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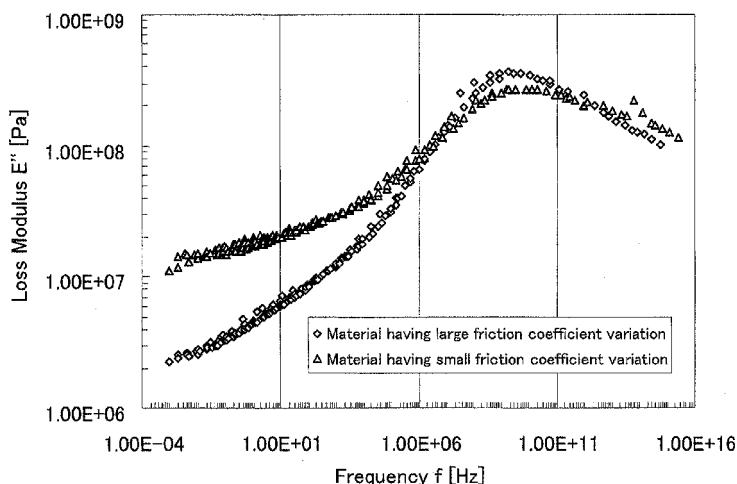
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(54) **ROPE FOR ELEVATOR**

(57) An elevator rope of the present invention includes: a rope main body; and a covering resin layer that covers the periphery of the rope main body and comprises a molded product of a composition for forming the covering resin layer, wherein the composition is produced by mixing a thermoplastic polyurethane elastomer, a friction stabilizer having a melting point of 100°C

or more to 150 °C or less and an isocyanate compound having two or more isocyanate groups per molecule. In order to further stabilize the friction coefficient, inorganic fillers may be further mixed in the composition for forming the covering resin layer. The elevator rope of the present invention has a stable friction coefficient that does not depend on temperature or sliding velocity.

**FIG. 1**



**Description**

## TECHNICAL FIELD

5 **[0001]** The present invention relates to an elevator rope for suspending an elevator car.

## BACKGROUND ART

10 **[0002]** A sheave having a diameter 40 times or more the diameter of a rope has been conventionally used in an elevator apparatus in order to prevent early abrasion or breakage of the rope. Therefore, in order to reduce the diameter of the sheave, it is also necessary to make the diameter of the rope smaller. However, if the diameter of the rope is made smaller without changing the number of ropes, then there is a risk that the maximum weight capacity of an elevator is decreased due to a decrease in strength of the rope. Further, an increase in the number of ropes results in a complicated structure of the elevator apparatus. In addition, if the diameter of a driving sheave is made smaller, bending fatigue life of the rope decreases. As a result, the rope needs to be frequently replaced.

15 **[0003]** As means for solving such problems, it has been proposed to use a rope obtained by: twisting a plurality of steel wires together to form strands; twisting a plurality of the strands together to form a wire rope; and covering the outermost periphery of the wire rope with a resin material (for example, see Patent Document 1). An elevator using such rope is driven by a frictional force between a sheave and the resin material forming the outermost periphery. Therefore, it is desired to stabilize or improve the friction characteristics of the resin material. Accordingly, in order to improve the friction characteristics of an elevator rope, it has been proposed to use a rope covered with a polyurethane covering material containing no wax (for example, see Patent Document 2). On the other hand, in order to reduce the friction coefficient to a predetermined level, a flat belt covered with a polyether-based thermoplastic polyurethane elastomer including a isoparaffinic wax of low oil content has been proposed (for example, see Patent Document 3). Further, in order to obtain a rope and belt having a friction coefficient which is not significantly reduced under the condition that oil adheres to the contact surface between a sheave and a rope or belt and less-wearing of a resin covering body at sliding, a rope and belt covered with a resin covering body comprising a resin base material and insoluble solid additive particles, in particular, insoluble solid additive particles with a hardness higher than the hardness of the surface material of a sheave has been proposed (for example, see Patent Document 4).

25 **[0004]** In general, the friction coefficient of a resin material is known to heavily depend on sliding velocity and temperature. Further, viscoelastic characteristics such as dynamic viscoelasticity of the resin material are known to have velocity and temperature dependencies which can be converted into each other (Williams-Landel-Ferry equation (WLF equation)). In addition, such conversion is achieved for the sliding velocity and temperature as well in the case of rubber friction, and hence it has been shown that the viscoelastic characteristics of rubber are involved in the friction characteristics of the rubber (for example, see Non Patent Document 1).

