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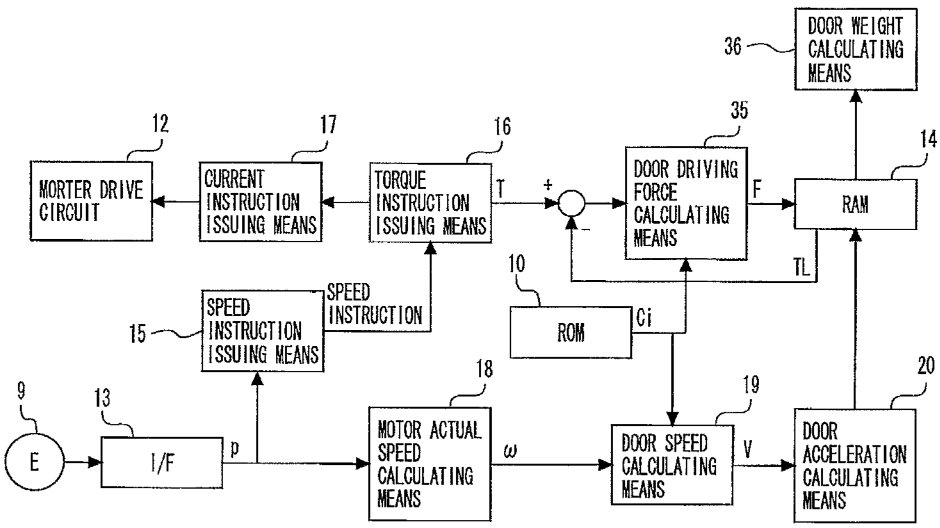
(54) DOOR CONTROL DEVICE FOR ELEVATOR

(57) There is provided an elevator door control device capable of measuring the weight of an elevator door more correctly. For this purpose, the control device has a configuration including a torque instruction issuing means for issuing torque instructions to a door motor for moving the elevator door, a torque instruction storing means for storing the value of torque instruction at the time when the door is moved at a fixed speed, a door driving force calculating means for calculating the value of the force applied to the door when the door is moved while being accelerated, based on a value obtained by subtracting the value of torque instruction at the time when the door is moved at the fixed speed from the value of torque instruction at the time when the door is moved while being accelerated, and a door weight calculating means for calculating the weight of the door by dividing the value of the force applied to the door when the door is moved while being accelerated by the value of the acceleration of the door at the time when the door is moved while being accelerated.

FIG. 8



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Description

Technical Field

[0001] The present invention relates to an elevator door control device.

Background Art

[0002] As the quantity representing the degree of shock at the time when an object is caught between a door and a door or between a door and a door stop post of elevator, kinetic energy has been used widely. Taking the weight of object as W(kg) and the speed of object as V(m/s), the kinetic energy of this object is represented by $WV^2/2$(J). That is, as the value of the weight W or the speed V of object increases, the shock becomes stronger.

[0003] In Japan, there are no regulations with regard to the kinetic energy of elevator door. However, for example, European elevator standard EN81-1-1998 specifies that "the kinetic energy of a car door and a hall door at the time of average door closing speed shall be 10(J) or lower". In some other districts as well, the kinetic energy at the door closing time has been specified. When an elevator is installed in such a district, the regulations with regard to the kinetic energy of door must be observed.

[0004] When the kinetic energy of door is calculated, before the door is installed, the weight M of the door can be grasped by actual measurement. However, the weight M of door takes various values depending on the material of door, the breadth of elevator entrance, and the like. Therefore, the weight M of door must be measured for every elevator. Also, in order to keep the kinetic energy at the door closing time at a fixed value or less, after the door has been installed, the speed of door must be adjusted considering the weight M of door. For this reason, the adjustment of kinetic energy of the door requires much time and labor.

[0005] To save such time and labor, a means for automatically measuring the door weight has been used. In this means, the door weight is measured by utilizing the equation of motion. Specifically, acceleration a at the time when the door is opened and closed and force F applied to the door are calculated, and F/a is determined to obtain the door weight (for example, refer to Patent Literature 1).

[0006] In this means, a mechanical loss occurs on account of a mechanism such as a speed reducer and a link during the time when the power of a door motor is transmitted to the door. That is, the door motor delivers torque necessary for moving the door and the mechanism. Therefore, if the door motor torque, which is a power source for the door, is converted simply into the force F applied to the door, the measurement error of door weight increases.

[0007] That is, in order to measure the force F applied to the door more correctly, it is necessary to subtract the mechanical loss occurring on account of the mechanism such as the speed reducer and the link from the door motor torque. This mechanical loss can be calculated theoretically from the size and weight of the mechanism such as the speed reducer and the link. Therefore, if the door weight W is made (Fm-FL)/a by taking the quantity obtained by converting door motor torque into force as Fm and taking the theoretical value of mechanical loss as FL, the measurement error of door weight W can be reduced.

Citation List

Patent Literature

[0008] Patent Literature 1: Japanese Patent Laid-Open No. 2009-1430

Summary of Invention

Technical Problem

[0009] Actually, however, each elevator shows its peculiar mechanical loss. For example, the running resistance of door is a mechanical loss peculiar to individual elevator. For this reason, even if the door weight W is made (Fm-FL)/a, a difference occurs between the theoretical value of door weight and the actual value of door weight.

[0010] That is, the motor torque is delivered as a torque including the torque for resisting the mechanical loss peculiar to individual elevator. Therefore, in order to measure the door weight more correctly, an overall mechanical loss including not only the theoretical value FL but also the mechanical loss peculiar to individual elevator must be subtracted from the quantity Fm obtained by converting motor torque into force.

[0011] However, the mechanical loss peculiar to individual elevator cannot be estimated on the top of a desk. Also, it requires time and labor to measure the mechanical loss peculiar to individual elevator when the elevator is installed. For these reasons, when the door weight is measured, the mechanical loss peculiar to individual elevator is actually ignored.

[0012] Consideration is given to the case where the value obtained by converting motor torque into force is increased by ΔFm by the mechanical loss peculiar to individual elevator. The measured value W' of door weight in this case is (Fm + ΔFm - FL)/a. Therefore, the error between the actual door weight W and the measured value W' is ΔFm/a.

[0013] In the case where the kinetic energy at the door closing time is going to be kept at a fixed value or less based on the measured value W' of door weight including this error, a speed such that the kinetic energy takes the fixed value or less at the measured value W' of door weight has only to be selected. Considering the operation efficiency of elevator, the door opening/closing speed is preferably faster. That is, for the actual elevator, it is demanded that the door opening/ closing speed be made as fast as possible while the kinetic energy of door is kept at the fixed value or less. However, if the measured value W' of door weight is used when the speed such that the kinetic energy of door takes the fixed value or less is selected, there arises a problem that the door closing speed undesirably becomes slower than necessary.

[0014] The present invention has been made to solve the above-described problems, and accordingly an object thereof is to provide an elevator door control device capable of measuring the weight of elevator door more correctly.

Means for Solving Problems

[0015] An elevator apparatus of the present invention includes torque instruction issuing means for issuing torque instructions to a door motor for moving an elevator door, torque instruction storing means for storing the value of torque instruction at the time when the door is moved at a fixed speed, door driving force calculating means for calculating the value of the force applied to the door when the door is moved while being accelerated, based on a value obtained by subtracting the value of torque instruction at the time when the door is moved at the fixed speed from the value of torque instruction at the time when the door is moved while being accelerated and door weight calculating means for calculating the weight of the door by dividing the value of the force applied to the door when the door is moved while being accelerated by the value of the acceleration of the door at the time when the door is moved while being accelerated.

Advantageous Effect of Invention

[0016] According to the present invention, the weight of elevator door can be measured more correctly.

Brief Description of Drawings

[0017]

Figure 1 is a front view of a car entrance, being viewed from the outside of elevator car for which an elevator door control device in accordance with a first embodiment of the present invention is used.

Figure 2 is a block diagram for explaining the outline of the elevator door control device in accordance with a first embodiment of the present invention.

Figure 3 is a block diagram of the door controller of elevator in accordance with the first embodiment of the present invention.

Figure 4 is a diagram for explaining the door speed, the speed ratio of door to door motor, and the motor speed in the case where the speed ratio of door and motor of the elevator for which the elevator door control device in accordance with the first embodiment of the present invention is used is inconstant.

Figure 5 is a diagram for explaining a standard at the time when it is determined, by the elevator door control device in accordance with the first embodiment of the present invention, that the door speed is not fixed.

Figure 6 is a diagram for explaining the door motor torque corresponding to the overall mechanical loss sampled by the elevator door control device in accordance with the first embodiment of the present invention.

Figure 7 is a flowchart for explaining the motion at the time when the elevator door control device in accordance with the first embodiment of the present invention learns the torque of door motor corresponding to the overall mechanical loss.

Figure 8 is a block diagram of the elevator door control device in accordance with the first embodiment of the present invention.

Figure 9 is a diagram for explaining the method by which the elevator door control device in accordance with the first embodiment of the present invention measures the weight of the door 1.

Figure 10 is a flowchart for explaining the motion at the time when the elevator door control device in accordance with the first embodiment of the present invention measures the weight of the door 1.

Description of Embodiment

[0018] An embodiment for carrying out the present invention will now be described with reference to the accompanying drawings. In the drawings, the same reference signs are applied to the same or equivalent parts, and the duplicated explanation thereof is simplified or omitted as appropriate.

First embodiment

[0019] Figure 1 is a front view of a car entrance, being viewed from the outside of elevator car for which an elevator door control device in accordance with a first embodiment of the present invention is used. Figure 2 is a block diagram for explaining the outline of the elevator door control device in accordance with a first embodiment of the present invention.

