(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 508 459 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
10.10.2012 Bulletin 2012/41

(21) Application number: **09851847.5**

(22) Date of filing: **02.12.2009**

(51) Int Cl.:
B66B 7/06 $^{(2006.01)}$

(86) International application number:
PCT/JP2009/070233

(87) International publication number:
WO 2011/067839 (09.06.2011 Gazette 2011/23)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR

(71) Applicant: **Mitsubishi Electric Corporation**
Tokyo 100-8310 (JP)

(72) Inventors:
- **MURAI, Michio**
  Tokyo 100-8310 (JP)
- **MITSUI, Atsushi**
  Tokyo 100-8310 (JP)
- **NAKAGAWA, Hiroyuki**
  Tokyo 100-8310 (JP)

(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) ROPE FOR ELEVATORS, AND ELEVATOR DEVICE

(57) Provided is an elevator rope comprising a rope main body and a covering resin layer that covers a periphery of the rope main body, in which the covering resin layer includes a molded product of a resin composition including a first resin component and a second resin component at a mass ratio of 90:10 to 70:30, the first resin component and the second resin component having a difference in glass transition temperature of 20°C or more. The elevator rope can stably brake a car in a wide range of sliding velocities from a range of small sliding velocities required for maintaining a static condition of the car to sliding velocities during normal operation by covering a rope with a resin material having a stable friction coefficient independent of temperature and sliding velocity.

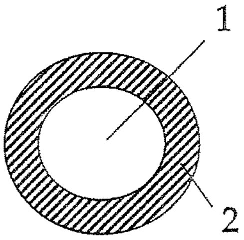

FIG. 2

Printed by Jouve, 75001 PARIS (FR)

Description

Technical Field

[0001] The present invention relates to an elevator rope used for suspending a car in an elevator, and an elevator apparatus.

Background Art

[0002] In general, an elevator apparatus has the following structure. That is, a rope is looped around a sheave that is fixed to a motor of a hoisting machine, and a car is suspended at one end of the rope while a weight for keeping balance with the car is suspended at the other end of the rope. Conventionally, in an elevator apparatus having the structure as described above, in order to prevent early abrasion and breakage of the rope, there has been used a sheave having a diameter that is at least 40 times as large as the diameter of the rope (hereinafter, referred to as "rope diameter"). The diameter of the sheave (hereinafter, referred to as "sheave diameter") has a direct relationship with drive torque of the motor that is necessary to raise and lower the car. Therefore, various components of the elevator apparatus as typified by the motor can be reduced in size and weight by reducing the sheave diameter. In particular, in order to reduce the sheave diameter, the rope diameter also needs to be reduced for the reason described above.

[0003] However, when the rope diameter is reduced without changing the number of ropes, the strength of the rope decreases, and as a result, the maximum rated load of the elevator decreases. On the other hand, when the number of ropes is increased, the structure of the elevator apparatus becomes complicated. Further, when the sheave diameter is reduced, the bending fatigue life of the rope is shortened, which raises a need to replace the rope frequently.

[0004] As a measure to solve the problems, there is proposed an elevator rope, which is obtained by twisting together a plurality of strands formed by twisting a plurality of steel wires together, and covering it with a resin material on its outermost periphery (see, for example, Patent Document 1). An elevator apparatus using such an elevator rope is driven by a frictional force between the sheave and the resin material that covers the outermost periphery of the rope. Therefore, there is a demand for improvement and stabilization of the friction characteristics of the resin material.

In order to improve the friction characteristics of the sheave and the rope, there is proposed an elevator rope covered with a polyurethane covering material containing no wax (see, for example, Patent Document 2).

[0005] In general, a friction coefficient of a resin material is known to heavily depend on sliding velocity and temperature. It is also known that viscoelastic characteristics such as dynamic viscoelasticity of the resin material correlate with the sliding velocity and temperature (Williams-Landel-Ferry equation (WLF equation)). In particular, it is described that, even in the case of rubber, the viscoelastic characteristics correlate similarly with the sliding velocity and temperature, and hence viscoelastic characteristics of rubber are related to friction characteristics of rubber (see, for example, Non Patent Document 1).

Citation List

Patent Documents

[0006]

Patent Document 1: JP 2001-262482 A
Patent Document 2: JP 2004-538382 A

Non Patent Document

[0007]

Non Patent Document 1: K. A. Grosch, "The relation between the friction and visco-eleastic properties of rubber," Proceedings of the Royal Society A, June 25, 1963, Vol. 274, No. 1356, p. 21-39.

Disclosure of the Invention

Problems to be Solved by the Invention

[0008] As described above, in a resin material containing rubber, the friction coefficient changes depending on changes in sliding velocity and temperature, and the friction coefficient varies depending on an increase in sliding velocity or an increase in temperature. Therefore, even in the polyurethane covering material containing no wax described in Patent Document 2, the friction coefficient changes depending on changes in sliding velocity and temperature, and hence there is a problem in that it is impossible to brake a car stably. Further, in order to stop the car for a long period of time, it is necessary to maintain the static condition of the car by the frictional force between the rope and the sheave. However, even when a rope is covered with the polyurethane covering material containing no wax as described in Patent Document 2, there is a problem in that a friction coefficient at a small sliding velocity cannot be maintained stably because the polyurethane covering material has a large variation in friction coefficient, with the result that the stop position of the car shifts with time.

