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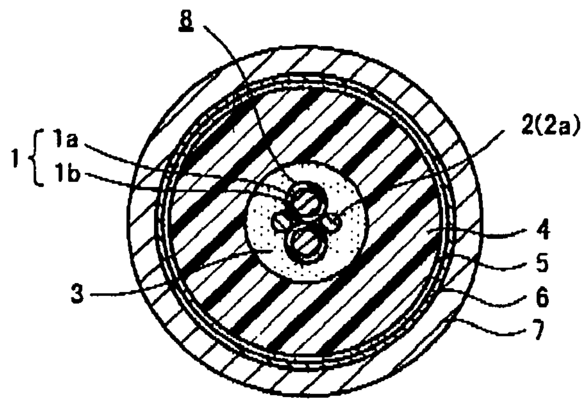
(54) **RESIN COMPOSITION FOR INSULATION, AND WIRE/CABLE USING THE SAME**

(57) Disclosed is a resin composition for insulation containing a polyolefin as a base polymer, wherein (a) an ash content is 20% by mass or below, (b) a relative permittivity t is 2.8 or below, and (c) a type A durometer hardness is 90 or below. Also disclosed is an electric wire/cable having a high voltage insulator (4) which is composed of the resin composition for insulation.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a resin composition for insulation useful as an insulator material or the like for a high voltage cable for X-ray apparatus which connects the X-ray tube of an x-ray apparatus and a high voltage generator, and to an electric wire/cable using the same.

Background Art

[0002] Generally, the high voltage cable for X-ray apparatus for connecting the X-ray tube of the x-ray apparatus and the high voltage generator is demanded that it has a small outer diameter, light weight, good flexibility, easiness of handling, small electrostatic capacitance of a high voltage insulator, followability to the repeated application of a high voltage, and the like.

[0003] Conventionally, such a known high voltage cable for X-ray apparatus is formed by stranding two low-voltage insulated conductors and one or two bare conductors, forming an inner semiconductive layer on the stranded conductors, and sequentially forming thereon a high voltage insulator, an outer semiconductive layer, a shielding layer and a sheath. For the high voltage insulator, an EP rubber (ethylene-propylene rubber) which is flexible and has relatively good electrical characteristics is generally used (see, for example, patent Reference 1).

[0004] Recently, X-ray apparatuses is advancing significantly, and a cable having higher performance is demanded accordingly. Especially, demands for the high voltage insulator having lower electrostatic capacitance are increasing.

[0005] To decrease the electrostatic capacitance of the high voltage insulator, the high voltage insulator may be formed to have a large thickness, but there is a problem that the cable has a large diameter. And, as a material for the high voltage insulator, a material having a relative permittivity lower than that of an existing EP rubber (a relative permittivity of about 3.0), for example, crosslinked polyethylene, polyethylene and the like having a relative permittivity of about 2.3 may be used. But, since such insulator materials having a low relative permittivity have large hardness, there is a problem that flexibility of the cable is impaired. For example, a high voltage cable for X-ray apparatus used for a medical CT (computerized tomography) apparatus is required to have heat resistance against heat generation of the X-ray tube, but there is a problem that polyethylene is poor in heat resistance and its application to such usage becomes difficult.

Patent Reference 1: JP-A 2002-245866 (KOKAI)

Disclosure of Invention

[0006] The present invention has been made in view of the above circumstances and provides a resin composition for insulation, which is useful as a high voltage insulator material or the like for a high voltage cable for X-ray apparatus and capable of decreasing the electrostatic capacitance of an insulator without increasing a diameter of the cable and without decreasing flexibility and heat resistance, and an electric wire/cable using the same.

[0007] A resin composition for insulation of the present invention contains a polyolefin as a base polymer, wherein (a) an ash content is 20% by mass or below, (b) a relative permittivity is 2.8 or below, and (c) a type A durometer hardness is 90 or below.

[0008] An electric wire/cable of the present invention has a coating formed of the above-described resin composition for insulation.

[0009] According to an aspect of the present invention, (a) the ash content is 10% by mass or below, (b) the relative permittivity is 2.6 or below, and (c) the type A durometer hardness is 80 or below.

[0010] According to an aspect of the present invention, (d) a tensile strength retention is 80% or more and an elongation retention is 80% or more after heat aging (100°C, 96 hours).

