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B66B 7/02

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B8L LCB L24

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Online databases: WPI

(54) **Elevator system and method of control thereof**

(57) An elevator system in which a guide apparatus is reduced in size and controlled in simple manner at a saving of power consumption, without adversely affecting the passenger cage guide function even at the time of power failure, achieved by installing in the passenger cage a contact-type guide unit (12) for guiding the passenger cage in contact with at least a guide rail (14) and reducing the lateral vibration transmitted to the passenger cage and a non-contact type guide unit (13) for reducing the offset load acting on the contact-type guide unit (12). The contact guides (15a-c) comprise adjustable spring pressed rollers and the non contact guides are electromagnets or magnets (23-25).

FIG. 5

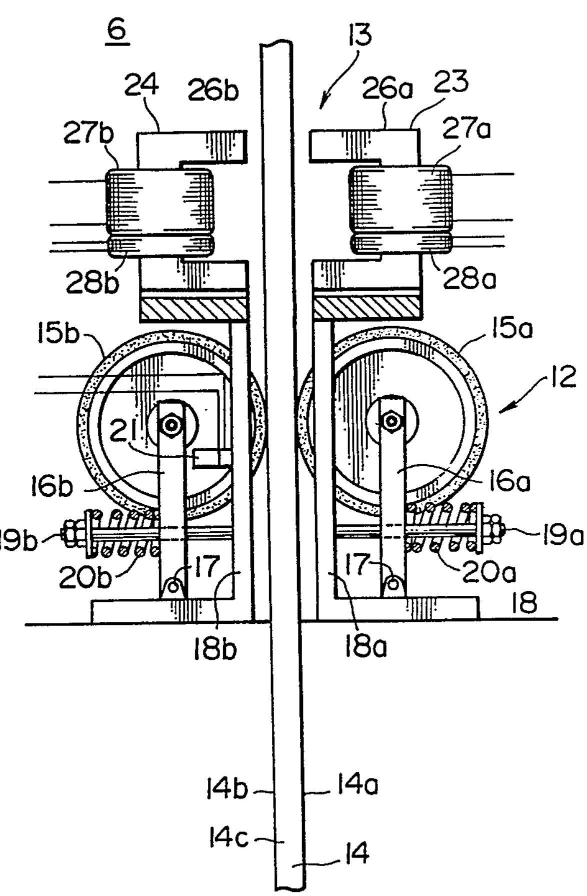

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FIG. 1

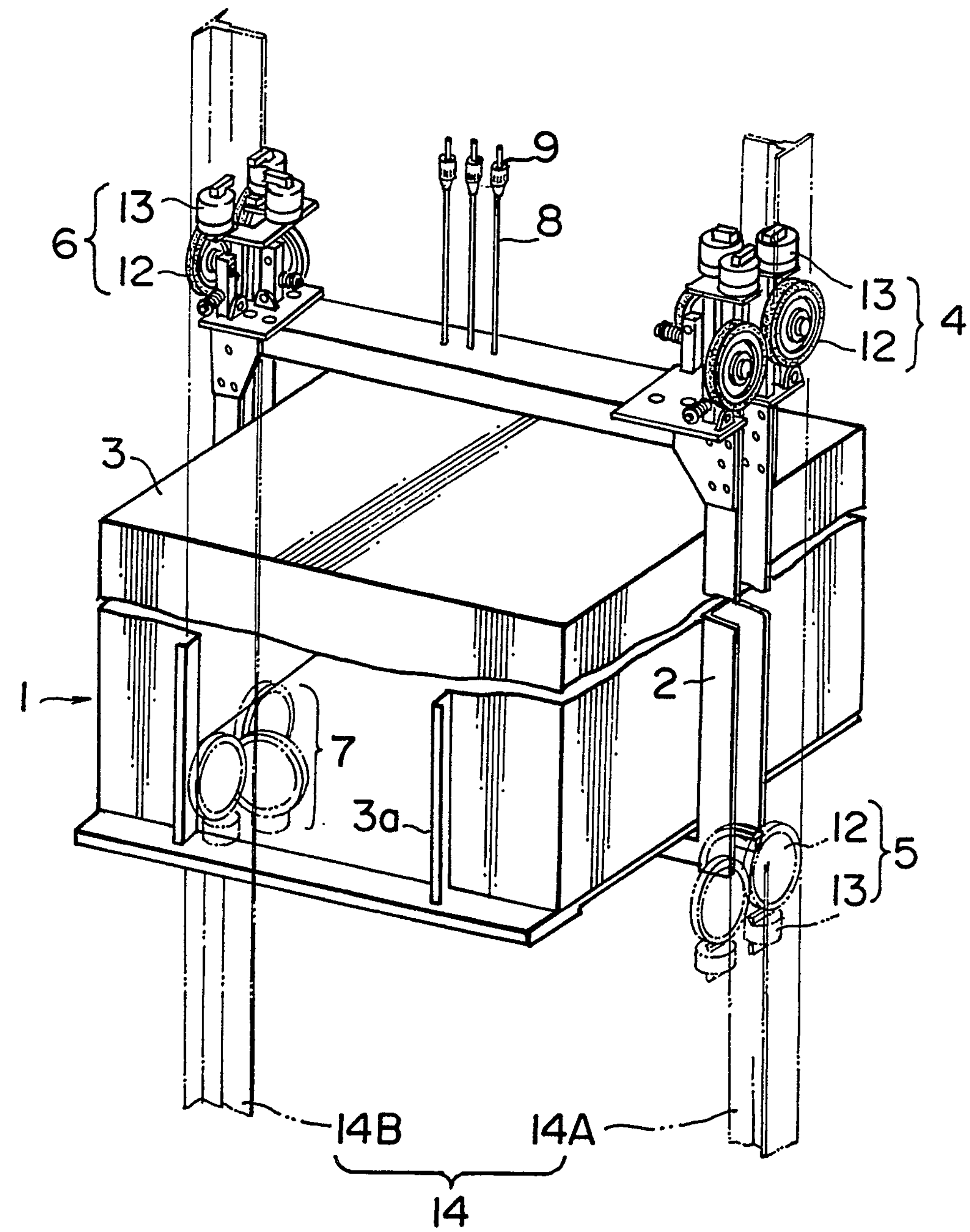

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FIG. 2

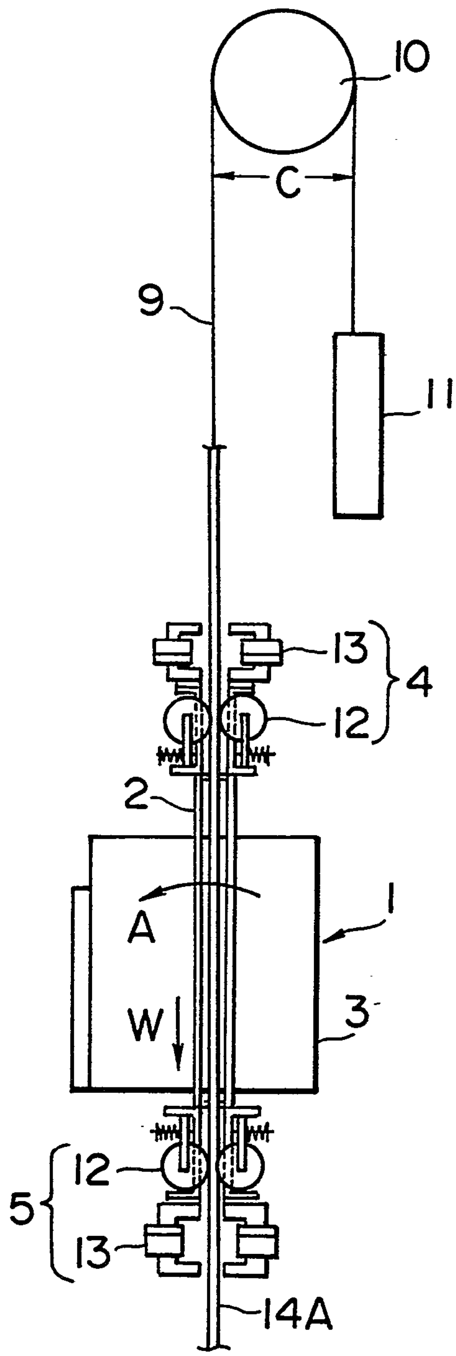
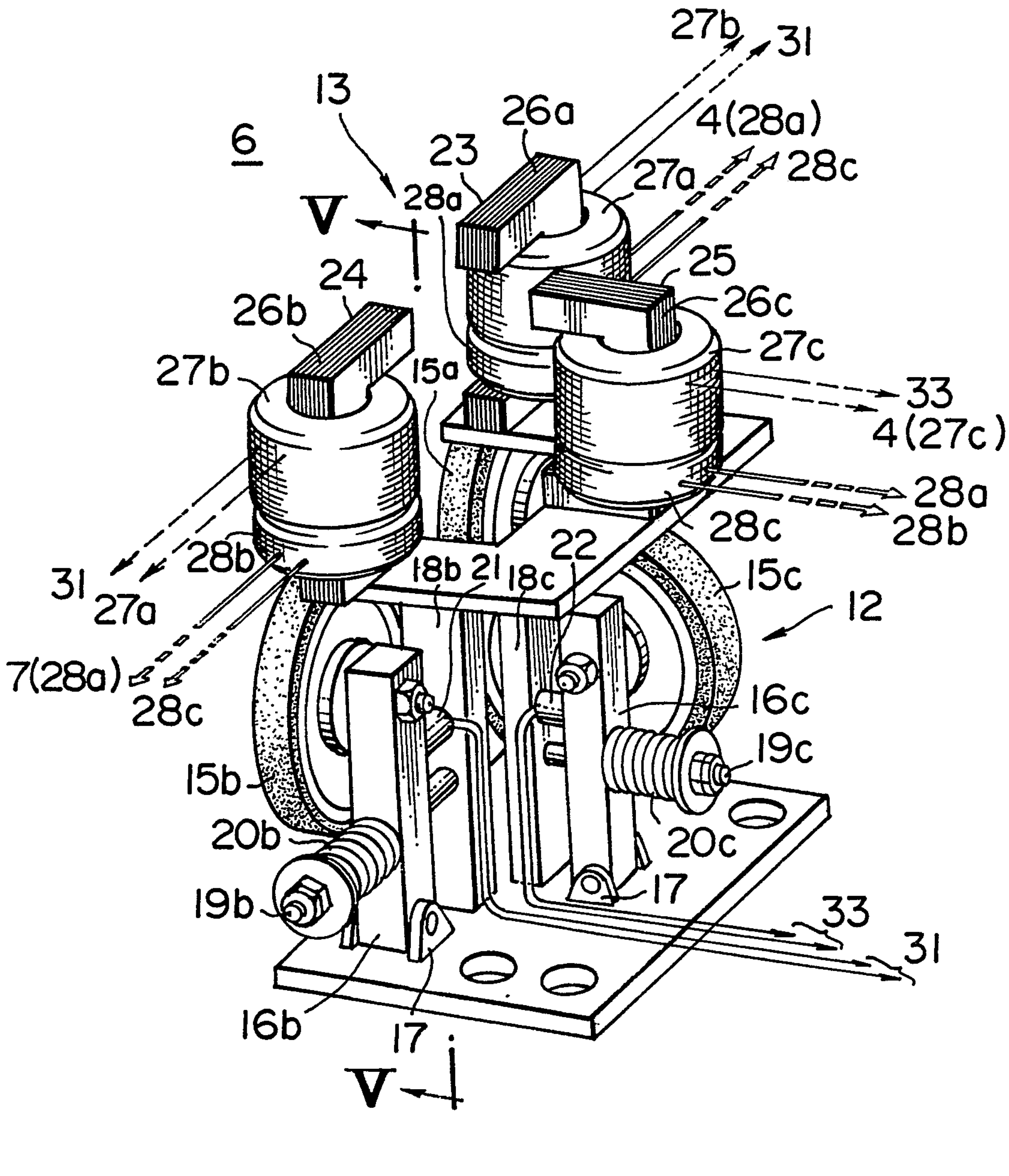
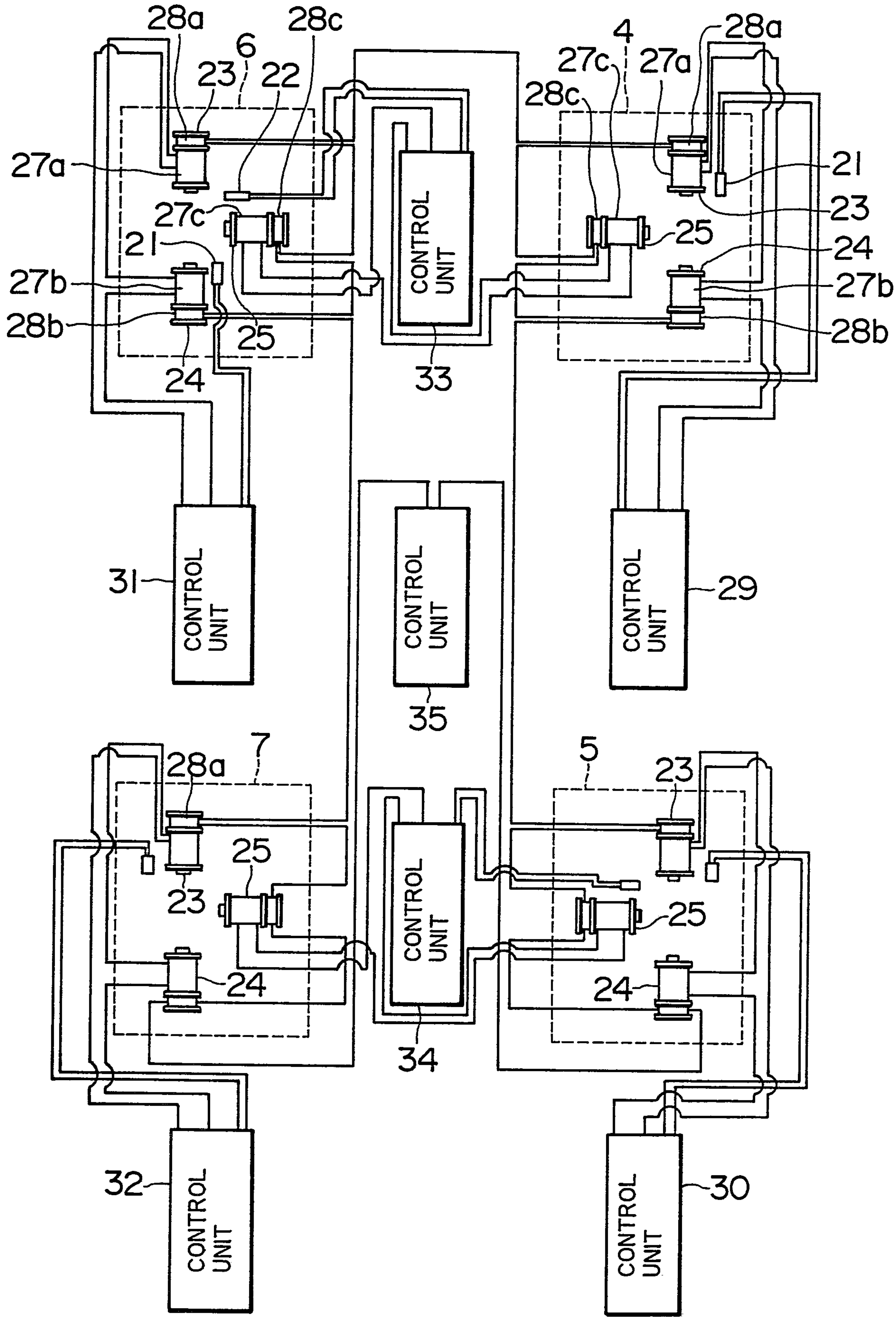