[0020] In Figure 1, reference sign 1 denotes an elevator door. Specifically, the door 1 is a car door. The doors 1 are provided at the entrance of elevator car. These doors 1 are hung from a door rail 2 in the upper edge portion of car entrance. Above the door rail 2, a door motor 3 is provided. At the side of the door motor 3, a speed reducer 4 is provided. To the speed reducer 4, one end of a link 5 is connected. The other end of the link 5 is connected to the back surface of the door 1. Also, in an upper portion in the center of the door rail 2, a closed position detecting switch 6 is provided. On the other hand, in an upper portion on one side of the door rail 2, an open position detecting switch 7 is provided. Above the speed reducer 4, a door controller 8 is provided.

[0021] As shown in Figure 2, in the vicinity of the door motor 3, a pulse generator 9 is provided. The pulse generator 9 generates pulses of the number corresponding to the rotation quantity of the door motor 3 based on the open position or the closed position of the door 1. The door controller 8 is provided with a ROM 10, a CPU 11, a motor drive circuit 12, an interface circuit 13, and a RAM 14.

[0022] The ROM 10 has a function of storing various kinds of data and the like concerning the opening/closing control of the door 1. For example, in the ROM 10, an algorithm for opening and closing the door 1 smoothly has been written. The CPU 11 has a function of issuing motor speed instructions based on the algorithm stored in the ROM 10. Also, the CPU 11 has a function of issuing motor torque instructions based on the motor speed instructions.

[0023] The motor drive circuit 12 has a function of supplying an electric current corresponding to the motor torque instruction issued by the CPU 11 to the door motor 3. The interface circuit 13 has a function of capturing the pulse signals generated from the pulse generator 9. The RAM 14 has a function of storing the calculation results of the CPU 11 as appropriate.

[0024] In the door controller 8, the CPU 11 calculates the actual speed of the door motor 3 based on the pulses captured by the interface circuit 13. Also, the CPU 11 adjusts the value of motor torque instruction as appropriate so that the actual speed of the door motor 3 agrees with the motor speed instruction. By this adjustment, the door 1 is opened and closed smoothly.

[0025] The door controller 8 of this embodiment has a function of automatically measuring the weight of the door 1. Specifically, in the ROM 10, parameters necessary for automatically measuring the weight of the door 1 have been written. The CPU 11 calculates the weight of the door 1 based on the actual speed of the door motor 3 and the motor torque instruction. Hereunder, the basic concept concerning the measuring method for the weight of the door 1 in this embodiment is explained.

[0026] As shown in Figure 1, the power for the door motor 3 is transmitted to the door 1 via a mechanism such as the speed reducer 4 and the link 5. In this case, the power for the door motor 3 includes a mechanical loss FL produced by the mechanism of the speed reducer 4 and the link 5 in addition to the force necessary for moving the door 1. This mechanical loss FL is calculated theoretically.

[0027] In the case where only this theoretical mechanical loss FL is a mechanical loss at the time when the door 1 is driven, taking the power for the door motor 3 as Fm, the weight of the door 1 as W, and the acceleration of the door 1 as a, the equation of motion can be expressed by Formula (1).

$$\mathrm{Fm} - \mathrm{FL} = \mathrm{W} \times \mathrm{a} \qquad (1)$$

[0028] That is, in the case where only the theoretical mechanical loss FL is a mechanical loss at the time when the door 1 is driven, the weight W of the door 1 can be represented by Formula (2).

$$\mathrm{W} = (\mathrm{Fm} - \mathrm{FL})/\mathrm{a} \qquad (2)$$

[0029] If the power Fm for the door motor 3 at the time when the acceleration of the door 1 is zero is made Fm', substituting a = 0 into Formula (1) gives the following relationship expressed by Formula (3).

$$Fm' - FL = W \times 0 = 0 \qquad (3)$$

[0030] That is, the power Fm' for the door motor 3 in the case where the acceleration of the door 1 is zero can be represented by Formula (4).

$$Fm' = FL \qquad (4)$$

[0031] However, the power for the door motor 3 includes a force resisting a mechanical loss peculiar to individual elevator. For example, the running resistance produced by the movement of the door 1 along the door rail 2 yields the mechanical loss peculiar to individual elevator. This mechanical loss peculiar to individual elevator cannot be estimated theoretically on the top of a desk.

[0032] In this case, taking the mechanical loss peculiar to individual elevator as ΔFL, and the force for resisting the mechanical loss peculiar to individual elevator as ΔFm, in the case where the acceleration of the door 1 is zero, substituting a = 0 into Formula (1) gives the following relationship expressed by Formula (5).

$$Fm' + \Delta Fm - (FL + \Delta FL) = W \times a = 0 \qquad (5)$$

[0033] In this case, considering the relationship expressed by Formula (4), the force ΔFm for resisting the mechanical loss peculiar to individual elevator can be represented by Formula (6).

$$\Delta Fm = \Delta FL \qquad (6)$$

[0034] That is, the force ΔFm for resisting the mechanical loss peculiar to individual elevator is the mechanical loss ΔFL peculiar to individual elevator itself. In other words, the power (Fm' + ΔFm) for the door motor 3 including the force ΔFm for resisting the mechanical loss peculiar to individual elevator is an overall mechanical loss obtained by adding the mechanical loss ΔFL peculiar to individual elevator to the theoretical mechanical loss FL.

[0035] Accordingly, when the door 1 is opened or closed ordinarily, the door controller 8 of this embodiment calculates the weight W' of the door 1 by utilizing the overall mechanical loss. Specifically, when the value obtained by converting the motor torque including the force ΔFm for resisting the mechanical loss peculiar to individual elevator into a force is taken as FM, the door controller 8 calculates the weight W' of the door 1 represented by Formula (7).

$$W' = \{FM - (FL + \Delta FL)\}/a \qquad (7)$$

in which FM = Fm + ΔFm

[0036] As shown in Formula (6), ΔFm equals ΔFL. Therefore, the weight W' of the door 1 is represented by Formula (8).

$$W' = (Fm - FL)/a \qquad (8)$$

[0037] Also, as shown in Formula (2), (Fm - FL)/a equals W. Therefore, the weight W' of the door 1 can be represented by Formula (9).

$$W' = W \qquad (9)$$

[0038] That is, the weight W' of the door 1 considering the mechanical loss peculiar to individual elevator takes the same value as that of the weight W of the door 1 in the case where only the theoretical mechanical loss FL is the mechanical loss. In other words, theoretically, the weight W' of the door 1 has no error.

[0039] When the door 1 is opened or closed, the acceleration and the deceleration of the door 1 are necessary. Therefore, in the process from acceleration to deceleration of the door 1, the acceleration a of the door 1 becomes zero at some time. In this case, a equals zero, so that the weight W' of the door 1 cannot be calculated by Formula (8). Accordingly, the door controller 8 of this embodiment calculates the weight W' of the door 1 by using a force F1 applied to the door 1 when the acceleration a of the door 1 takes the maximum value a1 and a force F2 applied to the door 1 when the acceleration of the door 1 takes the minimum value a2.

[0040] Taking Fm, ΔFm, FL and ΔFL at the time when the acceleration of the door 1 takes the maximum value a1 as Fm1, ΔFm1, FL1 and ΔFL1, respectively, the force F1 applied to the door 1 at this time can be represented by Formula (10).

$$F1 = Fm1 + \Delta Fm1 - (FL1 + \Delta FL1) \qquad (10)$$

[0041] Also, taking Fm, ΔFm, FL and ΔFL at the time when the acceleration of the door 1 takes the minimum value a2 as Fm2, ΔFm2, FL2 and ΔFL2, respectively, the force F2 applied to the door 1 at this time can be represented by Formula (11).

$$F2 = Fm2 + \Delta Fm2 - (FL2 + \Delta FL2) \qquad (11)$$

[0042] In this embodiment, the weight W' of the door 1 is calculated by Formula (12).

$$W' = (F1 - F2) / (a1 - a2)$$
$$= \{(Fm1 - FL1) - (Fm2 - FL2) / (a1 - a2) \qquad (12)$$

[0043] Next, referring to Figures 3 to 7, a method of calculating the overall mechanical loss at the time when the door 1 is moved is explained.
First, referring to Figure 3, the outline of a method of moving the door 1 at a fixed speed is explained.
Figure 3 is a block diagram of the door controller of elevator in accordance with the first embodiment of the present invention.
As described above, in order to calculate the overall mechanical loss at the time when the door 1 is moved, it is necessary to move the door 1 at a fixed speed. In this case, a special motor speed instruction different from the ordinary door opening/closing time becomes necessary.

[0044] Accordingly, in the ROM 10 of this embodiment, a speed control constant Cj for moving the door 1 at a fixed speed and a value V for setting the fixed speed have been written. When the door 1 is moved at the fixed speed, the CPU 11 functions as a speed instruction issuing means 15, a torque instruction issuing means 16, a current instruction issuing means 17, a motor actual speed calculating means 18, a door speed calculating means 19, a door acceleration calculating means 20, and an acceleration monitoring means 21.

[0045] The speed instruction issuing means 15 has a function of issuing motor speed instructions based on the number of pulses p generated by the pulse generator 9, the speed control constant Cj and the fixed speed value V of the door 1 having been written in the ROM 10. The torque instruction issuing means 16 has a function of issuing motor torque instructions T to the door motor 3 based on the motor speed instructions issued by the speed instruction issuing means 15. The current instruction issuing means 17 has a function of issuing current instructions corresponding to the electric current supplied to the door motor 3 based on the torque instructions T issued by the torque instruction issuing means 16. The motor actual speed calculating means 18 has a function of calculating the actual speed ω of the door motor 3 based on the number of pulses p introduced into the interface circuit 13.

[0046] The door speed calculating means 19 has a function of calculating the speed of the door 1 based on the speed control constant Cj having been written in the ROM 10 and the actual speed ω of the door motor 3 calculated by the motor actual speed calculating means 18. The door acceleration calculating means 20 has a function of calculating the acceleration a of the door 1 based on the speed of the door 1 calculated by the door speed calculating means 19. The acceleration monitoring means 21 has a function of monitoring the acceleration a of the door 1 calculated by the door acceleration calculating means 20.

