that this is of advantage in manufacture and avoids breakage of the core in manufacturing the cable.

Referring to the drawing:

Fig. 1 is a part sectional view of a cable embodying my invention;

Fig. 2 is a cross section of the cable of Fig. 1;

Figs. 3 and 4 are cross sectional views illustrating the relative positions of the cable conductor and core at different stages of elongation of the cable;

Fig. 5 shows one strand of the unstretched cable conductor about a core of extensible substantially incompressible material;

Fig. 5A is an end view of the structure of Fig. 5;

Fig. 5B is a development of a cylinder whose diameter is the pitch diameter of the strand of Fig. 5 and whose length is the length of lay of the strand of Fig. 5;

Fig. 6 shows the core and strand of Fig. 5 in stretched position;

Fig. 6A is an end view of Fig. 6;

Fig. 6B is a development of a cylinder whose diameter is the pitch diameter of the stretched strand of Fig. 6 and whose length is the length of lay of the strand of Fig. 6;

Fig. 7 shows the condition of the conductor strand after the strand and core of Fig. 5 have been elongated and then allowed to contract;

Fig. 7A is an end view of Fig. 7;

Fig. 7B is a development of a cylinder whose diameter is the pitch diameter of the strand of Fig. 7 and whose length is the length of lay of the strand of Fig. 7;

Fig. 8 shows one type of conductor which may be employed in the practice of my invention;

Fig. 9 shows another type of conductor; and Fig. 10 still another type;

Figs. 11 and 12 are views of modified embodiments of my invention wherein multi-conductor cables are shown instead of the single conductor cable of Fig. 1.

Referring to the drawing in detail and first of all to the construction illustrated in Figs. 1 to 7B, inclusive. 1 designates the core of my improved cable. This core is of pliable, extensible, substantially incompressible material such as rubber. A fibrous material may be employed for the core if desired, such as silk or cotton thread, for example, which may be twisted together so as to provide a core which is sufficiently incompressible and yet at the same time sufficiently extensible and pliable for my purpose.

About this extensible, substantially incompressible core I apply the conductor 2. This conductor may be composed of copper strands helically applied in parallel relation with a predetermined lay about the core 1 as will be brought out in detail hereinafter. Directly over the conductor 2 I apply insulation 3. This may be the usual rubber or rubber compound insulation commonly employed in electric cable work.

About the insulation 3 I apply a fabric covering 4 which may be in the form of a fabric tape saturated with oil and moisture impervious material such as Harvel which is an acid condensation product made from the oil obtained from cashew nut shells.

5 designates a supporting armor consisting of stranded steel wires. These wires are the same as commonly employed in steel wire rope and may be laid up in any of the methods common to wire rope manufacture.

As pointed out at the outset of this description, one of the objects of my invention is the provision of an electric cable wherein a construction is provided by which detrimental stretching of the conductor is avoided, the present construction providing that the elongation of the cable conductor shall be limited to a point or degree where the cable as a whole may elongate and contract without detrimental buckling and eventual breaking of the conductor. This construction is provided under the present invention by applying the conductor to the extensible, incompressible core of the cable with a predetermined lay, which I term the "critical" lay. If the angle of lay of the conductor about the core is too long then upon elongation of the cable the inside diameter of the helix provided by the conductor decreases too fast as compared with the decrease in the outside diameter of the core and upon desired elongation of the cable the conductor will be excessively stretched. On the other hand, if the lay is too short then the outside diameter of the core decreases too fast as compared with the decrease in the inside diameter of the helix provided by the conductor and the conductor adds no strength to the core. In accordance with the present invention the conductor is laid about the core at such an angle that initially were the cable compressed, i. e. shortened, the core would increase in diameter faster than the conductor, and on elongation of the cable the conductor tends to pull down on the core.

With reference to the showing in Figs. 5 through 7B of the drawing, Figs. 5 and 5A show the initial position of each conductor strand.

d_0=the diameter of the core 1
d =the diameter of each strand of the cable conductor
D =pitch diameter of each strand of the conductor
$=d_0+d$
L =length of lay of each strand of the conductor
a =length of each conductor strand for one complete turn about the core 1

In Fig. 6 I have illustrated the core and strand of Fig. 5 in stretched position. Here

d'_0=the diameter of the core 1 under the assumed conditions
D' =the pitch diameter of the conductor strands
a' =length of conductor strand for one complete turn about the core 1
S =percentage elongation (in decimal) for which the cable is designed

In Fig. 7 the cable has been elongated and then allowed to contract and here

d''_0=the diameter of the core $1=d_0$
D'' =the pitch diameter of the conductor strand

The lay of the conductor 2 about the core 1 is such that initially, as shown in Fig. 5, it lies about and in contact with the core 1. Upon initial elongation the core reduces in diameter and the conductor tends to pull down on the core stretching the conductor, as illustrated in Fig. 6. When the cable is allowed to contract, as shown in Fig. 7, to its original length, the core 1 of course assumes its original outside diameter, the conductor 2, however, owing to the fact that the conductor has been stretched slightly, is no longer in contact with the core. On subsequent elongations of the cable the inside diameter of the conductor will again decrease faster than the outside diameter of the core 1 so that when the maximum elongation of the cable has been reached the conductor will again contact the core 1 but without further stretching of the conductor. These conditions exist only for a definite lay, "critical lay", of the conductor as determined by the formula

$$L=\pi\sqrt{\frac{d_o(d_o+d)}{2}}$$

In this type of cable the conductor adds materially to the tensile strength of the core as will be appreciated inasmuch as the permitted elongation of the conductor is less than possible elongation of the core before breaking. This is an advantage in manufacture in that it gives additional strength to the core.