[0011] According to an aspect of the present invention, a gel fraction is 60% or more.

[0012] According to an aspect of the present invention, the polyolefin contains an ethylene-propylene rubber.

[0013] According to an aspect of the present invention, the electric wire/cable is a cable for high-voltage electronics.

[0014] The present invention can decrease the electrostatic capacitance of the insulator without increasing the diameter of the cable or reducing the flexibility and heat resistance.

Brief Description of the Drawings

[0015]

[FIG. 1] FIG. 1 is a transverse sectional view showing an embodiment of the electric wire/cable of the invention.

[FIG. 2] FIG. 2 is a transverse sectional view showing another embodiment of the electric wire/cable of the invention.
[FIG. 3] FIG. 3 is a transverse sectional view showing still another embodiment of the electric wire/cable of the invention.

Mode for Carrying out the Invention

[0016] Embodiments of the invention are described below.

[0017] The individual components composing the resin composition for insulation of the invention and the physical properties of the composition are described below. The physical properties were measured by the following method.

(a) Ash content
Measured according to JIS K 6228.
(b) Relative permittivity
Measured by a high voltage Schering bridge method under conditions of 1 kV and a frequency of 50 Hz.
(c) Type A durometer hardness
Measured by a type A durometer of JIS k 6253.
(d) Tensile strength retention and elongation retention after heat aging (100°C, 96 hours)
Measured according to JIS K 6257 under heat aging conditions of 100°C $\times$ 96 hours.

[0018] Examples of polyolefin used as a base polymer of the resin composition for insulation according to the invention are ethylene-propylene rubbers such as ethylene-propylene copolymer (EPM) and ethylene-propylene-diene copolymer (EPDM), polyethylenes such as low-density polyethylene (LDPE), medium-density polyethylene (MDPE), high-density polyethylene (HDPE), ultralow-density polyethylene (VLDPE) and linear low-density polyethylene (LLDPE), polypropylene (PP), ethylene-ethyl acrylate copolymer (EEA), ethylene-methyl acrylate copolymer (EMA), ethylene-ethyl methacrylate copolymer, ethylene-vinyl acetate copolymer (EVA), polyisobutylene and the like. And, ethylene copolymerized with α-olefine or cyclic olefin such as propylene, butene, pentene, hexane or octane by a metallocene catalyst can also be used. They are used alone or as a mixture. The polyolefin is preferably an ethylene-propylene rubber such as an ethylerie-propylene copolymer (EPM), an ethylene-propylene-diene copolymer (EPDM) or the like, and another polyolefin is preferably used as a component used together with the ethylene-propylene rubber. The polyolefin is more preferably an ethylene-propylene rubber alone, and even more preferably an ethylene-propylene-diene copolymer (EPDM) alone. Specific examples of the ethylene-propylene-diene copolymer (EPDM) are MITSUI EPT (trade name, manufactured by MITSUI CHEMICALS, INC.), Esprene EPDM (trade name, manufactured by SUMITOMO CHEMICAL Co., LTD.).

[0019] It is preferable that the resin composition for insulation according to the invention is coated or formed and has a polymer component crosslinked. Thus, its mechanical properties such as heat resistance and abrasion resistance can be improved. As usable cross-linking methods, there are a chemical cross-linking method by which a resin composition for insulation is previously added with a cross-linking reagent, formed and crosslinked, an electron beam cross-linking method applying electron beam irradiation, and the like. The cross-linking reagents used to perform the chemical cross-linking method are dicumyl peroxide, di-tert-butyl peroxide, 2,5-dimethyl-2,5-di(tert-butylperoxy)hexane, 2,5-dimethyl-2,5-di(tert-butylperoxy)hexyne-3, 1,3-bis(tert-butylperoxyisopropyl)benzene, 1,1-bis(tert-butylperoxy)-3,3,5-trimethylcyclohexane, n-butyl-4,4-bis(tert-butylperoxy) valerate, benzoyl oxide, 2,4-dichlorobenzoyl peroxide, tert-butylperoxybenzoate, tert-butylperoxyisopropyl carbonate, diacetyl peroxide, lauroyl peroxide, and tert-butylcumyl peroxide.