[0009] Therefore, the present invention has been made to solve the above problems, and an object of the present invention is to provide an elevator rope and an elevator apparatus which can brake a car stably in a wide range of sliding velocities from a range of small sliding velocities required for maintaining a static condition of the car to sliding velocities during normal operation by covering a rope with a resin material having a stable friction coefficient independent of temperature and sliding velocity.

Means for Solving the Problems

[0010] The inventors of the preset invention have made intensive studies on friction characteristics of a variety of resin materials to solve the problems, and as a result, have obtained the following findings.
FIG. 1 is an example of a graph showing relationships between frequencies and loss moduli E" in resin materials different in sliding velocity dependency of a friction coefficient (i.e., resin materials having different variations in friction coefficient with respect to a sliding velocity). As clear from FIG. 1, a resin material having small sliding velocity dependency of the friction coefficient has small frequency dependency of the loss modulus E" (i.e., variation in loss modulus E" is small in the case where frequency varies), while a resin material having large sliding velocity dependency of the friction coefficient has large frequency dependency of the loss modulus E" (i.e., variation in loss modulus E" is large in the case where frequency varies). That is, the inventors have found that the sliding velocity dependency of the friction coefficient correlates with the frequency dependency of the loss modulus E", and the sliding velocity dependency of the friction coefficient can be decreased by decreasing the frequency dependency of the loss modulus E".

[0011] Based on such findings, the inventors have made further studies on compositions of resin materials, and as a result, have found that, both the frequency dependency of the loss modulus and the sliding velocity dependency of the friction coefficient can be decreased by a molded product obtained from a resin composition including two kinds of resin components having a difference in glass transition temperature of 20°C or more at a mass ratio within a predetermined range.

[0012] That is, the present invention is an elevator rope comprising a rope main body and a covering resin layer that covers a periphery of the rope main body, in which the covering resin layer is formed from a molded product of a resin composition comprising a first resin component and a second resin component at a mass ratio of 90:10 to 70:30, the first resin component and the second resin component having a difference in glass transition temperature of 20°C or more.
Further, the present invention is an elevator apparatus comprising the elevator rope.

Effects of the Invention

[0013] According to the present invention, it is possible to provide an elevator rope and an elevator apparatus which can brake a car stably in a wide range of sliding velocities from the range of small sliding velocities required for maintaining a static condition of the car to sliding velocities during normal operation by covering a rope with a resin material having a stable friction coefficient independent of temperature and sliding velocity.

Brief Description of the Drawings

[0014]

[FIG. 1] FIG. 1 is a graph showing relationships between frequencies and loss moduli in resin materials different in sliding velocity dependency of a friction coefficient.
[FIG. 2] FIG. 2 is a cross-sectional view of an elevator rope of the present invention.
[FIG. 3] FIG. 3 is viscoelastic spectra of a general resin material.
[FIG. 4] FIG. 4 is a configuration diagram of a system for evaluating a friction coefficient.

Modes for Carrying Out the Invention

Embodiment 1.

[0015] An elevator rope of the present invention comprises a rope main body and a covering resin layer that covers a periphery of the rope main body.
Hereinafter, preferred embodiments of the elevator rope of the present invention are described with reference to the drawings.
FIG. 2 is a cross-sectional view of the elevator rope. In FIG. 2, the elevator rope comprises a rope main body 1 and a covering resin layer 2 that covers a periphery of the rope main body 1.

[0016] The elevator rope is characterized by the covering resin layer 2 that covers the periphery of the rope main body 1, and hence the rope main body 1 on which the covering resin layer 2 is formed is not particularly limited and may be any known one. Examples of the rope main body 1 include a strand formed by twisting a plurality of steel wires together and a load-supporting member such as a cord. In addition, the load-supporting member may have not only a rope shape but also a belt shape. It should be noted that load-supporting members are described in detail in Patent Documents 1 and 2, WO 2003/050348 A1, WO 2004/002868 A1, and the like, which are incorporated herein by reference.

[0017] The covering resin layer 2 is formed from a molded product of a resin composition comprising two kinds of resin components (a first resin component and a second resin component) having a difference in glass transition temperature of 20°C or more.
Here, FIG. 3 shows an example of viscoelastic spectra (storage modulus E', loss modulus E", and loss tangent tanδ) of a general resin material (thermoplastic polyurethane elastomer). The viscoelastic spectra were determined under the following conditions: measurement mode: bending mode; measurement frequency: 10 Hz; and temperature increase rate: 5°C/min. As clear from FIG. 3, the spectrum of the loss modulus E" has a peak at about -40°C, and the temperature corresponds to a

glass transition temperature of the thermoplastic polyurethane elastomer.

In the present invention, a resin composition comprising two kinds of resin components having a difference in glass transition temperature of 20°C or more is used, and hence in the spectrum of the loss modulus E" of the covering resin layer 2 formed from a molded product of the resin composition, the peak of the loss modulus E" becomes broad or is divided into two small peaks. As a result, the frequency dependency of the loss modulus of the covering resin layer 2 formed from the molded product of the resin composition is decreased.

[0018] The first resin component in the resin composition for forming the covering resin layer 2 is not particularly limited as long as the first resin component and the second resin component have a difference in glass transition temperature of 20°C or more, but is preferably a thermoplastic polyurethane elastomer. In general, thermoplastic polyurethane elastomer refers to one which includes a hard segment having a urethane structure and a soft segment derived from a polyol raw material and which exhibits rubber elasticity at room temperature. The thermoplastic polyurethane elastomer is classified into polyether-based, polyester-based, polycarbonate-based, silicone-based, and olefin-based thermoplastic polyurethane elastomers depending on the type of the polyol raw material used.

