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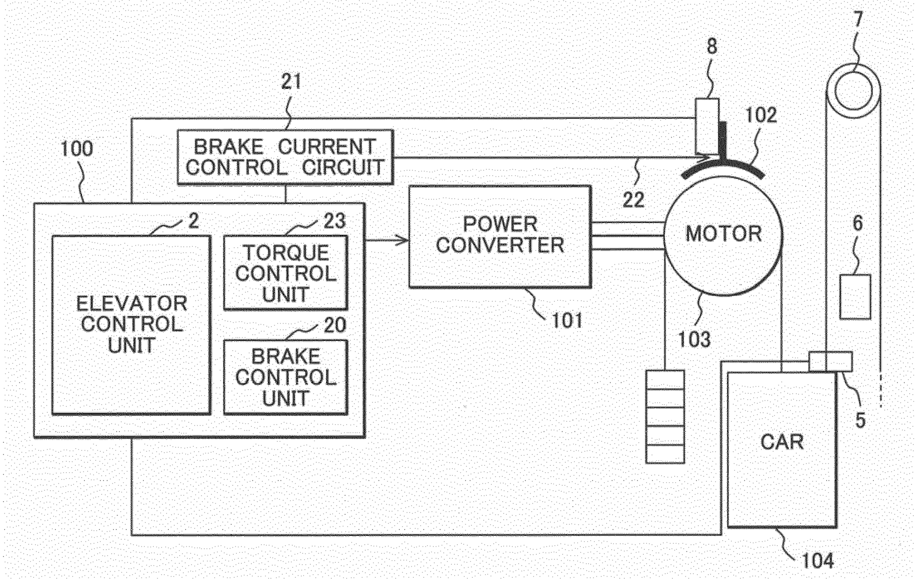
(54) ELEVATOR

(57) The elevator includes a car (104), a drive unit for moving the car by rotating a rotary body connected to the car, a brake (102) for applying a braking force to the rotary body, an elevator control unit (2) for controlling an operation of the car, a brake control unit (20) for changing a brake torque of the brake stepwise for releasing upon reception of a start signal of the elevator from the elevator control unit (2), and a torque control unit (23) for controlling a torque of the drive unit to approximate the car speed to zero upon reception of the start signal of the elevator from the elevator control unit (2).

FIG. 1



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Description

BACKGROUND

[0001] The present invention relates to an elevator.

[0002] The elevator car is normally driven under control to allow the motor to output compensation torque corresponding to the difference between the car and the counterweight so as to maintain static state of the car while preventing its fall even in the transition from the stop state under the braking force to the state where the braking force is released. In order to determine the compensation torque upon activation, it is necessary to detect inside weight of the car by means of the weighing sensor attached to the bottom of the car or the thimble rod. Possible error of the weighing sensor may fail to accurately output the required compensation torque, which shakes the car upon starting at a magnitude corresponding to the error. Japanese Patent Application Laid-Open No. 2015-00796 discloses the method of calibrating the weighing sensor for the purpose of solving the above-described problem.

SUMMARY

[0003] There may be the case that the car is shaken when starting the elevator if the weighing sensor fails, or high detection accuracy cannot be expected. As a result, the appropriate compensation torque cannot be output, thus shaking the car upon starting of the elevator.

[0004] The present invention provides the elevator including a car, a drive unit for moving the car by rotating a rotary body connected to the car, a brake for applying a braking force to the rotary body, an elevator control unit for controlling an operation of the car, a brake control unit for changing a brake torque of the brake stepwise for releasing upon reception of a start signal of the elevator from the elevator control unit, and a torque control unit for controlling a torque of the drive unit to approximate the car speed to zero upon reception of the start signal of the elevator from the elevator control unit.

[0005] It is an object of the present invention to lessen shaking of the car upon starting of the elevator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

Fig. 1 is a block diagram showing an overall structure of an embodiment according to the present invention;

Fig. 2 is a block diagram showing the process flow executed by an elevator controller according to the embodiment;

Fig. 3 is a view schematically showing the operation of the embodiment; and

Fig. 4 is a flowchart representing process steps of generating the drive torque according to the embodiment.

