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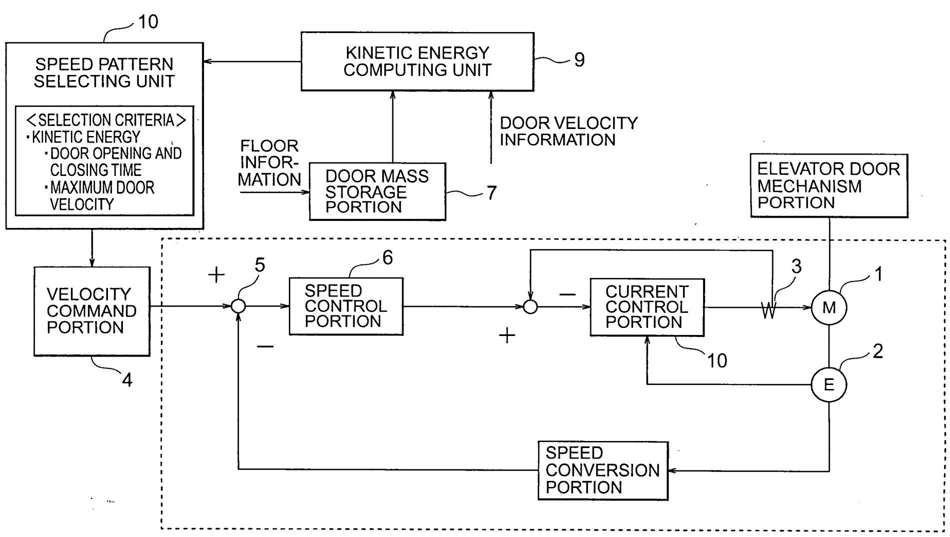
(54) **ELEVATOR DOOR CONTROLLER**

(57) An elevator door control device capable of setting an appropriate door velocity, where the door velocity is made faster, or the door opening and closing time is made shorter, in a range that can comply with kinetic energy restrictions is achieved. The elevator door control device performs elevator door opening and closing control by outputting a torque command to an elevator door driving unit, the torque command corresponding to a motor speed pattern selected from a plurality of motor speed patterns. The kinetic energy of the door is computed at each floor based on the mass of the elevator door at each floor and based on door velocity information during door opening and closing operations. One out of the plurality of motor speed patterns is selected as the motor speed pattern at each floor based on the computational results.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to an elevator door control device. In particular, the present invention relates to an elevator door control device that achieves compatibility between high levels of safety and comfort for elevator users.

Background Art

[0002] An elevator door is an interface portion between an elevator and users of the elevator. Accordingly, compatibility between safety and comfort for the elevator users is required.

[0003] A problem relating to safety involves how to reduce misfortune caused by accidents where a user gets caught by, or gets dragged by, the elevator door. One effective solution strategy for this problem is to make the door velocity slower.

[0004] On the other hand, a problem relating to comfort involves how to reduce waiting time by the users when utilizing the elevator. It is effective to quickly transport the users to their target floor, and therefore one effective solution strategy for this problem is to make the door velocity faster, or to shorten the amount of time for door opening and closing.

[0005] Compatibility between safety and comfort for the elevator users is a very important problem for an elevator door control device. Conventional elevators have achieved compatibility between safety and comfort when addressing this problem by using information on a torque command of a motor (motor current command) that performs driving for door opening and closing (refer to Patent Document 1, for example).

[0006] Safety is achieved by using the torque command information, which is output from a velocity control portion that controls the door velocity of a door driver motor for driving the elevator door. Specifically, the torque command is compared with a pattern used for judging door abnormalities, referred to as an overload detection pattern, and a door opening and closing operation abnormality is judged when the torque command exceeds the overload detection pattern. It should be noted that, in order to increase the abnormality detection sensitivity for door opening and closing operations, and thus improve safety, the overload detection pattern is selected from a plurality of overload detection patterns by utilizing a relationship whereby the torque command becomes larger when the door mass is large and the torque command becomes smaller when the door mass is small. Specifically, a large size overload detection pattern is selected when the door mass is large, and a small size overload detection pattern is selected when the door mass is small.

[0007] On the other hand, comfort is achieved by selecting one appropriate motor speed pattern from among a plurality of motor speed patterns in consideration of the size of the torque command (motor current command). Specifically, the relationship whereby the torque command becomes larger when the door mass is large, and the torque command becomes smaller when the door mass is small, is utilized. The appropriate motor speed pattern is selected from among the plurality of motor speed patterns based on the door mass and the size of the torque command at each floor so that the size of the torque command becomes nearly equal at each floor.

[Patent Document 1]: JP 2000-159461 A

[0008] That is, with conventional elevator door control devices, a motor speed pattern that corresponds to the door mass is selected for each floor in consideration of the size of the torque command so that the door velocity is slow when the door mass is large, and the door velocity is fast when the door mass is small. For the following reasons, however, there is a problem in that an appropriate door velocity cannot be achieved at which both safety and comfort are compatible.

[0009] Basic knowledge relating to safety and comfort from the viewpoint of the kinetic energy of the door is necessary in order to understand this problem.

[0010] From the standpoint of safety and comfort, the kinetic energy of an elevator door is restricted, especially for door closing operations, in regulations issued overseas (ASME Rule 112.4, for example). The kinetic energy of the door is found by the door mass (more accurately, the sum total of the mass of the door itself and the mass of each member that is mechanically connected to the door) and the door velocity, specifically by Eq. (1) shown below.

$$\text{Kinetic energy} = (1/2) \times (\text{door mass}) \times (\text{door velocity})^2 \qquad (1)$$

[0011] In order to satisfy the standard values of the overseas regulations described above, it is necessary to change the door velocity, that is the motor speed, according to the door mass.

[0012] In addition, as a supplement to the explanation relating to the kinetic energy, the term door velocity indicates an average velocity, and this is clearly specified in the regulations issued overseas described above and the like. Specifically, the average velocity is found by Eq. (2) below.

