

TITLE OF INVENTION:

WIRE ROPE FOR ELEVATOR DEVICE AND ELEVATOR DEVICE USING THE
WIRE ROPE

5 FIELD OF THE INVENTION

The present invention relates to a wire rope for an elevator device and an elevator device using the wire rope.

BACKGROUND OF THE INVENTION

10 In recent years, traction type elevators that do not need a machine room have been used for the elevators for low and medium-rise buildings. In a traction type elevator, the flexibility in designing the layout of an elevator tower can be enhanced because the elevator does not need a machine room,
15 and hence the elevator can be installed in a narrow space where it has been difficult before to install a traditional elevator. Accordingly, the traction type elevators are progressively used when elevators are newly installed or existing elevators are renewed.

20 Fig. 1 illustrates one example of the traction type elevator. Reference numeral 1 represents a car, 2 represents a counter weight (balance weight), 3 represents a sheave connected to a hoisting machine, 4 represents a wire rope, 5a and 5b represents pulleys for suspending the car and the counter
25 weight, respectively, 6 represents a pulley fixed to a top

portion, and 7 represents a hoistway. One end of the wire rope is fixed to a top portion of the hoistway, and the other end is fixed to another top portion of the hoistway with the wire rope being drawn around the suspension pulley for the car, the top pulley, the sheave, the pulley, and the suspension pulley for the counter weight in this order. The difference between the tensions generated by the car and the counter weight is balanced, via the wire rope, with the frictional force generated between the wire rope and the sheave.

A wire rope for an elevator is typically one specified, for example, in JIS (Japanese Industrial Standard) G 3525. The wire rope has a structure in which approximately 6 or 8 strands are arranged and twisted around a rope core made of a synthetic fiber or a natural fiber. The strand is formed by twisting a plurality of steel wires. When tension is applied to the wire rope, force is exerted in a direction in which the steel wire strands compress the rope core. Also, in order to inhibit both the friction between the steel wires and the wear thereof and to form an oil film between the rope and the sheave, an oil having a viscosity or a greasy oil is coated onto the surface of the wire rope. In the elevator of Fig. 1, when the tension of the wire rope is raised to increase a contact pressure (Hertz surface pressure) in a contact portion between the wire rope and the sheave, the oil of the wire rope forms an elastohydrodynamic lubrication film in the contact portion,

so that the power of the hoisting machine is transmitted to the wire rope through the contact portion. This is one type of a drive system that is referred to as traction drive, in which a car and a counter weight are driven by a movement of a wire rope, so that an elevator is raised or lowered.

Application of wire ropes having a small rope diameter has been recently studied. The diameter and winding angle of a sheave become smaller as the diameter of a wire rope becomes smaller, by which an elevator device can be made smaller in size. On the other hand, the contact area between the rope and the sheave becomes smaller as the diameter of the wire rope becomes smaller, which leads to a decrease in the power transmission (traction) of the wire rope. The driving force (traction force) of the wire rope, generated by traction, is indicated by a product of the contact pressure between the wire rope and the sheave and the traction coefficient of an oil (oil film). In order to acquire traction force for a small contact area, it is necessary to enhance the contact pressure in a contact portion between the wire rope and the sheave or to use an oil having a higher traction coefficient.

Herein, the tensile strength of a wire rope is further decreased as the diameter of the rope is smaller, while the contact pressure in the contact portion is increased. The contact pressure is further increased by making a car, etc., heavier, but the load to the wire rope becomes higher, so that

it is necessary to adjust the weight thereof in consideration of a safety factor of the wire rope. In addition to the miniaturization of an elevator device, the weight saving of a car, etc., has also been studied from the viewpoints of energy saving and long life, and accordingly there are many technical constraints for a method of enhancing the contact pressure. Therefore, there are needs for an oil and grease by which excellent traction can be obtained for a smaller contact area.

As an example of an elevator device using a high traction rope, Patent Document 1 discloses a technique in which semiliquid or greasy polyisobutylene having a liquid form is used in a wire rope. Patent Document 2 also discloses a high traction oil and a grease using the high traction oil.

[Related Art Document]

[Patent Document]

[Patent Document 1] JP 58-176298 A

[Patent Document 2] JP 2000-8058 A

The liquid polyisobutylene contained in the grease of Patent Document 1 is excellent in a traction characteristic; however, wear is likely to progress on the contact surface of a rope, which causes the life of the rope to be shorter than that of a general-purpose mineral oil-based traction grease.

The grease of Patent Document 2 is used in a speed changer for machine tools or transmissions and used in a high-temperature region of 200°C or higher, and hence the traction performance

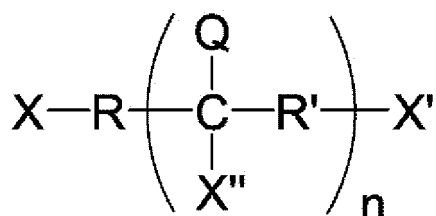
can be exerted at such a high temperature. That is, the high traction performance of the grease cannot be exerted even when used in a wire rope for an elevator operating at a temperature of room temperature to approximately 100°C.

5 An object of the present invention is to obtain a wire rope in which high traction and wear resistance can be both attained and obtain an elevator device using the wire rope.

SUMMARY OF THE INVENTION

10 In order to achieve the aforementioned object, the present invention provides a wire rope for an elevator device, which is formed by twisting a plurality of strands, each of which is made by twisting a plurality of copper wires, around a rope core of fibers, the wire rope including a mixed oil containing
15 both a base oil containing at least one compound represented by General Formula (1) and a viscosity modifying agent viscosity modifying agent having an average molecular weight of 1,000 to 100,000 (inclusive).

General Formula (1)



20 (Wherein, n represents an integer of 0 to 4. Each of X, X' and X'' independently represents a monocyclic hydrocarbon or

a cyclic hydrocarbon having a bridged structure; each of R and R' independently represents a direct bond or a C₁-C₃ alkylene group; and Q represents a hydrogen atom, a C₁-C₃ alkylene group, or a cyclic hydrocarbon. Each of X, X', X'', R, R', and Q may
5 independently have a C₁-C₃ alkyl group or a cyclic hydrocarbon in its side chain.)

The invention also provides an elevator device using the wire rope for an elevator device according to the aforementioned invention.