**[0005]**

[Patent Document 1] Japanese Patent Laid-Open No. 2001-262482

[Patent Document 2] Japanese Patent Laid-Open No. 2004-538382

40 [Patent Document 3] WO 2007/128622

[Patent Document 4] Japanese Patent Laid-Open No. 2009-234791

**[0006]**

45 [Non Patent Document 1] Grosch, K. A.: Proc. Roy. Soc., A274, 21 (1963)

## SUMMARY OF INVENTION

## TECHNICAL PROBLEM

50 **[0007]** As is clear from the above-mentioned facts, even in the polyurethane covering material containing no wax described in Patent Document 2, the friction coefficient of the material itself varies depending on the sliding velocity and temperature, and hence there has been a problem in that it is impossible to stably control an elevator. Further, as described in Non Patent Document 1, the friction coefficient of rubber has a maximal value for the sliding velocity. In order to stop an elevator for a long period of time, it is necessary to maintain the static condition of a car by the frictional force between a rope and a sheave. However, such conventional covering material having a large variation in friction coefficient and the covering material including a isoparaffinic wax of low oil content as described in Patent Document 3 have a problem in that the friction coefficient cannot be secured at a certain level or more at a low sliding velocity,

resulting in a misalignment of the stop position of the car with time. Meanwhile, in order to perform an emergency stop or sudden stop of the elevator in operation, it is necessary to brake the elevator by the frictional force between the rope and the sheave, but the conventional covering materials as described in Patent Documents 1 to 4 may cause a decrease in strength or melting by frictional heat. As a result, there has been a problem in that the friction coefficient between the rope and the sheave decreases significantly.

**[0008]** Therefore, the present invention has been made to solve the above-mentioned problems, and an object of the present invention is to obtain an elevator rope which has a stable friction coefficient that does not depend on temperature or sliding velocity.

## SOLUTION TO PROBLEM

**[0009]** The inventors of the present invention have studied the compositions of resin materials, and as a result, have found that, in order to obtain an elevator rope exhibiting a small variation in friction coefficient in a wide range of sliding velocities from the time of maintaining a static condition of an elevator car for a long period of time to the time of an emergency stop of an elevator car, it is useful to use, as a covering layer for a rope main body, a resin material obtained by adding a friction stabilizer having a melting point of 100°C or more to 150°C or less and an isocyanate compound having two or more isocyanate groups per molecule to a thermoplastic polyurethane elastomer, to complete the present invention.

## ADVANTAGEOUS EFFECTS OF THE INVENTION

**[0010]** According to the present invention, it is possible to obtain an elevator rope which has a stable friction coefficient that does not depend on temperature or the sliding velocity by using, as a layer for covering the periphery of a rope main body, a molded product of the composition for forming the covering resin layer obtained by adding the friction stabilizer having a melting point of 100°C or more to 150°C or less and the isocyanate compound having two or more isocyanate groups per molecule to the thermoplastic polyurethane elastomer.

## BRIEF DESCRIPTION OF THE DRAWINGS

### **[0011]**

Figure 1 is an example of results illustrating frequency dependency of loss moduli in materials having different sliding velocity dependency of friction coefficients (viscoelastic master curves).

Figure 2 is a conceptual diagram of an apparatus for measuring the friction coefficient in a low sliding velocity range used in the Examples.

Figure 3 is a conceptual diagram of an apparatus for measuring the friction coefficient at the time of an emergency stop used in the Examples.

## Description of Embodiments

**[0012]** Embodiments of the present invention are described below.

### Embodiment 1

**[0013]** An elevator rope according to Embodiment 1 of the present invention is characterized in that the periphery of a rope main body is covered with a molded product of a composition for forming a covering resin layer, wherein the composition is produced by mixing a thermoplastic polyurethane elastomer, a friction stabilizer having a melting point of 100°C or more to 150°C or less and an isocyanate compound having two or more isocyanate groups per molecule. The reason why a stable friction coefficient that does not depend on temperature or sliding velocity can be obtained is that since the friction stabilizer is not melted under sliding conditions that generate low amounts of frictional heat, such as those involving maintaining a static condition of an elevator car for a long period of time or normal operation, the friction coefficient does not decrease. On the other hand, since the friction stabilizer is melted under sliding conditions that generate high velocities and marked frictional heat, such as the time of an emergency stop of an elevator car, the lubricating property of the covering resin layer increases rapidly to prevent an increase in temperature on the friction surface, and as a result, the damage caused by friction can be prevented to maintain a certain level of friction coefficient since a decrease in strength and melting of the covering resin layer are not caused.

**[0014]** Examples of a thermoplastic polyurethane elastomer used in this embodiment include an ester-based thermoplastic polyurethane elastomer, an ether-based thermoplastic polyurethane elastomer, an ester-ether-based thermo-

plastic polyurethane elastomer, and a carbonate-based thermoplastic polyurethane elastomer. The elastomers may be used alone or in combinations of two or more kinds thereof.

Of those thermoplastic polyurethane elastomers, an ether-based thermoplastic polyurethane elastomer is preferably used to prevent hydrolysis which occurs in a usage environment. In consideration of flexibility and durability of the elevator rope, a polyether-based thermoplastic polyurethane elastomer having a JIS A hardness (hardness specified by JIS K7215 using a type A durometer) of 85 or more and 95 or less is more preferably used.

