

ELEVATOR TERMINAL DECELERATION SYSTEM

This invention relates to improvements in an elevator terminal deceleration system for decelerating and landing an elevator car at a terminal floor.

Speed feedback control systems for controlling
5 the speed of the elevator car in accordance with a command deceleration signal are employed in order that the elevator car is decelerated whilst maintaining a comfortable ride and lands accurately at that floor of a building on which the car is predetermined to be
10 stopped due to a call registered on the floor or on the elevator car. It has been recently proposed to cause the elevator car to decelerate and land at such a floor by using an electronic computer.

To this end, there have been already proposed
15 various types of elevator terminal deceleration systems. One type of elevator terminal deceleration system has comprised counter means for counting pulses corresponding to a distance of movement of an elevator car, and an electronic computer receiving a count from
20 the counter means upon the elevator car reaching a predetermined distance short of a terminal floor to subtract the count from the predetermined distance preliminarily stored therein to calculate a residual distance to the terminal floor and to generate a
25 command normal deceleration signal having a magnitude

successively decreased in accordance with the calculated residual distance.

On the other hand, when the elevator car approaches the terminal floor to engage successively a plurality of terminal sensors disposed adjacent to the terminal floor within an associated hoistway, command terminal deceleration generator means generates a command terminal deceleration signal having a magnitude successively decreased in accordance with the actual position of the elevator car and always higher than that of the command normal deceleration signal. Then comparison circuit means compares the command normal deceleration signal with the command terminal deceleration signal to deliver which of the two signals is smaller. The elevator car safely decelerates and lands at the terminal floor in accordance with the smaller signal normally the command normal deceleration signal.

If the command normal deceleration signal is equal to or greater than the command terminal deceleration signal for some reason, for example, an error in a positional signal indicating the actual position of the elevator car, then the latter signal controls similarly the elevator car to decelerate and land at the terminal floor.

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However, the number of terminal sensors is limited, making it difficult to change the resulting command terminal deceleration signal smoothly resulting in an uncomfortable ride. Also, in order to prevent any malfunction, the command terminal deceleration signal may be distant from the command normal deceleration signal. However this has caused an increase in delay relative to the command normal deceleration signal resulting in the deterioration of the landing accuracy.

Accordingly, it is an object of the present invention to provide a new and improved elevator terminal deceleration system by which an elevator car can decelerate and land at a terminal floor with a high landing accuracy while a comfortable ride is maintained even upon the occurrence of a fault in a positional signal indicating the actual position of the elevator car, or in a call sensing signal indicating which floor has a call registered thereon or on the elevator car.

The present invention provides an elevator terminal deceleration system comprising an elevator car, a plurality of terminal sensors disposed at predetermined intervals adjacent to a terminal floor within an associated hoistway, a counter for counting pulses corresponding to a distance of movement of said elevator car, means responsive to the car reaching a predetermined distance short of said terminal floor to receive a count from said counter, to subtract said count from a predetermined magnitude preliminarily stored therein and corresponding to said distance to calculate the residual distance between the actual position of the elevator car and said terminal floor, and to generate a command normal deceleration signal having a magnitude successively decreased in accordance with said residual distance, command terminal deceleration generator means responsive to the successive engagement of said elevator car with said plurality of terminal sensors during the approach of said elevator car to said terminal floor to generate a command terminal deceleration signal having a magnitude successively decreased in accordance with the actual position of said elevator car and always higher than that of said command normal deceleration signal, and a command auxiliary terminal deceleration generator

means responsive to the engagement of said elevator car with any of said terminal sensors to receive said count from said counter means to subtract said count from a stored value corresponding to the distance between the engaged terminal sensor and said terminal floor, to calculate the residual distance between the actual position of said elevator car and said terminal floor and to generate a command auxiliary terminal deceleration signal successively decreased in accordance with said residual distance, said system providing as its car-deceleration output signal the smallest of the aforesaid deceleration signals.