[0047] Even if the door motor 3 is rotated through the motor speed instruction corresponding to the fixed speed value V, in some cases, the actual speed ω of the door motor 3 deviates from the motor speed instruction, and the door 1 does not move at the fixed speed. In this case, the torque of the door motor 3 includes a torque for moving the door 1. That is, the overall mechanical loss cannot be learnt with high accuracy. In this embodiment, accordingly, the acceleration monitoring means 21 is configured so as to monitor whether or not the speed of the door 1 is fixed.

[0048] Specifically, based on the full opening/closing detection signal sent from the closed position detecting switch 6 and the open position detecting switch 7 and the door opening/closing instruction issued from a control panel 22, the acceleration monitoring means 21 monitors whether or not the speed of the door 1 is fixed. Also, based on the speed V of the door 1, the acceleration a of the door 1, and the actual speed ω of the door motor 3, the acceleration monitoring means 21 monitors whether or not the speed of the door 1 is fixed.

[0049] Next, referring to Figure 4, a specific method of moving the door 1 at the fixed speed is explained.

Figure 4 is a diagram for explaining the door speed, the speed ratio of door to door motor, and the motor speed in the case where the speed ratio of door and motor of the elevator for which the elevator door control device in accordance with the first embodiment of the present invention is used is inconstant.

[0050] In Figure 4, the abscissas represent the position of the door 1, and the ordinates represent the speed of the door 1, the speed ratio of the door 1 to the door motor 3, and the speed of the door motor 3.

In Figure 4, reference sign 23 denotes the speed of the door 1, 24 denotes the speed ratio of the door 1 to the door motor 3, and 25 denotes the speed of the door motor 3. As shown in Figure 4, in order to make the speed 23 of the door 1 a fixed speed value V, it is necessary to first increase the speed 23 of the door 1 to the fixed speed value V, and then keep the speed 23 of the door 1 at the fixed speed value V.

[0051] The speed ratio 24 of the door 1 to the door motor 3 can be determined from the number of pulses p of the pulse generator 9. In the case where the speed 23 of the door 1 is caused to correspond to the fixed speed value V, the speed ratio 24 of the door 1 to the door motor 3 can be expressed by Formula (13).

$$R(p) = V/\omega = \Sigma(Cj \times P^{j}) \qquad (13)$$

in which j = 0, 1, 2... N.

[0052] In the case where the power of the door motor 3 is transmitted to the door 1 via the speed reducer 4 and a belt or chain only, the speed 25 of the door motor 3 and the speed 23 of the door 1 have a proportional relationship with each other. In this case, C0 is the speed ratio of the door 1 to the door motor 3, and C1 = C2 = ... = CN = 0. In order to make the speed of the door 1 the fixed speed value V, the speed of the door motor 3 has only to be fixed.

[0053] On the other hand, in the mechanism in which the power of the door motor 3 is transmitted to the door 1 via the speed reducer 4 and the link 5 as shown in Figure 1, the speed 25 of the door motor 3 and the speed 23 of the door 1, generally, do not have a proportional relationship. Therefore, the speed ratio 24 of the door 1 to the door motor 3 is a function of the number of pulses p of the pulse generator 9.

[0054] As the fixed speed value V increases, the movement distance of the door 1 until the speed of the door 1 reaches the fixed speed value V lengthens. During the time when the speed of the door 1 reaches the fixed speed value V, the overall mechanical loss cannot be measured. That is, if the acceleration distance of the door 1 is shortened, the region in which the overall mechanical loss can be measured can be made long. Therefore, the fixed speed value V is preferably made smaller than the speed value of the door 1 at the ordinary operation time. That is, when the overall mechanical loss is measured, the door 1 is preferably moved at a slow speed.

[0055] Next, referring to Figure 5, a method of monitoring the speed of the door 1 is explained.

Figure 5 is a diagram for explaining a standard at the time when it is judged, by the elevator door control device in accordance with the first embodiment of the present invention, that the door speed is not fixed.

In Figure 5, the abscissas represent the position of the door 1, and the ordinates represent the speed of the door 1, the speed of the door motor 3, and the acceleration of the door 1. In Figure 5, reference sign 26 denotes the acceleration of the door 1, 27 denotes the fixed speed value V, and 28 denotes the motor speed instruction. The method of judging that the speed 23 of the door 1 does not reach the fixed speed value V is broadly divided into two methods.

[0056] In one method, when the door 1 reverses and moves in the reverse direction at a position other than the full-open position and the full-closed position, it is determined that the speed 23 of the door 1 does not take the fixed speed value V. Specifically, based on the full opening/closing detection signal sent from the open position detecting switch 7, the acceleration monitoring means 21 determines whether or not the door 1 is located at a position other than the full-open position and the full-closed position. Also, based on a change in door opening/closing instruction sent from the control panel 22 so as to correspond to the operation of a door opening/closing button and the like on an operating panel (not shown) in the car, the acceleration monitoring means 21 determines whether or not the door 1 has reversed and moved in the reverse direction. Then, the acceleration monitoring means 21 determines, based on these determinations, whether or not the speed 23 of the door 1 takes the fixed speed value V.

[0057] In the other method, when the acceleration of the door 1 moving in the same direction becomes not zero, it is determined that the speed 23 of the door 1 does not take the fixed speed value V. For example, the acceleration monitoring means 21 compares the actual speed ω of the door motor 3 with the value of the motor speed instruction 28. Then, when a difference not smaller than a predetermined difference arises between the actual speed ω of the door motor 3 and the value of the motor speed instruction 28 as in a motor speed abnormality region 29, the acceleration monitoring means 21 determines that the speed 23 of the door 1 does not take the fixed speed value V.

[0058] Also, when the speed of the door 1 deviates from the fixed speed value V by a predetermined value as in a door speed abnormality region 30, the acceleration monitoring means 21 determines that the speed 23 of the door 1 does not take the fixed speed value V. In this case, the acceleration monitoring means 21 compares the value obtained by multiplying the actual speed ω of the door motor 3 by the speed ratio R(p) with the fixed speed value V. However, the acceleration monitoring means 21 does not store the speed ratio R(p) itself. Therefore, the acceleration monitoring means 21 calculates the speed ratio R(p) by solving the polynomial while referring to the speed control constant Cj in Formula (13) from the ROM 10.

[0059] Further, when the acceleration a (26) deviates from zero by a predetermined amount or more as in a door acceleration abnormality region 31, the acceleration monitoring means 21 determines that the speed 23 of the door 1 does not take the fixed speed value V. In this case, the acceleration monitoring means 21 monitors the acceleration a (26) represented by Formula (14).

$$a = \{\omega[i] \times R(p[i]) - \omega[i-1] \times R(p[i-1])\} / (t[i] - t[i-1]) \qquad (14)$$

in which i is a serial number, and t is sampling time.

[0060] The acceleration monitoring means 21 of this embodiment is set so as to determine, by using at least one of the above-described methods, that the speed 23 of the door 1 does not take the fixed speed value V.

[0061] Next, referring to Figure 6, the torque of the door motor 3 that corresponds to the sampled overall mechanical loss is explained.

Figure 6 is a diagram for explaining the door motor torque corresponding to the overall mechanical loss sampled by the elevator door control device in accordance with the first embodiment of the present invention.

In Figure 6, the abscissas represent the position of the door 1, and the ordinates represent the torque value of the door motor 3. In Figure 6, reference sign 32 denotes the torque of the door motor 3 corresponding to the theoretical mechanical loss FL, 33 denotes the torque of the door motor 3 corresponding to the mechanical loss ΔFL peculiar to individual elevator, and 34 denotes the torque of the door motor 3 corresponding to the overall mechanical loss.

[0062] As explained referring to Figure 5, when the acceleration a of the door 1 deviates from zero by the predetermined amount or more, it is determined that the speed of the door 1 does not take the fixed speed value V. Therefore, the region up to a position at which the speed of the door 1 takes the fixed speed value V is a non-measurement region.

[0063] The region in which the speed of the door 1 takes the fixed speed value V is a measurement region. In this measurement region, the torque 33 of the door motor 3 corresponding to the overall mechanical loss obtained by adding the torque 33 to the torque 32 is calculated.

[0064] Next, referring to Figure 7, a procedure for learning the torque of the door motor 3 corresponding to the overall mechanical loss is explained.

Figure 7 is a flowchart for explaining the motion at the time when the elevator door control device in accordance with the first embodiment of the present invention learns the torque of door motor corresponding to the overall mechanical loss.

[0065] First, in Step S1, after the power has been turned on, the region of the RAM 14 for later storing the learning data is reset. Specifically, the number of pulses p[i] corresponding to the serial number i, the motor torque TL[i] corresponding to the serial number i, and the number of learning times K are reset. Thereafter, the process proceeds to Step S2, where the door opening is started by following the door opening instruction signal sent from the control panel 22. Then, the process proceeds to Step S3, where the motor speed instruction is calculated. Until the speed of the door 1 reaches the fixed speed value V, the door 1 is accelerated. For this reason, Formula (5) does not hold. In this region, therefore, the torque 34 of the door motor 3 corresponding to the overall mechanical loss is not measured automatically.

[0066] Thereafter, if the speed of the door 1 reaches the fixed speed value V in Step S4, the process proceeds to Step S5. In Step S5, the door motor 3 is controlled so that the speed of the door 1 takes the fixed speed value V, and the process proceeds to Step S6. In Step S6, it is determined whether or not the door 1 has reversed. If the door 1 has not reversed, the process proceeds to Step S7, where it is determined whether or not the acceleration a is zero. If the acceleration a is zero, the process proceeds to Step S8.

[0067] In Step S8, it is determined whether or not the predetermined number of pulses set for every several tens to several thousands of pulses has been reached. Herein, the torque of the door motor 3 corresponding to the overall mechanical loss is changed by the position of the door 1. Therefore, the torque of the door motor 3 corresponding to the overall mechanical loss is preferably sampled at a largest possible number of positions of the door 1.