DETAILED DESCRIPTION

[0007] An embodiment according to the present invention will be described referring to the drawings.

[0008] Fig. 1 is an overall view of an elevator system structure according to the present invention. An elevator controller 100 controls movement of a car 104 of the elevator. The elevator controller 100 includes a brake control unit 20 and a torque control unit 23 in addition to an elevator control unit 2 for operation control of the elevator.

[0009] The car 104 operated to move between floors of the building through the hoistway is connected to a weight or counterweight with a rope for balancing with the car 104. The car 104 includes a car door that is opened and closed in engagement with the door at the landing floor side. The car 104 is operated by a motor 103 which drives the sheave. A power converter 101 supplies drive power to the motor 103. The power converter 101 outputs power for controlling the motor in accordance with a car position control command from the elevator controller 100. A rotation sensor as the pulse generator such as an encoder is attached to the motor 103. The elevator controller 100 counts the pulse generated by rotation of the motor 103 so as to calculate speed of the motor 103, and moving direction, position, movement distance of the car 104 in the hoistway. The rotation sensor attached to the motor will be referred to as a machine encoder. The elevator controller outputs a brake power source stop command and a power supply stop command (not shown) for braking the car. In response to those stop commands, the brake power source actuates a brake 102, and the power supply interrupts power supply to the power converter 101 so as to brake the car 104. The brake power source and the power supply are circuits each constituted by an electromagnetic contactor called contactor.

[0010] The brake 102 includes a brake pad for braking the sheave through friction sliding operation, a solenoid coil for lifting the brake pad so as to generate the gap between the sheave and the brake pad, and a core. Generally, upon power supply to the solenoid coil, the brake pad is lifted under electromagnetic force so that the sheave released from restraint of the brake pad becomes freely rotatable. Power is supplied to the solenoid coil through relay from the brake power source. The brake 102 is connected to a brake current control circuit 21 as the circuit configured to control the current (brake current 22) applied to the solenoid coil and configured to make the braking force of the brake variable. The brake 102 is provided with a brake check switch 8 configured to mechanically detect whether the brake pad and the sheave are separated (uncontact state). The information detected by the brake check switch 8 indicating as to whether the brake and the sheave are separated (uncontact state) is output to the elevator control unit 2.

[0011] The brake current control circuit 21 is constituted by a converter for controlling current or voltage, for example, inverter circuit, chopper circuit or the like, a hall

CT for detecting the brake current, and a control unit for controlling the brake current. In response to the current command value (brake current command) applied from the elevator controller 100 to the solenoid coil, the brake current 22 is controlled into the command value. This embodiment has been described by taking the brake mechanism for varying the braking force in accordance with the current using the solenoid coil as an example of varying the braking force. It is also possible to employ the brake configured to vary the braking force in accordance with the distance by utilizing the actuator of direct drive type, or the brake (shoe brake) configured to vary the braking force in accordance with the rotation angle by utilizing the rotation mechanism. Arbitrary type of brake may be employed so long as the braking force of the brake is variable in accordance with the specific command.

[0012] A position sensor 5 is a door zone sensor configured to detect a detection plate 6 so as to determine if the elevator is at the position where the door can be opened. A car speed sensor 7 for detecting the car speed may be formed as a rotation sensor attached to the governor, for example. The rotation sensor attached to the governor will be referred to as a governor encoder. It is also possible to directly attach the acceleration sensor to the car.

[0013] Fig. 2 is a block diagram representing correlation between the brake control unit 20 and the torque control unit 23 with respect to processing executed by those units. Upon reception of an operation start command input from the elevator control unit 2, a speed command output processing unit 30 issues a zero speed command. The difference between the zero speed command and a car speed feedback input from a car speed detection processing unit 31 is calculated for execution of target value follow-up control, for example, proportional integral control. Finally, the torque command is output. In other words, the torque command is output so that the car speed becomes zero. The car speed detection processing unit 31 detects a car speed feedback signal derived from the machine encoder so that the signal is output for speed command output processing.

