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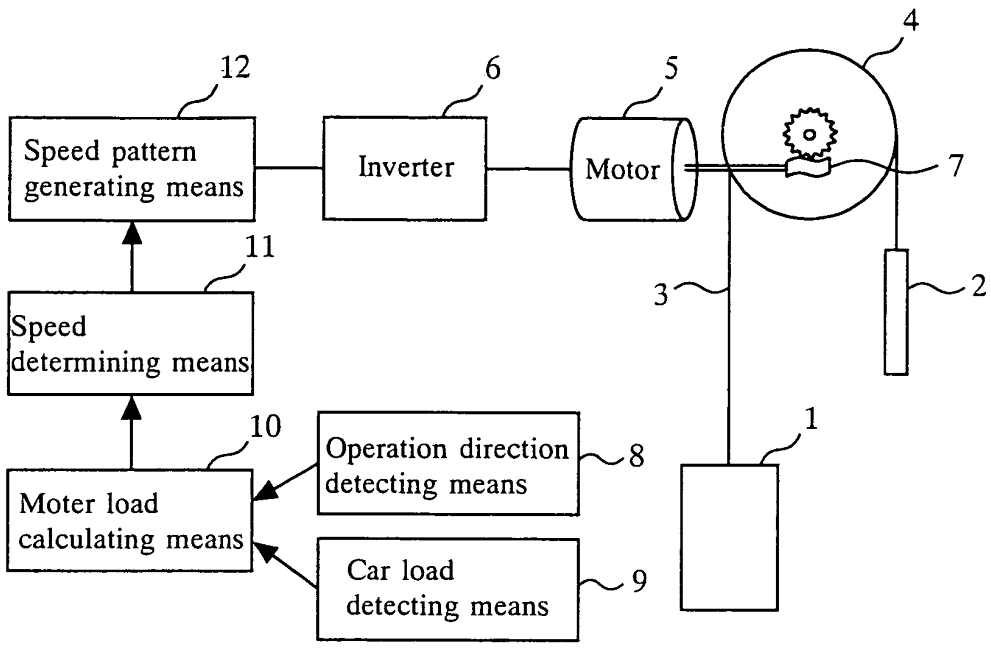
(54) Controller for elevator

(57) A controller for an elevator equipped with a gear-type traction machine which transmits the driving force of a motor to a driving sheave via a gear, which is constituted by a car which ascends and descends in an elevator shaft, car load detecting means which detects a load acting on the car, operation direction detecting means which detects an operation direction of the car, and speed determining means which determines a maximum speed of the car according to characteristics of the motor during a power running operation and a maximum speed of the car according to characteristics of the gear of the gear-type traction machine during a braking operation on the basis of detection results of the car load detecting means and the operation direction detecting means.

Fig.1



EP 1 721 855 A2

Description

Technical Field

[0001] The present invention relates to a controller for an elevator which is provided with a geared traction machine which transmits the driving force of a motor to a driving sheave via a gear.

Background Art

[0002] There have been proposed conventional controllers for elevators which are provided with car load detecting means which detects the weight of a car as car load and next stop-floor setting means which sets a next stop floor and changes the maximum speed and acceleration of a car within an allowable driving range of a motor of a traction machine according to a car load obtained by the car load detecting means and a moving distance of the car obtained from the next stop-floor setting means, whereby the operation efficiency of the elevator is improved by shortening the operation time of the car (refer to Patent Document 1, for example).
[0003] Patent Document 1: Japanese Patent Laid-Open No. 2003-238037

Disclosure of the Invention

Problems to be Solved by the Invention

[0004] In the controller for an elevator described in the Japanese Patent Laid-Open No. 2003-238037, the maximum speed and acceleration of a car have been set within an allowable driving range of a motor of a traction machine so that a car can arrive at a next stop-floor which is registered in the shortest time. However, in a case where the elevator is equipped with a gear-type traction machine which transmits the driving force of a motor to a driving sheave via a gear, the elevator had the problem that in some characteristics of the gear, it is impossible to obtain a desired speed and acceleration even when the control is within the range of motor characteristics particularly during a braking operation. The elevator had also the problem that by continuing operation control based on the characteristics of the motor alone, an excessive overload acts on the gear of the gear-type traction machine, thereby adversely worsening the operation efficiency and shortening the life of the gear-type traction machine.
[0005] The present invention has been made in order to solve problems as described above, and the object of the invention is to provide a controller for an elevator which can perform optimum operation control of a car according to motor characteristics and gear characteristics in an elevator provided with a gear-type traction machine which transmits the driving force of a motor to a driving sheave via a gear.

Means for Solving the Problems

[0006] The present invention provides a controller for an elevator equipped with a gear-type traction machine which transmits the driving force of a motor to a driving sheave via a gear, which comprises a car which ascends and descends in an elevator shaft, car load detecting means which detects a load acting on the car, operation direction detecting means which detects an operation direction of the car, and speed determining means which determines a maximum speed of the car suited to characteristics of the motor during a power running operation and determines a maximum speed of the car suited to characteristics of the gear of the gear-type traction machine during a braking operation on the basis of detection results of the car load detecting means and the operation direction detecting means.

