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(54) Coil type high-voltage resistive cable for preventing noise.

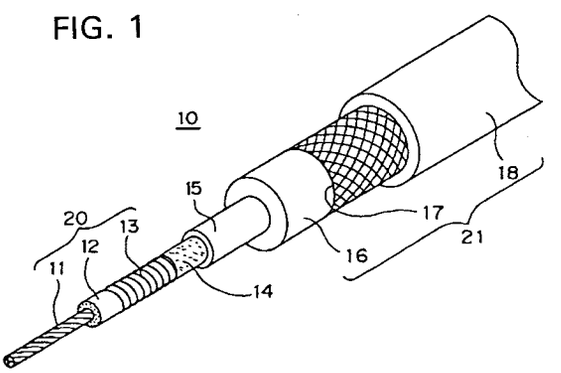
(57) [Object]

To improve the dielectric strength and prevent a reduction in the noise preventing performance in a thin coil type high-voltage resistive cable having an outer diameter of 5 mm.

[Construction]

A rubber layer (12) is formed around the outer circumferential surface of a core (11) made of reinforced fibers by applying a coating material obtained by mixing fluororubber and ferrite powder. A resistance wire (13) is wound around an outer circumferential surface of the rubber layer (12) in an direction normal to the longitudinal axis of the core (11), thereby obtaining a conductor (20) having an outer diameter of 0.6 mm or smaller. A partially conductive inner conductor layer (15) is formed around the outer circumferential surface of the conductor (20) and a resin layer (16), a net (17) and a sheath (18) are formed around the inner conductor layer (15) one over another, such that the obtained resistive cable has an outer diameter of 5 mm or smaller. The rubber layer (12) is formed of mixture obtained by mixing 400 parts by weight of ferrite powder to 100 parts by weight of fluororubber, and the inner conductor layer 15 is formed of partially conductive polyolefin resin by means of extrusion.

FIG. 1



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The present invention relates to a coil type high-voltage or high-tension resistive cable for preventing noise which is used, for example, as an ignition cable in an internal combustion engine and is particularly designed to obtain a satisfactory dielectric strength without reducing a noise preventing effect with a thin resistive cable having an outer diameter of 7 mm or smaller.

Generally, a high-voltage resistive or resistant or resistance cable is structured as shown in Fig. 2. Specifically, a rubber layer 2 is formed around the outer circumferential surface of a core 1 made of a bundle of high-strength fibers such as aramid fibers, and a resistance wire 3 is wound around the outer circumferential surface of the rubber layer 2 in a direction normal to the longitudinal axis of the core 1, thereby forming a conductor 4. An insulator layer 5, a net 6 made of glass fibers and a sheath 7 are formed around the outer circumferential surface of the conductor 4, i.e., over the resistance wire one after another in this order.

A variety of modifications have been made in above high-voltage resistive cables in order to improve the noise preventing performance, to increase the inductance per unit length, to stabilize the resistance value and to make the cable thinner.

For example, a magnetic material such as ferrite powder has been mixed in the rubber layer 2 in order to improve the noise preventing performance and the resistance wire is wound densely at a small pitch in order to make the inductance per unit length larger. Further, in order to prevent the variation of the pitch of the wound resistance wire, the resistance wire is wound around the rubber layer in an unvulcanized state so that it cuts in the rubber layer, and the rubber layer is then vulcanized (Japanese Unexamined Patent Publication No. 63-168915) or the resistance wire is wound such that it cuts in the already vulcanized rubber layer (Japanese Unexamined Patent Publication No. 3-184213).

There has been also proposed a high-voltage resistive cable designed to eliminate a resistance value variation, which cable is provided with an inner conductor layer over the resistance wire 3. For example, as shown in Fig. 3, a bundling layer 8 made of resin is formed around the outer circumferential surface of the core 1 and the resistance wire 3 is wound around the outer circumferential surface of the bundling layer 8. Thereafter, a partially conductive silicone rubber layer 9 which acts as an inner conductor layer is formed over the resistance wire 3 by means of extrusion, and the insulator layer 5, the net 6 and the sheath 7 are formed around the outer circumferential surface of the silicone rubber layer 9 one over another in this order (Japanese Unexamined Patent Publication No. 60-3809).

