

Description

Title of Invention: SHIELD CABLE

Technical Field

- [1] The present invention relates to a shield cable, and more particularly, to a shield cable that is located in the vicinity of a high voltage alternating current power line like an electric railway line, thereby providing excellent electromagnetic shielding performance.

Background Art

- [2] As railways have been electrified, communication and signal transmission are performed to share the running information and control information of trains with a central operating system.
- [3] For the power system of the electrified railways, an electric railway line is installed along a rail to supply power to railway vehicles, and a cable is also installed along the rail to perform bi-directional communication or signal transmission in a given direction.
- [4] In case of short-range urban electric railways, the power used for the power system of the railway is direct current (DC) power, and the power system of the railway using the DC power just has the electrostatic interference with the electric wires therearound. So as to prevent the electrostatic interference, thus, the cable is surrounded with a metal tape having low electrical resistance.
- [5] However, the power system for electrified metropolitan railways uses alternating current (AC) power, and in this case, the AC power causes electromagnetic induction as well as electrostatic interference.
- [6] The current flowing to the electric railway line from which power is supplied to the electrified railway (hereinafter, referred to as electric train) causes electromagnetic/electrostatic interference to the cable installed in a parallel relation with the rail for the running of the electric train. Unlike the railway system using the DC power, however, the railway system using the AC power generates electromagnetic induction as well as electrostatic interference. Even if the cable is surrounded with a metal tape having low electrical resistance, such electromagnetic interference is still transmitted to the cable.
- [7] So as to reduce the electromagnetic interference occurring on the cable installed along the rail, a high permeability material is wound on the cable, and as a result, the cable is shielded partially from the electromagnetic interference.
- [8] One example of conventional shield cables is disclosed in Japanese Patent Application No.2004-234870 wherein an electromagnetic shielding cable for a communication cable installed on a high voltage power line has good electromagnetic

shielding performance at a high voltage area, for example, at electric field strength of 300 V/km or more and ensures the easiness in the installation work.

- [9] In more detail, the above-mentioned conventional shield cable includes an electromagnetic shielding layer composed of two sheets of tapes made of oriented silicon steel or electric iron, wherein the oriented silicon steel constituting the electromagnetic shielding layer has a thickness between 0.29mm and 0.31mm.
- [10] The above-mentioned conventional shield cable adopts the shielding layers to improve the electromagnetic shielding performance, but does not suggest any configuration or endeavor wherein induced current flows spirally to increase the inductance in the electromagnetic shielding layer.
- [11] In case where the electromagnetic shielding layer is composed of two sheets of tapes made of oriented silicon steel or electric iron to improve the electromagnetic shielding performance, the manufacturing cost becomes increased, as shown by the curve A in FIG.6, and if the shielding layer made of silicon steel is provided alone, as shown by the curve B in FIG.6, the electromagnetic shielding performance becomes much deteriorated at a low electric field strength area (about 270 V/km or less).

Disclosure of Invention

Technical Problem

- [12] Accordingly, the present invention has been made in view of the above-mentioned problems occurring in the prior art, and it is an object of the present invention to provide a shield cable that is located in the vicinity of a high voltage alternating current power line like an electric railway line, thereby providing excellent electromagnetic shielding performance.

Solution to Problem

- [13] In accordance with an aspect of the present invention, the above and other objects can be accomplished by the provision of a shield cable comprising a plurality of coated cable cores, an inside shielding layer made of a metallic material to surround the outer periphery of the plurality of cable cores, an outside shielding layer made of a metallic material to spirally surround the outer periphery of the inside shielding layer in such a manner as to be insulated from the inside shielding layer and a covering layer adapted to surround the outer periphery of the outside shielding layer.
- [14] The outside shielding layer may be coated with insulation material.
- [15] The outside shielding layer may be a single layered shielding tape adapted to be wound in the lengthwise direction of the shield cable, and if the shielding tape is wound spirally, separated distances on the shielding tape do not exist or overlapped portions thereon exist.
- [16] The outside shielding layer may be a single layer shielding tape, and if the shielding

tape is wound spirally, separated distances on the shielding tape exist.

[17]

[18] The outside shielding layer may have double layer shielding tapes wound with separated distances in the lengthwise direction of the shield cable, and at least one of the shielding tapes is coated with insulation material.

[19] The outside shielding layer may have double layer shielding tapes wound with separated distances in the lengthwise direction of the shield cable, and an insulation sheet is provided between the shielding tapes.

[20] At least one of the shielding tapes of the outside shielding layer may be made of any one of nickel steel and silicon steel.

[21] The shielding tape of the outside shielding layer which is made of any one of nickel steel and silicon steel may be disposed on the inside of the outside shielding layer, and the other shielding tape surrounding the outer periphery of one shielding tape is made of galvanized steel.

[22] The silicon steel may be non-oriented silicon steel.

[23] The nickel steel may have 50 to 80% by weight of nickel.

