

"A method of and apparatus for generating speed commands for an elevator".

The present invention relates to a method of and apparatus for generating speed commands for an elevator, and more particularly to an improved method and apparatus for generating speed commands which is capable of making
5 the operation of an elevator change from an acceleration state to a deceleration state smoothly.

In one well known construction, an elevator is driven by a DC motor or induction motor through cables or a hydraulic mechanism. Accordingly, great importance is
10 placed on the control of the motor for the purpose of improving the comfort of the passengers and the accuracy with which the elevator stops at any hall landing. A speed command device enables the accurate and correct control of the elevator to be achieved.

15 In a practical construction, a speed command for an elevator is produced so as to drive the elevator smoothly within the range of a maximum acceleration and deceleration predetermined in view of the comfort of the passengers. Further, from a viewpoint of improving the accuracy at
20 which the elevator cage arrives at a hall landing, that is, minimizing the difference in level between the actual stopping position and the desired stopping position of the elevator cage, the speed command is generated in proportion to the remaining distance for the elevator cage to reach
25 the desired stopping position during the deceleration.

In this respect, the speed command is generated in such a manner that, at the time of acceleration, the elevator is driven in accordance with a time-base speed pattern which increases in proportion to a lapse of time after the departure of the elevator while, at the time of deceleration, it is driven in accordance with a distance-base speed pattern which decreases in proportion to the remaining distance for the elevator to reach the desired stopping position, thereby satisfying not only the condition of comfort but also the accuracy of the stopping position of the elevator car at any hall landing.

If, when the speed control of the elevator cage changes from the time-base speed pattern to the distance-base speed pattern, there is a difference between both speed patterns, the elevator cage vibrates, and when the speed difference is large, not only will the passengers feel a jolt, but also the elevator cage will be unable to follow the distance-base speed pattern causing a reduction in the accuracy of the stopping position at the hall landing.

Therefore, the technique for smoothly changing the speed of the elevator cage from the time-base speed pattern has also become an important problem. For example, Japanese Patent Publication No. 58-27193 proposes a method for changing the speed of an elevator cage from a time-base speed pattern to a distance-base speed pattern smoothly wherein a provisional time-base speed

pattern and the distance-base speed pattern are compared to each other from time to time to find a difference between them, the acceleration of the elevator is modified in proportion to the detected difference in pattern speed
5 and the actual time-base speed pattern is generated on the basis of an integrated value of the modified acceleration.

However, this method has been resulted in certain drawbacks since it requires a complicated process of
10 operation. As a result the circuit becomes complicated and especially, when such a method is realized with a microcomputer, the time required for necessary data processing becomes long and the microcomputer is solely devoted to the processing of data regarding the speed
15 command without being able to perform other proceedings.

It is an object of the present invention to provide a method of and apparatus for generating speed commands, which is capable of generating a speed pattern used as a speed command for the speed control in an
20 elevator which can achieve the smooth transition from an acceleration operation to a deceleration one, from an acceleration operation to a constant speed one or from a constant speed operation to a deceleration one.

In its broadest concept, the present invention
25 provides a method of and apparatus for generating speed commands for an elevator in which there are provided a plurality of partial speed patterns each of which is

generated in accordance with a desired acceleration or deceleration pattern and a final speed pattern as a speed command is formed by combining the partial speed patterns, a difference between a first partial speed pattern actually serving as the final speed pattern and a second partial speed pattern to be transferred from the first one is detected and a transition operation from the first partial speed pattern toward the second one is commenced when the difference reaches a predetermined value corresponding a speed difference caused by a whole amount of variation of the acceleration or deceleration over a transition period. A speed variation at a certain point in time within the transition period is calculated on the basis of a variation of the acceleration or deceleration which occurs during the remaining duration from the certain point in time to the end of the transition period. The calculation speed variation is subtracted from the second partial speed pattern whereby a speed command value at the certain time point is obtained. The calculation of the speed variation and the subtraction for obtaining the speed command value are contained over the transition period so that the speed pattern for the transition is formed.

