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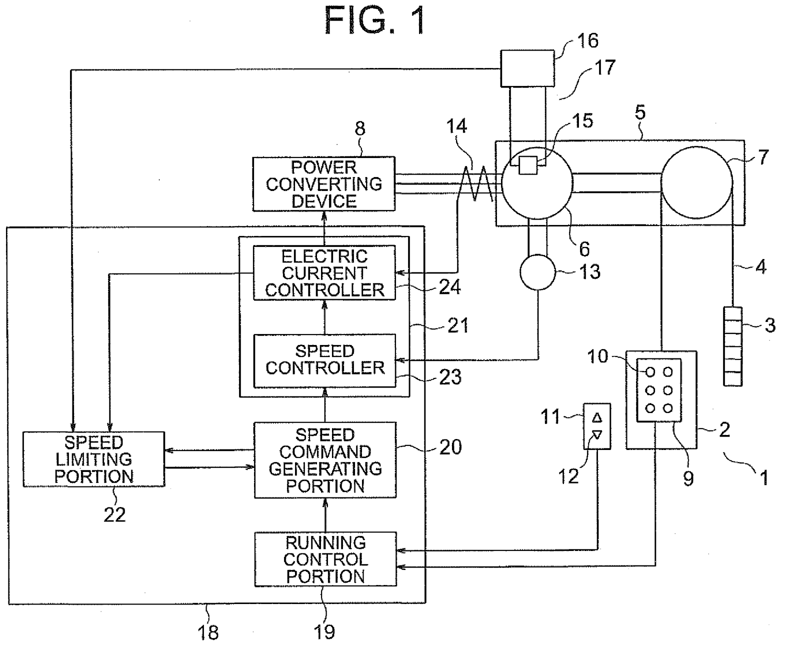
(54) **ELEVATOR CONTROL SYSTEM**

(57) In an elevator control system, supply of electric power to a motor of a driving machine that moves a car is controlled by a control apparatus. A temperature warning signal is output from a temperature signal generating apparatus to the control apparatus if a temperature of predetermined subject equipment that includes the driving machine reaches a predetermined temperature reference value. The control apparatus performs speed priority control in which a maximum value of rotational speed of the motor is kept to a predetermined speed by passing a field weakening current to the motor when receipt of the temperature warning signal is stopped, and performs torque priority control in which a maximum value of rotational speed of the motor is kept lower than the predetermined speed within a range in which output torque is at a maximum relative to the supply of electric power of the motor by lowering the field weakening current to the motor further than during the speed priority control when the temperature warning signal is received.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to an elevator control system that controls movement of a car.

BACKGROUND ART

[0002] Conventionally, in order to prevent predetermined elevator components from becoming overloaded, elevator control devices have been proposed that predict continuous temperature conditions of the components by computation, and control elevator operation based on those predicted temperature conditions. In these conventional elevators, elevator operation is performed in a range in which component temperature limits will not be exceeded, by switching between high-speed and low-speed speed patterns (See Patent Literature 1).
[0003] [Patent Literature 1]
WO 2004/030627

DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004] However, maximum speed and acceleration of the speed pattern are set low so as to allow for detection errors, etc., in car internal load, for example. Consequently, if elevator operation is performed in accordance with a speed pattern that has been set low in this manner, the car is moved well below hoisting machine driving capacity, and hoisting machine driving capacity cannot be utilized efficiently. Thus, elevator operating efficiency deteriorates.
[0005] The present invention aims to solve the above problems and an object of the present invention is to provide an elevator control system that can prevent temperature of predetermined subject equipment that includes a driving machine from reaching an abnormally high temperature, and that can also suppress deterioration of elevator operating efficiency.

MEANS FOR SOLVING THE PROBLEM

[0006] In order to achieve the above object, according to one aspect of the present invention, there is provided an elevator control system including: a control apparatus that controls supply of electric power to a motor of a driving machine that moves a car; and a temperature signal generating apparatus that sends a temperature warning signal to the control apparatus if a temperature of predetermined subject equipment that includes the driving machine reaches a predetermined temperature reference value, the control apparatus performing speed priority control in which a maximum value of rotational speed of the motor is kept to a predetermined speed by passing a field weakening current to the motor when receipt of the temperature warning signal is stopped, and performing torque priority control in which a maximum value of rotational speed of the motor is kept lower than the predetermined speed within a range in which output torque is at a maximum relative to the supply of electric power of the motor by lowering the field weakening current to the motor further than during the speed priority control when the temperature warning signal is received.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

Figure 1 is a structural diagram that shows an elevator according to Embodiment 1 of the present invention;
Figure 2 is a flowchart for explaining decision operations of a speed limiting portion from Figure 1;
Figure 3 is a graph that shows relationships between time and a speed command, acceleration that corresponds to the speed command, a voltage command, a field weakening current, presence or absence of a temperature warning signal, and presence or absence of a speed limiting command, respectively, when output of a temperature warning signal from a temperature signal generator from Figure 1 is stopped;
Figure 4 is a graph that shows relationships between time and a speed command, acceleration that corresponds to the speed command, a voltage command, a field weakening current, presence or absence of a temperature warning signal, and presence or absence of a speed limiting command, respectively, when the temperature warning signal is output from the temperature signal generator from Figure 1; and
Figure 5 is a flowchart for explaining a speed command calculating operation by a speed command generating portion from Figure 1.

BEST MODE FOR CARRYING OUT THE INVENTION

[0008] Preferred embodiments of the present invention will now be explained with reference to the drawings.

Embodiment 1

[0009] Figure 1 is a structural diagram that shows an elevator according to Embodiment 1 of the present invention. In the figure, a car 2 and a counterweight 3 are suspended inside a hoistway 1 by a main rope 4. A hoisting machine (a driving machine) 5 for moving the car 2 and the counterweight 3 is disposed in an upper portion of the hoistway 1. The hoisting machine 5 has: a motor 6; and a driving sheave 7 that is rotated by the motor 6.

[0010] The motor 6 is constituted by a permanent magnet motor. The driving sheave 7 is rotated by supplying electric power to the motor 6. The supply of electric power to the motor 6 is performed by a power converting device 8. The main rope 4 is wound around the driving sheave 7. The car 2 and the counterweight 3 are moved inside the hoistway 1 by the rotation of the driving sheave 7.

[0011] A car operating panel 9 is disposed inside the car 2. A plurality of car call buttons 10 for performing call registration are disposed on the car operating panel 9. Landing operating panels 11 are disposed on landings of respective building floors. A plurality of landing call buttons 12 for performing call registration are disposed on the landing operating panels 11.

[0012] A speed detector (an encoder, for example) 13 for detecting rotational speed of the driving sheave 7 is disposed on the motor 6. A value for electric current that is supplied to the motor 6 (motor current) from the power converting device 8 is detected by an electric current detector (CT) 14 as a motor current value.