[0014] A torque control processing unit 32 obtains the difference between the torque command input from the speed command output processing unit 30 and a torque feedback signal calculated from a motor current feedback signal, executes such process as proportional integral control, and outputs the torque output command. The torque output command is input to the power converter 101 so that voltage is applied to a synchronous motor for generating the desired torque.

[0015] The brake control unit 20 includes a brake current command generation unit 33 and a type information database (DB) 34. Upon reception of an operation start command input from the elevator control unit 2, the brake current command generation unit 33 outputs the brake current command in reference to the type information DB 34 to be described later. The brake current command is input to the brake current control circuit 21, based on which the brake current control circuit 21 controls the brake current 22 to be applied to the brake solenoid coil.

[0016] Fig. 3 graphically represents the time-series correlation among waveforms generated upon start of the brake control unit 20 and the torque control unit 23. For convenience of explanation, the time axis is divided into four sections from (a) to (d). The basic operation process will be described with respect to the sections sequentially from the section (a).

[0017] In the section (a), the operation start command has not been input to the respective control units, and therefore, the brake current command is in the zero state. In other words, the car is kept under braking force by the brake, and accordingly, the car speed is also zero. Because of the braking force applied by the brake, the torque output command is also in the zero state.

[0018] In the section (b), the operation start command is input. Then the brake control unit 20 gradually increases the brake current command value so that the brake current output from the brake current control circuit 21 is applied to the solenoid for lifting the brake 102. Upon increase in the brake current command value, the brake 102 is lifted slowly so as to decrease the brake torque T. In the case that the unbalance torque between the car and the counterweight is made larger under the decreasing brake torque, the car is likely to move. At this time, the speed command output processing unit 30 has already output the zero speed command. Then the torque control processing unit 32 outputs the torque output command to the power converter 101 so that the car speed becomes zero. Then power is output to the motor 103 to output the torque in accordance with the torque output command to the power converter 101. Since the speed command output processing unit 30 has already output the zero speed command, the brake is lifted. As the unbalance torque is made relatively larger than the brake torque, the motor torque for maintaining the zero speed is increased as well as the output of the torque command. By releasing the brake slowly, the brake torque insufficient to bring the car into static state may be compensated in response to the torque output command. This may maintain the static state of the car. The gradient of the brake current command in the section (b) is determined in reference to the type information DB 34 in order to cope with the response which differs depending on the brake type. For example, in the case of brake torque response delay to change in the brake current command, the gradient may be reduced or shaped into step-like form so as to facilitate the response following up to the command.

[0019] The section (c) represents the transitional change into the state that brings the brake torque into zero state as a result of separation of the brake pad from the sheave resulting from increasing brake current. At this time, the torque required for making the car into static state has been already output in the section (b). Therefore, shaking of the car owing to torque change rarely occurs even in the state that the brake is released.

[0020] The section (d) represents the state that the brake has been separated. The torque sufficient to bring the car into static state has been output in the section (c) so that the car is kept in the static state. At this time, the torque control processing unit 32 has output the torque output command to set the car speed to zero. Subsequently, the speed command is applied to start operation of the car.

[0021] Fig. 4 is a flowchart according to the present invention. In step S101, the elevator control unit 2 detects whether the operation start command has been input. If the operation start command is OFF, the process ends. If the operation start command is ON, the process proceeds to step S102. In step S102, the car speed detection processing unit 31 converts the machine encoder information or the information output from the car speed sensor 7, which has been input via the elevator control unit into the car speed. The speed command output processing unit 30 judges whether or not the car speed is zero. If the car speed is zero, the process proceeds to step S103 where the brake current command value is increased through the brake current command generation process. In step S104, the brake torque is reduced as the brake current varies. If it is judged in step S102 that the car speed is not zero, the process proceeds to step S105 where the speed command output processing unit outputs the torque control command to set the car speed to zero. In step S106, it is judged whether or not the brake pad has been separated. Separation of the brake pad may be detected by utilizing the brake check switch 8 for detecting the brake operation state. If the brake pad has not been separated, the process proceeds to the step prior to step S102. That is, when the brake pad is not separated at the speed other than zero, the control for increasing the brake current is executed while outputting the torque that approximates the speed to zero. If the brake pad is separated by decreasing the brake torque stepwise, the process proceeds to step S107 where the process is kept stand-by until the operation command is input while allowing the speed control unit to output the torque to set the car speed to zero. The current command generation increasing process executed by the brake current command generation unit 33 ends to terminate the series of process steps.