Further, there has been proposed a high-voltage resistive cable designed to have a small diameter. A core is immersed in liquid resin so that fibers making up the core are combined and a liquid rubber coating material including silicone rubber and ethylene propylene rubber is applied to the surface of the core. A resistance wire is wound around the outer circumferential surface of this coat, and an insulator layer, a net and a sheath are formed over the resistance wire one over another in this order (Japanese Unexamined Patent Publication No. 63-69107).

For use as an ignition cable, the high-voltage resistive cables of the above types are required to have an outer diameter of 5 mm or smaller so that they can be bent freely in a densely stuffed engine compartment and are also required to have a distributed capacitance of 80 pF/m or smaller in order to prevent a voltage reduction.

Further, there is a demand for a higher voltage in an ignition system in order to improve the mileage of an internal combustion engine. The high-voltage resistive cables are required to have a specified dielectric strength against this high voltage.

However, when the outer diameter is set at 5 mm or smaller and the capacitance is set at 80 pF/m or smaller under the condition of a required high voltage, the conventional high-voltage resistive cables cannot have a specified dielectric strength without reducing the noise preventing effect.

More specifically, the rubber layer containing a magnetic material such as ferrite powder displays a noise preventing effect. However, being formed by means of extrusion, this rubber layer has a large thickness and the inner conductor layer cannot be provided between the resistance wire and the insulator layer in order for the high-voltage resistive cable to have an outer diameter of 5 mm or smaller. Since the resistance wire is directly coated with the insulator layer and no inner conductor layer is provided therebetween, the dielectric strength cannot be increased.

On the other hand, since the high-voltage resistive cable provided with the inner conductor layer to increase the dielectric strength is not provided with the rubber layer containing ferrite powder, the noise preventing effect is reduced.

The high-voltage resistive cable obtained by applying the liquid rubber coating material to the surface of the core and winding the resistance wire around the rubber coat is allowed to have a small outer diameter. However, with this resistive cable, the noise preventing effect is reduced since the liquid rubber does not contain ferrite powder and the dielectric strength cannot be increased since no inner conductor layer is provided.

In view of the problems residing in the prior art, it is an object of the invention to provide a coil type high-voltage resistive cable which has an outer diameter of 5 mm or smaller, a capacitance of 80 pF/m, an improved dielectric strength against high voltage, and an enhanced noise preventing performance.

In order to realize the object, in one embodiment, the invention is directed to a coil type high-voltage resistive cable for preventing noise, wherein a coating material obtained by mixing fluororubber and ferrite powder is applied to the outer circumferential surface of a core made of reinforced fibers to form a rubber layer, that a resistance wire is wound around the outer circumferential surface of the rubber layer in a direction normal to the axis of the core, thereby obtaining a conductor having an outer diameter of 0.6 mm or smaller, and that an inner conductor layer formed of partially conductive material, a resin layer, a net and a sheath are formed around the outer circumferential surface of the conductor one over another in this order such that the obtained coil type high-voltage resistive cable has an outer diameter of 5 mm or smaller.

The rubber layer is preferably formed of the coating material obtained by mixing 300 to 500 parts by weight of ferrite powder with 100 parts by weight of fluororubber. The inner conductor layer is preferably formed by extruding partially conductive polyolefin resin.

Further, the inner conductor layer may be formed by means of extrusion after applying a release agent to the outer circumferential surface of the conductor.

The rubber layer of the conductor is formed by applying the fluororubber coating material containing a high concentration of ferrite powder to the outer circumferential surface of the core. Accordingly, the rubber layer is allowed to have a small thickness while the noise preventing performance is not reduced. This enables the partially conductive inner conductor layer for improving the dielectric strength to be formed between the conductor and the insulator layer by means of extrusion.

These and other objects, features and advantages of the present invention will become more apparent upon a reading of the following detailed description and accompanying drawings in which:

Fig. 1 is a perspective view showing a high-voltage resistive cable for preventing a noise according to the invention;

Fig. 2 is a front view showing a conventional high-voltage resistive cable; and

Fig. 3 is a front view showing another conventional high-voltage resistive cable.

Fig. 1 shows an embodiment of a coil type high-voltage resistive cable 1 according to the invention. The outer circumferential surface of a core 11 is coated with a rubber layer 12, a resistance wire 13, a release agent 14, an inner conductor layer 15, an insulator layer 16, a net 17 and a sheath 18 one over another in this order.