[24] The slits formed during the spiral winding of the inside shielding tape of the double layer shielding tapes of the outside shielding layer may be shielded by the outside shielding tape.

[25] The insulation coating may be formed of varnish coating by an organic material having an inorganic filler and has a thickness of 4 μ m or more.

[26] The insulation coating may have surface insulation resistance between 30 Ω/cm^2 and 50 Ω/cm^2 .

[27] And in accordance with an aspect of the present invention, the above and other objects can be accomplished by the provision of a shield cable comprising a core part having a plurality of cable cores, an electrostatic shielding part made of a metallic material to surround the outer periphery of the core part, an electromagnetic shielding part made of a metallic material to surround the electrostatic shielding part in such a manner as to be insulated from the electrostatic shielding part, from which induced current flows spirally and a covering layer adapted to surround the outer periphery of the electromagnetic shielding part.

[28] The electrostatic shielding part has a double layer structure where an inside shielding tape may be made of a high permeability material and an outside shielding tape is made of a low permeability material, and the inside and outside shielding tapes are wound spirally.

[29] The inside shielding tape may be made of non-oriented silicon steel.

[30] The inside shielding tape may be made of nickel steel having 50 to 80% by weight of nickel.

- [31] Any one of the inside shielding tape made of the high permeability material and the outside shielding tape made of the low permeability material of the electromagnetic shielding part is coated with insulation material.
- [32] An insulation sheet may be disposed between the inside shielding tape made of the high permeability material and the outside shielding tape made of the low permeability material of the electromagnetic shielding part.
- [33] The electrostatic shielding part and the electromagnetic shielding part may be insulated from each other by an insulation sheet made of the same material as the insulation sheet adapted to insulate the inside and outside shielding tapes of the electromagnetic shielding part from each other.
- [34] The slits spacedly formed by the spiral winding of the inside shielding tape made of the high permeability material of the electromagnetic shielding part may be shielded when the outside shielding tape made of the low permeability material is wound spirally.
- [35] And in accordance with an aspect of the present invention, the above and other objects can be accomplished by the provision of a shield cable comprising a plurality of cable cores, an electrostatic shielding part made of a metallic material to surround the cable cores and an electromagnetic shielding part having an inside shielding tape made of a high permeability metallic material and an outside shielding tape made of a low permeability metallic material in such a manner as to be insulated from the electrostatic shielding part, wherein when the inside and outside shielding tapes are wound spirally in a state of being insulated from each other, a shielding rate is 0.05 or less in accordance with the input voltage between 0 V/km and 500 V/km.
- [36] Any one of the inside shielding tape made of the high permeability metallic material and the outside shielding tape made of the low permeability metallic material of the electromagnetic shielding part may be coated with insulation material to allow the inside and outside shielding tapes to be insulated from each other, and alternatively, an insulation sheet is disposed between the inside shielding tape and the outside shielding tape to allow the inside and outside shielding tapes to be insulated from each other.
- [37] The electrostatic shielding part may be formed of a corrugated pipe made of copper.
- [38] The electrostatic shielding part and the electromagnetic shielding part may be insulated from each other by a sheath member made of polyethylene.

[39]

Advantageous Effects of Invention

- [40] According to the present invention, the shield cable is located in the vicinity of a high voltage alternating current power line like an electric railway line, thereby providing excellent electromagnetic shielding performance.

[41] Further, the shield cable is capable of minimizing the structural change for improving electromagnetic shielding performance, thereby providing the reduction of manufacturing cost.

[42] Furthermore, the shield cable is capable of providing an electromagnetic shielding part having a single layer shielding tape through insulation coating, thereby improving the work effectiveness and reducing the weight and volume thereof.

[43]

Brief Description of Drawings

[44] FIGS.1a and 1b are perspective and sectional views showing a shield cable according to a first embodiment of the present invention.

[45] FIGS.2a and 2b are perspective and sectional views showing a shield cable according to a second embodiment of the present invention.

[46] FIGS.3a and 3b are perspective and sectional views showing a shield cable according to a third embodiment of the present invention.

[47] FIGS.4a and 4b are perspective and sectional views showing a shield cable according to a fourth embodiment of the present invention.

[48] FIG.5 is a graph showing the shielding performance experiments of the shield cable according to the preferred embodiments of the present invention.

[49] FIG.6 is a graph showing the shield performance experiments of a conventional shield cable.

[50]

Best Mode for Carrying out the Invention

[51] Hereinafter, an explanation on a shield cable according to preferred embodiments of the present invention will be in detail given with reference to the attached drawings. The explanation on the specific structure and functions are given just to define the preferred embodiments of the present invention, and the preferred embodiments of the present invention may be provided in various manners, which are not limited to the embodiments described below. In the description of the invention with reference to the attached drawings, further, the same components are indicated by the same reference numerals as each other, and for the brevity of the description, the explanation on their repeated features will be avoided.