Effect of the Invention

[0007] The present invention provides a controller for an elevator equipped with a gear-type traction machine which transmits the driving force of a motor to a driving sheave via a gear, which comprises a car which ascends and descends in an elevator shaft, car load detecting means which detects a load acting on the car, operation direction detecting means which detects an operation direction of the car, and speed determining means which determines a maximum speed of the car suited to characteristics of the motor during a power running operation and determines a maximum speed of the car suited to characteristics of the gear of the gear-type traction machine during a braking operation on the basis of detection results of the car load detecting means and the operation direction detecting means. Therefore, even in an elevator equipped with a gear-type traction machine which transmits the driving force of a motor to a driving sheave via a gear, it is possible to perform optimum operation control of the car according to motor characteristics and gear characteristics.

Best Mode for Carrying Out the Invention

[0008] The present invention will be described in further detail with reference to the accompanying drawings. Incidentally, the same or corresponding parts in the drawings are identified by the same reference numerals, and overlapping descriptions of these parts are appropriately simplified or omitted.

Embodiment 1

[0009] Fig. 1 is a configuration diagram of a controller for an elevator in Embodiment 1 of the present invention. In Figure 1, the reference numeral 1 denotes a car which ascends and descends in an elevator shaft, and the reference numeral 2 denotes a counterweight which ascends and descends in the elevator shaft in a direction reverse to the car 1. The weight of the whole counterweight 2 is adjusted beforehand so that this weight becomes almost equal to the weight of the whole car 1 when half a designated number of passengers ride on the car 1, that is, when a load equivalent to half a rated load acts on the car 1. The reference numeral 3 denotes a main rope which is connected to the car 1 and the counterweight 2 and suspends the car 1 and the counterweight 2 like a well bucket, the reference numeral 4 denotes a driving sheave of a gear-type traction machine in which by winding the main rope 3 around a rope groove formed in an outer peripheral surface of the driving sheave 4, the car 1 and the counterweight 2 are caused to ascend and descend in conjunction with the rotation of the driving sheave 4, the reference numeral 5 denotes a motor which is driven by supplying power from an inverter 6, and the reference numeral 7 denotes a gear of a gear-type traction machine which is constituted by a worm gear and the like and transmits the driving force of the motor 5 to the driving sheave 4. That is, the gear-type traction machine provided in the elevator is constructed in such a manner as to transmit the driving force of the motor 5 to the driving sheave 4 via the gear 7.

[0010] The reference numeral 8 denotes operation direction detecting means which detects the operation direction of the car 1, the reference numeral 9 denotes car load detecting means which is provided on the floor or the like of the car 1 and detects a load acting on the car 1 from a live load and the like in the car 1, and the reference numeral 10 denotes motor load calculating means which calculates a load acting on the motor 5 on the basis of detection results of the operation direction detecting means 8 and detection results of the car load detecting means 9. Incidentally, the motor load calculating means 10 calculates the load ratio of the car 1 on the basis of live load information of the car 1 which is inputted from the car load detecting means 9 and rated load information of the car 1 which has been registered beforehand and calculates a load acting on the motor 5 on the basis of this load ratio and operation direction information which is inputted from the operation direction detecting means 8. The above-described load ratio means the ratio of a live load acting on the car 1 to a rated load. The load ratio is 0% when nothing is loaded on the car 1, and the load ratio is 100% when a rated load acts on the car 1.

[0011] The reference numeral 11 denotes speed determining means which determines a maximum speed of the car 1 suited to the characteristics of the motor 5 during a power running operation and a maximum speed of the car 1 suited to the characteristics of the gear 7 of the gear-type traction machine during a braking operation on the basis of motor load information which is inputted from the motor load calculating means 10. The above-described power running operation refers to a case where the energy supplied from the power source is supplied from the power source side to the car 1 side via the motor 5, the inverter 6 and the like. Concretely, an ascent operation of the car 1 when the weight of the car 1 is heavier than the weight of the counterweight 2 and a descent operation of the car 1 when the weight of the car 1 is lighter than the weight of the counterweight 2 fall under the power running operation. The above-described braking operation refers to a case where the energy generated by the ascent and descent of the car 1 is supplied from the car 1 side to the power source side via the motor 5, the inverter 6 and the like. Concretely, a descent operation of the car 1 when the weight of the car 1 is heavier than the weight of the counterweight 2 and an ascent operation of the car 1 when the weight of the car 1 is lighter than the weight of the counterweight 2 fall under the braking operation.

[0012] Figure 2 is a diagram to describe the operation of the above-described speed determining means 11 in Embodiment 1 of the present invention. In Figure 2, the maximum speed of the car 1 during a power running operation is set on the basis of the characteristics of the motor 5, for example, a driving range of the motor 5 which is electrically allowable and the maximum speed of the car 1 during a braking operation is set on the basis of the characteristics of the gear 7 of the gear-type traction machine, for example, an operation rage of the gear 7 which is thermally allowable. Incidentally, Figure 2 shows a case where a maximum speed of the car 1 when a rated load acts on the car 1 is set at 60 m/min both during a power running operation and during a braking operation. The setting of a maximum speed of the car 1 will be described later.

