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FIG. 1

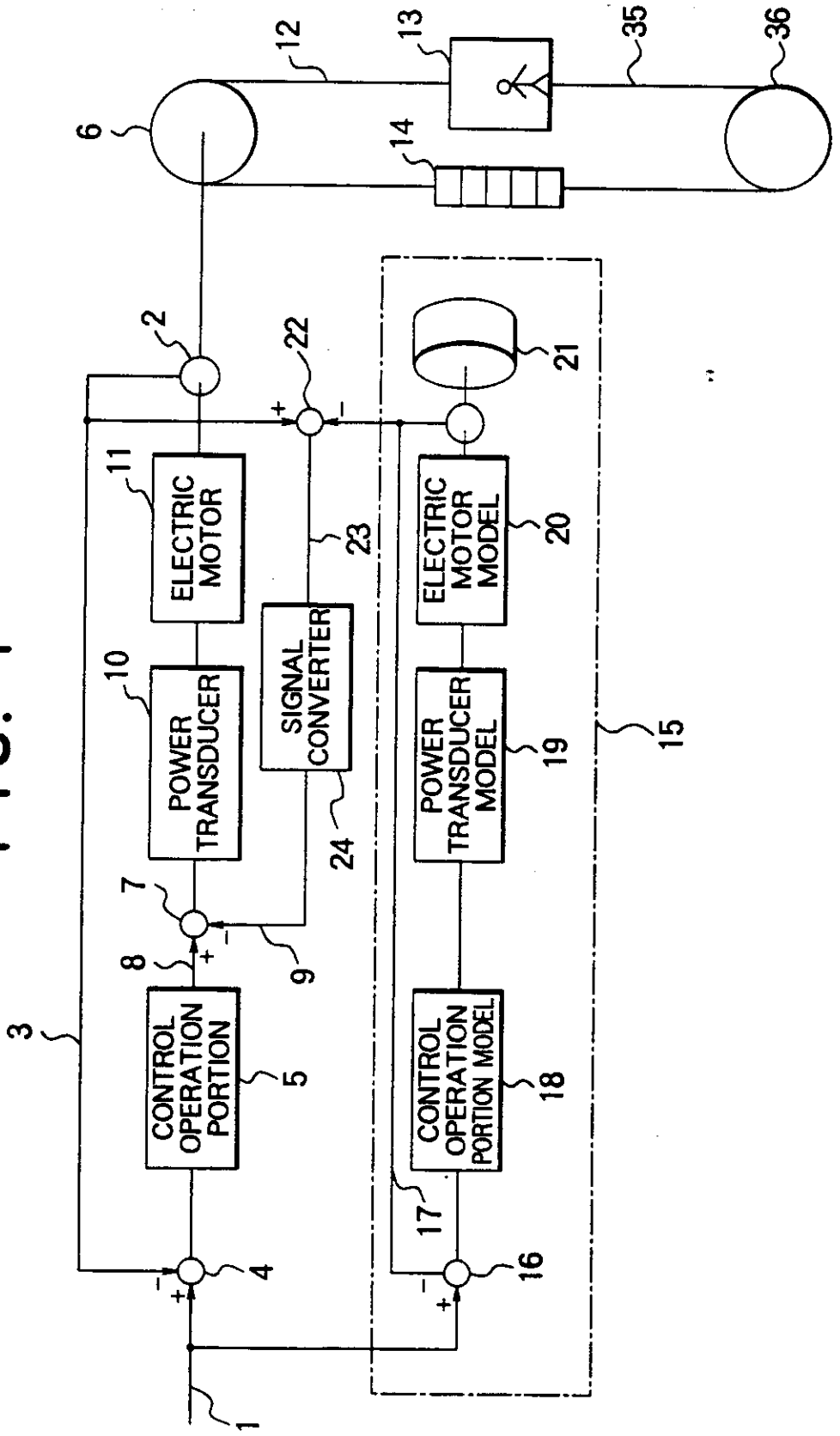

6
12
13
35
36
14
2
22
21
11
ELECTRIC MOTOR
23
ELECTRIC MOTOR MODEL
20
10
POWER TRANSDUCER
SIGNAL CONVERTER
POWER TRANSDUCER MODEL
19
15
7
8
9
24
3
CONTROL OPERATION PORTION
5
CONTROL OPERATION PORTION MODEL
18
17
16
4
1

