



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
24.10.2007 Bulletin 2007/43

(51) Int Cl.:
B66B 15/04 (2006.01)

(21) Application number: **07008115.3**

(22) Date of filing: **20.04.2007**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(72) Inventors:
• **Maeda, Taichi**
Tokyo 100-8220 (JP)
• **Ariga, Masaki**
Tokyo 100-8220 (JP)
• **Hayano, Tomio**
Tokyo 100-8220 (JP)

(30) Priority: **20.04.2006 JP 2006116285**

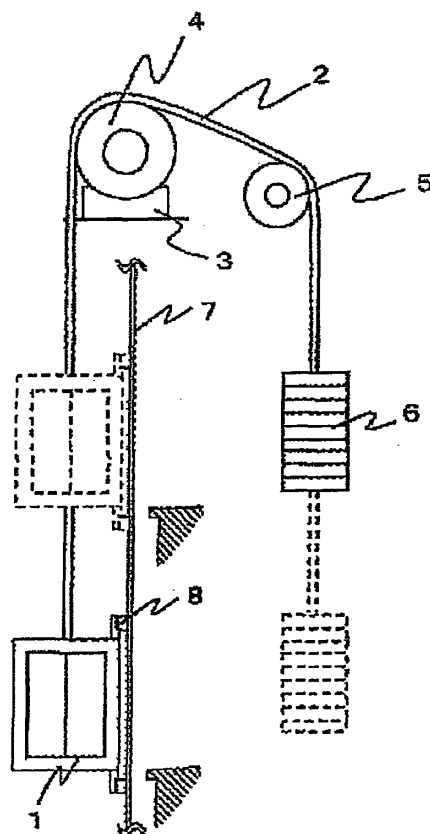
(71) Applicant: **Hitachi, Ltd.**
Tokyo
100-8280 (JP)

(74) Representative: **Beetz & Partner**
Steinsdorfstrasse 10
80538 München (DE)

(54) **Elevator and elevator sheave**

(57) The present invention relates to an elevator where friction coefficient between a rope (2) and a sheave (4) is kept stable. The elevator includes a car (1), a rope (2) connected to the car (1), and a sheave (4), having the rope (2) therearound and rotating to travel the car (1). The rope (2) is a resin-covered wire rope (2) formed by twisting steel wires and by coating the twisted wires with resin. The sheave (4) is provided with at least one groove having a surface of which arithmetic mean deviation of the profile Ra ranges from $4\mu\text{m}$ to $10\mu\text{m}$ in longitudinal and width directions of the groove. Further, a ratio of Zva to Zpa falls within a range from 1.5 to 2.0, where Zva indicates an average of depths of lower parts on the surface of the groove, and Zpa indicates an average of heights of higher parts thereon.

FIG.1



Description**BACKGROUND OF THE INVENTION**

1. Field of the Invention

[0001] The present invention relates to an elevator where a car is driven by rotating a sheave around which a rope connected to the car is wound, and is directed to the sheave. More specifically, the present invention is concerned with a technique for stabilizing a friction coefficient between a rope and a sheave in an elevator, and for reducing a wear amount of the rope appropriately.

2. Description of the Related Art

[0002] In a typical rope elevator, a wire rope that is wound around a sheave mounted on a machine has one end connected to a car, and the other end connected to a counter weight. Further, the counter weight and the car are kept balanced. In this elevator, once the machine rotates the sheave, the car that is hung from the sheave by the rope moves by means of a frictional force between the rope and the sheave. In order for an elevator to operate appropriately, a friction coefficient between the rope and the sheave needs to be stable and to be high enough to drive the car.

[0003] Generally, a steel wire rope for elevators is composed of twisted steel element wires and a core made of greased hemp. However, it is more preferable that a resin-covered rope composed of twisted steel element wires or a synthetic fiber rope is used, because they are light in weight, and have high corrosion resistance and high durability. In addition, since such a resin-covered rope or a synthetic fiber rope is softer and more flexible than metal, the pressure from the rope to a sheave can be lowered.

[0004] However, if the pressure is low, then foreign matters such as water or oil in a hoistway are more likely to enter a space between the rope and the sheave. If a lot of foreign matters enter, then the friction coefficient between the rope and the sheave is prone to decrease. In this case, the elevator may fail to operate appropriately.

[0005] On the other hand, Japanese Patent Translation Publication No. 2003-512269 discloses the following techniques. In order to transmit traction or driving power from a sheave to a rope in an elevator appropriately, the sheave needs to have roughness of $1\mu\text{m}$ to $3\mu\text{m}$ on its circumferential surface. Moreover, for the purpose of improving the durability of a rope, the circumferential surface of the sheave needs to be coated with hard corrosion-resistant material.

[0006] Furthermore, Japanese Unexamined Patent Application Publication 2001-139267 discloses that the roughness class of grooves formed on a circumferential surface of a sheave is set N7 to N12 (i.e. arithmetic mean deviation of the profile $R_a=1.6\mu\text{m}$ to $50\mu\text{m}$), so that a synthetic fiber rope is driven appropriately.

[0007] However, the above techniques have the following disadvantages.

[0008] If the surface roughness of grooves in the sheave is on the order of several micro meters, a lot of foreign matters such as oil may be adhered to the grooves, and cover them. In this case, the friction coefficient between the grooves and a rope is reduced excessively.

[0009] Otherwise, if the surface roughness of grooves in the sheave is on the order of several tens micro meters, the friction coefficient is not strongly affected by foreign matters. However, the resin rope is more like to be worn, because resin is softer than metal.

[0010] Taking the above disadvantages into account, the present invention has been conceived. An object of the present invention is to provide an elevator where a friction coefficient between the rope and a sheave is kept stable, so that traction is transmitted from the sheave to the rope appropriately, even when a resin-coated or synthetic fiber rope sensitive to foreign matters is used. An additional object of the present invention is to present an elevator in which a rope is less prone to be worn.

SUMMARY OF THE INVENTION

[0011] According to an aspect of the present invention, there is provided, an elevator including a car, a rope being connected to the car, and a sheave around which the rope is wound rotates to thereby travel the car. The rope is a resin-covered wire rope being formed by twisting a plurality of steel wires and by coating the twisted wires with resin. The sheave is provided with at least one groove having a surface of which arithmetic mean deviation of the profile R_a ranges from $4\mu\text{m}$ to $10\mu\text{m}$ in longitudinal and width directions of the groove. Further, a ratio of Z_{va} to Z_{pa} falls within a range from 1.5 to 2.0, where Z_{va} indicates an average of depths of lower parts on the surface of the groove, and Z_{pa} indicates an average of heights of higher parts thereon.

[0012] According to another aspect of the present invention, there is provided, an elevator including a car, a resin-covered wire rope being connected to the car, and a sheave around which the rope is wound rotates to thereby travel the car. Further, the sheave is provided with at least one groove which is formed by including the steps of projecting

indefinite-polygonal or spherical particles to a surface of the groove along a normal line with respect to a circumferential surface of the sheave, and/or projecting indefinite-polygonal or spherical particles to the surface of the groove along a tangent line with respect to the circumferential surface of the sheave.

[0013] In the elevator of the present invention, even when foreign matters such as water or oil are adhered to the sheave, the friction coefficient between the rope and the sheave is kept stable, so that traction is transmitted from the sheave to the rope appropriately. Thus, it is possible to present the elevator that possesses enhanced reliability.