[0013] For example, in a case where the load ratio of the car 1 which is inputted from the motor load calculating means 10 is 80% and operation direction information states an ascent operation (UP), that is, in the case of a power running operation at a load ratio of 80% (a balanced condition is obtained when the load ratio is 50%), a maximum speed of the car 1 is determined to be 75 m/min by the speed determining means 11 and this speed is outputted as speed information of the car 1. In a case where the load ratio of the car 1 which is inputted from the motor load calculating means 10 is

95% and operation direction information states a descent operation (DN), that is, in the case of a braking operation at a load ratio of 95%, a maximum speed of the car 1 is determined to be 60 m/min and this speed is outputted as speed information of the car 1.

[0014] The reference numeral 12 in Figure 1 denotes speed pattern generating means which generates a speed pattern for controlling the inverter 6 on the basis of speed information of the car 1 which is inputted from the speed determining means 11 and the like. Incidentally, any configuration of this speed pattern generating means 12 is permitted so long as the speed pattern generating means 12 can generate a speed pattern which is appropriate for each piece of speed information which is inputted from the speed determining means 11. For example, the speed pattern generating means 12 may be such that it determines the acceleration and maximum ascent and descent speeds of the car 1 on the basis of speed information which is inputted from the speed determining means 11, load ratio information which is inputted from the motor load calculating means 10, destination floor information which is inputted from a destination floor registering device which is not shown, car position information which shows the present position of the car 1 and the like, and prepares a speed pattern so that the car 1 arrives at a registered destination floor in the shortest time.

[0015] Incidentally, Fig. 3 shows an example of a speed pattern which is prepared on the basis of a maximum speed of the car 1 which is shown in Fig. 2. In Figure 3, P1 to P3 each indicate a speed pattern for each load ratio which is prepared when the car ascends and descends in the same route. In the speed patterns P1 to P3 shown in Figure 3, the acceleration and deceleration are set at a constant value to simplify the illustration.

[0016] Next, a maximum speed of the car 1 set in the above-described speed determining means 11 will be described in detail.

[0017] If in Figure 1 the speed of the car 1 is denoted by V, the weight of the car 1 is denoted by M and the weight of the counterweight 2 is denoted by m, then the energy Pm resulting from the ascent and descent of the car 1 is calculated by the following equation. (Coefficients are omitted in the following equation.)

$$Pm = V \cdot (M - m) \qquad \text{...... Eq.1}$$

[0018] During a power running operation, energy of Pm is supplied to the car 1 from the power source side. Incidentally, energy losses corresponding to the energy Pm supplied to the car 1 are generated in an electric wire from the power source to the inverter 6, in the inverter 6, the motor 5, the gear 7 and the like. In a case where a live load of the car 1 decreases and the weight M of the car 1 decreases to M' from the weight Mo while a rated load acts on the car 1, the above-described value of Pm naturally decreases if the speed V of the car 1 remains to be the rated speed Vo. That is, the energy which is supplied to the above-described electric wire, inverter 6, motor 5, gear 7 and the like also decreases. For this reason, a margin is produced in the electrical performance, i.e., operation capacity of each electric devices such as the motor 5, and it becomes possible to increase the speed V of the car 1 to such an extent that the above-described value of Pm becomes equivalent to a value which is calculated with Mo, which is the weight of the car 1 while a rated load acts on the car 1, and at the rated speed Vo. If the speed of the car 1 at this time is denoted by V', then the following equation holds.

$$Pmo = Vo \cdot (Mo - m) = V' \cdot (M' - m) \qquad \text{...... Eq.2}$$

[0019] Incidentally, Figure 4 shows the relationship of this equation, which shows a maximum speed of the car 1 suited to the electrical characteristics of the motor 5 during a power running operation.

[0020] During a braking operation, energy is supplied from the car 1 side to the power source side via the gear 7, the motor 5, the inverter 6 and the like. In the same manner as during a power running operation, energy losses are generated in the gear 7, the motor 5, the inverter 6 and the like. Incidentally, the energy loss generated in the gear 7 is large compared to the energy losses generated in the electric devices, mainly the motor 5 and the like, and this tendency is remarkable especially when the gear 7 is constituted by a worm gear. For this reason, even when energy of the same quantity as the energy which is supplied from the power source side during a power running operation is generated on the car 1 side during a braking operation, the energy supplied to the electric devices such as the motor 5 is smaller during a braking operation than during a power running operation by a quantity which passes through the gear 7 with a large energy loss. That is, during a braking operation, a margin is produced in the electrical operation capacity of the electric devices such as the motor 5 even while a rated load acts on the car 1. Therefore, when attention is paid to the electric devices such as the motor 5 alone, it is possible to increase the speed of the car 1 even during a braking operation while a rated load acts on the car 1.

