United States Patent

Seguin

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[54] **HIGH-STRENGTH NON-EXTENSIBLE CONDUCTIVE WIRE**

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[51] **Int. Cl.** **H01b 7/18**

[58] **Field of Search** ....174/103, 107, 108, 109, 110 R, 174/121 R

[56] **References Cited**

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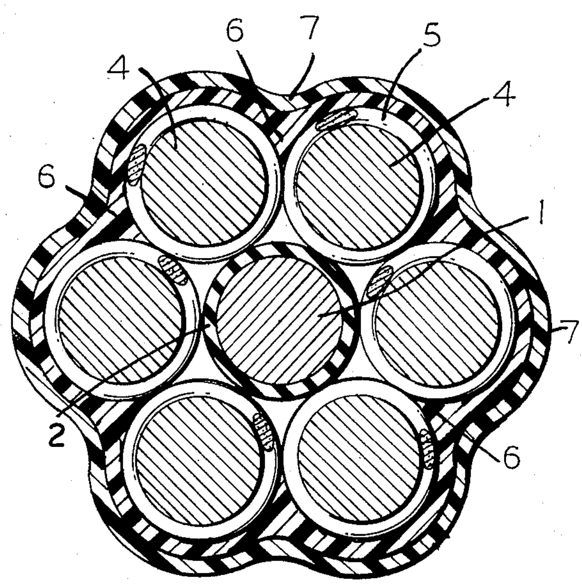
[57] **ABSTRACT**

A flexible, sealed, non-inflammable, low-weight, non-extensible conductive wire having great tensile and bending strength and resistance to friction comprising a core material composed of a very good conductor of electricity, this core material being electrically insulated; a sheath comprising a bundle of metallic wires that are either conductive or may be made conductive, this sheath having high strength; and a protective envelope comprising at least one coating layer. This high-strength, low-weight, non-extensible conductive wire is particularly well adapted for use in the remote control of rockets or in other applications where resistance to high temperature and high stress is necessary.

10 Claims, 2 Drawing Figures



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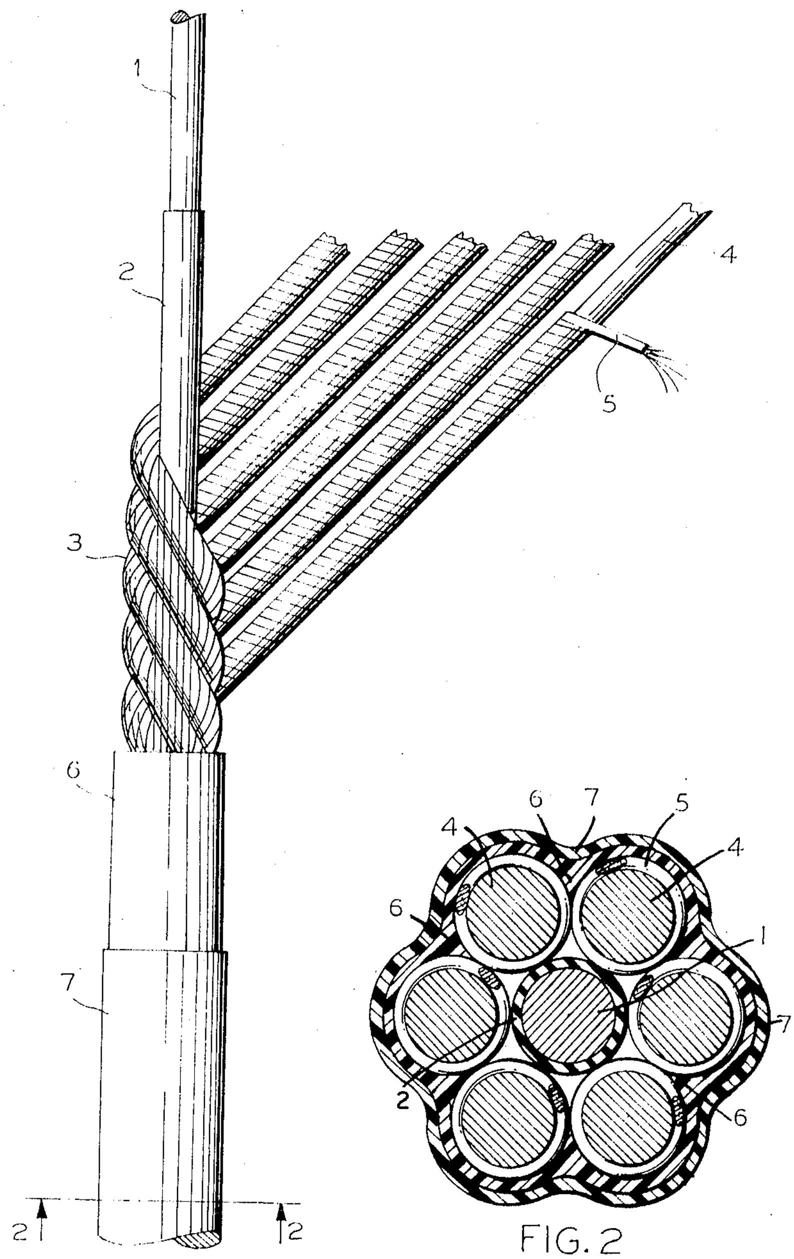