[0019] Such thermoplastic polyurethane elastomers may be produced by generally known methods. For example, the elastomers may be produced by copolymerization of an isocyanate, a polyol, and a chain extender as raw materials. The polymerization reaction is generally known, and the blending ratio of the raw materials and synthetic conditions may be appropriately adjusted depending on the raw materials used, and are not particularly limited.

Further, any commercially available thermoplastic polyurethane elastomer may be used.

[0020] When the thermoplastic polyurethane elastomer is obtained by synthesis, examples of the isocyanate include tolylene diisocyanate, 4,4'-diphenylmethane diisocyanate, 1,5-naphthylene diisocyanate, tolidine diisocyanate, 1,6-hexamethylene diisocyanate, isophorone diisocyanate, xylene diisocyanate, hydrogenated xylene diisocyanate, triisocyanate, tetramethylxylene diisocyanate, 1,6,11-undecane triisocyanate, 1,8-diisocyanate methyloctane, a lysine ester triisocyanate, 1,3,6-hexamethylene triisocyanate, and bicycloheptane triisocyanate. These may be used alone or in combination of two or more kinds thereof.

[0021] Examples of the polyol include a polyester polyol, a polycarbonate polyol, a polyester ether polyol, a polyether polyol, a silicone polyol, and a polyolefin polyol. These may be used alone or in combination of two or more kinds thereof.

[0022] Examples of the polyester polyol include: a polyester polyol obtained through a condensation reaction between a dicarboxylic acid or an esterified compound or acid anhydride thereof and a diol; and a polylactonediol obtained through ring-opening polymerization of a lactone monomer such as ε-caprolactone. Here, as the dicarboxylic acid, there may be used: aliphatic dicarboxylic acids such as succinic acid, adipic acid, sebacic acid, and azelaic acid; aromatic dicarboxylic acids such as phthalic acid, terephthalic acid, isophthalic acid, and naphthalenedicarboxylic acid; and alicyclic dicarboxylic acids such as hexahydroterephthalic acid, hexahydrophthalic acid, and hexahydroisophthalic acid. As the diol, there may be used, for example, ethylene glycol, 1,3-propylene glycol, 1,2-propylene glycol, 1,3-butanediol, 1,4-buanediol, 1,5-pentanediol, 1,6-hexanediol, 3-methyl-1,5-pentanediol, neopentyl glycol, 1,3-octanediol, and 1,9-nonanediol. These may be used alone or in combination of two or more kinds thereof.

[0023] Examples of the polycarbonate polyol include a polycarbonate polyol obtained by allowing diethylene carbonate, diethyl carbonate, or the like to react with one or more kinds of polyhydric alcohols such as ethylene glycol, 1,3-propylene glycol, 1,2-propylene glycol, 1,3-butanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, 3-methyl-1,5-pentanediol, neopentyl glycol, 1,8-octanediol, 1,9-nonanediol, and diethylene glycol. Specific examples thereof include polyhexamethylene carbonate diol, polytrimethylene carbonate diol, poly-3-methyl(pentamethylene) carbonate diol, and copolymers thereof. These may be used alone or in combination of two or more kinds thereof.

[0024] Examples of the polyester ether polyol include condensation reaction products of the aliphatic dicarboxylic acids, aromatic dicarboxylic acids, alicyclic dicarboxylic acids, or esters or acid anhydrides thereof with glycols such as diethylene glycol and a propylene oxide adduct. These may be used alone or in combination of two or more kinds thereof.

[0025] Examples of the polyether polyol include polyethylene glycol, polypropylene glycol, polytetramethylene glycol, and the like obtained by polymerizing cyclic ethers such as ethylene oxide, propylene oxide, and tetrahydrofuran, respectively, and copolyethers thereof. These may be used alone or in combination of two or more kinds thereof.

[0026] Examples of the silicone polyol include dimethylpolysiloxanediol, methylphenylpolysiloxanediol, an amino-modified silicone oil, a both-end diamine-modified silicone oil, a polyether-modified silicone oil, an alcohol-modified silicone oil, a carboxyl group-modified silicone oil, and a phenyl-modified silicone oil each having two active hydrogens at both ends. These may be used alone or in combination of two or more kinds thereof.

[0027] Examples of the polyolefin polyol include polyisoprene polyol, polybutadiene polyol, or copolymers thereof with styrene and acrylonitrile and hydrogenated products thereof. These may be used alone or in combination of two or more kinds thereof.

[0028] As the chain extender, a low molecular weight polyol may be used, and examples thereof include:

aliphatic polyols such as ethylene glycol, 1,3-propylene glycol, 1,2-propylene glycol, 1,3-butanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, 3-methyl-1,5-pentanediol, neopentyl glycol, 1,8-octanediol, 1,9-nonanediol, diethylene glycol, 1,4-cyclohexanedimethanol, and glycerin; and aromatic glycols such as 1,4-dimethylolbenzene, bisphenol A, and an ethylene oxide adduct and propylene oxide adduct of bisphenol A. These may be used alone or in combination of two or more kinds thereof.