The invention also provides an elevator terminal deceleration system for controlling an elevator car, comprising a counter arranged to count pulses corresponding to the distance of travel of the car, a plurality of terminal sensors at predetermined intervals along the path of approach of the car to a terminal floor for providing respective signals indicating the passage of the car, a deceleration-initiation sensor arranged to provide a further signal indicating passage of the car at a predetermined distance short of the terminal floor, the said signals indicating respective actual positions of the car, computing means responsive to said further

signal to compute from the count on said counter and
from said predetermined distance the residual distance
between the car and the terminal floor and to generate a
normal deceleration signal which decreases progressively
5 in accordance with the computed residual distance, the
said computing means being also responsive to the said
signals provided by the terminal sensors to compute,
from said count and the known distances of said terminal
sensors from said terminal floor, the residual distance
10 between each respective terminal sensor and the terminal
floor and to generate an auxiliary deceleration signal
corresponding to the computed residual distance, means
for generating in response to the signals from the
terminal sensors a terminal deceleration signal which
15 decreases in accordance with the residual distance of
the car from the terminal floor corresponding to the
terminal sensor positions and greater than the
deceleration signals generated by the computing means,
and car speed control means arranged to respond to the
20 smallest of the deceleration signals.

The present invention will become more readily apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

Figure 1 is a block diagram of a conventional
5 elevator terminal deceleration system;

Figure 2 is a graph illustrating voltages developed at various points in the arrangement shown in Figure 1 and plotted in ordinate against the distance to a terminal floor in abscissa;

10 Figure 3 is a block diagram of an embodiment of the elevator terminal deceleration system of the present invention and a schematic view of an elevator system with which the present invention is operatively associated; and

15 Figure 4 is a circuit diagram of the details of the command terminal deceleration generator shown in Figure 3.

Referring now to Figure 1 of the drawings, there is illustrated a conventional elevator terminal deceleration system. The arrangement illustrated comprises an
20 electronic computer 10 applied with a positional signal 10a for an elevator car (not shown) involved generated by counting pulses corresponding to the distance of movement of the car, a readiness-for-deceleration
25 sensing signal 10b generated upon the elevator car reaching a predetermined distance short of that floor

on which the elevator car is predetermined to be stopped due to a call registered on the floor or on the elevator car and a call sensing signal $10c$ indicating the presence of the call.

5 The electronic computer 10 is connected to a digital-to-analog converter 12 where a digital signal from the electronic computer 10 is converted to a corresponding analog signal and a command normal deceleration signal V_n is generated.

10 On the other hand, a command terminal deceleration generator 14 is connected to a comparison circuit 16 to which the digital-to-analog converter 12 is also connected. Then the comparison circuit 16 is connected to a speed control device 18. The command terminal
15 deceleration generator 14 receives successively terminal signals $14a$ generated upon the successive operations of a plurality of terminal sensors (not shown) disposed at predetermined equal intervals in a longitudinal or a vertical array within an associated hoistway (not shown)
20 and adjacent to a terminal floor or each of the uppermost and lowermost floors (not shown). The command terminal deceleration generator 14 responds to each of the terminal sensor signals $14a$ to generate a command terminal deceleration signal V_s which is always higher
25 in magnitude than the command normal deceleration signal V_n . The comparison circuit 16 compares the

command normal deceleration signal $\underline{V_n}$ with the command terminal deceleration signal $\underline{V_s}$ so that, when $\underline{V_n}$ is less than $\underline{V_s}$ as determined thereby, the command normal deceleration signal $\underline{V_n}$ is delivered to the speed control
5 device 18 and that, when $\underline{V_n}$ is equal to or greater than $\underline{V_s}$ as determined thereby, the command terminal deceleration signal $\underline{V_s}$ is delivered to the speed control device 18.

When the elevator car reaches the predetermined
10 distance short of the destination floor, the electronic computer calculates the residual distance between the actual position of the elevator car and the destination floor by using the positional signal 10a, the readiness for-deceleration sensing signal 10b and the call sensing
15 signal 10c.