[0014] Moreover, a resin-covered wire rope, which is light in weight and has high corrosion resistance and high durability, is applicable to the elevator of the present invention. This makes it possible to prolong the lifetime of the rope, so that the frequency of exchanging ropes decreases. As a result, the elevator is easy to be maintained, thus leading to the reduction in maintenance costs.

[0015] Other aspects, features and advantages of the present invention will become apparent upon reading the following specification and claims when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] For more complete understanding of the present invention and the advantages hereof, reference is now made to the following description taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a schematic view depicting an elevator according to one embodiment of the present invention;

Fig. 2A is a side view depicting a sheave according to one embodiment of the present invention;

Fig. 2B is a cross-section view depicting the sheave shown in Fig. 2A;

Fig. 3 is an enlarged cross-section view depicting a surface of groove formed in the sheave;

Fig. 4 is a graph showing a relationship between the Ra of the groove and a ratio of μ_a to μ_b ;

Fig. 5 is a graph showing a relationship between the Ra of the groove and relative wear amount of a rope;

Fig. 6A is a roughness profile of the groove of the sheave;

Fig. 6B is a roughness profile of the groove of the sheave;

Fig. 7 is a graph showing a relationship between a ratio of Zva to Zpa and a ratio of μ_a to μ_b ;

Fig. 8 is a graph showing a relationship between a ratio of Zva to Zpa and a relative wear amount of the rope;

Fig. 9A is a side view showing a direction to which particles are projected;

Fig. 9B is a side view showing a direction to which particles are projected;

Fig. 10 is a graph showing a relationship between a wavelength of the groove and an amplitude thereof;

Fig. 11 is a histogram showing a relative wear amount of each example in a wear test;

Fig. 12 is a graph showing a relationship between a wavelength of the groove and an amplitude thereof;

Fig. 13 is a graph showing a relationship between a wavelength of the groove and an amplitude thereof;

Fig. 14 is a graph showing a relationship between a wavelength of the groove and an amplitude thereof;

Fig. 15 is a histogram showing a ratio of μ_a to μ_b of each example in a wear test;

Fig. 16 is an enlarged cross-section view depicting a surface of a groove which is coated with metal plating;

Fig. 17 is a partial enlarged view of Fig. 16.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS OF THE INVENTION

[0017] Referring to Fig. 1, a reference numeral 1 denotes a car for carrying some passengers. This car 1 is connected to a rope 2, and this rope 2 is wound around a sheave 4 mounted on a machine 3. Further, the rope 2 passes through a beam pulley 5 and is coupled to a counter weight 6. In a hoistway, a guide rail 7 is installed vertically, and it is sandwiched by guide shoes 8 attached to the car 1.

[0018] While the machine 3 is rotating the sheave 4, the rotational power generated at the sheave 4 is transferred to the rope 2 by means of a frictional force between the rope 2 and the sheave 4. Consequently, the car 1 travels vertically along the guide rail 7 in the hoistway. In Fig. 1, the positions of the car and the counter weight are shown by dashed lines, when the car 1 moves upward by one floor.

[0019] Referring to Figs. 2A and 2B, the sheave has three grooves 9 for setting the rope. The surface of each groove shown in Fig. 3 is finished by a process by which abrasive grains are projected to the surface, such as the shotblast process. In this way, the surface's arithmetic mean deviation of the profile Ra is set 4 μ m to 10 μ m.

[0020] Fig. 4 is a graph showing a measurement result of the friction coefficient between a rope and a sheave.

[0021] Note that in all the following results, resin-covered wire rope composed of twisted copper wires is used. A symbol " μ_a " represents a friction coefficient between a clean rope and a clean sheave, while a symbol " μ_b " represents a friction coefficient between an oiled rope and an oiled sheave. The vertical line of the graph shown in Fig. 4 indicates a friction coefficient ratio of μ_a to μ_b . When this ratio is of a great value, the frictional force between the rope and the sheave can be deemed to be unstable. When the Ra exceeds 4 μ m, the friction coefficient ratio is as low as about 1.2.

Thus, the frictional force is considered to be stable.

[0022] Fig. 5 is a graph showing a measurement result of the wear amount of a rope. Note that this wear amount is indicated by a relative value where the wear amount at the Ra of $1\mu\text{m}$ is set "1." In this measurement, the resin of the rope is worn by sliding the resin-covered wire rope along a metal sheave. The mode of such wear between metal and resin is classified into two types; one is adhesive wear where a part of the resin is adhered to the metal, and the other is abrasive wear where the projections of the metal grind the resin.

[0023] In this graph, the adhesive wear is dominant within a region where the Ra of the groove in the sheave is equal to/less than $10\mu\text{m}$. As the Ra is larger in this region, the wear amount increases gradually. Meanwhile, when the Ra of the groove is more than $10\mu\text{m}$, the abrasive wear is dominant. As the Ra is larger, the wear amount increases rapidly.

[0024] In consideration of the above result, in order to keep the wear amount of the rope low, the Ra of the groove in the sheave needs to be set equal to/less than $10\mu\text{m}$.

[0025] In consideration of the graphs of Figs. 4 and 5, in order to stabilize the friction coefficient between a rope and a sheave, the Ra of grooves in a sheave needs to be set $4\mu\text{m}$ to $10\mu\text{m}$. This condition results in the appropriate operation of an elevator. This makes it possible to decrease the wear of the rope, thereby prolonging its lifetime. Note that the characteristics shown in Figs. 4 and 5 are obtained on the condition that a ratio of Zva to Zpa (described later) is 1.5 to 2.0 where:

Zpa: average of Zp;

Zva: an average of Zv;

Zp: a height of higher portions in a roughness profile; and

Zv: a depth of lower portions in the roughness profile.

[0026] Figs. 6A and 6B show a roughness profile of a groove of a sheave. Referring to the figures, a dashed line is an average line of a roughness profile, and the parts of the profile above the average line are called "higher portions," while the parts of the profile below the average line are called "lower portions." In the profile of Fig. 6A, the average value Zpa is nearly equal to the average value Zva. In contrast, in the profile of Fig. 6B, Zva is greater than Zpa.

[0027] The average value Zpa is obtained by summing the heights of the respective higher portions (Zp1 to Zpn) on the roughness profile of the groove in a sheave, and by dividing the sum by the numbers of the higher portions.

[0028] The average value Zva is obtained by summing the depths of the respective lower portions (Zv1 to Zvm) on the roughness profile, and by dividing the sum by the numbers of the lower portions.

[0029] The groove of Fig. 6A is formed by projecting indefinite-polygonal abrasive grains, of which diameter is about $450\mu\text{m}$, to the surface of the groove along a normal line of the surface. The Ra of the groove is finished to $6.0\mu\text{m}$.

[0030] The groove of Fig 6B is formed by the following two steps. First, indefinite-polygonal abrasive grains having a diameter of about $1500\mu\text{m}$ are projected to the surface of the groove along a normal line of the surface. Subsequently, indefinite-polygonal abrasive grains having a diameter of about $110\mu\text{m}$ are projected to the surface of the groove along the tangent line of the surface. As a result, the Ra of the groove is finished to $6.0\mu\text{m}$.

[0031] The surface of the groove shown in Fig. 6B differs from that of Fig. 6A in that the tips of the higher portions are cut away by the projection along the tangent line.

[0032] The diameter of each abrasive grain may be $100\mu\text{m}$ to $1700\mu\text{m}$. Preferably, the diameter of each abrasive grain to be projected along the normal line and the tangent line is $400\mu\text{m}$ to $1700\mu\text{m}$ and $100\mu\text{m}$ to $600\mu\text{m}$, respectively. Furthermore, it is preferable that the diameter of abrasive grains to be projected along the tangent line is smaller than that to be projected along the normal line.