[52] FIGS.1a and 1b are perspective and sectional views showing a shield cable according to a first embodiment of the present invention.

[53] In more detail, FIGS.1a shows a perspective view of the shield cable according to the first embodiment of the present invention, and FIG.1b shows a sectional view of the shield cable according to the first embodiment of the present invention.

[54] The shield cable 100 according to the first embodiment of the present invention

includes a core part 10 where a plurality of cable cores 11 is provided, an electrostatic shielding part 40 disposed on the outer periphery of the core part 10, an electro-magnetic shielding part 60 disposed on the outer periphery of the electrostatic shielding part 40 in such a manner as to allow induced current to flow along a spiral trajectory thereof; and a covered part 70 disposed on the outer periphery of the electro-magnetic shielding part 60.

[55] The core part 10 of the shield cable 100 according to the first embodiment of the present invention has the plurality of cable cores 11 coated for the bidirectional transmission of communication signals or for the transmission of signals in a specific direction. Desirably, it should be understood that the shield cable 100 according to the first embodiment of the present invention includes the cable for the transmission of signals in a specific direction as well as the cable for the bidirectional communication.

[56] The plurality of cable cores 11 of the core part 10 has respective pairs in the state of being twisted.

[57] A film part 20 is disposed on the outer periphery of the core part 10 to a form of a film 21 (or sheet) to surround the plurality of cable cores 11 of the core part 10.

[58] The film part 20 is adapted to compress the plurality of cable cores 11 thereagainst, thereby minimizing the gaps between the cable cores 11 and preventing foreign matters from entering the core part 10.

[59] An inside sheath part 30 is disposed on the outer periphery of the film part 20 and has an inside sheath member 31 having a water resistance function.

[60] The inside sheath member 31 is made of polyethylene, which means a cross-linking high molecular compound made by the polymerization of ethylene.

[61] The inside sheath part 30 having the inside sheath member 31 is thicker than the film part 20, and the inside sheath part 30 has an opaque dark color.

[62] The electrostatic shielding part 40 as an inside shielding layer is disposed on the outer periphery of the inside sheath part 30. The electrostatic shielding part 40 is made of a low resistance metal, and in more detail, it includes an electrostatic shielding member 41 made of copper (Cu) to a form of corrugate pipe.

[63] The electrostatic shielding part 40 as an inside shielding layer provides an electrostatic shielding effect to the core part 10 in accordance with electrostatic induction, and in addition to the low resistance metal copper, it may be made of aluminum (Al). In this case, aluminum may become aluminum coated with a high molecular coating material.

[64] Instead of having the form of the corrugated pipe, further, the electrostatic shielding part 40 may have a form of a braided wire.

[65] An outside sheath part 50 is disposed on the outer periphery of the electrostatic shielding part 40, while having an outside sheath member 51. The outside sheath part

50 serves to insulate and separate the electrostatic shielding part 40 as an inside shielding layer and the electromagnetic shielding part 60 as an outside shielding layer as will be discussed later.

[66] In the same manner as the inside sheath member 31, the outside sheath member 51 of the outside sheath part 50 is also made of polyethylene.

[67] The electromagnetic shielding part 60 is disposed on the outer periphery of the outside sheath part 50.

[68] If the shield cable 100 according to the present invention is disposed in a parallel relation with a high voltage power line or an electric railway line, therefore, so as to greatly reduce the induced current generated by the electrostatic induction or electromagnetic induction from the cable cores, the shield cable 100 is provided with the electrostatic shielding part 40 made of the low resistance metal as an inside shielding layer disposed at the inside thereof and the electromagnetic shielding part 60 made of a high permeability material as an outside shielding layer disposed at the outside thereof.

[69] Magnetic permeability is the strength ratio in vacuum of the magnetic flux density created when a material is magnetized under the influence of a magnetic field to the magnetizing field. General materials, that is, paramagnetic and diamagnetic materials have the permeability close to 1, and the permeability values are determined upon the kinds of materials. In this case, ferromagnetic materials like iron or ferrimagnetic materials have substantially large values, and the values are varied in accordance with the magnetic history or the strength of the magnetic field. Especially, alloys such as nickel steel (permalloy), sendust (Fe-Si-Al alloy), ferrite (ceramic-like materials with magnetic properties inclusive of iron oxide), silicon steel and the like have extremely high permeability to exhibit peculiar electrical and magnetic features, and thus, they are used as permanent magnets as a high permeability material or cores of radio frequency devices. To the contrary, copper and aluminum are representative examples of low permeability metals.

[70] The electromagnetic shielding part 60 as an outside shielding layer is made of a generally high permeability silicon steel strip. The electromagnetic shielding part 60 is provided to minimize the induced current generated by the electromagnetic induction of the cable cores 11 of the core part 10 and further to protect the cable.

[71] The electromagnetic shielding part 60 allows the induced current to flow spirally, as will be discussed later, and also has a shielding tape 61 as an electromagnetic shielding member, which improves the work effectiveness upon the installation of the shield cable.