[0013] Average door closing velocity = (door travel distance from fully open position to fully closed position) / (travel time) (2)

[0014] Further, there is also a regulation for the travel time used here. For example, the travel time for a door that opens from the center is defined as the amount of time necessary for travel from a position 25 mm from the fully open position to a position 25 mm from the fully closed position.

[0015] It should be noted that the value of the kinetic energy found using the average velocity is restricted to be equal to, or less than, 10 Joules.

[0016] Although the kinetic energy restriction is normally only indicated for door closing as described above, similar management of the kinetic energy during door opening, albeit using different values, can be considered effective for door safety. Accordingly, the kinetic energy is treated hereinafter as being capable of being defined using similar forms for door opening and door closing.

[0017] Furthermore, although a case of using the average velocity as the door velocity for evaluating the kinetic energy is explained above, using the instantaneous velocity, that is the maximum velocity, can also be considered to be suitable for satisfying safety in consideration of impact damage. Accordingly, the average velocity and the maximum velocity can both be used hereinafter as the door velocity for the kinetic energy shown by Eq. (1). It should be noted that the values to which the kinetic energy is restricted will differ according to which velocity is used, however.

[0018] Relationships between the kinetic energy, safety, and comfort are clarified next. For the problem of safety, it can easily be understood that the degree of bodily harm caused when a user gets caught by, or gets dragged by, the elevator door is proportional to the amount of kinetic energy of the door. It can therefore be understood that the kinetic energy of the door should be made as small as possible.

[0019] On the other hand, for the problem of comfort, it is desirable that the door velocity be made fast (that time for door opening and closing be shortened) in order to shorten the amount of time spent waiting for the elevator, and transport the user quickly to the target floor. The kinetic energy of the door should therefore be made as large as possible.

[0020] It is understood that both safety and comfort can be restricted by the kinetic energy of the door. At the same time it is understood that making the door velocity as fast as possible, or making the amount of time for door opening and closing as short as possible, within a range that complies with the restrictions for the kinetic energy of the door leads to appropriate safety and comfort.

[0021] Conventional elevator door control devices only considers the size of the torque command, and do not have measures foe computing the kinetic energy of the door, measures for evaluating, and the like. A problem therefore exists in that an appropriate door velocity, where the door velocity is made faster or the amount of time for opening and closing the door is made shorter, in a range that complies with the kinetic energy restriction, that is, by utilizing the maximum limit of the kinetic energy restriction, is not achieved. Appropriate safety and comfort are thus insufficient.

[0022] The present invention has been made in order to solve problems like those described above. An object of the present invention is to realize an elevator door control device that is capable of achieving a suitable door velocity by making the door velocity faster, or by making the amount of time for door opening and closing shorter, in a range that complies with kinetic energy restrictions.

Disclosure of the Invention

[0023] According to the present invention, there is provided an elevator door control device that performs elevator door opening and closing control by outputting a torque command to an elevator door driving unit, the torque command corresponding to a motor speed pattern that is selected from a plurality of motor speed patterns, the elevator door control device being characterized by including: a door parameter computing unit that computes door parameters at each floor based on a mass of an elevator door at each floor; and a speed pattern selecting unit that selects, based on computational results from the door parameter computing unit, one of a plurality of motor speed patterns as a motor speed pattern for elevator door opening and closing control at each floor.

Brief Description of the Drawings

[0024]

Fig. 1 is a schematic diagram that shows an example of an elevator door control device according to Embodiment 1 of the present invention;

Fig. 2 is a diagram for explaining operation of a speed pattern selecting unit in the elevator door control device according to Embodiment 1 of the present invention;

Fig. 3 is a schematic diagram that shows an example of an elevator door control device according to Embodiment 2 of the present invention;

Fig. 4 is a schematic diagram that shows an example of an elevator door control device according to Embodiment 3 of the present invention; and

Fig. 5 is an explanatory diagram of a map storing unit in the elevator door control device according to Embodiment 4 of the present invention.

Best Modes for carrying out the Invention

Embodiment 1

[0025] Fig. 1 is a schematic diagram that shows an example of an elevator door control device according to Embodiment 1 of the present invention. As shown in Fig. 1, a pulse generator 2 is connected directly to a motor shaft of a door driver motor 1 in an elevator door mechanism portion that drives an elevator door. The pulse generator 2 generates pulse information that shows positions of the door driver motor 1. Further, a current detector 3 detects a load current on the door driver motor 1. It should be noted that a vector control induction motor, a brushless DC motor, or the like is assumed to be used as the door driver motor 1.

[0026] A velocity command portion 4 stores a plurality of predetermined motor speed patterns and outputs the velocity command according to the plurality of stored motor speed pattern. An adder portion 5 outputs a speed deviation between the velocity command output by the velocity command portion 4, and an actual motor speed (feedback speed) obtained from the pulse generator 2 through a speed conversion portion. A speed control portion 6 outputs a motor current command, which corresponds to a torque command corresponding to the speed deviation output by the adder portion 5, to the door driver motor 1 as a torque command corresponding to the output speed deviation, thus performing speed control.

[0027] More precisely, the adder portion obtains a deviation in current from the actual motor current, which is detected by the current detector 3, with respect to the motor current command that is output from the speed control portion 6. The motor current command is then output to a current control portion 10. The current control portion 10 generates the load current for driving the door driver motor 1 according to the input current deviation, thus performing speed control of the motor 1. The current control portion 10 implements vector control based on phase information from the pulse generator 2 when performing speed control.

[0028] Further, the door mass at each floor is stored in advance in a door mass storage portion 7. A kinetic energy computing unit 9 is a door parameter computing unit that computes door parameters at each floor based on the mass of the elevator door at each floor. The kinetic energy computing unit 9 computes the kinetic energy of the door as a door parameter based on the mass of the doors at each floor, stored within the door mass storage portion 7, and on door velocity information such as the average velocity, values of the velocity over time, or the like.

[0029] The speed pattern selecting unit 10 outputs a velocity command from the velocity command portion 4 by using a motor speed pattern that is selected from a plurality of motor speed patterns stored in the velocity command portion 4 according to computational results from the kinetic energy computing unit 9. It should be noted that portions that are identical to, or that correspond to, portions of a normal elevator door control device are shown within a dashed line portion of Fig. 1.