[0029] Of the thermoplastic polyurethane elastomers of various kinds, the first resin component is preferably a thermoplastic polyurethane elastomer other than a polyester-based thermoplastic polyurethane elastomer from the viewpoint of prevention of hydrolysis which occurs under a usage environment. In consideration of the variety of characteristics (such as flexibility, durability, and cold resistance) required for an elevator rope, the first resin component is more preferably a polyether-based thermoplastic polyurethane elastomer having a JIS A hardness (hardness specified by JIS K7215 and determined using a type A durometer) of 85 to 95.

[0030] The second resin component in the resin composition for forming the covering resin layer 2 is a resin component which has a glass transition temperature higher or lower by 20°C or more than that of the first resin component.

The second resin component having such characteristics is not particularly limited as long as it satisfies the above-mentioned conditions. However, from the viewpoints of durability and abrasion resistance, the second resin component is preferably a thermoplastic polyurethane elastomer obtained using, as a raw material, a polyol different from the thermoplastic polyurethane elastomer as the first resin component, or a polyamide resin. Further, among the thermoplastic polyurethane elastomers of various kinds, the second resin component is preferably a polycarbonate-based thermoplastic polyurethane elastomer or a silicone-based thermoplastic polyurethane elastomer having a JIS A hardness (hardness specified by JIS K7215 and determined using a type A durometer) of 85 to 95 in consideration of a variety of characteristics (such as flexibility, durability, and cold resistance) required for an elevator rope.

[0031] Examples of the polyamide resin include a polyamide-based thermoplastic elastomer and a polyamide-based thermoplastic resin.

In general, polyamide-based thermoplastic elastomer refers to one which includes a hard segment of a polyamide and a soft segment of a polyether or a polyester and which exhibits rubber elasticity at room temperature. Of these, the elastomer is preferably a polyamide-based thermoplastic elastomer which includes a hard segment of a polyamide and a soft segment of a polyether from the viewpoint of hydrolysis resistance.

In general, polyamide-based thermoplastic resin refers to a thermoplastic resin having a polyamide bond in its molecular chain, and examples thereof include nylon 6, nylon 66, nylon 11, and nylon 12. These may be used alone or in combination of two or more kinds thereof.

[0032] The mass ratio of the first resin component to the second resin component is 90:10 to 70:30. When the mass ratio of the second resin component is too low, an effect obtained by blending the second resin component (in particular, a stable friction coefficient in the covering resin layer 2) cannot be obtained. On the other hand, when the mass ratio of the second resin component is too high, the characteristics of the second resin component become dominant. In consequence, the covering resin layer 2 formed from a molded product of a resin composition becomes too hard, and flexibility of the rope may be impaired or durability of the covering resin layer 2 may be lowered. As a result, when an elevator apparatus using such rope is driven, problems such as increased power consumption and impaired durability when the rope is bent repeatedly may be caused.

[0033] The resin composition for forming the covering resin layer 2 can be prepared by mixing the above-mentioned components using known means. The covering resin layer 2 can be formed by molding the resin composition so that the composition covers the periphery of the rope main body 1 by known molding means such as extrusion molding or injection molding. Further, in order to stabilize physical properties of the molded product of the resin composition, a heat treatment may be carried out. Conditions for the heat treatment may be appropriately adjusted depending on the resin composition used, and are not particularly limited.

[0034] As the glass transition temperature of the covering resin layer 2 increases, the sliding velocity dependency of the friction coefficient tends to decrease, while the elastic modulus of the covering resin layer 2 tends to increase. Therefore, in the case where a rope having formed thereon the covering resin layer 2 having a higher glass transition temperature is employed for an elevator apparatus, the flexibility of the rope is liable to be impaired or fatigue failure such as cracking of the covering resin layer 2 is liable to occur owing to stress when the rope is bent repeatedly in an environment having a temperature higher than the glass transition temperature of the covering resin layer 2. Accordingly, the glass transition temperature of the covering resin layer 2, specified by the peak temperature of the loss modulus E" in the viscoelastic spectra, is desirably set to -20°C or less, more preferably -25°C or less in the case where there is only one peak. Meanwhile, in the case where there are two peak temperatures, the glass transition temperature of the first resin component in the covering resin layer 2 is desirably set to -20°C or less, more preferably -25°C or less.

[0035] In addition, when the JIS A hardness (hardness specified by JIS K7215 and determined using a type A durometer) of the covering resin layer 2 is more than 98, the flexibility of the rope is liable to be impaired, resulting in increased power consumption in the case where an elevator apparatus using the rope is driven. On the other hand, when the JIS A hardness of the covering resin layer

2 is less than 85, the durability is liable to be impaired when the layer is bent repeatedly as an elevator rope. Therefore, the JIS A hardness of the covering resin layer 2 is desirably set to 85 to 98.

[0036] From the viewpoint of improvement of adhesion between the rope main body 1 and the covering resin layer 2 in the elevator rope, the covering resin layer 2 may be formed after an adhesive is applied in advance to the rope main body 1. The adhesive is not particularly limited as long as it is an adhesive for metal and polyurethane, and examples thereof include Chemlok (registered trademark) 218 (manufactured by LORD Far East, Inc.).

[0037] In an elevator rope having the above-mentioned characteristics, a rope is covered with a resin material having a stable friction coefficient independent of a temperature and a sliding velocity. Therefore, in the case where the rope is used for an elevator apparatus, a car can be braked stably in a wide range of sliding velocities from a range of small sliding velocities required for maintaining a static condition of the car to sliding velocities during normal operation.