[0068] If the predetermined number of pulses has not been reached in Step S8, the motions in Steps S5 to S7 are repeated. On the other hand, if the predetermined number of pulses has been reached, the process proceeds to Step S9. In Step S9, the motor torque instruction at this time provides the torque TL[i] of the door motor 3 corresponding to the overall mechanical loss. In the state of being caused to correspond to the number of pulses p[i], the torque TL[i] is stored in the RAM 14. Thereafter, in Step S10, i is incremented, and the process proceeds to Step S11. In Step S11, it is determined whether or not the door 1 has been fully opened. If the door 1 has not been fully opened, the motions in and after Step S5 are repeated.

[0069] On the other hand, if the door 1 has been fully opened, the process proceeds to Step S12. In Step S12, it is determined whether or not the number of learning times is K or larger. If the number of learning times is smaller than K, the motions in and after Step S2 are repeated. On the other hand, if the number of learning times is K or larger, the process proceeds to Step S13. In Step S13, a value obtained by averaging K number of TL[i] is stored in the RAM 14 in the state of being caused to correspond to the number of pulses p[i], and the motion ends.

[0070] If the door 1 has reversed in Step S6, the process returns to Step S1, where TL[i] and the like stored in the RAM 14 are reset. Also, if the acceleration a is not zero in Step S7, the process returns to Step S1, where TL[i] and the like stored in the RAM 14 are reset. That is, the speed of the door 1 is monitored at every calculation period.

[0071] Considering the variations in torque of the door motor 3, the number of learning times is preferably larger. However, at the learning time, the door 1 must be moved slowly, so that considering the operation efficiency of elevator, the number of learning times is preferably smaller. Therefore, the number of learning times should be set properly considering the performance of the door motor 3, the service situation of elevator, and the like.

[0072] Next, referring to Figures 8 to 10, a method of automatically calculating the weight of the door 1 by utilizing the torque of the door motor 3 corresponding to the learnt overall mechanical loss.

First, referring to Figure 8, the outline of a method of calculating the weight of the door 1 is explained.

Figure 8 is a block diagram of the elevator door control device in accordance with the first embodiment of the present invention.

[0073] When the weight of the door 1 is calculated, the CPU 11 functions as a door driving force calculating means 35 and a door weight calculating means 36. The door driving force calculating means 35 has a function of calculating the torque for driving the door 1 only by subtracting the torque TL of the door motor 3 corresponding to the overall mechanical loss stored in the RAM 14 from the motor torque instruction T. Further, the door driving force calculating means 35 has a function of calculating the force F applied to the door 1 by utilizing the speed ratio R(p) stored in the ROM 10 from the torque for driving the door 1 only. The door weight calculating means 36 has a function of calculating, based on the force F applied to the door 1 only and the acceleration a of the door 1, the weight of the door 1.

[0074] Next, referring to Figure 9, a specific method of measuring the weight of the door 1 is explained.

Figure 9 is a diagram for explaining the method by which the elevator door control device in accordance with the first embodiment of the present invention measures the weight of the door 1. In Figure 9, the abscissas represent the acceleration a of the door 1, and the ordinates represent the force F applied to the door 1 only. In Figure 9, reference sign 37 denotes sampled data, 38 denotes a data range used on the acceleration peak value side, 39 denotes a data range used on the deceleration peak value side, 40 denotes a data average point in the data range 38, and 41 denotes a data average point in the data range 40.

[0075] As shown in Figure 9, a plurality of points corresponding to the sampled data 37 are approximated by a straight line drawn through the origin. Due to the equation of motion, the inclination of straight line indicates the weight of the door 1. In this embodiment, the door weight calculating means 36 determines a point (a1, F1), which is the average point 40 of the point corresponding to the acceleration peak value and several points in the vicinity of that point. Also, the door weight calculating means 36 determines a point (a2, F2), which is the average point of the point corresponding to the deceleration peak value and several points in the vicinity of that point.

[0076] Then, the door weight calculating means 36 determines the weight W' of the door 1 from Formula (15).

$$W' = (F1 - F2) / (a1 - a2) \qquad (15)$$

As the method of determining the inclination of straight line, a method that does not use Formula (15) may be used.

[0077] Next, referring to Figure 10, a procedure for measuring the weight of the door 1 is explained.

Figure 10 is a flowchart for explaining the motion at the time when the elevator door control device in accordance with the first embodiment of the present invention measures the weight of the door 1.

[0078] First, in Step S21, the serial number i is reset, and the process proceeds to Step S22. In Step S22, the number of pulses at the time when the acceleration a of the door 1 and the force F applied to the door 1 only are sampled is caused to coincide with the number of pulses at the time when the torque of the door motor 3 corresponding to the overall mechanical loss is learnt. That is, in Step S22, if the present number of pulses becomes equal to p[i] stored in the ROM 10, the acceleration a of the door 1 and the force F applied to the door 1 only are sampled, and the process proceeds to Step S23.

[0079] In Step S23, the actual speed ω of the door motor 3 is converted into the speed of the door 1 by using the speed ratio R(p), and the process proceeds to Step S24. In Step S24, the speed of the door l is differentiated with respect to time, and is converted into the acceleration a of the door 1. Thereafter, in Step S25, the torque for moving the door 1 only is determined by subtracting TL[i] stored in the RAM 14 from the motor torque instruction T[i] at this time. Then, this torque is converted into the force F[i] applied to the door 1 only by using the speed ratio R(p[i]).

[0080] Specifically, the motor torque instruction T[i] is calculated by Formula (16).

$$F[i] = (T[i]-TL[i])/R(p[i]) \qquad (16)$$

T[i] and TL[i] correspond to Fm+ΔFm and FL+ΔFL in Formula (5), respectively.

[0081] Thereafter, in Step S26, the acceleration a of the door 1 and the force F applied to the door 1 are stored in the RAM 14, and the process proceeds to Step S27. In Step S27, i is incremented, and the process proceeds to Step S28. In Step S28, it is determined whether or not the door 1 has been fully opened. If the door 1 has not been fully opened, the process returns to Step S22. On the other hand, if the door 1 has been fully opened, the average a1 of accelerations on the acceleration peak side and the average F1 of forces are calculated, and the average a2 of accelerations on the deceleration peak side and the average F2 of forces are calculated. Thereafter, the process proceeds to Step S30, where the weight of the door 1 is calculated by using Formula (15).

[0082] According to the first embodiment described above, based on the value obtained by subtracting the value of motor torque instruction at the time when the door 1 is moved at the fixed speed from the value of motor torque instruction at the time when the door 1 is moved while being accelerated, the value of the force applied to the door 1 when the door 1 is moved while being accelerated is calculated. Then, the weight of the door 1 is calculated by dividing the value of the force applied to the door 1 when the door 1 is moved while being accelerated by the value of the acceleration of the door 1 at the time when the door 1 is moved while being accelerated. Therefore, the weight of the elevator door 1 can be measured more correctly. That is, the measuring error of the weight of the door 1 is small. For this reason, the door 1 can be opened and closed at a proper speed.

[0083] Also, based on the force applied to the door 1 and the acceleration of the door 1, which are calculated at every position of the door 1, the weight of the door 1 is calculated. Therefore, the measurement variations in weight of the elevator door 1 can be suppressed.

[0084] Further, when the overall mechanical loss is calculated, the coefficient at the time when the speed ratio of the door 1 to the door motor 3 is expressed by the polynomial of the number of pulses and the fixed speed value V are used as speed control constants. This speed ratio is the speed ratio having also been used in the conventional measurement of the weight of the door 1 when the speed of the door motor 3 has been converted into the acceleration of the door 1 or when the torque of the door motor 3 has been converted into a force. Therefore, the speed control constant added newly has only to be the fixed speed value V.

[0085] In addition, when the overall mechanical loss is calculated, it is monitored, by any of various methods, whether or not the door 1 is moving at the fixed speed. Therefore, the overall mechanical loss including the force applied to the door 1 can be prevented from being learnt. The signals and instructions used when it is determine whether or not the door 1 is moving at the fixed speed are ones that have also been used for the ordinary elevator. Therefore, by a minimum change of programs, it can be determined whether or not the door 1 is moving at the fixed speed.

[0086] In the first embodiment, the case where the weight of the door 1 is measured at the door opening time has been explained. However, even in the case where the weight of the door 1 is measured at the door closing time, if the configuration is made the same as described above, the weight of the door 1 can be measured more correctly.

Industrial Applicability

[0087] As described above, the elevator door control device in accordance with the present invention can be applied to an elevator in which the weight of the elevator door is measured more correctly.

Description of symbols

[0088]

1 door, 2 door rail, 3 door motor, 4 speed reducer, 5 link,
6 closed position detecting switch, 7 open position detecting switch,
8 door controller, 9 pulse generator, 10 ROM, 11 CPU,
12 motor drive circuit, 13 interface circuit, 14 RAM,
15 speed instruction issuing means, 16 torque instruction issuing means,
17 current instruction issuing means,
18 motor actual speed calculating means,
19 door speed calculating means,
20 door acceleration calculating means,
21 acceleration monitoring means, 22 control panel, 23 speed of door,
24 speed ratio, 25 speed of motor, 26 acceleration of door,
27 fixed speed value, 28 motor speed instruction,
29 motor speed abnormality region, 30 door speed abnormality region,
31 door acceleration abnormality region, 32 theoretical mechanical loss,
32 to 33 torque, 35 door driving force calculating means,
36 door weight calculating means, 37 data, 38, 39 data range,
40, 41 data average point.

Claims

1. An elevator door control device comprising:

torque instruction issuing means for issuing torque instructions to a door motor for moving an elevator door;
torque instruction storing means for storing the value of torque instruction at the time when the door is moved at a fixed speed;
door driving force calculating means for calculating the value of the force applied to the door when the door is moved while being accelerated, based on a value obtained by subtracting the value of torque instruction at the time when the door is moved at the fixed speed from the value of torque instruction at the time when the door is moved while being accelerated; and
door weight calculating means for calculating the weight of the door by dividing the value of the force applied to the door when the door is moved while being accelerated by the value of the acceleration of the door at the time when the door is moved while being accelerated.