FIG. 1

FIG. 2

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HIGH-STRENGTH NON-EXTENSIBLE CONDUCTIVE WIRE

This invention relates to a sealed, flexible, non-inflammable, light, non-extensible conductive wire. More particularly, this invention relates to a non-extensible conductive wire having high tensile and bending strength and also good resistance to friction. This invention is particularly well adapted for use in controlling rockets or for other similar applications where a light, strong and flame resistant wire is necessary.

Although low-bulk conductive wires having good strength and excellent electrical properties, as far as their time constants are concerned, have been heretofore described in French Pat. No. 1,477,500 and in the two addition patents thereto, namely No. 90,970 and No. 93,154, the wires disclosed in these patents afford excellent results only under conditions that are not too demanding. These wires, although they are useful for ordinary applications requiring low-density conductive wires, are too fragile for use in the guidance system of a rocket which has a high acceleration at take-off. These prior art wires are also particularly vulnerable to "burning", that is, becoming ignited due to the high temperature created by the combustion of the fuel used for propelling the rocket. It has been found that it is possible to overcome these objections to prior art low-density conductive wires by utilizing the wire of the present invention.

Briefly, the non-extensible conductive wire of the present invention comprises an electrically insulated core, said core comprising a material which is an excellent electrical conductor and an insulating layer, said insulating layer surrounding the conductor material; a sheath comprising a bundle of conductive metallic wires, said metallic wires being inherently conductive or capable of being made conductive, said wires also having a high strength and capable of serving as a mechanical support; and a protective envelope comprising at least one coating layer.

Accordingly, it is the principal object of the present invention to produce a low-density conductive wire having high strength and good flame-resistant properties.

It is a further object of this invention to provide a non-extensible conductive wire having high tensile and bending strength, and good friction resistance.

It is a still further object of this invention to provide a high tensile and bending strength, friction resistant, non-extensible conductive wiring which is also light and non-inflammable.

Other objects and advantages of the non-extensible conductive wire of the present invention will become more apparent from the following drawings and the more detailed description thereof:

FIG. 1 is a schematic view of the wire of the present invention with successive layers removed to show the individual components; and

FIG. 2 shows a cross-sectional view taken along line 2—2, showing the relative location of the various components of the wire of the present invention.

Referring to FIG. 1, the flexible wire produced in accordance with the present invention comprises a core wire 1 and an insulating layer 2. The core wire 1 should be constructed of an excellent electrical conductor such as copper or other similar metallic wires having the same or similar conductance. Insulating layer 2, which surrounds core wire 1, should be a material having a high insulating value, i.e., a low conductance, while at the same time is relatively light and flexible. Suitable materials for the insulating layer 2 comprise various insulating enamels, resinous polymeric films, etc. The core wire should be as thin as possible with a diameter in the range of from 0.05 to 0.15 mm being preferable. The insulating layer also should be as thin as possible, with a layer thickness in the range of from 0.01 to 0.05 mm being preferable. This core wire structure is then sheathed by means of wires 3. Although FIG. 1 shows six wires 3 used to sheath the core wire, the flexible wire of the present invention is not to be limited to any specific number of sheathing wires. Each of these sheathing wires 3 comprises a core wire 4 which may or may not be wrapped with an insulating material 5. Although the wire of the present invention may be prepared with uninsulated wires 3, it is preferred to use an insulating yarn such as the various linear polyamides, e.g., nylons, i.e., nylon 6, nylon 66, nylon 610, nylon 11, nylon 12, etc. The core 4 of the sheathing wires comprises a high-strength wire such as any of the various high-strength steels. These wires should either be conductive or capable of being made conductive, and should be approximately from 0.05 to 0.15 mm in diameter. The nylon yarn should be wrapped around the high-strength sheathing wire with a Z-twist having approximately 2000 turns per meter. The twist of the sheathing wires about the core wire should have an S-twist having 250 turns per meter, the twist of the assembly of the wrapped sheathing wire upon the core wires having a compensation twist of about 10 per cent, i.e., a Z-twist of about 25 turns per meter given at the time of the cabling operation. This compensation twist avoids the tendency on the part of the composite wire to kink. Although the twist around the sheath wires 3 was illustrated as a Z-twist while the wrapping of the sheathing wires around the core wire was illustrated as an S-twist, these twisting directions are not critical with respect to the conductive wire of this invention. Although it is advantageous to reverse the twist of the wrapping wires around the core wire with respect to the wrapping on the sheathing wires, this wrapping scheme is not necessary for the production of the non-extensible conductive wire of the present invention. However, by wrapping the sheathing wires around the core wire in such a way that the sheathing wires are twisted so that this twist is the reverse of the twist of the wrapping of the synthetic yarn around the sheathing wires, this produces yarn windings which are substantially parallel to the direction of the core wire and produces a more flexible product. As stated above, the yarn useful for wrapping the sheathing wires may be any known insulating material capable of forming a filament or yarn.