FIG. 2

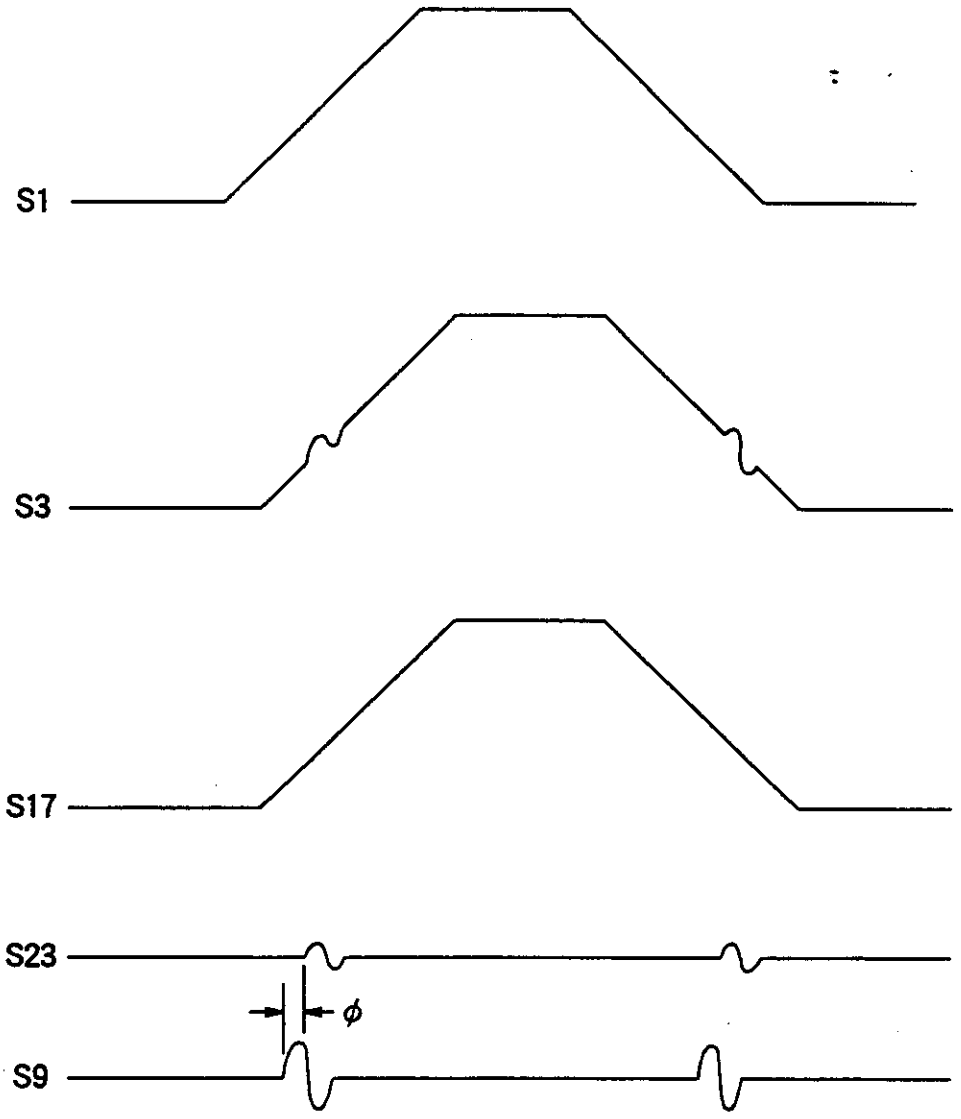


FIG. 3

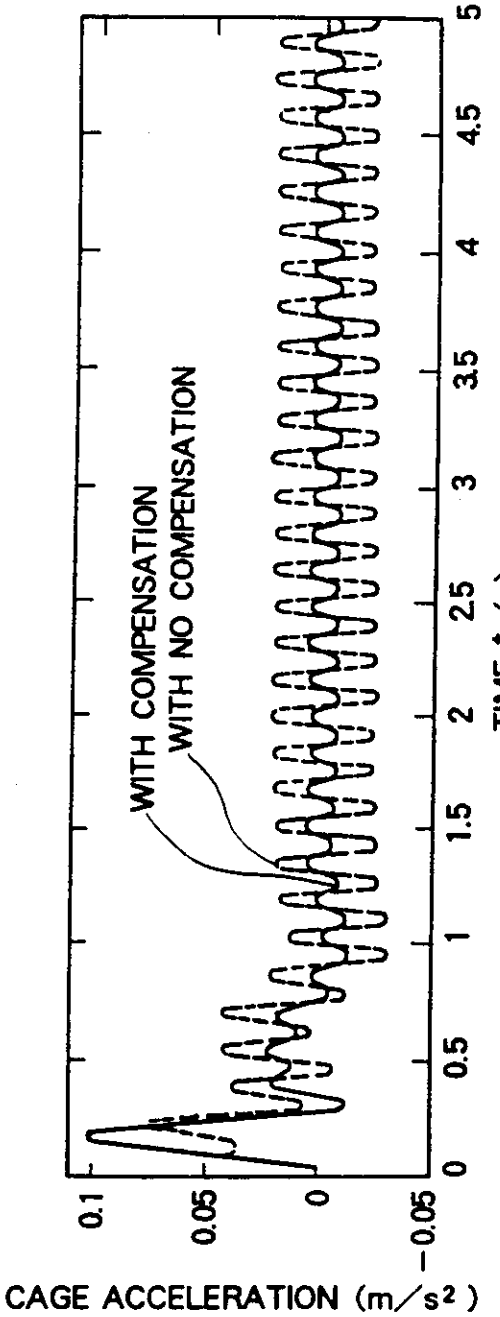

WITH COMPENSATION
WITH NO COMPENSATION
CAGE ACCELERATION (m/s²)
TIME t (s)
0.1
0.05
0
−0.05
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

FIG. 4

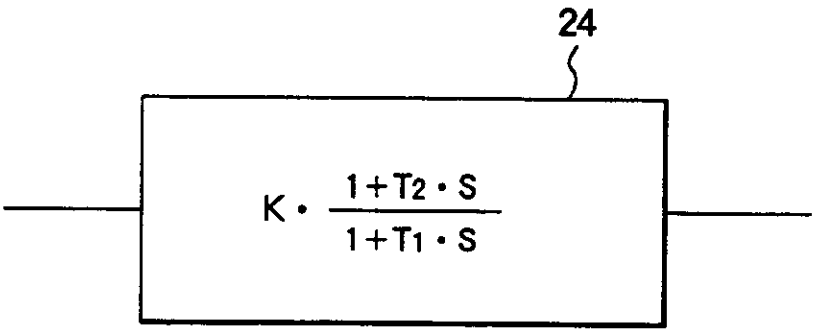


FIG. 5

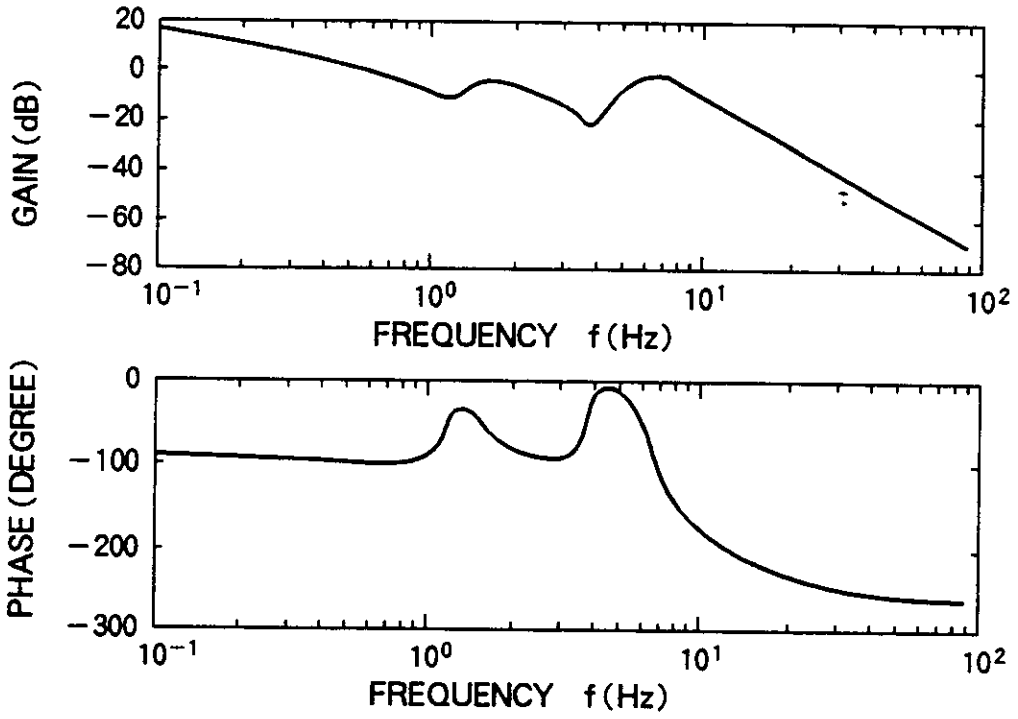

GAIN (dB)
20
0
−20
−40
−60
−80
10^{-1}
10^{0}
10^{1}
10^{2}
FREQUENCY f (Hz)
PHASE (DEGREE)
0
−100
−200
−300
10^{-1}
10^{0}
10^{1}
10^{2}
FREQUENCY f (Hz)

