United States Patent

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[73] Assignee Hitachi, Ltd.
Tokyo, Japan
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[33] Japan
[31] 43/66106

[54] SPEED CONTROL SYSTEM FOR ELEVATORS

3 Claims, 6 Drawing Figs.

[52] U.S. Cl. .... 187/29 R, 318/397
[51] Int. Cl. B66b 1/30
[50] Field of Search .... 187/29; - 318/396–398

[56] References Cited
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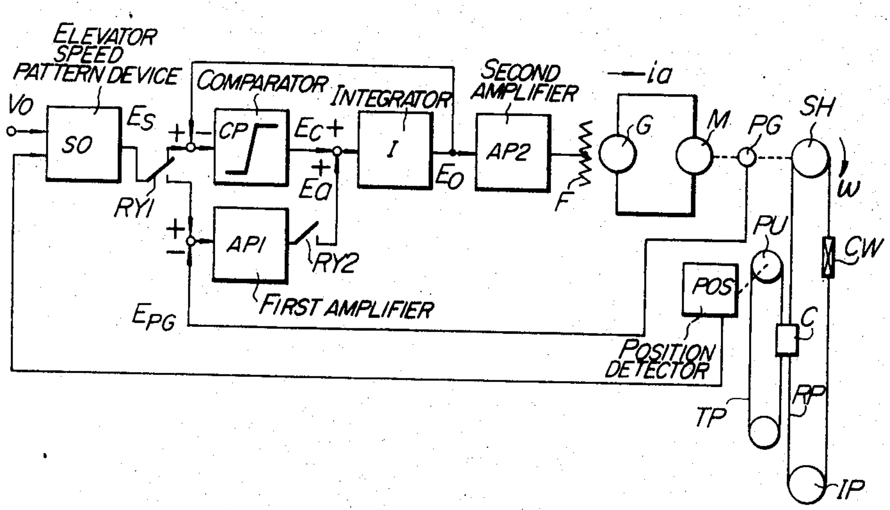
ABSTRACT: A speed control system for elevators, wherein there is provided a speed pattern means SO for providing a constant speed pattern voltage during the accelerating operation and a deceleration pattern voltage which decreases in a stepped manner whenever the elevator cage arrives at each one of a plurality of present deceleration points during the decelerating operation, the output of the said means SO is supplied to a comparator CP having positive and negative saturation characteristics, the output of the comparator CP is integrated by an integrator I, and the output of the integrator is negatively fed back to the input side of the comparator CP and at the same time to the elevator speed control system, and wherein during the accelerating operation the output of the speed pattern means SO is supplied to the comparator, and during the decelerating operation, a correction signal corresponding to the difference between the output of the said means SO and a voltage corresponding to the actual elevator speed is generated to be supplied to the integrator, thereby correcting the output of the said integrator in accordance with the actual elevator speed.



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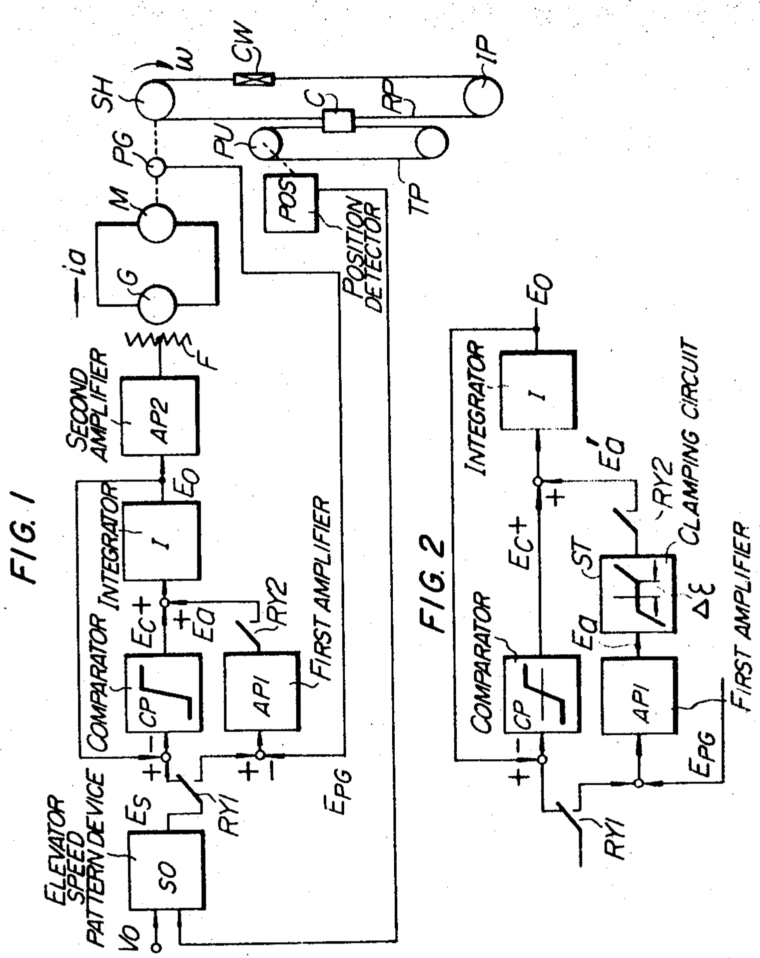
4 Sheets-Sheet 1