2. The elevator door control device according to claim 1, wherein
the torque instruction storing means stores the value of torque instruction at the time when the door is moved at a fixed speed so that the value of torque instruction is caused to correspond to the position of the door;
the door driving force calculating means calculates the value of the force applied to the door at every position of the door; and
the door weight calculating means calculates the weight of the door based on the force applied to the door at every position of the door and the acceleration of the door.

3. The elevator door control device according to claim 1 or 2, wherein
the elevator door control device further comprises:

a pulse generator for generating pulses of the number corresponding to the rotation quantity of the door motor;
speed control constant storing means which stores the coefficient at the time when the speed ratio of the door to the door motor is expressed by a polynomial of the number of pulses and stores the fixed speed value; and
speed instruction issuing means for issuing, based on the polynomial expressed by using the coefficient and the value of the fixed speed, motor speed instruction at the time when the door is moved at the fixed speed, and
the torque instruction issuing means issues torque instruction at the time when the door is moved at the fixed speed so as to correspond to the motor speed instruction.

4. The elevator door control device according to any one of claims 1 to 3, wherein

the elevator door control device further comprises monitoring means for monitoring whether or not the door is moving at the fixed speed; and
if the door is not moving at the fixed speed, the torque instruction storing means erases the stored torque instruction value.

5. The elevator door control device according to claim 4, wherein
if the door opening/closing instruction signal sent from a control panel of the elevator is changed at a position other than the full-open position and the full-closed position, the monitoring means determines that the door is not moving at the fixed speed.

6. The elevator door control device according to claim 4, wherein
if the difference between the speed instruction of the door motor and the actual speed of the door motor takes a predetermined or larger value, the monitoring means determines that the door is not moving at the fixed speed.

7. The elevator door control device according to claim 4, wherein
if the acceleration of the door deviates from zero by a predetermined or larger value, the monitoring means determines that the door is not moving at the fixed speed.

8. The elevator door control device according to claim 4, wherein
if the speed of the door deviates from the fixed value by a predetermined or larger value, the monitoring means determines that the door is not moving at the fixed speed.

