

PATENT SPECIFICATION

(11) 1206470

DRAWINGS ATTACHED

- (21) Application No. 57457/67 (22) Filed 18 Dec. 1967
(31) Convention Application No. 606337 and No. 606338
(32) Filed 30 Dec. 1966 in
(33) United States of America (US)
(45) Complete Specification published 23 Sept. 1970
(51) International Classification H 01 b 5/00
(52) Index at acceptance
H1A 4B.4C
(72) Inventors AUBREY THOMAS EDWARDS and
GUY AUBREY MUSSEN



1206470

(54) SELF-DAMPING TRANSMISSION LINE CONDUCTOR

(71) We, ALCAN RESEARCH AND DEVELOPMENT LIMITED, formerly named Aluminium Laboratories Limited, a Company incorporated under the laws of the Dominion of Canada, of 1, Place Ville Marie, Montreal, Quebec, Canada, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to conductors for overhead transmission lines.

Conventional overhead transmission line conductors are composed of individual wires stranded together. Such conductors are often composed of a core of wires formed of high tensile material and specifically intended to serve almost exclusively as tension members, while other wires, composed of highly conductive metal, are arranged around the core wires and serve to conduct electricity.

Overhead transmission line conductors in series are prone to serious vibration problems. These vibration problems arise in two ways. When subjected to low velocity winds, i.e. in the range 1-30 kms/hr, "aeolian vibrations" occur. Aeolian vibrations are of low peak-to-peak amplitude (e.g. an amplitude up to about the conductor diameter), and high frequency (e.g. 2 to 200 cycles per second) and become increasingly troublesome as conductor tension is increased.

The present invention is concerned with damping these vibrations in overhead transmission line conductors, so that the destructive tendencies of such vibrations are avoided, i.e. weakening of the supports for the line, fatigue of the conductor metal, by overtensioning.

It is known to damp these vibrations by employing an inner core of steel wires and a separate outer sheath of conductor wires, the outer sheath having a greater internal diameter than the external diameter of the core, which is highly tensioned and thus contributes to the conductor strength. When subject to vibration during use, the sheath

wires and core wires strike one another, thereby damping the vibrations by interference, and by absorbing and exchanging the vibration energy in the impact between the inner core and outer sheath. Since the strong steel core wires are much harder than the high conductivity sheath wires, usually aluminium alloy, past constructions have, while damping transmission line vibrations, been subject to rapid wear.

The term "aluminium" is hereinafter employed to refer both to aluminium and aluminium alloys of the type employed in transmission line conductors.

Adjacent layers of the core and sheath wires are generally stranded in opposite directions, for maximum torsional strength and stability, and thus, if stranded with round wires in opposite directions, impact between core and sheath wires takes place at points of contact, thereby introducing very high impact loadings at such points. However, some adjacent layers of the core and sheath wires may also be stranded in the same direction, but even so, impact still takes place at points of contact, because while the pitch of the two layers may be the same, coincidence of the lay of the wires is improbable, so that high loadings are still introduced at contact points.

Under vibration, the core and sheath wires clash, as they are intended to do, but because of the aforesaid point contacts, any soft protective coating, such as zinc, on the individual steel core wires wears away, and the aluminium or other high conductivity metal sheath wires also become worn at these points. If the coating is worn away on the steel core wires, they may become subject to corrosive attack, and if the aluminium outer wires are scored or otherwise worn, they may be seriously reduced in strength. These results are very undesirable from the service standpoint, and are scarcely exceeded in undesirability by the vibration-induced problems themselves.

It is well known that the phenomenon of corona discharge may require the external diameter of an overhead transmission line conductor to be above a certain minimum to limit the discharge loss to an acceptable figure. The cross section of the conductor sheath required to carry the current may in consequence dictate a minimum interior diameter which is far in excess of the diameter of a conventional stranded steel wire core necessary to support the conductor sheath and the consequent large difference between the internal diameter of the sheath and the external diameter of the core can lead to excessively heavy impact loads between the core and the sheath as the result of vibration. It has accordingly already been proposed to provide a hollow sheath of conductor wires with a hollow core, having a smooth external surface, to reduce the gap between the sheath and core. However, in such construction the opposed surfaces of the sheath and core, although smooth, were of widely differing hardnesses with the result that the rate of wear of the conductor sheath would have been severe and furthermore the hollow core would have been of excessive rigidity.