Then a command deceleration magnitude preliminarily stored with respect to the calculated residual distance in the electronic computer is read out and generated as the command normal deceleration signal $\underline{V_n}$.
20 This command normal deceleration signal $\underline{V_n}$ is applied to the speed control device 18 through the comparator 16 and generates a control signal 18a therefrom. Then the elevator car decelerates and lands at the destination floor in accordance with the control signal 18a.

25 The process as described also happens on approach to a terminal floor, but in addition the command

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terminal deceleration signals $\underline{V_s}$ are successively generated as the elevator car approaches the terminal floor. The successive command terminal deceleration signals $\underline{V_s}$ and the command normal deceleration signal $\underline{V_n}$ are substantially as shown in Figure 2 wherein there are illustrated various signal voltages plotted in ordinate against distance to the terminal floor in abscissa.

If the positional signal 10a and/or the readiness-for-deceleration sensing signal 10b are or is erroneously generated and/or if a fault occurs in a central processor disposed in the electronic computer 10, a command normal deceleration generator disposed therein and/or the digital-to-analog converter 12, then the command normal deceleration signal $\underline{V_n}$ may be equal to or greater than the command terminal deceleration signal $\underline{V_s}$. In that case, the comparison circuit 16 delivers the command terminal deceleration signal $\underline{V_s}$ to the speed control device 18, as described above, and the elevator car safety decelerates and lands at the terminal floor in accordance with the command terminal deceleration signal $\underline{V_s}$.

However the number of terminal sensors is necessarily limited and therefore the resulting command terminal deceleration signal $\underline{V_s}$ has a small number of discontinuities with the result that it is difficult

to change the command terminal deceleration signal $\underline{V_s}$ smoothly. Accordingly an uncomfortable ride results.

Also in order to prevent any malfunction, the
 5 command terminal deceleration signal $\underline{V_s}$ may be distant from the command normal deceleration signal $\underline{V_n}$. This causes an increase in time delay relative to the command normal deceleration signal $\underline{V_n}$ resulting in deterioration of the landing accuracy.

10 Referring now to Figure 3, wherein like reference numerals designate the components identical to those shown in Figure 1, there is illustrated one embodiment of the elevator terminal deceleration system of the present invention. The arrangement illustrated
 15 comprises the uppermost floor 20, and a plurality of terminal switches, in this case four switches, disposed at predetermined equal intervals in a longitudinal or a vertical array adjacent to the upper most floor 20 within an associated hoistway (not shown). These four
 20 switches form four terminal sensors 22A, 22B, 22C and 22D. The lowermost terminal sensor 22A as viewed in Figure 3 is located at a first predetermined distance A_1 short of the uppermost floor 20 and an up readiness-for-deceleration sensing cam 24 is also disposed in
 25 the hoistway at a second predetermined distance A_2 short of the floor 20.

An elevator car 26 is connected to a counter-weight 28 through a traction rope 30 trained over a hoist wheel 32. The elevator car is provided on the outer surface of the ceiling thereof with both a terminal sensing cam 34 selectively engaging the terminal sensors 22A, 22B, 22C and 22D and a readiness-for-deceleration sensing switch forming a readiness-for-deceleration sensor 36 engaging the cam 24 during the ascent of the elevator car. The hoist wheel 32 is connected to a reversible electric hoist motor 38. When driven in the appropriate direction, the motor 38 raises the elevator car 26 through the hoist wheel 32 and the traction rope 30. During this upward movement of the elevator car 26, the readiness-for-deceleration sensor 36 first engages the associated cam 24 and then the terminal sensing cam 34 successively engages the terminal sensors 22A to 22D.