FIG. 1

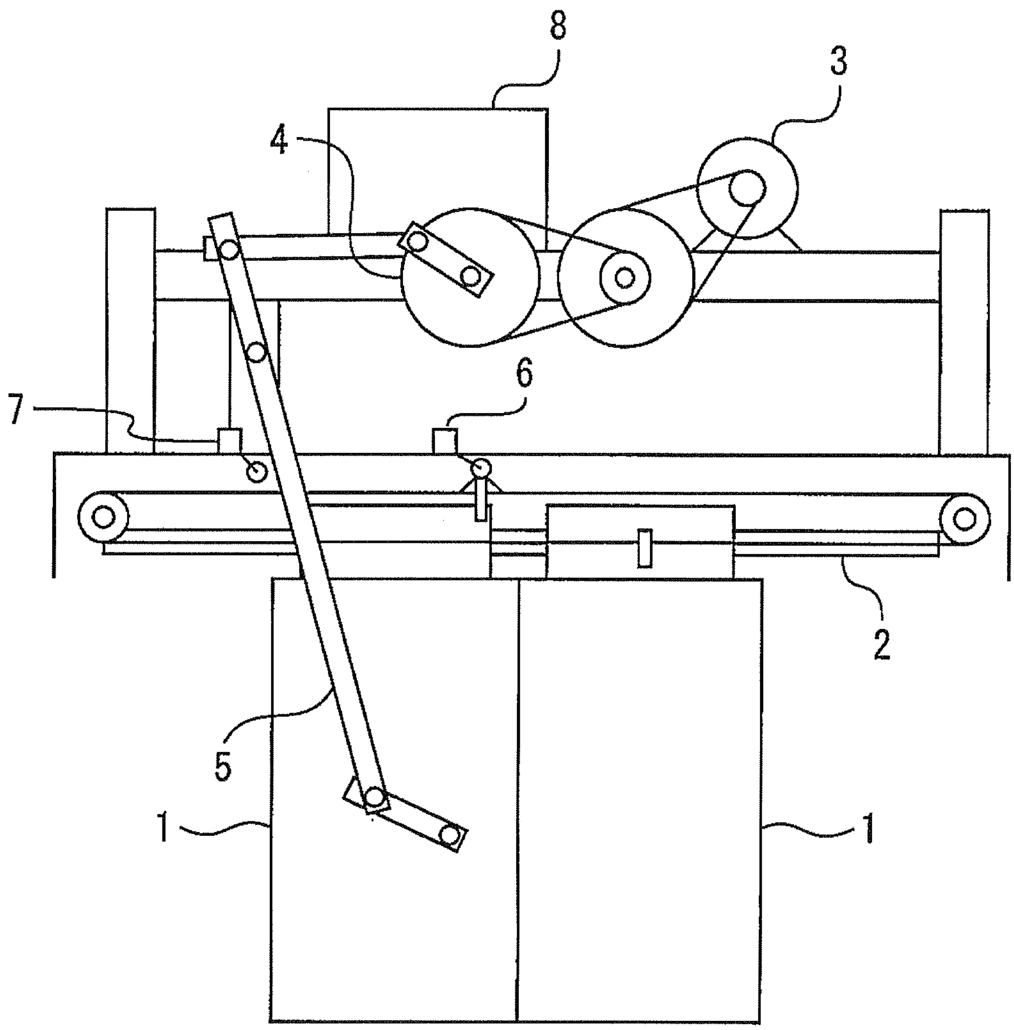


FIG. 2

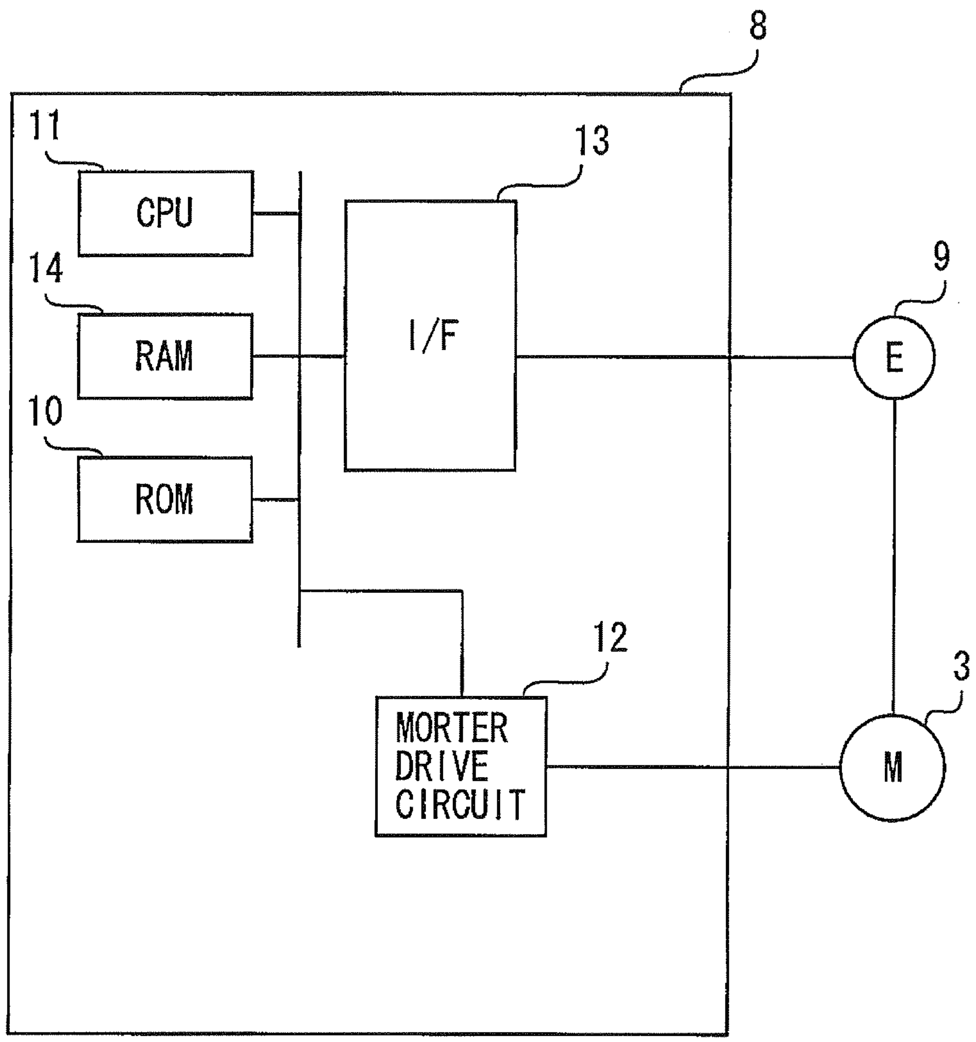


FIG. 3

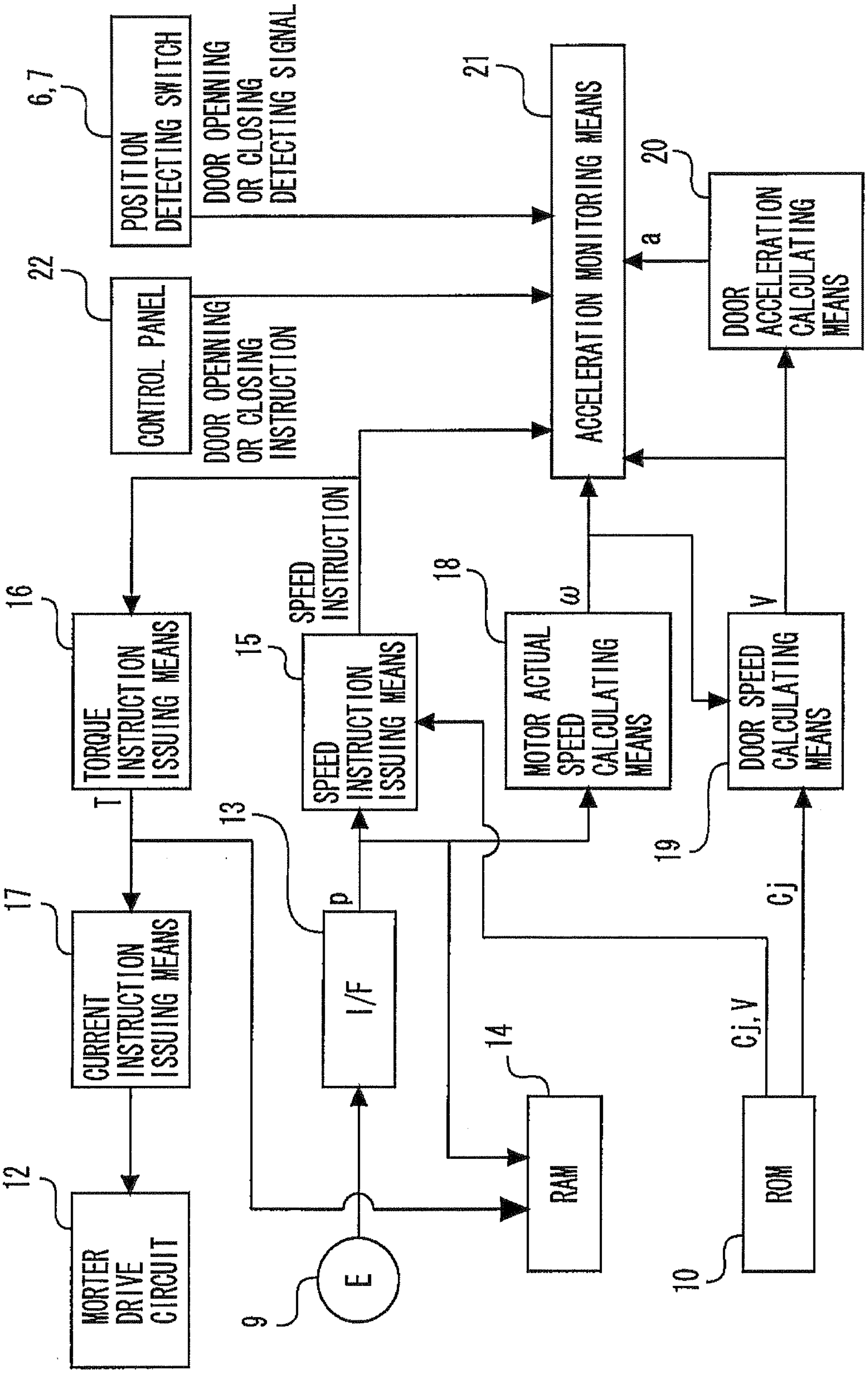

6,7
POSITION DETECTING SWITCH
DOOR OPENNING OR CLOSING DETECTING SIGNAL
22
CONTROL PANEL
DOOR OPENNING OR CLOSING INSTRUCTION
21
ACCELERATION MONITORING MEANS
20
a
DOOR ACCELERATION CALCULATING MEANS
16
TORQUE INSTRUCTION ISSUING MEANS
T
15
SPEED INSTRUCTION
SPEED INSTRUCTION ISSUING MEANS
18
ω
MOTOR ACTUAL SPEED CALCULATING MEANS
V
DOOR SPEED CALCULATING MEANS
19
13
p
17
CURRENT INSTRUCTION ISSUING MEANS
I/F
14
RAM
Cj,V
Cj
ROM
10
12
MORTER DRIVE CIRCUIT
9
E

FIG. 4

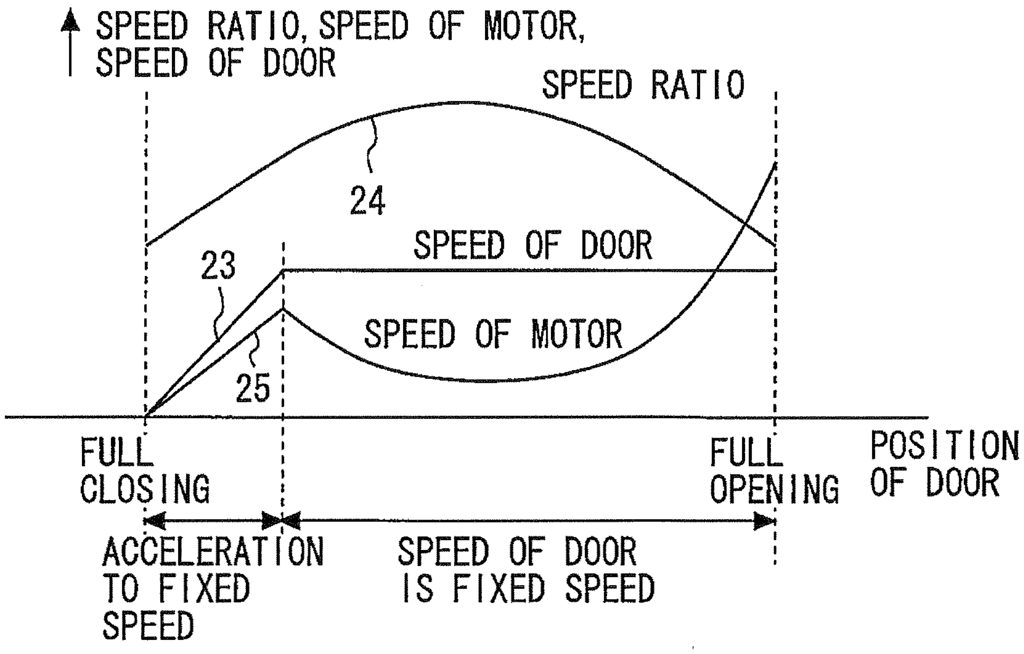

SPEED RATIO, SPEED OF MOTOR,
SPEED OF DOOR
SPEED RATIO
24
SPEED OF DOOR
23
SPEED OF MOTOR
25
FULL CLOSING
FULL OPENING
POSITION OF DOOR
ACCELERATION TO FIXED SPEED
SPEED OF DOOR IS FIXED SPEED

FIG. 5

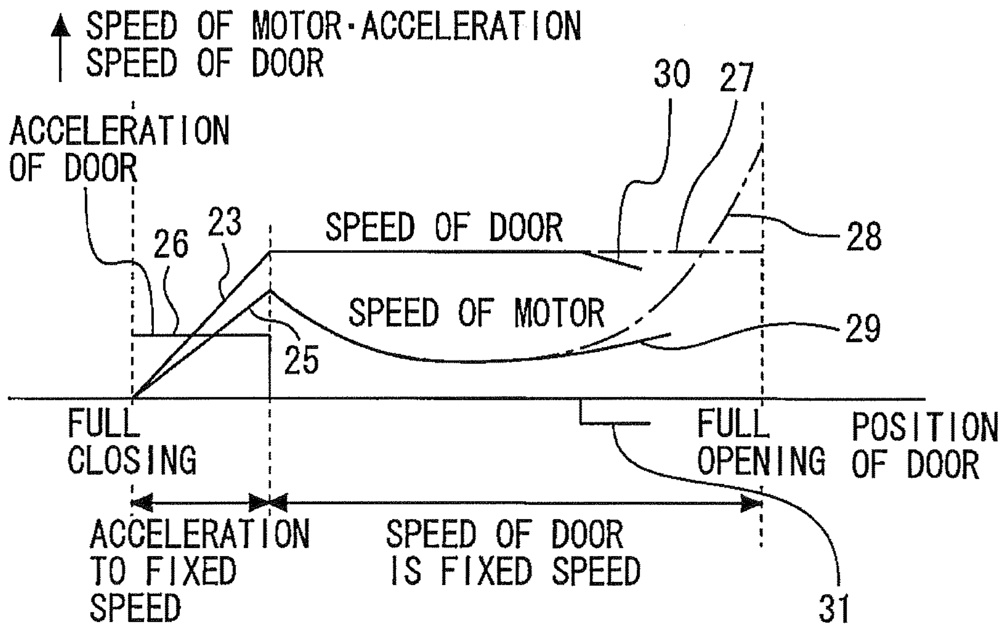

SPEED OF MOTOR·ACCELERATION
SPEED OF DOOR
30
27
ACCELERATION OF DOOR
26
23
SPEED OF DOOR
28
SPEED OF MOTOR
29
25
FULL CLOSING
FULL OPENING
POSITION OF DOOR
ACCELERATION TO FIXED SPEED
SPEED OF DOOR IS FIXED SPEED
31