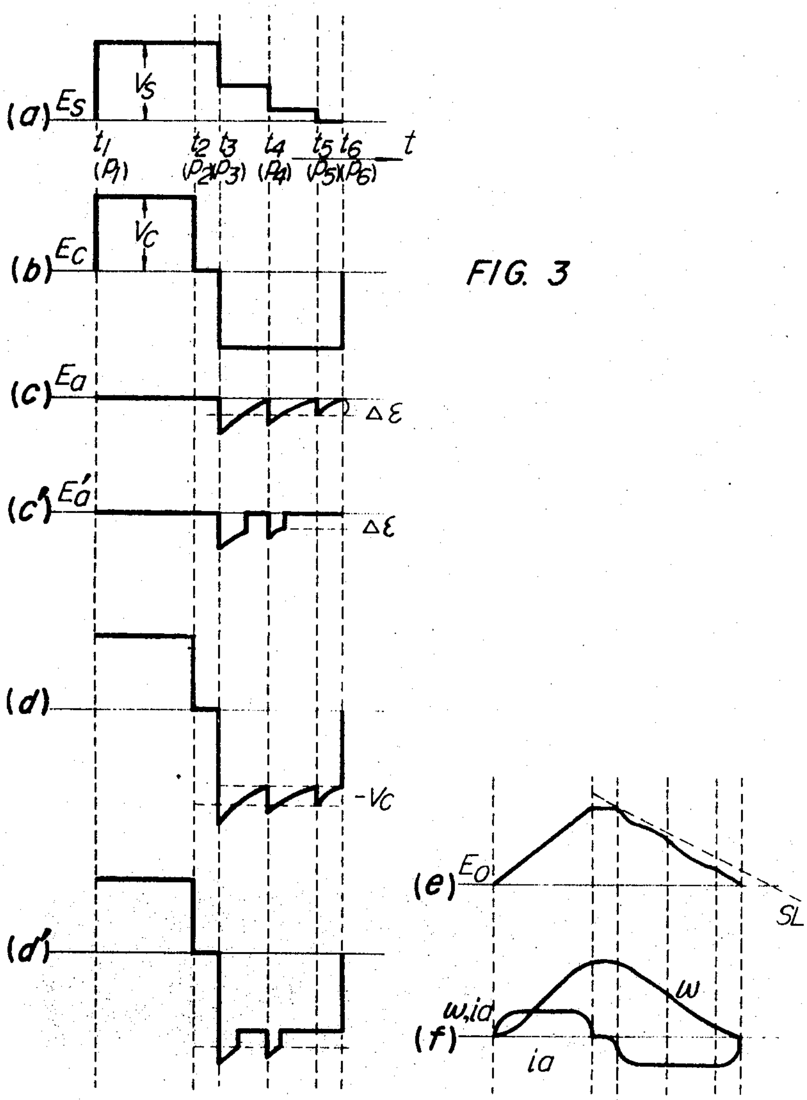

(a) Es
Vs
t1 (P1)
t2 (P2)
t3 (P3)
t4 (P4)
t5 (P5)
t6 (P6)
t
(b) Ec
Vc
(c) Ea
ΔE
(c') E'a
ΔE
(d)
-Vc
(d')
(e) Eo
SL
(f) ω, ia
ω
ia