The arrangement comprises further a pulse generator 40 connected directly to the hoist motor 38 to generate pulses whose number is proportional to that of rotation of the hoist motor 38 and therefore to the distance of movement of the elevator car 26. The pulse generator 40 is connected to a counter 42 for counting the pulses generated by the same. Then the counter 42 is connected to an electronic computer 10 through a converter 44 to which the terminal sensor 22A to 22D and the readiness-for deceleration sensor 36 are connected. The converter 44 is operative

to convert an input applied thereto to data suitable for being processed by the electronic computer 10 and to apply the converted data to the computer 10.

In the example illustrated the electronic computer 10 comprises a micro-computer commercially available as TYPE 8085A from Intel. However it is to be understood that the electronic computer may comprise any suitable micro-computer marketed, for example, under TYPE M6800 from Motorola or under TYPE 80A from Zilog or any other digital computer such as a small-sized computer.

The electronic computer or micro-computer 10 includes an input port 10A connected to the converter 44 and also to a data bus 46, and a read only memory device (which is abbreviated hereinafter to an "ROM") 10B a random access memory device (which is abbreviated hereinafter to an "RAM") 10C, an interrupting period control timer 10D, a central processor 10E and an output port 10F connected to the data bus 46. The input port 10A and the ROM 10B are arranged to supply data to the data bus 46 while the timer 10D and the output port 10F are arranged to receive data from the data bus 46. The RAM 10C and central processor 10E are arranged to apply and receive data to and from the data bus 46.

In the example illustrated, the input port 10A, the ROM 10B, the RAM 10C, the timer 10D, the central

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processor 10E and the output port 10F are TYPES 8212, 2716, 2114A, 8155, 8085A and 8212 commercially available from Intel respectively.

5 The output port 10F is then connected to a digital-to-analog converter 12 subsequently connected to a comparison circuit 16 to which a terminal deceleration generator 14 is also connected. The comparison circuit 16 is connected to a speed control device 18 subsequently connected to the hoist motor 38 as in the arrangement of Figure 1.

10 The terminal deceleration generator 14 is preferably of a circuit configuration as shown in Figure 4. In the arrangement illustrated, a series combination of a plurality of resistors, in this case 15 four resistors R_1, R_2, R_3 and R_4 , is connected across a voltage source $-V$ and ground through a resistor R_5 connected directly to the voltage source $-V$. Each of the resistors R_1, R_2, R_3 and R_4 is connected across an associated one of the serially connected terminal 20 sensors 22A to 22D for the uppermost floor and also a mating one of serially connected terminal sensors 50A, 50B, 50C and 50D for the lowermost floor (not shown) identical to the terminal switches 22A, 22B, 22C and 22D respectively. For example, the resistor R_2 is connected 25 across the terminal sensor 22B and also across the terminal sensor 50B.

The junction of the resistor R_1 , and the terminal switches 22A and 50A is connected via a resistor R_6 to a negative input (-) to an operational amplifier 48 with the other or positive input (+) connected to ground through a resistor R_7 . The output of the operational amplifier 48 is connected to a negative input through a parallel combination of a capacitor C and a resistor R_8 forming a negative feedback network.

The operation of the arrangement shown in Figure 3 will now be described. When the elevator car 26 ascends, the pulse generator 40 generates the pulses which are, in turn, counted by the counter 42. Meanwhile the elevator car 26 reaches the second predetermined distance A_2 short of the uppermost floor 20 which is a destination floor whereupon the readiness-for-deceleration sensor 36 engages the cam 24. Therefore the sensor 36 generates a readiness-for-deceleration sensing signal. That signal is converted to data for the micro-computer 10 by the converter 44. The central processor 10E senses the converted data through the input port 10A and data bus 46 to read out from the ROM 10B the distance A_2 stored therein and write it into the RAM 10C at an address predetermined therefor.

Thereafter the count on the counter 42 is entered into the micro-computer 10 through the converter 44 for each of the calculating time periods. The central

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processor 10E subtracts the entered count from the distance A_2 written into the RAM 10C thereby to calculate the residual distance to the uppermost floor 20.