[72] In more detail, the shielding tape 61 having a given width is wound onto the outside sheath part 50, and when the shield cable 100 is bent, it can be easily bent by the boundaries formed in the width direction of the shielding tape 61, thereby ensuring

good work effectiveness.

- [73] Further, if the shielding tape 61 constituting the electromagnetic shielding part 60 as the outside shielding layer is made of a high permeability metal, the magnetic field causing noise to the cable cores is almost converged to the shielding tape 61, and destructive interference occurs between the induced current generated by the magnetic field causing noise to the cable cores and the induced current generated by the electrostatic shielding tape, thereby minimizing the influence of the induced current on the cable cores. Such high permeability metal is nickel steel (permalloy) or silicon steel.
- [74] The silicon steel is non-oriented silicon steel from which the orient of the magnetic field is removed, and the nickel steel desirably has 50 to 80% by weight of nickel.
- [75] If the shielding layer is made of a high permeability material, generally, the electromagnetic shielding performance can be improved, and K (shielding coefficient) determining the electromagnetic shielding performance can be decreased.
- [76] The shielding coefficient compares the sizes of the induced electromotive forces induced to the cable cores in accordance with the existence/non-existence of the electromagnetic shielding part 60, which is determined as follows:
- [77] $K \text{ (shielding coefficient)} = E \text{ (induced current induced to cable core)} / E_o \text{ (input voltage applied to shielding layer)}$ or,
- [78] $K \text{ (shielding coefficient)} = E' \text{ (induced current in case of the existence of shielding layer)} / E_o' \text{ (induced current in case of the non-existence of shielding layer)}$
- [79] The lower the K (shielding coefficient) is, the higher the shielding performance is.
- [80] The permeability (μ_o) has a relation with inductance L by a first equation as follows:
- [81] $L = \Phi / I = n * \varphi / I = n * B * S / I = n * \mu_o * H * S / I$ -----(first equation), wherein L is inductance, Φ total magnetic flux, n the number of windings, I current, B magnetic flux density, S surface, and H magnetic field strength.
- [82] As described above, the electromagnetic shielding part 60 as the outside shielding layer is made of a high permeability material, and since the electromagnetic shielding performance is proportional to the permeability (μ_o), in the first equation, the permeability (μ_o) of the shielding layer is increased, so that the inductance L which is proportional to the permeability (μ_o) is increased ($\mu_o \propto L$).
- [83] If the inductance (L) of the electromagnetic shielding layer is increased, accordingly, the electromagnetic shielding performance is improved and the shielding coefficient of the electromagnetic shielding layer is decreased.
- [84] So as to improve the shielding performance of the shielding tape 61 of the electromagnetic shielding part 60, therefore, the shield cable 100 according to the first embodiment of the present invention adopts a method for increasing the inductance (L) of the electromagnetic shielding part 60 as the outside shielding layer.
- [85] In summary, K (shielding coefficient) of the electromagnetic shielding part 60 is

inversely proportional to the inductance (L) of the electromagnetic shielding part 60, and so as to lower the K (shielding coefficient) of the electromagnetic shielding part 60, the shielding tape 61 constituting the electromagnetic shielding part 60 is made of a high permeability material. So as to more increase the inductance (L) of the electromagnetic shielding part 60, at the same time, the induced current caused by the shielding tape 61 does not flow in a linear direction along the lengthwise direction of the shield cable, but flows to have a spiral trajectory, thereby inducing coil effects.

[86] So as to allow the induced current to flow spirally, the shielding tape 61 constituting the electromagnetic shielding part 60 is wound spirally on the outer periphery of the outside sheath part 50 and further coated with insulation material.

[87] That is, the shielding tape 61 constituting the electromagnetic shielding part 60 is coated with insulation material and then wound spirally, so that the induced current on the outside shielding layer flows spirally, and even though the shielding tape 61 constituting the electromagnetic shielding part 60 is contacted with the outside sheath part 50 during the winding process, the inductance through the coil effect is increased to make K (shielding efficient) lowered.

[88] The insulation coating applied to the shielding tape 61 constituting the electromagnetic shielding part 60 becomes vanish coating by an organic material having an inorganic filler and has a thickness of 4 μ m or more, desirably about 5 μ m through experimental verification.

[89] The surface insulation resistance of the insulation coating in the state where the shielding tape 61 constituting the electromagnetic shielding part 60 has been coated with insulation material has a range between 30 Ω/cm^2 and 50 Ω/cm^2 , desirably about 40 Ω/cm^2 through experimental verification.

[90] When a direct current voltage is applied to an insulated material, substantially minute current flows, and at this time, the ratio of the voltage to the current indicates insulation resistance. The insulation resistance is classified into surface insulation resistance and volume insulation resistance in accordance with the flowing of the current on the surface or interior of the insulated material, and in this case, the surface insulation resistance is measured to check the quality of insulation coating.