With a view to overcoming these difficulties the present invention provides a number of different overhead transmission line conductors, each of which employs a relatively small diameter core and a hollow conductor sheath and provide that vibration of a higher frequency (i.e. more than one cycle per second) shall be taken up by the self-damping effect of two spaced members, having opposed surfaces, at least one of which is smooth and both of which are formed of a material soft in relation to steel, the difference in diameter between such surfaces being in the range of 0.2—6 millimetres.

In one basic arrangement the core comprises a plurality of stranded steel wires, not necessarily of circular section, the said core having a smooth surfaced set of aluminium conductor wires formed about the steel wires or having an extruded plastics coating, whilst the sheath is formed of helically wound aluminium wires arranged to present a generally smooth internal surface. The sheath is preferably forced of at least two layers of helically wound aluminium wires, of which the wires comprising the innermost layer are preferably formed into a wedge shape to present a generally smooth internal surface. This arrangement will satisfactorily damp aeolian vibrations while improving wear resistance over similar conductors described in the prior art.

In another basic arrangement a conductor has at least two helically wound sheath layers spaced from one another.

When referring above to a member (either core or sheath layer) having a surface formed of a material soft in relation to steel it is

intended to imply that the relevant surface of the member is defined by a layer of material of substantial thickness and not a thin film or coating, such as is produced by galvanising steel wire.

Referring now to the accompanying drawings:—

Figure 1 is a perspective view of a conductor according to the invention showing both the core and the sheath;

Figure 2 is a cross section of the conductor shown in Figure 1;

Figure 3 is a cross section of an alternative form of sheath for use in conjunction with the core element of Figure 1;

Figures 4 to 8 are cross sections of alternative forms of core to be employed with the sheath shown in Figures 1 and 3;

Figure 9 is a section view of a conductor having an inner sheath layer and an outer sheath layer and having a loose multi-wire core having a smooth outer surface;

Figure 10 is a section view through an alternative arrangement having an inner sheath layer and an outer sheath layer and having a loose multi-wire core having a smooth outer surface;

Figure 10 is a section view through an alternative arrangement having an inner sheath layer and an outer sheath layer and having a core formed of stranded round wires;

Figure 11 is a partial section view of another arrangement of a sheath comprising an inner sheath layer and outer sheath layer, for use in conjunction with the core shown in Figure 9 or Figure 10;

Figures 12, 13 and 14 are section views similar to Figure 11 showing sections of other sheaths comprised of spaced inner and outer sheath layers.

Referring firstly to Figures 1 and 2, there is shown a conductor construction according to the invention, comprising a multi-wire core 10 loosely contained within a multi-wire sheath 50. For the practice of the invention the gap between the core and the sheath may be as small as 0.1 millimetre. In general, it is preferred to keep this gap as small as possible for economy and for this it should not exceed approximately 3 millimetres, so that the difference in diameter between the outer surface of the core and the inner surface of the sheath is 0.2—6 millimetres.

In the embodiment of Figures 1 and 2, the core 10 as a substantially smooth cylindrical outer surface 11 and the sheath 50 has a substantially smooth cylindrical inner surface 51.

Referring now to Figures 1 to 3, two alternative embodiments of a sheath having a substantially smooth cylindrical inner surface will now be described. The sheath 50 shown in Figures 1 and 2 includes a plurality of sheath conductor wires 52 helically wound in one direction to form an inner cylindrical

sheath layer, and an outer sheath layer of round wires 53 helically wound, preferably in the opposite direction to the direction of wires 52, although both wires 52 and 53 may be wound in the same direction. The layer of round wires 53 is in peripheral contact with the outside surface of the cylinder of wires 52. In this embodiment the wires 53 are illustrated as circular in section but may be provided with a shape corresponding to that of the wires 52, which are wedge shaped (shaped as truncated sectors) so that the plurality of shaped conductor wires 52 may be fitted together to form a continuous circular tube of wires having a substantially smooth cylindrical inner surface 51. In some circumstances it may be preferred to omit the outer layer of wires 53. Each of wires 52 has an arcuate inner surface 54 which forms a portion of the cylindrical inner surface 51. A pair of tapered side surfaces 55, 56 lie on either side of surface 54 and coincide with radii of cylindrical inner surface 51.

Conductor wires 52 may be placed by stranding them over a mandrel (not shown) having the diameter of inner surface 51 while constrained by an external die (not shown) sufficiently small in diameter to force initially round wires to assume the illustrated configuration of the wires 52. As a result of this procedure the outer surface 57 of each wire 52 will also form an arc of a cylindrical surface. The outer layer of conductor wires 53 is added to the inner cylinder of conductor wires 52 to increase the cross-sectional area of the sheath 50 to any desired extent, and these outer wires may remain round.