Thus, a smooth transition between two partial speed patterns can be performed by the simple operation or the simple structure of the apparatus without affecting the comfort of the passengers. Especially, in the case

where the second partial speed pattern to be transferred from the first one is a speed pattern for deceleration such as a distance-base speed pattern, there exists no difference in a pattern speed when finishing the transition to the
5 second partial speed pattern. Accordingly, the deceleration operation can be entered completely smoothly so that the accuracy at which the elevator stops at a hall landing can be improved.

The present invention will now be described in
10 greater detail by way of examples with reference to the accompanying drawings, wherein:-

Figures 1A and 1B are diagrams showing a speed pattern and an acceleration pattern for explaining the principle of operation of the present invention;

15 Figure 2 shows a block diagram of the structure of the elevator control apparatus having a speed command apparatus according to an embodiment of the present invention;

Figure 3 is a flow chart for explaining the
20 operation of a speed command apparatus according to the principle of operation described with reference to Figure 1;

Figures 4 and 5 are diagrams showing the speed pattern and the acceleration pattern for explaining a
25 further principle of operation of the present invention, in which Figure 4 shows those in a case of an acceleration operation and Figure 5 shows those in a case of an

deceleration operation; and

Figures 6 and 7 are flow charts for explaining the operation according to the further principle of operation shown in Figures 4 and 5, respectively.

5 Referring first to Figures 1A and 1B, in order to facilitate the understanding of the principle of operation, description is first of all made of an example of a so-called short range operation where an elevator cage does not reach its rated speed, although the maximum
10 travelling speed depends on the number of floors through which the elevator cage passes. In such an operation, the deceleration operation follows just after the acceleration one. Further, Figure 1(A) shows a speed pattern v_p which is used as a speed command for the speed control of the
15 elevator cage and Figure 1(B) illustrates an acceleration and deceleration pattern α_p according to which the speed v_p is generated.

Now, upon request of the starting of the operation of the elevator cage, an acceleration pattern α_{1t} is at
20 first generated. As shown by a broken line in Figure 1(B), the pattern α_{1t} is linearly increased with time during an initial short duration and, after that, kept constant at a maximum value α_1 . The rate of the linearly increasing portion and the maximum value α_1 of the pattern α_{1t} is
25 predetermined for the maximum comfort of the passengers.

When the time has arrived after the departure of the elevator cage that a time point t_0 is reached, the

acceleration pattern α_p starts to be decreased toward a maximum deceleration α_2 at a predetermined rate.

Accordingly, the control operation is transferred from the dependence on the acceleration pattern α_{1t} to that on a
5 deceleration pattern with the maximum value α_2 as shown by a broken line α_{2t} in Figure 1(B), which has been already generated before the time point t_0 . The decreasing rate of the acceleration must be selected so as not to affect the comfort of the passengers.

10 The transition begins at the time point t_0 and finishes at a time point t_2 at which the maximum deceleration α_2 is reached, and therebetween the acceleration pattern α_p passes through zero at a time point t_1 . Usually the absolute value of α_2 in the
15 deceleration pattern α_{2t} is selected equally to that of α_1 in the acceleration pattern α_{1t} . Therefore, the duration T_1 between the time points t_0 and t_1 becomes equal to the duration T_2 between the time points t_1 and t_2 . The deceleration is maintained at α_2 until a time point t_3
20 and, after that, decreased linearly down to zero. In this manner, the desired acceleration pattern α_p as shown by the solid line in Figure 1(b) can be generated.