[91] In the first embodiment of the present invention as shown in FIGS.1a and 1b, in more detail, the electromagnetic shielding part 60 as the outside shielding layer is formed of the single layer shielding tape 61.

[92] The shielding tape 61 has insulation coating layers c formed on both surfaces thereof, as shown in the enlarged circle of FIG.1b.

[93] The formation of the insulation coating layers c enables the induced current by the electromagnetic induction to flow in the lengthwise direction of the shielding tape 61, even if the induced current is contacted or overlapped during the spiral winding

process of the shielding tape 61 or in case where separated gaps, that is, slits 62 formed upon the spiral winding do not occur.

[94] Unlike FIGS. 1a and 1b, that is, if the electromagnetic shielding part 60 as the outside shielding layer is formed of the single layer shielding tape 61, the shielding tape 61 is wound spirally, without having any separated gaps, or has an overlapped portion where the slits 62 are not exposed to the outside.

[95] If the insulation coating layers c are not provided, the shielding tape 61 is wound spirally to form the slits 62, thereby maintaining the insulation state, as shown FIGS. 1a and 1b.

[96] The first embodiment of the present invention as shown in FIGS. 1a and 1b shows the case where the shielding tape 61 is wound spirally to form the slits 62, while having the insulation coating layers c formed thereon. In this case, if the insulation coating layers c are not formed sufficiently on both surfaces of the shielding tape 61 or it is hard to form the insulation coating layers c thereon, the formation of the slits 62 prevents the insulation breakdown caused by the surface contact with an insulating tape through bending.

[97] Accordingly, even if the insulation coating layers c are provided on the shielding tape 61, the separation gaps are artificially formed to prevent the shielding tape 61 from having overlapping portions or contacted portions.

[98] The covered part 70 is disposed on the outer periphery of the electromagnetic shielding part 60. A covered material 71 constituting the covered part 70 is formed of unleaded PVC or halogen free resin.

[99] FIGS. 2a and 2b are perspective and sectional views showing a shield cable according to a second embodiment of the present invention.

[100] In more detail, FIGS. 2a shows a perspective view of the shield cable according to the second embodiment of the present invention, and FIG. 2b shows a sectional view of the shield cable according to the second embodiment of the present invention, wherein the parts that have been already explained in FIGS. 1a and 1b will be not explained again for the brevity of the description.

[101] The shielding tape 61 of the electromagnetic shielding part 60 as shown in FIGS. 1a and 1b serves as the electromagnetic shielding layer and further as a stiffness reinforcement member for reinforcing the stiffness of the shield cable.

[102] So as to improve the work effectiveness and to allow the induced current to flow spirally, the shielding tape 61 of the electromagnetic shielding part 60 is wound spirally.

[103] However, if the shielding tape 61 is wound spirally, the electromagnetic shielding effect may be decreased through the separated gap (slits) between the wound portions of the shielding tape 61 formed every winding, and accordingly, the electromagnetic

shielding part 60 may be composed of a plurality of shielding tape layers.

- [104] If the electromagnetic shielding part 60 is formed of a plurality of shielding tape layers, the work effectiveness upon the installation of the shield cable is not decreased greatly, and the inflow and outflow of the magnetic field through the slits generated during the spiral windings are shielded, thereby optimizing the electromagnetic shielding effects.
- [105] The electromagnetic shielding part 60 as an outside shielding layer as shown in FIGS.2a and 2b includes first and second shielding tapes 61 and 66, but may include a triple layered shielding tape.
- [106] In the same manner as the first embodiment of the present invention, the electromagnetic shielding part 60 as shown in FIGS.2a and 2b has at least one or both of the first and second shielding tapes 61 and 66 having insulation coating layers formed thereon so as to increase the inductance of the electromagnetic shielding part 60 and to allow the induced current induced to the electromagnetic shielding part 60 to flow spirally.
- [107] Also, one of the first and second shielding tapes 61 and 66 is not coated on the entire surface thereof, but at least one of the outer surface of the first shielding tape 61 and the inner surface of the second shielding tape 66 is coated to make the outer surface and the inner surface contacted with each other.
- [108] In this case, if the insulation coating layer is formed on both of the outer surface of the first shielding tape 61 and the inner surface of the second shielding tape 66, it has a thickness smaller than the thickness thereof when formed on at last one surface.
- [109] The slits 62 formed during the spiral windings of the first shielding tape 61 are shielded by the second shielding tape 66, thereby minimizing the exposure of the slits 62 and directly preventing the inflow and outflow of the magnetic field.
- [110] Further, the first and second shielding tapes 61 and 66 are sequentially wound spirally on the inside sheath part 30.
- [111] As shown in FIGS.2a and 2b, if the first and second shielding tapes 61 and 66 of the electromagnetic shielding part 60 are mutually insulated from each other by the respective coating layers and at the same time wound spirally independently of each other, they serve as independent induction coils. Since the induction coils are laid on top of each other, accordingly, the inductance of the electromagnetic shielding part 60 becomes larger than the single layer shielding tape in the first embodiment of the present invention, thereby much more improving the electromagnetic shielding performance of the shielding tapes.
- [112] That is, the shielding tapes are just laid on top of each other, without having any spiral winding and mutually insulated from each other, thereby inducing the coil effects having the spiral trajectory and increasing the inductance of the electromagnetic

shielding part 60.