The sheath 50a in Figure 3 comprises a cylindrical tube 70, having a substantially cylindrical inner surface 51a corresponding to inner surface 51 of the first embodiment, on which is helically wound an inner layer of conductor wires 52a closely conforming to the outer surface 70a of tube 70, and an outer layer of conductor wires 53a, preferably in the opposite direction to the conductor wires 52a. In this embodiment the conductor wires 52a and 53a are round and formed of highly conductive material. The cylindrical tube 70 may be formed of an extruded plastics material, but is preferably formed of a highly conductive but soft material such as aluminium or copper. In such event it may be a solid tube or may be seam-welded or indeed be formed of a single strip shaped into tubular form without subsequent seam-welding.

The sheath construction of Figure 1 is however preferred to that of Figure 3.

Referring now to Figures 4 to 8, and to Figures 1 and 2, there are shown six embodiments of a core. In the first embodiment of Figures 1 and 2, the core 10 comprises a cylindrical steel inner-strand 12 surrounded

by a plurality of conductor wires 13, fabricated in aluminium or another relatively soft conductor material. The steel strand 12 may comprise a single wire, as shown, or a plurality of stranded steel wires.

Each of conductor wires 13 is shaped to the same configuration as has already been described with respect to sheath conductor wires 52. The core 10 of this first embodiment may therefore be fabricated by drawing a steel wire 12, surrounded by a plurality of initially round conductor wires, through a die having a sufficiently small diameter to bring the conductor wires 13 to the shape indicated in Figures 1 and 2. The conductor wires 13 then provide a substantially smooth and relatively soft cylindrical outer surface 11 to core 10.

In Figure 4 there is shown a second embodiment of a core indicated as core 10a. In this second embodiment, a central steel wire 12a is employed, together with a plurality of conductor wires 13a, all as already described with reference to the first embodiment of Figures 1 and 2. In addition, a thin-walled cylindrical conductor metal tube 15 is fitted about the outer perimeter of conductor wires 13, and the outer surface of tube 15 provides the substantially smooth and soft outer surface 11a of core element 10a. This second embodiment of a core may be fabricated in the manner already described with reference to the core of Figures 1 and 2, with the additional provision that tube 15 may be either drawn through the die together with the conductor wires 12a, 13a, or may be drawn over the conductor wires 12a, 13a after they have been drawn through the die, or may be extruded over conductor wires 12a, 13a.

In Figures 5 to 7, there are shown the third, fourth and fifth embodiments of a core. In Figure 5, a steel wire 12b is surrounded by a plurality of wires 13b, which may be steel or a conductor metal such as aluminium. Around the outer periphery of wires 13b is arranged a plurality of shaped conductors 14, each of which is approximately in the configuration of a truncated sector and is formed of a conductor metal, such as aluminium or copper. The embodiment of Figure 5 can be assembled by stranding and forming a plurality of initially round wires to bring them to the shape of the conductor wires 14 so that they present a substantially smooth outer surface 11b. As has already been explained with reference to other embodiments, each layer of wires may be counterwound with respect to radially adjacent layers.

In the embodiment shown in Figure 6, a steel wire 12c is surrounded by a plurality of wires 13c just as has been described with reference to the embodiment of Figure 5. In this embodiment a smaller number of outer conductor wires 14a is employed, and these conductor wires 14a have a much larger

initial diameter than those employed in the embodiment of Figure 5. In this embodiment, the combination of wires 12c, 13c is drawn through a die with the plurality of initially round conductor wires spaced around the periphery thereof. This drawing process shapes the larger diameter conductor wires 14a so that portions thereof are pressed into the undulations formed by the wires 13c, and so that a substantially smooth outer surface 11c is presented by the outermost portions of the shaped conductor wires 14a. In the embodiment of Figure 7 a central steel wire 12d is surrounded by a plurality of wires 13d, in the manner already described with reference to the embodiments of Figures 5 and 6. In this embodiment a plastics or relatively soft conductor metal 20 is extruded or otherwise formed onto the outer periphery of wires 13d to form a substantially smooth outer surface 11d of core 10d.

In the sixth embodiment shown in Figure 8, a core 10f comprises an inner steel wire 12f surrounded by a plurality of interlocking conductor wires 13f. Remembering that the conductor wires 13f are helically wound on the central steel wire 12f, it will be appreciated that the conductor wires 13f are shaped so as to be interlocked and thus held closely to centre wire 12f. In the illustrated embodiment of Figure 8 this locking is accomplished by a lateral lobe 25 on each conductor wire 13f, which is matched by an indentation 26 in the opposite face of each conductor wire 13f. Accordingly each lateral lobe 25 is locked into a lateral indentation 26 of its neighbour, and the assembly of conductor wires 13f is helically locked in place against central wire 12f.