FIG. 6

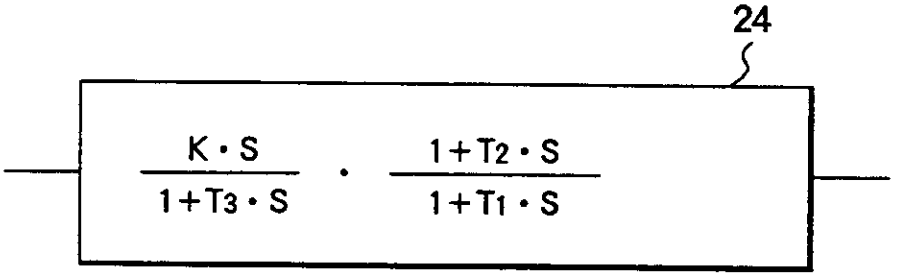

24
$\frac{K \cdot S}{1+T_3 \cdot S} \cdot \frac{1+T_2 \cdot S}{1+T_1 \cdot S}$

FIG. 7

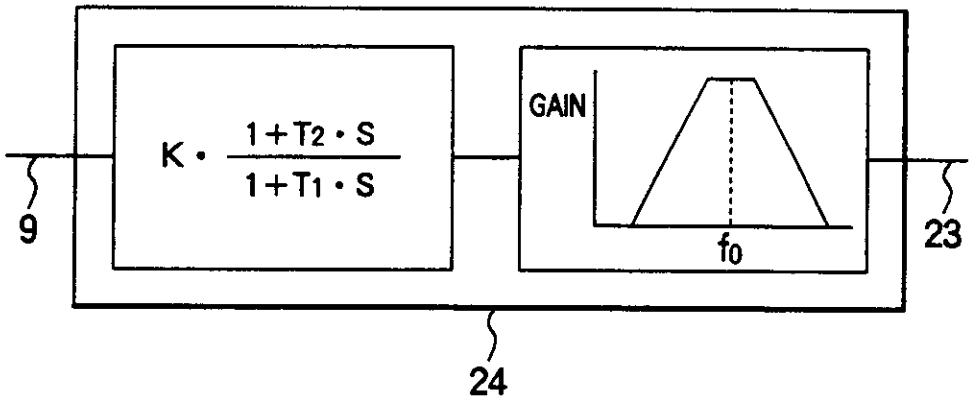
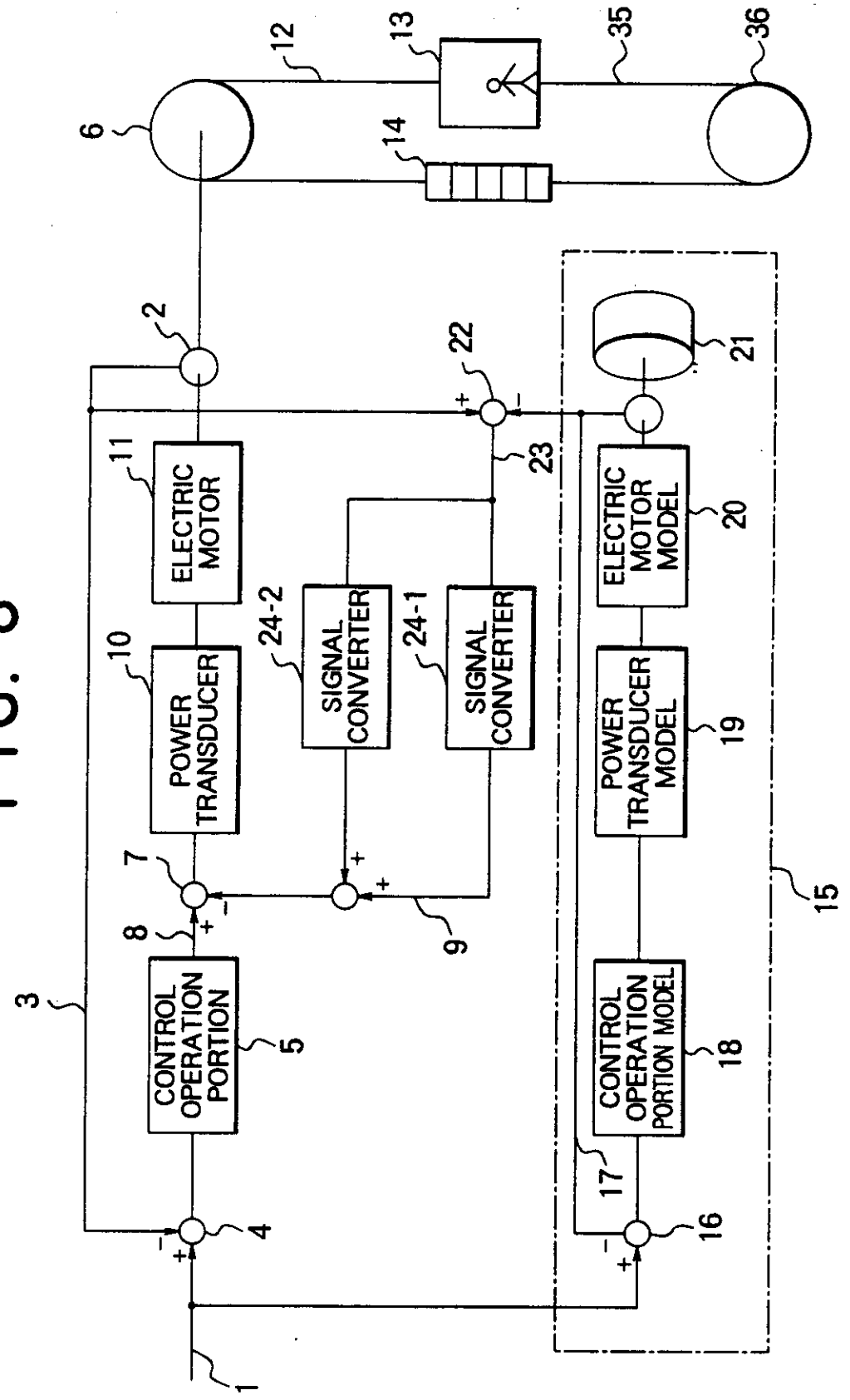


FIG. 8


6
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2
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21
11
ELECTRIC MOTOR
23
ELECTRIC MOTOR MODEL
20
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POWER TRANSDUCER
24-2
SIGNAL CONVERTER
24-1
SIGNAL CONVERTER
POWER TRANSDUCER MODEL
19
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CONTROL OPERATION PORTION
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CONTROL OPERATION PORTION MODEL
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17
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16
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FIG. 9

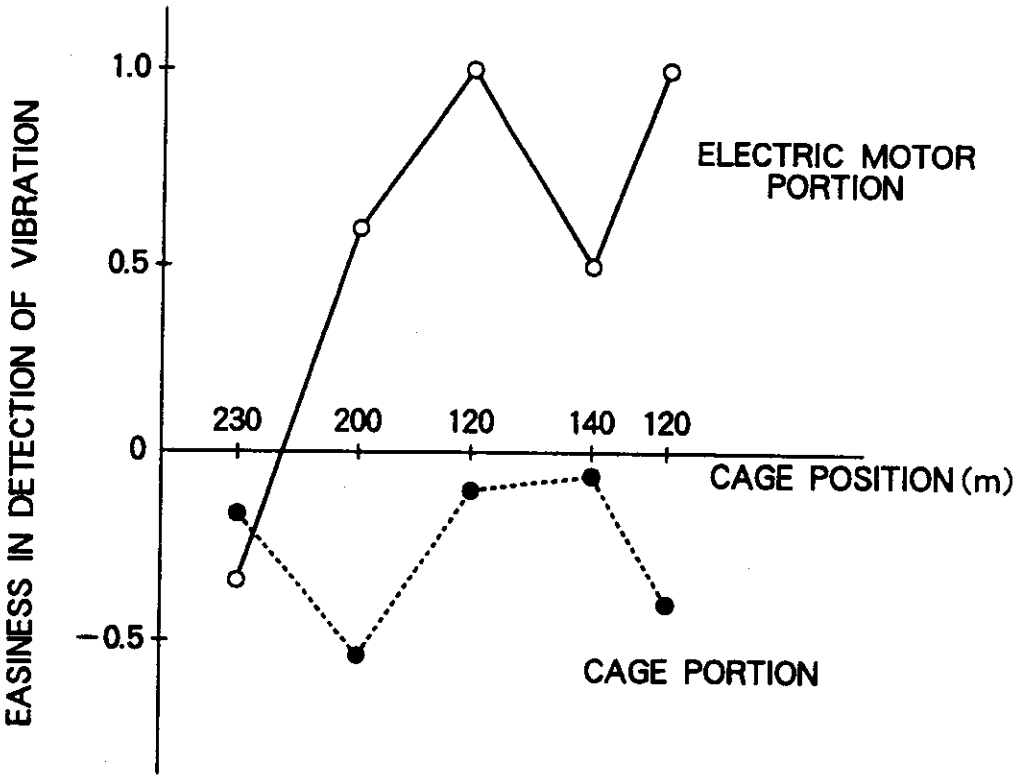
1.0
0.5
0
−0.5
EASINESS IN DETECTION OF VIBRATION
230
200
120
140
120
CAGE POSITION (m)
ELECTRIC MOTOR PORTION
CAGE PORTION