[0030] Operations relating to selecting the motor speed pattern that is a characteristic of the elevator door control device according to Embodiment 1 are explained below. Door opening operations and door closing operations can be based completely on similar operations, and therefore only door closing operations are explained here.

[0031] Basic operation relating to motor speed pattern selection is explained first. A specific example of operations relating to motor speed pattern selection is then introduced to make understanding easier. Basic operation relating to motor speed pattern selection is as follows. After performing driving for door closing by using a certain motor speed pattern, the kinetic energy at each floor is computed in the kinetic energy computing unit 9 based on information according to floor. The door mass obtained from the door mass storage portion 7, and the door velocity information such as the average velocity, values of the velocity over time, or the like, are used.

[0032] The above operation is repeated for a plurality of motor speed patterns. The kinetic energy computational results for each of the motor speed patterns are organized for each floor. Specifically, a motor speed pattern having the shortest door opening and closing time is selected in the speed pattern selecting unit 10 as the motor speed pattern for each floor. The selection is made for each floor from among each of the motor speed patterns that satisfies a desired door kinetic energy limit.

[0033] It should be noted that, although the motor speed pattern having the shortest door opening and closing time for each floor is selected by the speed pattern selecting unit 10 as the motor speed pattern of each floor in the description above, the selection is not limited to this method. For example, a motor speed pattern that obtains a maximum door kinetic energy may also be selected, from among each of the motor speed patterns that satisfy the desired door kinetic energy limit, as the motor speed pattern of each floor.

[0034] A high level of safety can thus be achieved by selecting a motor speed pattern that satisfies the desired door kinetic energy limit for each floor. In addition, superior comfort can be thus be achieved by selecting a motor speed pattern that has a high kinetic energy in a range that satisfies the desired door kinetic energy limit.

[0035] Further, a condition, or a range, for selecting the door kinetic energy having not only an upper limit but also a lower limit may also be used as the door kinetic energy limit described above.

[0036] In addition, it is also possible to obtain the average velocity, which is the door velocity information used in computing the kinetic energy, by a method other than that which uses Eq. (2) in accordance with the restrictions described above. The average velocity may be computed by using numerical results (approximate values) in which values of the door velocity (values of the velocity over time) are integrated with respect to time, and then divided by the amount of time for door opening and closing. Accordingly, the door velocity information may be the average velocity, or values of the velocity over time, when input to the kinetic energy computing unit 9 in Fig. 1 for computing the kinetic energy.

[0037] For cases where a plurality of minimum motor speed patterns having the shortest door opening and closing time exist for each floor from among the motor speed patterns that satisfy the desired door kinetic energy limit, the motor speed pattern having the smallest maximum door velocity is chosen by the speed pattern selecting unit 10 as the velocity command.

[0038] An example of operation relating to motor speed pattern selection is explained next while using an operation explanatory diagram shown in Fig. 2. Operation relating to motor speed pattern selection for a case in which the velocity command portion 4 includes a speed pattern memory portion that stores the plurality of motor speed patterns in a limited format arranged in advance, in order from the pattern having the shortest door opening and closing time to the pattern having the longest door opening and closing time. It should be noted that all of the motor speed patterns here are motor speed patterns having the same travel distance for the door from a fully open position to a fully closed position.

[0039] First, as shown in Fig. 2, an initial period motor speed pattern is set to a speed pattern B, for example, and door closing operations are performed. The kinetic energy at that time is computed, and it is verified whether or not the kinetic energy limit is satisfied. If the kinetic energy limit is not satisfied, the speed pattern is set to a speed pattern C, which is one level (one rank) lower than the speed pattern B, because the energy is large. If the kinetic energy limit is satisfied, however, the speed pattern is set to a speed pattern A, which is one level (one rank) higher than the speed pattern B, because the energy is small.

[0040] By repeating this procedure, the motor speed pattern can be determined at the point where the kinetic energy limit is satisfied. The elevator door control device according to Embodiment 1 can be realized by implementing these determination operations at each floor.

[0041] The plurality of motor speed patterns (door closing speed patterns) stored in the speed pattern storage portion within the velocity command portion 4 are arranged in advance in this example, in order from the pattern having the shortest door opening and closing time to the pattern having the longest door opening and closing time. Setting an appropriate door velocity can therefore easily be achieved.

[0042] It should be noted that, although door closing operations have been explained above, it is of course also possible to similarly achieve an appropriate door velocity for door opening operations.

[0043] An appropriate door velocity can thus be achieved according to the elevator door control device of Embodiment 1. The door velocity at each floor is set to the highest velocity, or the door opening and closing time is shorter, in a range that complies with the kinetic energy restrictions. As a result, an elevator door control device that achieves compatibility between safety and comfort for elevator users can be provided.

[0044] Further, for cases where the motor speed pattern having the shortest door opening and closing time is selected as the motor speed pattern for each floor from among the plurality of motor speed patterns that satisfy the desired door kinetic energy limit, an appropriate door velocity can be achieved. The door velocity is fast, or the amount of time needed for door opening and closing is short, in a range that complies with the kinetic energy restrictions.

[0045] In addition, the motor speed pattern having the smallest maximum door velocity is selected for cases where a plurality of motor speed patterns having the shortest door opening and closing time exist at each floor from among the motor speed patterns that satisfy the desired door kinetic energy limit. A solution that wholeheartedly achieves an appropriate door velocity in which the door velocity is the fastest, or the amount of time for door opening and closing is the shortest, in a range that complies with the kinetic energy restrictions.

Embodiment 2

[0046] Fig. 3 is a schematic diagram that shows an example of an elevator door control device relating to Embodiment 2 of the present invention. Reference numerals in Fig. 3 that are identical to those of Embodiment 1 shown in Fig. 1 denote identical, or equivalent, structures, and an explanation of those structures is omitted. Regarding novel structures, a door / motor speed conversion portion 8 detects an actual motor speed that is output from a velocity conversion portion, and converts the actual motor speed into the door velocity. Further, a door mass computing unit 11 computes a door mass based on the door velocity that is converted by the door / motor speed converter portion 8, and the torque command that is output from the velocity control portion 6.