- [113] Through the improvement of the electromagnetic shielding performance, the magnetic flux of the magnetic field from which the induced current is generated is converged to a maximum degree to the electromagnetic shielding part 60 formed by winding the double layer shielding tapes with no slits, and the induced current caused by the electromagnetic induction flows to the electrostatic shielding part 40 disposed inside the electromagnetic shielding part 60, so that destructive interference occurs between the induced current generated by the electromagnetic induction and the induced current causing noise to the cable cores 11, thereby improving the electromagnetic shielding performance of the shielding tapes.
- [114] The first and second shielding tapes 61 and 66 of the electromagnetic shielding part 60 of the shield cable 100 as shown in FIGS.2a and 2b are made of a steel plate material such as nickel steel, silicon steel, galvanized steel and the like.
- [115] The first shielding tape 61 located at the inside of the electromagnetic shielding part 60 is made of any one of nickel steel, silicon steel, and galvanized steel, and the second shielding tape 66 located at the outside of the electromagnetic shielding part 60 is made of any one of nickel steel, silicon steel, and galvanized steel. The first and second shielding tapes 61 and 66 are made of the same material as each other or different materials from each other.
- [116] If the first shielding tape 61 is made of a high permeability material such as nickel steel (permalloy) having 50 to 80% by weight of nickel or non-oriented silicon steel and the second shielding tape 66 wound on the outside of the first shielding tape 61 is made of galvanized steel for corrosion prevention, it is experimentally checked that the electromagnetic shielding performance and the corrosion prevention performance were excellent.
- [117] In addition to the above-mentioned experimental result, however, it is found that the electromagnetic shielding performance when the steel plate type first and second shielding tapes 61 and 66 are wound to the double layer in the state of being insulated from each other was more excellent than that when they are wound in the state of being not insulated from each other.
- [118] FIGS.3a and 3b are perspective and sectional views showing a shield cable according to a third embodiment of the present invention.
- [119] In more detail, FIGS.3a shows a perspective view of the shield cable according to the third embodiment of the present invention, and FIG.3b shows a sectional view of the shield cable according to the third embodiment of the present invention, wherein the parts that have been already explained in FIGS.1a to 2b will be not explained again for the brevity of the description.
- [120] Unlike the second embodiment of the present invention as shown in FIGS.2a and 2b,

the third embodiment of the present invention as shown in FIGS.3a and 3b adopts a method wherein the whole surface or contact surface of at least one of the first and second shielding tapes 61 and 66 are not coated with insulation material, but an insulation sheet S is provided between the first and second shielding tapes 61 and 66, to insulate them from each other.

- [121] That is, the insulation coating is avoided, and the insulation sheet S, which is made of a non-woven fabric or resin material, is disposed between the first and second shielding tapes 61 and 66. The insulation sheet S may be insertedly located during the winding process of the electromagnetic shielding part 60 or may be attached to one side contact surface of any one of the first and second shielding tapes 61 and 66.
- [122] If the insulation sheet S is insertedly located during the winding process of the electromagnetic shielding part 60, it is formed of a resin sheet or film, thereby strengthening the water resistance performance and fastening the parts at the inside thereof to allow them to be wound without any gap.
- [123] In summary, the electromagnetic shielding part 60 as the outside shielding layer has a double layer structure, and the respective shielding layers are the first and second shielding tapes 61 and 66 wound in the state of being separated in the lengthwise direction of the shield cable 100, while the insulation sheet S being interposed between the two layer first and second shielding tapes 61 and 66.
- [124] In this case, as shown in FIGS.3a and 3b, the insulation coating layers may be formed on the first and second shielding tapes 61 and 66 to minimize the possibility of the insulation breakdown, but if the insulation reliability of the insulation sheet S exists, the formation of the insulation coating layers is not needed.
- [125] FIGS.4a and 4b are perspective and sectional views showing a shield cable according to a fourth embodiment of the present invention.
- [126] In more detail, FIGS.4a shows a perspective view of the shield cable according to the fourth embodiment of the present invention, and FIG.4b shows a sectional view of the shield cable according to the fourth embodiment of the present invention, wherein the parts that have been already explained in FIGS.1a to 3b will be not explained again for the brevity of the description.
- [127] Unlike the third embodiment of the present invention as shown in FIGS.3a and 3b, the fourth embodiment of the present invention as shown in FIGS.4a and 4b does not adopt the outside sheath part 50 and adopts an insulation sheet S1 made of a non-woven fabric or resin material in the same manner as in FIGS.3a and 3b, so as to insulate the electrostatic shielding part 40 as the inside shielding layer from the electromagnetic shielding part 60 as the outside shielding layer.
- [128] The removal of the outside sheath part 50 allows the diameter of the shield cable 100 to be much more decreased, and further, insulates the electrostatic shielding part 40

from the electromagnetic shielding part 60.