On the basis of the acceleration pattern as mentioned above, a speed pattern for the speed control of
25 the elevator cage is prepared. The speed pattern v_p shown by the solid line in Figure 1(A) is composed of a first speed pattern v_1 until the time point t_0 , a second speed

pattern v_2 after the time point t_2 and a third speed pattern smoothly interpolating the first two speed patterns v_1 , v_2 between the time points t_0 and t_2 . These two speed patterns v_1 , v_2 are obtained by use of the following equations:-

$$v_1 = \int \alpha_1 t \, dt \quad \dots\dots(1)$$

$$v_2 = \sqrt{2 \alpha_2 (L - L_0)} \quad \dots\dots(2)$$

wherein:-

(a) L denotes the remaining distance from the present position of the elevator cage to the desired stopping position at the hall landing, which is actually measured by an appropriate detector; and

(b) L_0 denotes a distance corresponding to the area of the hatched portion in the speed pattern shown in Figure 1(A).

The distance L_0 is taken into account, because the deceleration is gradually decreased after the time point t_3 as shown in Figure 1(B).

As will be apparent from the above equations, the first speed pattern v_1 is obtained by integrating the acceleration pattern $\alpha_1 t$ with time, and hence this pattern v_1 is called a time-base speed pattern. The second speed pattern v_2 is produced so that the elevator cage can be decelerated over the remaining distance L (precisely, $L-L_0$) at a constant deceleration α_2 . Therefore, the second pattern v_2 is called a distance-base speed pattern.

Next, reference is made to, the third speed pattern which smoothly interpolates the above mentioned two speed patterns. The speed pattern v_p is at first transferred from the time-base speed pattern v_1 to the third speed pattern at the time point t_0 , and the transition of the speed pattern is done in a manner as described below. As mentioned above, the deceleration pattern α_{2t} is generated even before the time point t_0 and the speed pattern v_2 is also produced in accordance with equation (2).

10 The difference d_v between both the speed patterns v_1 and v_2 is noted, and when the difference d_v becomes equal to a certain speed variation Δv_0 , that time point is made the time point t_0 . The certain speed variation Δv_0 can be obtained as a speed variation caused by an acceleration

15 variation $(\alpha_1 + \alpha_2)$ during the transition time $(T_1 + T_2)$. In this case, the certain speed variation Δv_0 in Figure 1(A) corresponds to the area of the triangle ACE in Figure 1(B), which is equal to the sum of the area S_1 of a trapezoid ABDE and that S_2 of a triangle BCD. Accordingly, the speed

20 variation Δv_0 is obtained by the following equation.

$$\Delta v_0 = \frac{1}{2} (\alpha_2 + \alpha_1 + \alpha_2) T_1 + \frac{1}{2} \alpha_2 T_2 \quad \dots\dots(3)$$

Equation (3) above relates to a general case in which α_1 and T_1 are different from α_2 and T_2 respectively. As has already been mentioned, however, if there are the

25 relations of $\alpha_1 = \alpha_2$ and $T_1 = T_2$, equation (3) can be rewritten as follows:-

$$\Delta v_0 = \frac{1}{2} (\alpha_1 + \alpha_2) (T_1 + T_2) \quad \dots\dots(4)$$

The speed pattern is transferred from the first time-base to the third one, when the difference d_v between the speed patterns v_1 and v_2 becomes equal to the speed variation Δv_0 obtained in a manner as mentioned above, that is to say, at the time point t_0 . Further, assuming that a lapse of time from the time point t_0 is measured by t' , a speed variation Δv during the time $(T_1 + T_2)$ can be generally derived as follows. At a certain time point during the transition time from t_0 to t_2 , the difference between the distance-base speed pattern v_2 and the third speed pattern, which corresponds to the speed variation Δv , is equal to the area of a triangle defined by the line $\overline{AC}$ of the acceleration pattern and the line $\overline{EC}$ in Figure 1(B) after the aforesaid certain time point. For example, the difference Δv_1 between the speed pattern v_2 and the third speed pattern at the time point t_1 is equal to the area S_2 of a hatched triangle BCD in Figure 1(B). Therefore, the area of such a triangle in the acceleration pattern is obtained by the following equation.

$$\int_{t'}^{T_1+T_2} \left\{ (\alpha_1 + \alpha_2) - \frac{\alpha_1 + \alpha_2}{T_1 + T_2} t' \right\} dt' \quad \dots\dots(5)$$