[0020] A cross-linking degree is preferably 60% or more at a gel fraction, more preferably 80% or more, and most preferably 85% or more. If the gel fraction is less than 60%, the heat resistance becomes insufficient. For example, when the resin composition of the invention used as the insulator material for the high voltage cable for X-ray apparatus used for the medical CT apparatus, there is a possibility that heat resistance durable to the heat generation of the X-ray tube cannot be obtained. The gel fraction may be measured according to the testing method for degree of cross-linking specified in JIS C 3005.

[0021] In addition to the above-described components, the resin composition for insulation according to the invention may be further blended with inorganic fillers (for example, talc, calcium carbonate, clay, silica, magnesium hydroxide, etc.), processing aids, cross-linking aids, flame retardants, antioxidants, ultraviolet absorbers, coloring agents, softening agents, plasticizers, lubricants, and other additives in a range not inhibiting the effects of the invention, if necessary.

[0022] The resin composition for insulation of the invention has (a) an ash content of 20% by mass or below, preferably 10% by mass or below, more preferably 5% by mass or below, and most preferably 3% by mass or below. If the ash content exceeds 20% by mass, a relative permittivity increases, and the electrostatic capacitance of the insulator cannot be decreased.

[0023] The resin composition for insulation of the invention has (b) a relative permittivity of 2.8 or below, preferably 2.6 or below, and more preferably 2.4 or below.
If the relative permittivity exceeds 2.8, the electrostatic capacitance of the insulator cannot be decreased without involving

an increase of the diameter of the cable.

[0024] In addition, the resin composition for insulation of the invention has (c) a type A durometer hardness of 90 or below, preferably 80 or below, and more preferably 70 or below. If the type A durometer hardness exceeds 90, flexibility and ease in handling of the cable are degraded.

[0025] The resin composition for insulation of the invention has a tensile strength retention and an elongation retention after (d) heat aging (100°C, 96 hours) each of preferably 80% or more, and more preferably 90% or more. If either the tensile strength retention or the elongation retention after the heat aging (100°C, 96 hours) is less than 80%, the heat resistance becomes insufficient, and thus it becomes difficult to apply to the insulator material for the high voltage cable for X-ray apparatus, which is used for the medical CT apparatus.

[0026] The resin composition for insulation of the invention can be produced easily by kneading homogeneously the above-described individual components by an ordinary kneader such as a Banbury mixer, a tumbler, a pressurizing kneader, a kneading extruder, a mixing roller or the like.

[0027] The obtained composition is coated on the outer periphery of the conductor directly or via another coating by extruding or wound in a tape shape to produce the electric wire/cable of the invention. As described above, the composition is preferably crosslinked after coating or after forming.

[0028] FIG. 1 is a transverse sectional view showing a high voltage cable for x-ray apparatus of an embodiment of the electric wire/cable of the invention.

[0029] In FIG. 1, 1 denotes a low-voltage core, and the low-voltage core 1 is composed of, for example, a conductor 1a having a cross-sectional area of 1.8 mm^2 which is formed by concentric stranding of 19 tin-coated annealed copper wires having a diameter of 0.35 mm, and an insulator 1b having a thickness of, for example, 0.25 mm which is formed of, for example, a fluorine resin such as polytetrafluoroethylene, and formed on the conductor 1a. And, 2 denotes a high-voltage core, which is composed of a bare conductor 2a having a cross-sectional area of 1.25 mm^2 which is formed by, for example, concentric stranding of 50 tin-coated annealed copper wires having a diameter of 0.18 mm. A semiconductive coating may be formed on the bare conductor 2a, if necessary.

[0030] Two low-voltage cores 1 and two high-voltage cores 2 are stranded to form a core portion 8, and an inner semiconductive layer 3, a high voltage insulator 4 and an outer semiconductive layer 5 are sequentially formed on the outer periphery of it. The inner semiconductive layer 3 and the outer semiconductive layer 5 are formed by, for example, winding a semiconductive tape formed of a nylon substrate, a polyester substrate or the like and/or extrusion coating of a general-purpose semiconductive ethylene-propylene rubber, and the high voltage insulator 4 is formed by extrusion coating of the above-described resin composition for insulation. The inner semiconductive layer 3 is determined to have an outer diameter of, for example, 5.0 mm, and the high voltage insulator 4 and the outer semiconductive layer 5 each are coated to have, for example, a thickness of 4.4 mm and 0.2 mm.