FIG. 6

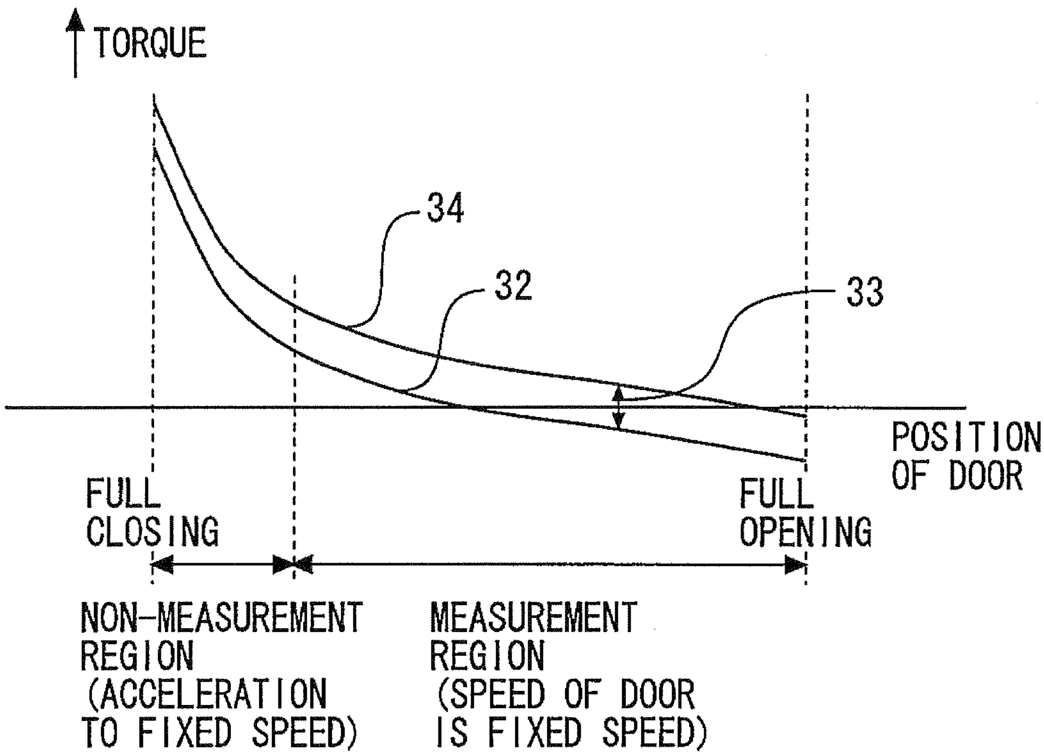

TORQUE
34
32
33
POSITION OF DOOR
FULL CLOSING
FULL OPENING
NON-MEASUREMENT REGION (ACCELERATION TO FIXED SPEED)
MEASUREMENT REGION (SPEED OF DOOR IS FIXED SPEED)

FIG. 7

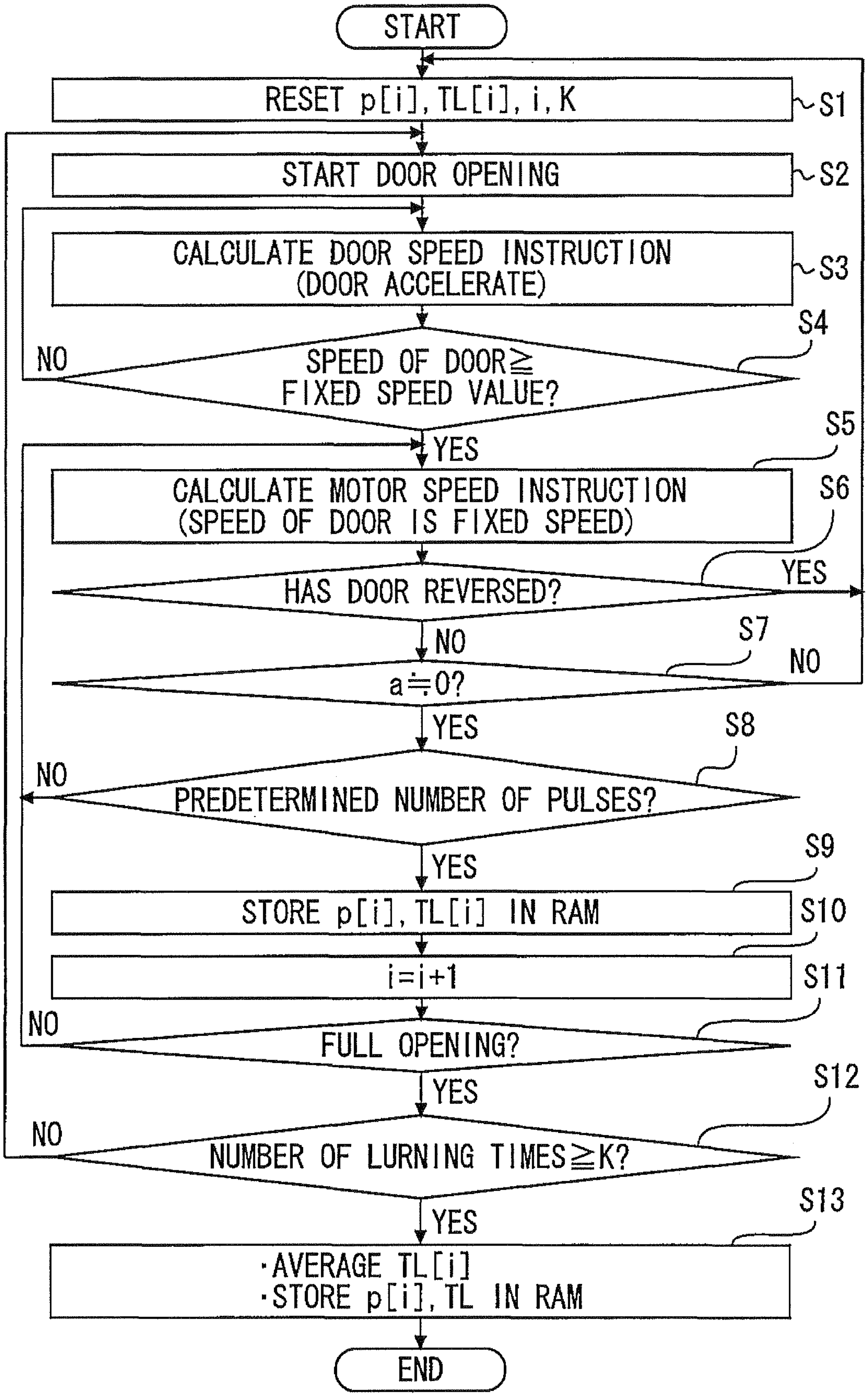

START
RESET p[i], TL[i], i, K
S1
START DOOR OPENING
S2
CALCULATE DOOR SPEED INSTRUCTION
(DOOR ACCELERATE)
S3
S4
SPEED OF DOOR≧
FIXED SPEED VALUE?
NO
YES
S5
CALCULATE MOTOR SPEED INSTRUCTION
(SPEED OF DOOR IS FIXED SPEED)
S6
HAS DOOR REVERSED?
YES
NO
S7
a≒0?
NO
YES
S8
PREDETERMINED NUMBER OF PULSES?
NO
YES
S9
STORE p[i], TL[i] IN RAM
S10
i=i+1
S11
FULL OPENING?
NO
YES
S12
NUMBER OF LURNING TIMES≧K?
NO
YES
S13
·AVERAGE TL[i]
·STORE p[i], TL IN RAM
END

FIG. 8

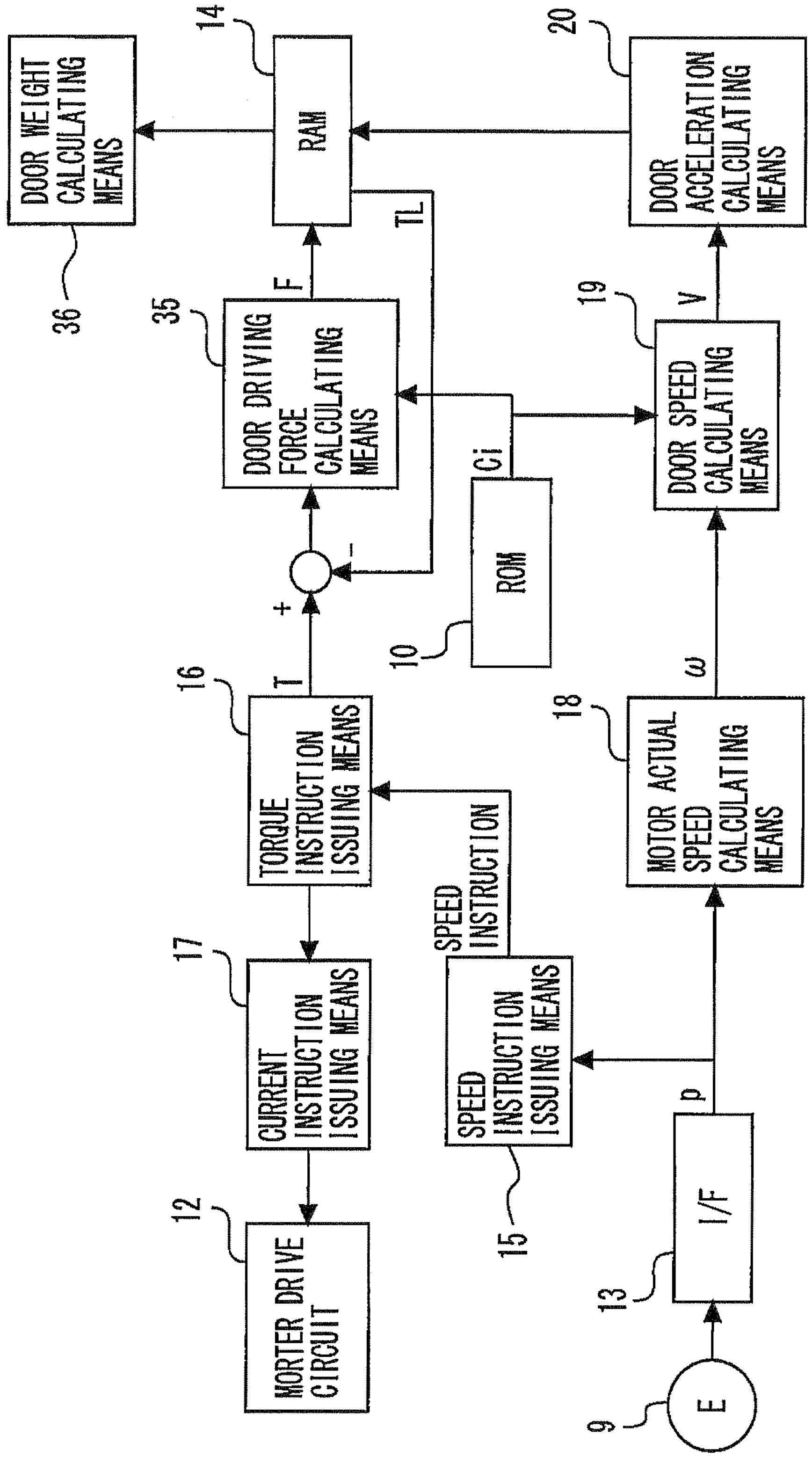

DOOR WEIGHT CALCULATING MEANS
36
RAM
14
DOOR ACCELERATION CALCULATING MEANS
20
TL
F
35
DOOR DRIVING FORCE CALCULATING MEANS
19
V
DOOR SPEED CALCULATING MEANS
Ci
ROM
10
+
-
T
16
TORQUE INSTRUCTION ISSUING MEANS
ω
18
MOTOR ACTUAL SPEED CALCULATING MEANS
SPEED INSTRUCTION
17
CURRENT INSTRUCTION ISSUING MEANS
SPEED INSTRUCTION ISSUING MEANS
15
p
12
MORTER DRIVE CIRCUIT
I/F
13
E
9