FIG. 3

FIG. 4

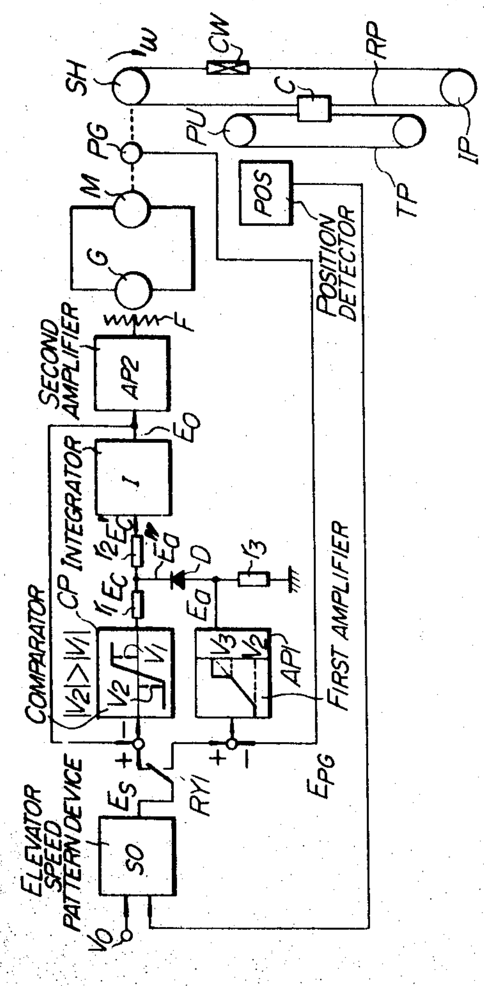

SH
CW
RP
C
PU
PG
M
IP
TP
POS
POSITION DETECTOR
G
F
SECOND AMPLIFIER
AP2
INTEGRATOR
I
CP
COMPARATOR
|V2|>|V1|
D
FIRST AMPLIFIER
AP1
ELEVATOR SPEED PATTERN DEVICE
SO
RY1

FIG. 5A

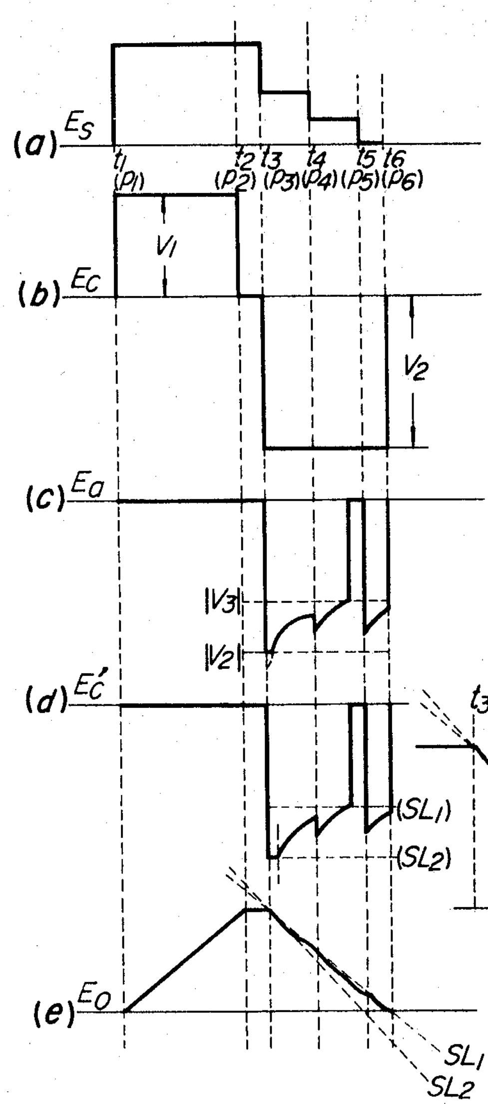
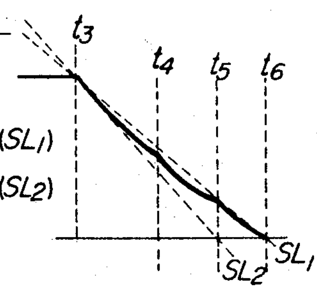