[0022] The above-described structure allows the unbalance torque corresponding to the difference between the car and the counterweight to be gradually activated under the decreasing braking force resulting from the brake slowly released by the elevator control unit. The control unit subjects the torque command to the follow-up control, which allows slow follow-up to the unbalance torque without causing sharp torque change. This makes it possible to make the acceleration change owing to torque gentle. In the case of error in the weighing sensor and the rotation sensor, the resultant shaking may be suppressed.

[0023] The present invention is useful for the case that the magnetic pole position of the motor as the drive unit is estimated for driving operation. In particular, so called vector control is executed for the general torque control or speed control of the motor as the permanent magnet synchronous motor. As the above-described control needs detection of the magnetic pole position of the synchronous motor, the magnetic pole is detected by the rotation sensor. The detection error of the rotation sensor attached to the synchronous motor with respect to the magnetic pole position may influence the compensation torque. As a result, the large detection error and the error in estimation with respect to the magnetic pole position through sensor-less driving operation may cause shaking of the car.

[0024] The current value kept constant for the magnetic pole position estimation is output immediately after execution of step S101, and the brake is gradually released by the control unit to bring the unbalance torque as the difference between the car and the counterweight into activated state under the weakening braking force. At this time, the control unit subjects the torque command to the follow-up control to allow slow follow-up to the unbalance torque without causing sharp torque change. This makes it possible to make the acceleration change owing to torque gentle. In spite of torque inversion, large torque is not required, and shaking may be lessened without generating high acceleration under the active braking force. In the case of error in the weighing sensor and the rotation sensor, it is possible to lessen shaking of the car.

List of Reference Signs

[0025]

2 elevator control unit

Claims

1. An elevator comprising:

    a car;
    a drive unit for moving the car by rotating a rotary body connected to the car;
    a brake for applying a braking force to the rotary body;
    an elevator control unit for controlling an operation of the car;
    a brake control unit for changing a brake torque of the brake stepwise for releasing upon reception of a start signal of the elevator from the elevator control unit; and
    a torque control unit for controlling a torque of the drive unit to approximate the car speed to zero upon reception of the start signal of the elevator from the elevator control unit.

2. The elevator according to claim 1, further comprising

a brake check switch for detecting a contact state between the brake and the rotary body, wherein in the case that the brake check switch detects separation of the brake from the rotary body, the brake control unit fully releases the brake from the rotary body.

3. The elevator according to claim 1, further comprising a brake check switch for detecting a contact state between the brake and the rotary body, wherein the brake check switch detects separation of the brake from the rotary body, and the torque control unit controls a torque of the drive unit to approximate the car speed to zero until reception of an operation command from the elevator control unit.

4. The elevator according to claim 3, wherein the brake control unit determines a brake control process of gradually releasing the brake from the rotary body based on information stored in a type information DB of the brake control unit.