[0033] Referring to a graph of Fig. 7, the friction coefficient between a clean rope and a clean sheave is represented by " μ_a ," while the friction coefficient between an oiled rope and an oiled sheave is represented by " μ_b ." Within a region where the ratio of Zva to Zpa is equal to/less than 2.0, the ratio of μ_a to μ_b is about as low as 1.2. In other words, the friction coefficient is almost constant. This is because the puddles of oil tend to be made on the surface of the groove. Therefore, even if the rope and the sheave are oiled, the friction coefficient is scarcely lowered. In contrast, within a region where the ratio of Zva to Zpa is more than 2.0, the puddles of oil do not tend to be made. Accordingly, oil stays a contact surface between the rope and the sheave. This may cause the decrease in the friction coefficient when the rope and the sheave are oiled, that is, the increase in the ratio of μ_a to μ_b .

[0034] Referring to a graph of Fig. 8, a relative wear amount of a rope is indicated by a relative value where the wear amount at the Zva/Zpa of 3.0 is set "1."

[0035] Within a region where the ratio of Zva/Zpa is equal to/less than 1.5, the wear amount of the rope has a large value. This is attributed to the relatively sharp projections on surface of a groove. In contrast, within a region where the ratio of Zva to Zpa is more than 1.5, the wear amount is of a small value, because the projections on surface of the groove are relatively dull.

[0036] In consideration of the above property, by setting the ratio of Zva to Zpa to be within a range of 1.5 to 2.0, the friction coefficient can be stable. This leads to the normal operation of an elevator. In addition, since the wear of a rope

decreases, the lifetime of the rope is prolonged. Note that the measurements in Figs. 7 and 8 are conducted on the condition that the Ra of the groove falls within a range of $4\mu\text{m}$ to $10\mu\text{m}$.

[0037] A process of setting a ratio of Zva to Zpa to be within the range of 1.5 to 2.0 is illustrated in Figs. 9A and 9B. As shown in Fig. 9A, indefinite polygonal or spherical particles 10 are projected to the groove 9 of the sheave 4 along a normal line with respect to the circumferential surface of the sheave 4. Following this, as shown in Fig. 9B, the indefinite polygonal or spherical particles 10 are projected to the groove 9 in the sheave 4 along a tangent line with respect to the circumferential surface of the sheave 4. Consequently, the tips of projections of the groove 9 are cut away.

[0038] Fig. 10 is a graph showing an FFT (fast Fourier transform) analysis of the surface of the groove 9 shown in Figs. 6A and 6B. In this analysis, the window function of the FFT is the Hanning of which side lobes sharply fall in order to obtain a wide dynamic range of the measurement. The resulting values that have been subjected to the FFT are considered to form a sound wave. Accordingly, the amplitude of the sound wave is determined using one-third octave-band center frequency. Then, based on the inverse of the frequency, the wavelength is determined.

[0039] In the graph of Fig. 10, a curve indicated by a comparative example 3-1 corresponds to the roughness profile of Fig. 6A, and a curve indicated by an example 3-1 corresponds to the roughness profile of Fig. 6B. Moreover, an example 3-2 is prepared by the following process. Indefinite-polygonal abrasive grains having a diameter of $400\mu\text{m}$ to $500\mu\text{m}$ are projected to the surface of groove of the sheave along a normal line with respect to the circumferential surface of the sheave. Subsequently, indefinite-polygonal abrasive grains having a diameter of $400\mu\text{m}$ to $500\mu\text{m}$ are projected to the surface of groove of the sheave along a tangent line with respect to the circumferential surface of sheave. As a result, the Ra of the groove is finished to about $4.0\mu\text{m}$.

[0040] The following table 1 is a chart showing respective working processes of the examples 3-1 and 3-2 and the comparative example 3-1, and the Ras thereof.

TABLE 1

	WORKING PROCESS	RA (μm)
EXAMPLE 3-1	PROJECTION OF ABRASIVE GRAINS (ALONG NORMAL AND TANGENT LINES)	6.0
EXAMPLE 3-2	PROJECTION OF ABRASIVE GRAINS (ALONG NORMAL AND TANGENT LINES)	4.0
COMPARATIVE EXAMPLE 3-1	PROJECTION OF ABRASIVE GRAINS (ALONG NORMAL LINE)	6.0
The diameter of abrasive grains is $400\mu\text{m}$ to $500\mu\text{m}$		

[0041] Fig. 11 is a histogram showing a wear test of respective ropes in the comparative example and the examples of Fig. 10. The vertical line of this graph designates a relative wear amount of each example on the condition that the wear amount of the example 3-1 is set "1." The graph indicates that the comparative example 3-1 exhibits a larger wear amount than those of examples 3-1 and 3-2. Thus, the graph teaches even if the Ras of individual grooves are substantially the same, if the amplitudes at each wavelength component are different, then the wear amounts of their ropes differ.

[0042] Fig. 12 is a graph showing an FFT-analyzed result of surfaces of the grooves in sheaves in the case where the projection conditions of abrasive grains change. When the respective amplitudes of examples 3-3 and 3-4 at each wavelength component are compared, the example 3-4 exhibits larger amplitudes than those of the example 3-3 within a region where the wavelength components are shorter than $70\mu\text{m}$. However, when both examples are subjected to the wear test, their wear amounts are almost the same. Thus, this result teaches that the amplitude at the wavelength less than $70\mu\text{m}$ hardly have an influence on the wear amount. This is because the wavelength less than $70\mu\text{m}$ are deemed to be so short that the projections of the sheave, which correspond to this short wavelength, are hardly engaged in the resin on the rope.

[0043] Fig. 13 is an additional graph showing an FFT-analyzed result of surfaces of the grooves in the case where the projection conditions of abrasive grains are changed. When their amplitudes of examples 3-5 and 3-6 at each wavelength component are compared, the example 3-5 exhibit larger amplitudes than those of example 3-6 at the wavelength components more than $140\mu\text{m}$. However, when they are subjected to the wear test, their wear amounts are almost the same. This proves that the amplitude at the wavelength longer than $140\mu\text{m}$ hardly have an influence on the wear amount. This reason is as follows. When the wavelength exceeds $140\mu\text{m}$, the contact area between the rope and the sheave is enlarged. This property is responsible for the decrease in the pressure therebetween, so that the resin on the rope is less prone to be adhered to the surface of the groove, as well as the projections of the sheave does not tend to be cut away.

[0044] Referring back to the graph of Fig. 10 showing the relationship between the wavelength and the amplitude, the respective amplitudes of the examples 3-1 and 3-2 within a region where the wavelength ranges from $70\mu\text{m}$ to $140\mu\text{m}$

is below a range from $0.5\mu\text{m}$ to $1.0\mu\text{m}$, which are one hundred-fortieth ($1/140$) of $70\mu\text{m}$ and $140\mu\text{m}$, respectively.

[0045] In contrast, the amplitude of the comparative example 3-1 within the same range is above the range from $0.5\mu\text{m}$ to $1.0\mu\text{m}$. Thus, the amplitude of surface of the groove within a range where the wavelength ranges from $70\mu\text{m}$ to $140\mu\text{m}$ needs to be below a range from $(1/140) \times 70\mu\text{m}$ to $(1/140) \times 140\mu\text{m}$, that is, a range from $0.5\mu\text{m}$ to $1.0\mu\text{m}$. This makes it possible to decrease the wear amount of the resin on the rope, thereby prolonging the lifetime of the rope. Even when the amplitude within a region where the wavelength ranges from $70\mu\text{m}$ to $140\mu\text{m}$ partially exceeds $1/140$ of the wavelength range, the wear of the rope may be reduced. However, it is preferable that the whole amplitude within a wavelength range of $70\mu\text{m}$ to $140\mu\text{m}$ falls below $1/140$ of the wavelength range.