FIG. 10

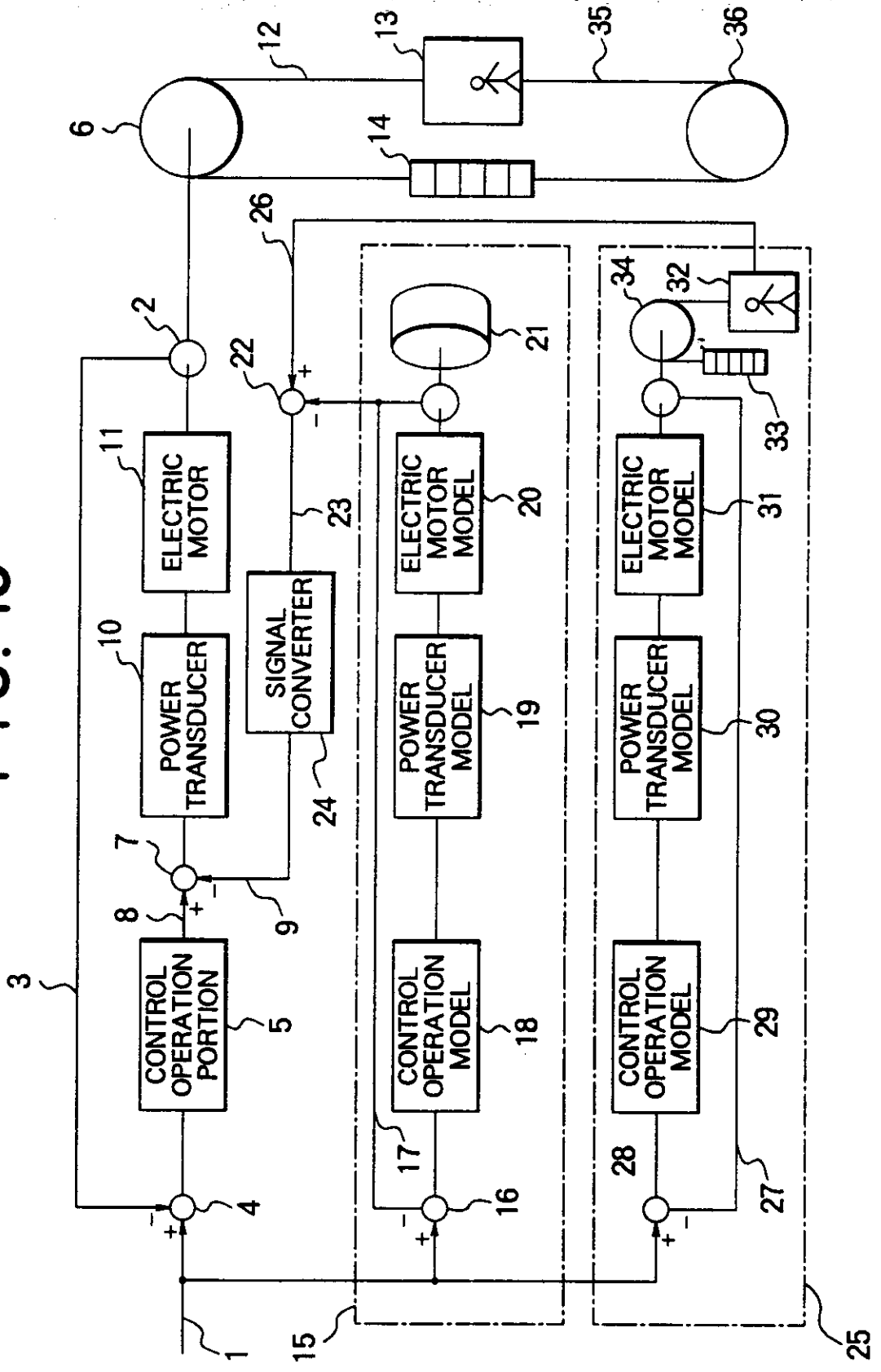
CONTROL OPERATION PORTION
ELECTRIC MOTOR
POWER TRANSDUCER
SIGNAL CONVERTER
CONTROL OPERATION MODEL
ELECTRIC MOTOR MODEL
POWER TRANSDUCER MODEL
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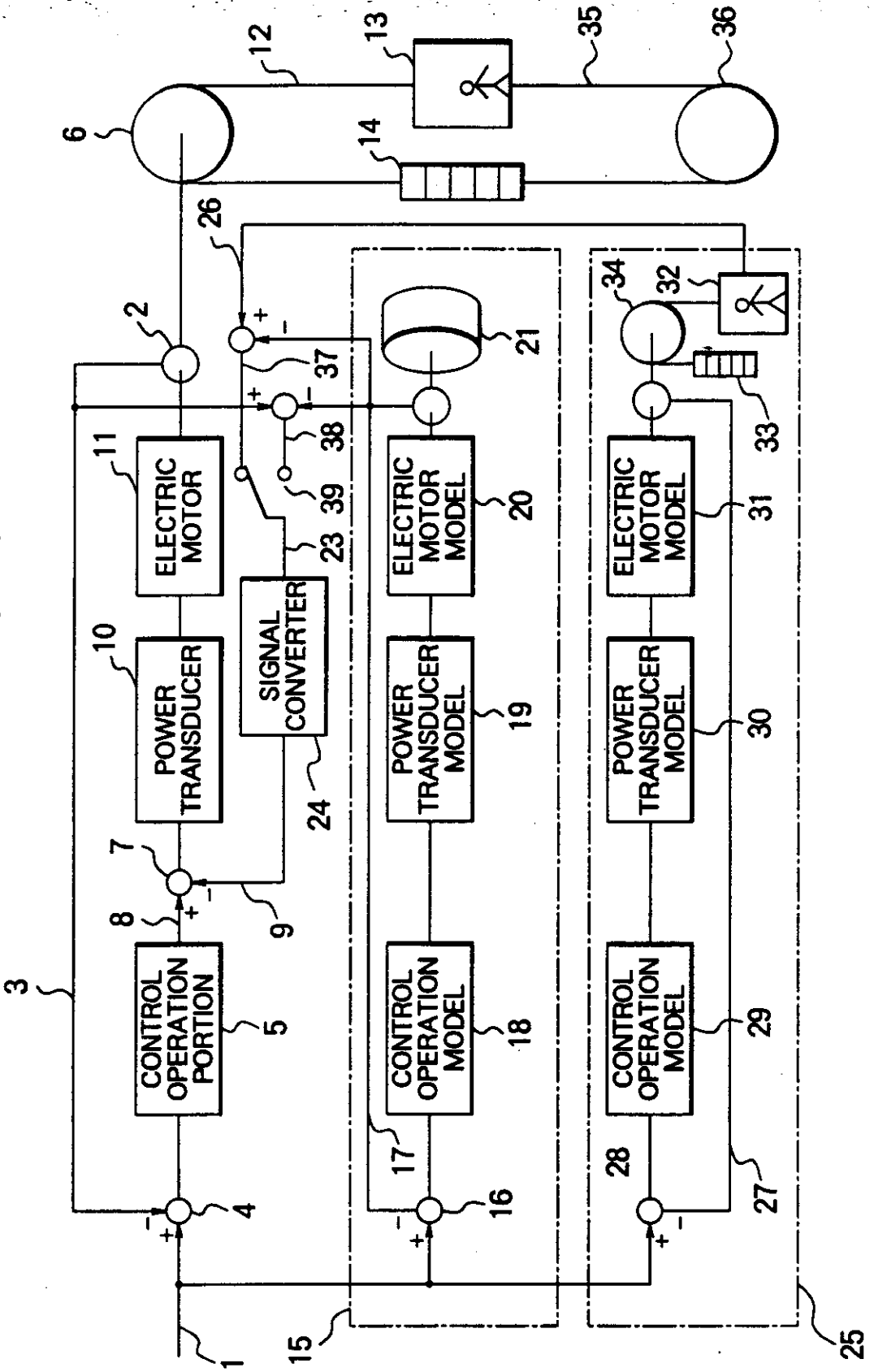
FIG. 11


ELECTRIC MOTOR
POWER TRANSDUCER
SIGNAL CONVERTER
CONTROL OPERATION PORTION
ELECTRIC MOTOR MODEL
POWER TRANSDUCER MODEL
CONTROL OPERATION MODEL
ELECTRIC MOTOR MODEL
POWER TRANSDUCER MODEL
CONTROL OPERATION MODEL
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ELEVATOR SYSTEM

The present invention relates to an elevator system, and particularly relates to an elevator system having a vibration suppressing device which can provide comfortable ride.