[0031] The outer semiconductive layer 5 has thereon, for example, a shielding layer 6 having a thickness of 0.3 mm composed of a braid of tin-coated annealed copper wires, and additionally has thereon, for example, a sheath 7 having a thickness of 1.0 mm formed by extrusion coating of a vinyl chloride resin.

[0032] The above-configured high voltage cable for X-ray apparatus has the high voltage insulator 4 formed of the resin composition for insulation having a relative permittivity of 2.8 or below and a type A durometer hardness of 90 or below. Therefore, the electrostatic capacitance of the high voltage insulator 4 can be made smaller than that of the conventional high voltage insulator, the cable flexibility does not become low, and the cable outer diameter can be made to be substantially the same as the conventional cable.

[0033] In other words, a cable for high-voltage electronics suitable as a high voltage cable for X-ray apparatus can be provided without increasing the thickness of the high voltage insulator (i.e. without increasing the cable outer diameter). If it is sufficient by having the same electrostatic capacitance as the conventional electrostatic capacitance, the outer diameter of the high voltage insulator can be decreased within a range not affecting the insulation performance. Namely, the cable can be reduced to have a small diameter and a light weight, and a cable for high-voltage electronics which is good in flexibility and easy to handle can be provided.

[0034] Examples of the cables for high-voltage electronics include a high voltage cable for X-ray apparatus used for the X-ray apparatus and a high-voltage DC cable used for the high-voltage DC circuit of an electron beam welding device, an electric discharge machining device, an electrostatic coating device, a vacuum deposition device and the like.

[0035] FIG. 2 and FIG. 3 each are transverse sectional views showing a high voltage cable for X-ray apparatus of another embodiment of the electric wire/cable of the invention.

[0036] The high voltage cable for X-ray apparatus shown in FIG. 2 is configured in the same manner as the high voltage cable for X-ray apparatus shown in FIG. 1 except that the core portion 8 is configured by stranding two low-voltage cores 1 and one high-voltage core 2 (the drawing shows an example that a semiconductive coating 2b is formed on the bare conductor 2a). And, the high voltage cable for X-ray apparatus shown in FIG. 3 is an example of a so-called single core cable, which has a structure that the core portion 8 is formed of the conductor 2a only, and the inner semiconductive layer 3, the high voltage insulator 4, the outer semiconductive layer 5, the shielding layer 6 and the sheath 6 are sequentially formed on the conductor 2a. When the above cables are compared with a conventional similar type of cable, the electrostatic capacitance of the high voltage insulator 4 can be made smaller than that of the conventional cable, the cable flexibility is not lowered, and the cable outer diameter can be made substantially the same as that of the conventional cable.

[0037] In other words, a cable for high-voltage electronics suitable as a high voltage cable for X-ray apparatus can be provided without increasing the thickness of the high voltage insulator (i.e. without increasing the cable outer diameter). If it is sufficient by having the same electrostatic capacitance as the conventional one, the outer diameter of the high voltage insulator can be decreased within the range not affecting the insulation performance. Namely, the cable can be reduced to have a small diameter and a light weight, and a cable for high-voltage electronics which is good in flexibility and easy to handle can be provided.

[0038] The present invention is described in further detail below with reference to examples but not limited to the examples at all in any aspect.

[0039] Examples 1 to 7, Comparative Examples 1 to 3 As a base polymer, EPDM (manufactured by MITSUI CHEMICALS, INC., trade name MITSUI EPT1045), as an inorganic filler, talc (manufactured by TAKEHARA KAGAKU KOGYO CO., LTD., trade name Hytron), as a softening agent, a process oil (manufactured by Idemitsu Kosan Co., Ltd., trade name Diana Process Oil PW-90) and as a cross-linking reagent, dicumyl peroxide (manufactured by NOF CORPORATION, trade name PERCUMYL D), which is one type of organic peroxide, were used. They were kneaded homogeneously at the ratios shown in Table 1 by a mixing roll and extruded into a sheet form.