5 Then the central processor 10E reads out successively from the ROM 10B command deceleration magnitudes which progressively decrease in accordance with the residual distances thus calculated. The command deceleration magnitudes read out from the ROM 10B are
 10 successively supplied to the output port 10F and thence to the digital-to-analog converter 12 where the deceleration magnitudes are successively converted to corresponding analog magnitudes. The analog magnitudes are successively applied, as a command normal deceleration
 15 signal $\underline{V}_1$, to the speed control device 18 through the comparison circuit 16 thereby to control the hoist motor 38. Accordingly the elevator car 26 is smoothly decelerated until it lands accurately at the floor 20.

On the other hand, all the terminal sensors 22A
 20 to 22D are in their open position before the elevator car 26 approaches the uppermost floor 20. Under these circumstances the operational amplifier 40 produces an output of a command terminal deceleration signal $\underline{V}_s$ having a magnitude $\underline{V}_1$ expressed by

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$$V_1 = V \times \frac{R_1 + R_2 + R_3 + R_4}{R_5 + R_1 + R_2 + R_3 + R_4} \times \frac{R_8}{R_6}$$

where V designates the input voltage.

Then the elevator car 26 reaches the first pre-determined distance A_1 short of the uppermost floor 20 whereupon the first terminal sensor 22A engages the
 5 cam 34 resulting in the closure of the terminal sensor 22A. The closure of the terminal sensor 22A generates a command terminal deceleration signal $\underline{V_s}$ having a magnitude $\underline{V_2}$ expressed by

$$V_2 = V \frac{R_2 + R_3 + R_4}{R_5 + R_2 + R_3 + R_5} \times \frac{R_8}{R_6}$$

10 The magnitude $\underline{V_2}$ is smaller than the magnitude $\underline{V_1}$. In this way, the terminal sensors 22B, 22C and 22D are successively closed to cause the operational amplifier 48 to provide successively outputs having magnitudes $\underline{V_3}$, $\underline{V_4}$... successively decreased as shown at the dotted
 15 lines in Figure 2.

Under these circumstances, when the command normal deceleration signal $\underline{V_s}$ is not erroneous, $V_n < V_s$ holds. This means that the elevator car 26 decelerates and lands at the uppermost floor 20 in accordance with the
 20 command normal deceleration signal $\underline{V_n}$.

On the other hand, when the first terminal sensor 22A engages the cam 34, it also produces an output which is, in turn, entered into the micro-computer 10 through

the converter 44. This results in the repeating of the process as described above in conjunction with the closure of the readiness-for-deceleration sensor 36, excepting that the first predetermined distance A_1 is read out from the ROM 10B and written into the RAM 10C. As a result, a command auxiliary terminal deceleration signal V_x corresponding to the calculated residual distance is generated. Each time the terminal sensors 22B to 22D are successively closed, the process as described above is repeated to generate similar a command auxiliary terminal deceleration signal V_x having a magnitude successively decreased in accordance with the calculated residual distances corresponding to the positions of sensors 22A-D.

Accordingly even if the command normal deceleration signal V_n is erroneous due to a fault occurring on at least one of the readiness-for-deceleration sensing cam 24 and the terminal sensor 36, it is possible to decelerate and land the elevator car at the uppermost floor in accordance with the command auxiliary terminal deceleration signal V_x . The command auxiliary signal V_x is computed in the same manner as and so has a magnitude similar to that of the command normal

deceleration signal V_n . This prevents the comfort of ride of the elevator car from deteriorating, as the deceleration remains similar to the normal deceleration.

Each of the terminal sensors 22A to 22D has
5 generally an error in its location and the error becomes larger as the terminal sensor is farther from the uppermost floor 20. This results in a danger that the landing accuracy is decreased. However, the landing accuracy can be improved by using all or some of the
10 terminal sensors except for the first terminal sensor 22A to correct residual distances during the ascent of the elevator car.

Should the worst case happen where both the command normal deceleration signal V_n and the command
15 auxiliary deceleration signal V_x are erroneous, the elevator car safety decelerates and lands at the uppermost floor in accordance with the command terminal deceleration signal V_s when the signal V_n is equal to or greater than the signal V_s as described above.