FIG. 1

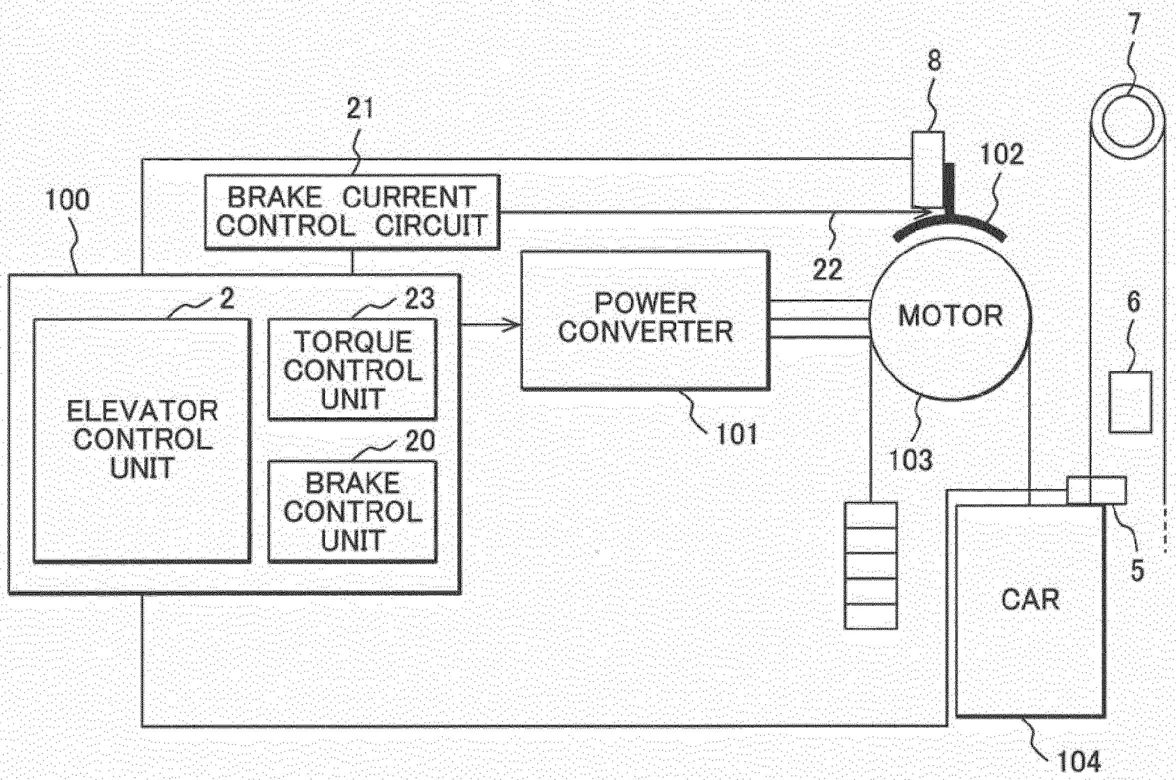

7
8
21
102
100
BRAKE CURRENT CONTROL CIRCUIT
22
POWER CONVERTER
MOTOR
6
2
23
TORQUE CONTROL UNIT
ELEVATOR CONTROL UNIT
101
103
20
BRAKE CONTROL UNIT
5
CAR
104