The core 11 is obtained by twisting reinforced fibers such as aramid fibers and glass fibers. In this embodiment, three reinforced fibers having 400 denier are twisted to make up the core 11 having an outer diameter of 0.4 mm to 0.45 mm.

The rubber layer 12 is formed by immersing the core 11 in a liquid fluororubber based coating material obtained by mixing ferrite powder with fluororubber and dissolving this mixture in an organic solvent. A mixing weight ratio of fluororubber to ferrite powder in the coating material is set at 100 : 400 in this embodiment. The rubber layer 12 contains a high concentration of ferrite powder having a noise preventing performance.

By applying the above ferrite rubber, the rubber layer 12 is allowed to have an outer diameter of as small as 0.56 mm and a capacitance of 80 pF/m or smaller. In extruding the ferrite rubber in a conventional manner, the rubber needs to be made softer so that it can be smoothly extruded. However, in this embodiment, the ferrite rubber is applied as a coating material. Since the rubber is dissolved in the solvent in this embodiment, hard rubber can be used. Although the rubber layer 12 contains a high concentration of ferrite powder, a coating strength thereof is not reduced because of the use of hard rubber.

The resistance wire 13: a nichrome (Ni-Cr) wire having a diameter of 40 μm, is wound around the outer circumferential surface of the rubber layer 12 densely at a small pitch (10000 winds/m) in a direction normal to the longitudinal axis of the core 11 by a winding machine. The resistance wire 13 is wound before the applied ferrite rubber is completely vulcanized, so that it is secured to the rubber layer 12 and the pitch thereof does not vary.

A conductor 20 made of the core 11, rubber layer 12 and resistance wire 13 has an outer diameter of 0.6 mm.

Since the outer diameter of the conductor 20 can be as small as 0.6 mm, the resistive cable 10 is allowed to have an outer diameter of 5 mm or smaller even if the inner conductor layer 15 is formed around the outer circumferential surface of the conductor 20. After applying the release agent 14 over the resistance wire 13, the inner conductor layer 15 having an outer diameter of 0.8 mm is formed by extruding partially conductive polyethylene (PE) obtained by mixing carbon with polyethylene. The presence of the inner conductor layer 15 brings about an improved dielectric strength.

In forming the inner conductor layer 15 by means of extrusion, the rubber layer 12 comes off due to the pressure and heat generated during this operation unless the rubber layer 12 has a sufficient strength. This leads to an inability to form the inner conductor layer 15 by means of extrusion. However, since fluororubber is used to form the rubber layer 12, the rubber layer 12 is allowed to have a coating strength required during the extrusion of the inner conductor layer 15 even if it contains as high a concentration as 300 to 500 parts by weight of ferrite powder which assures a satisfactory noise preventing performance.

After the high-voltage resistive cable is fabricated, a terminal fitting (not shown) is cramped to the conductor 20. The release agent 14 is applied so that the inner conductor layer 15, resin layer 16, net 17 and sheath 18 can be easily peeled during this cramping operation.

The insulator layer 16 having an outer diameter of 3.8 mm or smaller is formed around the outer circumferential surface of the inner conductor layer by extruding ethylene propylene copolymer which is nonflammable and has a small dielectric constant.

The net 17 made of glass fibers is wound around the outer circumferential surface of the insulator layer 16 so as to increase a cramping force when the terminal (not shown) is cramped to the resistive cable 10 and to enhance a breaking strength.

The sheath 18 which is an outermost layer of the resistive cable 10 is formed around the outer circumferential surface of the net 17 by extruding ethylene propylene copolymer or silicone rubber. The sheath 18 is formed such that the obtained resistive cable 10 has an outer diameter of 5 mm or smaller.

In the thus structured coil type high-voltage resistive cable 10, since the rubber layer 12 is formed by applying the ferrite rubber coating material to the core 11, the conductor 20 made of the core 11, rubber layer 12 and resistance wire 13 is allowed to have a small outer diameter. Thus, the partially conductive inner conductor layer 15 can be formed by means of extrusion between the conductor 20 and an outer layer 21 including the insulator layer 16, net 17 and sheath 18. This inner conductor layer 15 functions to enhance a dielectric strength against a high voltage.