10 According to the present invention, a wire rope in which high traction and wear resistance can be both attained and an elevator device using the wire rope can be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

15 Fig. 1 is a schematic view of a traction type elevator; and

Fig. 2 is a schematic view of a cross section of a wire rope.

20 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, embodiments directed to the present invention will be described with reference to the drawings. The invention should not be limited to the embodiments described herein, and the embodiments can be appropriately combined or
25 improved within a scope not changing the gist of the invention.

The wire rope according to the present embodiment is made by twisting a plurality of steel wire strands, each of which is formed by twisting a plurality of steel wires, around a rope core made of a synthetic fiber or a natural fiber. Fig. 2 illustrates a schematic view of a cross section of the wire rope. The wire rope 4 has a structure in which approximately 6 or 8 strands 9 are arranged around a rope core 8 made of a synthetic fiber or a natural fiber and they are twisted. The strand 9 is made by twisting a plurality of steel wires 10. Fig. 2 illustrates the case where a grease 11 is present on the surface of the strand 9. The surfaces of the rope core and the strands are covered with at least one of a mixed oil containing both a base oil and a viscosity modifying agent and a grease in which a thickening agent is mixed in the mixed oil, or the insides of the rope core and the strands are impregnated with at least one of the above mixed oil and the grease. Herein, an oil containing a base oil and a viscosity modifying agent is referred to as a "mixed oil" or a "rope oil", and a greasy oil in which a thickening agent is added to the "mixed oil" or the "rope oil" is referred to as a "grease", in the present invention.

The base oil is at least one type of the compound represented by the above General Formula (1). The viscosity modifying agent is one having an average molecular weight of 1,000 to 100,000 (inclusive). The grease is caused to have

a worked penetration of 200 to 475 by blending a thickening agent into the mixed oil.

In General Formula (1), n represents an integer of 0 to 4. Each of X , X' and X'' independently represents a monocyclic hydrocarbon or a cyclic hydrocarbon having a bridged structure; each of R and R' independently represents a direct bond or a C_1 - C_3 alkylene group; and Q represents a hydrogen atom, a C_1 - C_3 alkylene group, or a cyclic hydrocarbon. Each of X , X' , X'' , R , R' and Q may independently have a C_1 - C_3 alkyl group or a cyclic hydrocarbon in its side chain.

A compound represented by General Formula (1) has a plurality of cyclic hydrocarbons such as a cyclohexyl backbone and has a very bulky molecular structure (large steric hindrance) by a hydrocarbon linkage or direct bonding of the rings. The compound has a large shearing resistance and can maintain the thickness of an oil film even when the surface pressure is increased, thereby allowing a high traction characteristic and a high wear resistance to be achieved. A rope oil or a grease excellent in a traction characteristic can be prepared by using the compound as a base oil.

On the other hand, the viscosity of the compound alone is low, and hence a viscosity modifying agent having a weight average molecular weight of 1,000 to 100,000 (inclusive) is added to the base oil. Thereby, the base oil has a sufficient thickness of the oil film for the contact between the rope and

the sheave and can reduce a damage to the rope oil even when used in a wire rope for an elevator device to which high contact pressure is applied, and hence the rope oil retains a viscosity and is excellent in a sticking property. Accordingly, a rope oil excellent also in a traction characteristic can be obtained.

A greasy oil made of a high-viscosity oil can be obtained by adding a thickening agent suitable for the temperature condition under which the grease works, and the greasy oil can be used in place of a rope oil or used by being added to a rope oil.

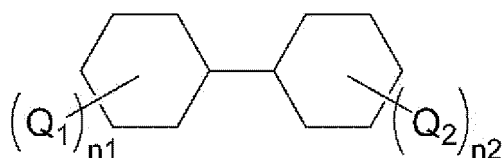
By arranging the rope oil or the grease on a wire rope (rope core and strand), a wire rope can be obtained, the wire rope having a sufficient oil thickness and a sufficient sticking property for the contact between the rope and the sheave in an elevator device and being excellent also in a traction characteristic. When the surfaces of the rope core and the strands are covered with the rope oil or the grease, the wire rope can exhibit a traction performance; however, when the inside of the rope core is impregnated with the oil or the grease, the oil is sequentially supplied to the surfaces of the strands during the use of the wire rope, thereby allowing the performance of the wire rope to be maintained for a long period of time. When the insides of the strands are also impregnated with the rope oil or the grease, more of the rope oil or the grease can be held, thereby allowing the performance of the wire rope to

be maintained for a longer period of time.

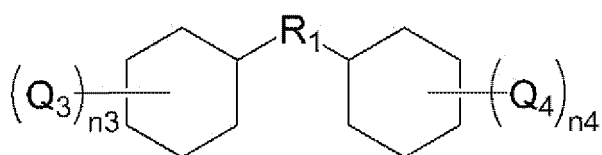
When the rope core is impregnated with the rope oil and the strands are covered or impregnated with the grease having a viscosity higher than that of the rope oil, the rope oil having a higher flowability can be efficiently supplied to the strands that contact an external device and the strands can be imparted with a high sticking property, and hence it is desirable to distinguish the use of the rope oil and the grease for the rope core and the strands.

The base oil used in the rope oil and the grease of the present embodiment is characterized in that the best form of the base oil is made of at least one compound represented by General Formulae (2) to (7).

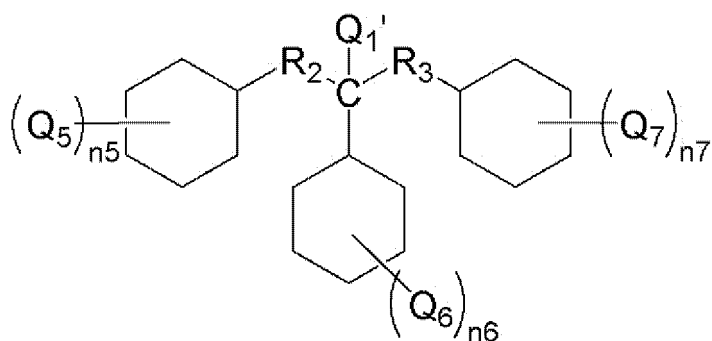
General Formula (2)