In JP-A No. 60-254201 (JP-B No. 3-30161, Japanese Patent Application No. 59-110264), there is disclosed a control system comprising an operation mechanism for operating an object to be controlled in accordance with an operation quantity instruction value, a detector for detecting a control quantity of the object to be controlled, and a control operation portion supplied with a control quantity detection value from the detector and the control quantity instruction value for outputting the operation quantity instruction value, wherein a signal of deviation of a control quantity detection value from an control quantity instruction value is supplied as an input, and a deviation of the control quantity from a control quantity estimation value obtained as a result of operation from an operation quantity instruction to a detection value through a model is added in an operation quantity instruction value portion to thereby improve the performance against disturbance. That is, there is such a proposal that the control operation portion outputs, as an operation quantity instruction value, a difference

(B-A) between a value A obtained from a control quantity detection value through a desired transfer function $G_x(s)$, and a value B obtained through a transfer function $\{G_x(s) \cdot G_{LH}(s)+1\}$ which is obtained by adding "1" to a transfer function $G_x(s) \cdot G_{LH}(s)$ which is a product between a transfer function $G_x(s)$ and a transfer function $G_{LH}(s)$ which simulates a transfer function $G_L(s)$ from the operation quantity instruction value to the control quantity detection value, at an output of a control amplifier which is supplied with a control quantity detection value and a control quantity instruction value, thereby improving disturbance response without changing instruction value response.

According to JP-A No. 52-43246, 61-203081, 61-27882, 62-211277, etc., there is such a proposal that a vibration component of an elevator cage is detected directly, and this component is fed back to a speed control device to thereby suppress the vibration of the cage.

However, according to the above-mentioned first prior art, since also a vibration disturbance component is already mixed into an operation instruction value which is an input signal to the model, a control quantity estimation value obtained as an operation result through the model contains a component of the value estimated upon the control quantity instruction and a component of the value estimated upon the disturbance component. Accordingly, the value obtained

as a difference signal to a control quantity detection value cannot be an instruction for eliminating disturbance in the control quantity detection portion. That is, even considering the case in which a control quantity estimation value and a control quantity detection value are ideally coincident in phase relationship with each other, a component causing a disturbance suppressing signal is expressed by (the control quantity estimation value - the control quantity detection value), which is a value different from that to be used as a disturbance suppressing signal, and gain correction or the like becomes therefore necessary. Further, if a control quantity estimation value and a control quantity detection value are not coincident with each other in phase relationship, signal components other than a reference signal relating to a disturbance component (components the phase and size of which change correspondingly to the phase difference, and so on) are mixed into a disturbance suppressing signal, so that it becomes difficult to effectuate the suppression of vibration strongly because of the production of other bad influences as well as the mixture. Further, for adjustment of the gain, phase, and so on, it is necessary to provide two adjusting portions, one where a control quantity estimation value and a control quantity detection value are made coincident with each other in phase relationship, and the other where a deviation signal between the control quantity estimation value and

the control quantity detection value is adjusted in gain, phase and so on. Accordingly, the adjustment is extremely difficult because of the correlation of these portions.

On the other hand, according to the above-mentioned second prior art, various devices have been provided for directly detecting a vibration component of an elevator cage so as to use this component as a signal for controlling the suppression of vibration, but there have been a lot of problems in practical use, for example, in the points how to ensure the reliability of an acceleration sensor itself, how to eliminate noises superimposed on a signal line wired up to a control device in a machine room located on the uppermost floor several hundred meters away from the sensor, and so on.

It is an object of the present invention to solve or at least mitigate the foregoing problems of the prior arts, and to provide an elevator system which can reduce uncomfortable vibration of a cage.

According to an aspect of the present invention, the elevator system comprising a cage, an elevator driving device for driving said cage, a speed instruction device, an elevator speed detection device, and a speed control loop for controlling said driving device in accordance with a deviation of a detection elevator speed from a speed instruction; further comprising an elevator model supplied with a speed instruction for outputting an estimation speed of said driving device when a mechanical system up to said cage is regarded as a perfect rigid body, so that a deviation signal of a detected speed of said driving device from an output of said model is supplied to said speed control loop.

A vibration suppressing signal may be derived from the elevator model supplied with an elevator

speed instruction, and the means for supplying the speed control loop with the output of this model, and so on. The vibration suppressing signal is used for speed control so that bad influences such as a noise mixture from the outside, are so reduced that the elevator speed control can be realized with lowered vertical vibration and without special cost-up. Moreover, the number of the phase and gain adjusting portions can be reduced to only one.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Fig. 1 is a diagram illustrating the whole structure of an elevator to which the present invention is applied,

Fig. 2 is a diagram for explaining the principle of the operation of the present invention,

Fig. 3 is a simulation result diagram showing the effect of the present invention,

Fig. 4 is a diagram illustrating a specific embodiment of the signal converter 24,

Fig. 5 is a diagram for explaining the principle of the operation of the present invention,

Fig. 6 is a diagram illustrating a specific embodiment of the signal converter 24,

Fig. 7 is a diagram illustrating a specific

embodiment of the signal converter 24,

Fig. 8 is a diagram illustrating another embodiment of the present invention,

Fig. 9 is a diagram for explaining the principle of the operation of the present invention.

Fig. 10 is a diagram illustrating another embodiment of the invention, and

Fig. 11 is a diagram illustrating another embodiment,

An embodiment of a vibration suppression control system of an elevator according to the present invention will be described in detail with reference to the drawings. Fig. 1 is a block diagram illustrating the whole arrangement of an elevator system to which the present invention is applied.

In Fig. 1, the reference numeral 1 represents a speed instruction; and 2, a speed detector for detecting the actual speed of an elevator system, preferably, a pulse encoder which is directly connected to a rotary shaft of an electric motor or which is friction-driven by a traction sheave 6 or a brake drum (not-shown) to thereby detect the speed of the electric motor. The reference numeral 3 represents a detection actual speed signal obtained by processing the output of the actual speed detector; 4, a comparator for obtaining the deviation between the speed instruction and the detection actual speed signal; 5, a control operation portion such as a proportional integrator or the like

for constructing a speed control system; 7, an adder for adding a vibration suppression instruction 9 to a torque instruction 8 which is the output of the control operation portion 5; 10, a power transducer such as an inverter, a converter or the like; 11, an electric motor such as an induction motor, a DC motor, or the like, for driving the elevator; 12, a main rope; 13, a cage; 14, a counter weight; 35, a compensation rope; 36, a compensation pulley; 15, an elevator rigid body model system including an inertia system in which a mechanical system including a cage, ropes, and so on, is regarded as a perfect rigid body, and an electric system including a driving system, a control system and so on; 16, a comparator model for obtaining the deviation between the speed instruction 1 and an estimation motor speed 17 obtained from the elevator rigid body model system including an inertia system in which a mechanical system including a cage, ropes, and so on, is regarded as a perfect rigid body; 18, a control operation portion model simulating the control operation portion 5; 19, a power transducer model simulating the power transducer 10; 20, an electric motor model simulating the motor 11; 21, an inertia system model in which a mechanical system including a cage, ropes, and so on, is regarded as a perfect rigid body; 22, a comparator for obtaining a speed ripple signal 23 which is the deviation between the detection actual speed signal 3 and the estimation speed 17 obtained from the elevator rigid body model

system 15; and 24, a signal converter supplied with this speed ripple signal 23 to thereby form the vibration suppressing signal 9.