It will be recognised that an electrical conductor constructed from a combination of the above described cores and conductor sheaths provides damping of aeolian vibrations by clashing of the sheath with the core, but without the heavy wear which has heretofore characterised such arrangements. For example, a sheath similar to that shown in Figure 3, but without the cylindrical tube 70, was fitted with a core similar to that shown in Figure 5, but without the smooth outer surfaced conductor elements 14, so that both the sheath and the core included facing surfaces which were comprised of round conductor wires, wound in opposite directions to one another. After a period of only 12 days, during which there occurred approximately ten million cycles of vibration, the electrical conductor was inspected, and it was seen that the steel core wires had been deprived of their zinc coating through mechanical action and had themselves cut into the aluminium sheath conductor wires to a depth of about 0.4 millimetres. Another conductor was made up employing the same sheath, but employing a core such as that shown in

Figures 1 and 2. After the same period of time and approximately equal number of vibration cycles, this electrical conductor was inspected and the wear was barely visible. The resultant savings in maintenance and replacement are very large. More important, conductor failures, either structural or electrical, are greatly reduced, thus increasing reliability of power transmission lines.

Briefly in the constructions illustrated in Figures 9 to 14, the conductor has at least two spaced helically wound sheath layers, at least one of those layers being arranged so that the individual wires have large area of mutual contact with adjacent wires to that axial conductor tensions (e.g. service loads) lead to little, if any, radial forces in such layer.

In Figure 9 a conductor 110 comprises a sheath 111 and a loose inner core 112. The sheath 111 is comprised of two layers 113 and 114. Each of layers 113 and 114 is comprised of a plurality of conductors 113a, 114a respectively, which are shaped to provide stable contact with adjacent wires within the same layer under circumferential forces.

Between the pair of layers 113, 114 there is an annular gap indicated at 115. The layers 113, 114 and their individual wires 113a, 114a are dimensioned so that gap 115 between layers 113, 114 exists when the conductor 110 is subjected to the normal tension produced by the weight of the conductor itself and its external loads when suspended and this condition is illustrated in Figure 9.

To maintain gap 115, the individual wires, e.g. wires 113a of layer 113, are dimensioned in such a way that each layer has a substantially constant inner and outer diameter when the layer wires are under service tension.

In Figure 10 there is shown a conductor 110' comprising a two layer sheath 111', and a core 112'. The principles of operation in this embodiment are the same as those already described with relation to Figure 9. This embodiment illustrates another form of individual wires 113b, 114b. In this embodiment, the layers 113', 114' comprise alternate round section wires and scalloped section wires, the alternate arrangement giving a circumferential locking effect and yet employing a quantity of round section wires for economy. The overall effect is the same because the helical wires in each of layers 113', 114' are pressed together circumferentially by service tensions to define the interlayer gap 115' which gives the advantages already described.

In Figure 11 to 14 there are shown further embodiments, wherein the wires 113c, 114c to 113f, 114f are provided with various cross-sections which provide circumferential locking under circumferential forces so that the integrity of each layer under tension is preserved and thereby the gap is maintained be-

tween the layers. In all of these embodiments, a core of various designs may be employed which may be a tight core (i.e. fits tightly against the inner surface of the inner sheath layer) or a loose core, or the entire conductor may consist of such layers.

While it is preferred that each sheath layer have the same composition in terms of the cross-section of wires contained therein, this is not essential. An outer layer of round or other cross-section wires may be used on the outside of the outer layer, i.e. on the outside of layer 113 in Figure 9 to protect it from the effects of weather.

It is known in the construction of aluminium overhead conductors to employ a stranded core of relatively high tensile strength aluminium alloy in place of a stranded steel core. It will be understood that in all the examples given the steel core or core members could be replaced by an aluminium alloy core or aluminium alloy core members of appropriate dimension and alloy material. In particular the stranded core formed of round wires shown in Figure 10 could conveniently be formed of stranded wires of aluminium alloy of appropriate tensile strength since this would lead to low wear of the inner sheath layer arising from impact between the core and the inner sheath layer.

In the appended claims a "member" may be either a core or a sheath layer.

WHAT WE CLAIM IS:—

1. A self-damping conductor for use in overhead transmission lines comprising a core and a hollow conductor sheath, said conductor including two spaced members, having opposed surfaces characterised in that at least one of said surfaces is smooth and in that both of said surfaces are formed of a material soft in relation to steel, the difference in diameter between such surfaces being in the range of 0.2—6 millimetres.