Examples

[0038] Hereinafter, the present invention is described in detail by way of examples, but is not limited by the following examples.

(Example 1)

[0039] Pellets of a polyether-based thermoplastic polyurethane elastomer (JIS A hardness: 95, glass transition temperature: -30°C) obtained by reacting polytetramethylene glycol, 4,4'-diphenylmethane diisocyanate, and 1,4-butanediol were mixed with pellets of a polycarbonate-based thermoplastic polyurethane elastomer (JIS A hardness: 95, glass transition temperature: 5°C) obtained by reacting polyhexamethylene carbonate diol, 4,4'-diphenylmethane diisocyanate, and 1,4-butanediol at a mass ratio of 90:10 to prepare a resin composition.

[0040] Next, the resin composition was supplied to an extrusion molding machine, and extrusion molding was carried out so that the composition covered the periphery of a rope main body, to thereby mold a covering resin layer on the periphery of the rope main body. Here, a strand formed by twisting a plurality of steel wires together, as described in WO 2003/050348 A1, was used as the rope main body, and Chemlok (registered trademark) 218 (manufactured by LORD Far East, Inc.) was applied in advance to the rope main body and dried before the formation of the covering resin layer.

Subsequently, in order to stabilize the physical properties of the covering resin layer, the rope was heated at 100°C for 2 hours, to thereby obtain an elevator rope having a diameter of 12 mm. The viscoelastic spectra of the covering resin layer of the elevator rope were measured. (The measurement was carried out under the following conditions: measurement mode: bending mode; measurement frequency: 10 Hz; and temperature increase rate: 5°C/min. In the Examples and Comparative Examples below, the measurement was carried out under the same conditions.) As a result, the loss modulus E" in the viscoelastic spectra was found to have one peak, and the peak temperature corresponding to the glass transition temperature was found to be -30°C. Further, the JIS A hardness of the covering resin layer of the elevator rope was measured, and as a result, the JIS A hardness was found to be 95.

(Example 2)

[0041] An elevator rope was obtained in the same manner as in Example 1 except that the mass ratio of the pellets of the polyether-based thermoplastic polyurethane elastomer to the pellets of the polycarbonate-based thermoplastic polyurethane elastomer was changed to 80:20. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in the viscoelastic spectra was found to have one peak, and the peak temperature corresponding to the glass transition temperature was found to be -28°C. Further, the JIS A hardness of the covering resin layer was found to be 95.

(Example 3)

[0042] An elevator rope was obtained as in the same manner as in Example 1 except that the mass ratio of the pellets of the polyether-based thermoplastic polyurethane elastomer to the pellets of the polycarbonate-based thermoplastic polyurethane elastomer was changed to 70:30. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in the viscoelastic spectra was found to have one peak, and the peak temperature corresponding to the glass transition temperature was found to be -25°C. Further, the JIS A hardness of the covering resin layer was found to be 95.

(Example 4)

[0043] An elevator rope was obtained in the same manner as in Example 1 except for using a resin composition obtained by mixing the pellets of the polyether-based thermoplastic polyurethane elastomer used in Example 1 with pellets of a silicone-based thermoplastic polyurethane elastomer (JIS A hardness: 95, glass transition temperature: -50°C) obtained by reacting both-end carbinyl-modified siloxane, polytetramethylene glycol, 4,4'-diphenylmethane diisocyanate, and 1,4-butanediol at a mass ratio of 80:20. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in viscoelastic spectra was found to have one peak, and the peak temperature corresponding to the glass transition temperature was found to be -32°C. Further, the JIS A hardness of the covering resin layer was found to be 95.

(Example 5)

[0044] An elevator rope was obtained in the same manner as in Example 1 except for using a resin composition obtained by mixing the pellets of the polyether-based thermoplastic polyurethane elastomer used in Example 1 with pellets of nylon 6 (glass transition temperature: 50°C) at a mass ratio of 80:20. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in the viscoelastic spectra was found to have two peaks, and the peak temperature corresponding to the glass transition temperature of the polyether-based thermoplastic polyurethane elastomer as the first resin component was found to be -28°C. Further, the JIS A hardness of the covering resin layer was found to be 97.

(Example 6)

[0045] An elevator rope was obtained in the same manner as in Example 1 except for using a resin composition obtained by mixing the pellets of the polyether-based thermoplastic polyurethane elastomer used in Example 1 with pellets of nylon 66 (glass transition temperature: 55°C) at a mass ratio of 80:20. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in the viscoelastic spectra was found to have two peaks, and the peak temperature corresponding to the glass transition temperature of the polyether-based thermoplastic polyurethane elastomer as the first resin component was found to be -30°C. Further, the JIS A hardness of the covering resin layer was found to be 98.

(Example 7)

[0046] An elevator rope was obtained in the same manner as in Example 1 except for using a resin composition obtained by mixing the pellets of the polyether-based thermoplastic polyurethane elastomer used in Example 1 with pellets of nylon 12 (glass transition temperature: 40°C) at a mass ratio of 80:20. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in the viscoelastic spectra was found to have two peaks, and the peak temperature corresponding to the glass transition temperature of the polyether-based thermoplastic polyurethane elastomer as the first resin component was found to be -30°C. Further, the JIS A hardness of the covering resin layer was found to be 97.