(a) Es
t1 (p1)
t2 (p2)
t3 (p3)
t4 (p4)
t5 (p5)
t6 (p6)
(b) Ec
V1
V2
(c) Ea
|V3|
|V2|
(d) Ec'
(SL1)
(SL2)
(e) Eo
SL1
SL2

FIG. 5B


t3
t4
t5
t6
SL2
SL1

SPEED CONTROL SYSTEM FOR ELEVATORS

This invention relates to a speed control system for elevators, and more particularly it pertains to improvements in a speed control system for elevators wherein during the accelerating operation, a constant speed pattern voltage is produced, and during the the decelerating operation, there is produced a speed pattern voltage which is decreased in a stepped manner whenever the elevator cage arrives at each one of a plurality deceleration points, each of the said voltages being applied to an integrator, thereby producing a smoothly changing speed pattern.

Generally, a DC elevator uses the Ward-Leonard control system including the static Leonard system, wherein a current flowing through the field winding of the generator is programcontrolled in a stepped manner or a continuously changing current produced by a pattern generator is made to flow through the said field winding, thereby permitting the speed of the motor to be changed along a desired speed curve.

During the acceleration control, the desired purpose can be substantially achieved merely by increasing the field current smoothly in terms of time, but during the deceleration control, it is necessary to effect speed control while detecting the elevator control. That is, in order that the elevator may be made to land precisely at the desired floor, the speed pattern should be changed in accordance with the elevator position.

An enhanced floor-landing accuracy and improved riding comfort is essentially required of any elevator. In order to enhance the floor-landing accuracy, it may be conceivable to produce a continuous speed pattern in accordance with the elevator position with the aid of a number of position detecting means provided in juxtaposition or continuous position detecting means (such as, for example, a differential transformer). With such an arrangement, the riding comfort can also be improved. Disadvantageously, however, the entire system becomes extremely complicated and expensive.

It is an object of the present invention to provide a control system capable of improving the riding comfort and floorlanding accuracy by using only a small number of position detecting means.

Another object of the present invention is to provide a control system wherein during the decelerating operation, an input to the integrator is maintained at a level corresponding to a predetermined deceleration without being corrected when an error signal corresponding to the difference between the output of the speed pattern means which is decreased in a stepped manner and the actual elevator speed is lower than a predetermined level, and only when the said error signal is higher than the said predetermined level, the input to the integrator is corrected to change the deceleration, thereby reducing the floor-landing error.

Still another object of the present invention is to provide a control system wherein the deceleration of the elevator is so controlled as to be maintained in a range between prescribed maximum and minimum deceleration levels.

Other objects, features and advantages of the present invention will become apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram showing the system according to an embodiment of the present invention;

FIG. 2 is a block diagram showing the system according to a second embodiment of the present invention;

FIG. 3 is a view useful for explaining the operation of the present invention;

FIG. 4 is a block diagram showing the system according to a third embodiment of the present invention; and

FIGS. 5*a* and *b* are views useful for explaining the operation of the system shown in FIG. 4.

In FIG. 1, a constant voltage V_O is applied to an elevator speed pattern means SO which is adapted to provide a constant voltage V_s corresponding to a commanded speed during the acceleration of the elevator and a pattern voltage E_s which drops in a stepped manner at present position P_3, P_4 and P_5 in response to the operation of a position detecting means POS during the deceleration of the elevator. In this example, the position detector means POS is so designed as to decrease the pattern voltage E_s whenever the elevator arrives at the three positions P_3, P_4 and P_5, as shown in FIG. 3(*a*).