The general formula of the speed variation Δv can be obtained by solving the above equation as follows.

$$\Delta v = \frac{1}{2} (\alpha_1 + \alpha_2) (T_1 + T_2) - \left\{ (\alpha_1 + \alpha_2) t' - \frac{1}{2} \frac{\alpha_1 + \alpha_2}{T_1 + T_2} t'^2 \right\} \dots (6)$$

The third speed pattern v_p is obtained as a difference between the distance-base speed pattern v_2 and the speed variation Δv acquired by the above equation (6).

5 Accordingly, the third speed pattern v_p can be expressed as follows.

$$v_p = v_2 - \Delta v \dots (7)$$

Further, as can be seen from Figure 1(B), the deceleration is maintained constant after $t' = T_1 + T_2$, that
10 is, the deceleration variation is zero. Accordingly, the speed variation Δv becomes zero, so that, as is apparent from the equation (7) above, the third speed pattern v_p becomes equal to the distance-base speed pattern v_2 .

This means that the third speed pattern coincides with
15 the distance-base speed pattern v_2 at the time point t_3 . Therefore, the smooth transition from the time-base speed pattern v_1 to the distance-base speed pattern v_2 can be realized by using the interpolating third speed pattern as mentioned above.

20 In this way, in the case where there exist a first speed pattern operative at that time and a second speed pattern to be next transferred from the first one, a third speed pattern for the transition from the first to the second speed patterns is prepared which is
25 derived on the basis of the second speed pattern and the speed variation caused by the variation of acceleration or deceleration during the transition. As a result, there

can be no deviation in a pattern speed at the end of the transition.

In the final portion of the speed pattern v_p , the distance-base speed pattern v_2 is modified as follows.

- 5 Assuming that the duration in which the deceleration is reduced from its maximum value α_2 to zero is made T_3 , a lapse of time t''' is measured from the time point t_3 at which the following relation is established.

$$v_2 = \frac{1}{2} \alpha_2 T_3 \quad \dots\dots(8)$$

- 10 From the time point t_3 , the speed pattern v_p is made as follows.

$$v_p = \frac{1}{2} \alpha_2 \left(\frac{T_3 - t'''}{T_3} \right) (T_3 - t''') \quad \dots\dots(9)$$

- To summarize, the speed pattern v_p increased from the time of starting of the elevator cage to the time point t_0 in accordance with the time-base speed pattern v_1 obtained by integrating the desired acceleration pattern α_{1t} with time; in the period from the time point t_0 to the time point t_2 , the speed pattern v_p changes from acceleration to deceleration in accordance with the
20 interpolating speed pattern which is obtained by subtracting from the distance-base speed pattern v_2 the speed variation Δv determined by the acceleration variation $(\alpha_1 + \alpha_2)$ during the transition time $(T_1 + T_2)$; in the period from the time point t_2 to the time point t_3 ,
25 the speed pattern v_p is reduced at a predetermined rate of

deceleration on the basis of the distance-base speed pattern v_2 ; and in the final period from the time point t_3 to the time point t_4 , the speed pattern v_p is subject to the variation of the desired deceleration pattern a_{2t} in accordance with time.

Referring next to Figure 2, the description will now be given with respect to an elevator control apparatus having a speed command device according to an embodiment of the present invention. In this example, there is shown a so-called AC elevator in which an elevator cage is driven by an AC induction motor controlled by an inverter, but it is of course possible to apply the speed command device of the present invention to a DC elevator or hydraulic elevator.

As shown, an induction motor 1 is supplied with power through a converter 2 and an inverter 3 and drives a pulley 4 over which a cable 5 is suspended. To both ends of the cable 5 are provided a counterweight 6 and an elevator cage 7. A pulse generator 8 is driven by a drive tape 9 connected to the cage 7 and generates a pulse every time when the cage 7 travels a unit distance (e.g. 1 to 2 mm). Such pulses are supplied as an input to a speed control device 11, an operation management device 12 and a speed command device 10, in which, as is well known, they are used to detect the speed and the present position of the cage 7.