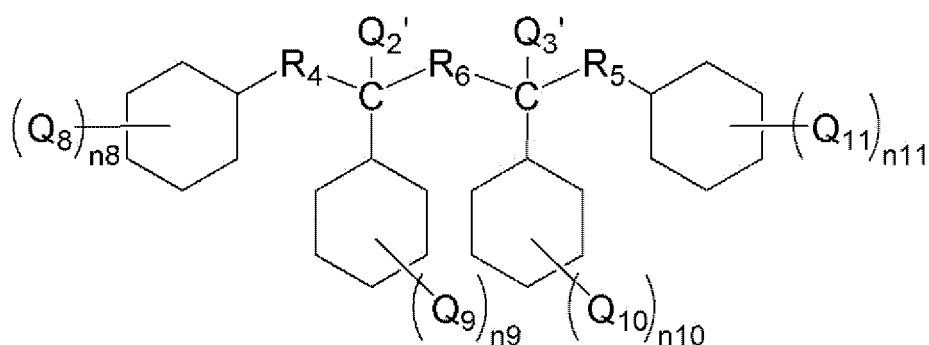
General Formula (3)



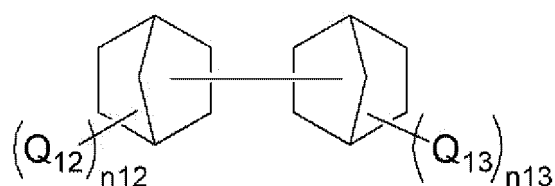
General Formula (4)



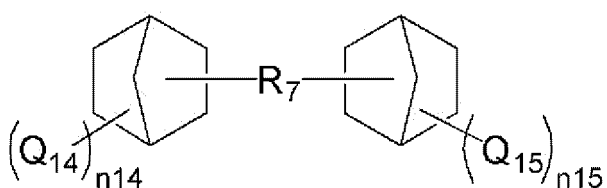
General Formula (5)



General Formula (6)



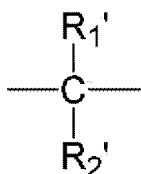
General Formula (7)



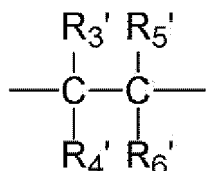
Wherein, each of R_1 to R_7 is made of a hydrocarbon group represented by each of General Formulae (8) to (10), and wherein each of R_1' to R_{12}' is independently selected from hydrogen, a C_1 - C_3 alkyl group, a monocyclic cyclohexyl group, or a cyclohexyl group having a bridged structure. Each of n_1 - n_{15}

represents an integer of 0 to 9 or 0 to 11 in accordance with the structure of a cyclic hydrocarbon, and each of Q_1 to Q_{15} is independently selected from a C_1 - C_3 alkyl group, a monocyclic cyclohexyl group, or a cyclohexyl group having a bridged structure. When each of n_1 to n_{15} is an integer of 2 or more, it is independently selected for a plurality of Q_1 to Q_{15} . Each of Q_1' to Q_3' is independently selected from a hydrogen atom, a C_1 - C_3 alkyl group, a monocyclic cyclohexyl group, or a cyclohexyl group having a bridged structure.

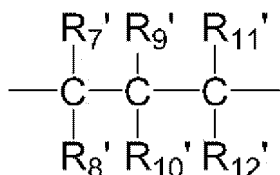
10 General Formula (8)



General Formula (9)



General Formula (10)



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In the compounds represented by General Formulae (2) to (7), the alkyl group of each of R_1' to R_{12}' and Q_1 and Q_{15} is specifically a methyl group, an ethyl group, an n-propyl group, or an i-propyl group. Each of R_1' to R_{12}' is more

preferably hydrogen or a methyl group, and most preferably a group in which the carbon atom adjacent to a cyclohexyl group is methylated. The compound represented by each of General Formulae (2) to (7) may be used alone or be mixed with any of
5 the other compounds in any ratio.

Preferred examples of the compounds represented by General Formula (2) to (7) are compounds containing 2 to 4 cyclic compounds, and specific examples thereof include bicyclohexyl, 1,2-dicyclohexyl propane, 1,2-dicyclohexyl-2-methylpropane,
10 2,3-dicyclohexyl butane, 2,3-dicyclohexyl-2-methylbutane, 2,3-dicyclohexyl-2,3-dimethylbutane, 1,3-dicyclohexyl butane, 1,3-dicyclohexyl-3-methylbutane, 2,4-dicyclohexyl pentane, 2,4-dicyclohexyl-2-methylpentane, 2,4-dicyclohexyl-2,4-dimethylpentane,
15 1,3-dicyclohexyl-2-methylbutane, 2,4-dicyclohexyl-2,3-dimethylbutane, 2,4-dicyclohexyl-2,3-dimethylpentane, 2,4,6-tricyclohexyl-2, 4-dimethylheptan, 2,4,6-tricyclohexyl-2-methylhexane, 2,4,6-tricyclohexyl-2,4,6-trimethylheptane,
20 2,4,6,8-tetracyclohexyl-2,4,6,8-tetramethylnonane, bicyclo[2.2.1]hept-2-ene, 2-methylenebicyclo[2.2.1] heptane, 2-methylbicyclo[2.2.1]hept-2-ene, 2-methylene-3-methylbicyclo[2.2.1]heptane, 3-methylene-2-methylbicyclo[2.2.1]heptane,
25 2,3-dimethylbicyclo[2.2.1]hept-2-ene,

2-methylene-7-methylbicyclo[2.2.1]heptane,
 3-methylene-7-methylbicyclo[2.2.1]heptane,
 2,7-dimethylbicyclo[2.2.1]hept-2-ene,
 2-methylene-5-methylbicyclo[2.2.1]heptane,
 5 3-methylene-5-methylbicyclo[2.2.1]heptane,
 2,5-dimethylbicyclo[2.2.1]hept-2-ene,
 2-methylene-6-methylbicyclo[2.2.1]heptane,
 3-methylene-6-methylbicyclo[2.2.1]heptane,
 2,6-dimethylbicyclo[2.2.1]hept-2-ene,
 10 2-methylene-1-methylbicyclo[2.2.1]heptane,
 3-methylene-1-methylbicyclo[2.2.1]heptane,
 1,2-dimethylbicyclo[2.2.1]hept-2-ene,
 2-methylene-4-methylbicyclo[2.2.1]heptane,
 3-methylene-4-methylbicyclo[2.2.1]heptane,
 15 2,4-dimethylbicyclo[2.2.1]hept-2-ene,
 2-methylene-3,7-dimethylbicyclo[2.2.1]heptane,
 3-methylene-2,7-dimethylbicyclo[2.2.1]heptane,
 2,3,7-trimethylbicyclo[2.2.1]hept-2-ene,
 2-methylene-3,6-dimethylbicyclo[2.2.1]heptane,
 20 3-methylene-2,6-dimethylbicyclo[2.2.1]heptane,
 2-methylene-3,3-dimethylbicyclo[2.2.1]heptane,
 3-methylene-2,2-dimethylbicyclo[2.2.1]heptane,
 2,3,6-trimethylbicyclo[2.2.1]hept-2-ene,
 2-methylene-3-ethylbicyclo[2.2.1]heptane,
 25 3-methylene-2-ethylbicyclo[2.2.1]heptane,