- [129] In addition to the application of the insulation sheet S1 so as to insulate the electrostatic shielding part 40 from the electromagnetic shielding part 60, further, the inner surface of the first shielding tape 61 of the electromagnetic shielding part 60 is coated.
- [130] Also, according to the forth embodiment of the present invention as shown in FIGS.4a and 4b, an insulation sheet S2 is provided between the first and second shielding tapes 61 and 66 constituting the outside shielding layer to insulate the first and second shielding tapes 61 and 66 from each other, and further, the insulation coating layers may be formed on the first and second shielding tapes 61 and 66 so as to reduce the possibility of the insulation breakdown.
- [131] The second to fourth embodiments of the present invention as shown in FIGS.2a to 4b has the double layer shielding tapes constituting the electromagnetic shielding part 60, but only if the shielding tapes are triple layered and wound spirally in the state of being insulated from one another, the effect of the increase of the number of coils from which the inducted current is generated can be obtained, thereby greatly improving the electromagnetic shielding performance.
- [132] FIG.5 is a graph showing the shielding performance experiments of the shield cable according to the preferred embodiments of the present invention. In more detail, in the experiment graph as shown in FIG.5, the electromagnetic shielding part 60 (the first shielding tape 61) of the shield cable 100 as shown in FIGS.2a and 2b is made of a high permeability material such as nickel steel (permalloy) having 50 to 80% by weight of nickel or non-oriented silicon steel, and the second shielding tape 66 wound on the outside of the first shielding tape 61 is made of galvanized steel for corrosion prevention. In this condition, while the input voltage E_o on both ends of the second shielding tape 66 is being increased, the electromagnetic induced voltage E is measured inside the electromagnetic shielding part 60 to measure K (shielding coefficient), wherein K (shielding coefficient) = E (induced voltage) / E_o (input voltage). According to the detailed experimental conditions, the input voltages (E_o , V/km) are varied on the outermost shielding layers of general shield cable A, conventional high voltage shield cable B and the shield cable C according to the present invention as shown in FIGS.2a and 2b, thereby measuring K (shielding coefficient).
- [133] In case of the general shield cable A where no electromagnetic shielding layer exists, the shielding coefficient is greatly increased when the input voltages (E_o , V/km) are low and reach a high voltage of 500 V/km, so that it is checked that the signal interference due to noise occurs inside the shield cable (wherein $K > 0.15$). In case where the induced current flows along the lengthwise direction of the shield cable like the conventional high voltage shield cable B, the shield cable B has more excellent shielding performance than the shield cable A, but high deviations in the shielding

rates are obtained according to the input voltages (E_o , V/km). If the input voltages (E_o , V/km) are at a low voltage area ($E_o < 70$ V/km), especially, the shielding performance of the shield cable B is greatly lower than the shield cable C according to the present invention, thereby checking a lot of noise occurring on the cable cores.

[134] Further, it is checked that the shielding performance of the shield cable B on the whole section of the input voltages (E_o , V/km) is relatively lower ($K < 0.05$) than the shield cable C according to the present invention.

[135] That is, if the shield cable C according to the present invention is provided with the electromagnetic shielding part having the first shielding tape made of a high permeability metal and located at the inside thereof and the second shielding tape made of a low permeability metal and located at the outside thereof, in the state of being insulated from the electrostatic shielding part, the first and second shielding tapes are wound spirally in the state of being insulated from each other, so that the shielding performance corresponding to the shielding rate of 0.05 or less is ensured in the range of the input voltage of 0 to 500 V/km, and the shielding performance of the shield cable for the signal transmission installed in a parallel relation with a high current electric railway line is ensured.

[136] While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by the embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention.

[137]