[0046] Fig. 14 is a graph showing an FET-analyzed result. In this graph, a comparative example 4-1 has R_a of $3\mu\text{m}$. Furthermore, the comparative example 3-1 and the examples 3-1 and 3-2 are identical to those shown in Fig. 11. The comparative example 4-1 has smaller R_a than other comparative examples and examples and, therefore its amplitude at each wavelength component is also smaller than them.

[0047] Referring to a histogram of Fig. 15, each of the comparative example 3-1 and the examples 3-1 and 3-2 exhibits a friction coefficient ratio of nearly 1. In contrast, the comparative example 4-1 exhibits a friction coefficient ratio of 3, which means that this example is sensitive to the condition of the surface.

[0048] Referring to Fig. 14 again, the amplitude of the comparative example 4-1 within a wavelength range from $70\mu\text{m}$ to $140\mu\text{m}$ is smaller than a range from $0.05\mu\text{m}$ to $0.10\mu\text{m}$, which is $1/1400$ of the wavelength range. As described above, if the amplitude within a wavelength range from $70\mu\text{m}$ to $140\mu\text{m}$ is smaller than a range from $0.05\mu\text{m}$ to $0.10\mu\text{m}$, the puddles of oil on the surface fails to be made. This may cause the decrease in the friction coefficient, because oil is prone to go into a space between the rope and the sheave.

[0049] In conclusion, as long as the amplitude of a groove in a sheave within a wavelength range of $70\mu\text{m}$ to $140\mu\text{m}$ is larger than $1/1400$ of the wavelength range, the friction coefficient of the sheave is not degraded, because foreign matters are unlikely to enter.

[0050] The diameters of sheaves in the above examples are preferably 200mm . If the diameter exceeds 200mm , then the contact pressure between the sheave and the rope may decrease. In this case, the R_a , Z_v/Z_p or amplitude needs to increase by as much as the sheave exceeds 200mm in diameter.

[0051] Fig. 16 shows the cross-section of a groove of a sheave. This groove is formed by:

- projecting abrasive grains to a surface of the groove along a normal line with respect to a circumferential surface of the sheave;
- projecting abrasive grains to the surface of the groove along a tangent line with respect to the circumferential surface of the sheave; and
- coating the surface with metal plating 11.

[0052] Referring to Fig. 17, the plating layer is composed of two layers: one is metal plating layer 11, and the other is low-friction-resin-containing metal plating layer 12. It is preferable that the metal plating 11 is electroless nickel-phosphorus plating, and the low friction resin is tetra fluoro ethylene. The total thickness of both plating layers is preferably $10\mu\text{m}$ to $25\mu\text{m}$. If the thickness is less than $10\mu\text{m}$, then some pinholes may be formed in the plating layers in case where the material of the plating has any defects. Otherwise, if the thickness is more than $25\mu\text{m}$, then the plating layers may cover the surface roughness of grooves in the sheave. In this case, if oil is adhered to the surface, its friction coefficient may be degraded.

[0053] The thickness of the plating layer containing tetra fluoro ethylene is preferably $10\mu\text{m}$ to $15\mu\text{m}$. If this thickness is less than $10\mu\text{m}$, some pinholes may be formed in the plating layer in case where the material of the plating has any defects. Otherwise, if the thickness is more than $15\mu\text{m}$, then tetrafluoroethylene may not be distributed uniformly in the plating. Due to the above reasons, the recommended thickness of the plating layer containing tetrafluoroethylene is $10\mu\text{m}$ to $15\mu\text{m}$.

[0054] Features, components and specific details of the structures of the above-described embodiments may be exchanged or combined to form further embodiments optimized for the respective application. As far as those modifications are readily apparent for an expert skilled in the art they shall be disclosed implicitly by the above description without specifying explicitly every possible combination, for the sake of conciseness of the present description.

Claims

1. An elevator comprising:

- a car (1) ;
- a resin-covered wire rope (2) being connected to the car (1) ;

and

a sheave (4) around which the resin-covered wire rope (2) is wound, the sheave (4) for rotating, thereby driving the car (1) ;

the resin-covered wire rope (2) including a plurality of twisted steel wires that are coated with resin;

the sheave (4) on which at least one groove (9) is formed, the groove (9) having a surface of which arithmetic mean deviation of the profile Ra ranges from $4\mu\text{m}$ to $10\mu\text{m}$ in longitudinal and width directions of the groove (9);

wherein a ratio of Zva to Zpa falls within a range from 1.5 to 2.0, where Zva denotes an average of depths of lower parts on the surface of the groove (9), and Zpa denotes an average of heights of higher parts thereon.

2. The elevator according to claim 1, wherein the surface of the groove (9) has an amplitude falling below a range from $0.5\mu\text{m}$ to $1.0\mu\text{m}$ within a region where a wavelength of the surface ranges from $70\mu\text{m}$ to $140\mu\text{m}$.

3. The elevator according to claim 1 or 2, wherein if the sheave (4) has a diameter equal to/more than 200mm, then the ratio of Zva to Zpa increases by as much as the diameter exceeds 200mm.

4. The elevator according to at least one of claims 1 to 3, wherein if the sheave (4) has a diameter equal to/more than 200mm, then the amplitude of the surface of the groove (9) within a region where a wavelength of the surface ranges from $70\mu\text{m}$ to $140\mu\text{m}$ is below a range obtained by increasing a range from $0.5\mu\text{m}$ to $1.0\mu\text{m}$ by as much as the diameter exceeds 200mm.

5. The elevator according to at least one of claims 1 to 4, wherein the groove (9) is coated with a metal plating layer (11) having a thickness of $10\mu\text{m}$ to $25\mu\text{m}$.

6. The elevator according to at least one of claims 1 to 5, wherein the groove is coated with a metal plating layer (12) that contains low friction resin.

7. The elevator according to at least one of claims 1 to 6, wherein the groove (9) is formed by a process comprising:

projecting indefinite-polygonal or spherical particles to the surface of the groove (9) along a normal line with respect to a circumferential surface of the sheave (4); and

projecting indefinite-polygonal or spherical particles (10) to the surface of the groove (9) along a tangent line with respect to the circumferential surface of the sheave (4).

8. An elevator comprising:

a car (1) ;

a resin-covered wire rope (2) being connected to the car (1) ;

and

a sheave (4) around which the resin-covered wire rope (2) is wound, the sheave (4) for rotating, thereby driving the car (1) ;

the sheave (4) on which at least one groove (9) is formed, the groove (9) being formed by comprising:

projecting indefinite-polygonal or spherical particles (10) to a surface of the groove (9) along a normal line with respect to a circumferential surface of the sheave (4); and

projecting indefinite-polygonal or spherical particles (10) to the surface of the groove (9) along a tangent line with respect to the circumferential surface of the sheave (4).

9. The elevator according to claim 8, wherein the sheave (4) is coated with a metal plating layer (12) that contains low friction resin.