2-methyl-3-ethylbicyclo[2.2.1]hept-2-ene, etc.

The compound represented by each of General Formulae (2) to (7) has a molecular structure in which a plurality of alicyclic hydrocarbons are contained, and has a structure in which the rings are bridged together by a direct bond or a hydrocarbon. Accordingly, the steric hindrance of the molecule is large, and hence the compound is hardly deformed even when applied with high pressure, thereby allowing an oil film having a sufficient thickness for the contact between the rope and the sheave to be formed. On the other hand, some base oils have a low viscosity when used alone, and the sticking thereof to the contact portion is weak, and hence wear of the rope occurs by an oil film shortage when power is transmitted from the sheave. Accordingly, it is necessary to maintain the structure of an oil film in the contact portion and to adopt a measure to increase the viscosity of a base oil.

A manufacturing method of the compound represented by each of General Formula (2) to (7) is not particularly limited, and a publicly known or arbitrary method can be adopted. Examples of the manufacturing method include, for example: a method in which the compound is produced by subjecting α -methylstyrene or styrene, etc., to a dimerization reaction or a trimerization reaction and then to a hydrogenation reaction; and a method in which a naphthene-based synthetic lubricating oil is produced. The compound may contain a tetrameric compound,

etc., that is produced in the manufacturing process, but it is more desirable to contain a dimeric compound or a trimeric compound because a polymer having a large molecular weight can be obtained as a solid.

5 If the blending amount of the base oil component is too small, a traction coefficient is decreased, and if the blending amount is too large, a sticking property to the wire rope, etc., cannot be secured. An optimal blending ratio of the rope oil is within a range of 40 to 90 mass%, and more preferably within
10 a range of 50 to 85 mass%.

 As the viscosity modifying agent, n-paraffin, isoparaffin (such as poly- α -olefin), polycyclic naphthene (such as cyclopentadiene-based petroleum resin), aromatic hydrocarbon, and copolymers thereof, etc., can be used. A viscosity
15 modifying agent that has a weight average molecular weight of 1,000 to 100,000 (inclusive) and can be dissolved or dispersed into an oil is preferred. In particular, polycyclic naphthene (such as cyclopentadiene) and isoparaffin (such as polyisobutylene) are more preferred because they are excellent
20 in a traction characteristic.

 A viscosity modifying agent having a larger molecular weight generally has a larger thickening effect and viscosity is increased by adding a smaller amount of the viscosity modifying agent, but the main chain of the molecule is likely
25 to be cut when applied with high contact pressure. Accordingly,

viscosity modifying agents having a large molecular weight are less likely to be used in the art. However, it can be considered that the base oil of the present embodiment has a large steric hindrance and has an oil film having a large thickness. Thereby, a damage to the viscosity modifying agent is reduced with the oil film serving as a buffer, and hence the molecular weight of the viscosity modifying agent can be increased. On the other hand, the solubility of a viscosity modifying agent having a larger molecular weight is further reduced, and hence the weight average molecular weight of the viscosity modifying agent is preferably within a range of 5,000 to 50,000 (inclusive), and more preferably within a range of 8,000 to 30,000 (inclusive). An optimal blending ratio of the rope oil is preferably within a range of 10 to 60 mass%, and more preferably within a range of approximately 15 to 50 mass%.

As a result of intensive study of the viscosity of a base oil to be required of a rope oil, it has been found that the kinematic viscosity at 40°C of the base oil is preferably 40 mm²/s or more, and more preferably within a range of 50 to 1,000 mm²/s. When the viscosity of a rope oil is high, the rope oil is less likely to be supplied to the strands, while the sticking property of the rope oil is increased, and hence the viscosity thereof should be appropriately selected in accordance with the specifications of a wire rope and an elevator. Examples of a method of applying the rope oil to the wire rope include

methods of: immersing the rope core and the wire rope into the rope oil; and coating or spraying the rope oil onto them. Also, the rope oil can be supplied directly to the wire rope at normal temperature as a maintenance oil for the elevator rope.

5 Any thickening agent can be used without being particularly limited, as far as it can make the rope oil be semi-solid or solidified. Examples of the thickening agent include: mineral oil-based waxes (micro wax, paraffin wax, etc.); synthetic hydrocarbon waxes (synthesized from cracked
10 gas of coal by the Fischer-Tropsch process); polymer waxes derived from an olefin (polyethylene wax, α -olefin wax); waxes derived from a fatty acid (amide wax, ketone wax); mineral waxes (montanic acid wax); animal waxes (beeswax, whale wax); plant-derived waxes (carnauba wax, hollow wax); and the like.
15 The type and blending ratio of these waxes should be determined in consideration of an influence on a traction coefficient and a sticking property to the wire rope. An optimal blending ratio of a wax is preferably within a range of 5 to 25 mass%, and more preferably within a range of 10 to 20 mass% of the rope
20 oil. Because an oil is likely to be solidified by a smaller amount of a wax having a higher melting point, it is more desirable to use a wax having a melting point within a range of 60°C to 110°C (inclusive) in consideration of an influence on a traction coefficient and easy manufacture of a grease. It is also
25 desirable for the grease to have a worked penetration of 200

to 475 and a dropping point of 30 to 110°C in consideration of the workability and long term adherability to the wire rope.

The grease using the thickening agent has a property in which it is liquefied when heated and solidified when cooled.