[0021] On the other hand, the energy loss generated in the gear 7 during a braking operation shows a value almost equivalent to the energy loss generated in the gear 7 during a power running operation. For example, when calculations are made for the gear 7 having a gear ratio of 67:1, in a case where the energy on the car 1 side is denoted by Pm, the energy loss Lm of the gear 7 during a power running operation and the energy loss Lb of the gear 7 during a braking operation are respectively calculated by the following equations.

$$Lm = Pm/\eta - Pm \cdot (1 - \eta)/\eta$$

$$Lb = Pm - \gamma Pm = Pm \cdot (1 - \gamma) \qquad \text{...... Eq.3}$$

where η is the efficiency of the gear 7 during a power running operation (efficiency during a power running operation), and γ is the efficiency of the gear 7 during a braking operation (efficiency during a braking operation). Incidentally, for the efficiency during a power running operation η and the efficiency during a braking operation γ, according to some data, $\eta = 0.63$ and $\gamma = 0.39$ when the gear ratio is 67:1. Substituting these values into Eq. 3, we obtain an energy loss during a power running operation Lm = 0.59 Pm and an energy loss during a braking operation Lb = 0.61 Pm.

[0022] As described above, the energy loss generated in the gear 7 shows almost the same value during a power running operation and during a braking operation. Therefore, for the heat generation resulting from the energy loss, almost the same heat is generated during a power running operation and during a braking operation. Usually, the operation capacity of the gear 7 is limited by the temperature characteristics of each gear which constitutes the gear 7 rather than the mechanical strength of each gear which constitutes the gear 7. Therefore, during a braking operation, even when there is a margin in the electrical operation capacity of the electric devices such as the motor 5, it is impossible to increase the speed of the car 1 above the operation capacity of the gear 7, because the operation capacity of the gear 7 is limited by the heat generation resulting from the energy loss.

[0023] Incidentally, in a case where during a braking operation, a live load of the car 1 decreases and the weight M of the car 1 decreases to M' from the weight Mo while a rated load acts on the car 1, the quantity of heat generated in the gear 7 naturally decreases if the speed V of the car 1 remains to be the rated speed Vo. As a result, it becomes possible to increase the speed V of the car 1 to such an extent that the above-described value of Pm becomes equivalent to a value which is calculated with Mo, which is the weight of the car 1 while a rated load acts on the car 1, and at the rated speed Vo. If the speed of the car 1 at this time is denoted by V', then the following equation holds.

$$Pmo = Vo \cdot (Mo - m) = V' \cdot (M' - m) \qquad \text{...... Eq.4}$$

[0024] Incidentally, Figure 5 shows the relationship of this equation, which shows a maximum speed of the car 1 suited to the temperature characteristics of the gear 7 during a braking operation.

[0025] In Figure 4 and Figure 5, a maximum speed of the car 1 suited to the characteristics of the motor 5 and the characteristics of the gear 7 is shown so as to be capable of being increased without limitation in a balanced condition (M = m) in which the weight M of the car 1 is equal to the weight m of the counterweight 2. In an actual operation, however, a prescribed maximum speed exists under other constraints of safety equipment and the like. Fig. 6 is a diagram which shows a maximum speed of the car 1 during a power running operation and during a braking operation when the constraints of safety equipment and the like are considered. In Figure 6, during a power running operation, a maximum speed based on the electrical characteristics of the electric devices, among others, the motor 5 is lower than a maximum speed based on the thermal characteristics of the gear 7. For this reason, a maximum speed of the car 1 which is set in the speed determining means 11 is determined mainly by the electrical characteristics of the motor 5. Incidentally, even during a power running operation, in a condition close to the balanced condition of M = m, a maximum speed is determined on the basis of the constraints of safety equipment and the like. On the other hand, during a braking operation, a maximum speed based on the thermal characteristics of the gear 7 is much lower than a maximum speed based on the electrical characteristics of the motor 5. For this reason, a maximum speed of the car 1 set in the speed determining means 11 is determined mainly by the thermal characteristics of the gear 7. Incidentally, also during a braking operation, in a condition close to the balanced condition of M = m, a maximum speed is determined on the basis of the constraints of safety equipment and the like.

[0026] In Embodiment 1 of the present invention, a maximum speed of the car 1 in the formation of a speed pattern is determined according to the characteristics of the motor 5 during a power running operation and according to the characteristics of the gear 7 during a braking operation. Therefore, it becomes possible to perform optimum operation control of the car 1 and to improve the operation efficiency of the elevator. That is, it becomes possible to prevent the operation efficiency from becoming worse due to an excessive overload on the gear 7 during elevator operations and also to prevent the life of the gear-type traction machine from becoming short due to excessive heat generated in the gear 7.

Embodiment 2

[0027] Figure 7 is a configuration diagram of a controller for elevators in Embodiment 2 of the present invention. In Figure 7, the reference numeral 13 denotes gear temperature detecting means which detects the temperature of a gear 7 of a gear-type traction machine, and the reference numeral 14 denotes gear temperature judging means which judges whether the temperature of the gear 7 detected by the gear temperature detecting means 13 exceeds a prescribed value. Incidentally, the gear temperature detecting means 13 may be either a type which directly measures the temperature of the gear 7 or a type which indirectly detects the temperature of the gear 7 on the basis of the temperature of a gear oil and the like used in the gear 7. Other configurational features are the same as in Embodiment 1.

[0028] Next, the operation of the controller for an elevator having the above-described configurational features will be described.