[0040] The above-described individual sheets were crosslinked by application of heat and pressure by a press machine under conditions of 170°C x 30 minutes and a pressure of 19 MPa to produce test sheets. The test sheets were produced in two types having thickness of 0.5 mm and 2 mm.

[0041] The obtained test sheets were evaluated by measuring an ash content, a gel fraction, a type A durometer hardness, a relative permittivity, and also a tensile strength retention and elongation retention after heat aging (100°C, 96 hours). In the measurement/evaluation test, the test sheet having thickness of 2 mm was used in only the heat aging test. The results are shown in the lower half columns of Table 1.

[0042]

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7
Composition*	EPDM	100	100	100	100	100	100	100
	Filler (talc)	-	6	12	20	30	20	30
	Softening agent	10	20	20	20	20	75	130
	Cross-linking reagent	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Test results	Ash content (% by mass)	1	5	10	15	20	10	10
	Gel fraction (%)	90	85	85	85	85	60	50
	Durometer hardness (Type A)	60	60	70	75	78	60	55
	Relative permittivity	2.2	2.4	2.5	2.7	2.8	2.6	2.6
	Tensile strength retention (%)	85	85	85	90	90	80	75
	Elongation retention (%)	90	90	90	85	85	85	80

		Comparative Example 1	Comparative Example 2	Comparative Example 3
Composition*	EPDM	100	100	100
	Filler (talc)	50	70	90
	Softening agent	40	40	40
	Cross-linking reagent	2.4	2.4	2.4
Test results	Ash content (% by mass)	25	35	40
	Gel fraction (%)	80	75	75
	Durometer hardness (Type A)	70	75	80
	Relative permittivity	3.0	3.2	3.5
	Tensile strength retention (%)	90	85	85
	Elongation retention (%)	80	85	85

* Numerals in the column of composition are indicated by a unit of a part by mass.

[0043] It is apparent from Table 1 that Comparative Examples 1 to 3 having an ash content of exceeding 20% by mass had a relative permittivity of 3.0 or more, and Examples 1 to 7 having an ash content of 20% by mass or below had a type A durometer hardness of 90 or below and a relative permittivity of 2.8 or below. Thus, it was confirmed that Examples 1 to 7 had both low hardness required to provide the cable with flexibility and a low relative permittivity required to achieve a cable having both a small diameter and a low electrostatic capacitance. In addition, Examples 1 to 6, in which a tensile strength retention and elongation retention after heat aging (100°C, 96 hours) were 80% or more and a gel fraction was 60% or more, had good heat resistance.

[0044] Examples 8 to 13, Comparative Examples 4 to 6 As a base polymer, EPDM (MITSUI EPT1045), as an inorganic filler, silica (manufactured by TOSOH SILICA CORPORATION, trade name Nip Seal VN3), as a softening agent, a process oil (Diana Process Oil PW-90) and as a cross-linking reagent, dicumyl peroxide (PERCUMYL D), which is one type of organic peroxide, were used. They were kneaded homogeneously at the ratios shown in Table 2 by a mixing roll and extruded into a sheet form.

[0045] The above-described individual sheets were crosslinked by application of heat and pressure by a press machine under conditions of 170°C x 30 minutes and a pressure of 19 MPa to produce test sheets. The test sheets were produced in two types having thickness of 0.5 mm and 2 mm.

[0046] The obtained test sheets were evaluated by measuring an ash content, a gel fraction, a type A durometer hardness, a relative permittivity, and also a tensile strength retention and elongation retention after heat aging (100°C, 96 hours). In the measurement/evaluation test, the test sheet having a thickness of 2 mm was used in only the heat aging test. The results are shown in the lower half columns of Table 2.

[0047]

[Table 2]

		Example 8	Example 9	Example 10	Example 11	Example 12	Example 13
Composition*	EPDM	100	100	100	100	100	100
	Filler (silica)	-	1	3	5	10	20
	Softening agent	-	-	-	-	-	-
	Cross-linking reagent	2.4	2.4	2.4	2.4	2.4	2.4
Test results	Ash content (% by mass)	0	1	3	5	10	20
	Gel fraction (%)	95	90	89	87	85	82
	Durometer hardness (Type A)	70	70	71	72	75	80
	Relative permittivity	2.2	2.2	2.2	2.3	2.4	2.8
	Tensile strength retention (%)	80	80	82	85	85	85
	Elongation retention (%)	80	80	80	82	82	85