Meanwhile, from the viewpoint of workability such as the mixing of the friction stabilizer and the isocyanate compound having two or more isocyanate groups per molecule with the thermoplastic polyurethane elastomer, a thermoplastic polyurethane elastomer processed into pellets is preferably used.

**[0015]** Examples of a friction stabilizer having a melting point of 100°C or more to 150°C or less, which is used in this embodiment, include: waxes such as paraffin wax, microcrystalline wax and low-molecular weight polyolefin-based waxes; fatty acid amides; and polyolefin resins such as polyethylene and polypropylene. Of those, in order to reduce variations in the friction coefficient at the time of maintaining a static condition of an elevator car, the olefin-based compounds are preferably used.

If the melting point of the friction stabilizer is less than 100°C, the friction coefficient on the surface of a rope under a high-ambient temperature environment such as during summer, in particular, the friction coefficient under sliding conditions with extremely-low sliding velocities, such as at the time of maintaining a static condition of an elevator car, may be too low. On the other hand, if the melting point of the friction stabilizer is more than 150°C, the friction stabilizer is melted under sliding conditions that generate extremely-high amounts of frictional heat to slow down expression of a lubricating property. As a result, since a decrease in strength and melting of the covering resin layer are caused, the friction coefficient may decrease rapidly.

The amount of the friction stabilizer added is not particularly limited, but is preferably from 0.5% or more to 5% or less by weight, and more preferably from 1% or more to 3% or less by weight with respect to the composition for forming the covering resin layer. When the amount of the friction stabilizer added is less than 0.5% by weight, a covering resin layer having a stable friction coefficient may not be obtained. On the other hand, when the amount is more than 5% by weight, decreases in strength, abrasion resistance and adhesiveness of the covering material may be caused or the flexibility and durability of the rope may be impaired.

**[0016]** Examples of an isocyanate compound having two or more isocyanate groups per molecule, which is used in this embodiment, include: aliphatic isocyanates such as 1,6-hexamethylene diisocyanate, 2,2,4-trimethyl hexamethylene diisocyanate, lysine methyl ester diisocyanate, methylene diisocyanate, isopropylene diisocyanate, lysine diisocyanate, 1,5-octylene diisocyanate, and a dimer acid diisocyanate; alicyclic isocyanates such as 4,4'-dicyclohexylmethane diisocyanate, isophorone diisocyanate, hydrogenated tolylene diisocyanate, methyl cyclohexane diisocyanate, and isopropylidene dicyclohexyl-4,4'-diisocyanate; and aromatic isocyanates such as 2,4- or 2,6-tolylene diisocyanate, 4,4'-diphenylmethane diisocyanate, 1,5-naphthylene diisocyanate, xylylene diisocyanate, triphenylmethane triisocyanate, tris(4-phenyl isocyanate) thiophosphate, tolidine diisocyanate, p-phenylene diisocyanate, diphenyl ether diisocyanate, and diphenylsulfone diisocyanate. Those compounds may be used alone or in combinations of two or more kinds thereof. Alternatively, an isocyanate prepolymer having isocyanate groups at its molecular ends, which can be obtained by reacting an active hydrogen compound such as a polyol or a polyamine with the above-mentioned isocyanate, can also be used as the isocyanate compound having two or more isocyanate groups per molecule. These isocyanate compounds show the effects that the friction coefficient can be further stabilized against temperature or sliding velocity. From the viewpoint of workability such as the mixing with the thermoplastic polyurethane elastomer, the isocyanate compound is preferably used as a resin composition (hereinafter, referred to as "isocyanate batch") in the form of pellets, in which a thermoplastic resin other than the thermoplastic polyurethane elastomer, which is unreactive to the isocyanate compound, and the isocyanate compound are preliminarily mixed. Examples of the thermoplastic resin other than the thermoplastic polyurethane elastomer, which is used in this case, include an epoxy resin, a polystyrene resin, a poly vinyl chloride resin, a poly vinyl acetate resin, an ethylene-vinyl acetate copolymer resin, a polyethylene resin, a polypropylene resin, and a polyester resin.

The amount of the isocyanate compounds added may be appropriately adjusted so that the molded product has a JIS A hardness of 98 or less and a glass transition temperature of -20°C or less.

**[0017]** The covering resin layer used in this embodiment is usually obtained by: mixing the above-mentioned thermoplastic polyurethane elastomer pellets with the above-mentioned friction stabilizer and isocyanate compound (or the isocyanate batch) to prepare a mixture; and feeding the mixture into a molding machine such as an extrusion molding machine or an injection molding machine to mold the mixture.