The speed control device 11 detects an actual

speed of the cage 7 on the basis of the pulse from the pulse generator 8 and obtains the speed deviation between the actual speed and a speed command from the speed command device 10. Further, it controls gates of thyristors forming the converter 2 and the inverter 3 in accordance with the obtained speed deviation, so that the speed of the motor 1 follows the speed command. The operation management device 12 receives as inputs call signals from a hall call device 13 provided at an elevator landing hall of every floor and a destination call device 14 provided within the elevator cage 7 and performs the known control operations such as the determination of the travelling direction of the cage 7 and a next call to be made and the control of starting and stopping the cage 7. Since these devices 11, 12 and the operation thereof are well known and they have nothing to do with the inventive concept of the present invention, no further description thereof will be made.

The speed command device 10, which forms a characteristic feature of the present invention, receives as inputs, start and stop signals from the operation management device 12 and the pulses as a position signal from the pulse generator 8 and generates the speed command v_p as mentioned above. That is, the time-base speed pattern v_1 is produced by a first pattern generator 101, and when the next floor to be served is determined, the distance-base speed pattern v_2 is produced by a second

pattern generator 102. A d_v detector 103 compares the outputs of the first and second pattern generators 101 and 102 to detect the speed difference d_v in both patterns v_1 and v_2 and produces an output signal to a Δv generator 104 and a switching means 106, when the detected difference d_v becomes equal to the predetermined speed variation Δv_0 obtained by equation (4) referred to above.

Upon receipt of the output signal from the d_v detector 103, the Δv generator 104 calculates the speed variation Δv in accordance with equation (6). A subtractor 105 executes the subtraction of the speed variation Δv calculated in the Δv generator 104 from the distance-base speed pattern v_2 generated by the second pattern generator 102 to produce the interpolating speed pattern v_p described above as the third speed pattern. The thus obtained speed pattern v_p is supplied to the switching means 106. Further, as has already been mentioned, the speed variation Δv output from the Δv generator 104 is made zero after the transition time $(T_1 + T_2)$, i.e. after the deceleration is maintained constant. Therefore, after the lapse of time $(T_1 + T_2)$ from the generation of the output of the d_v detector 103, the subtractor 105 outputs the distance-base speed pattern v_2 generated by the second pattern generator 102 as it is.

The switching means 106 holds the position as shown in Figure 2 before the appearance of the output of the d_v detector 103, so that the time-base speed pattern v_1

generated by the first pattern generator 101 is output from the switching means 106 as the speed pattern v_p . When the d_v detector 103 produces the output signal, the switching means 106 changes its state to output the signal from the subtractor 105 as the speed pattern v_p . The thus output signal, i.e. the speed pattern v_p , from the switching means 106 is supplied to the speed control device 11, whereby the operation of the elevator cage 7 is controlled following the speed pattern v_p .

10 The above description has been made with reference to Figure 2 in which all functions are shown as discrete means or devices. However, it will be understood from Figure 2 that these functions can be achieved by using an existing microcomputer. Therefore, an embodiment
15 in which the speed command device 10 is realized by a microcomputer will be described hereinafter. Since a known microcomputer having the usual structure can be employed for this purpose, the description of the microcomputer itself is omitted here.

20 Figure 3 is a flow chart showing the processing for generating the speed command according to the embodiment of the present invention. It is to be understood that individual processing for generation of the patterns v_1 and v_2 , which is easily realized by one
25 ordinarily skilled in the art on the basis of the above equations (1) and (2), is executed separately from the processing shown in Figure 3. This figure particularly

shows the flow chart of a part in which the speed pattern v_p is transferred from the time-base speed pattern v_1 to the distance-base speed pattern v_2 .