A changeover relay RY1 operates to pass the command voltage E_s available from the elevator speed pattern SO to a comparator CR during the accelerating operation, and during the decelerating operation, it operates to pass this voltage to a first amplifier AP1. Preferably, the comparator CP is so designed as to represent a saturation comparison characteristic as shown in the drawing, which may be constituted by a transistor operational amplifier or the like. This comparator is saturated upon application of a small voltage thereto so as to provide a positive or negative constant output voltage V_c or $-V_c$. The output of the comparator CP is integrated by an integrator I and then negatively fed back to the input side of the comparator CP. At the same time, the output voltage E_o of the integrator I is amplified in a second amplifier AP2 and then applied to the field winding F of a Ward-Leonard generator G. A Ward-Leonard motor M is driven in a controlled manner by the output voltage of the generator G, whereby a traction sheave SH is driven in a controlled manner.

A tachometer generator PG is coupled directly to the aforementioned motor M to thereby detect the moving speed of the elevator. Output voltage E_{PG} of the tachometer generator PG is negatively fed back to the first amplifier AP1. Provided in such a manner as to run around the traction sheave SH and an idle pulley IP is rope RP which includes a counter weight CW and a cage C with which is connected a tape TP to detect the position thereof, the tape TP being driven in synchronism with the cage C. The movement of this tape TP is detected by a pulley PU, so that the position detector POS is operated. The position detector is shown as being of a mechanical system, but it goes without saying that an electric system position detector can equally be employed.

A relay RY2 is adapted to pass the output voltage E_a of the first amplifier AP1 to the integrator I only during the decelerating operation.

In the foregoing arrangement, if a voltage V_s corresponding to a commanded speed is provided by the elevator speed pattern means SO during the accelerating operation as shown in FIG. 3(*a*) (a point of time t_1 to a point of time t_2), then this voltage is passed to the comparator CP since the changeover relay RY1 is switched to the upper position during the accelerating operation.

A a result, a constant positive output voltage V_c is provided by the comparator, which, is directly integrated by the integrator I, so that the output voltage E_O of the latter builds up with a predetermined slope as shown in FIG. 3(*e*). When the output voltage E_O of the integrator I becomes equal to the pattern voltage E_s available from the elevator speed pattern means SO (at the point of time t_2 in FIG. 3), the input voltage $E_s = -E_o$ to the comparator CP becomes zero, so that the output voltage E_c or the input voltage to the integrator I also becomes zero. Thus, the output voltage E_o of the integrator I is maintained at the value as shown in FIG. 3(*e*), so that the output of the second amplifier AP2 becomes constant. When the cage reaches deceleration starting point P_3, the position detector POS is operated to reduce the pattern voltage of the elevator speed pattern means SO in such a stepped manner as shown in FIG. 3(*a*). During the decelerating operation, the pattern voltage E_s is applied to the first amplifier AP1 rather than to the comparator CP, due to the operation of the changeover relay RY1. Since the voltage E_{PG} corresponding to the actual speed of the elevator is negatively fed back to the first amplifier AP1 as described above, the output voltage E_a of the first amplifier AP1 becomes negative as shown in FIG. 3(*c*). This voltage is applied to the integrator I through the relay RY2. At this point, since the input to the comparator CP is only the voltage $-E_o$ fed back thereto by the integrator I, the comparator CP provides a constant negative voltage $-V_c$ (FIG. 3(*b*), so that the overall input E_c+E_a of the integrator I begins decreasing, with a result that the elevator is decelerated. As the elevator speed is reduced, the speed voltage E_{PG} is decreased so that the output voltage E_a of the first amplifier RY1 is increased as shown in FIG. 3(*c*). (This increasing curve depends upon the deceleration curve of the actual elevator).

If the voltage E_s supplied from the elevator speed pattern device SO to the comparator CP is made zero when the cage reaches the position P_3 during the decelerating operation (needless to say, the output of the first amplifier AP1 is not supplied to the integrator I), then the output voltage of the integrator I will be reduced in accordance with a slope opposite to that of the accelerating operation so that such an output voltage as approximately indicated by a dotted line SL in FIG. 3 will be produced.