The cabling operation for producing the composite wire of the present invention may be performed using any known apparatus. The textile yarns may be wrapped around the steel wires using any conventional twisting machine, and similarly the wrapping of the core wires with the steel wires may be done on any known type of strand-laying machine.

This composite wound structure is then coated. Although FIG. 1 illustrates a two-layer coating, i.e., layers 6 and 7, the composite wire of the present invention may have 1, 2, or more successive coatings. With reference to the structure shown in FIGS. 1 and 2, the composite wire is coated with a thin layer 6, having a thickness on the order of from 0.005 to 0.015 mm, of an insulating polymer. Again, any insulating polymer such as the various linear polyamides and copolyamides may be used, although an amide copolymer obtained by copolymerizing caprolactam and hexamethylene diamine adipate, which is deposited from an aqueous alcohol solution, is preferred. As is shown in FIG. 2, this inner coating 6 fills in the spaces between sheathing wires 3.

Following the application of coating 6, a second coating layer 7 of any heat-sealing polymer, such as vinyl polymers and vinyl copolymers, etc., is then applied to the composite wire above. As stated above, although this second coating may be any heat-sealable polymer, a thin layer, i.e., on the order of from 0.005 to 0.015 mm, of a copolymer of a vinyl chloride and vinyl propionate dissolved in ethyl acetate is the preferred coating. This copolymer is applied to the composite structure and then baked to form the completed structure.

Wires constructed in the above manner have a tensile strength on the order of 14 kg for a diameter in the range of about 0.4 mm. These wires also weigh about 400 g/km and have a coefficient of rupture of about 35,000 (the coefficient of rupture being defined as the ratio of the resistance to rupture in kilograms to the weight of the wire in kilograms per meter). Also, the wires produced in accordance with this invention have an ohmic resistance of about 8,000 ohms per kilometer and a capacitance of 370 pF/m (between straight conductors).

As is readily apparent, the wire of the present invention is very strong, sufficiently thin to allow several kilometers of winding, flexible, and also has desirable electrical properties. Also, even if one of the steel wires is partially damaged because of flames or heat generated during take-off, the control signals will continue to be transmitted since the copper wire inside the sheathed steel or high-strength wires will not be damaged.

While the foregoing is offered by way of illustration, the conductive wire of the present invention is to be in no way limited thereby and is to be construed as broadly as all equivalents contained in the appended claims.

What I claim is:

1. A high-strength, non-extensible conductive wire comprising a core, said core comprising a good conductor of electricity and an insulating layer surrounding said good conductor; a helically wound sheath surrounding said core comprising a bundle of high-strength conductive metallic wires each of said wires having a textile yarn helically wound thereon; and a protective covering comprising at least one coating layer surrounding the sheath.

2. The conductive wire of claim **1** wherein said good conductor of electricity is a copper wire and said insulator surrounding said good conductor is enamel.

3. The conductive wire of claim **1** wherein said sheathing wires are high-strength steel.

4. The conductive wire of claim **2** wherein said sheathing wires are high-strength steel.

5. The conductive wire of claim **1** wherein said protective covering comprises at least two thin coatings with the outermost coating comprising a heat-sealing composition selected from the group consisting of vinyl polymers and vinyl copolymers.

6. The conductive wire of claim **4** wherein said protective covering comprises at least two thin coatings with the outermost coating comprising a heat-sealing composition selected from the group consisting of vinyl polymers and vinyl copolymers.

7. The conductive wire of claim **4** wherein said textile yarn is wound around said high-strength metallic sheathing wires with a twist the reverse of that of said sheathing wires around said core.

8. The conductive wire of claim **6** wherein said textile yarn is wound around said high-strength metallic sheathing wires with a twist the reverse of that of said sheathing wires around said core.

9. The conductive wire of claim **8** wherein the turns of said helically wound textile yarn are substantially parallel to the direction of said core wire.

10. The conductive wire of claim **7** wherein the turns of said helically wound textile yarn are substantially parallel to the direction of said core.

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