**[0018]** In order to stabilize the friction coefficient against temperature or sliding velocity more, inorganic fillers can be further added to the above-mentioned composition for forming the covering resin layer. Examples of the inorganic filler include: a spherical inorganic filler such as calcium carbonate, silica, titaniumoxide, carbonblack, acetylene black, or barium sulfate; a fibrous inorganic filler such as a carbon fiber or a glass fiber; and a plate-like inorganic filler such as mica, talc, or bentonite. The fillers may be used alone or in combinations of two or more kinds thereof. Of those, in order

to reduce variations in the friction coefficient, a fibrous inorganic filler and a plate-like inorganic filler are preferably used. A hardness of the inorganic fillers is not particularly limited. The amount of the inorganic fillers added may be appropriately adjusted so that the molded product has a JIS A hardness of 98 or less and a glass transition temperature of -20°C or less.

**[0019]** The reason why the JIS A hardness of the molded product is specified as 98 or less is that studies by the inventors have revealed that, in the case where the hardness is more than 98, the flexibility of the rope is liable to be impaired, resulting in an increase in power consumption during driving of an elevator using such rope. The JIS A hardness of the molded product is more preferably 85 or more and 98 or less.

Meanwhile, the reason why the glass transition temperature of the molded product (sliding velocity dependency of the friction coefficient becomes smaller as the glass transition temperature of the molded product increases, while the elastic modulus of the molded product becomes larger as the glass transition temperature of the molded product increases) is specified as -20°C or less is that studies by the inventors have revealed that, in the case where a molded product having a higher glass transition temperature is employed for an elevator rope as the covering resin layer, the flexibility of the rope is liable to be decreased or fatigue failure such as cracking of the covering resin layer is liable to occur due to stress applied to the covering resin layer when the rope is bent repeatedly in an environment having a temperature higher than the glass transition temperature of the molded product. The glass transition temperature of the molded product is more preferably -25°C or less.

**[0020]** It should be noted that the elevator rope according to this embodiment is characterized by the resin material of the outermost layer that covers the periphery of the rope main body. Therefore, the structure of the rope main body is not particularly limited, but in general, the rope main body contains strands or cords formed by twisting a plurality of steel wires together as a load-supporting member. The rope main body in this embodiment may have a belt shape including the above-mentioned strands or cords. Meanwhile, in order to improve adhesion between the rope main body and the covering resin layer, an adhesive for metal and polyurethane such as Chemlok (registered trademark) 218 (manufactured by LORD Far East, Inc.) is preferably applied in advance to the above-mentioned strands or cords.

**[0021]** According to this embodiment, it is possible to obtain an elevator rope having a small variation in the friction coefficient in a wide range of sliding velocities from a low sliding velocity range required for maintaining a static condition of an elevator car to a large sliding velocity range during emergency or sudden stops of an elevator in operation.

**[0022]** In addition, though this embodiment explains the case where the present invention is applied to an elevator rope, the present invention can be also applied to an elevator belt.

## EXAMPLES

**[0023]** Hereinafter, the present invention is described in more detail by way of Examples and Comparative Examples, but is not limited by the examples.

### <Examples 1 to 11>

**[0024]** A friction stabilizer and as necessary, inorganic fillers were added to an ether-based thermoplastic polyurethane elastomer having a JIS A hardness of 95 (hereinafter, referred to as "TPU") to process it in the form of pellets. A specific amount of an pelletized isocyanate batch obtained by kneading 1.85 parts by mass of a polystyrene resin, 1.3 parts by mass of an epoxy resin, and 1.85 parts by mass of 4,4'-diphenylmethane diisocyanate using a twin screw extruder was added to the pelletized resin composition, and the resultant was mixed well and supplied to an extrusion molding machine, to thereby mold the mixture as a covering resin layer for covering the periphery of a rope main body. The rope main body was covered with the covering resin layer and then heated at 100°C for 2 hours in order to conduct a curing of an adhesive and an annealing treatment of the covering resin layer, to thereby obtain an elevator rope having a diameter of 12 mm. It should be noted that the resultant elevator rope had the cross-sectional structure described in FIG. 1 of WO 2003/050348 A1. Here, the rope main body corresponds to the elevator rope including: the inner layer rope having a plurality of core strands in each of which a plurality of steel wires are twisted together and a plurality of inner layer strands in each of which a plurality of steel wires are twisted together; the inner layer cladding made of a resin and covering the periphery of the inner layer rope; and the outer layer rope provided in a peripheral portion of the inner layer cladding and having a plurality of outer layer strands in each of which a plurality of steel wires are twisted together, and the covering resin layer corresponds to the outer layer cladding. Before covering the rope main body with the covering resin layer, Chemlok (registered trademark) 218 (manufactured by LORD Far East, Inc.) was applied to the peripheral strands of the rope main body and dried. Compositions of the covering resin layers are shown in Table 1.

### <Comparative Examples 1 and 7 to 9>

**[0025]** As necessary, inorganic fillers were added to TPU to process it in the form of pellets. The same procedure as in Examples 1 to 11 was carried out except that the pelletized resin composition was used for a covering resin layer for

covering the periphery of a rope main body, to thereby obtain an elevator rope. Compositions of the covering resin layers are shown in Table 2.