FIG. 2

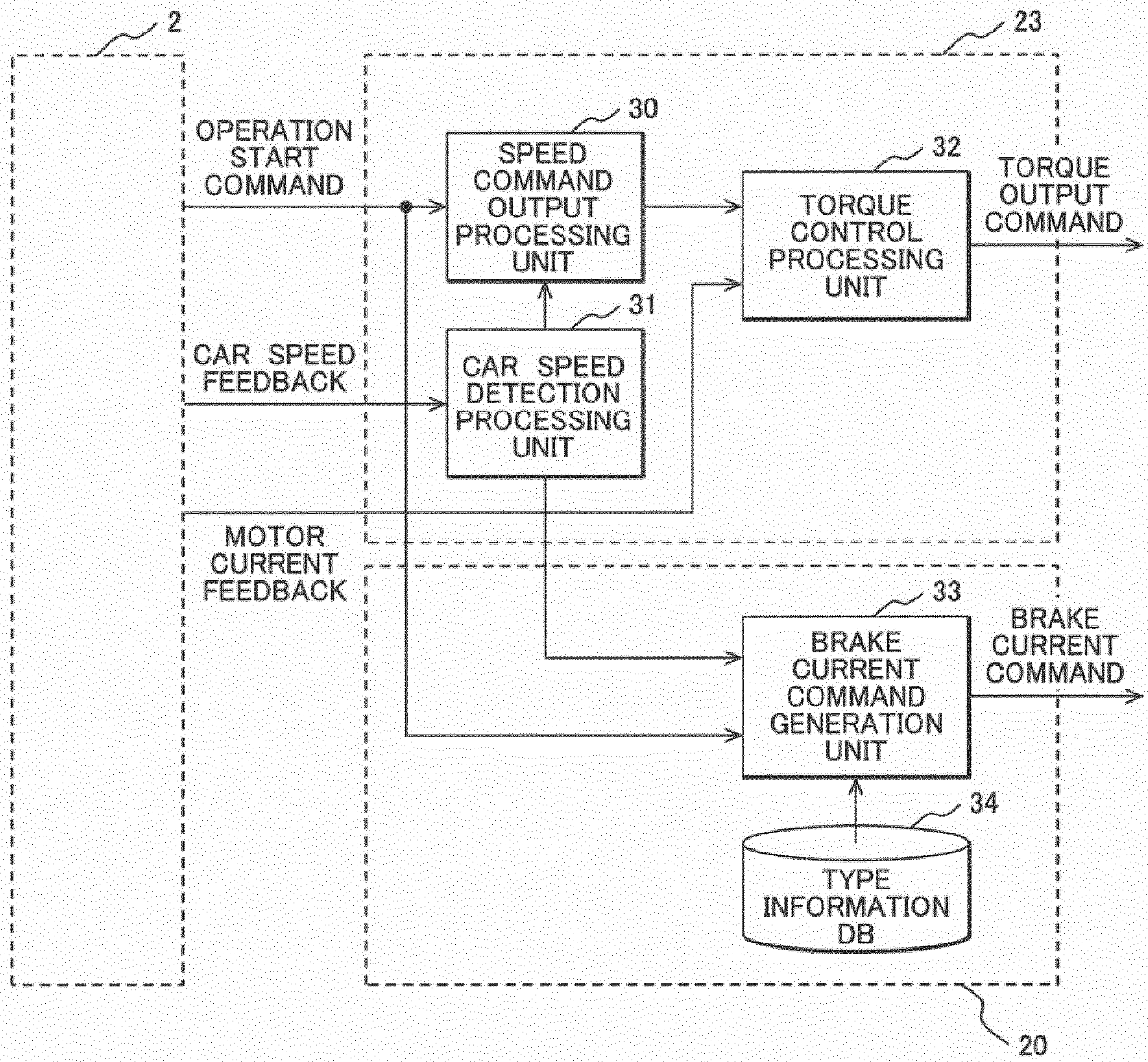

2
23
30
SPEED COMMAND OUTPUT PROCESSING UNIT
31
CAR SPEED DETECTION PROCESSING UNIT
32
TORQUE CONTROL PROCESSING UNIT
OPERATION START COMMAND
CAR SPEED FEEDBACK
MOTOR CURRENT FEEDBACK
TORQUE OUTPUT COMMAND
33
BRAKE CURRENT COMMAND GENERATION UNIT
BRAKE CURRENT COMMAND
34
TYPE INFORMATION DB
20