[0013] Electric power is supplied from a commercial power supply to the power converting device 8 through a circuit breaker (not shown). Overcurrent to the power converting device 8 is prevented by the circuit breaker. The power converting device 8 is constituted by a pulse-width modulation (PWM) control inverter that adjusts output voltage by generating a plurality of direct-current voltage pulses within a fundamental frequency of an alternating-current voltage (bus voltage). In other words, output voltage of the power converting device 8 is controlled by adjusting a voltage switching duty ratio to the motor 6.

[0014] A temperature detector 15 is disposed on the motor 6. The motor 6 thereby constitutes subject equipment for which temperature is measured by the temperature detector 15. A predetermined temperature reference value is preset in the temperature detector 15. The temperature detector 15 outputs a temperature warning signal if the temperature of the motor 6 reaches the predetermined temperature reference value, and stops outputting of the temperature warning signal if the temperature of the motor 6 is lower than the predetermined temperature reference value. In other words, the temperature detector 15 decides whether to not to output the temperature warning signal by comparing the temperature of the motor 6 with the predetermined temperature reference value.

[0015] The temperature warning signal from the temperature detector 15 is captured by a receiver 16. The temperature warning signal that has been captured by the receiver 16 is output without modification by the receiver 16. Moreover, a temperature signal generating apparatus 17 includes the temperature detector 15 and the receiver 16.

[0016] Respective information from the car operating panel 9, the landing operating panels 11, the speed detector 13, the electric current detector 14, and the temperature signal generating apparatus 17 is sent to a control apparatus 18 that controls elevator operation. The control apparatus 18 controls the power converting device 8 based on the respective information from the car operating panel 9, the landing operating panels 11, the speed detector 13, the electric current detector 14, and the temperature signal generating apparatus 17. Moreover, the control apparatus 18 performs computational processing once every computational period ts.

[0017] The control apparatus 18 has a running control portion 19, a speed command generating portion 20, a movement controlling portion 21, and a speed limiting portion 22.

[0018] The running control portion 19 prepares running management information for elevator operation (information concerning destination floors and run commands, etc., for the car 2, for example) based on respective information from the car operating panel 9 and the landing operating panels 11.

[0019] The speed command generating portion 20 finds a speed command for controlling speed of the car 2 based on the running management information from the running control portion 19.

[0020] The movement controlling portion 21 controls the supply of electric power to the motor 6 based on the speed command from the speed command generating portion 20. The movement of the car 2 is thereby controlled. Control of the supply of electric power to the motor 6 is performed by the movement controlling portion 21 controlling the power converting device 8. The movement controlling portion 21 has a speed controller 23 and an electric current controller 24.

[0021] The speed controller 23 finds a difference between the speed command from the speed command generating portion 20 and information from the speed detector 13 concerning the rotational speed as speed deviation information, and outputs the speed deviation information that is found to the electric current controller 24.

[0022] The electric current controller 24 generates a control command that controls the power converting device 8 based on both the speed deviation information from the speed controller 23 and the information concerning the motor current from the electric current detector 14. Specifically, the electric current controller 24 finds a motor current target value based on the speed deviation information from the speed controller 23, and controls the power converting device 8 such that the motor current value that is detected by the electric current detector 14 matches the motor current target value.

[0023] An electric current command for adjusting the motor current that is supplied to the motor 6, and a voltage command for adjusting the voltage that is imparted to the motor 6 are included in the control command. Information concerning the voltage switching duty ratio to the motor 6 is also included in the voltage command.

[0024] Moreover, the bus voltage, the motor current value, an electric current command value, a voltage command value, and the voltage switching duty ratio relative to the motor 6 of the power converting device 8 constitute driving information that corresponds to the output from the motor 6, since they relate to output from the motor 6.

[0025] The speed limiting portion 22 can output a speed limiting command for suppressing the rotational speed of the motor 6 to the speed command generating portion 20. The speed limiting portion 22 receives information from the temperature signal generating apparatus 17 (the temperature warning signal), information from the electric current controller 24 (the voltage command), and information from the speed command generating portion 20 (the speed command). The speed limiting portion 22 further decides whether or not to output the speed limiting command based on the respective information from the temperature signal generating apparatus 17, the electric current controller 24, and the speed command generating portion 20. Specifically, the speed limiting portion 22 outputs the speed limiting command to the speed command generating portion 20 if all conditions are satisfied, namely that the speed of the car 2 is increasing at a constant acceleration, that the temperature warning signal is being received, and that the value of the voltage command exceeds a preset limiting value Vlim (i.e., command output conditions), and stops outputting the speed limiting command when the command output conditions are not satisfied.

[0026] Now, if a terminal voltage Vt of the motor 6 is high, the maximum voltage that can be generated by the power converting device 8 may be exceeded, giving rise to distortion in the motor voltage. As a result, noise may also be generated due to distortion also arising in the motor current, and in the worst cases, the motor may also become uncontrollable. Consequently, it is necessary to lower the terminal voltage Vt of the motor 6 to control the rotational speed of the motor 6 at higher speeds.

[0027] Adjustment of the motor current is performed by adjusting an effective component that generates torque (q-axis component), and a reactive component which does not contribute to the generation of torque (d-axis component). A normal voltage equation on the d-q coordinates of a permanent magnet motor can be expressed by Formula (1).

[0028]

[Mathematical Formula 1]

$$\begin{bmatrix} vd \\ vq \end{bmatrix} = \begin{bmatrix} Ra & -\omega \cdot Lq \\ \omega \cdot Ld & Ra \end{bmatrix} \begin{bmatrix} id \\ iq \end{bmatrix} + \begin{bmatrix} 0 \\ \omega \cdot \phi\ a \end{bmatrix} \quad \cdots (1)$$

[0029] Here, id and iq are d-axis and q-axis components of motor armature current, vd and vq are d-axis and q-axis components of motor armature voltage, Ra is armature winding resistance, ω is electrical angular speed, Ld and Lq are winding d-axis and q-axis inductances, and φa is armature interlinked flux from the permanent magnets on the d-q coordinates.

[0030] From Formula (1), the terminal voltage Vt of the motor 6 can be expressed by Formula (2).

[0031]

[Mathematical Formula 2]

$$Vt = \sqrt{(Ra \cdot id - \omega \cdot Lq \cdot iq)^2 + (Ra \cdot iq + \omega \cdot \phi\ a + \omega \cdot Ld \cdot id)^2} \quad \cdots (2)$$

[0032] From Formula (2), the terminal voltage Vt of the motor 6 can be lowered by passing a negative d-axis electric current (a field weakening current). Consequently, the maximum value of the rotational speed of the motor 6 can be increased by performing control of the supply of electric power to the motor 6 while passing a field weakening current to the motor 6 (i.e., performing field weakening control).

[0033] On the other hand, when a field weakening current is passed to the motor 6, power factor of the motor 6 deteriorates. In other words, the electric current required to generate identical torque is larger when performing field weakening control than when not performing field weakening control. Consequently, heat that is generated by the motor 6 is greater when performing field weakening control than when not performing field weakening control.