FIG. 3


6
13
23
26a
27b
31
4(28a)
28c
27a
28a
V
24
26b
25
26c
27c
27b
15a
33
4(27c)
28a
28b
28c
28b
31
27a
22
18b
21
18c
15c
12
7(28a)
28c
16c
19c
15b
20b
20c
19b
17
33
31
16b
17
V

2/10

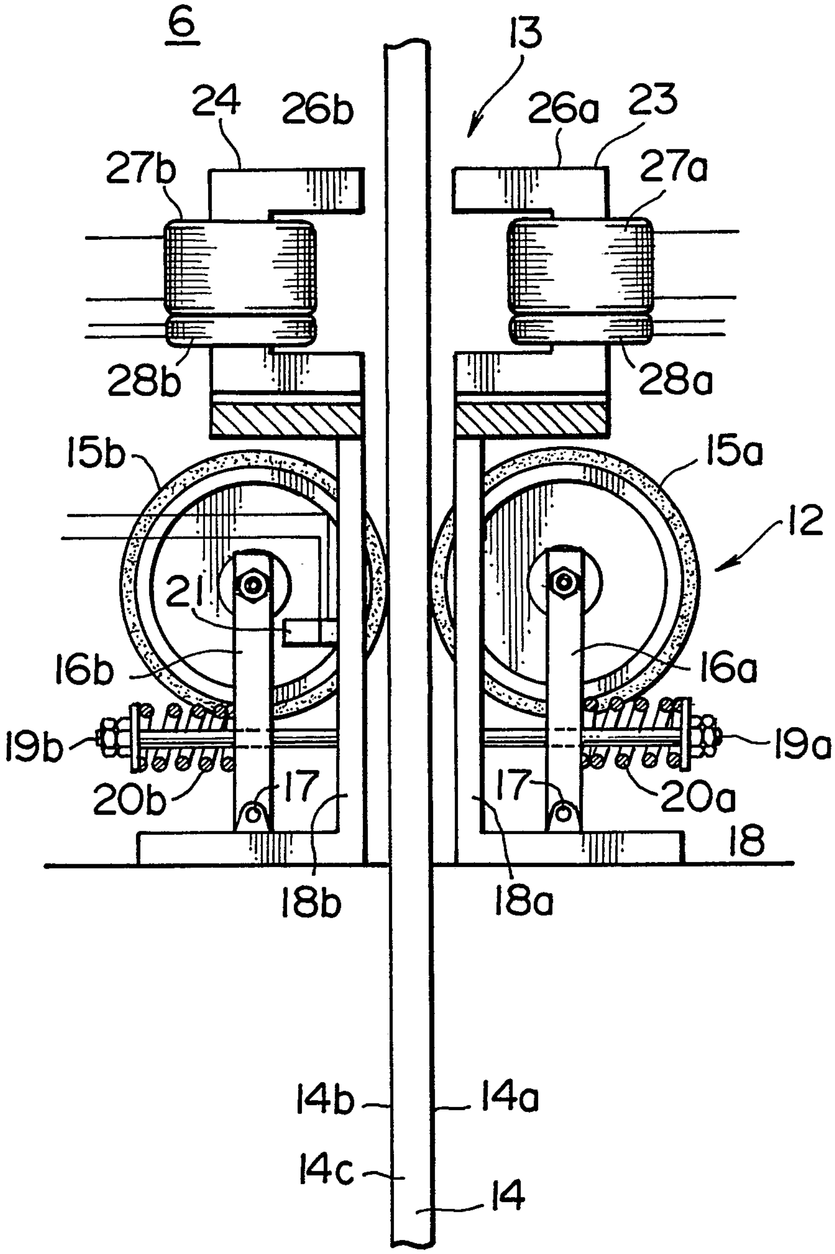
FIG. 4



28a
6
23
22
28c
27a
27c
21
27b
28b
25
24
CONTROL UNIT
33
4
28a
27c
27a
28c
21
23
25
24
27b
28b
CONTROL UNIT
31
CONTROL UNIT
35
CONTROL UNIT
29
7
28a
23
25
24
CONTROL UNIT
34
5
23
25
24
CONTROL UNIT
32
CONTROL UNIT
30

5/10

FIG. 5


6
13
24
26b
26a
23
27b
27a
28b
28a
15b
15a
12
21
16b
16a
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20b
20a
17
17
18
18b
18a
14b
14a
14c
14