[0047] That is, the configuration of the elevator door control device according to Embodiment 2 is substantially the same as the configuration of the elevator door control device according to Embodiment 1 that is shown in Fig. 1. However, the door / motor speed converter portion 8 that converts from the motor speed to the door velocity, and the door mass computing unit 11 that computes the door mass by using the door velocity that is obtained from the door / motor speed converter portion 8 and the torque command that is output from the velocity control portion 6, are portions that differ from Embodiment 1.

[0048] An explanation is provided below centering on the different portions. With the door mass storage portion 7 in the elevator door control device according to Embodiment 1 and shown in Fig. 1, the door mass at each floor is stored in advance. In contrast, the door mass that is stored in the door mass storage portion 7 in the elevator door control device according to Embodiment 2 and shown in Fig. 3 is computed by the door mass computing unit 11 based on the door velocity, which is converted by the door / motor speed converter portion 8, and the torque command, which is output from the velocity control portion 6.

[0049] Next, a method for computing the door mass at each floor by using the door mass computing unit 11 described above is explained. In order to simplify the explanation, a door type that possesses a door mechanism for transmitting torque of the door driver motor 1 directly to a door portion by a belt, without using a linking mechanism, is taken as an object door type here. A non-linear generator link that utilizes weight is attached to the door for generating a mechanical door closing retention force when a power source is cut off.

[0050] The door type used here is characterized in that there is a linear relationship between the door velocity and the motor speed, and there is a linear relationship between the door acceleration and the motor acceleration. That is, the relationships are fixed gain relationships. It is thus clear that the motor angular velocity can easily be replaced by the door velocity, and that the motor angular acceleration can easily be replaced by the door acceleration in the explanation hereinafter. It should be noted that a schematic diagram is shown in Fig. 3 in which the door velocity is used as the input to the door mass computing unit 11.

[0051] An approximate equation in which viscous velocity components items are ignored can be assumed as a dynamic model for this door type. The total torque working on the door motor is taken as T, the motor torque command is taken as Tm, the torque due to the non-linear generator link is taken as T1, a fixed door closing torque is taken as T2, a door inertia seen from the door driver motor 1 (moving portion inertias, including inertias of pulleys, the door driver motor 1 itself, and the like, in addition to the door itself) is taken as J, the motor angular acceleration is taken as a, and a torque caused by running resistances during vehicle operation (frictional forces) is taken as b.

$$T = J \cdot a + b \tag{3}$$

where

$$T = Tm + T1 + T2 \tag{4}$$

[0052] The motor torque command Tm and the motor acceleration a, capable of being found by a difference computation of the motor angular velocity (corresponding to the door velocity), are data that can be obtained by measurement in order to determine the door inertia J by using Eqs. (3) and (4). The torque T1 by the non-linear generator link, and the fixed door closing torque T2 cannot be found by direct measurement.

[0053] It should be noted that it is possible to determine the torque T1 due to the non-linear generator link, and the fixed door closing torque T2, in advance through functional computations by imparting door opening and closing position information utilizing the fact that the mass and shape of the non-linear generator link and the like are already known. The door inertia J at each floor is found by adding the torque T1 due to the non-linear generator link and the fixed door closing torque T2, which are found in advance, to the motor torque command Tm and taking the result as the total door torque T, and by applying a least squares method to the total door torque T and the motor angular velocity a. In addition, the door mass can be computed from the door inertia J.

[0054] With the elevator door control device according to Embodiment 2, the kinetic energy is computed using the door mass, which is computed by the door mass computing unit 11, similar to the elevator door control device according to Embodiment 1 described above. A motor speed pattern 3 capable of achieving an appropriate door velocity is selected by the speed pattern selecting unit 10 based on the kinetic energy.

[0055] According to the elevator door control device of Embodiment 2, the door mass at each floor, which is necessary for computing the kinetic energy, can be calculated automatically by arithmetic processing based on Eq. (3). For example, an enormous amount of effort for finding the door mass from structural information such as size and material properties becomes unnecessary. The calculation of an erroneous door mass due to human mistakes can therefore be prevented. It becomes possible to obtain a highly accurate door mass, and therefore highly accurate kinetic energy computational results can be obtained.

[0056] An appropriate door velocity can thus be achieved in which the door velocity at each floor is set to the highest velocity, or the door opening and closing time is shorter, in a range that complies with the kinetic energy restrictions. As a result, an elevator door control device that achieves high levels of safety and comfort for elevator users can be provided.

Embodiment 3

[0057] Fig. 4 is a schematic diagram that shows an example of an elevator door control device according to Embodiment 3 of the present invention. Reference numerals in Fig. 4 that are identical to those of Embodiment 1 shown in Fig. 1 denote identical, or equivalent, structures, and an explanation of those structures is omitted. Regarding novel structure, a velocity limit value computing unit 9a is a door parameter computing unit that computes door parameters at each floor based on the mass of the elevator door at each floor. The velocity limit value computing unit 9a is provided as a substitute for the kinetic energy computing unit 9 of Fig. 1, and computes a limit value of the average door velocity at each floor based on a predetermined door kinetic energy limit value, which is based on the mass of the elevator door at each floor from the door mass storage portion 7 and Eq. (1).

[0058] With the elevator door control device according to Embodiment 3, the limit value of the average door velocity at each floor is computed in advance in the velocity limit value computing unit 9a by using the predetermined door kinetic energy limit value, which is based on the elevator door mass at each floor in accordance with floor information, and Eq. (1). It should be noted that the limit value of the average door velocity unit a condition on the average door velocity that is necessary in order to satisfy the door kinetic energy limit value. Further, the condition need not be only an upper limit, but may also include a lower limit as the door kinetic energy limit value. That is, a selection condition according to the door kinetic energy having a fixed range may also be used.

[0059] With the speed pattern selecting unit 10, a motor speed pattern having the shortest door opening and closing time is selected as the motor speed pattern for each floor from among the various motor speed patterns that satisfy the predetermined door kinetic energy limit, similar to the embodiments described above. The selection is made by using the limit value from the velocity limit value computing unit 9a, which becomes the average door velocity condition. A velocity command is output from the velocity command portion 4.