2. A self-damping conductor according to Claim 1 further characterised in that the core comprises at least one inner steel strand and a plurality of wedge-shaped aluminium

strands wound helically around said inner steel strand to form a layer of substantial thickness.

3. A self-damping conductor according to Claim 2 further characterised in that a metal tube is drawn around said wedge-shaped aluminium strands.

4. A self-damping conductor according to Claim 1 further characterised in that the core comprises at least one inner steel strand and a circular outer coating of a plastics material.

5. A self-damping conductor according to any preceding claim further characterised in that said sheath incorporates at least one layer of helically wound strands which present a substantial bearing width to adjacent strands in said layer, said layer being spaced from said core and other layers of said sheath (if any).

6. A self-damping conductor according to Claim 5 further characterised in that said sheath incorporates an inner sheath layer and an outer sheath layer spaced therefrom, the wires of both of said layers comprising helically wound strands which present a substantial bearing width to adjacent strands in the same layer.

7. A self-damping conductor according to Claim 5 or 6 further characterised in that the individual strands are in the form of truncated sectors.

8. A self-damping conductor according to claim 1 in which said two spaced members are constituted by a core and a hollow-sheath layer.

9. A self-damping conductor according to Claim 1 wherein said two spaced members are constituted by an inner sheath layer and an outer sheath layer, said inner sheath layer having a core arranged internally thereof.

STEVENS, HEWLETT & PERKINS,
Chartered Patent Agents,
5 Quality Court,
Chancery Lane,
London, W.C.2.
Agents for the Applicants.

tween the layers. In all of these embodiments, a core of various designs may be employed which may be a tight core (i.e. fits tightly against the inner surface of the inner sheath layer) or a loose core, or the entire conductor may consist of such layers.

While it is preferred that each sheath layer have the same composition in terms of the cross-section of wires contained therein, this is not essential. An outer layer of round or other cross-section wires may be used on the outside of the outer layer, i.e. on the outside of layer 113 in Figure 9 to protect it from the effects of weather.

It is known in the construction of aluminium overhead conductors to employ a stranded core of relatively high tensile strength aluminium alloy in place of a stranded steel core. It will be understood that in all the examples given the steel core or core members could be replaced by an aluminium alloy core or aluminium alloy core members of appropriate dimension and alloy material. In particular the stranded core formed of round wires shown in Figure 10 could conveniently be formed of stranded wires of aluminium alloy of appropriate tensile strength since this would lead to low wear of the inner sheath layer arising from impact between the core and the inner sheath layer.

In the appended claims a "member" may be either a core or a sheath layer.

WHAT WE CLAIM IS:—

1. A self-damping conductor for use in overhead transmission lines comprising a core and a hollow conductor sheath, said conductor including two spaced members, having opposed surfaces characterised in that at least one of said surfaces is smooth and in that both of said surfaces are formed of a material soft in relation to steel, the difference in diameter between such surfaces being in the range of 0.2—6 millimetres.

2. A self-damping conductor according to Claim 1 further characterised in that the core comprises at least one inner steel strand and a plurality of wedge-shaped aluminium

strands wound helically around said inner steel strand to form a layer of substantial thickness.

3. A self-damping conductor according to Claim 2 further characterised in that a metal tube is drawn around said wedge-shaped aluminium strands.

4. A self-damping conductor according to Claim 1 further characterised in that the core comprises at least one inner steel strand and a circular outer coating of a plastics material.

5. A self-damping conductor according to any preceding claim further characterised in that said sheath incorporates at least one layer of helically wound strands which present a substantial bearing width to adjacent strands in said layer, said layer being spaced from said core and other layers of said sheath (if any).

6. A self-damping conductor according to Claim 5 further characterised in that said sheath incorporates an inner sheath layer and an outer sheath layer spaced therefrom, the wires of both of said layers comprising helically wound strands which present a substantial bearing width to adjacent strands in the same layer.

7. A self-damping conductor according to Claim 5 or 6 further characterised in that the individual strands are in the form of truncated sectors.

8. A self-damping conductor according to claim 1 in which said two spaced members are constituted by a core and a hollow-sheath layer.

9. A self-damping conductor according to Claim 1 wherein said two spaced members are constituted by an inner sheath layer and an outer sheath layer, said inner sheath layer having a core arranged internally thereof.

STEVENS, HEWLETT & PERKINS,
Chartered Patent Agents,
5 Quality Court,
Chancery Lane,
London, W.C.2.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1970.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.



* C L M S *