[0029] In the same manner as in Embodiment 1, motor load calculating means 10 detects a load acting on a motor 5 on the basis of detection results of operation direction detecting means 8 and detection results of car load detecting means 9. Speed determining means 11 determines a maximum speed of a car 1 suited to the characteristics of the motor 5 during a power running operation and a maximum speed of the car 1 suited to the characteristics of the gear 7 of the gear-type traction machine during a braking operation on the basis of motor load information which is inputted from the motor load calculating means 10 and judgment results of the gear temperature judging means 14.

[0030] Figure 8 is a diagram to describe the operation of the speed determining means 11 in Embodiment 2 of the present invention. In Figure 8, a maximum speed of the car 1 during a power running operation is set in the same manner as in Embodiment 1 according to the characteristics of the motor 5 on the basis of calculation results of the motor load calculating means 10. On the other hand, a maximum speed of the car 1 during a braking operation is set according to the characteristics of the gear 7 on the basis of judgment results of the gear temperature judging means 14 and calculation results of the motor load calculating means 10. That is, in a case where during a braking operation, it is judged by the gear temperature judging means 14 that the temperature of the gear 7 of the gear-type traction machine does not exceed a prescribed value, in the same manner as in Embodiment 1, the speed determining means 11 determines a maximum speed of the car 1 which is set on the basis of an operation range of the gear 7 which is thermally allowable.

[0031] In contrast to this, in a case where during a braking operation, it is judged by the gear temperature judging means 14 that the temperature of the gear 7 of the gear-type traction machine exceeds a prescribed value, the speed determining means 11 determines a maximum speed which is limited to not more than a maximum speed of the car 1 in the case where it is judged by the gear temperature judging means 14 that the temperature of the gear 7 of the gear-type traction machine does not exceed a prescribed value. That is, when during a braking operation, the temperature of the gear 7 exceeds a prescribed value, a maximum speed of the car 1 is limited below a maximum speed during an ordinary operation, whereby the heat generated in the gear 7 is suppressed and the worsening of the operation efficiency of the elevator and the shortening of the life of the gear-type traction machine are prevented. Incidentally, in other respects, Embodiment 2 performs the same operation and produces the same effects as in Embodiment 1.

Brief Description of the Drawings

[0032]

Figure 1 is a configuration diagram of a controller for an elevator in Embodiment 1 of the present invention.
Figure 2 is a diagram to describe the operation of speed determining means in Embodiment 1 of the present invention.
Figure 3 is a diagram which shows a speed pattern of a car in Embodiment 1 of the present invention.
Figure 4 is a diagram which shows a maximum speed of a car based on electrical characteristics of electrical devices during a power running operation.
Figure 5 is a diagram which shows a maximum speed of a car based on temperature characteristics of a gear during a braking operation.
Figure 6 is a diagram which shows a maximum speed of a car during a power running operation and during a braking operation.
Figure 7 is a configuration diagram of a controller for an elevator in Embodiment 2 of the present invention.
Figure 8 is a diagram which shows a speed of a car in Embodiment 2 of the present invention.

Description of the Symbols

[0033]

1 Car, 2 Counterweight, 3 Main rope, 4 Driving sheave,
5 Motor, 6 Inverter, 7 Gear,
8 Operation direction detecting means, 9 Car load detecting means,
10 Motor load calculating means, 11 Speed determining means,
12 Speed pattern generating means, 13 Gear temperature detecting means,
14 Gear temperature judging means

Claims

1. A controller for an elevator equipped with a gear-type traction machine which transmits the driving force of a motor (5) to a driving sheave(4) via a gear(7), comprising:

a car(1) which ascends and descends in an elevator shaft;
car load detecting means(9) which detects a load acting on the car(1);
operation direction detecting means(8) which detects an operation direction of the car(1); and
speed determining means(11) which determines a maximum speed of the car(1) suited to characteristics of the motor(5) during a power running operation and determines a maximum speed of the car(1) suited to characteristics of the gear(7) of the gear-type traction machine during a braking operation on the basis of detection results of the car load detecting means(9) and the operation direction detecting means(8).

2. A controller for an elevator equipped with a gear-type traction machine which transmits the driving force of a motor (5) to a driving sheave(4) via a gear(7), comprising:

a car(1) which ascends and descends in an elevator shaft;
car load detecting means(9) which detects a load acting on the car(1);
operation direction detecting means(8) which detects an operation direction of the car(1);
gear temperature judging means(14) which detects a temperature of the gear(7) of the gear-type traction machine and judges whether the temperature of the gear(7) exceeds a prescribed value; and
speed determining means(11) which determines a maximum speed of the car(1) suited to characteristics of the motor(5) during a power running operation and determines a maximum speed of the car(1) suited to characteristics of the gear(7) of the gear-type traction machine during a braking operation on the basis of detection results of the car load detecting means(9) and the operation direction detecting means(8) and judgment results of the gear temperature judging means(14).

3. The controller for an elevator according to claim 2, **characterized in that** the speed determining means(11) determines, during a power running operation, a maximum speed of the car(1) suited to characteristics of the motor(5) on the basis of detection results of the car load detecting means(9) and the operation direction detecting means(8) and determines, during a braking operation, a maximum speed of the car(1) suited to characteristics of the gear(7) of the gear-type traction machine on the basis of detection results of the car load detecting means(9) and the operation direction detecting means(8) and judgment results of the gear temperature judging means(14).