FIG. 6

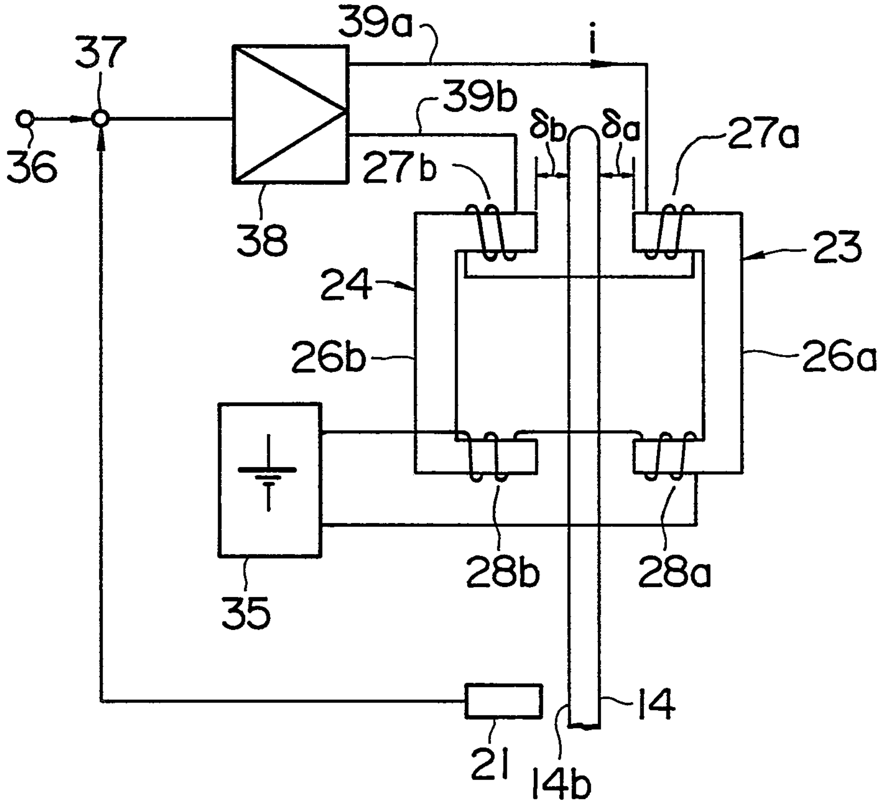

39a
i
37
39b
δb
δa
27a
36
27b
38
23
24
26b
26a
35
28b
28a
14
21
14b

FIG. 7

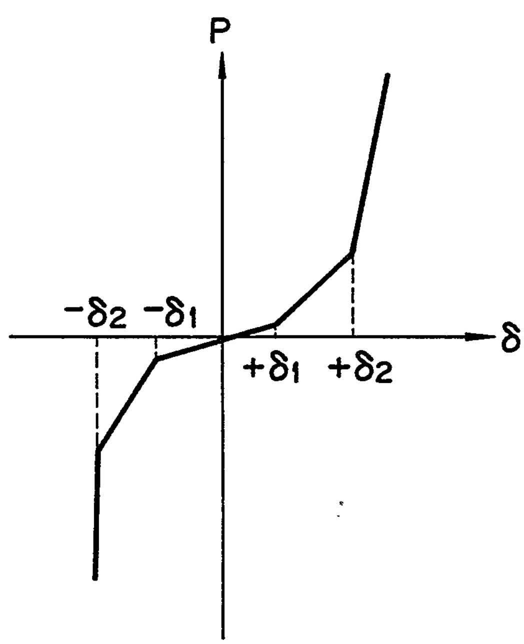

P
-δ2
-δ1
δ
+δ1
+δ2

FIG. 8

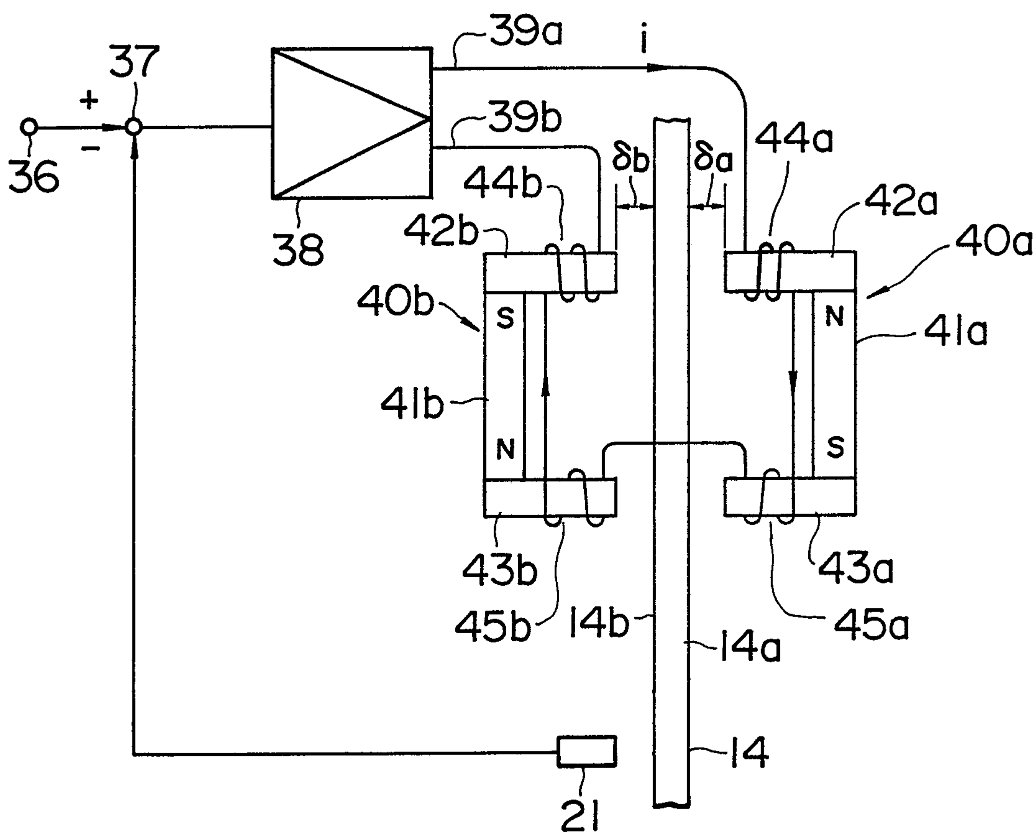

36
+
−
37
38
39a
i
39b
δb
δa
44a
44b
42a
42b
40a
40b
S
N
N
S
41a
41b
43b
43a
45b
14b
14a
45a
14
21