10. An elevator sheave (4) around which a resin-covered wire rope (2) connected to a car (1) is wound, the elevator sheave (4) for rotating, thereby driving the car (1), the elevator sheave (4) provided with at least one groove (9) which is formed by a process comprising:

EP 1 847 503 A1

projecting indefinite-polygonal or spherical particles (10) to a surface of the groove (9) along a normal line with respect to a circumferential surface of the sheave (4);
projecting indefinite-polygonal or spherical particles (10) to the surface of the groove (9) along a tangent line with respect to the circumferential surface of the sheave (4); and
5 coating the groove (9) with metal plating (12) that contains low friction resin.

5

10

15

20

25

30

35

40

45

50

55

FIG.1

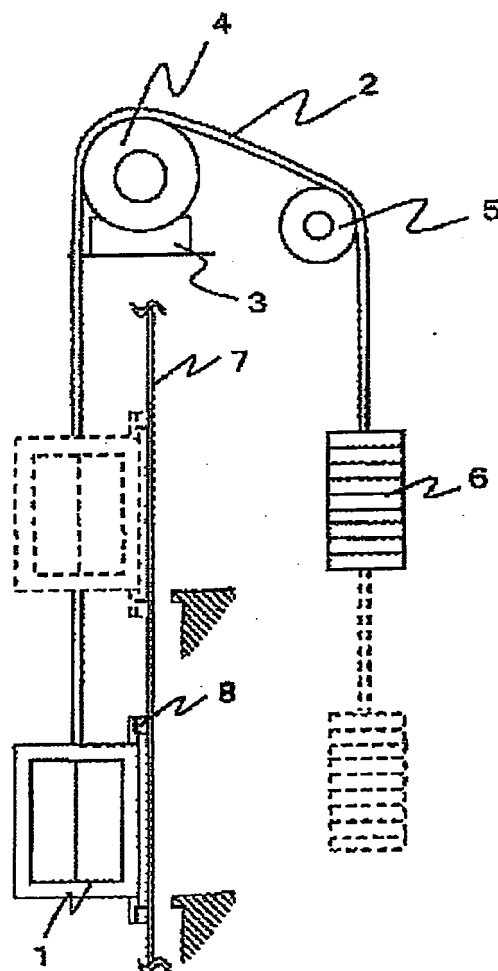


FIG.2A

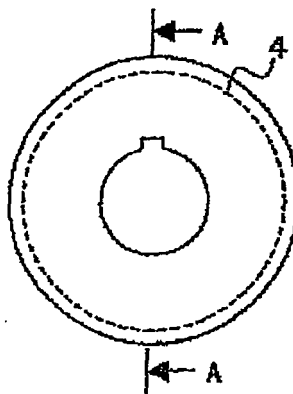


FIG.2B



FIG.3



FIG.4

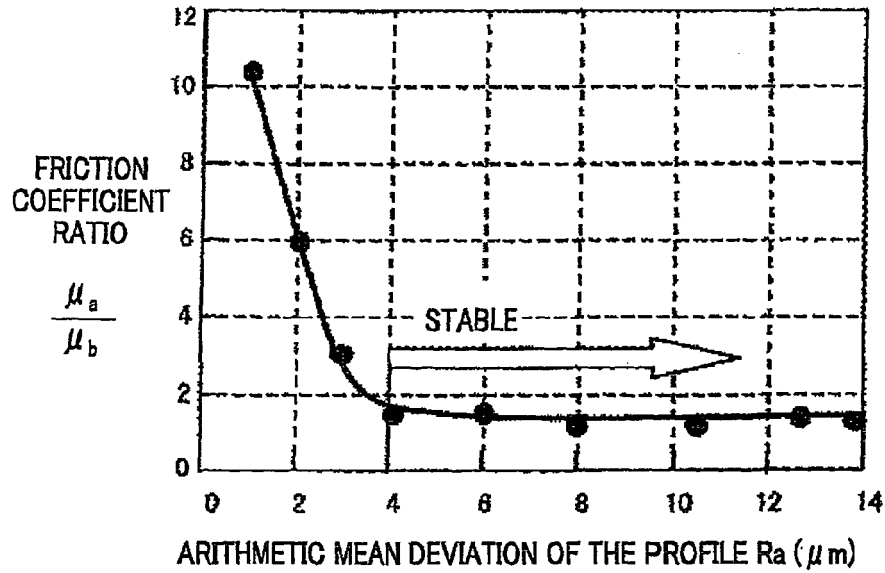


FIG.5

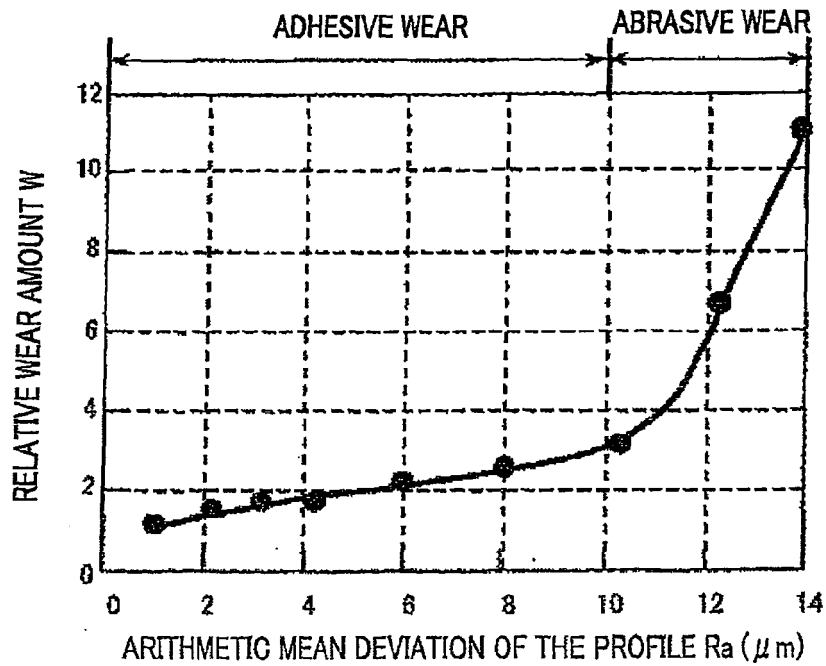


FIG.6A

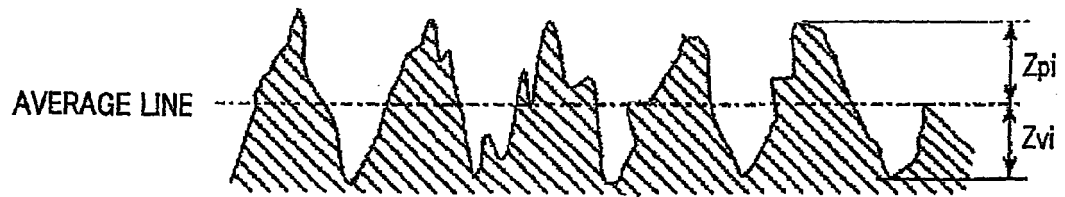


FIG.6B



FIG.7

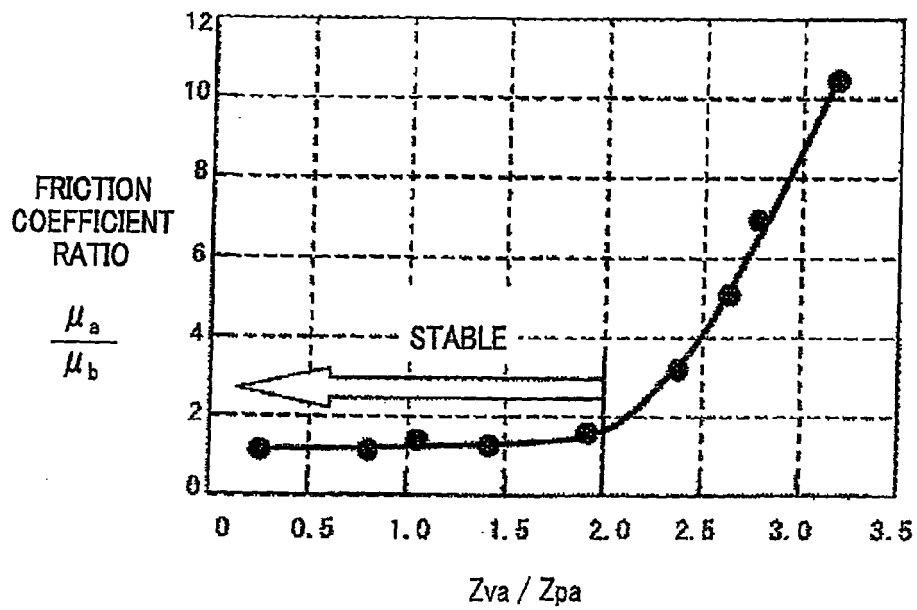


FIG.8

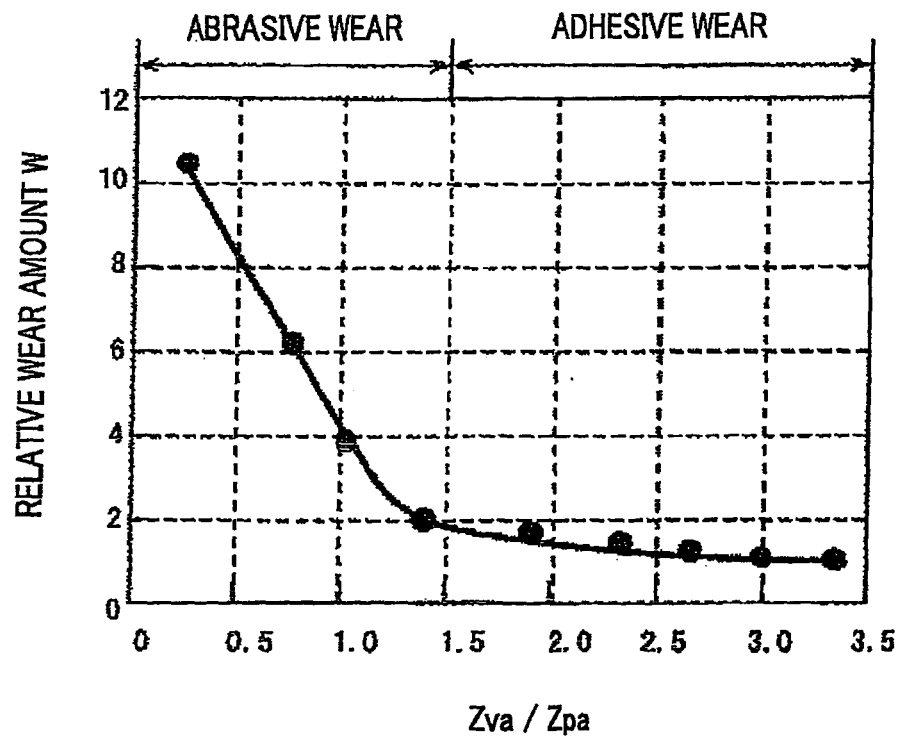


FIG.9A

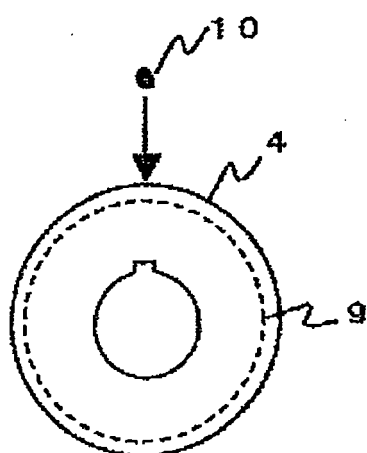


FIG.9B

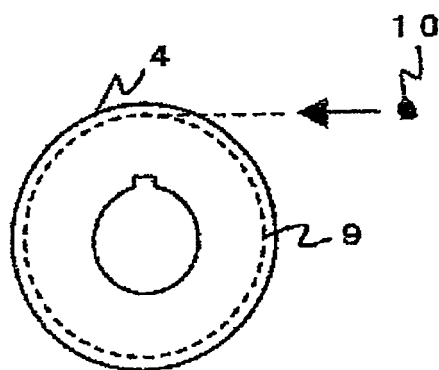


FIG. 10