5 Examples of a method of applying the grease, which has been melted by heat, to the wire rope include methods of: immersing the rope core, the steel wire strands and the wire rope into the grease; and coating or spraying the grease onto them, similarly to the rope oil. Alternatively, the wire rope can
10 be impregnated and coated with the grease by melting, when the wire rope is manufactured, the grease with heat in a port where the rope core and the steel wire strands are twisted (voice port).

An additive can be added to the aforementioned rope oil
15 and grease in order to impart the functions such as rust prevention, oxidation prevention, and wear inhibition, as far as a traction coefficient is not decreased. Examples of a rust-prevention agent include, for example, metal salts of sulfonic acid compounds and amines. Examples of an antioxidant
20 include, for example: phenolic antioxidants such as 2,4,6-tri-tert-butylphenol; amine antioxidants such as alkylated diphenylamine; and organic sulfur antioxidants such as zinc dialkyldithiophosphate. Examples of a wear inhibitor include, for example, fine graphite, molybdenum disulfide,
25 tetrafluoroethylene powder, etc.

In the wire rope according to the present embodiment, made of the aforementioned components, power can be transmitted and a direct contact with the sheave can be prevented with the rope oil and the grease being interposed between the wire rope and the sheave. In addition, the elevator device can be further reduced in size and the rope can be further reduced in diameter in comparison with traditional elevator devices, because the wire rope has a higher traction coefficient.

Example

Hereinafter, the present invention will be specifically described with reference to Examples and Comparative Examples, but the invention should not be limited thereto. A method of evaluating a rope oil and a grease will be described below.

(1) Measurement of Kinematic Viscosity, Consistency, and Dropping Point

The kinematic viscosity (at 40, 100°C) of an oil was measured according to JIS K 2283. The consistency (worked penetration) and dropping point of a grease were measured according to JIS K 2220. A viscosity index was evaluated from the kinematic viscosity values at 40°C and 100°C of a rope oil according to JIS K 2288. A viscosity grade was evaluated from the kinematic viscosity value at 40°C of a rope oil according to ISO (International Organization for Standardization) 3448.

(2) Measurement of Traction Coefficient

A traction coefficient was measured by using a

ball-on-disk test apparatus. The test apparatus has a mechanism in which a ball and a disk both rotate and a slipping velocity and a rolling velocity can be changed arbitrarily. The measurement was performed under the conditions described as follows: load: 30 N (Hertz surface pressure: 0.82 GPa), rolling velocity: 500 mm/s, temperature: 30°C, and slipping velocity: 0 to 1000 mm/s. Traction coefficients were measured by changing the slipping velocity, and the maximum of the traction coefficients ($\mu_{\max}$) was set to be the traction coefficient of a sample.

High-carbon chromium material for bearing steel (SUJ2 steel) of JIS G 4805:2008 was used as the material for a rotating body.

(3) Falex Wear Test

An extreme pressure test for an oil was performed by using a Falex friction wear test apparatus with reference to ASTM (American Society for Testing and Materials)-D2670. In a sample, nickel-chromium steel (SAE 3135) was used as a material for carbon steel (journal pin ($\phi 6.35$ mm)), and sulfur free cutting steel (AISI 1137) as a material for a V block. The sample immersed in an oil was tested under conditions in which the velocity and the load were fixed (rotation speed: 290 min⁻¹, temperature: 70°C, break-in operation: 89 N, 5 min, actual measurement: 445 N, 3h). A wear amount was determined by calculation in which the wear depth of the pin and that of the

block, which were measured from the changes in the scale of the ratchet in a load applying mechanism, were summed together.

(4) Measurement of Gel Filtration Chromatography

The weight average molecular weights of the viscosity modifying agent, etc., were measured by using a gel filtration chromatography (GPC) apparatus (solvent: tetrahydrofuran, polystyrene standards).

(Reference Example 1)

After 5 kg of α -methylstyrene and 100 g of 12-tungstic acid as a catalyst were put into a 10-L (hereinafter, liter is denoted as "L") glass reactor, they were heated to 50°C and stirred for 1 hour to be reacted together, and then they were cooled in a 20°C water bath to filter the solid catalyst. This filtrate was put into a 200-L autoclave, and 100 kg of cyclohexane, 500 g of hydrogenation catalysts supported by an activated carbon support containing Pd (5 mass% Pd support) (hereinafter, this catalyst is denoted as "Pd/C hydrogenation catalyst") were further put therein. After the autoclave was sealed up, a hydrogenation reaction was performed at hydrogen pressure of 60 kg/cm² (G) and 180°C for 8 hours, and then they were cooled to room temperature to filter the catalyst.

It has been found from the analysis of the obtained product with GPC that 48.2 mass% of a dimeric component (2,4-dicyclohexyl-2-methylpentane: base oil 1), 32.3 mass% of a trimeric component

(2,4,6-tricyclohexyl-2,4-dimethylheptan: base oil 2), and 9.7 mass% of a tetrameric component (base oil 3) were produced.

After a monomer (cyclohexane) and light components were distilled off by treating the whole reaction liquid with a rotary evaporator, each component was isolated by vacuum distillation. (Reference Example 2)

After 1000 g of α -methylstyrene dimer, 5000 g of cyclohexane, and 10 g of Pd/C hydrogenation catalyst were put into a 10-L autoclave equipped with a stirrer, the autoclave was sealed. They were stirred at room temperature (25°C) for 18 hours while the pressure in the autoclave were being maintained at 0.1 MPa with hydrogen. Thereafter, the autoclave was opened such that the Pd/C hydrogenation catalyst was filtered, and then the cyclohexane was distilled off to obtain 1125 g of 2-methyl-2,4-diphenylpentane. Subsequently, 1000 g of the 2-methyl-2,4-diphenylpentane and 100 g of AlCl_3 were put into a 10-L three-necked reactor equipped with a calcium chloride tube, a cooling tube, and a dropping funnel. After 2000 g of diisobutylene were dropped from the dropping funnel over 30 minutes while the reaction mixture was being stirred, the mixture was heated to 60°C and stirred at the temperature for 3 hours. 3000 g of distilled water were dropped over 30 minutes while the reactor was being cooled in an ice bath, so that the AlCl_3 was degraded. Thereafter, an organic layer was separated by leaving the reactor at rest, and then by performing a dehydration

reaction with the use of anhydrous Na_2SO_4 , 3000 g of a mixture containing an alkylated product of the 2-methyl-2,4-diphenylpentane and a polymer of the diisobutylene were obtained. After the whole reaction liquid, 5 30000 g of cyclohexane, and 300 g of N-113 nickel-based hydrogenation catalyst were put into an autoclave, the autoclave was sealed, and a nuclear hydrogenation reaction was then performed at hydrogen pressure of 6.1 MPa and a temperature of 200°C for 2 hours, and after the autoclave was cooled, the catalyst was filtered and the cyclohexane was distilled off. 10 The reaction liquid was distilled by vacuum distillation at 2 mm Hg and a temperature of 165 to 180°C to obtain 1600 g of a fraction of distillation (hydrogenated compound of the alkylated product of 2-methyl-2,4-diphenylpentane: base oil 15 4).