		Comparative Example 4	Comparative Example 5	Comparative Example 6
Composition*	EPDM	100	100	100
	Filler (silica)	30	40	50
	Softening agent	-	-	-
	Cross-linking reagent	2.4	2.4	2.4
Test results	Ash content (% by mass)	25	30	35
	Gel fraction (%)	82	80	80
	Durometer hardness (Type A)	90	92	94
	Relative permittivity	3.0	3.2	3.5
	Tensile strength retention (%)	85	80	80
	Elongation retention (%)	85	90	90

* Numerals in the column of composition are indicated by a unit of a part by mass.

[0048] It is apparent from Table 2 that Comparative Examples 4 to 6 having an ash content of exceeding 20% by mass had a relative permittivity of 3.0 or more even when silica was used as an inorganic filler, and Examples 8 to 13 having an ash content of 20% by mass or below, a type A durometer hardness of 90 or below and a relative permittivity of 2.8 or below had a type A durometer hardness of 90 or below and a relative permittivity of 2.8 or below. Thus, it was confirmed that Examples 8 to 13 had both low hardness required to provide the cable with flexibility and a low relative permittivity required to achieve a cable having both a small diameter and a low electrostatic capacitance. In addition, Examples 8 to 13, in which a tensile strength retention and elongation retention after heat aging (100°C, 96 hours) were 80% or more and a gel fraction was 60% or more, also had good heat resistance.

[0049] The invention is not limited to the embodiments and examples described above. It is to be understood that modifications and variations of the embodiments can be made without departing from the spirit and scope of the invention.

[0050] This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2007-55864 filed on March 6, 2007; the entire contents of which are incorporated herein by reference.

Industrial Applicability

[0051] The resin composition for insulation of the invention can be used extensively for an electrical insulating material and a sheath material of various kinds of electric wires/cables such as power cables, cables for high-voltage electronics, cables for control, cables for communications, cables for instrumentation, cables for signals, cables for moving and the like, and also for usages requiring electrical insulation such as electric wire/cable attachments such as plugs. Especially, since the resin composition for insulation of the invention has a small relative permittivity and excellent flexibility, it is useful as an insulator material of a cable for high-voltage electronics, such as a high voltage cable for X-ray apparatus, a high-voltage DC cable, and the like.

Claims

1. A resin composition for insulation containing a polyolefin as a base polymer,
wherein (a) an ash content is 20% by mass or below, (b) a relative permittivity is 2.8 or below, and (c) a type A durometer hardness is 90 or below.

2. The resin composition for insulation according to claim 1,
wherein (a) the ash content is 10% by mass or below, (b) the relative permittivity is 2.6 or bellow, and (c) the type A durometer hardness is 80 or below.

3. The resin composition for insulation according to claim 1,
wherein (a) the ash content is 5% by mass or below, (b) the relative permittivity is 2.4 or below, and (c) the type A durometer hardness is 70 or below.

4. The resin composition for insulation according to claim 1,
wherein (d) a tensile strength retention is 80% or more and an elongation retention is 80% or more after heat aging (100°C, 96 hours).

5. The resin composition for insulation according to claim 1,
wherein a gel fraction is 60% or more.

6. The resin composition for insulation according to claim 1,
wherein the gel fraction is 80% or more.

7. The resin composition for insulation according to claim 1,
wherein the polyolefin comprises an ethylene-propylene rubber.

8. The resin composition for insulation according to claim 1,
wherein the polyolefin comprises an ethylene-propylene-diene copolymer.

9. An electric wire/cable having a coating which is composed of a resin composition for insulation containing a polyolefin as a base polymer, wherein (a) an ash content is 20% by mass or below, (b) a relative permittivity is 2.8 or below, and (c) a type A durometer hardness is 90 or below.

10. The resin composition for insulation according to claim 9, wherein (a) the ash content is 10% by mass or bellow, (b) the relative permittivity is 2.6 or below, and (c) the type A durometer hardness is 80 or below.

11. The electric wire/cable according to claim 9,
wherein (a) the ash content is 5% by mass or below, (b) the relative permittivity is 2.4 or below, and (c) the type A durometer hardness is 70 or below.