In the foregoing embodiment, however, the voltage E_a which corresponds to the difference between the pattern voltage E_s and the voltage E_{PG} corresponding to the actual elevator speed is added to the input to the integrator I. Therefore, in a range such as the interval t_3 to t_4 where there occurs a great deviation, the correction input voltage E_a becomes high so that the decreasing rate of the output voltage E_o of the integrator I also becomes high. Thus, the second amplifier AP2 makes such a command control as to increase the deceleration of the elevator.

Whenever the elevator arrives at each one of the other positions P_4 and P_5, the output voltage of the elevator speed pattern device SO is reduced in a stepped manner so that the output E_a of the first amplifier AP1 becomes as shown in FIG. 3(*c*).

The input to the integrator I is changed in accordance with the deviation between the actual elevator speed and the pattern speed at each deceleration point, with a result that the output of the integrator I or the decreasing rate of the pattern applied to the Ward-Leonard system generator G is automatically controlled. Thus, in case the elevator speed is different from the desired speed at each deceleration point, the speed pattern is continuously controlled so as to stop the elevator exactly at any desired point.

At a point intermediate between the ones corresponding to, for example, the points of time t_3 and t_4 respectively where a positional command is provided, the correction voltage E_a is smoothly changed in accordance with the deceleration of the elevator so that the output voltage E_o of the integrator I is also smoothly decreased, thus resulting in an improved riding comfortability. In addition, the floor-landing accuracy is also improved because of the fact that the speed pattern is varied in accordance with the actual elevator speed. Thus, there is no possibility that the riding quality is deteriorated, even if stepped changes in the voltage E_s available from the elevator speed pattern device SO are too remarkably made (the number of position detectors is reduced). The floor-landing accuracy is not deteriorated, either.

This means that the number of the position detectors to be provided can be reduced or that the floor-landing accuracy can be improved for the same number of position detectors.

In FIGS. 1 and 2, ω is the elevator speed, and i_a is the load current.

FIG. 2 shows another embodiment of the present invention, wherein a clamping circuit ST is provided in series with the first amplifier AP1. Assume now that the preset voltage the dead band provided by the clamping circuit ST is $\Delta\epsilon$. Thus, a correction voltage E_a' is applied to the integrator I only when the output of first amplifier AP1 is greater than $\Delta\epsilon$ (in absolute value) (when the difference between the pattern voltage E_s and the voltage corresponding to the actual elevator speed is greater than the preset value), as shown in FIG. 3(*c*). Thus, the overall input E_c+E_a' to the integrator I becomes as shown in FIG. 3(*d'*). According to this embodiment, in case the difference signal between the pattern voltage and the voltage corresponding to the actual elevator speed is small, the output of the integrator or the command for the elevator corresponds to a predetermined deceleration, thus resulting in a high riding comfortability. As described above in connection with FIG. 1, correction is made only in case the aforementioned difference signal is decreased for some reason when the cage reached a certain position, thus ensuring that a sufficient floor-landing accuracy is obtained.

With the foregoing arrangement wherein no correction signal is applied when the speed control system is sufficiently performing the function thereof and correction is made when there is a great speed error, a variation in deceleration can be minimized so that the speed control can be very easily performed.

Referring to FIG. 4, there is shown a further embodiment of the present invention wherein the first amplifier AP1 has a dead band such as shown in the drawing. The output voltage E_a of this amplifier AP1 is applied to the integrator I through a clamping circuit constituted by a diode D and resistor r_1, r_2 and r_3. When the elevator arrives at the predetermined deceleration point P_3, P_4 or P_5 (point of time t_3, t_4 or t_5), the position detector POS is operated so that the voltage of the elevator speed pattern device SO is decreased in stepped manner as shown in FIG. 5(*a*).

At this point, the changeover relay RY1 is switched to the lower position, and the comparator CP is made to provide a constant negative voltage V_2, as shown in FIG. 5(*b*).

The speed voltage E_{PG} corresponding to the actual elevator speed and the aforementioned command voltage E_s are added to each other so as to be an input to the first amplifier AP1.