Claims

- [Claim 1] A shield cable comprising:
a plurality of coated cable cores;
an inside shielding layer made of a metallic material to surround the outer periphery of the plurality of cable cores;
an outside shielding layer made of a metallic material to spirally surround the outer periphery of the inside shielding layer in such a manner as to be insulated from the inside shielding layer, so that induced current flows spirally in the outside shielding layer; and
a covering layer adapted to surround the outer periphery of the outside shielding layer.
- [Claim 2] The shield cable according to claim 1, wherein the outside shielding layer is coated with insulation material.
- [Claim 3] The shield cable according to claim 2, wherein the outside shielding layer is a single layered shielding tape adapted to be wound in the lengthwise direction of the shield cable, and if the shielding tape is wound spirally, separated distances on the shielding tape do not exist or overlapped portions thereon exist.
- [Claim 4] The shield cable according to claim 1, wherein the outside shielding layer is a single layer shielding tape, and if the shielding tape is wound spirally, separated distances on the shielding tape exist.
- [Claim 5] The shield cable according to claim 1, wherein the outside shielding layer has double layer shielding tapes wound with separated distances in the lengthwise direction of the shield cable, and at least one of the shielding tapes is coated with insulation material.
- [Claim 6] The shield cable according to claim 1, wherein the outside shielding layer has double layer shielding tapes wound with separated distances in the lengthwise direction of the shield cable, and an insulation sheet is provided between the shielding tapes.
- [Claim 7] The shield cable according to claim 5 or 6, wherein at least one of the shielding tapes of the outside shielding layer is made of any one of nickel steel and silicon steel.
- [Claim 8] The shield cable according to claim 7, wherein the shielding tape of the outside shielding layer which is made of any one of nickel steel and silicon steel is disposed on the inside of the outside shielding layer, and the other shielding tape surrounding the outer periphery of one shielding tape is made of galvanized steel.
- [Claim 9] The shield cable according to claim 7, wherein the silicon steel is non- oriented silicon steel.

- [Claim 10] The shield cable according to claim 7, wherein the nickel steel has 50 to 80% by weight of nickel.
- [Claim 11] The shield cable according to claim 3 or 4, wherein the slits formed during the spiral winding of the inside shielding tape of the double layer shielding tapes of the outside shielding layer are shielded by the outside shielding tape.
- [Claim 12] The shield cable according to claim 2 or 5, wherein the insulation coating is formed of vanish coating by an organic material having an inorganic filler and has a thickness of 4 μ m or more.
- [Claim 13] The shield cable according to claim 12, wherein the insulation coating has surface insulation resistance between 30 Ω / cm² and 50 Ω / cm².
- [Claim 14] A shield cable comprising:
 a core part having a plurality of cable cores;
 an electrostatic shielding part made of a metallic material to surround the outer periphery of the core part;
 an electromagnetic shielding part made of a metallic material to surround the electrostatic shielding part in such a manner as to be insulated from the electrostatic shielding part, so that induced current flows spirally in the electromagnetic shielding part; and
 a covering layer adapted to surround the outer periphery of the electromagnetic shielding part, wherein the electromagnetic shielding part has a double layer tape structure insulated from each other.
- [Claim 15] The shield cable according to claim 14, wherein an inside shielding tape of the double layer tape is made of a high permeability material and an outside shielding tape of the double layer tape is made of a low permeability material, and the inside and outside shielding tapes are wound spirally.
- [Claim 16] The shield cable according to claim 15, wherein the inside shielding tape is made of non-oriented silicon steel.
- [Claim 17] The shield cable according to claim 15, wherein the inside shielding tape is made of nickel steel having 50 to 80% by weight of nickel.
- [Claim 18] The shield cable according to claim 15, wherein any one of the inside shielding tape made of the high permeability material and the outside shielding tape made of the low permeability material of the electromagnetic shielding part is coated with insulation material.
- [Claim 19] The shield cable according to claim 15, wherein an insulation sheet is disposed between the inside shielding tape made of the high permeability material and the outside shielding tape made of the low permeability material of the electromagnetic shielding part.

- [Claim 20] The shield cable according to claim 19, wherein the electrostatic shielding part and the electromagnetic shielding part are insulated from each other by an insulation sheet made of the same material as the insulation sheet adapted to insulate the inside and outside shielding tapes of the electromagnetic shielding part from each other.
- [Claim 21] The shield cable according to claim 15, wherein the slits spacedly formed by the spiral winding of the inside shielding tape made of the high permeability material of the electromagnetic shielding part are shielded when the outside shielding tape made of the low permeability material is wound spirally.
- [Claim 22] A shield cable comprising:
a plurality of cable cores;
an electrostatic shielding part made of a metallic material to surround the cable cores; and
an electromagnetic shielding part having an inside shielding tape made of a high permeability metallic material and an outside shielding tape made of a low permeability metallic material in such a manner as to be insulated from the electrostatic shielding part, wherein when the inside and outside shielding tapes are wound spirally in a state of being insulated from each other, a shielding rate is 0.05 or less in accordance with the input voltage between 0 V/km and 500 V/km.
- [Claim 23] The shield cable according to claim 22, wherein any one of the inside shielding tape made of the high permeability metallic material and the outside shielding tape made of the low permeability metallic material of the electromagnetic shielding part is coated with insulation material to allow the inside and outside shielding tapes to be insulated from each other, and alternatively, an insulation sheet is disposed between the inside shielding tape and the outside shielding tape to allow the inside and outside shielding tapes to be insulated from each other.
- [Claim 24] The shield cable according to claim 22, wherein the electrostatic shielding part is formed of a corrugated pipe made of copper.
- [Claim 25] The shield cable according to claim 22, wherein the electrostatic shielding part and the electromagnetic shielding part are insulated from each other by a sheath member made of polyethylene.