FIG. 3

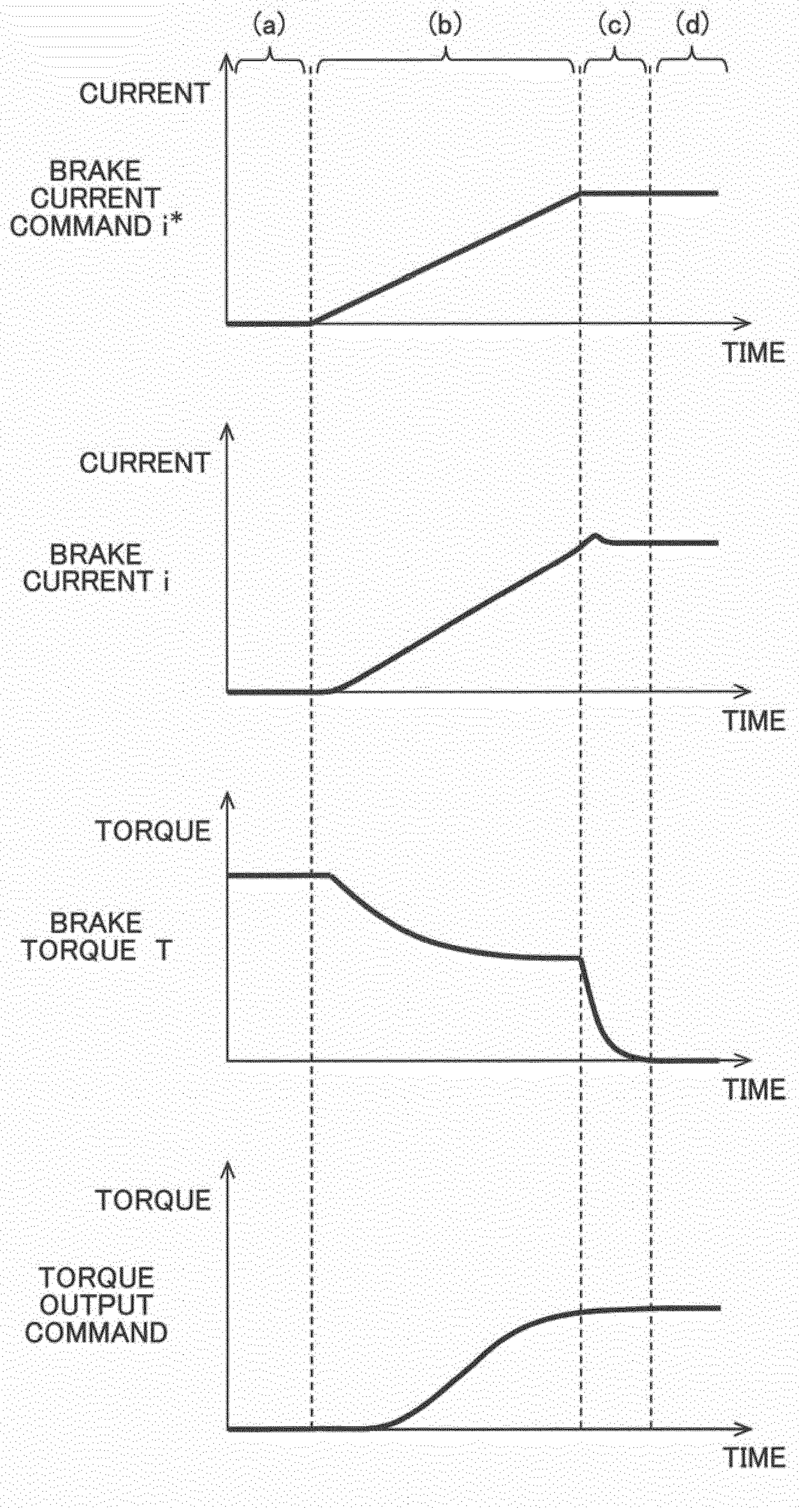
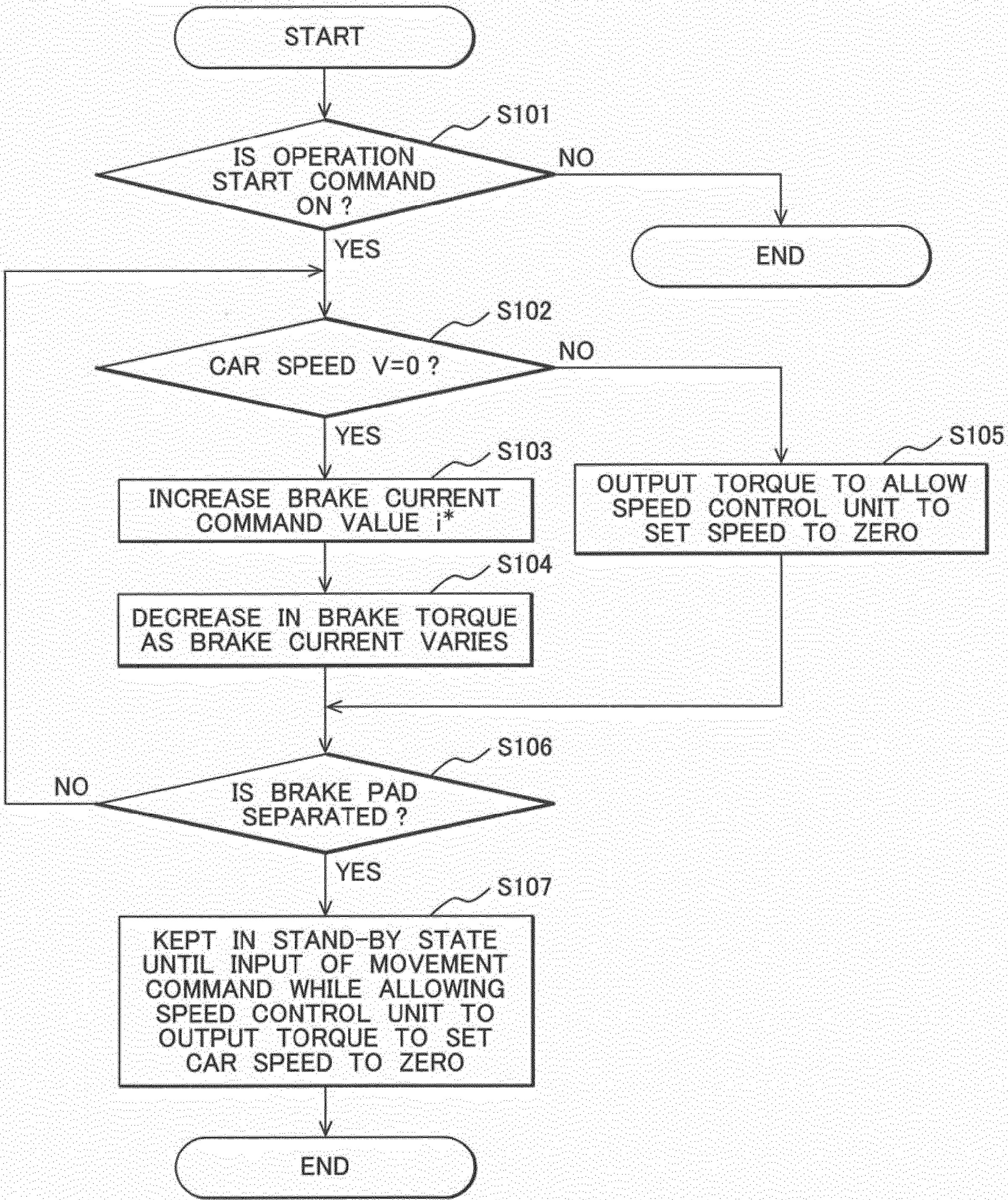