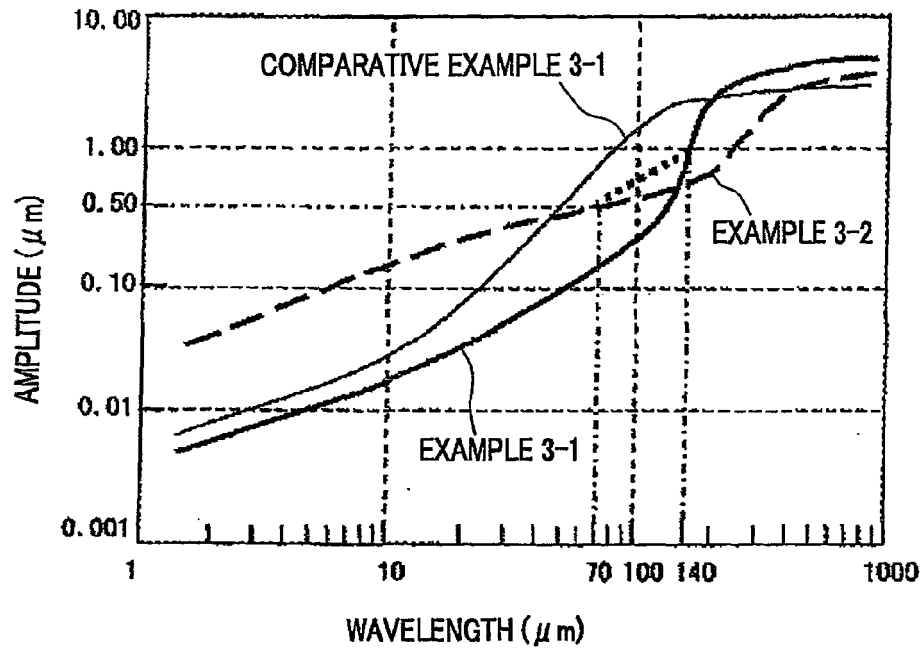


FIG. 11

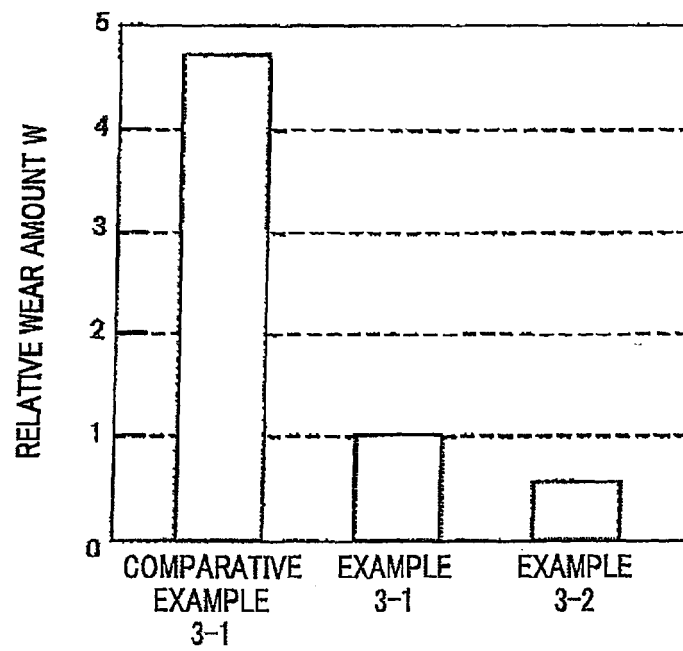


FIG.12

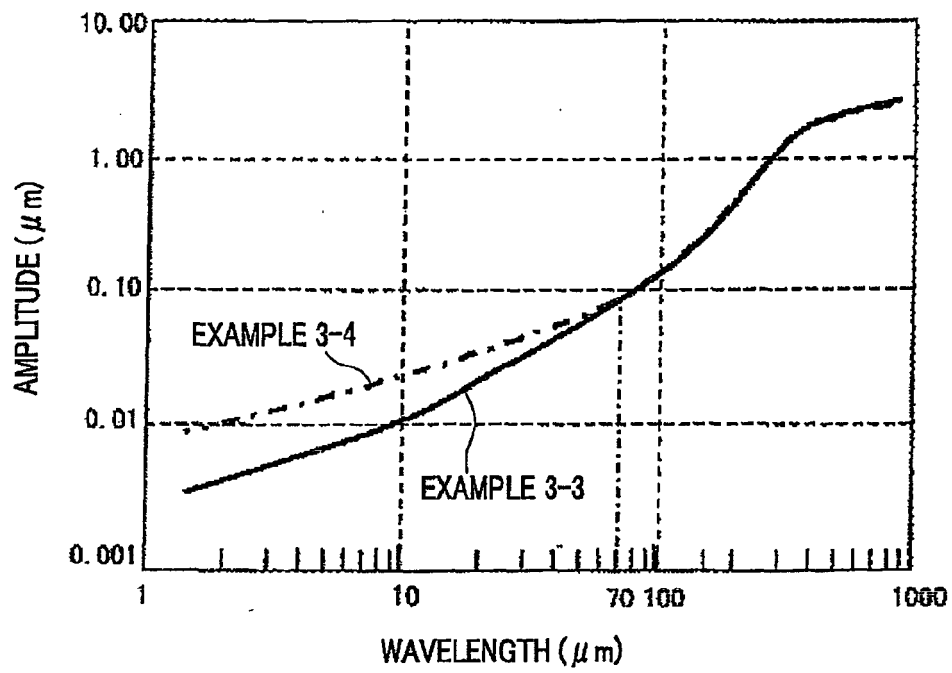


FIG.13

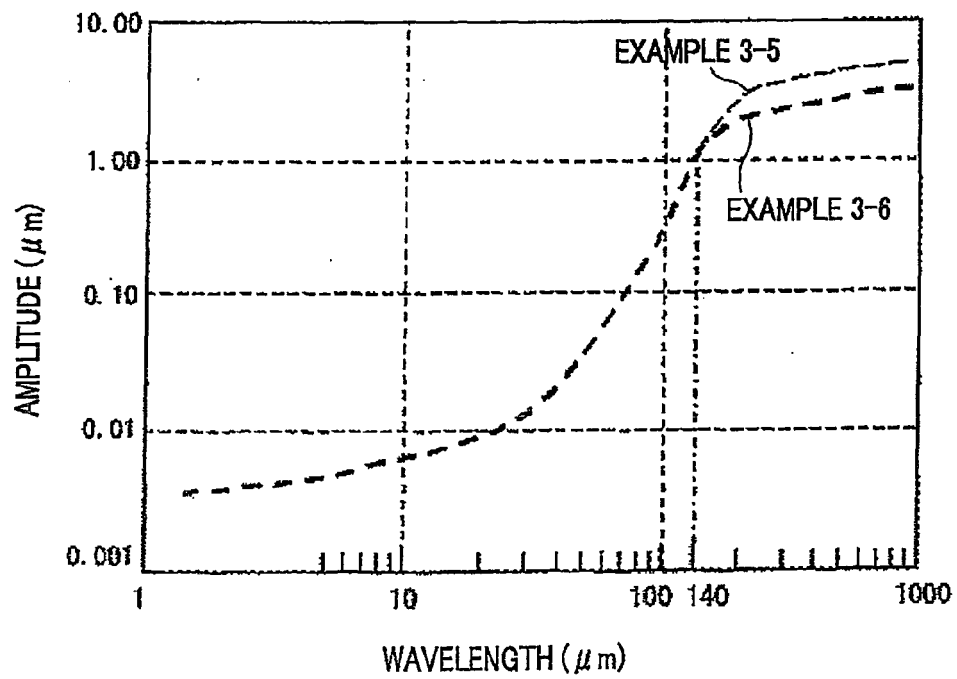


FIG.14

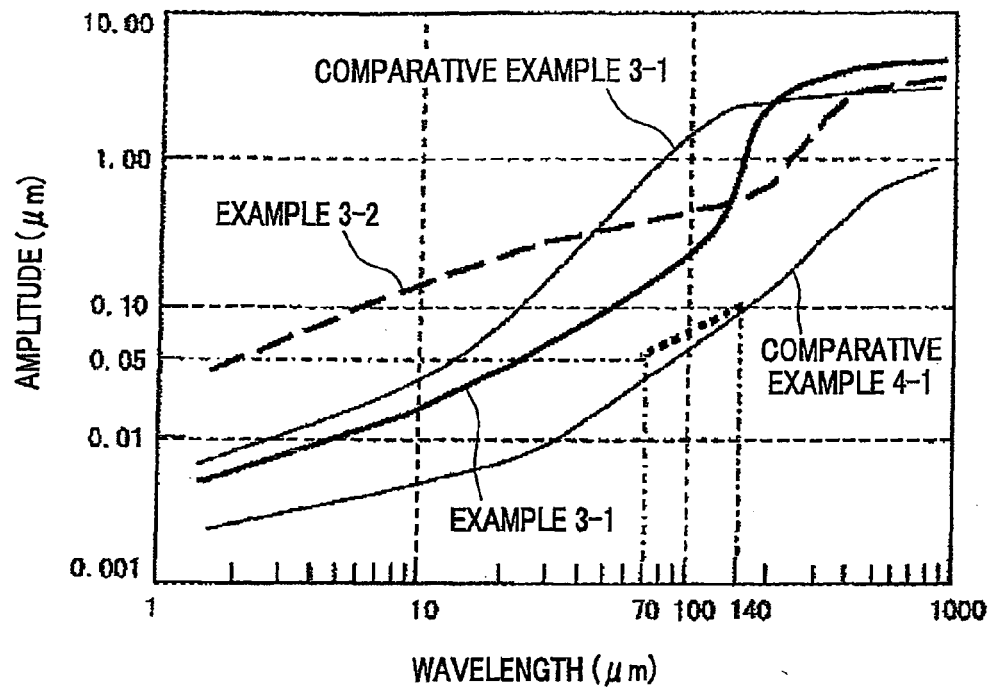


FIG.15

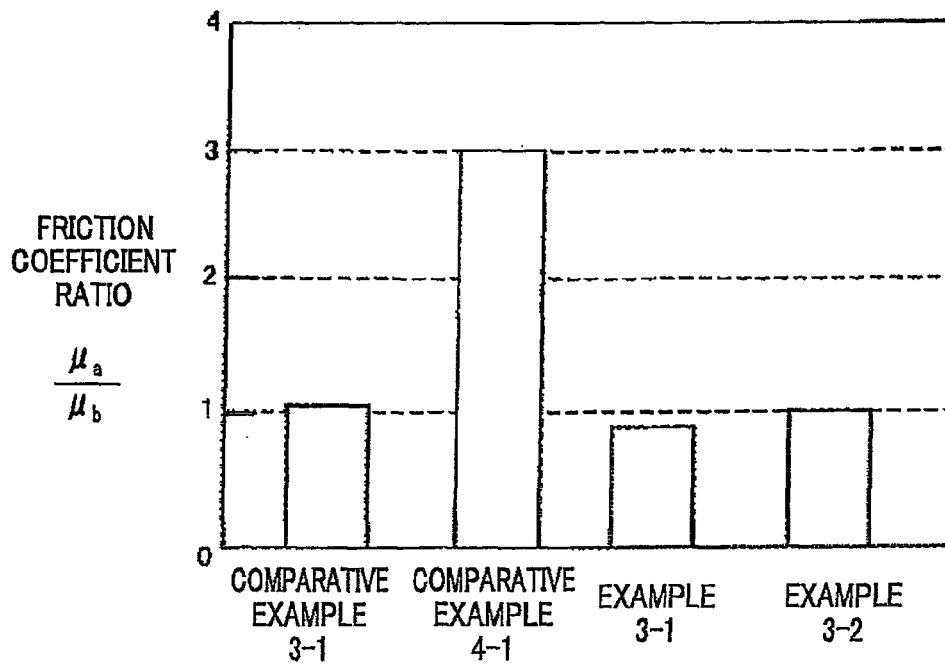


FIG.16

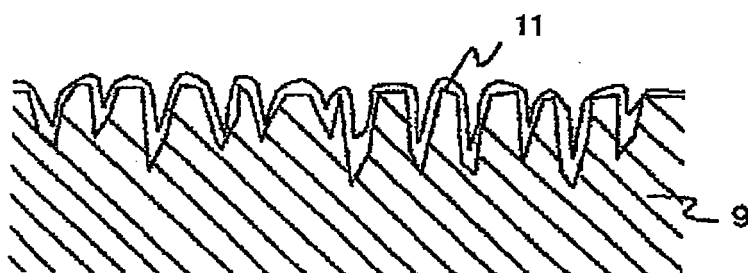
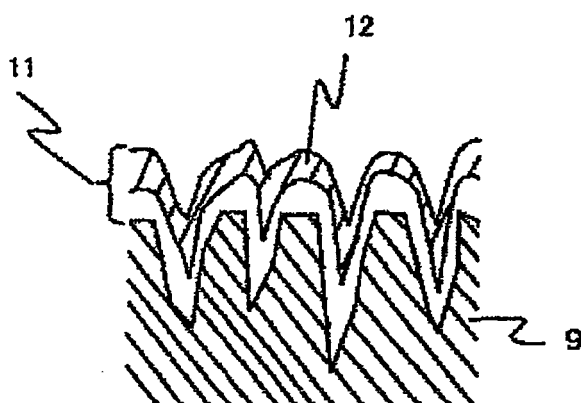


FIG.17





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 00 8115

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
D,A	US 6 371 448 B1 (DE ANGELIS CLAUDIO [CH]) 16 April 2002 (2002-04-16) * abstract * * column 1, line 57 - column 3, line 23 * * column 6, line 6 - line 39 * * figures 1,2 *	1-23	INV. B66B15/04
D,A	US 6 419 208 B1 (BARANDA PEDRO S [US] ET AL) 16 July 2002 (2002-07-16) * abstract * * column 2, line 3 - column 3, line 25 * * figures 1-3 *	1-23	
A	US 2003/192743 A1 (AULANKO ESKO [FI] ET AL) 16 October 2003 (2003-10-16) * abstract * * paragraph [0008] - paragraph [0024] * * paragraphs [0033], [0034] * * figures 1-3 *	1-23	
A	US 2005/221938 A1 (YOSHIDA MAKOTO [JP] ET AL) 6 October 2005 (2005-10-06) * abstract * * paragraph [0005] - paragraph [0009] * * paragraph [0024] - paragraph [0080] * * figures 1-13 *	1-23	TECHNICAL FIELDS SEARCHED (IPC) B66B B66D F16H