[0060] In addition, for cases where a plurality of motor speed patterns having the shortest door opening and closing time exist, the motor speed pattern having the lowest maximum door velocity may be selected from among those motor speed patterns with the speed pattern selecting unit 10 and a velocity command may be output.

[0061] It should be noted that, although the motor speed pattern having the shortest door opening and closing time is selected as the motor speed pattern for each floor with the speed pattern selecting unit 10, the selection is not limited to this method. For example, the motor speed pattern with which the largest average door velocity is obtained may also be selected from among each of the motor speed patterns that satisfy the average door velocity limit value.

[0062] Effects similar to those of Embodiment 1 described above can thus also be attained by the elevator door control device according to Embodiment 3.

Embodiment 4

[0063] It should be noted that the door parameters are computed by using the kinetic energy computing unit 9, or the velocity limit computing unit 9a, as the door parameter computing unit according to the elevator door control devices of Embodiments 1 to 3 described above. However, a configuration in which a map storing unit for storing a map (table) in advance that has correspondence between a plurality of motor speed patterns and the elevator door mass can also be considered as a substitute for the configurations of Embodiments 1 to 3.

[0064] Fig. 5 is a diagram that shows an example of the map storing unit. An example of a case in which four motor speed patterns V1, V2, V3, and V4 are provided is shown in the figure. Average velocities within the figure are values computed from experiments performed using the four motor speed patterns, or from door velocity waveforms obtained by numerical simulation. It should be noted that the units shown in Fig. 5 are m/sec for average velocity, J for door kinetic energy, and kg for door mass.

[0065] From Fig. 5, it can be understood that there is a relationship between each motor speed pattern and an elevator door mass range when the door kinetic energy limit is specified. A case in which the door kinetic energy limit value is specified at 8 J (corresponding to a portion surrounded by a rectangular frame) is explained. Fig. 5 shows, for example, that if the motor speed pattern V1 is used when the door mass is equal to or less than 370 kg, the motor speed pattern V2 is used when the door mass is in a range from 370 to 462 kg, the motor speed pattern V3 is used when the door mass is in a range from 462 kg to 649 kg, and the motor speed pattern V4 is used when the door mass is in a range from 649 to 665 kg, then the door kinetic energy at that time will always be equal to or less than 8 J.

[0066] The speed pattern selecting unit 10 performs selection by reading in the corresponding motor speed pattern from the map, which is stored in advance in the map storing unit, based on the elevator door mass at each floor. The velocity command portion 4 performs elevator door opening and closing control according to the motor speed pattern that is read. Actual computations by the door kinetic energy computing unit 9, the velocity limit value computing unit 9a, or the like can thus be substituted by using the map or table.

[0067] It should be noted that, although cases of using the average velocity as the door velocity for computing the kinetic energy are explained with the elevator door control devices according to Embodiment 1 to Embodiment 4, it is clear that similar effects can also be attained for cases where the maximum velocity is used.

Industrial Applicability

[0068] As described above, an appropriate door velocity considering the door parameter relating to the kinetic energy restrictions can be achieved according to the present invention. As a result, an elevator door control device that achieves compatibility between safety and comfort for elevator users can be provided.

Claims

1. An elevator door control device that performs elevator door opening and closing control by outputting a torque command to an elevator door driving means, the torque command corresponding to a motor speed pattern that is selected from a plurality of motor speed patterns, the elevator door control device being **characterized by** comprising:

   door parameter computing means that computes door parameters at each floor based on a mass of an elevator door at each floor; and
   speed pattern selecting means that selects, based on computational results from the door parameter computing means, one of a plurality of motor speed patterns as a motor speed pattern for elevator door opening and closing control at each floor.

2. The elevator door control means according to claim 1, **characterized in that**:

   the door parameter computing means is a kinetic energy computing means that computes door kinetic energy for each floor based on the mass of the elevator door at each floor and door velocity information at a time of door opening and closing operation; and
   the speed pattern selecting means selects one of the plurality of motor speed patterns as the motor speed pattern that controls opening and closing of the elevator door at each floor, the selection being based on computational results of the door kinetic energy at each floor from the kinetic energy computing means.

3. The elevator door control device according to claim 2, **characterized in that** the speed pattern selecting means selects a motor speed pattern having a shortest elevator door opening and closing time from motor speed patterns that satisfy a predetermined door kinetic energy limit from among a plurality of door kinetic energies that are computed by the kinetic energy computing means.

4. The elevator door control means according to claim 3, **characterized in that**, for cases where a plurality of motor speed patterns exist having the shortest elevator door opening and closing time, the speed pattern selecting means selects a motor speed pattern having a smallest maximum door velocity from among the plurality of the shortest motor speed patterns.

5. The elevator door control device according to claim 2, **characterized in that** the speed pattern selecting means selects a motor speed pattern that obtains a maximum door kinetic energy that satisfies a predetermined door kinetic energy limit from among a plurality of door kinetic energies that are computed by the kinetic energy computing means.

6. The elevator door control means according to claim 1, **characterized in that**:

   the door parameter computing means is a velocity limit value computing means that computes an average door velocity or a maximum door velocity limit value for each floor based on the mass of the elevator door at

each floor and a predetermined door kinetic energy limit; and
the speed pattern selecting means selects one of the plurality of motor speed patterns as the motor speed pattern that controls opening and closing of the elevator door at each floor, the selection being based on the computational results of the limit value of the average door velocity or a maximum door velocity at each floor from the velocity limit value computing means.

7. The elevator door control device according to claim 6, **characterized in that** the speed pattern selecting means selects a motor speed pattern having a shortest elevator door opening and closing time from motor speed patterns that satisfy the computed average door velocity or a maximum door velocity limit value.

8. The elevator door control means according to claim 7, **characterized in that**, for cases where a plurality of motor speed patterns exist having the shortest elevator door opening and closing time, the speed pattern selecting means selects a motor speed pattern having a smallest maximum door velocity from among the plurality of the shortest motor speed patterns.