FIG. 9

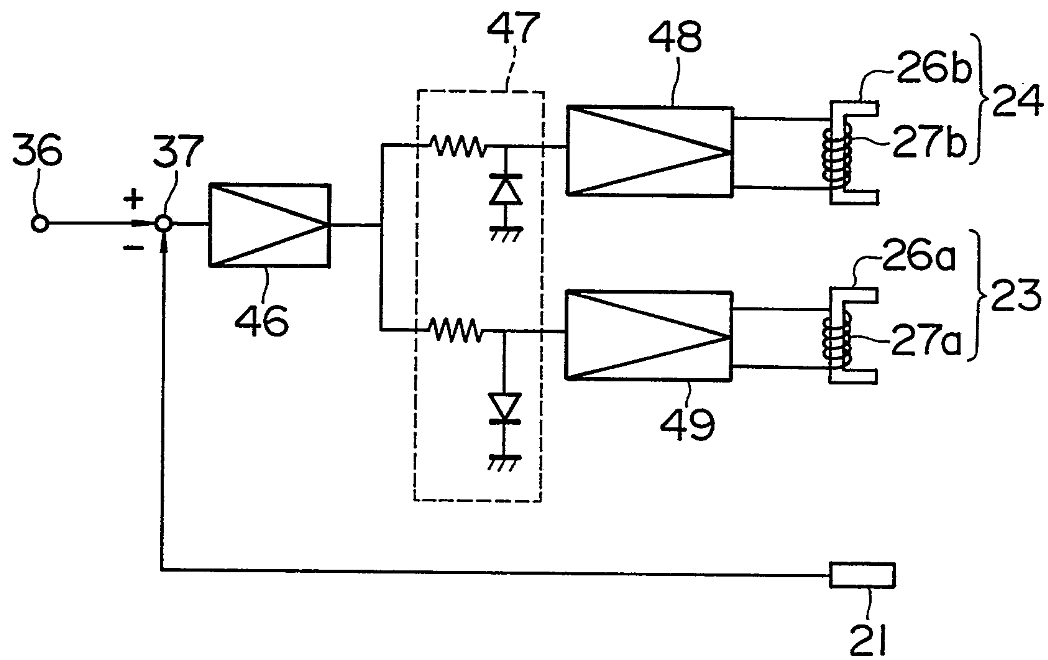

47
48
26b
24
36
37
+
−
27b
46
26a
23
27a
49
21

FIG. 10

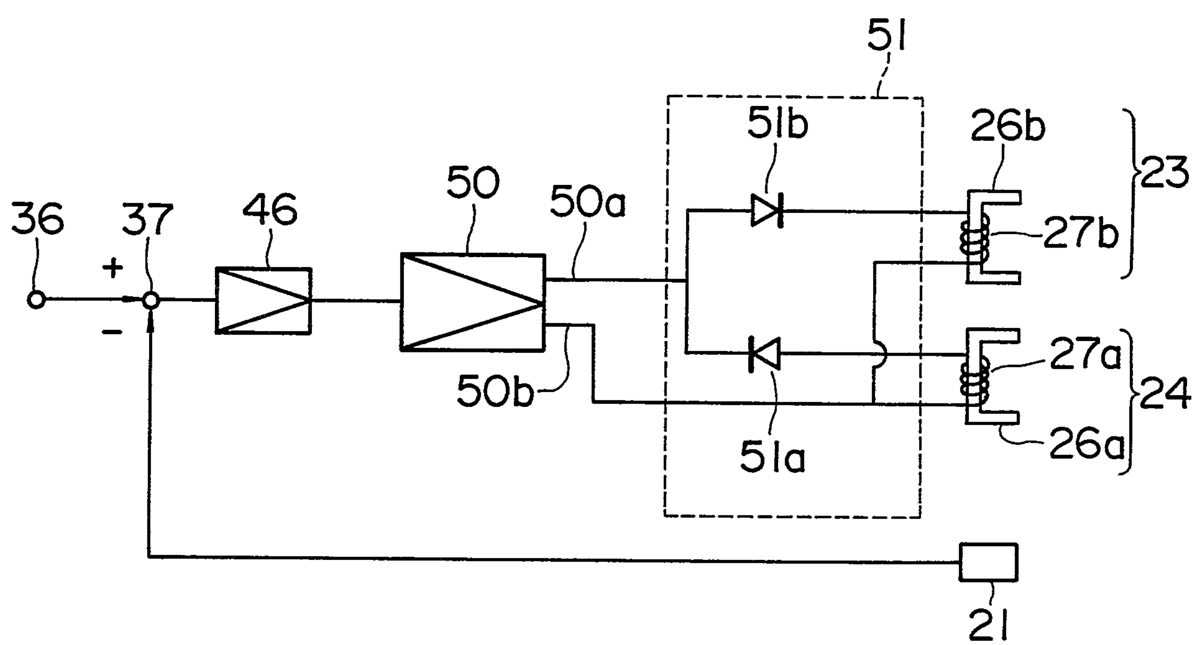

51
51b
26b
23
50
50a
36
37
46
+
−
27b
27a
24
50b
26a
51a
21

FIG. 11

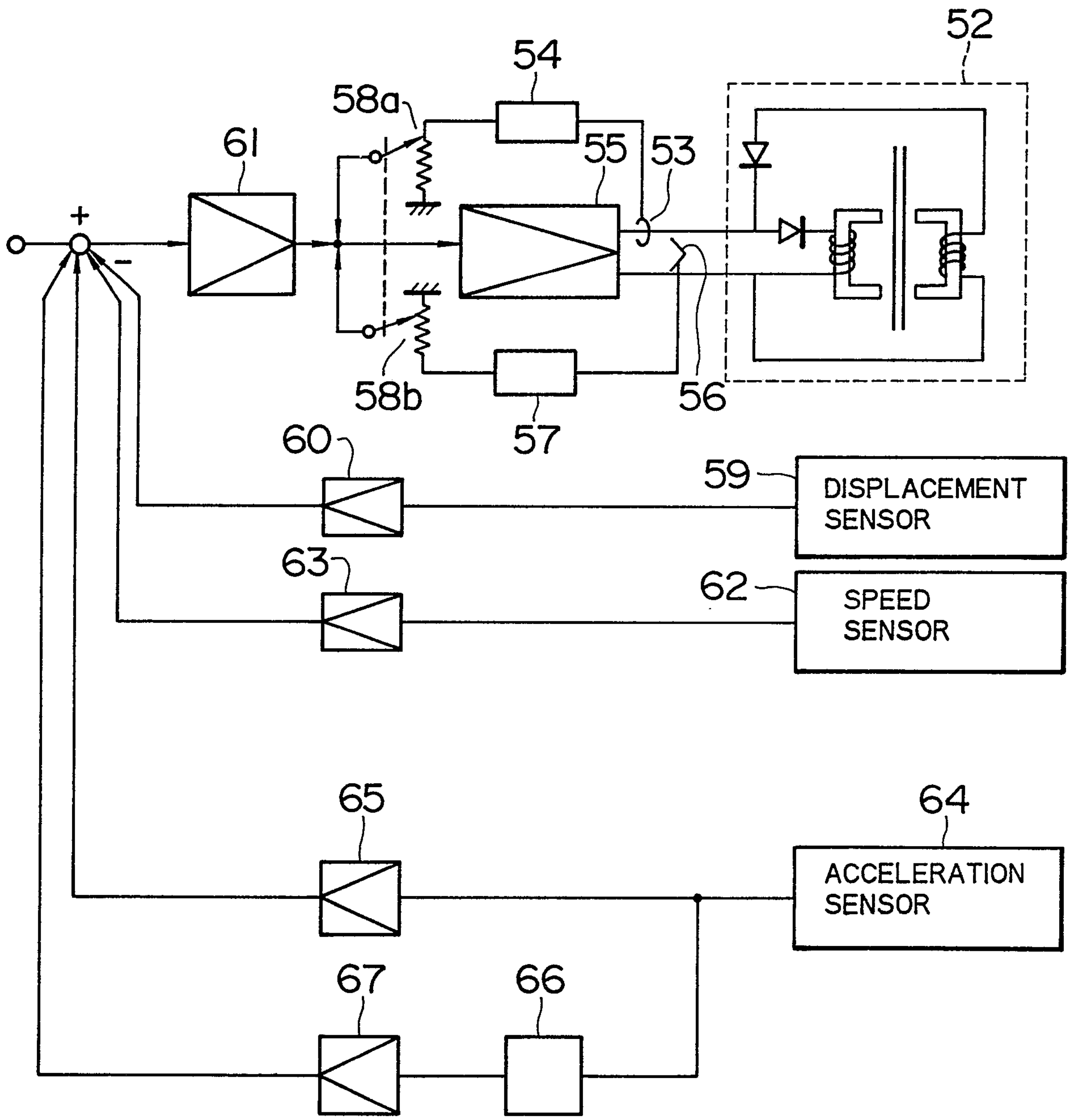

52
54
58a
61
55
53
+
-
58b
57
56
60
59
DISPLACEMENT SENSOR
63
62
SPEED SENSOR
65
64
ACCELERATION SENSOR
67
66

FIG. 12

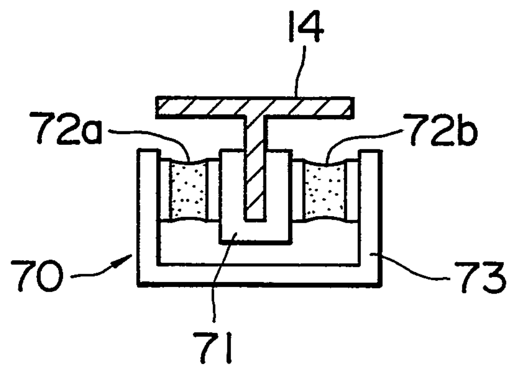
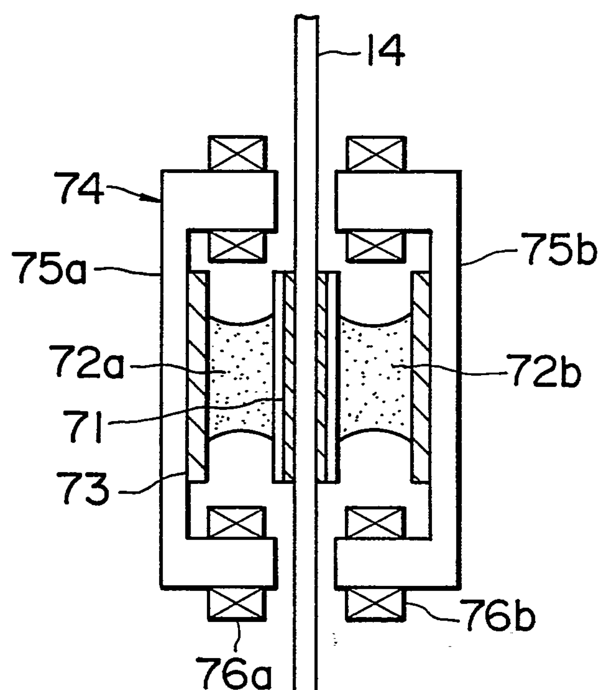


FIG. 13



ELEVATOR SYSTEM AND METHOD OF CONTROL THEREOF

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The present invention relates to an elevator system and a control method thereof, or more in particular to an elevator system and a control method thereof capable of reducing the lateral displacement of a passenger cage.

As a conventional elevator system, a guide apparatus as disclosed in JP-A-63-87482, for example, is well known, in which the change in the clearance between the normal base line and a passenger cage is detected by a sensor, the passenger cage is vertically driven along the normal base line by controlling the attraction force of electromagnets arranged in opposed relationship with the guide rail, and the rolling is prevented thereby to improve the riding quality of the passenger cage.