In Figure 3, at a step 31, the time-base speed pattern v_1 , which is generated separately as mentioned above, is made the speed pattern v_p as a speed command. At a next step 32, it is judged whether the difference d_v of the speed pattern v_2 from the speed pattern v_1 reaches the predetermined speed variation Δv_0 or not. If the answer at the step 32 is negative, the same operation as previous is continued. Accordingly, the speed pattern v_p follows the time-base speed pattern v_1 .

On the other hand, with the lapse of time, the time-base speed pattern v_1 is increased and the distance-base speed pattern v_2 is decreased. As a result, if the answer at the step 31 becomes affirmative, i.e. when it is judged that the time point t_0 is reached, the processing for the transition of the speed pattern is commenced.

Namely, the flow of operation goes to a step 33 at which the speed variation Δv is calculated in accordance with equation (6) mentioned before. At a step 34, the speed pattern for the transition is obtained by using the speed variation Δv calculated at the step 33 in accordance with equation (7). Next, at a step 35, the sign of the speed variation Δv is determined. If the sign thereof is positive, the flow of operation returns to the step 33. This operation is repeated until the sign of the speed

variation Δv becomes zero.

As will be understood from equation (6), the speed variation Δv decreases with the lapse of time t' and finally becomes zero when $t' = T_1 + T_2$, i.e. at the time point t_2 . When the time point t_2 is reached, the flow of operation goes to a step 36, in which the speed pattern v_p is transferred from the third pattern for the transition to the distance-base speed pattern v_2 . After that, a decision is made at a step 37 whether the time point t_3 is reached or not. Until the time point t_3 , the speed pattern v_p follows the distance-base speed pattern v_2 .

When the time point t_3 is reached, the flow of operation advances to a step 38, in which the operation is executed in accordance with equation (9). Thereby, the speed pattern v_p is modified to achieve a smooth stopping of the elevator cage. This operation continues until it is judged at a step 39 that the speed pattern v_p becomes zero.

The explanation described above has been made of the speed pattern for the short range operation of the elevator cage. The concept of the present invention can of course be applied to the case of the speed pattern for the long range operation where the elevator cage travels passing through many floors. In such an operation, the speed of the elevator cage can reach its rated value, i.e. the maximum speed $v_{\max}$ and the cage travels at that speed for a time. This principle of operation will now be

described with reference to Figure 4.

In Figure 4, the speed pattern and the acceleration pattern during the acceleration period are shown. As is apparent from the figure, it is similar to a case of Figure 1 that the time-base speed pattern v_1 is generated on the basis of the desired acceleration pattern α_{1t} . In this case, however, the difference d_v between the time-base speed pattern v_1 and the maximum speed $v_{\max}$ is noted, and when the difference d_v becomes equal to the predetermined speed variation Δv_{T_1} , i.e. at a time point t_0 , the transition from the time-base speed pattern v_1 toward the maximum speed $v_{\max}$ has to be begun. The predetermined speed variation Δv_{T_1} can be determined by the following equation (10) on the basis of the transition time T_1 and the varied amount α_1 of the acceleration during the transition time T_1 .

$$\Delta v_{T_1} = \frac{1}{2} \alpha_1 T_1 \quad \dots\dots(10)$$

Further, the speed pattern v_p during the transition can be obtained by the following equation (11), assuming that the lapse of time from the point t_0 is measured with time t' :

$$v_p = v_{t_0} + \int_0^{t'} \frac{\alpha_1}{T_1} (T_1 - t') dt' \quad \dots\dots(11)$$

wherein v_{t_0} denotes the value of the time-base speed pattern v_1 at the time point t_0 . In correspondence to the form of the equations (6) and (7), the above equation can be rewritten as follows.

$$v_p = v_{\max} - \Delta v \quad \dots\dots(12)$$

$$v = \frac{1}{2} \alpha_1 T_1 - \int_0^{t'} \frac{\alpha_1}{T_1} (T_1 - t') dt' \quad \dots\dots(13)$$

As is apparent from equation (12) above, the speed pattern from the transition from a first speed pattern, i.e. the time-base one v_1 to a second speed pattern to be next transferred, i.e. the constant speed pattern $v_{\max}$, is generated on the basis of the second speed pattern and the speed variation caused by the variation of acceleration during the transition.