[0034] A set speed maximum value Vmax that is calculated based on the running management information is set to a speed that is achievable by the car 2 by performing field weakening control on the motor 6. In other words, the set speed maximum value Vmax that is based on the running management information is set to a speed that is unachievable by the car 2 when field weakening control on the motor 6 is stopped.

[0035] The speed command generating portion 20 calculates a speed command that conforms to the set speed that is based on the running management information when receipt of the speed limiting command is stopped, and calculates a speed command that lowers the maximum value of the speed of the car 2 below the set speed maximum value Vmax that is based on the running management information when receiving the speed limiting command. The speed command generating portion 20 calculates a speed command that stops acceleration of the car 2 on receiving a speed limiting command.

[0036] When a speed command that conforms to the set speed is calculated, control of supply of electric power to the motor 6 is field weakening control due to the speed of the car 2 being within a predetermined range that includes the set speed maximum value Vmax. On the other hand, a speed command that is calculated upon the speed command generating portion 20 receiving a speed limiting command is a speed command that lowers the field weakening current to maximize output torque relative to the supply of electric power to the motor 6. In this example, a speed command that stops supply of the field weakening current to the motor 6 is calculated by the speed command generating portion 20. On the speed command generating portion 20 receiving the speed limiting command, accelerative operation of the car 2 is stopped, and the maximum value of the speed of the car 2 becomes lower than the set speed maximum value Vmax.

[0037] In other words, when receipt of the temperature warning signal from the temperature signal generating apparatus 17 is stopped, the control apparatus 18 performs speed priority control in which a field weakening current is passed to the motor 6 to make the maximum value of the rotational speed of the motor 6 a predetermined speed (i.e., a rotational speed value of the motor 6 that corresponds to the set speed maximum value Vmax), and when the temperature warning signal is received, the control apparatus 18 performs torque priority control in which the field weakening current to the motor 6 is made lower than during speed priority control to make the maximum value of the rotational speed of the motor 6 lower than the predetermined speed in a range in which torque output from the motor 6 is at a maximum.

[0038] Next, operation will be explained. When call registration is performed, by operating the car operating panel 9 or at least one of the landing operating panels 11, information concerning the call registration is sent to the control apparatus 18. When a starting command is subsequently input into the control apparatus 18, supply of electric power to the motor 6 from the power converting device 8, and release of a brake that stops rotation of the driving sheave 7 are performed by control from the control apparatus 18. Movement of the car 2 is thereby commenced. The speed of the car 2 is subsequently adjusted by control of the power converting device 8 by the control apparatus 18, and the car 2 is moved to the destination floor for which call registration was performed.

[0039] Next, operation of the control apparatus 18 will be explained. Whether or not to output the speed limiting command is decided by the speed limiting portion 22 in the control apparatus 18 based on the respective information from the temperature signal generating apparatus 17, the electric current controller 24, and the speed command generating portion 20.

[0040] When call registration information is input into the control apparatus 18, running management information is prepared by the running control portion 19 based on the call registration information. If receipt of the speed limiting command from the speed limiting portion 22 by the speed command generating portion 20 is subsequently stopped, a set speed that is found using a predetermined calculating formula based on the running management information is calculated by the speed command generating portion 20 as the speed command. If the speed command generating portion 20 receives the speed limiting command from the speed limiting portion 22, a speed that is lower than the set speed is calculated by the speed command generating portion 20 as the speed command. The calculation of the speed command by the speed command generating portion 20 is performed once every computational period ts.

[0041] The power converting device 8 is subsequently controlled by the movement controlling portion 21 in accordance with the calculated speed command. The supply of electric power to the motor 6 is thereby controlled such that the speed of the car 2 is controlled.

[0042] Next, decision operations of the speed limiting portion 22 will be explained. Figure 2 is a flowchart for explaining the decision operations of the speed limiting portion 22 from Figure 1. As shown in the figure, the speed limiting portion 22 decides whether or not the car 2 is accelerating constantly based on the information from the speed command generating portion 20 (S1). If the car 2 is not moving at a constant acceleration, a decision is made to stop outputting the speed limiting command (S2).

[0043] If the car 2 is moving at a constant acceleration, the speed limiting portion 22 decides whether or not a temperature warning signal has been received based on the information from the temperature signal generating apparatus 17 (S3). If a temperature warning signal has not been received, a decision is made to stop outputting the speed limiting command (S2).

[0044] If a temperature warning signal has been received, the speed limiting portion 22 decides whether or not the value of the voltage command has exceeded the limiting value Vlim based on the information from the electric current controller 24 (S4). If the voltage command value is less than or equal to the limiting value Vlim, a decision is made to stop outputting the speed limiting command (S5). If, on the other hand, the voltage command value has exceeded the limiting value Vlim, a decision is made to output the speed limiting command (S6).

[0045] Next, a speed command by the speed command generating portion 20 when output of the temperature warning signal from the temperature signal generating apparatus 17 has been stopped will be explained. Figure 3 is a graph that shows relationships between time and a speed command, acceleration that corresponds to the speed command, a voltage command, a field weakening current, presence or absence of a temperature warning signal, and presence or absence of a speed limiting command, respectively, when output of a temperature warning signal from the temperature signal generator 17 from Figure 1 is stopped.

[0046] Moreover, in the figure, a state in which there is no input of the starting command and the speed command is 0 (a rest state) has been designated MODE = 1, a state in which acceleration > 0 and jerk > 0 has been designated MODE = 2, a state in which acceleration > 0 and jerk = 0 has been designated MODE = 3, a state in which acceleration > 0 and jerk < 0 has been designated MODE = 4, a state of constant speed has been designated MODE = 5, a state in which acceleration < 0 and jerk < 0 has been designated MODE = 6, a state in which the acceleration < 0 and jerk = 0 has been designated MODE = 7, and a state in which acceleration < 0 and jerk > 0 has been designated MODE = 8. Furthermore, acceleration in MODE = 3 is assumed to be preset maximum acceleration αa, and acceleration in MODE = 7 is assumed to be preset maximum deceleration αd.

[0047] In this case, as shown in Figure 3, the speed limiting portion 22 has decided to stop outputting the speed limiting command in every MODE = 1 through 8. Consequently, the speed command generating portion 20 does not receive a speed limiting command. Thus, the set speed that is found by the preset calculating formula is calculated as a speed command by the speed command generating portion 20 without modification. In other words, the speed command that is calculated by the speed command generating portion 20 is an unmodified value that has been calculated based on the running management information, and is not limited by the decision of the speed limiting portion 22. In this case, when the voltage command has exceeded the limiting value Vlim in MODE = 3, control of the supply of electric power to the motor 6 is set to field weakening control in order to raise the speed of the car 2 further.