The above-mentioned prior art poses the problem in that all the guide loads exerted on the passenger cage including the lateral vibration due to the bend of the guide rail and the offset load are reduced by a single guide means, and no consideration is taken agaisnt the fact that the guide means is bulky and the guide function is lost by power failure while the system is in operation.

The present invention at its most general, proposes that there is provided contact-type guide means in contact with a guide rail and non-contact type guide means out of contact with the guide rail for guiding the passenger cage.

The present invention may thus provide an elevator system with a guide means reduced in size.

The present invention may also provide an elevator system in which an external force acting on the passenger cage is reduced while saving electric power.

The present invention may also provide an elevator system capable of guiding a running passenger cage without any shock even at the time of power failure.

As seen from the construction described above, the guide load acting on the passenger cage is shared between the contact and non-contact type guide means. Therefore, each guide means is reduced in size, thereby making possible a smaller guide apparatus. Further, the non-contact type guide means, which is operated exclusively for an offset load, is controlled easily with a smaller electric power. Also, since the passenger cage in operation can be guided continuously by the contact-type guide means at the time of power failure, the guide function of the passenger cage is not lost.

In the drawings:

Fig. 1 is a perspective view schematically showing an embodiment of an elevator system according to the present invention.

Fig. 2 is a side view schematically showing an embodiment of the elevator system according to the present invention.

Fig. 3 is a perspective view showing an embodiment of the guide apparatus used with an elevator system according to the present invention.

Fig. 4 is a connection block diagram of a guide apparatus used with an elevator system according to the present invention.

Fig. 5 is a schematic diagram along line V-V in Fig.2.

Fig. 6 is a block diagram showing a control system of a guide apparatus used with an elevator system according to the present invention.

Fig. 7 is a characteritic diagram showing the relationship between the displacement and spring force of a support spring used with an elevator system according to the present invention.

Fig. 8 is a block diagram showing another control system of a guide apparatus used with an elevator system according to the present invention.

Fig. 9 is another block diagram showing another control system of a guide apparatus used with an elevator system according to the present invention.

Fig. 10 is a block diagram showing a control system of another guide apparatus used with an elevator system according to the present invention.

Fig. 11 is a block diagram showing a control system of still another guide apparatus used with an elevator system according to the present invention.

Fig. 12 is a plan view schematically showing another embodiment of the guide apparatus used with an elevator system according to the present invention.

Fig. 13 is a side view schematically showing a combination of other embodiments of the guide apparatuses used with an elevator system according to the present invention.

An embodiment of the present invention will be explained with reference to Figs.1 to 6. An elevator passenger cage 1 includes a cage frame 2 shaped in square, a cage room having an entrance/exit 3a supported by the cage frame 2, and guide means 4, 5, 6, 7 mounted on the vertical and lateral ends of the cage frame 2. The passenger cage 1 is suspended by being connected to an end of a rope 9 through a connector 8 mounted through the upper beam of the cage frame 2. The rope 9 is hung on a drive sheave 10 of a winch installed in a machine room (not shown) at the top of the hoistway, and has the other end thereof connected with a counterweight 11. The guide means 4, 5, 6, 7 include two types of guide means having different frequency characteristics to be reduced, i.e., first guide means 12 and second guide means 13 for guiding the passenger cage 1 movably only in the vertical direction in engagement with a pair of guide rails 14A, 14B erected in the hoistway. By the way, the suspension center of the passenger cage 1 is sided toward the counterweight 11 with respect to the gravity centr W, so that an offset load is imposed on the passenger cage 1 with the upper side thereof turned toward the direction A of the entrance/exit 3a around the gravity center W (Fig.2).

The first guide means 12 is of contact type and has three guide elements in opposed relationship with three guide surfaces 14a to 14c of the guide rail 14, i.e., a pair of guide rollers 15a, 15b sandwiching the guide rail 14 from the direction along the depth of the passenger cage and a guide roller 15c kept in contact with the guide rail 14 from the direction perpendicular to the depth of the passenger cage (Fig.3). The guide rollers 15a to 15c are supported pivotally at an end of the support arms 16a to 16c respectively. The support arms 16a to 16c have the other ends thereof rotatably supported by a bearing 17 on a mount 18 fixed on the cage frame 2. The support arms 16a to 16c are also held by support springs 20a to 20c of elastic material in such a direction as to press the guide rollers 15a to 15c against the guide surfaces 14a, 14b, 14c of the guide rail 14. The support springs 20a to 20c are coupled to an end of the support members 18a to 18c on the mount 18 and are fitted at the other ends thereof through the support arms 16a to 16c. A damping device or what is called a damper may be mounted in parallel to the support springs 20a to 20c if required. In addition, the support members 18a to 18c have installed thereon displacement sensors 21, 22 such as a light sensor or an eddy current sensor in opposed relationship with the support arms 16a to 16c through a minute clearance. The displacement sensors 21, 22 need not be installed on the support members 18a to 18c to the extent that the direction and magnitude of displacement from the guide rail 14 of the guide means 4 to 7 is known, as will be described below.

On the other hand, there is installed the second guide means 13 in the vicinity of the first guide means constructed as described above. This second guide means 13 is of non-contact type, and like the guide rollers 15a, 15b, include three guide elements having a pair of electromagnets 23, 24 in spaced opposed relationship with the three guide surfaces 14a to 14c of the guide rail 14 and an electromagnet 25 arranged in a position perpendicular to the electromagnets 23, 24. The electromagnets 23 to 25 include channel-shaped yokes 26a to 26c and coils 27a to 27c and coils 28a to 28c wound on the yokes 26a to 26c. The electromagnets 23 to 25, as shown in Fig.4, are such that a couple of the electromagnets 23, 24 opposed to each other in the guide means 4 to 7 respectively are controlled by a single one of the control units 29 to 32. Further, the guide means 4 to 7 are such that a couple of electromagnets 25 in the upper guide means 4, 6 and a couple of electromagnets 25 in the guide means 5, 7 are controlled respectively by single ones of the control units 33, 34, respectively. The coils 28a to 28c of the guide means 4 to 7 are connected to a DC power supply 35.

The yokes 26a, 26b have the channel-shaped leg ends arranged in opposed spaced relationship to the guide surfaces 14a, 14b of the guide rollers 15a, 15b. The yoke 26c, on the other hand, has the channel-shaped leg ends thereof arranged in spaced opposed relationship with the guide surface 14c of the guide roller 15c, and the yokes are fixed on the support members 18a to 18c.

Now, an example of operation of the passenger cage 1 guided by the first guide means 12 and the second guide means 13 having the above-mentioned construction will be explained with reference to the guide apparatus 6. With the rotation of the drive sheave 10 of the winch, the passenger cage 1 is driven vertically through the rope 9. Assuming that the suspension center is deflected as shown in Fig.2 with respect to the gravity center W of the passenger cage 1 (Fig.2), the support spring 20a of the first guide means 12 shown in Fig.5 is compressed, thereby extending the support spring 20b. As a result, the mount 18 approaches the guide rail 14. The support springs 20a, 20b are thus required to have a predetermined value of rigidity to prevent the emergency brake (not shown), etc. in the passenger cage or the mount 18 from coming into contact with the guide surfaces 14a, 14b against an assumed offset load. In the case where the guide rail 14 has a curve (caused at the joints between guide rail members), therefore, the guide rollers 15a, 15b are displaced by the curved displacement while the passenger cage 1 is running, so that the force as a lateral vibration expressed as $P = kr \cdot Sr$ (the amount of relative displacement Sr between the guide rollers 15a, 15b and the mount 18 multiplied by the combined spring constant kr of the support springs 20a, 20b) is transmitted to the passenger cage 1, thereby causing the lateral vibration thereof.