(Reference Example 3)

Into a 2-L stainless autoclave, 561 g of crotonaldehyde and 352 g of dicyclopentadiene were put, and they were reacted together by stirring at 170°C for 3 hours. After the reaction 20 solution was cooled to room temperature, 18 g of Raney nickel catalyst was added to perform a hydrogenation reaction at hydrogen pressure of 9 kg/cm² (G) and 150°C for 4 hours. After the reaction solution was cooled, the catalyst was filtered, and the filtrate was subjected to vacuum distillation at 105°C/20 25 mm Hg to obtain 500 g of a fraction of distillation.

Subsequently, 20 g of γ -alumina was put in and then a dehydration reaction was performed at reaction temperature of 285°C to obtain 450 g of a product. Further, 8 g of boron trifluoride-diethyl ether complex and 400 g of the dehydration reaction product were put into a 1-L four-necked flask, and a dimerization reaction was then performed at 20°C for 4 hours while the reaction mixture was being stirred. After the reaction mixture was cleaned with a dilute NaOH aqueous solution and saturated saline, 12 g of nickel/diatom earth catalyst was added to a 1-L autoclave to perform a hydrogenation reaction at hydrogen pressure of 30 kg/cm² (G) and a reaction temperature of 250°C for a reaction time of 6 hours. After the reaction was completed, the catalyst was removed by filtration, so that 200 g of a mixture of target dimeric hydrides (base oil 5) was obtained by subjecting the filtrate to vacuum distillation.

The base oil 4 was obtained as a mixture of a plural material. The main component of the base oil 4 was base oil A, base oil B, base oil C and base oil D. The total content of the base oil A and the base oil B was 20 mass %, and the total content of the base oil C and the base oil D was 60 mass %. The component of the base oil A-D were as follows:

base oil A:

exo-2-methyl-exo-3-methyl-endo-2-[(endo-3-methylbicyclo[2.2.1]hept-2-yl)methyl]bicyclo[2.2.1] heptane

base oil B:

exo-2-methyl-exo-3-methyl-endo-2-[(endo-2-methylbicyclo[2.2.1]hept-exo-3-yl)methyl]bicyclo[2.2.1] heptane

base oil C:

endo-2-methyl-exo-3-methyl-exo-2-[(exo-3-methylbicyclo[2.2.1]hept-exo-2-yl)methyl]bicyclo[2.2.1]heptane

base oil D:

endo-2-methyl-exo-3-methyl-exo-2-[(exo-2-methylbicyclo[2.2.1]hept-exo-3-yl)methyl]bicyclo[2.2.1]heptane

(Examples 1 to 7)

Rope oils were prepared from the base oils 1 to 5 and bicyclohexyl (base oil 6) by adding solid polyisobutylene (weight average molecular weight 9,000) as a viscosity modifying agent to each of them. The compositions and measured values of some physical properties of the rope oils are shown in Table 1. Each of them exhibits an excellent traction coefficient and accordingly an excellent performance as a rope oil. The viscosity of each of the rope oils can be arbitrarily adjusted by changing the molecular weight and addition amount of the viscosity modifying agent.

In Example 7, a rope oil was prepared by using the base oil 1 and as a viscosity modifying agent a styrene elastomer (styrene-ethylene copolymer, styrene copolymerization ratio = approximately 70%, weight average molecular weight 80,000), the composition and the physical properties of which are also shown in Table 1. Even when a viscosity modifying agent having

a different molecular structure was used, a high traction characteristic was maintained.

[Table 1]

Composition of rope oil			Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7
	Base oil 1		90 mass%	50 mass%	40 mass%	50 mass%			90 mass%
	Base oil 2			40 mass%					
	Base oil 3				30 mass%				
	Base oil 4					40 mass%			
	Base oil 5						90 mass%		
	Base oil 6							85 mass%	
	viscosity modifying agent	Solid polyisobutylene (Mw=9,000)	10 mass%	10 mass%	10 mass%	10 mass%	10 mass%	15 mass%	
		Styrene elastomer (Mw=80,000)							10 mass%
Measured value	ISO viscosity grade (ISO 3448)		VG 100	VG 100	VG 100	VG 100	VG 100	VG 100	VG 100
	Traction coefficient (30°C)		0.13	0.13	0.12	0.13	0.12	0.1	0.11

(Comparative Example 1)

In order to compare with the rope oils used in Examples, a polyisobutene oil (weight average molecular weight 700) was used.

5 (Example 8)

The measured values of the physical properties of the rope oil of Example 1, the base oil 1 of Reference Example 1, and the polyisobutene oil of Comparative Example 1 are shown in Table 2. Herein, an oil corresponding to the VG 100 in the
10 ISO viscosity grade (ISO 3448) was selected for each of the rope oil of Example 1 and the polyisobutene oil of Comparative Example 1. Each oil exhibited a high traction coefficient; however, in the results of the Falex wear test, as compared with Example 1, the oil of Reference Example 1 burned and
15 accordingly the operation of the device was stopped, and the wear amount in Comparative Example 1 was two or more times larger.

Although the oil of Reference Example 1 is the base oil of Example 1, it is assumed that the viscosity of the oil alone is low, and hence the sticking property to the interface of
20 a sample is low, thereby burning occurred due to an oil film shortage. Accordingly, it is essential to increase the viscosity of an oil in order to stably and firmly maintain an oil film for surface pressure. On the other hand, the wear amount in the polyisobutene oil of Comparative Example 1 became
25 large in spite of having a viscosity. A polyisobutene oil

exhibits a sticking property to an interface, but it can be considered that the thickness of the polyisobutene oil is smaller than that in Example 1. Accordingly, the oil film was more likely to be cut and the wear amount became large under a condition in which surface pressure was high.