<Comparative Examples 2 to 6 and 10 to 12>

**[0026]** A friction stabilizer or inorganic fillers were added to TPU to process it in the form of pellets. A specific amount of a pelletized isocyanate batch obtained by kneading 1.85 parts by mass of a polystyrene resin, 1.3 parts by mass of an epoxy resin, and 1.85 parts by mass of 4,4'-diphenylmethane diisocyanate using a twin screw extruder was added to the pelletized resin composition, and the resultant was mixed well. The same procedure as in Examples 1 to 11 was carried out except that the resultant mixture was used for a covering resin layer for covering the periphery of a rope main body, to thereby obtain an elevator rope. Compositions of the covering resin layers are shown in Table 2.

[Measurement of glass transition temperature (T<sub>g</sub>) of covering resin layer]

**[0027]** The glass transition temperature (T<sub>g</sub>) of the covering resin layer was measured as follows. A composition for molding having the same composition as that of the covering resin layer used in each of the Examples and Comparative Examples was supplied to an extrusion molding machine and molded into a plate having a size of 100 mm×100 mm×thickness 2 mm, followed by heating at 100°C for 2 hours, and then a test piece having a size of 50 mm×10 mm×thickness 2 mm was cut off from the center portion of the plate. The loss modulus of the test piece was measured using a viscoelastic spectrometer DMS120 manufactured by Seiko Instruments Inc. under conditions of deformation mode: bending mode, measurement frequency: 10 Hz, temperature increase rate: 2°C/min, and vibration amplitude: 10 μm, and the peak temperature of the loss modulus was adopted as T<sub>g</sub>.

[JIS A hardness of covering resin layer]

**[0028]** According to JIS K7215, a type A durometer was used to measure durometer A hardness.

[Measurement of friction coefficient of rope]

(1) Measurement method in low sliding velocity range and sliding velocity range during normal operation

**[0029]** FIG. 2 is a conceptual diagram of an apparatus for measuring the friction coefficient in a low sliding velocity range. As illustrated in FIG. 2, an elevator rope 1 obtained in each of the Examples and Comparative Examples was twisted 180 degrees around a sheave 2, and one end thereof was fixed on a measurement apparatus 3. The other end was connected to a weight 4, and a tension was applied to the elevator rope 1. Here, when the sheave 2 was rotated in a clockwise direction at a predetermined rate, rope tension on the fixed side (T<sub>2</sub>) loosens just for the friction force between the elevator rope 1 and the sheave 2, resulting in a tension difference from rope tension on the weight side (T<sub>1</sub>). The rope tension on the weight side (T<sub>1</sub>) and rope tension on the fixed side (T<sub>2</sub>) were measured using a load cell provided on the connection part between the rope and the weight. The low sliding velocity was defined as 1×10<sup>-5</sup> mm/s, the sliding velocity at the time of maintaining a static condition of an elevator car was defined as 1mm/s, and T<sub>1</sub> and T<sub>2</sub> (provided that T<sub>1</sub>>T<sub>2</sub>), a contact angle of the rope on the sheave θ (=180 degrees), and a coefficient K<sub>2</sub> (=1.19) determined by the shape of the groove of the sheave were substituted into the following equation 1, to thereby determine a friction coefficient μ<sub>1</sub> between the elevator rope 1 and the sheave 2. The measurement was conducted under a 25°C atmosphere. The results are shown in Tables 1 and 2.

**[0030]**

$$\mu_1 = \frac{\ln(T_1/T_2)}{K_2\theta} \quad (\text{Equation 1})$$

(2) Measurement method in large sliding velocity range at the time of an emergency stop

**[0031]** FIG. 3 is a conceptual diagram of an apparatus for measuring a friction coefficient in a large sliding velocity range at the time of an emergency stop. The elevator rope 1 obtained in each of the Examples and Comparative Examples was twisted 180 degrees around a driving sheave 5. One end thereof was connected to a weight 4a, and the other end was connected to a weight 4b having a larger mass than the weight 4a. The driving sheave 5 was rotated in a clockwise direction to raise the weight 4a, and the driving sheave 5 was suddenly stopped when the rope speed reached 4 m/s,

to thereby have the elevator rope 1 slip against the driving sheave 5. In this case, the minimum deceleration  $\alpha$  of the weight 4a, the tension on the weight 4a side ( $T_3$ ), and the tension on the weight 4b side ( $T_4$ ) were measured using a load cell provided on the connection part between the rope and the weight, and the resultant values were substituted into the following equation 2, to thereby determine a minimum friction coefficient  $\mu_2$  during slipping. The measurement was conducted under a 25°C atmosphere. The results of a first test (first time) and of a test repeating the slip 10 times on the same side of the covering resin layer are shown in Tables 1 and 2.