(a)
(b)
(c)
(d)
CURRENT
BRAKE CURRENT COMMAND i*
TIME
CURRENT
BRAKE CURRENT i
TIME
TORQUE
BRAKE TORQUE T
TIME
TORQUE
TORQUE OUTPUT COMMAND
TIME

FIG. 4


START
S101
IS OPERATION START COMMAND ON ?
NO
END
YES
S102
CAR SPEED V=0 ?
NO
YES
S103
INCREASE BRAKE CURRENT COMMAND VALUE i*
S105
OUTPUT TORQUE TO ALLOW SPEED CONTROL UNIT TO SET SPEED TO ZERO
S104
DECREASE IN BRAKE TORQUE AS BRAKE CURRENT VARIES
S106
NO
IS BRAKE PAD SEPARATED ?
YES
S107
KEPT IN STAND-BY STATE UNTIL INPUT OF MOVEMENT COMMAND WHILE ALLOWING SPEED CONTROL UNIT TO OUTPUT TORQUE TO SET CAR SPEED TO ZERO
END

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EUROPEAN SEARCH REPORT

Application Number
EP 17 18 1466

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 247 140 A (IWASA MASAO [JP] ET AL) 21 September 1993 (1993-09-21) * abstract; figures 1-5 * * column 4, line 49 - column 6, line 49 * -----	1-4	INV. B66B1/30 B66B1/32
X	CN 104 671 022 A (MITSUBISHI ELECTRIC CORP) 3 June 2015 (2015-06-03) * abstract; figures 1-4 * * paragraphs [0100] - [0107] * -----	1-4	

TECHNICAL FIELDS SEARCHED (IPC)

B66B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	16 January 2018	Bleys, Philip

CATEGORY OF CITED DOCUMENTS

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16-01-2018

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		JP H0780650 B2	30-08-1995
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2015000796 A **[0002]**