4. The controller for an elevator according to claim 2 or claim 3, **characterized in that** in a case where it is judged by the gear temperature judging means(14) that the temperature of the gear(7) of the gear-type traction machine has exceeded a prescribed value, the speed determining means(11) limits a maximum speed of the car(1) during a braking operation to a value which is not more than the maximum speed of the car(1) in a case where it is judged by the gear temperature judging means(14) that during a braking operation, the temperature of the gear(7) of the gear-type traction machine does not exceeds a prescribed value.

5. The controller for an elevator according to any one of claims 2 to 4, **characterized in that** the gear temperature judging means(14) detects the temperature of the gear(7) on the basis of the temperature of a gear oil used in the gear(7) of the gear-type traction machine.

6. The controller for an elevator according to any one of claims 1 to 5, **characterized in that** a maximum speed during a braking operation which is determined by the speed determining means(11) is set on the basis of temperature characteristics of the gear(7) of the gear-type traction machine.

7. The controller for an elevator according to any one of claims 1 to 6, **characterized in that** the gear(7) of the gear-type traction machine is constituted by a worm gear.

Fig.1

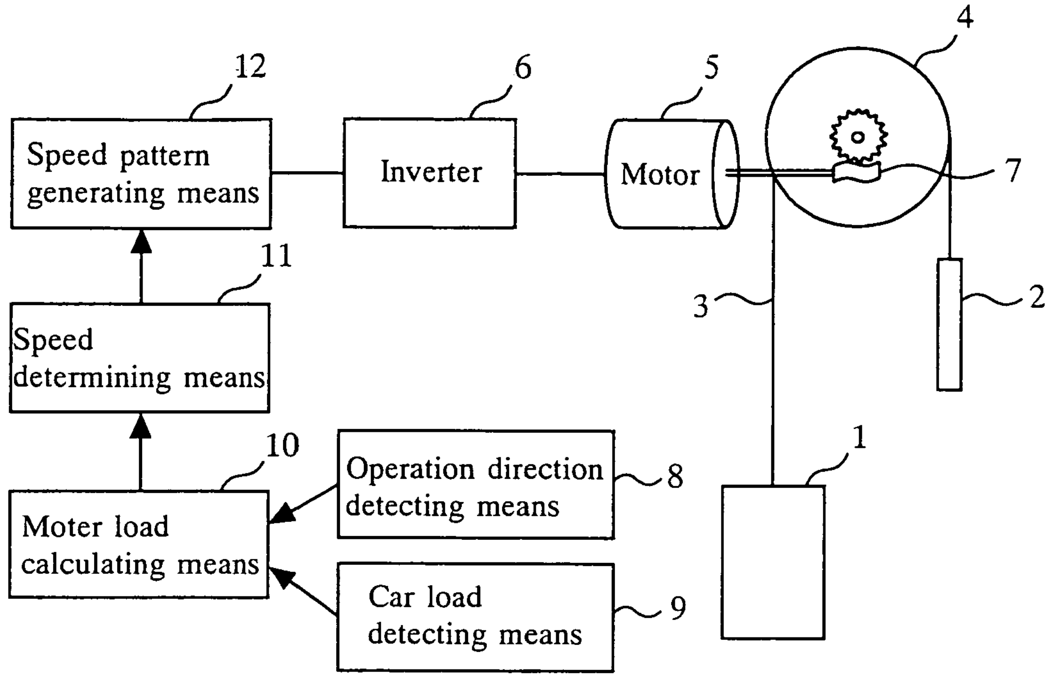


Fig.2

Load ratio	Operation direction	
	UP	DN
100% - 90%	60m/min	60m/min
90% - 70%	75m/min	75m/min
70% - 30%	90m/min	90m/min
30% - 10%	75m/min	75m/min
10% - 0%	60m/min	60m/min

Fig.3

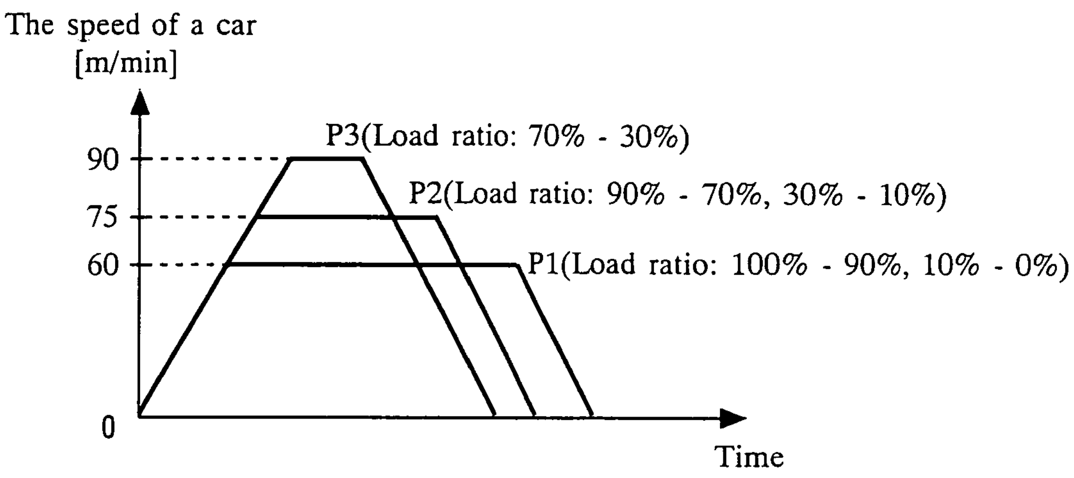

The speed of a car
[m/min]
90
75
60
0
P3(Load ratio: 70% - 30%)
P2(Load ratio: 90% - 70%, 30% - 10%)
P1(Load ratio: 100% - 90%, 10% - 0%)
Time