[0032]

$$\mu_2 = \frac{\ln(T_4(1 + \alpha/g) / T_3(1 + \alpha/g))}{K_2 \theta} \quad (\text{Equation 2})$$

[0033] Here,  $K_2$  represents the same value as that used in the measurement method in the low sliding velocity range,  $g$  represents a gravity constant (=9.80665 m/s<sup>2</sup>), and  $\theta$  represents a contact angle of the rope on the sheave (=180 degrees).

[0034]

Table 1

		Example										
		1	2	3	4	5	6	7	8	9	10	11
Compositions of covering resin layer	TPU	99.5	97	95	97	97	97	87	92	87	97	97
	Friction stabilizer 1	0.5	3	5				3	3	3	3	3
	Friction stabilizer 2				3							
	Friction stabilizer 3					3						
	Friction stabilizer 4						3					
	Friction stabilizer 5											
	Friction stabilizer 6											
	Friction stabilizer 7											
	Friction stabilizer 8											
	Isocyanate batch	10	10	10	10	10	10	10	10	10	5	25
	Inorganic filler 1							10				
	Inorganic filler 2								5			
	Inorganic filler 3									10		
Glass transition temperature (°C)		-28	-28	-28	-28	-29	-30	-24	-21	-25	-29	-22
JIS A hardness		97	97	97	97	96	96	97	98	97	96	98

(continued)

		Example										
		1	2	3	4	5	6	7	8	9	10	11
5	Friction properties	Normal operation	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
10		Maintaining static condition	○	○	○	○	Δ	Δ	○	○	○	○
		Emergency stop (first time)	○	○	○	○	○	○	⊙	⊙	○	○
15		Emergency stop (tenth time)	Δ	Δ	Δ	Δ	Δ	○	⊙	⊙	Δ	Δ

[0035]

Table 2

		Comparative Example											
		1	2	3	4	5	6	7 8		9	10	11	12
Compositions of covering resin layer	TPU	100	97	97	97	97	100	90	90	90	90	90	90
	Friction stabilizer 1												
	Friction stabilizer 2												
	Friction stabilizer 3												
	Friction stabilizer 4												
	Friction stabilizer 5		3										
	Friction stabilizer 6			3									
	Friction stabilizer 7				3								
	Friction stabilizer 8					3							
	Isocyanate batch		10	10	10	10	10				10	10	10
	Inorganic filler 1							10			10		
	Inorganic filler 2								5			5	
	Inorganic filler 3									10			10
Glass transition temperature (°C)		-30	-29	-28	-27	-28	-28	-25	-23	-25	-24	-21	-24



(continued)

		Comparative Example											
		1	2	3	4	5	6	7 8		9	10	11	12
JIS A hardness		95	97	97	97	97	97	95	97	96	97	98	97
Friction properties	Normal operation	⊙	⊙	×	Δ	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
	Maintaining static condition	×	×	×	×	○	○	○	○	○	○	○	○
	Emergency stop (first time)	×	○	×	Δ	Δ	Δ	×	Δ	Δ	○	⊙	⊙
	Emergency stop (tenth time)	×	Δ	×	Δ	×	×	×	×	×	×	×	×

**[0036]** Here, in the tables, Friction stabilizer 1 is a polyethylene wax having a melting point of 115°C, Friction stabilizer 2 is a polypropylene wax having a melting point of 150°C, Friction stabilizer 3 is ethylenebis(stearylamide) having a melting point of 144°C, Friction stabilizer 4 is stearylamine having a melting point of 100°C, Friction stabilizer 5 is a hydrogenated castor oil having a melting point of 85°C, Friction stabilizer 6 is a paraffin wax having a melting point of 55°C, Friction stabilizer 7 is a poly- $\alpha$ -olefin wax having a melting point of 53°C, Friction stabilizer 8 is calcium stearate having a melting point of 155°C, Inorganic filler 1 is titan dioxide, Inorganic filler 2 is glass fiber (fiber length of 1mm) and Inorganic filler 3 is talc. The friction coefficient measured under each measurement condition of less than 0.15 was determined as x, the friction coefficient measured under each measurement condition of 0.15 or more to less than 0.2 was determined as Δ, the friction coefficient measured under each measurement condition of 0.2 or more to less than 0.25 was determined as o, and the friction coefficient measured under each measurement condition of 0.25 or more to 0.6 or less was determined as ⊙. In addition, no Examples and Comparative Examples indicated a friction coefficient of more than 0.6.

**[0037]** As is clear from the results shown in Tables 1 and 2, the friction coefficients in the low sliding velocity range ( $1 \times 10^{-5}$  mm/s) and at the time of an emergency stop, determined using the elevator ropes obtained in the Examples and Comparative Examples, were found to have a tendency of being lower than the friction coefficients during normal operation. Further, the friction coefficients of the covering resin layers after repeating the slip 10 times on the same side of the covering resin layers under the sliding condition at the time of an emergency stop were found to have a tendency of being lower than the friction coefficients of the first test.