(Comparative Example 1)

[0047] An elevator rope was obtained in the same manner as in Example 1 except that a covering resin layer was formed by using only the polyether-based thermoplastic polyurethane elastomer used in Example 1. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in the viscoelastic spectra was found to have one peak, and the peak temperature corresponding to the glass transition temperature was found to be -30°C. Further, the JIS A hardness of the covering resin layer was found to be 95.

(Comparative Example 2)

[0048] An elevator rope was obtained in the same manner as in Example 1 except that a covering resin layer was formed by using only the polycarbonate-based thermoplastic polyurethane elastomer used in Example 1. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in the viscoelastic spectra was found to have one peak, and the peak temperature corresponding to the glass transition temperature was found to be 5°C. Further, the JIS A hardness of the covering resin layer was found to be 95.

(Comparative Example 3)

[0049] An elevator rope was obtained in the same manner as in Example 1 except that a covering resin layer was formed by using only the silicone-based thermoplastic polyurethane elastomer used in Example 4. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in the viscoelastic spectra was found to have one peak, and the peak temperature corresponding to the glass transition temperature was found to be -50°C. Further, the JIS A hardness of the covering resin layer was found to be 95.

(Comparative Example 4)

[0050] An elevator rope was obtained in the same manner as in Example 1 except that a covering resin layer was formed by using only the nylon 12 used in Example 7. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in the viscoelastic spectra was found to have one peak, and the peak temperature corresponding to the glass transition temperature was found to be 40°C. Further, the JIS A hardness of the covering resin layer was found to be 100.

(Comparative Example 5)

[0051] An elevator rope was obtained in the same manner as in Example 1 except that the mass ratio of the pellets of the polyether-based thermoplastic polyurethane elastomer to the pellets of the polycarbonate-based thermoplastic polyurethane elastomer was changed to 60:40. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in the viscoelastic spectra was found to have one peak, and the peak temperature corresponding to the glass transition temperature was found to be -15°C. Further, the JIS A hardness of the covering resin layer was found to be 95.

(Comparative Example 6)

[0052] An elevator rope was obtained in the same manner as in Example 1 except for using a resin composition obtained by mixing the polyether-based thermoplastic polyurethane elastomer used in Example 1 with pellets of a polyester-based thermoplastic polyurethane elastomer (JIS D hardness: 60, glass transition temperature: -20°C) obtained by reacting polycaprolactone diol, 4,4'-diphenylmethane diisocyanate, and 1,4-butanediol at a mass ratio of 80:20. The viscoelastic spectra and JIS A hardness of the covering resin layer of the elevator rope were measured. As a result, the loss modulus E" in the viscoelastic spectra was found to have one peak, and the peak temperature corresponding to the glass transition temperature was found to be -28°C. Further, the JIS A hardness of the covering resin layer was found to be 97.

[0053] The friction coefficient of the elevator rope obtained in each of Examples and Comparative Examples above was evaluated. It should be noted that the elevator rope of each of Comparative Examples 4 and 5 was not evaluated here because the covering resin layer was hard, and as a result, it was impossible to produce a rope having such flexibility that the rope was capable of being bent repeatedly.

The friction coefficient was evaluated for both small sliding velocity and sliding velocity during normal operation. FIG. 4 illustrates a configuration diagram of a system for this evaluation. As illustrated in FIG. 4, an elevator rope 10 obtained in each of Examples and Comparative Examples was wound around a sheave 11 at an angle of 180 degrees, and one end thereof was connected to a weight 12. The other end was fixed to the ground 13. Further, in order to measure a rope tension (T_1) on the weight 12 side, a load cell 14 was provided in the vicinity of a connection part between the elevator rope 10 and the weight 12. Similarly, in order to measure a rope tension (T_2) on the ground 13 side, the load cell 14 was provided in the vicinity of a connection part between the elevator rope 10 and the ground 13.

[0054] In this system, when the sheave 11 is rotated in a clockwise direction at a predetermined rate, a rope tension (T_2) on the ground 13 side is decreased by a value corresponding to a friction force between the elevator rope 10 and the sheave 11, resulting in a tension difference from a rope tension (T_1) on the weight 12 side. At that time, the rope tensions (T_1 and T_2) were measured using the load cell 14, and the results were substituted into the following equation, to thereby determine a friction coefficient between the elevator rope 10 and the sheave 11. It should be noted that measurement of the rope tensions (T_1 and T_2) was carried out by rotating the sheave 11 in a clockwise direction at a small sliding velocity defined as 1×10^{-5} mm/sec or sliding velocities during normal operation defined as 0.01 mm/sec and 1 mm/sec. In addition, the measurement was carried out at a temperature of 25°C.

[0055]

[Equation 1]

$$\mu = \frac{\ln(T_1/T_2)}{K_2\theta}$$

[0056] In the equation, θ represents a rope winding angle (i.e., 180 degrees), and K_2 represents a coefficient dependent on the shape of a sheave groove (i.e., 1.19). For the results of friction coefficients obtained by the equation, the friction coefficients at sliding velocities of 0.01 mm/sec and 1×10^{-5} mm/sec were expressed as relative values to the friction coefficient at a sliding velocity of 1 mm/sec, which was defined as 100. Table 1 shows the results.