In such a configuration, the principle of the operation will be described with reference to Fig. 2. In Fig. 2, the reference numeral S1 represents an example of the speed instruction 1; S3, an example of the detection actual speed signal 3; S17, an example of the estimation speed 17 obtained from the elevator rigid body model system 15; S23, an example of the deviation signal between the detection actual speed signal 3 and the estimation speed 17;, and S9, an example of the vibration suppressing signal 9 which is the output of the signal converter 24. Then, a ripple of speed accompanied with the vibration of a mechanical system during increasing/decreasing of the speed is superimposed on the detection actual speed S3, but a vibration component caused by the vibration of the mechanical system is not superimposed on the estimation speed S17 since the model is a rigid body. Therefore, according to the deviation signal S23 between S3 and S17, the vibration component of the mechanical system can be extracted as it is. Next, the signal S23 is passed through the signal converter 24 to compensate the factor of delay in the power transducer 10 or the electric motor 11, and to perform the adjustment of the phase ϕ or the adjustment of the gain as in the signal S9, and the signal S23 is supplied to the adder point 7

as a minor loop to thereby construct such a control system that the production of vibration is canceled at the point of the speed detector 2 by this instruction component.

Fig. 3 shows the effect of the present invention by an example of the result of simulation. As the conditions of simulation, the state where a driving motor produces not only a driving force but also a torque ripple when the driving of lifting up is performed in the case where the height of a building is 230m, the number of passengers in a cage is zero, the cage being running near the uppermost floor, is simulated and the acceleration of vertical vibration produced in the cage is calculated. Without performing any compensation process according to the present invention, the acceleration of vertical vibration of the cage is about $\pm 0.025 m/S^2$, while the acceleration of vertical vibration of the cage is about $\pm 0.007 m/S^2$ if the compensation process is performed, so that it is understood the acceleration of vertical vibration is improved into about 1/3. According to this system, if a vibration component in a mechanical system can be only detected in an elevator driving motor portion, the vibration component can be obtained as the speed ripple signal 23 as it is since there is no interference signal source or factor from the outside to the model, and further the production of a ripple in the electric motor portion can be suppressed since the signal converter 24

compensates the characteristic of delay from the adder 7 to the electric motor 11 properly, so that it is also possible to suppress the uncomfortable vertical vibration of the cage which is hung thereunder.

Further, according to the method using this elevator model system 15, since a signal to be estimated is an estimation signal 17 corresponding to a speed instruction, the frequency characteristic thereof can be said to be comparatively slow. There is therefore also an effect that as a microcomputer constructing the model, any expensive one having a high speed processing ability is not always required.

Fig. 4 shows a specific embodiment of the construction of the signal converter 24. In Fig. 4, taking into consideration the characteristic of delay in the elements from the adder 7 to the electric motor 11, a phase lead/lag adjustment element and a gain adjustment element are built in for properly suppressing the production of ripples in the electric motor portion. Fig. 5 shows an example of the frequency characteristic from the adder 7 to the electric motor 11, in which the characteristics (phase as well as gain) of the elevator system also changes in response to the change of the input vibration frequency. In the case of effectuating the technique of the present invention to the frequency band before and after 1.2Hz as an example of the primary vibration of a rope system, the phase lag from the adder point 7 to the production of speed is before and after

-35°, so that the injection of a ripple component of the speed can give enough effective suppression of vibration if the phase lead of about 35° is set in the signal converter 24 to compensate this 35° of phase lag. Further, if the condition changes as the position of the cage or the like changes, for example, under the condition in which vibration near 7Hz is apt to be produced as an example of the secondary vibration of the rope system, a plurality of resonance vibration phenomena changed and produced in accordance with the condition of driving can be suppressed effectively if the correction quantities of the phase and gain are made variable in accordance with the condition of driving, for example, the quantity of phase lead being made variable to about 100°.

In Fig. 6, a high pass-filter as well as the function of Fig. 4 is built in to suppress low frequency ripples produced by the decrease of the stationary gain of a control system, so that a bad influence caused by feeding back a deviation signal with a minor loop can be excluded to provide another effect that a good transient response can be obtained while a usual vibration suppression effect is ensured.

There is also another effect that adjustment can be performed easily since it goes well if the phase, gain and so on are adjusted only in the signal converter 24 as mentioned above in order to make up a vibration suppressing signal 9.

As for another embodiment, more preferably as shown in Fig. 7, a band-pass filter is provided in the signal converter 24 in order to cut off components other than a frequency band f_0 which is a target of vibration suppression, so that the operation of a main route for injecting a ripple signal can be made invalid to frequency bands other than the frequency which is a target of vibration suppression to thereby make it possible to nearly eliminate a bad influence of the main route to the other frequency bands.

Further, in the case where there are a plurality of mechanical system resonance frequencies aimed on vibration suppression, if a plurality of signal converters 24-1 and 24-2 and signal injection routes effective to the respective frequency bands are provided as shown in Fig. 8, and if suppression control sharing the frequency bands is performed, there is another effect that it is possible to realize comfortable riding which is always stable against vibrations of various frequencies caused by a plurality of inertia systems such as an elevator.

Further preferably, if band-pass filters which allow different target frequency vibration suppressing signals to pass are built in the signal converters 24-1 and 24-2 for the frequency sharing control, it is possible to prevent a bad influence to other frequency bands through the plurality of signal injection routes.

Although the elevator rigid body model system

15 and the signal converter 24 are illustrated in Fig. 1 as if they are provided separately from a usual speed control system, if they are constituted by a software in a microcomputer for elevator control in the same manner as the comparators 22 and 4, the control operation portion 5, and so on, it is possible to construct a control system which is strong against noises or the like. Of course, even if they are constructed by analog circuits or the like independently of a control operation portion such as a proportional integrator and so on constituting a speed control system, there is no fear that the effect of vibration suppression of the present invention is lost, and in this case, there is no limit on the speed of processing which usually comes into problem in the case of a software, resulting in another effect that the frequency of vibration aimed on vibration suppression can be expanded up to a high frequency area.

Further, in order to detect a deviation signal between a model and the actual speed in Fig. 1, the actual speed of an elevator system is detected by a speed detector friction-driven on the shaft end of an electric motor or on the circumference of a traction sheave. Accordingly, the actual speed can be used in common with an actual speed signal used for essential speed control, so that the signal fetching to a control circuit, or a signal line is short enough to reduce the possibility of noise mixture, resulting in an effect to

make it possible to construct a system having a high reliability suitable to an elevator.

Further, if the actual speed of a cage is used as an actual speed to be used for calculating a deviation signal from the estimation speed 17 obtained from the model system 15, indeed the system may be slightly weakened in noises from the point of view of wiring a long signal line up to a machine room, but the vibration suppressing component of the cage can be detected all over the area of an elevator passageway as shown in Fig. 9 differently from the case of detection in an electric motor portion, so that the effect to suppress the vibration of the cage can be expected all over the area of the elevator passageway. This is because there is a difference in easiness in detection of a vibration component with respect to the position of the cage between the case of indirect detection in the electric motor portion and the case of direct detection in the cage portion as shown in detail in Fig. 9, and because in the case of the detection in the electric motor portion there is an area in which the vibration component can be hardly detected in the vicinity of 220m, as is apparent from the result of calculation.

Therefore, if a signal detected in the electric motor portion and having high resistance against noises is used normally while a signal detected in the cage portion is switchably selectively used in an area, for example in the vicinity of 220m, where

vibration is hardly detected in the electric motor portion, there is another effect that it is possible to construct a totally high reliable system suitable to an elevator. In Fig. 9, the result of calculation is omitted with respect to the floors lower than the midst one.

Further, from the point of view of the change of gain, the gain K in Figs. 4 and 6 is made variable in accordance with the position of a cage or the quantity of passengers (not-shown) in order to operate a vibration suppression control system stably since the easiness in detection of vibration, that is, the gain of detection changes in accordance with the position of the cage or the quantity of passengers as well as the frequency characteristic from the adder 7 to the electric motor 11 shown in Fig. 5, as is apparent from Fig. 9. In this manner, vibration suppression can be controlled stably independently of the operation condition of the elevator, so that it is possible to obtain comfortable riding. Specifically, if the values of K with respect to various positions of the cage or various quantities of passengers are described in a table in advance, and if this table is searched on the basis of the position of the cage or the quantity of passengers, it is possible to complete the processing in a short time, and it is possible to expand the area in which vibration suppression can be controlled. Further, if the value of K is calculated each occasion, there is

another effect that the memory for the table can be omitted though it takes somewhat long time for calculation.