[0048] Next, the speed command by the speed command generating portion 20 when the temperature warning signal from the temperature signal generating apparatus 17 is being output will be explained. Figure 4 is a graph that shows relationships between time and a speed command, acceleration that corresponds to the speed command, a voltage command, a field weakening current, presence or absence of a temperature warning signal, and presence or absence of a speed limiting command, respectively, when the temperature warning signal is output from the temperature signal generator 17 from Figure 1.

[0049] In this case, as shown in Figure 4, the speed limiting portion 22 outputs the speed limiting command when the voltage command exceeds the limiting value Vlim in MODE = 3. Thus, a speed command that is lower than the set speed that is based on the running management information is calculated by the speed command generating portion 20. In this case, field weakening control on the motor 6 is also stopped.

[0050] Next, the speed command calculating operation by the speed command generating portion 20 will be explained. Figure 5 is a flowchart for explaining a speed command calculating operation by the speed command generating portion 20 from Figure 1. As shown in the figure, the speed command generating portion 20 first decides whether or not a starting command has been input into the control apparatus 18 (S11). If a starting command has not been input, acceleration α is set to 0, the speed V to 0, and MODE to 1 (S12). The speed command generating portion 20 subsequently calculates a speed command V by substituting acceleration α = 0 and speed V = 0 into Formula (3) (S13).

[0051]

$$V = V + \alpha \cdot ts \ \ldots \ (3)$$

[0052] The speed command generating portion 20 subsequently outputs the calculated speed command V to the speed controller 23 (S14), completing computation for the period in question.

[0053] If a starting command has been input, the speed command generating portion 20 decides whether or not MODE = 1 (S15). If MODE = 1, MODE is set to 2 because this is the first computation after the starting command has been input. Here, acceleration α is set using Formula (4), and also transition speed Va when transferring to MODE = 4 from MODE = 3 is set using Formula (5) (S16).

[0054]

$$\alpha = \alpha + j \cdot ts \ ... \ (4)$$

$$Va = Vmax - \alpha^2/(2 \cdot j) \ ... \ (5)$$

[0055] Here, j is jerk, and Vmax is the set speed maximum value.

[0056] Next, the speed command generating portion 20 calculates a new speed command V by substituting the acceleration α and the speed command V from the previous computation into Formula (3) (S13). The speed command generating portion 20 subsequently outputs the calculated speed command V to the speed controller 23 (S14), completing computation for the period in question.

[0057] If, on the other hand, MODE is not 1, the speed command generating portion 20 decides whether or not MODE = 2 (S17). If MODE = 2, the speed command generating portion 20 decides whether or not the acceleration α is at the maximum acceleration αa (S18). If not at the maximum acceleration αa, acceleration α is set using Formula (4), and a transition speed Va is also set using Formula (5). Here, MODE = 2 is kept unchanged (S16).

[0058] If the acceleration α is at the maximum acceleration αa, the acceleration α and the transition speed Va are maintained without modification, and MODE is set to 3 (S19).

[0059] Next, the speed command generating portion 20 calculates a speed command V by substituting the acceleration α and the speed command V from the previous computation into Formula (3) (S13). The speed command generating portion 20 subsequently outputs the calculated speed command V to the speed controller 23 (S14), completing computation for the period in question.

[0060] If MODE is not 2, the speed command generating portion 20 decides whether or not MODE = 3 (S20). If MODE = 3, the speed command generating portion 20 decides whether or not either of the following is applicable: that the speed command V is the transition speed Va; or that a speed limiting command has been received (S21). If neither is applicable, the acceleration α and the transition speed Va are maintained, and MODE = 3 is kept unchanged.

[0061] If it is applicable that either the speed command V is the transition speed Va or the speed command generating portion 20 has received a speed limiting command, the acceleration α is set using Formula (6), and MODE is set to 4 (S22).

[0062]

$$\alpha = \alpha - j \cdot ts \ ... \ (6)$$

[0063] Next, the speed command generating portion 20 calculates a speed command V by substituting the acceleration α and the speed command V from the previous computation into Formula (3) (S13). The speed command generating portion 20 subsequently outputs the calculated speed command V to the speed controller 23 (S14), completing computation for the period in question.

[0064] If MODE is not 3, the speed command generating portion 20 decides whether or not MODE = 4 (S23). If MODE = 4, the speed command generating portion 20 decides whether or not the absolute value of the acceleration α is less than or equal to the absolute value of the product of the jerk j and the computational period ts. In other words, the speed command generating portion 20 decides whether or not Formula (7) is satisfied (S24).

[0065]

$$|\alpha| \leq |j \cdot ts| \ ... \ (7)$$

[0066] If Formula (7) is not satisfied, the acceleration α is set using Formula (6), and MODE = 4 is kept unchanged (S22). If Formula (7) is satisfied, the acceleration α is set to 0, and MODE is set to 5 (S25).

[0067] Next, the speed command generating portion 20 calculates a speed command V by substituting the acceleration α and the speed command V from the previous computation into Formula (3) (S13). The speed command generating portion 20 subsequently outputs the calculated speed command V to the speed controller 23 (S14), completing computation for the period in question.

[0068] If MODE is not 4, the speed command generating portion 20 decides whether or not MODE = 5 (S26). If MODE = 5, the speed command generating portion 20 decides whether or not the car 2 is at a deceleration commencing position (S27). If the deceleration commencing position has not been reached, the acceleration α is kept unchanged at 0, and MODE = 5 is kept unchanged (S25). If the deceleration commencing position has been reached, the acceleration α is set using Formula (6), and MODE is set to 6 (S28).

[0069] Next, the speed command generating portion 20 calculates a speed command V by substituting the acceleration

α and the speed command V from the previous computation into Formula (3) (S13). The speed command generating portion 20 subsequently outputs the calculated speed command V to the speed controller 23 (S14), completing computation for the period in question.

[0070] If MODE is not 5, the speed command generating portion 20 decides whether or not MODE = 6 (S29). If MODE = 6, the speed command generating portion 20 decides whether or not the acceleration α is at the maximum deceleration αd (S30). If not at the maximum deceleration αd, the acceleration α is set using Formula (6), and MODE = 6 is kept unchanged (S28). If at the maximum deceleration αd, the acceleration α is set to the maximum deceleration αd, and MODE is set to 7 (S31).

[0071] Next, the speed command generating portion 20 calculates a speed command V by substituting the acceleration α and the speed command V from the previous computation into Formula (3) (S13). The speed command generating portion 20 subsequently outputs the calculated speed command V to the speed controller 23 (S14), completing computation for the period in question.

[0072] If MODE is not 6, the speed command generating portion 20 decides whether or not MODE = 7 (S32). If MODE = 7, the speed command generating portion 20 decides whether or not the car 2 is at a floor alignment commencing position (S33). If the floor alignment commencing position has not been reached, the acceleration α is kept unchanged at the maximum deceleration αd, and MODE = 7 is kept unchanged (S31). Next, the speed command generating portion 20 calculates a speed command V by substituting the acceleration α and the speed command V from the previous computation into Formula (3) (S13). The speed command generating portion 20 subsequently outputs the calculated speed command V to the speed controller 23 (S14), completing computation for the period in question.