A	JP 05 010405 A (TOYOTA MOTOR CORP) 19 January 1993 (1993-01-19) * abstract * * paragraph [0009] - paragraph [0011] * * figures 1-6 *	1-23	
A	JP 2004 132457 A (TOYOTA MOTOR CORP) 30 April 2004 (2004-04-30) * abstract * * paragraph [0010] - paragraph [0016] * * figure 1 *	1-23	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 25 July 2007	Examiner Oosterom, Marcel
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

1
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 07 00 8115

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

25-07-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6371448	B1	16-04-2002	AR 026279 A1 05-02-2003
			AT 316213 T 15-02-2006
			AU 782437 B2 28-07-2005
			AU 6959800 A 03-05-2001
			BR 0005119 A 29-05-2001
			CA 2324740 A1 29-04-2001
			CN 1294271 A 09-05-2001
			DK 1096176 T3 15-05-2006
			ES 2255931 T3 16-07-2006
			HK 1038607 A1 21-04-2006
			ID 27875 A 03-05-2001
			IL 139055 A 25-09-2005
			JP 2001139267 A 22-05-2001
			MX PA00010467 A 23-05-2002
			NO 20005429 A 30-04-2001
			TR 200003153 A2 21-05-2001
			TW 243792 B 21-11-2005
			ZA 200005706 A 16-05-2001
US 6419208	B1	16-07-2002	BR 0009350 A 08-01-2002
			CN 1346329 A 24-04-2002
			DE 60020546 D1 07-07-2005