9. The elevator door control device according to claim 1, further comprising:

a map storing means as a substitute for the door parameter computing means, the map storing means storing, in advance, a map having correspondence between the plurality of the motor speed patterns and the mass of the elevator door;

the elevator door control device being **characterized in that**:

the speed pattern selecting means selects, based on the mass of the elevator door at each floor, a motor speed pattern by reading a corresponding motor speed pattern from the map that is stored in advance in the map storing means; and
elevator door opening and closing control is performed based on the read motor speed pattern.

10. The elevator door control device according to any one of claims 1 to 9, further comprising:

door mass computing means that computes the mass of the elevator door based on the motor speed of the driving means during elevator door opening and closing operations, and the torque command.

FIG. 1

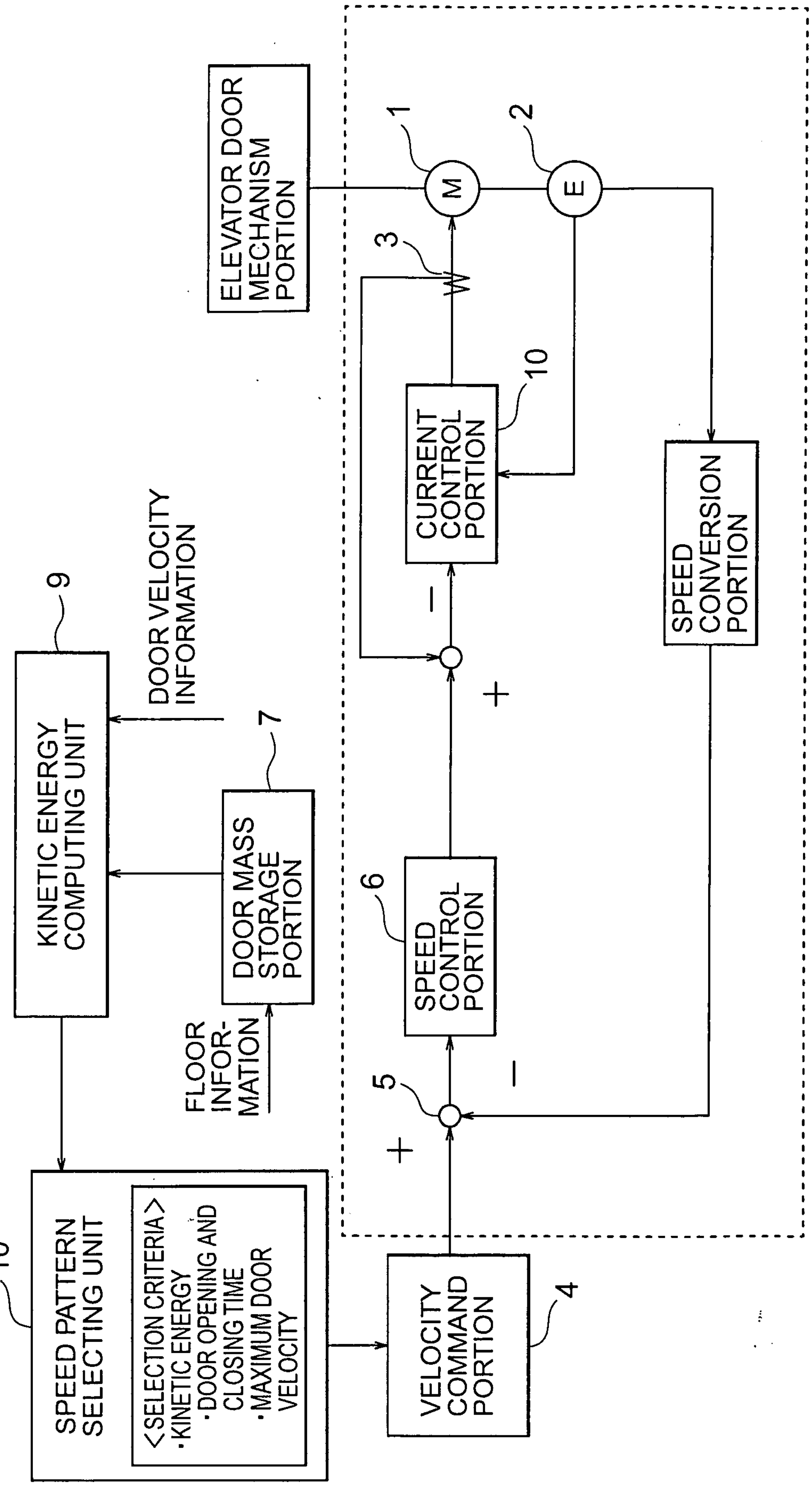
ELEVATOR DOOR MECHANISM PORTION
1
M
2
E
3
10
CURRENT CONTROL PORTION
SPEED CONVERSION PORTION
DOOR VELOCITY INFORMATION
9
KINETIC ENERGY COMPUTING UNIT
7
DOOR MASS STORAGE PORTION
FLOOR INFOR-MATION
6
SPEED CONTROL PORTION
5
+
−
+
−
10
SPEED PATTERN SELECTING UNIT
<SELECTION CRITERIA>
·KINETIC ENERGY
·DOOR OPENING AND CLOSING TIME
·MAXIMUM DOOR VELOCITY
4
VELOCITY COMMAND PORTION