Referring next to Figure 5, the operation during the deceleration is described. In this case, the distance-base speed pattern v_2 is generated from the time when the next floor to be served is determined, and the difference d_v between the distance-base speed pattern v_2 and the maximum speed $v_{\max}$ is detected after that time. As shown in the figure, when the difference d_v mentioned above becomes equal to the predetermined speed variation Δv_{T2} , that is, when the time point t_1' is reached, the transition from the maximum speed $v_{\max}$ toward the distance-base speed pattern v_2 is begun. The value of Δv_{T2} is obtained as follows.

$$\Delta v_{T2} = \frac{1}{2} \alpha_2 T_2 \quad \dots\dots(14)$$

Further assuming that the lapse of time from the time point t_1' is measured by t'' , the speed variation Δv during the transition time T_2 is expressed by the

following equation.

$$\Delta v = \frac{1}{2} \alpha_2 T_2^{-\frac{1}{2}} \frac{\alpha_2}{T_2} t^2 \quad \dots\dots(15)$$

Accordingly, the speed pattern v_p for the transition can be obtained in accordance with the relation which is the same as the equation (7) mentioned before. After the time point t_3 , the operation is the same as that in the case of Figure 1 and therefore the description thereof is omitted.

referring next to Figures 6 and 7, a description is given of the processing of the generation of the speed pattern v_p according to the principle of operation described with reference to Figures 4 and 5. Also in this case, the generation of the speed patterns v_1 and v_2 themselves are conducted by other processings provided separately, similarly to the case of Figure 3.

In Figure 6, at a step 61, the time-base speed pattern v_1 is made the speed pattern v_p after start of the operation. At a step 62, it is judged whether the difference d_v between the maximum speed v_{max} and the time-base speed pattern v_1 is less than the predetermined speed variation Δv_{T1} obtained by equation (11). While the difference d_v is larger than Δv_{T1} , the speed pattern v_p increases in accordance with the time-base speed pattern v_1 .

When the difference d_v becomes less than Δv_{T1} , i.e. when the time point t_0 is reached, the processing

for the transition is begun. Accordingly, at a step 63, the speed variation Δv is calculated in accordance with equation (13), and at a next step 64, the speed pattern for the transition from the time-base speed pattern v_1 to the maximum speed $v_{\max}$ is obtained in accordance with equation (12) by using the speed variation Δv calculated at the step 63. After that, a determination is made at a step 65 whether the speed pattern v_p comes up to the maximum speed $v_{\max}$. While the speed pattern v_p is less than $v_{\max}$, the speed pattern v_p is increased with time at a predetermined varied rate of acceleration.

When the speed pattern v_p becomes equal to $v_{\max}$, i.e. when the time point t_1 is reached, the maximum speed $v_{\max}$ is made the speed pattern v_p (cf. the step 66). At this time, the flow of operation is finished and, after that, the speed pattern v_p is maintained at the constant value $v_{\max}$.

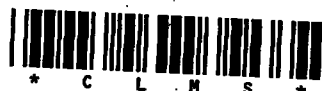
If the next floor to be served is determined during the travel of the elevator cage, the distance-base speed pattern v_2 is generated. From that time, the processing for the transition from the maximum speed $v_{\max}$ to the distance-base speed pattern v_2 is begun. As shown in Figure 7, at a step 71 in the flow for this processing, the difference d_v between the distance-base speed pattern v_2 and the maximum speed $v_{\max}$ is determined, and when the difference d_v becomes less than the predetermined speed variation Δv_{T2} , i.e. when the time

point t_1' in Figure 5 is reached, the flow of operation goes to a next step. The flow of operation after the step 71 is entirely the same as that in Figure 3, except that the step 33 in Figure 3 is executed on the basis of the equation (6) whereas that step in this case is conducted in accordance with the equation (15). Therefore, further description is omitted.