			DE 60020546 T2 27-04-2006
			EP 1169256 A2 09-01-2002
			ES 2240090 T3 16-10-2005
			JP 2003512269 T 02-04-2003
			TW 494083 B 11-07-2002
			WO 0059819 A2 12-10-2000
US 2003192743	A1	16-10-2003	AT 327960 T 15-06-2006
			AU 1717802 A 18-06-2002
			BR 0116040 A 14-10-2003
			CA 2427361 A1 13-06-2002
			CN 1476409 A 18-02-2004
			CZ 20031583 A3 13-10-2004
			DE 60120212 T2 21-09-2006
			DK 1339629 T3 25-09-2006
			EP 1339629 A1 03-09-2003
			ES 2260340 T3 01-11-2006
			WO 0246086 A1 13-06-2002
			FI 20002701 A 09-06-2002
			HK 1059073 A1 26-08-2005
			HU 0302652 A2 28-11-2003
			JP 2004515430 T 27-05-2004
			MX PA03004800 A 10-09-2003
			NO 20032530 A 04-06-2003

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 07 00 8115

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

25-07-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003192743 A1		PL 365519 A1	10-01-2005
		PT 1339629 T	29-09-2006
		SK 6932003 A3	04-11-2003
		UA 75096 C2	15-08-2003
		ZA 200303741 A	16-08-2004

US 2005221938 A1	06-10-2005	DE 102005014207 A1	13-10-2005
		JP 2005321090 A	17-11-2005
		KR 20060044717 A	16-05-2006

JP 5010405 A	19-01-1993	NONE	

JP 2004132457 A	30-04-2004	NONE	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2003512269 A [0005]
- JP 2001139267 A [0006]