The elevator ropes obtained in the Examples were found to have friction coefficients of 0.2 or more in the low sliding velocity range and at the time of an emergency stop after the first test. In particular, in Examples 7 to 9 where the friction stabilizer, the isocyanate compound serving as a cross-linking agent and the inorganic filler were used in combination, variations in the friction coefficients were found to be small. Of those, in Example 8 where a fibrous inorganic filler such as the glass fiber was added thereto and Example 9 where a plate-like inorganic filler such as talc was added thereto, variations in the friction coefficients were found to be very small. Further, in Examples 1 to 4 and 7 to 11 where the olefin-based compounds were used as the friction stabilizer, variations in the friction coefficients were found to be very small.

**[0038]** On the other hand, in the cases of all the elevator ropes obtained in the Comparative Examples, the problem that the friction coefficient during normal operation was too low or that variations in the friction coefficients were large occurred. In Comparative Examples 2 to 4 where the friction stabilizers having a low melting point were used, the friction coefficients during normal operation and at the time of maintaining a static condition decreased depending on a reduction in the melting point. In Comparative Example 5 where the friction stabilizers having too high a melting point were used, the friction coefficient decreased since the covering resin layer at the friction interface was badly damaged during the friction test at the time of an emergency stop. The reason was that the lubricating action of the friction stabilizer was inhibited by the friction heat generated at the sliding interface since the melting point of the friction stabilizer was too high. Further, in Comparative Examples 6 to 12 where no friction stabilizer was added and either an isocyanate compound or an inorganic filler was added thereto, the friction coefficient decreased with each test when slipping ropes under the sliding condition at the time of an emergency stop.

REFERENCE SIGNS LIST

[0039] 1 elevator rope, 2 sheave, 3 measurement apparatus, 4, 4 a, 4b weight, 5 driving sheave.

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Claims

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1. An elevator rope, comprising: a rope main body; and a covering resin layer that covers the periphery of the rope main body and comprises a molded product of a composition for forming a covering resin layer, wherein the composition is produced by mixing a thermoplastic polyurethane elastomer, a friction stabilizer having a melting point of 100°C or more to 150°C or less and an isocyanate compound having two or more isocyanate groups per molecule.

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2. An elevator rope according to claim 1, wherein the friction stabilizer is an olefin-based compound.

3. An elevator rope according to claim 1, wherein inorganic fillers are further mixed in the composition for forming the covering resin layer.

4. An elevator rope according to claim 3, wherein the inorganic fillers are in either fibrous or plate-like form.

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5. An elevator rope according to claim 1, wherein the composition for forming the covering resin layer comprises from 0.5% by weight to 5% by weight of the friction stabilizer.