As has been described above, according to the present invention, there can be provided a speed command generating method and apparatus for an elevator which is able to achieve the smooth transition from acceleration to deceleration or constant speed travelling, and from acceleration or constant speed travelling to deceleration. Further, such a speed command device has a simple structure or is composed of a simple operation, so that it can be realized economically.

CLAIMS:-

1. A method of generating speed commands for the speed control in an elevator, in which there are provided a plurality of partial speed patterns each of which is generated in accordance with a desired acceleration or deceleration and a final speed pattern as a command for the speed control is formed by combining the partial speed patterns, said method including the steps of:
- (a) detecting once only, a difference between a first partial speed pattern presently serving as the final speed pattern and a second partial speed pattern to be next transferred from the first one to serve as the final speed pattern after a transition period from the first partial speed pattern toward the second one;
- (b) outputting a transition initiating signal when the detected difference reaches a predetermined value corresponding to a speed difference caused by a whole amount of variation of the acceleration or deceleration over the transition period;
- (c) calculating from the output transition initiating signal, a speed variation at a certain point in time derived from a variation of the acceleration or deceleration during the remaining duration of the transition period from the certain point in time; and
- (d) executing the subtraction of the result obtained in said speed variation calculating step from the second partial speed pattern;



(e) repeating the steps of speed variation calculation and subtraction execution until the speed variation obtained in said step of speed variation calculation step becomes zero, whereby a speed pattern
5 for the transition period from the first preliminary step to the second one is generated.

2. A method of generating speed commands according to claim 1, wherein said first partial speed pattern is a time-based speed pattern obtained by integrating a desired
10 acceleration with time, said second partial speed pattern is a distance-base speed pattern produced so as to decrease over the remaining distance to a stopping position from a present position of an elevator cage at a desired deceleration and said final speed pattern is
15 formed by combining these two partial speed patterns.

3. A method of generating speed commands according to claim 1, wherein said first partial speed pattern is a time-base speed pattern obtained by integrating a desired acceleration with time and said second partial speed
20 pattern is a constant speed pattern.

4. A method of generating speed commands according to claim 1, wherein said first partial speed pattern is a constant speed pattern and said second partial speed pattern is a distance-base speed pattern produced so as
25 to decrease over the remaining distance to a stopping position from a present position of an elevator cage at a desired deceleration.



5. A speed command generating apparatus for the speed control in an elevator having a plurality of pattern generating means each of which generates a partial speed pattern in accordance with a desired acceleration or deceleration and switching means for switching the partial speed patterns in sequence to output a particular speed pattern to be served as a final speed pattern at that time, said apparatus including:

(a) first pattern generating means for generating a first partial speed pattern presently serving as the final speed pattern;

(b) second pattern generating means for generating a second partial speed pattern to be next switched from the first partial speed pattern to serve as the final speed pattern after a transition period from the first partial speed pattern toward the second one;

(c) difference detecting means for detecting only once, a difference between the first partial speed pattern and the second partial speed pattern to output a transition initiating signal when the detected difference reaches a predetermined value corresponding to a speed difference caused by a whole amount of variation of the acceleration or deceleration over the transition period;

(d) speed variation generating means for executing, in response to the transition initiating signal, the calculation of a speed variation derived from a variation of the acceleration or deceleration during



the remaining duration of the transition period;

(e) means for subtracting the speed variation obtained by said speed variation generating means from the second partial speed pattern; and

5 (f) switching means inputting the first partial speed pattern and the output of said subtracting means and outputting the final speed pattern by switching from the first partial speed pattern to the output of said subtracting means in response to the transition
10 initiating signal.

6. A speed command generating apparatus for the speed control in an elevator, constructed substantially as herein described with reference to and as illustrated in the accompanying drawings.



* C L M S *