From the above results, rope oils using the base oils shown in Examples exhibit an excellent performance in terms of high traction and wear resistance.

[Table 2]

	Example 1 (Rope oil)	Reference Example 1 (Base oil 1)	Comparative Example 1 (Polyisobutene oil)
Kinematic viscosity (40°C)	92.3mm ² /s	19.8mm ² /s	105.1mm ² /s
Kinematic viscosity (100°C)	12.4mm ² /s	3.7mm ² /s	10.6mm ² /s
Viscosity index (JIS K 2283)	129	49	80
ISO viscosity grade (ISO3448)	VG100	VG22	VG100
Traction coefficient (30°C)	0.13	0.13	0.11
Wear width (Falex Test: 70°C)	17.3	(Occurrence of burning)	45.8

(Examples 9 to 15, Comparative Example 2)

Greases were produced by adding thickening agents (wax) to the blends of the rope oils shown in Examples 1, 5, and 6. The compositions and measured values of the physical properties of the greases are shown in Table 3. The grease was prepared by mixing a certain amount of paraffin wax (melting point 69°C), micro wax (melting point 88°C), synthetic hydrocarbon wax

(melting point 102°C), polyethylene wax (melting point 110°C), amide wax (melting point 143°C) or montanic acid wax (melting point 100°C) with the rope oil.

In Comparative Example 2, a red rope grease, which is
5 a wire rope grease for a typical elevator, was used. The grease
in each of Examples 9 to 15 exhibited a traction coefficient
more excellent than that in Comparative Example 2, and hence
exhibited an excellent performance as a wire rope grease. The
viscosity of the rope oil can be arbitrarily adjusted by changing
10 the molecular weight and addition amount of the viscosity
modifying agent.

[Table 3]

Composition of grease			Example 9	Example 10	Example 11	Example 12	Example 13	Example 14	Example 15	Comparative Example 2
	Base oil 1		81 mass%	81 mass%	86 mass%	86 mass%	87 mass%	83 mass%		
	Base oil 5								81 mass%	
	Viscosity modifying agent	Solid polyisobutylene (Mw=9,000)	9 mass%	9 mass%	9 mass%	9 mass%	9 mass%	9 mass%	9 mass%	
	Thickening agent	Paraffin wax	10 mass%							
		Micro wax		10 mass%						
		Synthetic Hydrocarbon wax			5 mass%					
		Polyethylene wax				5 mass%				
		Amide wax					4 mass%			
		Montanic acid wax						8 mass%		
Measured value	Consistency (Worked penetration)		350	310	290	280	290	210	290	370
	Dropping point		47°C	57°C	80°C	87°C	98°C	82°C	55°C	72°C
	Traction coefficient (30°C)		0.11	0.12	0.12	0.11	0.11	0.11	0.12	0.05

A wire rope, in which the rope oil and the grease shown in each of the aforementioned Examples are arranged, can be used in the elevator device illustrated in Fig. 1. One end of the wire rope is fixed to a top portion of the hoistway, and the other end is fixed to another top portion of the hoistway with the wire rope being drawn around the suspension pulley for the car, the pulley fixed to a top portion, the sheave connected to the hoisting machine, the pulley fixed to a top portion, and the suspension pulley connected to the counter weight in this order. This is a traction type elevator device having a mechanism in which: the wire rope is driven via the sheave by the hoisting machine rotating; and then the counter weight and the car are driven. Because the wire rope exhibits a performance in which high traction and wear resistance are both attained, the elevator device has an excellent performance particularly for a decrease in traction associated with a reduction in the diameter of the wire rope and for a decrease in the life of the wire rope due to wear.

Functions, such as rust prevention, oxidation prevention, and wear inhibition, can be further imparted by adding an additive within a range where the traction coefficients of the rope oil and the grease are not affected, and hence required performances, such as miniaturization and less maintenance of the device, can be satisfied. As described above, it has been proved that a wire rope for an elevator device, in which high

traction and wear resistance can be both attained, and an elevator device using the wire rope can be obtained according to the present invention. The aforementioned Examples have been specifically described in order to help understand the invention, and the invention should not be limited to be provided with all the described configurations. For example, it is possible to replace part of the configuration of certain Example with the configuration of another Example, or also possible to add the configuration of certain Example to the configuration of another Example. Further, it is possible that part of the configuration of each Example is deleted, replaced with another configuration, or added with another configuration.

DESCRIPTION OF THE REFERENCE NUMERALS

- 15 1: Car
- 2: Counter Weight (Balance Weight)
- 3: Sheave connected to Hoisting Machine
- 4: Wire Rope
- 5a: Suspension Pulley for suspending Car
- 20 5b: Suspension Pulley for suspending Counter Weight
- 6: Pulley Fixed to Top Portion
- 7: Hoistway
- 8: Rope Core
- 9: Strand
- 25 10: Steel Wire

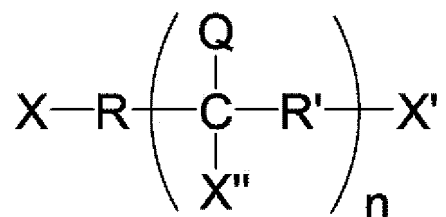
11: Grease (Surface of Steel Wire)

WHAT IS CLAIMED IS:

1. A wire rope for an elevator device, which is formed by twisting a plurality of strands, each of which is made by twisting a plurality of steel wires, around a rope core of fibers, the wire rope comprising:

a mixed oil containing both a base oil containing at least one compound represented by General Formula (1) and a viscosity modifying agent having an average molecular weight of 1,000 to 100,000:

General Formula (1)



(Wherein, n represents an integer of 0 to 4. Each of X, X', and X'' independently represents a monocyclic hydrocarbon or a cyclic hydrocarbon having a bridged structure; each of R and R' independently represents a direct bond or a C₁-C₃ alkylene group; and Q represents a hydrogen atom, a C₁-C₃ alkylene group, or a cyclic hydrocarbon. Each of X, X', X'', R, R' and Q may independently have a C₁-C₃ alkyl group or a cyclic hydrocarbon in its side chain.)