As above mentioned an object of my invention is to allow the conductor strands to elongate but to limit the elongation so that upon contraction of the cable the conductor will not buckle and break, and I have shown in Figs. 5, 6 and 7 with the above formula this result is obtained.

Using the same symbols as above:
Before

$$a=\sqrt{\pi D^2+L^2}$$

or

$$D=\frac{1}{\pi}\sqrt{a^2-L^2}$$

Upon stretching the conductor the strand length a' is increased as can be shown by an analysis of the equation

$$a'=\sqrt{\pi D_o'^2+[L(1+S)]^2}$$

remembering that

$$D_o'=d_o'+d$$

$$d_o'=\frac{d_o}{\sqrt{1+S}}$$

$$L=\pi\sqrt{\frac{d_o(d_o+d)}{2}}$$

Upon return of the conductor to its normal length after this initial stretch we have

$$D''=\frac{1}{\pi}\sqrt{a'^2-L^2}$$

which is obviously larger than D. The increase in D'' depends on the increase in a' or on the stretch S. If S is small, such as normally occurs in cables, the increase in D'' will be small and no distortion of the strand will result.

In this analysis, we have assumed d constant. For some constructions this might not be justified but for the usual constructions and for S less than $\frac{1}{6}$ the change in d is negligible.

It will be seen from all of the foregoing that the present invention provides an electric cable construction in which the conductor is applied about an incompressible but extensible core with such a lay which I have termed a "critical" lay, that the inside diameter of the helix provided by the conductor initially contracts or decreases just slightly faster than the outside diameter of the core so as to control or restrict to a predetermined extent the elongation of the conductor with a given predetermined elongation of the cable, this stretch of the conductor, however, is not sufficient to prevent the conductor contracting without buckling as the cable contracts, the conductor remaining out of contact thereafter with the core except on subsequent elongations of the cable wherein at the limit of elongation for which the cable is designed the conductor again is drawn into contact with the core. In other words, the lay is such that the inside diameter of the helix provided by the core always decreases faster than the outside diameter of the core, the initial elongation of the cable causing the conductor to stretch permanently so that on subsequent elongations the conductor will elongate without stretching until it contacts with the surface of the core.

Various types of conductor may be employed in the practice of my invention and in Figs. 8, 9 and 10 I have illustrated types of conductor different from that shown in Fig. 1, **8**a showing a conductor made up of a group of strands previously twisted together, **9**b a tape and **10**c woven or braided tape.

The invention of this application may be embodied in multi-conductor cables.

In Fig. 11 I have illustrated a multi-conductor cable in which a plurality of single conductor cables of the same type as shown in Figs. 1 and 2 are assembled around a core of hemp or other suitable material, these cables being designated **10** and the core **11**.

In Fig. 12 I have illustrated another modification in which two cables **12** of the type shown in Fig. 2, for instance, but without the supporting armor wire, are twisted together, a circular cross section built up with jute **13** surrounded by tape **10**, and a plurality of single conductor cables **15** of the type shown in Figs. 2 or 11 laid about this assembly.

What I claim is:—

1. An electric cable comprising in combination a core of extensible, substantially incompressible material, and a conductor helically applied about and in contact with said core with such a lay that initially were the cable compressed longitudinally the core would increase in diameter faster than the conductor, while on elongation the conductor would tend to pull down on the core.

2. A multi-conductor cable comprising in combination a plurality of single conductor cables twisted together and each composed of a core of extensible substantially incompressible material, a conductor helically applied about and in contact with said core with such a lay that initially were the cable compressed longitudinally the core would increase in diameter faster than the conductor, while on elongation the conductor would tend to pull down on the core, a plurality of similar single conductor cables laid up about said first mentioned cables, each of the last mentioned cables being enclosed in supporting wires.

3. A multi-conductor cable comprising in combination a plurality of single conductor cables disposed about a central core, each single conductor cable comprising a core of extensible, substantially incompressible material, a conductor helically applied about and in contact with said core with such a lay that initially were the cable compressed longitudinally the core would increase in diameter faster than the conductor, while on elongation the conductor would tend to pull down on the core, and armor supporting wire for each cable.

4. An electric cable comprising in combination a core of extensible, substantially incompressible material, and a conductor helically applied about and in contact with said core with such a lay that initially were the cable compressed longitudinally the core would increase in diameter faster than the conductor, while on elongation the conductor would tend to pull down on the core, insulation about the conductor and supporting wires about said insulation.

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