FIG. 2

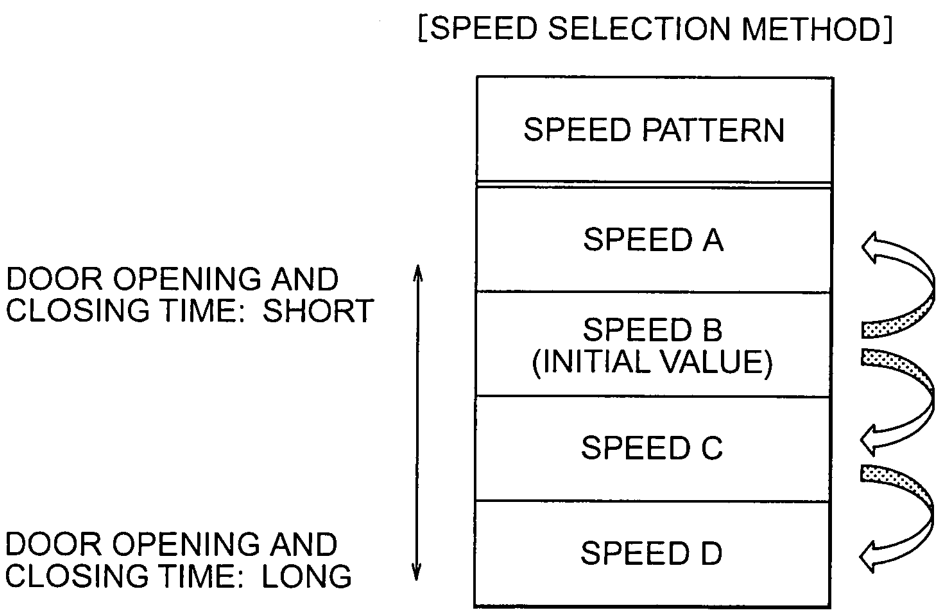
[SPEED SELECTION METHOD]
SPEED PATTERN
SPEED A
SPEED B
(INITIAL VALUE)
SPEED C
SPEED D
DOOR OPENING AND
CLOSING TIME: SHORT
DOOR OPENING AND
CLOSING TIME: LONG

FIG. 3

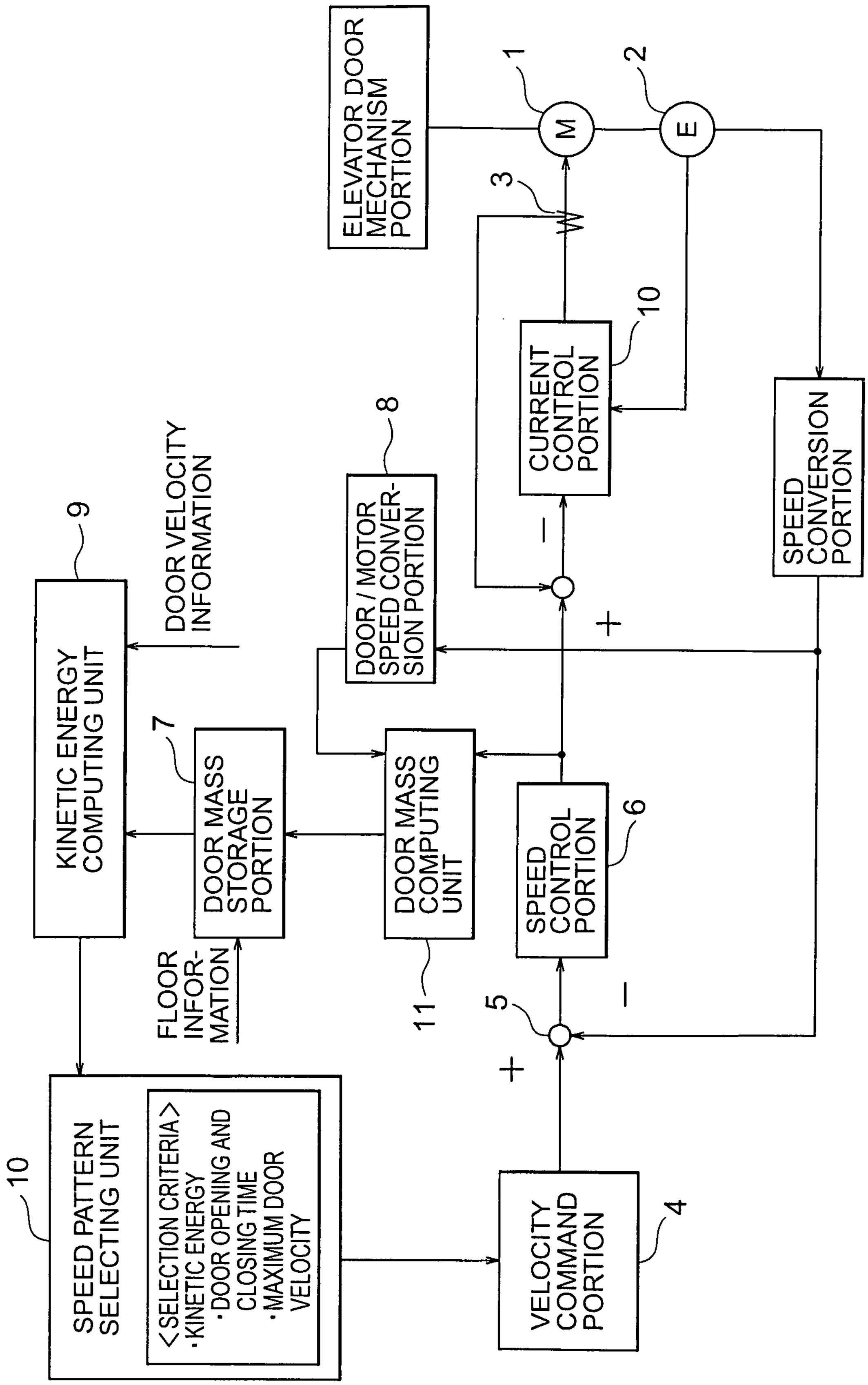
SPEED PATTERN SELECTING UNIT
<SELECTION CRITERIA>
·KINETIC ENERGY
·DOOR OPENING AND CLOSING TIME
·MAXIMUM DOOR VELOCITY
10
KINETIC ENERGY COMPUTING UNIT
9
DOOR VELOCITY INFORMATION
DOOR MASS STORAGE PORTION
7
FLOOR INFOR-MATION
DOOR MASS COMPUTING UNIT
11
DOOR / MOTOR SPEED CONVER-SION PORTION
8
VELOCITY COMMAND PORTION
4
5
+
−
SPEED CONTROL PORTION
6
+
−
CURRENT CONTROL PORTION
10
3
M
1
E
2
ELEVATOR DOOR MECHANISM PORTION
SPEED CONVERSION PORTION