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FIG. 1

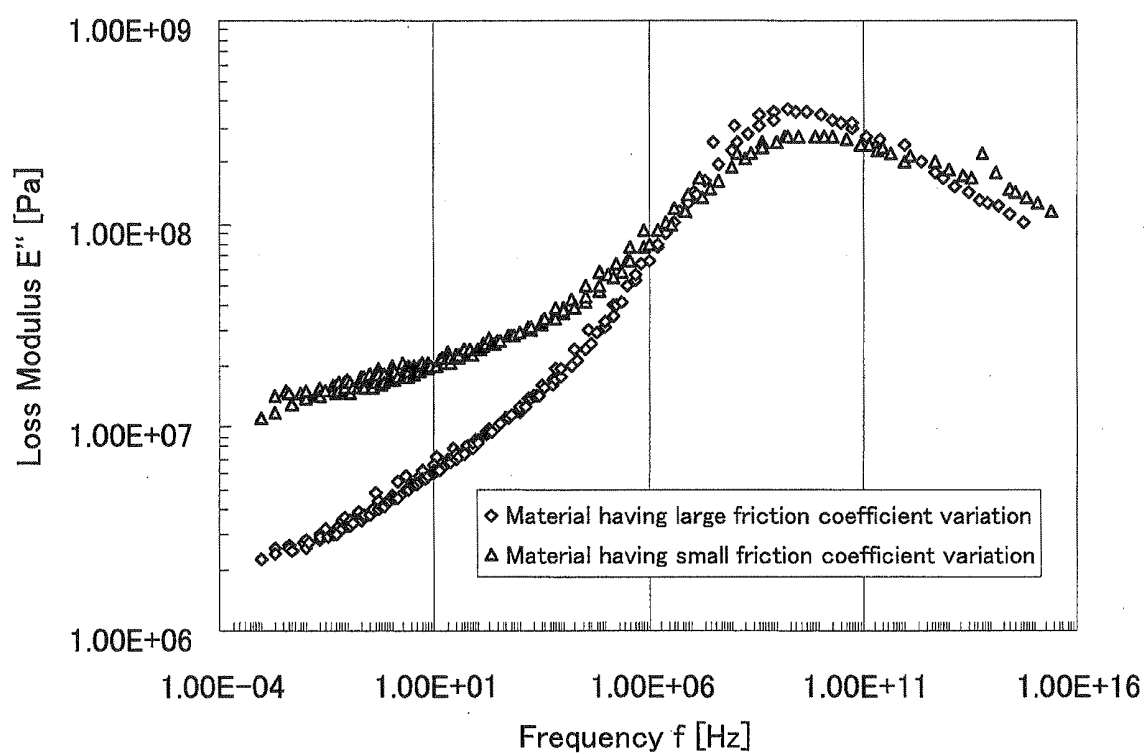


FIG. 2

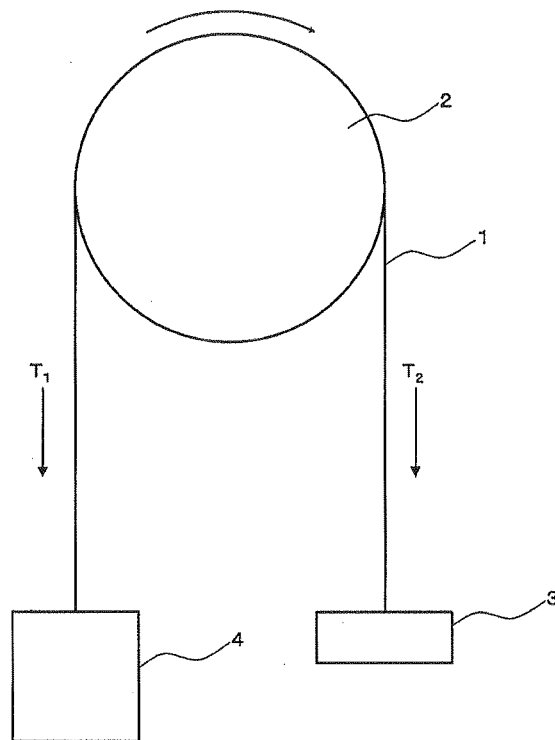
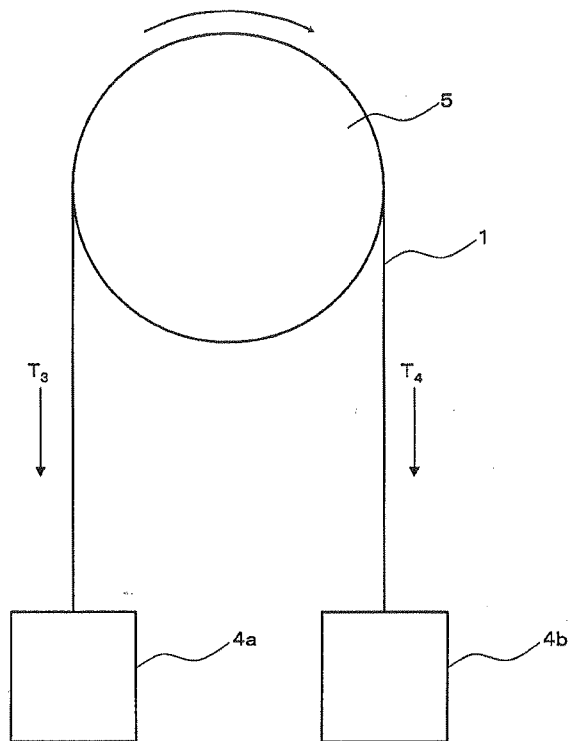


FIG. 3



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/058892

## A. CLASSIFICATION OF SUBJECT MATTER

B66B7/06(2006.01) i, D07B1/16(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, D07B1/16

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.
Y	JP 2001-262482 A (Hitachi, Ltd.), 26 September 2001 (26.09.2001), entire text; all drawings & US 2003/0089551 A1 & EP 1273695 A1 & WO 01/068973 A1 & CN 1388844 A	1-5
Y	JP 2002-47380 A (Wolff Walsrode AG.), 12 February 2002 (12.02.2002), claims; paragraphs [0006] to [0022] & US 2002/0010240 A1 & EP 1164162 A1 & DE 10029076 A & CN 1329110 A	1-5
A	JP 2009-234791 A (Hitachi, Ltd.), 15 October 2009 (15.10.2009), entire text; all drawings & CN 101525855 A	3-4

☒ 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

25 August, 2010 (25.08.10)

Date of mailing of the international search report

07 September, 2010 (07.09.10)

Name and mailing address of the ISA/

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Authorized officer

Facsimile No.

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/058892

## 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 2004-538382 A (Otis Elevator Co.), 24 December 2004 (24.12.2004), entire text; all drawings & US 2003/0024770 A1 & WO 03/014466 A1 & CN 1539039 A	1-5

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**REFERENCES CITED IN THE DESCRIPTION**

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