[0057]

[Table 1]

	Sliding velocity (mm/sec)	
	0.01	1×10^{-5}
Example 1	85	75
Example 2	90	85
Example 3	100	90
Example 4	90	85
Example 5	95	85
Example 6	100	85
Example 7	100	90
Comparative Example 1	80	20
Comparative Example 2	80	40
Comparative Example 3	85	45
Comparative Example 4	-	-
Comparative Example 5	-	-
Comparative Example 6	80	25

[0058] As is clear from the results shown in Table 1, the friction coefficients of the elevator ropes obtained in Examples and Comparative Examples displayed a tendency to decrease as the sliding velocity decreased. However, in the elevator rope obtained in each of the Examples, the friction coefficient at a sliding velocity of

1×10^{-5} mm/sec was able to be maintained to 75% or more of the friction coefficient at a sliding velocity of 1 mm/sec, and the variation in friction coefficient was small. On the other hand, in the elevator rope obtained in each of the Comparative Examples, the friction coefficient at a sliding velocity of 1×10^{-5} mm/sec decreased to 45% or less of the friction coefficient at a sliding velocity of 1 mm/sec, and the variation in friction coefficient was large. Further, as is clear from the results of Examples 1 to 3 and Comparative Example 5, as the ratio of the polycarbonate-based thermoplastic polyurethane elastomer becomes larger, the variation in friction coefficient becomes smaller. However, when the mass ratio of the polycarbonate-based thermoplastic polyurethane elastomer to the polyether-based thermoplastic polyurethane elastomer was too high, the covering resin layer of the elevator rope became too hard. As a result, it was impossible to produce a rope having such flexibility that the rope was capable of being bent repeatedly.

[0059] As is clear from the above-mentioned results, according to the present invention, it is possible to provide an elevator rope and elevator apparatus which can stably brake a car in a wide range of sliding velocities from a range of small sliding velocities required for maintaining a static condition of the car to sliding velocities during normal operation by covering a rope with a resin material having a stable friction coefficient independent of temperature and sliding velocity.

Claims

1. An elevator rope comprising a rope main body and a covering resin layer that covers a periphery of the rope main body, wherein the covering resin layer is formed from a molded product of a resin composition comprising a first resin component and a second resin component at a mass ratio of 90:10 to 70:30, the first resin component and the second resin component having a difference in glass transition temperature of 20°C or more.

2. An elevator rope according to claim 1, wherein the first resin component and the second resin component comprise thermoplastic polyurethane elastomers produced using different polyols as raw materials.

3. An elevator rope according to claim 1 or 2, wherein the first resin component is a polyether-based thermoplastic polyurethane elastomer, and the second resin component is at least one selected from the group consisting of a polycarbonate-based thermoplastic polyurethane elastomer and a silicone-based thermoplastic polyurethane elastomer.

4. An elevator rope according to claim 1, wherein the first resin component is a polyether-based thermoplastic polyurethane elastomer, and the second resin component is a polyamide resin.

5. An elevator apparatus comprising the elevator rope according to any one of claims 1 to 4.

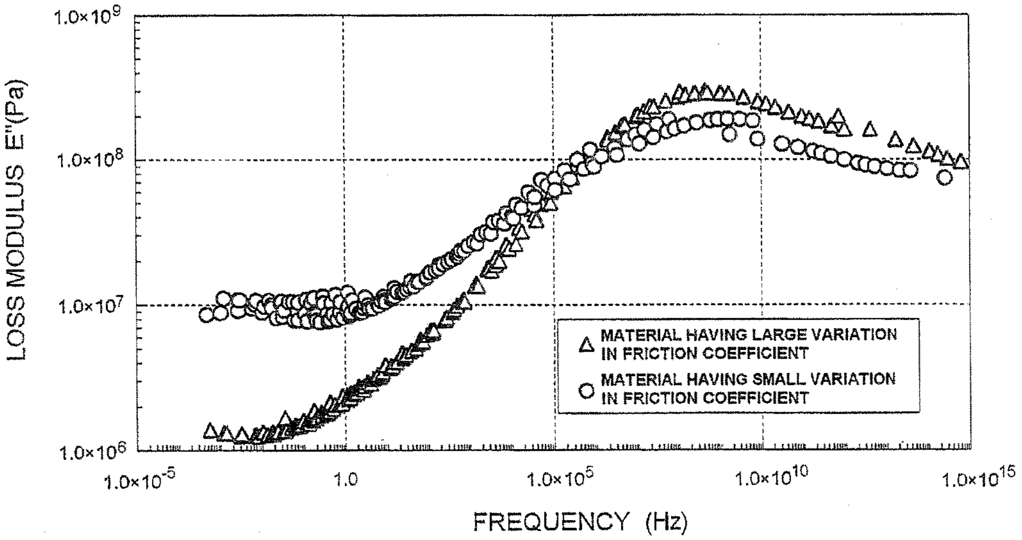
1.0×10^9
1.0×10^8
1.0×10^7
1.0×10^6
LOSS MODULUS E"(Pa)
1.0×10^-5
1.0
1.0×10^5
1.0×10^10
1.0×10^15
FREQUENCY (Hz)
△ MATERIAL HAVING LARGE VARIATION IN FRICTION COEFFICIENT
○ MATERIAL HAVING SMALL VARIATION IN FRICTION COEFFICIENT