As a result, the output voltage E_a of the first amplifier AP1 takes a sawtooth waveform as shown in FIG. 5(*c*).

The output voltage E_a is added to the output E_c of the comparator CP through a diode D, and therefore the input voltage E_c' to the integrator I becomes as shown in FIG. 5(*d*). Thus, the output E_o of the integrator I varies as shown in FIG. 5(*e*), since it is obtained by integrating the voltage E_c'. FIG. 5 (*b*) shows the details of FIG. 5 (*e*).

In case the difference (absolute value) between the pattern voltage E_s and the speed voltage E_{PG} is great as at the point P_3, the input voltage (absolute value) applied to the integrator I is increased so that the output voltage of the integrator I or the decreasing rate of the deceleration pattern is increased.

In case the difference (absolute value) between the pattern voltage E_s and the speed voltage E_{PG} is small on the contrary (deceleration points P_4, P_5), the input to the integrator I is decreased (in absolute value) so that the deceleration is set to a low level.

When the output voltage E_a of the first amplifier API is lower than V_2 ($|E_a|>|V_2|$), the diode D is rendered nonconductive so that the input voltage to the integrator I assumes the value $-V_2$. Thus, the output of the integrator I decreases along a dotted line SL_2. (See FIG. 5 (*e*).)

In case the pattern voltage E_s is close to the actual speed voltage E_{PG} so that E_a becomes equal to V_3, then the diode D is rendered conductive, so that the input voltage to the integrator I assumes the value of $-V_3$. Thus, the output voltage of the integrator I decreases along a dotted line SL_1. (See FIG. 5(*e*).)

In case E_a assumes a value intermediate between V_2 and V_3, then the corresponding line of decrease will be located between the dotted lines SL_1 and SL_2. Therefore, in actual cases, the output of the integrator I is so set as to be in the range between the dotted lines SL_1 and SL_2 by adjusting the slope of the characteristic of the first amplifier. By doing so, it is possible to prevent any sudden speed change. That is, the commanded speed is controlled in accordance with the actual elevator speed, thus making it possible to avoid any possibility of causing the passengers feel uncomfortable and achieve accurate floor-landing control. The slopes of the lines SL_1 and SL_2 can be changed by adjusting V_3 and V_2. The line SL_1 defines the minimum deceleration, and the line SL_2 defines the maximum deceleration.

With the arrangement of FIG. 4, it is possible to maintain the deceleration within the limits and sequential corrections are made with respect to it in the succeeding stages, even if the difference between the commanded speed E_s and the actual elevator speed E_{PG} becomes extraordinarily high ($E_s < E_{PG}$). In this way, it is possible to prevent any extreme increase in the deceleration.

What is claimed is:

1. A speed control system for elevators, comprising means for driving the elevator, speed pattern means for providing a voltage corresponding to a speed pattern irrespective of the elevator position during the accelerating operation and for reducing said voltage in a stepped manner in response to a position detecting means for providing a signal whenever the elevator arrives at any one of a plurality of preset deceleration points, comparator means having saturation characteristics in the positive and negative directions, integrator means connected to said comparator means for integrating the output of said comparator means and negatively feeding the integrated output back to the input of said comparator means the integrated output of said integrator means also being connected to said means for driving the elevator, correction means including a first amplifier for generating a correction signal in response to a detected difference between said commanded speed and the actual elevator speed and additionally for supplying said correction signal to said integrator means as an input during the decelerating operation to thereby control the output of said integrator means in accordance with the elevator speed, and changeover relay means for passing said voltage corresponding to the commanded speed from said speed pattern means to said comparator means during the accelerating operation and to said first amplifier during the decelerating operation.

2. A speed control system for elevators according to claim 1, wherein a clamping circuit for applying said correction signal to said integrator means when the difference between the commanded speed and the actual elevator speed exceeds a predetermined level is provided at the output of said first amplifier.

3. A speed control system for elevators according to claim 1, wherein said first amplifier represents a saturation characteristic, thereby limiting the maximum value of the output decreasing rate of said integrator means.

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