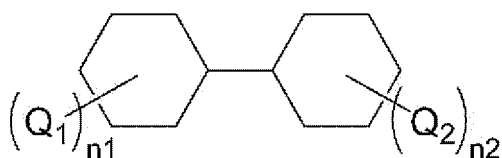
2. The wire rope for an elevator device according to claim 1 comprising a grease having a worked penetration of 200

to 475, in which a thickening agent is mixed in the mixed oil.

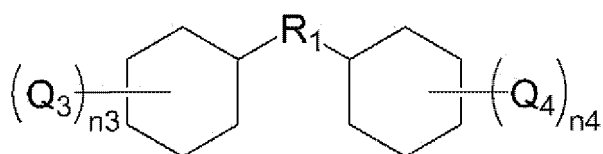
3. The wire rope for an elevator device according to claim 1 or claim 2, wherein

5 the base oil is at least one compound represented by General Formulae (2) to (7):

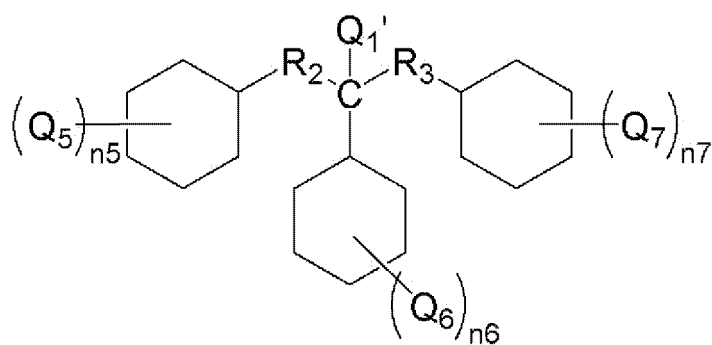
General Formula (2)



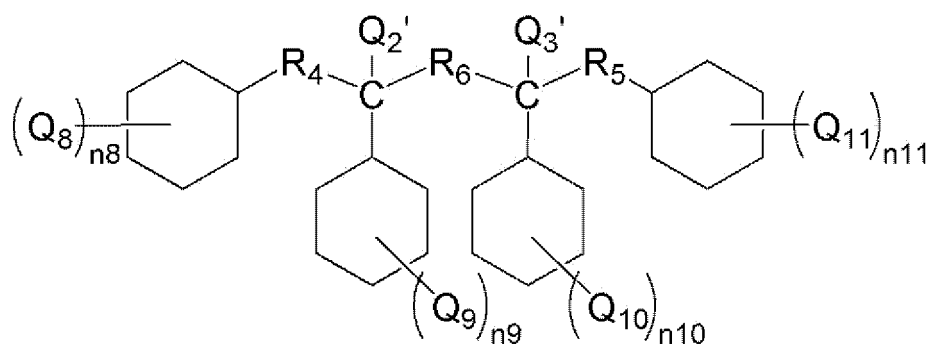
10 General Formula (3)



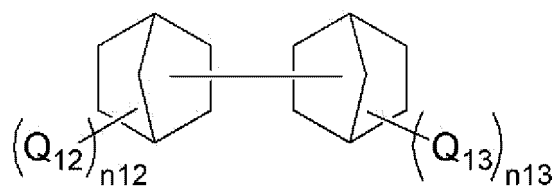
General Formula (4)



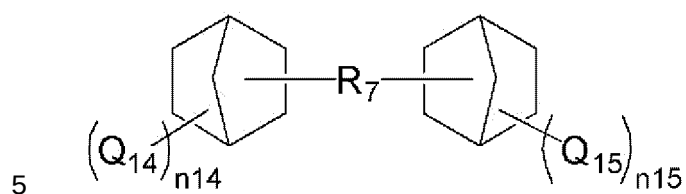
General Formula (5)



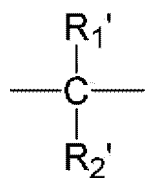
General Formula (6)



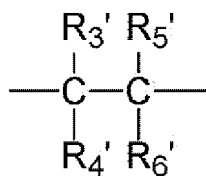
General Formula (7)



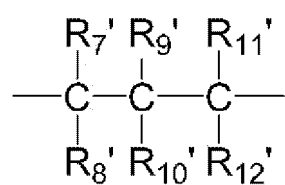
General Formula (8)



General Formula (9)



10 General Formula (10)



(Wherein, each of R_1 to R_7 is made of a hydrocarbon group represented by each of General Formulae (8) to (10), and wherein each of R_1' to R_{12}' is independently selected from hydrogen, a C_1 - C_3 alkyl group, a monocyclic cyclohexyl group, or a cyclohexyl group having a bridged structure. Each of n_1 - n_{15} represents an integer of 0 to 9 or 0 to 11 in accordance with the structure of a cyclic hydrocarbon, and each of Q_1 to Q_{15} is independently selected from a C_1 - C_3 alkyl group, a monocyclic cyclohexyl group, or a cyclohexyl group having a bridged structure, and when each of n_1 to n_{15} is an integer of 2 or more, it is independently selected for a plurality of Q_1 to Q_{15} . Each of Q_1' to Q_3' is independently selected from a hydrogen atom, a C_1 - C_3 alkyl group, a monocyclic cyclohexyl group, or a cyclohexyl group having a bridged structure.)

4. The wire rope for an elevator device according to claim 1 or claim 2, wherein the rope core includes the mixed oil and the strand includes the grease.

5. The wire rope for an elevator device according to claim 1 or claim 2, wherein the viscosity modifying agent is made of n-paraffin, isoparaffin, polycyclic naphthene, or aromatic hydrocarbon,

and the viscosity modifying agent is contained in an amount of 1 to 40 mass% of the base oil.

6. The wire rope for an elevator device according to
5 claim 2, wherein

the thickening agent is made of a mineral oil-based hydrocarbon wax or a synthetic hydrocarbon wax, and the thickening agent is contained in an amount of 1 to 20 mass% of the mixed oil, and a dropping point of the grease is 30°C
10 to 110°C.

7. A traction type elevator device comprising:
the wire rope of claim 1 or claim 2;
a hoisting machine that hoists the wire rope;
15 a counter weight connected to the wire rope; and
a car that is driven when the wire rope is hoisted.