[0073] If the floor alignment commencing position has been reached, the speed command generating portion 20 calculates a speed command V based on distance to a floor alignment position of the car 2, and MODE is set to 8 (S34). The speed command generating portion 20 subsequently outputs the calculated speed command V to the speed controller 23 (S14), completing computation for the period in question.

[0074] In an elevator control system of this kind, because a temperature warning signal is sent to a control apparatus 18 from a temperature signal generating apparatus 17 if the temperature of a motor 6 reaches a predetermined temperature reference value, and the control apparatus 18 performs speed priority control in which a maximum value of rotational speed of the motor 6 is set to a predetermined speed by field weakening control over the motor 6 when receipt of the temperature warning signal is stopped, and performs torque priority control by lowering a field weakening current to maximize output torque relative to the supply of electric power to the motor 6 when receiving the temperature warning signal, even if the temperature of the motor 6 increases and reaches a high temperature, heat generation in the motor 6 can be suppressed efficiently without lowering the maximum speed of the car 2 significantly. Consequently, the temperature of the motor 6 can be prevented from reaching abnormally high temperatures, and deterioration in the elevator operating efficiency can be suppressed.

[0075] Because a speed limiting portion 22 compares a voltage command and a limiting value and outputs a speed limiting command to a speed command generating portion 20 if the temperature warning signal has been received and the voltage command exceeds the limiting value when the car 2 is accelerating, and the speed command generating portion 20 calculates a speed command that stops acceleration of the car 2 on receiving the speed limiting command, a reactive current value that does not contribute to torque output from the motor 6 can be reduced. Consequently, the temperature of the motor 6 can be prevented from reaching abnormally high temperatures, and deterioration in the elevator operating efficiency can be suppressed.

[0076] Moreover, in the above example, a voltage command is compared with a limiting value, but is not limited to a voltage command, and any of the bus voltage of the power converting device 8, a terminal voltage value of the motor 6, a motor current value that represents a value of electric current to the motor 6, an electric current command value that is output to the power converting device 8 from the control apparatus 18 in order to adjust the motor current, or the voltage switching duty ratio to the motor 6 can also be compared with a limiting value. Because any of this information constitutes a deciding indicator as to whether or not the terminal voltage of the motor 6 is saturated compared to the bus voltage, operation in which the reactive current value is reduced can be performed by comparing this information with the limiting value and deciding whether or not to output the speed limiting command. Consequently, the temperature of the motor 6 can be prevented from reaching abnormally high temperatures, and deterioration in the elevator operating efficiency can be suppressed.

[0077] in the above example, the subject equipment for which the temperature detector 15 measures the temperature is the motor 6, but is not limited to the motor 6, and because it may be any equipment that generates heat due to the supply of electric power by the power converting device 8, the power converting device 8 or the speed detector 13, etc., may also be designated as subject equipment, for example.

[0078] In the above example, the temperature of the motor 6 is measured directly by the temperature detector 15, but the temperature of the motor 6 may also be estimated based on temporal changes in the electric current that has been detected by the electric current detector 14. In other words, a temperature estimator that estimates the temperature of the motor 6 based on the temporal changes in the electric current to the motor 6, and that outputs a temperature warning signal to the speed limiting portion 22 if the estimated temperature of the motor 6 reaches the predetermined temperature reference value may also be connected to the electric current detector 14.

Claims

1. An elevator control system **characterized in** comprising:

    a control apparatus that controls supply of electric power to a motor of a driving machine that moves a car; and
    a temperature signal generating apparatus that sends a temperature warning signal to the control apparatus if a temperature of predetermined subject equipment that includes the driving machine reaches a predetermined temperature reference value,
    the control apparatus performing speed priority control in which a maximum value of rotational speed of the motor is kept to a predetermined speed by passing a field weakening current to the motor when receipt of the temperature warning signal is stopped, and performing torque priority control in which a maximum value of rotational speed of the motor is kept lower than the predetermined speed within a range in which output torque is at a maximum relative to the supply of electric power of the motor by lowering the field weakening current to the motor further than during the speed priority control when the temperature warning signal is received.

2. An elevator control system according to Claim 1, **characterized in that:**

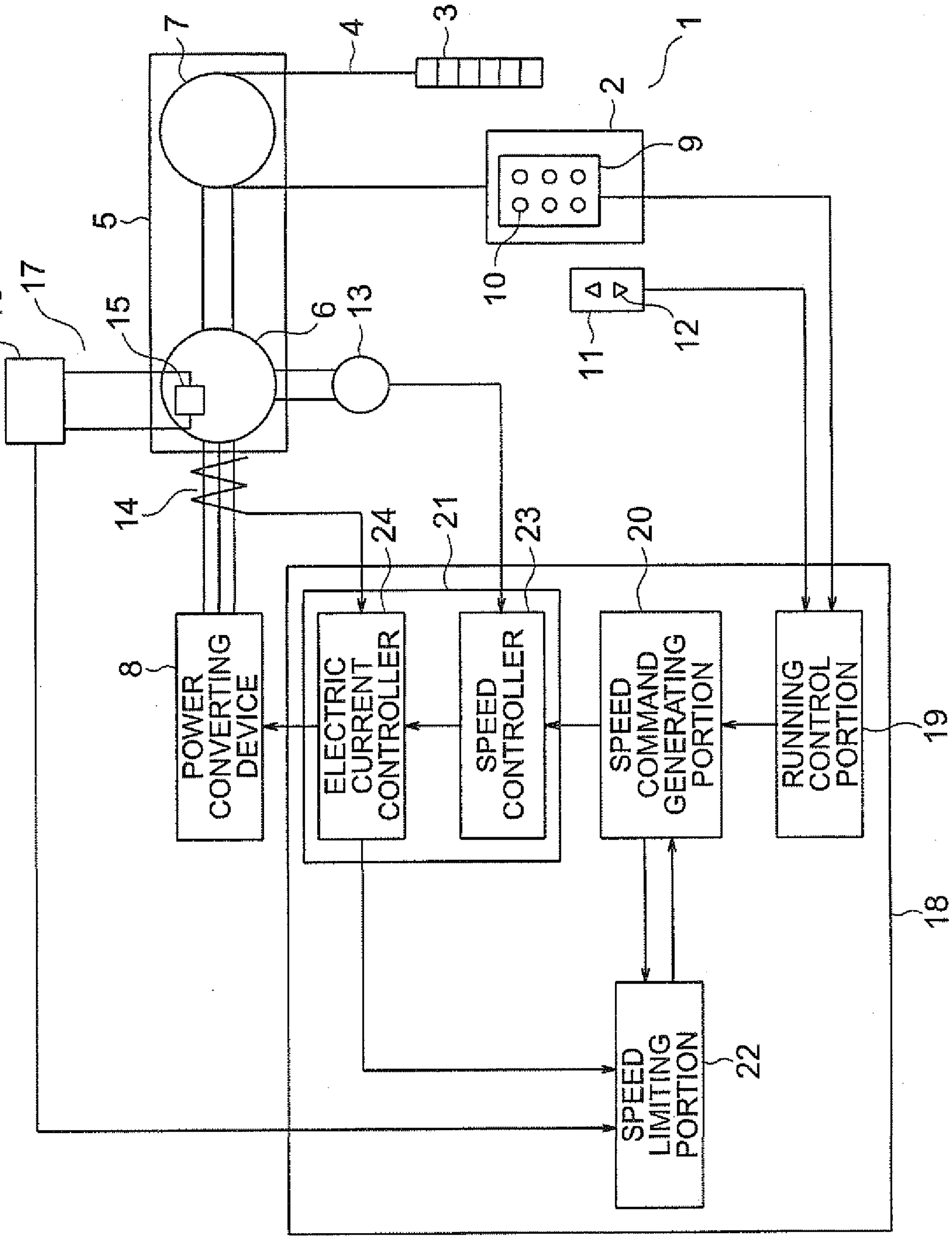
    the control apparatus comprises:

        a speed command generating portion that calculates a speed command for controlling the speed of the car; and
        a speed limiting portion that compares driving information that corresponds to output from the driving machine with a preset limiting value, and outputs a speed limiting command to the speed command generating portion upon the driving information exceeding the limiting value when the temperature warning signal has been received and the car is accelerating; and

    the speed command generating portion calculates the speed command so as to stop accelerative operation of the car and such that the maximum value of rotational speed of the motor is lower than the predetermined speed upon receiving the speed limiting command.

3. An elevator control system according to Claim 2, **characterized in that** the driving information is any of: a bus voltage of a power converting device that performs supply of electric power to the motor by control from the control apparatus ; a motor voltage value that represents a value of voltage of the motor; a motor current value that represents a value of electric current in the motor; an electric current command value that is output to the power converting device from the control apparatus in order to adjust motor current; a voltage command value that is output to the power converting device from the control apparatus in order to adjust motor voltage; or a voltage switching duty ratio to the motor.

FIG. 1


POWER CONVERTING DEVICE
ELECTRIC CURRENT CONTROLLER
SPEED CONTROLLER
SPEED COMMAND GENERATING PORTION
RUNNING CONTROL PORTION
SPEED LIMITING PORTION
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
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21
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23
24

FIG. 2

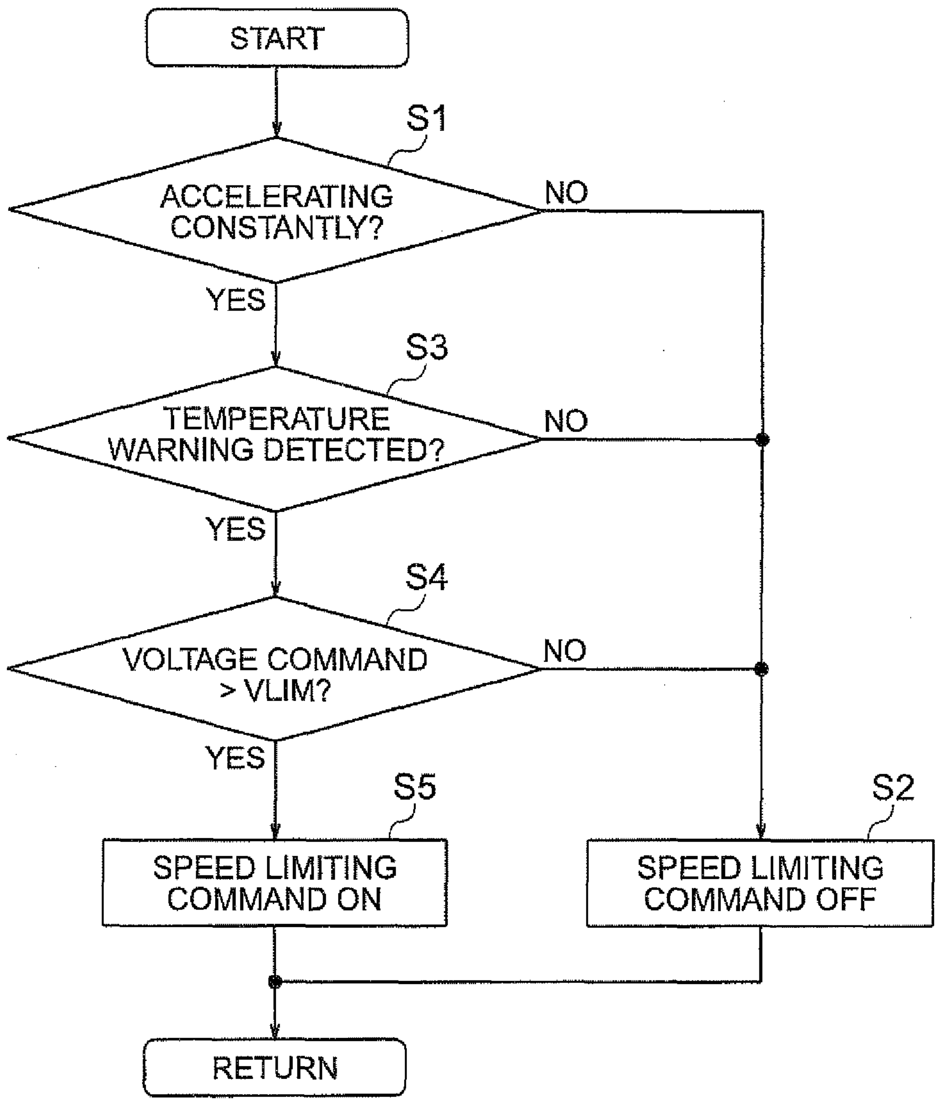
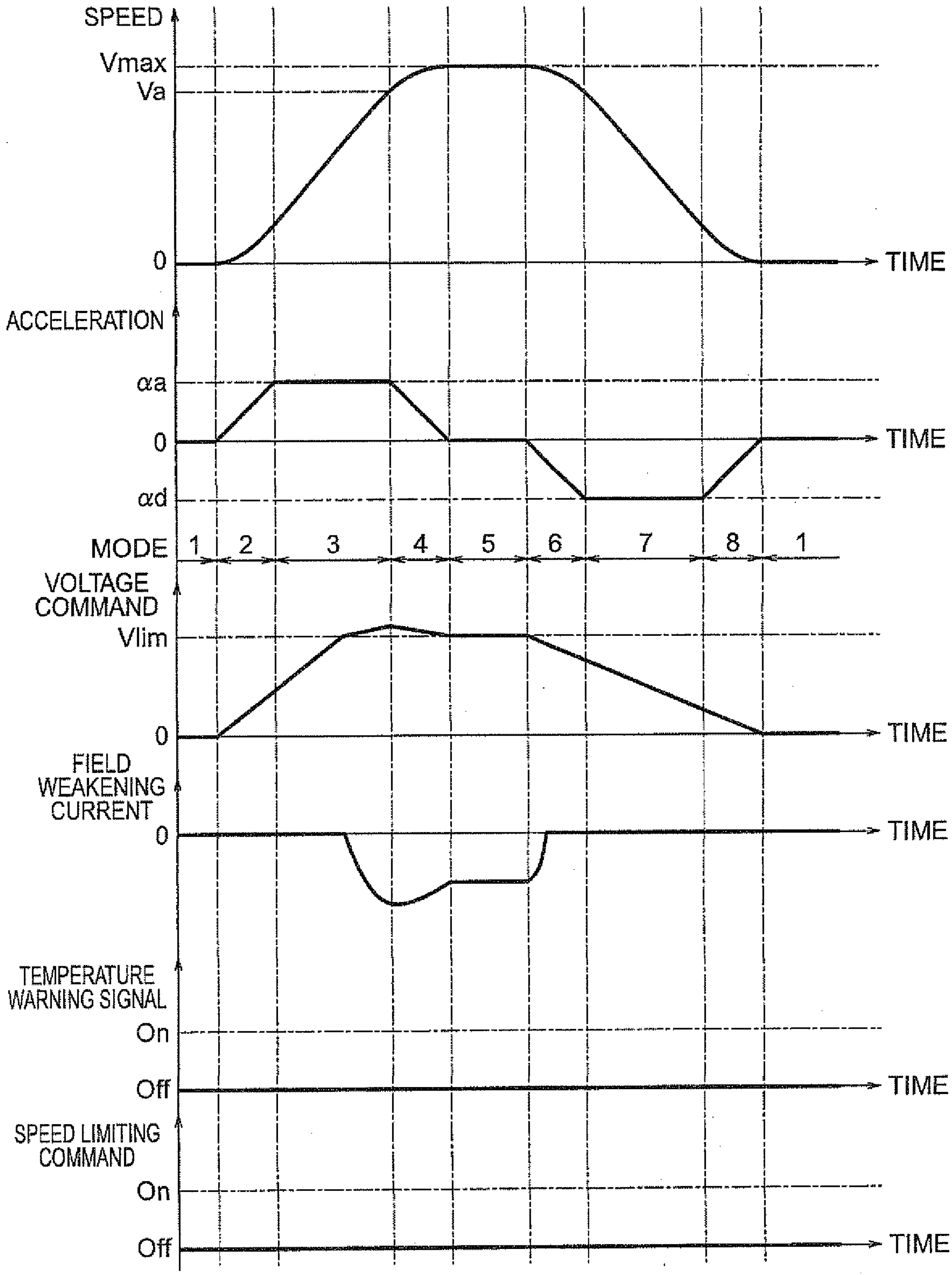