Fig.4

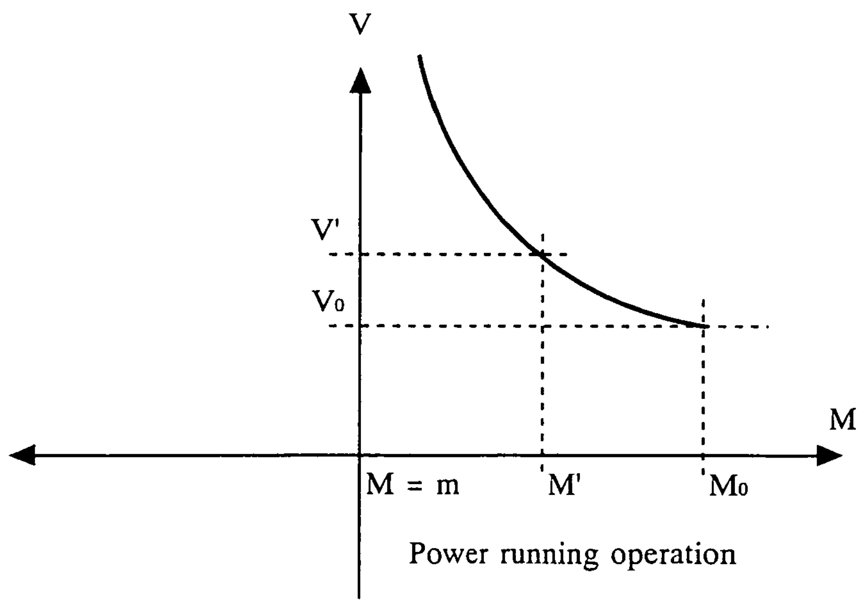

V
V'
Vo
M
M = m
M'
Mo
Power running operation

Fig.5

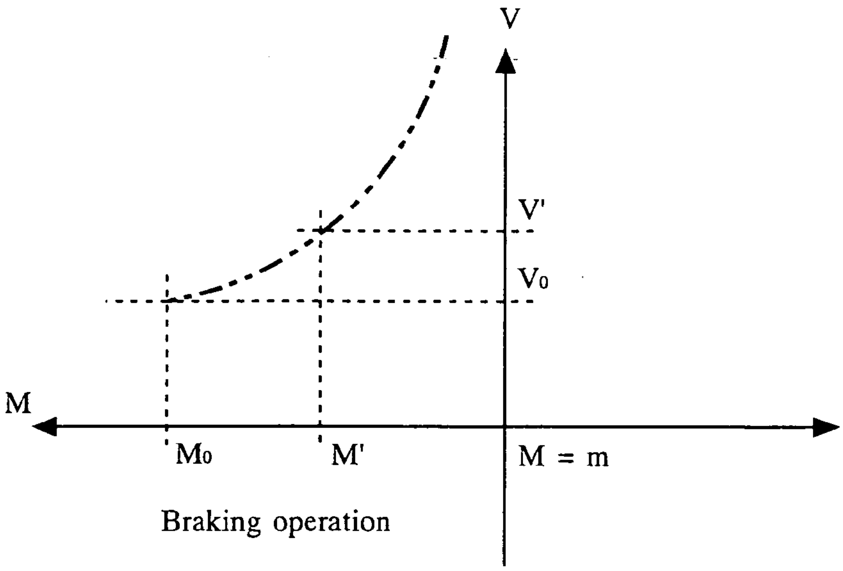

V
V'
V0
M
M0
M'
M = m
Braking operation

Fig.6

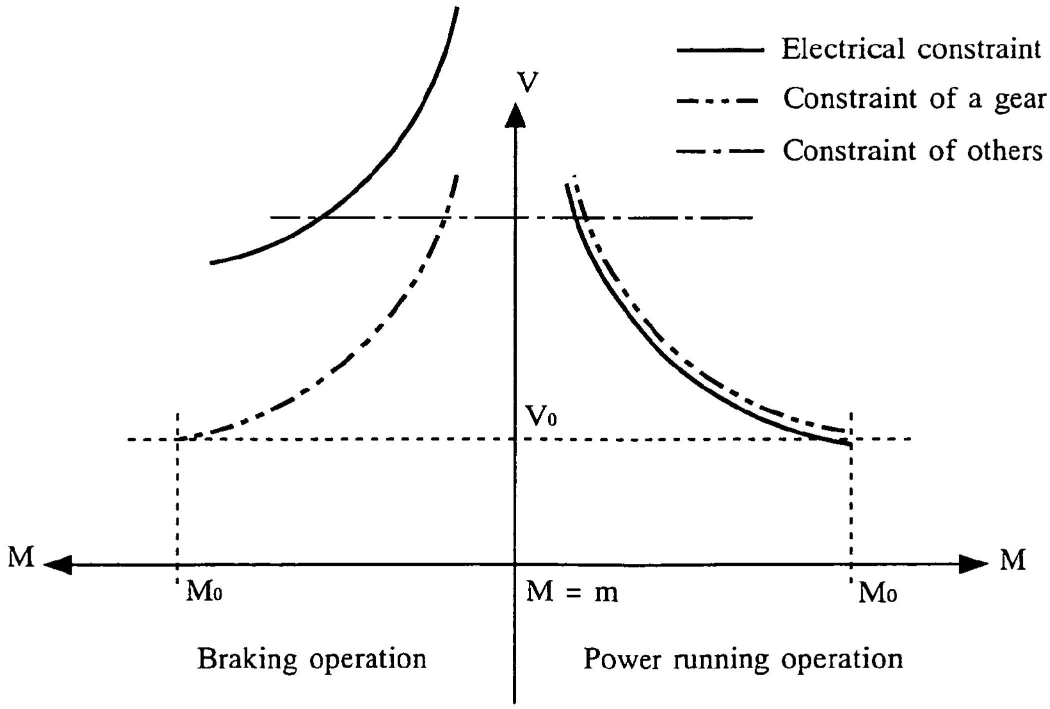

Electrical constraint
Constraint of a gear
Constraint of others
V
V0
M
M0
M = m
M0
M
Braking operation
Power running operation

Fig.7

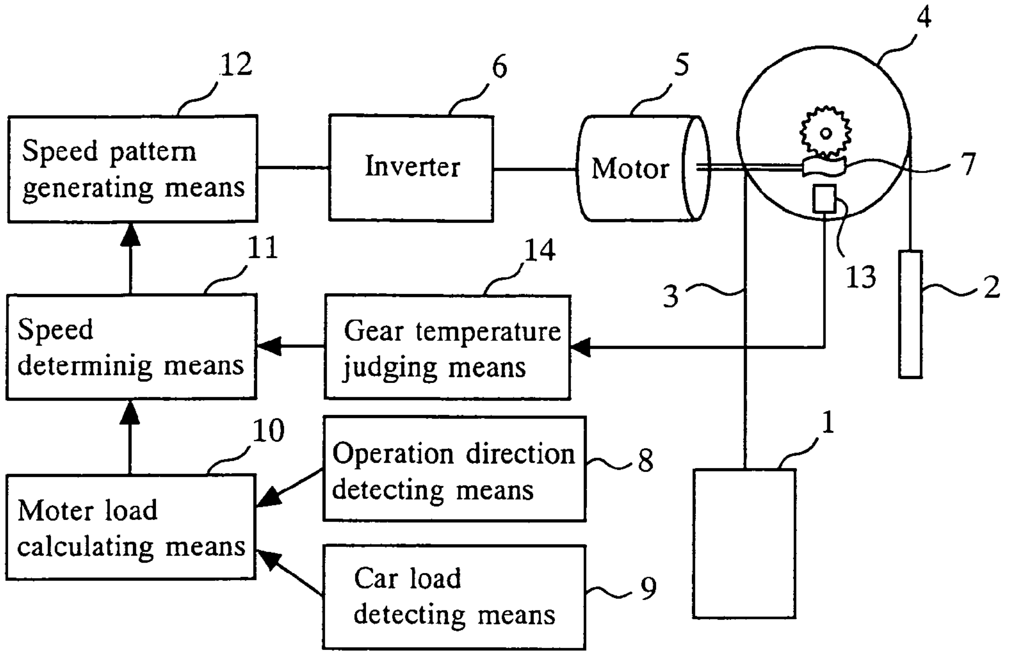


Fig.8

<table>
<tr><th rowspan="1">Gear temperature</th><th>Within a prescribed value</th><th colspan="2">When a prescribed value is exceeded</th></tr>
<tr><th>Operation direction / Load ratio</th><th>UP / DN</th><th>UP</th><th>DN</th></tr>
<tr><td>100% - 90%</td><td>60m/min</td><td>60m/min</td><td rowspan="2">60m/min</td></tr>
<tr><td>90% - 80%</td><td rowspan="2">75m/min</td><td rowspan="2">75m/min</td></tr>
<tr><td>80% - 70%</td><td rowspan="2">75m/min</td></tr>
<tr><td>70% - 60%</td><td rowspan="3">90m/min</td><td rowspan="2">90m/min</td></tr>
<tr><td>60% - 40%</td><td rowspan="2">90m/min</td></tr>
<tr><td>40% - 30%</td><td rowspan="2">75m/min</td></tr>
<tr><td>30% - 20%</td><td rowspan="2">75m/min</td><td rowspan="2">75m/min</td></tr>
<tr><td>20% - 10%</td><td rowspan="2">60m/min</td></tr>
<tr><td>10% - 0%</td><td>60m/min</td><td>60m/min</td></tr>
</table>

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003238037 A **[0003] [0004]**