FIG. 9

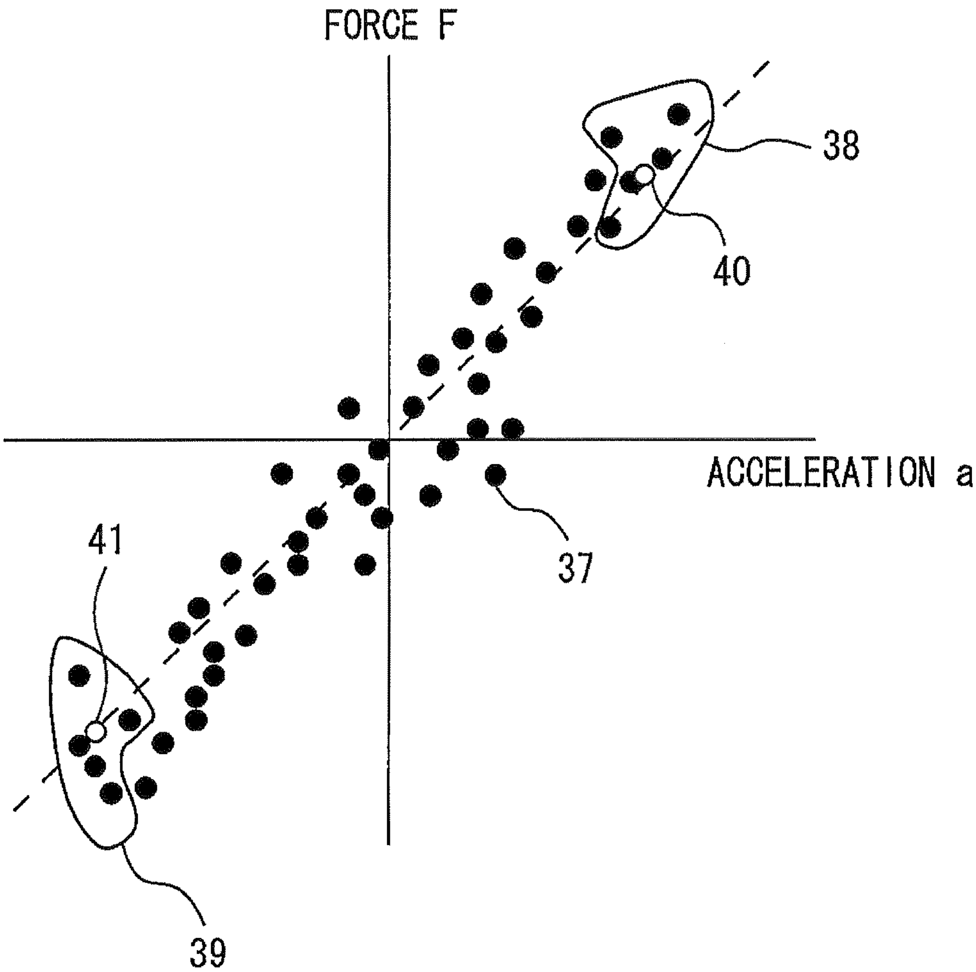
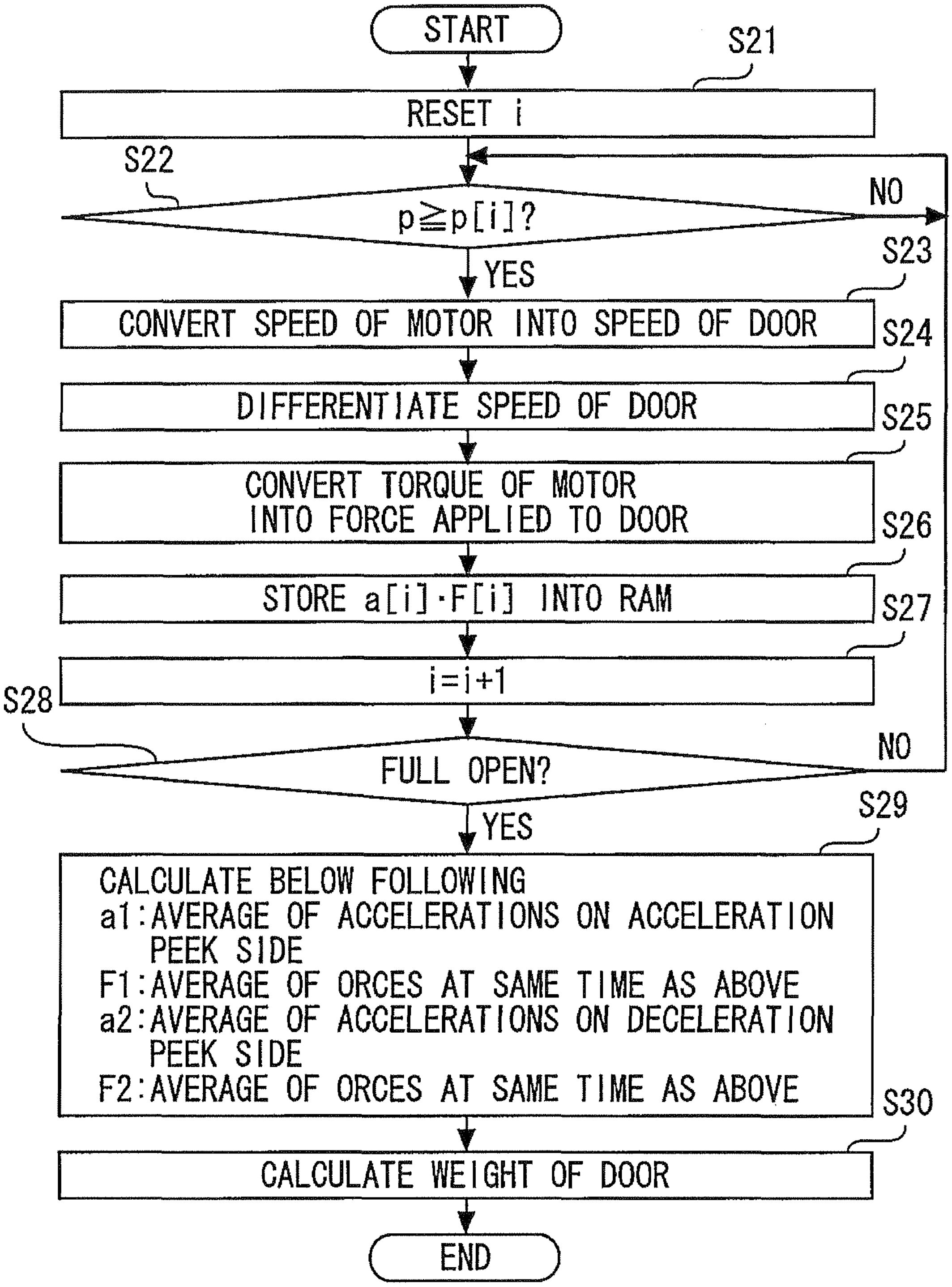


FIG. 10


START
S21
RESET i
S22
p≧p[i]?
NO
YES
S23
CONVERT SPEED OF MOTOR INTO SPEED OF DOOR
S24
DIFFERENTIATE SPEED OF DOOR
S25
CONVERT TORQUE OF MOTOR INTO FORCE APPLIED TO DOOR
S26
STORE a[i]·F[i] INTO RAM
S27
i=i+1
S28
FULL OPEN?
NO
YES
S29
CALCULATE BELOW FOLLOWING
a1:AVERAGE OF ACCELERATIONS ON ACCELERATION PEEK SIDE
F1:AVERAGE OF ORCES AT SAME TIME AS ABOVE
a2:AVERAGE OF ACCELERATIONS ON DECELERATION PEEK SIDE
F2:AVERAGE OF ORCES AT SAME TIME AS ABOVE
S30
CALCULATE WEIGHT OF DOOR
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/057703

A. CLASSIFICATION OF SUBJECT MATTER
B66B13/14(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)
B66B13/14

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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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 A	JP 2009-155086 A (Toshiba Elevator and Building Systems Corp.), 16 July 2009 (16.07.2009), paragraphs [0031] to [0038]; fig. 3 (Family: none)	1 2-3 4-8
Y A	JP 2009-214952 A (Mitsubishi Electric Corp.), 24 September 2009 (24.09.2009), paragraphs [0025] to [0037] (Family: none)	2-3 1,4-8
Y A	JP 2002-302369 A (Mitsubishi Electric Corp.), 18 October 2002 (18.10.2002), paragraphs [0025] to [0034]; fig. 5 (Family: none)	3 1-2,4-8

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

* Special categories of cited documents:
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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
11 August, 2010 (11.08.10)	24 August, 2010 (24.08.10)

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

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/057703

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 7-165383 A (Hitachi, Ltd.), 27 June 1995 (27.06.1995), paragraph [0011]; fig. 9 (Family: none)	3 1-2,4-8
A	JP 2-300080 A (Mitsubishi Electric Corp.), 12 December 1990 (12.12.1990), entire text; all drawings (Family: none)	6,8

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2009001430 A **[0008]**