Further, the inertia system model 21 of the elevator rigid body model system 15 in Fig. 1 may change its inertia component in accordance with the position of the cage or the quantity of passengers. This change produces a non-vibration component error of speed between the estimation speed 17 and the detection actual speed 3, and mixes an unnecessary component like a bias component into the ripple signal 23 of speed. Therefore, according to the present invention, the inertia component of the inertia system model 21 of the elevator rigid body model system 15 is made to change in accordance with the position of the cage or the quantity of passengers. Consequently there is another effect to realize a stable vibration suppression without respect to the driving condition of an elevator.

Further, according to the embodiment of Fig. 1, it goes well if the elevator rigid body model system 15 estimates only a component including no vibration component or the like of the speed produced by a speed instruction, that is, only a component corresponding to a so-called fundamental wave component, so that a strict simulation is not always required on the model. Therefore, the power transducer model 19 and the electric motor model 20 are not made up in detail, but approximated to an extent of first order delay. As a result,

it is possible not only to economize the memory space required for the models, but also to simplify their operations, so that there is an industrial effect to make it possible to use an inexpensive microcomputer.

Further, if the interval to detect a detection actual speed for the operation of deviation from the estimation speed 17 is made shorter than the interval to detect a value for use in the comparator 4, the vibration suppressing signal 9 can be supplied to a control system at a short interval, and the frequency band on vibration suppression can be expanded on the high frequency side, so that there is an effect to expand the effect of vibration suppression against higher frequency vibration.

Fig. 10 shows another embodiment of the present invention. Elements from a speed instruction 1 to a signal converter 24 are the same as those in Fig. 1. In this embodiment, an elevator higher order model system 25 including an element simulating an elevator mechanical system is also provided in addition to the elevator rigid body model system 15. This elevator higher order model system 25 is constituted by a comparator model 28 for comparing an estimation speed 27 in the electric motor portion with the speed instruction 1, a control operation model 29, a power transducer model 30, an electric motor model 31, a cage model 32, a counter weight model 33 and a traction sheave model 34. Further, a speed ripple signal 23 is obtained not by the

difference between an estimation speed 17 by use of the rigid body model and a detection actual speed 3, but by the difference between the estimation speed 17 by use of the rigid body model and an estimation speed 26 of a cage in the elevator higher order model system 25. This speed ripple signal 23 is fed to a signal converter 24 to make up a ripple suppressing signal 9 which is supplied to an adder 7 to thereby perform vibration suppression. Then, since the estimation speed 26 of the cage in the elevator higher order model system 25 is used to extract a speed ripple signal, there is no area in which a ripple component cannot be detected in a certain position of the cage as in the case of the detection in the electric motor portion, so that a stable effect to suppress vibration can be expected independently of the position of the cage.

Further, in this embodiment, the actual speed of the cage is directly detected as a speed signal on which a ripple is superimposed, and the estimation speed 26 of the cage producible in a control board in a machine room is used without leading a signal into the control board, so that there is no fear that any noise component is mixed into the speed signal from the outside in signal transfer, and not only there is an effect that it is possible to construct a cage vibration suppressing system having a high reliability, but also there is an industrial effect that a special hardware such as a speed sensor or an acceleration sensor for

detecting the speed or acceleration of the cage, or the like becomes unnecessary.

In the embodiment of Fig. 10, the mechanical system of the higher order model system 25 is constituted by three masses of the cage model 32, the counter weight model 33 and the traction sheave model 34. This is designed to simplify the compensation rope system of an actual mechanical system, so that it is indeed impossible to observe all the vibration phenomena of mechanical system resonance frequencies in the actual mechanical system, but it is possible to estimate at least primary and secondary resonances of the rope system, so that it can be said that it is possible to obtain an enough effect to suppress these vibrations which become particular problems on the comfortable riding. Further, as a result of simplifying the structure in this simple model, the operation in a microcomputer to estimate the vibration of the cage can be completed in a short time, so that there is also an industrial effect to estimate the vibration phenomenon of the cage without providing any expensive microcomputer for the operation.

Further, if the mass system of the mechanical system in the higher order model system 25 is simplified to have only the cage, indeed an estimatable resonance frequency on the mechanical system is limited to only the primary vibration of the rope system, but the time to operate can be made shorter, so that there is also an

effect to enable the microcomputer to share other works such as another elevator system processing.

If the inertia of the inertia system model 21 in the elevator rigid body model system is made variable in response to the present number of passengers in the elevator cage, or if the spring constant or damping coefficient which changes correspondingly to the rope length, and the weight of the cage which changes correspondingly to the number of passengers in the cage are finely changed in the mechanical system in the higher order model system 25 in accordance with the conditions (the position of the cage or the number of passengers) of the actual machine, it is possible to improve the accuracy of the estimation speed 17 obtained from the elevator rigid body model system 15 or the estimation value 26 of the cage speed, and it is thereby possible to make up an accurate ripple suppressing signal 9 to make it possible to improve the effect to suppress the vibration of the cage.

A check is made in the inside of the signal converter 24 as to whether the output thereof, that is a signal corresponding to the vibration suppression instruction 9, comes, or not, out of the size or frequency estimated in advance as a usual elevator system, and, if so, a limit is set in its output, or the output itself is prevented, or an alarm is generated. Then, there is an effect to realize two important things for an elevator system, that is, to ensure safety, as well

as to attain the essential object to improve the comfortable riding.

Further, in the elevator rigid body model system 15 and the elevator higher order model system 25 in Fig. 10, the interval to calculate the estimation speeds 17 and 27 for making up the speed ripple signal 23 is made shorter than the interval to detect the detection actual speed 3 in order to feed the ripple suppressing signal 9 back to the speed control loop in minor, so that it is possible to realize a rapid response, and it is possible to obtain an enough effect to suppress vibration.

In order to actuate the function of vibration suppression, it is effective to provide the function to compensate the frequency characteristic from the adder 7 to the electric motor 11 in the signal converter 24 in Fig. 10 for the ripple suppressing signal 9 which variously in accordance with the operation condition of the elevator in the same manner as shown in Fig. 1. However, a slight time lag is produced in calculating the estimation speed 26 since the speed including a ripple component is not directly detected but is estimated in the higher order model system in the case of the embodiment of Fig. 10. The phase shift due to such a time lag is compensated together in the signal converter 24 in this embodiment. Consequently, the structure of Fig. 10 can give an enough effect to suppress vibration.

Further, if the power transducer model 30 and the electric motor model 31 in the higher order model system 25 are also simplified by first order delay or the like, the effect to shorten the operation time is made obvious by the effect of cooperation with the simplification in the elevator rigid body model system 15. Consequently, it is possible to conduct two model operations in parallel by use of an inexpensive microcomputer, and it is possible to realize the suppression of vibration by a practical hardware structure.

With a band-pass filter provided in the signal converter 24, the operation of suppressing vibration in frequency bands other than a specially tuned frequency can be suppressed in such a structure that the higher order model system 25 is not always made a strict model or is difficult to be a strict model. This gives an effect from the point of view to ensure the reliability of an elevator system.

Fig. 11 shows another embodiment of the present invention. Elements from a speed instruction 1 to a compensation pulley 36 are the same as those in Fig. 10. In this embodiment, an elevator higher order model system 25 including elements simulating an elevator mechanical system is provided in addition to an elevator rigid body model system 15, and a ripple signal 38 which is the difference between a detection actual speed 3 and an estimation speed 17 obtained from the

rigid body model system 15, and a ripple signal 37 which is the difference between an estimation speed 26 obtained from the higher order model system 25 and the estimation speed 17 obtained from the rigid body model system 15 are obtained as speed ripple signals, both the ripple signals being switched by a switch 39 to obtain a speed ripple signal 23 which is supplied to an adder point 7 through a signal converter 24.