12. The electric wire/cable according to claim 9,
wherein (d) a tensile strength retention is 80% or more and an elongation retention is 80% or more after heat aging (100°C, 96 hours).

13. The electric wire/cable according to claim 9,
wherein a gel fraction is 60% or more.

14. The electric wire/cable according to claim 9,
wherein the gel fraction is 80% or more.

15. The electric wire/cable according to claim 9,
wherein the polyolefin comprises an ethylene-propylene rubber.

16. The electric wire/cable according to claim 9,
wherein the polyolefin comprises an ethylene-propylene-diene copolymer.

17. The electric wire/cable according to claim 9,
wherein the electric wire/cable is a cable for high-voltage electronics.

18. The electric wire/cable according to claim 9,
wherein the electric wire/cable is a high voltage cable for X-ray apparatus.

FIG. 1

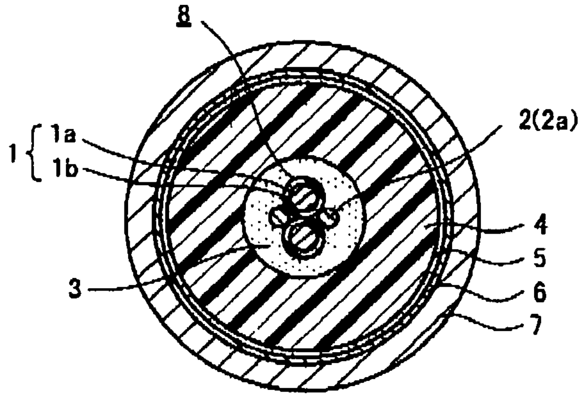


FIG. 2

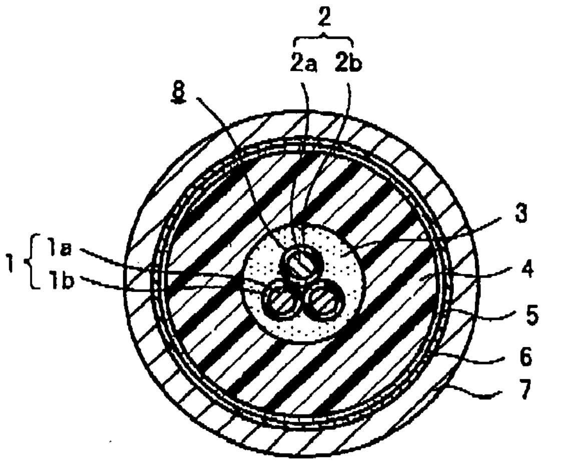
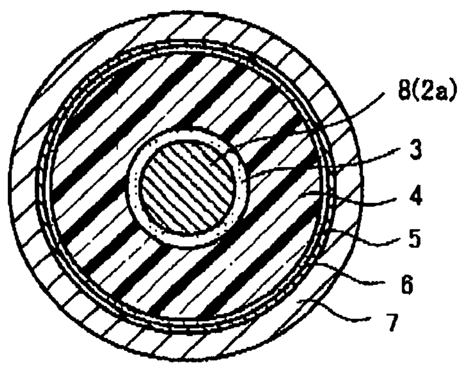


FIG. 3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/053820

A. CLASSIFICATION OF SUBJECT MATTER
H01B3/44(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01B3/44, C08L23/16, H01B7/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 08-022717 A (Fujikura Ltd.), 23 January, 1996 (23.01.96), Claims; Par. No. [0009] (Family: none)	1-18
X	JP 04-268350 A (Mitsubishi Cable Industries, Ltd.), 24 September, 1992 (24.09.92), Claims; Par. Nos. [0009], [0013] (Family: none)	1-18
X	JP 07-330990 A (Sumitomo Electric Industries, Ltd.), 19 December, 1995 (19.12.95), Claims (Family: none)	1-18

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
10 April, 2008 (10.04.08)	22 April, 2008 (22.04.08)

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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X	JP 2002-363361 A (Fujikura Ltd.), 18 December, 2002 (18.12.02), Claims (Family: none)	1-10
A	JP 2002-245866 A (Hitachi Cable, Ltd.), 30 August, 2002 (30.08.02), Claims (Family: none)	1-18

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2002245866 A **[0005]**
- JP 2007055864 A **[0050]**