The rubber layer 12 of the conductor 20 contains a high concentration of ferrite powder because it is formed of the mixture obtained by mixing 300 to 500 parts by weight of ferrite powder with 100 parts by weight of fluororubber. Thus, the noise preventing performance can be improved despite the thin rubber layer 12.

If the content of ferrite powder is smaller than 300 parts by weight, the noise preventing performance is unsatisfactory because the magnetic permeability μ is low. If the content of ferrite powder is larger than 500 parts by weight, the properties of the rubber layer 12 such as strength and heat resistance are reduced, thereby making it impossible to form the inner conductor layer 15 by means of extrusion.

As is clear from the above description, in the coil type high-voltage resistive cable according to the invention, a rubber layer of a conductor is formed by applying a fluororubber based coating material containing ferrite powder to a core. A resistance wire is wound around the outer circumferential surface of the rubber layer in a direction normal to the axis of the core and the rubber layer contains ferrite powder three to five times as much as fluororubber in part by weight; accordingly the noise preventing performance can be enhanced.

Since the ferrite rubber containing a high concentration of ferrite powder is applied as a coating material to form the rubber layer, the thickness of the rubber layer can be made smaller. This enables the conductor to have an outer diameter of 0.6 mm or smaller.

As a consequence, the resistive cable is allowed to have an outer diameter of 5 mm or smaller even if a partially conductive inner conductor layer for improving the dielectric strength can be formed by means of extrusion between the conductor and an outer layer including an insulator layer, a net and a sheath.

While this inventive resistive cable has an outer diameter of 5 mm or smaller and a capacitance of 80 pF/m or smaller, the resistance value thereof does not vary upon being subjected to high voltage, thereby improving the dielectric strength characteristic, and the noise preventing performance thereof can be enhanced. Thus, this resistive cable can be suitably used as an ignition cable for an automotive vehicle which requires higher voltage.

Lists of Reference Numerals

10	High-voltage Resistive Cable
11	Core
12	Rubber Layer
13	Resistance Wire
14	Release Agent
15	Inner Conductor Layer
16	Insulator layer
17	Net
18	Sheath
20	Conductor

Claims

1. A coil type high-voltage resistive cable (10) for preventing noise, comprising:
   a rubber layer (12) which is applied to the outer circumferential surface of a core (11) made of reinforced fibers as a coating,
   a resistance wire (13) which is wound around the outer circumferential surface of the rubber layer (12) in a direction normal to the longitudinal axis of the core (11), thereby obtaining a conductor (20), and
   an intermediate layer means (15,16), a net (17) and a sheath (18) which are formed around the outer circumferential surface of the conductor (20) one over another in this order such that the obtained coil type high-voltage resistive cable (10) has an outer diameter of 5 mm or smaller.

2. A cable (10) according to claim 1, wherein the rubber layer (12) is made by applying a coating material obtained by mixing fluororubber and ferrite powder to the outer circumferential surface of the core (11) and wherein the conductor (20) has an outer diameter of 0.6 mm or smaller.

3. A cable (10) according to claim 1 or 2, wherein a release agent (14) is provided between the conductor (20) and the intermediate layer means (15, 16).

4. A cable (10) according to claim 1 or 2, wherein the intermediate layer means comprises an inner conductor layer (15) and a resin layer (16).

5. A cable (10) according to one or more of claims 1 to 4, wherein the core (11) is made to have an outer diameter of 0.4 to 0.45 mm by twisting three reinforced aramid or glass fibers of about 400 denier each.

6. A cable (10) according to one or more of claims 1 to 5, wherein the rubber layer (12) is formed of a coating material mixture of 300 to 500 parts by weight of ferrite powder and 100 parts by weight of fluororubber.

7. A cable (10) according to claim 6, wherein the rubber layer (12) is formed of a coating material mixture of 300-400 parts by weight of ferrite powder and 100 parts by weight of fluororubber.

8. A cable (10) according to claim 6, wherein the rubber layer (12) is formed of a coating material mixture of 400-500 parts by weight of ferrite powder and 100 parts by weight of fluororubber.

9. A cable (10) according to claim 6, wherein the rubber layer (12) is formed of a coating material mixture of 400 parts by weight of ferrite powder and 100 parts by weight of fluororubber.