Assuming that the spring constant kr is small for the displacement $-\delta_1$ to $+\delta_1$ in the vicinity of the central setting of the first guide means 12 on the displacement/load characteristic of the support springs 20a, 20b as shown in Fig.7, the lateral vibratory force P is sufficiently reduced, thereby tolerating a small bend of the guide rail 14. In view of this, it is considered necessary to reduce the offset load component due to eccentricity between the gravity center W and the supension center from the guide load exerted on the guide rollers 15a, 15b. This offset load component, in the absence of the eccentricity between the gravity center W and the suspension center, varies also with the change in the gravity center W of the passenger cage 1 due to the load fluctuation of the tail cord (not shown) connected to the passenger cage 1 or the actual load distribution in the passenger cage 1. It is by reason of this fact that the offset load component of the guide load acting on the first guide means 12 is reduced by the guide means 13. The direction of the offset load is designated by A as shown in Fig.2 or opposite thereto above the gravity center W. The load reduction is necessary in both directions, and for this purpose, the electromagnets 23, 24 arranged in opposed relationship with the guide surfaces 14a, 14b of the guide rail 14 are operated. According to the present embodiment, the suspension center of the passenger cage 1 is decentered with respect to the gravity center W of the passenger cage 1, and therefore one of the guide loads of the guide rollers 15a, 15b is always larger than the other. As a result, by reducing the offset load component acting on the guide roller subjected to the larger guide load, the deflection of the guide load acting on the guide rollers 15a, 15b is prevented. In the case where an offset load is exerted to turn over the passenger cage 1 in the direction A in Fig.2, the support spring 20a on the guide roller 15a side of the first guide means 12 is compressed. At the same time, the yoke 26a of the electromagnet 23 of the second guide means 13 approaches the guide rail 14, while the yoke 26b tends to move away therefrom. The displacement of the clearance with the guide rail 14 is detected by the change sensor 21, and in accordance with the amount of displacement, the coil 27b wound on the yoke 26b tending to move away from the guide rail 14 is excited. Thus the attraction force is generated in the yoke 26b thereby to reduce the clearance with the guide rail 14. The reduction in the clearance with the guide rail 14 leads to the reduction in the offset load acting on the first guide means 12 and hence the passenger cage 1 thereby to prevent the turnover in the direction A. If the coil 27a is excited in reverse direction to expand the clearance between the yoke 26a and the guide rail 14, the offset load is reduced quickly.

As shown in Fig.7, the support spring constant kr should better be large in order to prevent a part of the components of the passenger cage 1 or the yokes 26a, 26b from coming into contact with the guide rail 14 for the spring displacement of more than an appropriately determined value of δ_2.

Now, explanation will be made about other effects caused by deflecting the suspension center of the passenger cage from the gravity center W in the embodiment described above with reference to Fig.2.

In conventional elevator systems, the suspension center of the passenger cage 1 is rendered to substantially coincide with the gravity center W, and therefore the distance between the suspension center of the counterweight 11 and that of the passenger cage 1 becomes larger than the diameter C of the drive sheave 10. In order to adjust to the distance between the drooping ropes 9, therefore, a deflector wheel is used in addition to the drive sheave 10.

According to the embodiment described above, by contrast, the suspension center of the passenger cage 1 is positioned toward the suspension center of the counterweight 11, and the resulting offset load is reduced by the second guide means 13. It is therefore possible to reduce the distance C between the suspension center of the counterweight 11 and that of the passenger cage 1 to a value substantially identical to the diameter C of the drive sheave 10. As a result, the need of the deflector wheel is eliminated, thereby reducing the space for winch installation. Further, according to the embodiment described above, by rendering the distance C between the suspension center of the passenger cage 1 and that of the counerweight 11 substantially equal to the diameter C of the drive sheave 3, the angle by which the rope 9 is wound on the drive sheave 10 (lap angle) is increased, thereby improving the frictional force between the rope 9 and the drive sheave 10 for stable operation of the passenger cage 1.

In this way, to render the distance C between the suspension center of the passenger cage 1 and that of the counterweight 11 substantially equal to the diameter C of the drive sheave 3 is especially effective for a small-size elevator system.

The offset load can be reduced by controlling the attraction force of the electromagnets 23, 24. The attraction force, in turn, can be controlled by controlling the current flowing in the coils 27a, 27b. The current is controlled on the basis of the signal of the displacement sensor 21 for detecting the change in the displacement of the support springs 20a, 20b, i.e., the clearance between the support member 18b and the support arm 16b. By doing so, the offset load component acting on the guide rollers 15a, 15b is reduced thereby to equalize the guide loads.

On the assumption that the guide load of the guide roller 15a (15b) is larger than that of the guide roller 15b (15a) due to an offset load, explanation will be made with reference to Fig.6. First, the output voltage of the displacement sensor 21 mounted on the support member 18b in Fig.5 is set to zero when the clearances δa, δb of the electromagnets 23, 24 with the guide rail 14 are equal to each other on right and left sides, to minus (plus) when the clearance δb (δa) is displaced upward by compression of the support spring 20a (20b), and to plus (minus) when the clearance δb (δa) is displaced downward by extension of the support spring 20a (20b). When the support spring 20a (20b) of the guide roller 15a (15b) is compressed due to a offset load under this condition, the clearance δb (δb) is increased so that the output voltage of the displacement sensor 21 is decreased (increased) to minus below (above) the reference voltage 36. As a result, the output voltage of the adder 37 becomes positive (negagive), and the resulting signal instructs the current amplifier 38 to supply a current in the direction from the output terminal 39a to coil 27a to coil 27b to output terminal 39b. This current makes it possible to control the attraction force of the electromagnets 23, 24 against the guide rail 7. This will be explained more specifically. A predetermined amount of magnetic fluxes Φc generated by the coils 28a, 28b connected to the DC power supply 35 causes a pair of electromagnets 23, 24 to attract the guide rail 7 to each other, with the result that an equilibrium, though unstable, exists in the vicinity of a point where the clearances δa and δb are equal to each other. Under this condition, assume that the clearance δa becomes smaller than the clearance δb, for example, due to an offset load. Then the output voltage of the displacement sensor 21 installed in opposed relation to the guide surface 14b of the guide rail 14 is reduced below the reference voltage 36, thereby instructing the current amplifier 38 on the direction and amount of the output current. If the output current i of the current amplifier 38 flows from the output terminal 39a in the direction of arrow, for instance, the magnetic fluxes in the clearance δb increase while those in the clearance δa decrease. In this way, by determining the direction in which the coils 27a, 27b are wound, the magnitude and direction of attraction force of the pair of electromagnets 23, 24 against the guide rail 14 are controlled in accordance with the magnitude and direction of the current. More specifically, the magnitude of attraction force of the pair of electromagnets 23, 24 constructed as above is such that to the extent that the magnetic fluxes Φi generated by the output current i and the magnetic fluxes Φc generated by the coils 28a, 28b are held in the range of $|\Phi i| < |\Phi c|$, the magnetic fluxes Φi generated by the coil 27b are added to the magnetic fluxes Φc generated by the coil 28b in the electromagnet 24, and therefore the combined magnetic fluxes are given as $\Phi c + \Phi i$. As for the electromagnet 23, on the other hand, the magnetic fluxes Φi generated by the coil 27a are subtracted from the magnetic fluxes Φc generated by the coil 28a, so that the combined magnetic fluxes are expressed as $\Phi c - \Phi i$. In this way, a single current amplifier 38 is capable of controlling the magnitude and direction of attraction of the pair of electromagnets 23, 24 against the guide rail 14. In applications to the elevator guide system, therefore, the control operation is possible with a fewer number of amplifiers and a smaller current capacity.

An example in which DC excitation of the coils 28a, 28b making up the fixed magnetic flux generator is effectd with a single DC power supply was explained above. Apart from this, as shown in Fig.4, the system can of course be simplified also by exciting the colis 28a, 28b of the guide means 4 to 7 with a common DC power supply 35.