Here, for example, consider the case of the cage being near 220m in the graph illustrated in Fig. 9. At this time, the system turns the switch 39 to the ripple signal 37 which acts as the speed ripple signal 23. The switch is turned onto the ripple signal 38 side in the case of the cage being at any other position. If a ripple signal source is switched in accordance with the position of the cage in such a manner, it is possible to avoid being unable to detect a ripple component at a certain position of the cage (if vibration is produced in the cage near 220m, it is difficult to detect the state through the ripple signal 38), and it is also possible to use a signal having reliability as high as possible. Accordingly, it is possible both to realize the comfortable riding and to ensure reliability in an elevator system which is required to have particularly high reliability.

As has been described in the foregoing embodiment, there is a frequency characteristic from the adder 7 to the electric motor 11 with respect to a

ripple frequency. Further, there is a change of gain because of controlling two ripple signals by switching in this embodiment. Accordingly, a function to adjust the phase and gain is provided in the signal converter 24 to thereby provide stable control to suppress vibration.

Further, sine the ripple signals are used alternatively in the embodiment of Fig. 11, it is not always necessary to perform operation of both the signals in parallel at the same time. Therefore, for example, only a signal to be used as a ripple signal is calculated in feed-forward in accordance with the position of the cage. Consequently, it is possible to omit an unnecessary operation processing, so that there is an effect to use an inexpensive microcomputer if the load on a processing unit is reduced.

As has been described, according to the present invention, it is difficult to suffer a bad influence such as noise mixture from the outside, and it is possible to control the phenomenon of vibration of a cage while avoiding a special additional device causing cost up. Accordingly, it is possible to reduce an uncomfortable vertical vibration of the cage caused by a rope system. Further, it is possible to simplify the adjustment of the gain, phase and so on of a vibration suppressing signal.

CLAIMS

1. An elevator system comprising a cage, an elevator driving device for driving said cage, a speed instruction device, an elevator speed detection device, and a speed control loop for controlling said driving device in accordance with a deviation of a detection elevator speed from a speed instruction; further comprising an elevator model supplied with a speed instruction for outputting an estimation speed of said driving device when a mechanical system up to said cage is regarded as a perfect rigid body, so that a deviation signal of a detected speed of said driving device from an output of said model is supplied to said speed control loop.

2. An elevator system according to Claim 1, wherein said detected speed for obtaining said deviation signal is a motor speed of said elevator driving device.

3. An elevator system according to Claim 1, wherein said detected speed for obtaining said deviation signal is a cage speed of said elevator.

4. An elevator system according to any one of the preceding claims, further comprising varying means for varying an input signal to said speed control loop in accordance with a running condition of said elevator.

5. An elevator system according to Claim 4, wherein said running condition of said elevator is a position of said cage or a quantity of passengers.

6. An elevator system according to claim 4 or claim 5, wherein said varying means includes means for controlling

the gain of said deviation signal.

7. An elevator system according to any one of claims 4 to 6, wherein said varying means includes means for controlling a value of phase of said deviation signal.

8. An elevator system according to any one of the preceding claims, wherein constants of said elevator model are variable in accordance with a quantity of passengers in said cage.

9. An elevator system according to any preceding claim, wherein the interval of speed detection of said driving device used for use for calculating said deviation is shorter than the interval of speed detection of said speed control loop.

10. An elevator system according to any preceding claim wherein the motor speed of said elevator driving device and the speed of said cage are switched so that one of them is selectively used as the detected speed of said driving device in accordance with the running condition of said elevator.

11. An elevator system according to claim 10, wherein said detected speed of said driving device is selectively switched in accordance with the position of said cage.

12. An elevator system according to any one of the preceding claims, wherein said elevator model includes means for approximating a power converter portion and an electric motor portion of said driving device with a first order delay.

13. An elevator system according to any preceding claim,

wherein supply of said deviation signal into said speed control loop is restricted when said deviation signal is not smaller than a predetermined value.

14. An elevator system according to any preceding claim, wherein said deviation signal is supplied to said speed control loop through a high-pass filter.

15. An elevator system according to any preceding claim, wherein said deviation signal is supplied to said speed control loop through a band-pass filter.

16. An elevator system according to any preceding claim, wherein said deviation signal is supplied to said speed control loop through a plurality of routes.

17. An elevator system according to Claim 16, wherein said input routes include filters for passing only a plurality of special frequency components different from each other.

18. An elevator system according to any preceding claim, wherein said elevator rigid body model system is constructed by a software of a compensation rope, a microcomputer.

19. An elevator system comprising a main rope, a compensation rope, two sheaves, a cage, a counterweight, an elevator driving device for driving said cage, a speed instruction device, an elevator speed detection device, and a speed control loop for controlling said driving device in accordance with a deviation of a detected elevator speed from a speed instruction; further comprising a first elevator model supplied with said

speed instruction for outputting an estimation speed of said driving device when a mechanical system including said cage, counterweight, sheaves and ropes is regarded as a perfect rigid body, a second elevator model supplied with said speed instruction and including an elevator mechanical system for outputting an estimation speed of said cage, and means for supplying a compensation input to said speed control loop in accordance with the outputs of said first and second models.

20. An elevator system according to Claim 19, wherein said second elevator model includes a mechanical system model constituted by three masses of a cage, a driving device and a counter weight, and a spring system of a main rope.

21. An elevator system according to Claim 19, wherein said second elevator model includes a mechanical system model constituted by a signal mass of a cage, and a spring system of a main rope between said cage and a driving device.

22. An elevator system according to any one of claims 19 to 21, wherein a deviation signal between the outputs of said first and second models is supplied to said speed control loop, and said system further comprising varying means for varying said deviation signal in accordance with a running condition of said elevator.

23. An elevator system according to Claim 22, wherein said running condition of said elevator is a position of said cage or a quantity of passengers.

24. An elevator system according to claim 22 or claim 23, wherein said varying means includes means for controlling the gain of said deviation signal.

25. An elevator system according to any one of claims 22 to 24, wherein said varying means controls a value of phase of said deviation signal.

26. An elevator system according to any one of claims 22 to 25, wherein constants of said first or second elevator model are variable in accordance with a position of said cage or a quantity of passengers in said cage.

27. An elevator system according to any one of claims 22 to 26, wherein the interval of estimation speed detection of said driving device for use for calculating said deviation is shorter than the interval of speed detection of said speed control loop.

28. An elevator system according to any one of claims 22 to 27, wherein supply of said deviation signal into said speed control loop is restricted or prevented when said deviation signal is not smaller than a predetermined value or includes a frequency component other than predetermined ones.

29. An elevator system comprising a cage, an elevator driving device for driving said cage, a speed instruction device, an elevator speed detection device, and a speed control loop for controlling said driving device in accordance with a deviation of a detected elevator speed from a speed instruction; further comprising a first elevator model supplied with said speed instruction for

outputting an estimation speed of said driving device when a mechanical system including said cage is regarded as a perfect rigid body, a second elevator model supplied with said speed instruction and including an elevator mechanical system for outputting an estimation speed of said cage, and means for supplying said speed loop with either one of a first deviation signal between the output of said first model and the output of said second model and a second deviation signal between the output of said first model and said detected speed.

30. An elevator system according to Claim 29, further comprising a means for switchably inputting selected one of said first and second deviation signals in accordance with the position of said cage.

31. An elevator system according to any one of Claims 19 to 30, wherein said first or second elevator model includes means for approximating a power converter portion and an electric motor portion of said driving device with a first order delay.

32. An elevator system according to any one of Claims 29 to 31, further comprising means for preventing said deviation signal from being supplied to said speed control loop when said deviation signal is not smaller than a predetermined value.

33. An elevator system as herein described with reference to the accompanying illustrative drawings.

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