START
S1
ACCELERATING CONSTANTLY?
NO
YES
S3
TEMPERATURE WARNING DETECTED?
NO
YES
S4
VOLTAGE COMMAND > VLIM?
NO
YES
S5
SPEED LIMITING COMMAND ON
S2
SPEED LIMITING COMMAND OFF
RETURN

FIG. 3



SPEED
Vmax
Va
0
TIME
ACCELERATION
αa
0
TIME
αd
MODE
1
2
3
4
5
6
7
8
1
VOLTAGE COMMAND
Vlim
0
TIME
FIELD WEAKENING CURRENT
0
TIME
TEMPERATURE WARNING SIGNAL
On
Off
TIME
SPEED LIMITING COMMAND
On
Off
TIME

FIG. 4

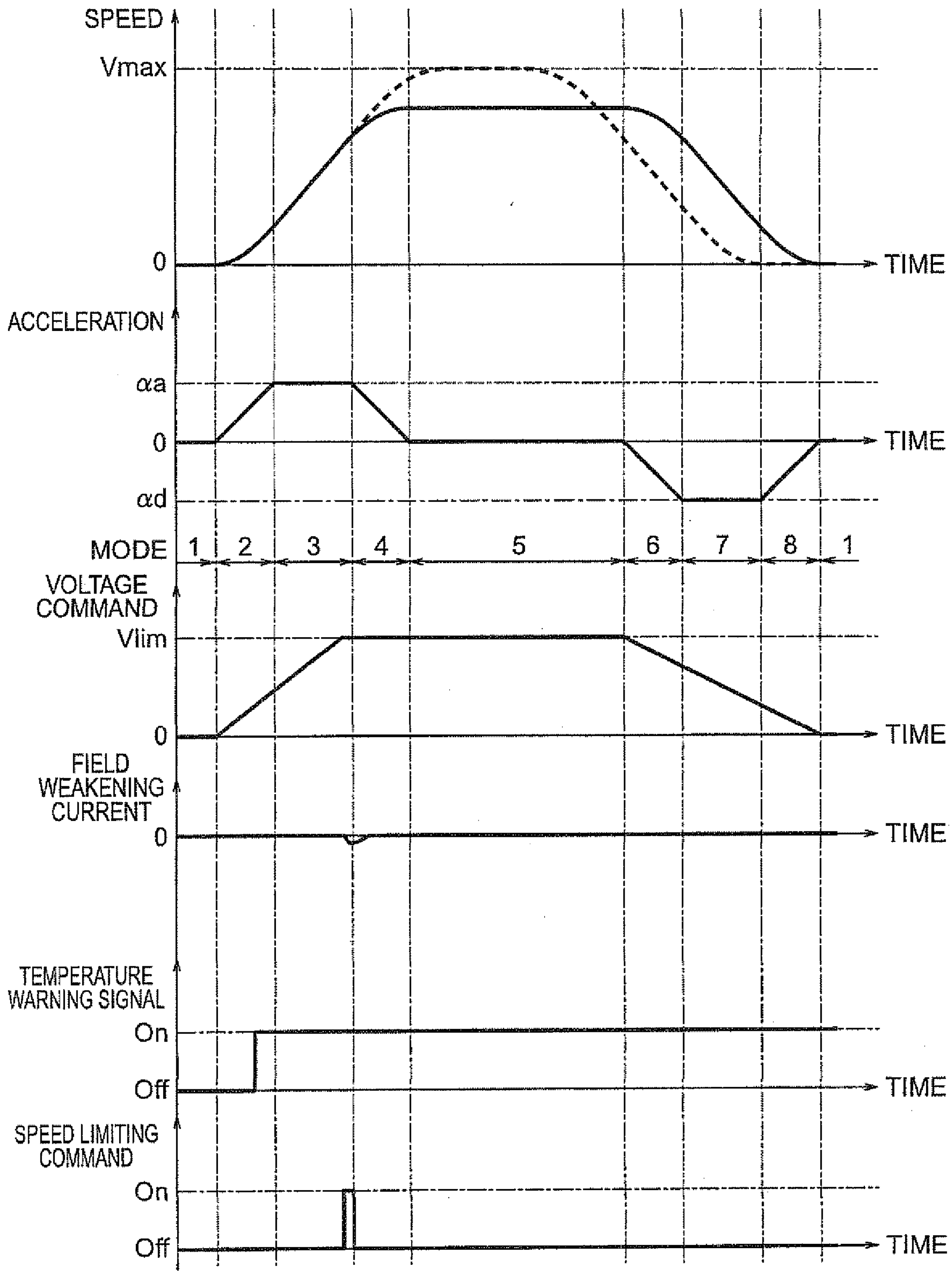
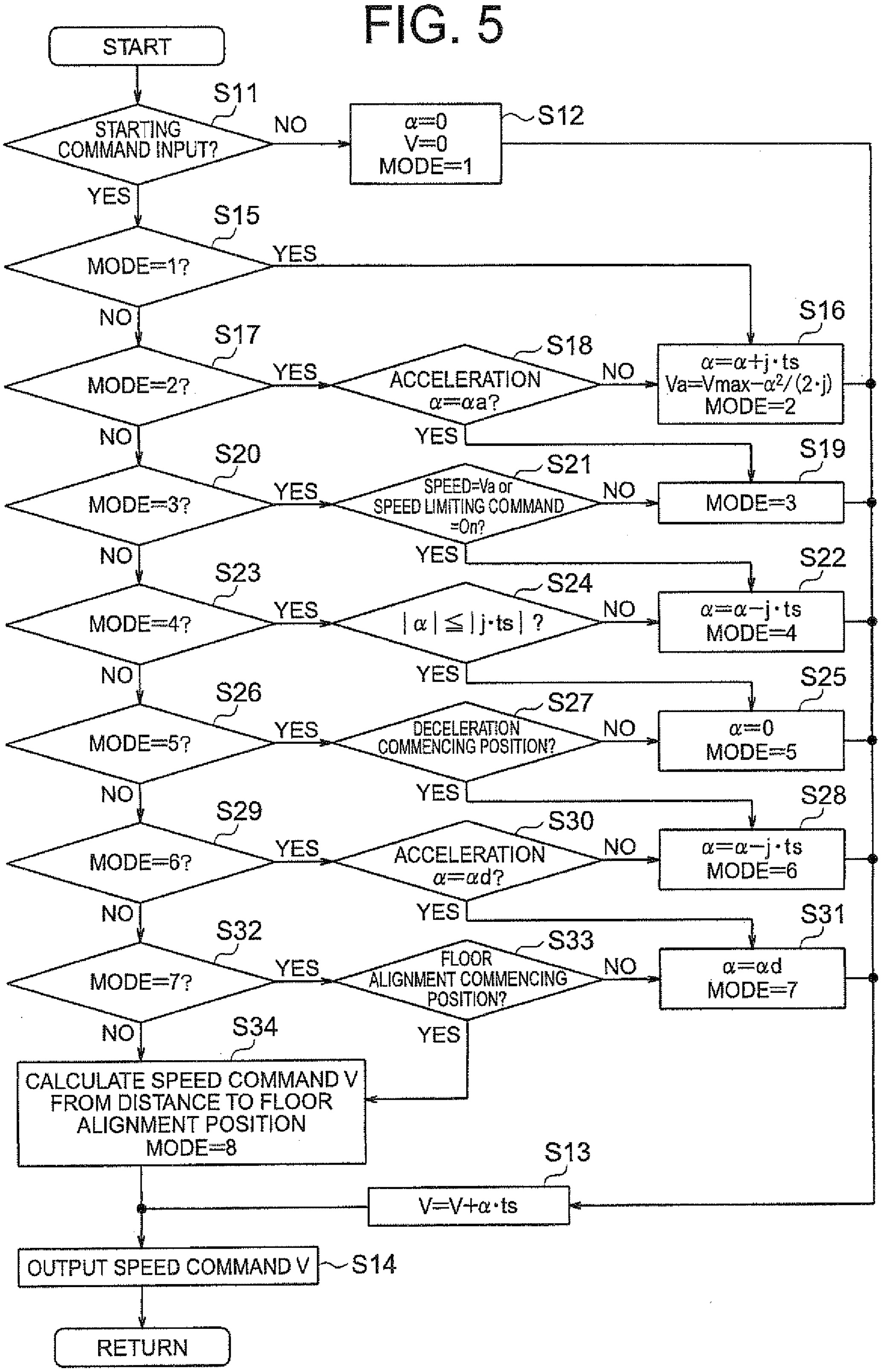

SPEED
Vmax
0
TIME
ACCELERATION
αa
0
TIME
αd
MODE
1
2
3
4
5
6
7
8
1
VOLTAGE COMMAND
Vlim
0
TIME
FIELD WEAKENING CURRENT
0
TIME
TEMPERATURE WARNING SIGNAL
On
Off
TIME
SPEED LIMITING COMMAND
On
Off
TIME

FIG. 5


START
S11
STARTING COMMAND INPUT?
NO
YES
S12
α=0
V=0
MODE=1
S15
MODE=1?
YES
NO
S16
α=α+j·ts
Va=Vmax−α²/(2·j)
MODE=2
S17
MODE=2?
YES
NO
S18
ACCELERATION α=αa?
NO
YES
S19
MODE=3
S20
MODE=3?
YES
NO
S21
SPEED=Va or SPEED LIMITING COMMAND =On?
NO
YES
S22
α=α−j·ts
MODE=4
S23
MODE=4?
YES
NO
S24
|α|≦|j·ts|?
NO
YES
S25
α=0
MODE=5
S26
MODE=5?
YES
NO
S27
DECELERATION COMMENCING POSITION?
NO
YES
S28
α=α−j·ts
MODE=6
S29
MODE=6?
YES
NO
S30
ACCELERATION α=αd?
NO
YES
S31
α=αd
MODE=7
S32
MODE=7?
YES
NO
S33
FLOOR ALIGNMENT COMMENCING POSITION?
NO
YES
S34
CALCULATE SPEED COMMAND V FROM DISTANCE TO FLOOR ALIGNMENT POSITION MODE=8
S13
V=V+α·ts
OUTPUT SPEED COMMAND V
S14
RETURN

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2008/055865

A. CLASSIFICATION OF SUBJECT MATTER
B66B5/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B66B5/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2005-200143 A (Mitsubishi Electric Corp.), 28 July, 2005 (28.07.05), Claims 1 to 2, 5 to 6 (Family: none)	1 2-3
Y	WO 2007/013448 A1 (Mitsubishi Electric Corp.), 01 February, 2007 (01.02.07), Claims 1 to 7 & US 2007/0284196 A1 & EP 1908719 A1 & KR 10-2007-0088740 A & CN 101068736 A	2-3

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 November, 2008 (25.11.08)	02 December, 2008 (02.12.08)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

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Patent documents cited in the description

- WO 2004030627 A **[0003]**