FIG. 1

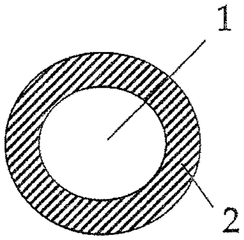
1
2

FIG. 2

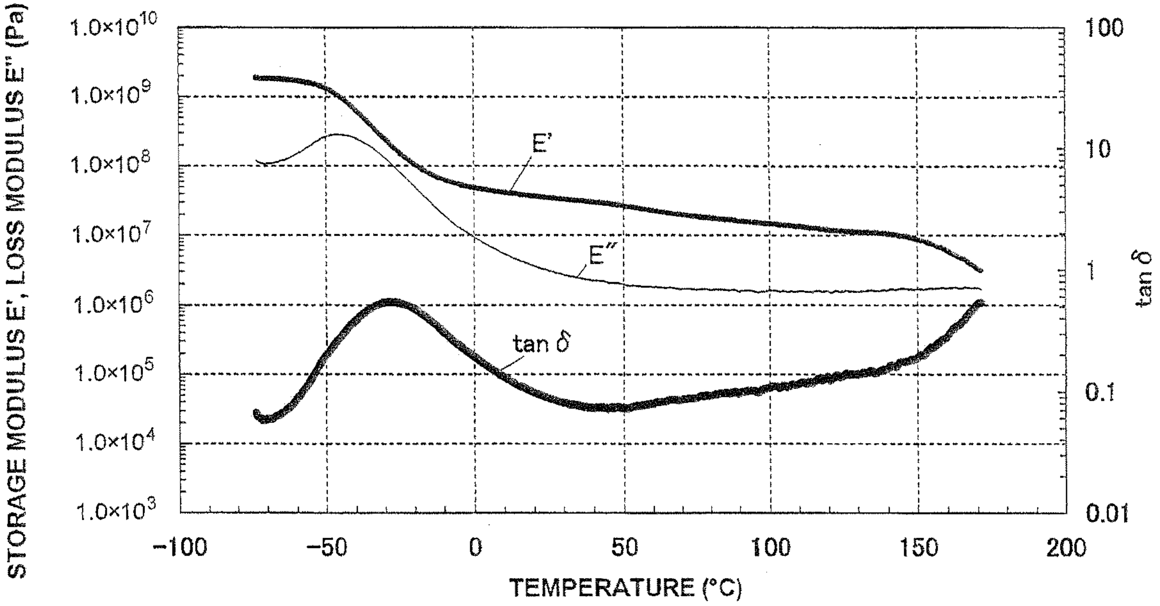
STORAGE MODULUS E', LOSS MODULUS E" (Pa)
1.0×10^10
1.0×10^9
1.0×10^8
1.0×10^7
1.0×10^6
1.0×10^5
1.0×10^4
1.0×10^3
E'
E"
tan δ
100
10
1
0.1
0.01
tan δ
−100
−50
0
50
100
150
200
TEMPERATURE (°C)

FIG. 3

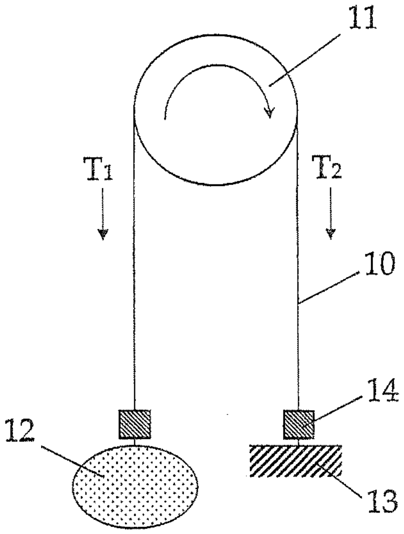
11
T1
T2
10
14
12
13

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/070233

A. CLASSIFICATION OF SUBJECT MATTER
B66B7/06(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)
B66B7/06

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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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.
A	JP 3756878 B2 (Tokyo Rope Mfg. Co., Ltd.), 15 March 2006 (15.03.2006), entire text; all drawings & EP 1431450 A2 & DE 60326808 D	1-5
A	JP 3048540 B2 (Shin-Etsu Polymer Co., Ltd.), 05 June 2000 (05.06.2000), paragraphs [0011] to [0012] (Family: none)	1-5
A	JP 2008-530342 A (General Electric Co.), 07 August 2008 (07.08.2008), claims 20, 26 & US 2006/0182967 A1 & EP 1853665 A & WO 2006/088707 A1	1-5

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

*	Special categories of cited documents:
"A"	document defining the general state of the art which is not considered to be of particular relevance
"E"	earlier application or patent but published on or after the international filing date
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O"	document referring to an oral disclosure, use, exhibition or other means
"P"	document published prior to the international filing date but later than the priority date claimed
"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&"	document member of the same patent family

Date of the actual completion of the international search 05 March, 2010 (05.03.10)	Date of mailing of the international search report 16 March, 2010 (16.03.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/070233

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2003-48937 A (Toyo Tire and Rubber Co., Ltd.), 21 February 2003 (21.02.2003), paragraphs [0019] to [0024] (Family: none)	1-5
A	JP 2002-533488 A (Bayer AG.), 08 October 2002 (08.10.2002), paragraphs [0006] to [0014] & US 6590028 B1 & EP 1141065 A & WO 2000/037521 A1	1-5

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2001262482 A **[0006]**
- JP 2004538382 A **[0006]**
- WO 2003050348 A1 **[0016]** **[0040]**
- WO 2004002868 A1 **[0016]**

Non-patent literature cited in the description

- **K. A. GROSCH.** The relation between the friction and visco-eleastic properties of rubber. *Proceedings of the Royal Society A,* 25 June 1963, vol. 274 (1356), 21-39 **[0007]**