20 Thus, the car is always decelerated in accordance with the lowest of the deceleration signals available from the deceleration control system.

While the present invention has been illustrated and described in conjunction with the uppermost floor it is to be understood that the same is equally applicable to the lowermost floor. In the latter case, terminal
5 sensors 50A to 50D (see Figure 4) are actuated instead of the terminal sensors 22A to 22D.

From the foregoing it is seen that the present invention provides an elevator terminal deceleration system such that even if the command normal deceleration
10 signal is erroneous, the elevator car can decelerate and land at the terminal floor with a high accuracy while a comfortable ride is maintained.

**CLAIMS:**

1. An elevator terminal deceleration system comprising an elevator car, a plurality of terminal sensors disposed at predetermined intervals adjacent to a terminal floor within an associated hoistway, a counter
5 for counting pulses corresponding to a distance of movement of said elevator car, means responsive to the car reaching a predetermined distance short of said terminal floor to receive a count from said counter, to subtract said count from a predetermined magnitude
10 preliminarily stored therein and corresponding to said distance to calculate the residual distance between the actual position of the elevator car and said terminal floor, and to generate a command normal deceleration signal having a magnitude successively decreased in
15 accordance with said residual distance, command terminal deceleration generator means responsive to the successive engagement of said elevator car with said plurality of terminal sensors during the approach of said elevator car to said terminal floor to generate a
20 command terminal deceleration signal having a magnitude successively decreased in accordance with the actual position of said elevator car and always higher than that of said command normal deceleration signal, and a command auxiliary terminal deceleration generator



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means responsive to the engagement of said elevator car with any of said terminal sensors to receive said count from said counter means to subtract said count from a stored value corresponding to the distance between the
5 engaged terminal sensor and said terminal floor, to calculate the residual distance between the actual position of said elevator car and said terminal floor and to generate a command auxiliary terminal deceleration signal successively decreased in accordance
10 with said residual distance, said system providing as its car-deceleration output signal the smallest of the aforesaid deceleration signals.

2. An elevator terminal deceleration system for controlling an elevator car, comprising a counter
15 arranged to count pulses corresponding to the distance of travel of the car, a plurality of terminal sensors at predetermined intervals along the path of approach of the car to a terminal floor for providing respective signals indicating the passage of the car, a
20 deceleration-initiation sensor arranged to provide a further signal indicating passage of the car at a predetermined distance short of the terminal floor, the said signals indicating respective actual positions of the car, computing means responsive to said further
25 signal to compute from the count on said counter and from said predetermined distance the residual distance between the car and the terminal floor and to generate a



normal deceleration signal which decreases progressively in accordance with the computed residual distance, the said computing means being also responsive to the said signals provided by the terminal sensors to compute, 5 from said count and the known distances of said terminal sensors from said terminal floor, the residual distance between each respective terminal sensor and the terminal floor and to generate an auxiliary deceleration signal corresponding to the computed residual distance, means 10 for generating in response to the signals from the terminal sensors a terminal deceleration signal which decreases in accordance with the residual distance of the car from the terminal floor corresponding to the terminal sensor positions and greater than the 15 deceleration signals generated by the computing means, and car speed control means arranged to respond to the smallest of the deceleration signals.

3. An elevator terminal deceleration system as claimed in claim 2 in which a comparator is provided which 20 compares terminal deceleration signals with the deceleration signals of the computing means and transmits one thereof to the car speed control means.



4. An elevator terminal deceleration system as claimed
in claim 2 or 3 in which the computing means comprise
digital circuitry provided with a digital-to-analogue
output converter and the means for generating the
5 terminal deceleration signal comprises analogue
circuitry.

5. An elevator terminal deceleration system
substantially as hereinbefore described with reference
to and as illustrated in Figures 3 and 4 of the
10 accompanying drawings.