FIG. 4

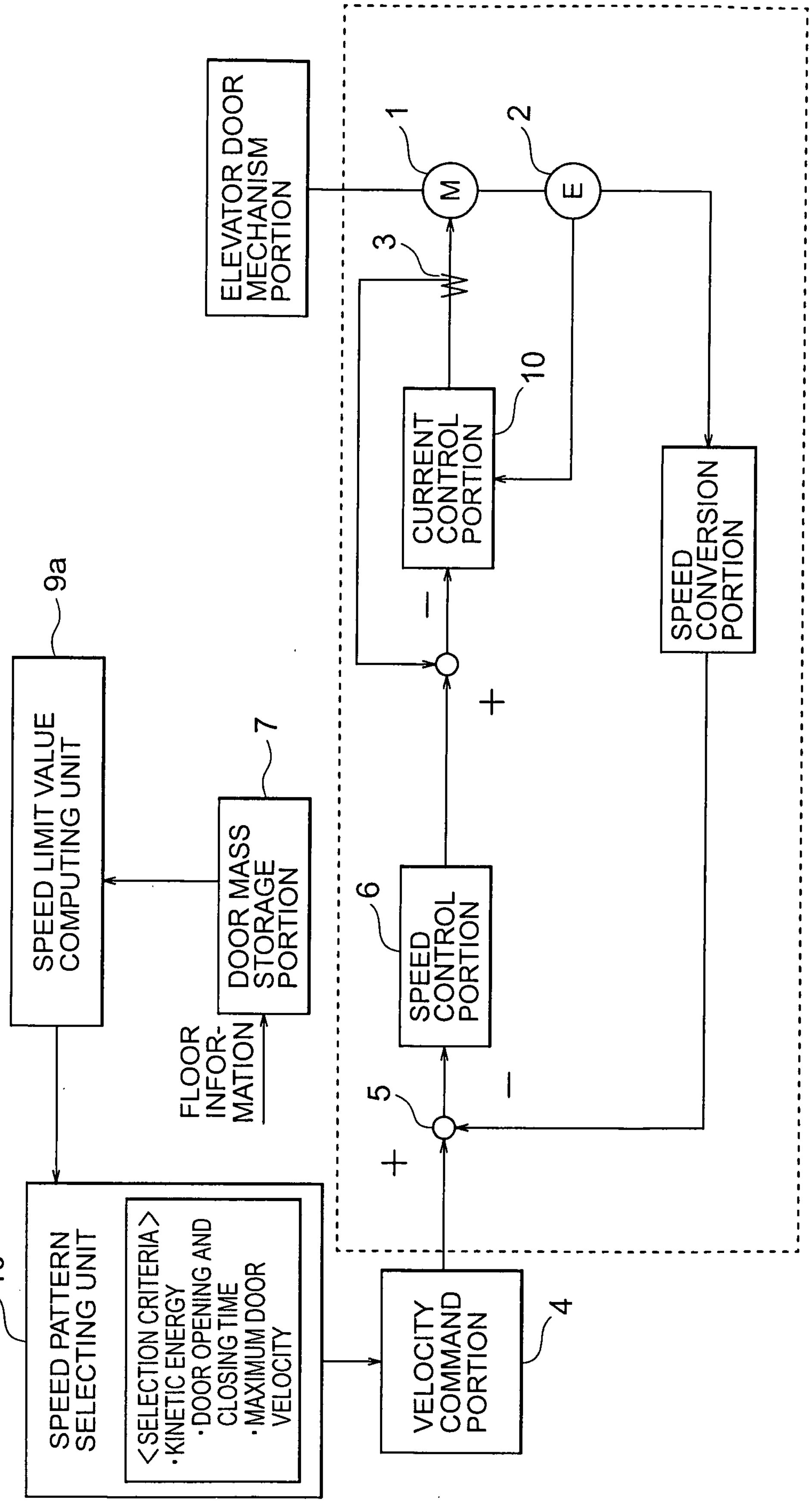
ELEVATOR DOOR MECHANISM PORTION
SPEED LIMIT VALUE COMPUTING UNIT
9a
DOOR MASS STORAGE PORTION
7
FLOOR INFOR-MATION
SPEED PATTERN SELECTING UNIT
10
<SELECTION CRITERIA>
·KINETIC ENERGY
·DOOR OPENING AND CLOSING TIME
·MAXIMUM DOOR VELOCITY
VELOCITY COMMAND PORTION
4
5
+
−
SPEED CONTROL PORTION
6
+
−
CURRENT CONTROL PORTION
10
3
M
1
E
2
SPEED CONVERSION PORTION

FIG. 5

	MOTOR SPEED PATTERN			
	V1	V2	V3	V4
AVERAGE SPEED / DOOR KINETIC ENERGY	0.208	0.186	0.157	0.155
15	~693	693~866	866~1216	1216~1247
14	~647	647~809	809~1135	1135~1163
13	~601	601~751	751~1054	1054~1080
12	~555	555~693	693~973	973~997
11	~508	508~635	635~892	892~914
10	~462	462~578	578~811	811~831
9	~416	416~520	520~730	730~748
8	~370	370~462	462~649	649~665
7	~324	324~404	404~568	568~582
6	~277	277~347	347~487	487~499
5	~231	231~289	289~405	405~416

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/12156

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl7 B66B13/14

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)
Int.Cl7 B66B13/00-B66B13/30

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	1996-2004
Kokai Jitsuyo Shinan Koho	1971-2004	Toroku Jitsuyo Shinan Koho	1994-2004

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 2000-159461 A (MITSUBISHI DENKI KABUSHIKI KAISHA), 13 June, 2000 (13.06.00), Par. Nos. [0023] to [0031] & CN 1255456 A	1,9,10 2-5 6-8
Y	US 5864104 A (MITSUBISHI DENKI KABUSHIKI KAISHA), 26 January, 1999 (26.01.99), & CN 1169395 A & JP 10-17250 A & KR 216154 B	2-5
A	JP 9-323877 A (MITSUBISHI DENKI KABUSHIKI KAISHA), 16 December, 1997 (16.12.97), (Family: none)	1,10

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 09 January, 2004 (09.01.04)	Date of mailing of the international search report 27 January, 2004 (27.01.04)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)