10. A cable (10) according to one or more of claims 1 to 6, wherein the inner conductor layer (15) is formed by extruding partially conductive polyolefin resin.

11. A method for making a coil type high-voltage resistive cable (10) for preventing noise, said method comprising the steps of:
   providing an elongate core (11) made of reinforced fibers;
   applying a rubber layer (12) as a coating on the core (11);
   winding a resistance wire (13) around the rubber layer (12) in a direction normal to the longitudinal axis of the core (11) to define a conductor (20);
   applying an inner conductor layer (15) to the conductor (20);
   applying a resin layer (16) to the inner conductor layer (15);
   applying a net (17) around the resin layer; and
   applying a sheath (18) around the net (17) to define the high-voltage resistive cable.

12. The method of claim 16, wherein the step of coating the rubber layer (12) on the core (11) comprises coating the core (11) with a rubber layer (12) defining a mixture of 300 to 500 parts by weight of ferrite powder and 100 parts by weight of fluororubber.

13. The method of claim 17, wherein the step of winding the resistance wire (13) comprises winding the resistance wire (13) at a pitch of approximately 10,000 lines per meter.

14. The method of claim 17, further comprises the step of vulcanizing the rubber layer (12) after coating the rubber layer (12) onto the core (11) and wherein the step of winding the resistance wire (13) is carried out prior to completing the vulcanizing step.

FIG. 1

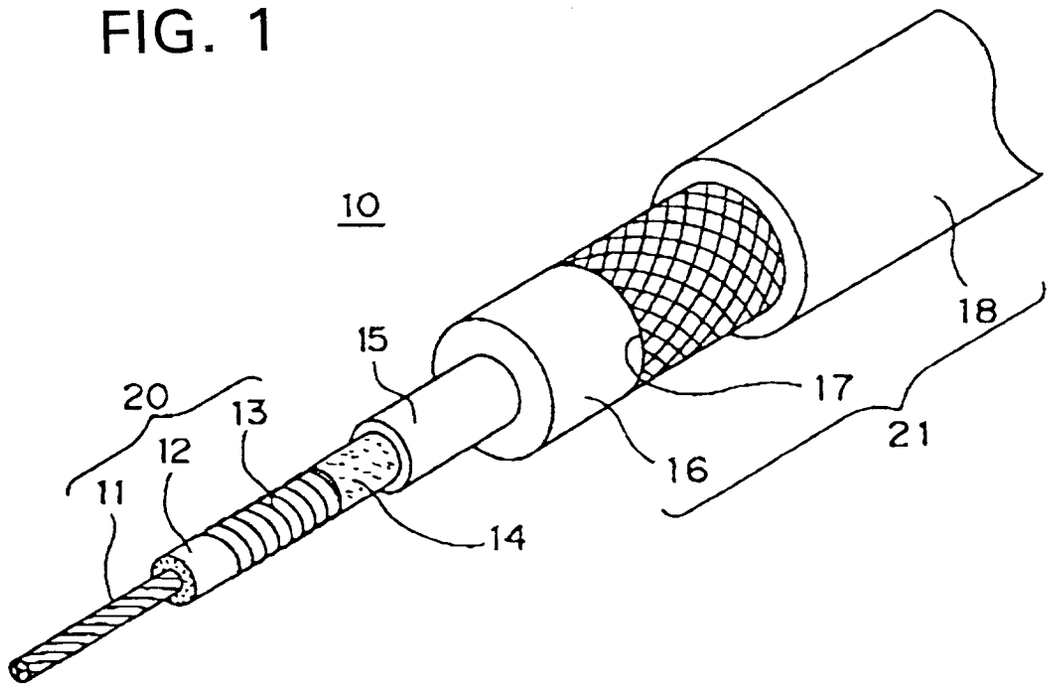

FIG. 2

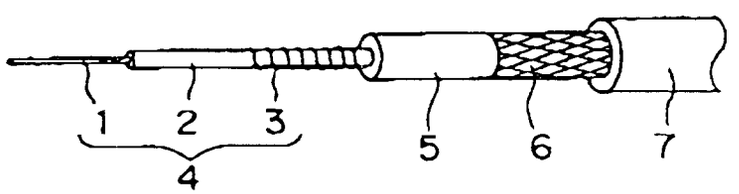

FIG. 3