Although the coils 28a, 28b subjected to DC excitation are used as a fixed magnetic flux generator in Fig.6, a fixed magnetic flux generator may alternatively be formed with a permanent magnet as shown in Fig.8. More specifically, a pair of electromagnets 40a, 40b opposed to guide surfaces 14a, 14b of a guide rail 14 are formed in channel-shaped structure by yokes 42a, 42b and 43a, 43b coupled to the ends thereof. A variable magnetic flux generator is formed by winding and connecting in series the coils 44a, 44b on the yokes 42a, 42b and 43a, 43b. The permanent magnets 41a, 41b have the magnetic poles thereof in opposite polarities to each other so that the magnetic fluxes generated by the permanent magnets 41a, 41b pass through the guide rail 14 located between the opposed yokes 42a and 42b and between the yokes 43a, 43b as a part of magnetic path when no current flows in the coils 44a, 44b and 45a, 45b. In the electromagnets 40a, 40b constructed in this way, the attraction force of the pair of electromagnets 40a, 40b against the guide rail 14 can be controlled by connecting the output terminals 39a, 39b of the current amplifier 38 to the coils 44a, 44b and 45a, 45b.

In Fig.9, the signal of an adder 37 is applied to a plus-minus decision circuit 47 through a phase compensation circuit 49 thereby to energize a positive voltage-current converter 48 (negative voltage-current converter 49), a current corresponding to the output voltage of the adders 37 is supplied to excite only the coil 27b (27a) to display the attraction thereof, and the extended clearance between the electromagnet 24 (23) and the guide rail 14 is thus narrowed into original position, thereby reducing the offset load exerted on the guide roller 15a (15b). In this way, a current is supplied to the coil only in the presence of an offset load. Also, the excitation current is controlled by selecting one of the coils 27a, 27b thereby to reduce the power consumption of the coils.

In the above-mentioned configuration, the adder 37 as well as the reference voltage 36 may be eliminated by reducing the output voltage of the displacement sensor 21 to zero when the right and left amounts of displacement are equal to each other. As another alternative, the positive voltage-current converter 48 and the negative voltage-current converter 37 are supplied with a bias current to effect the attraction of the electromagnets 23, 24 normally, while the electromagnets 23, 24 are operated differentially in the presence of an offset load. In this case, however, electric power will be wasted since the attraction force constitutes an internal force between the pair of electromagnets 23, 24.

Fig.10 shows another example for reducing power consumption by selecting one of the coils 27a, 27b to control the excitation current. A current converter 50 is used for converting positive and negative voltage signals of the phase compensator 46 into positive and negative currents. Diodes 51a, 51b are connected in opposite directions between an output terminal 50a of the current converter 50 and one of the terminals of the coils 27a, 27b, respectively, and the other output terminal 50b of the current converter 50 is connected with the other terminal of the coils 27a, 27b to make up the plus-minus decision circuit 51 with equal effect. This construction is economical since a single current converter 50 serves the guide means. The configuration of the remainng parts is the same as that shown in Fig.9.

By the way, if the response rate of attraction force for a vertically-moving passenger cage, i.e., a running passenger cage is differentiated from that for a stationary passenger cage in controlling a pair of electromagnets, an elevator system with a superior riding quality is obtained for the reason mentioned below.

Generally, when the passenger cage is stationary on the landing, it rolls due to the reaction caused by the passengers getting in and out of the cage. If this rolling is to be reduced, it is necessary to increase the rigidity of the support spring of the guide means as a countermeasure. With the increase in the rigidity of the support spring of the guide means, however, the passenger cage becomes liable to follow a curve, if any, of the guide rail while running as described above. This causes the rolling, resulting in a deteriorated riding quality. For this reason, the guide rail should desirably be installed without any curve, although some degree of curve is unavoidable. This problem may be solved by causigng the guide means to absorb the guide rail curve and thus preventing the rolling due to the rail curve from being transmitted to the passenger cage. However, this requires a smaller rigidity of the support spring of the guide means in conflict with the demand for a larger spring support rigidity.

In order to alleviate the rolling of a stationary passenger cage and the lateral vibration of a running passenger cage mentioned above, it is necessary to change the response rate of the attraction force of electromagnets. According to an embodiment of the present invention, the response rate of the attraction force is changed by switching the response rate of the current flowing in the electromagnet coils. More specifically, the response rate of current is increased when the passenger cage is stationary as compared when the cage is running to set the attraction force of the electromagnet to a predetermined value quickly, and decreased when the passenger cage is running as compared with when the cage is stationary to restore the attraction force of the electromagnets to a predetermined value slowly. This will be explained with reference to Fig.11. The current supplied to a pair of coils of an electromagnet making up second guide means 52 is detected by a current sensor 53, and fed back through a current feedback element 54 to a current amplifier 55. In this way, the current response is increased. The current response is decreased, on the other hand, by reducing the gain of the current feedback element 54 and detecting the output voltage of the current amplifier 55 with a voltage sensor 56 to energize the current feedback element 57. By the way, in switching the current feedback element 54 and the voltage feedback element 57, the gain of the current feedback element 54 is gradually decreased while gradually increasing the gain of the voltage feedback element 57 by operatively-interlocked variable resistors 58a, 58b. The sudden change in current response is thus eliminated.

The selectability of a feedback system of the current amplifier 55 between current feedback and voltage feedback described above realizes an elevator system with a superior riding quality in which the resonse rate of current, i.e., the response rate of the attraction force of an electromagnet is switched in such a manner that the lateral vibration is reduced by first guide means with the support spring rigidity decreased mainly while the passenger cage is running and the response rate of current is increased mainly while the passenger cage is stationary. The offset load is quickly reduced by use of the attraction force of such electromagnets.

A finely-detailed control is made possible by reducing the response rate of attraction force with the increase in the running speed when the passenger cage is running, and by increasing the response rate with the decrease in the running speed.

In still another system, the current feedback or voltage feedback is selectively employed as a feedback system for the current amplifier 55, and the gain of the current phase compensation element 61 or the gain element 60 of the displacement sensor 59 for detecting the displacement of the support spring of the guide means or the relative displacement between the second guide means 46 and the guide rail is increased when the cage is stationary as compared with when it is running thereby to switch the current response rate. The current response rate can be switched also by switching the gain of the gain element 63 of a speed sensor 62 inserted in parallel to the displacement sensor 59.

It is also possible to switch the current response rate by detecting the absolute acceleration of the passenger cage by an acceleration sensor 64 and switching the gain of the gain element 65 or by converting the output signal of the acceleration sensor 64 into a speed signal by an integrator 66 and switching the gain of the gain element 67 thereof.

Apart from the second non-contact type guide means according to the embodiment explained above as an example using an electromagnet, the present invention is not limited to a non-contact type electromagnet but is applicable also to a system which is operated to reduce an offset load when the offset load is exerted on contact-type guide means.

Although explanation was made above about a pair of electromagnets 23, 24 of the second guide means 13, 46 in the guide means 4 to 7, the displacement of the passenger cage can also be reduced in the direction between the guide rails 14A, 14B by controlling the electromagnets 25 as a pair in opposed relationship in the direction between the guide rals 14A, 14B in the guide means 4 to 7 shown in Fig.1. The electromagnet 25 may be eliminated from the guide means 4 to 7 in some cases.

Further, unlike the contact-type guide means using a guide roller as first guide means 12 in the above-mentioned embodiment, the use of a contact-type guide means with a guide slider in place of a guide roller as shown in Figs.12 and 13 also permits reduction in the offset load components as in the case of guide roller. In Fig.12, a guide slider 71 of the guide means 70 in engagement with the three guide surfaces of the guide rail 14 from three directions has a U-shaped structure and is mounted fixedly on the mounting frame 73 through rubbers 72a, 72b as an elastic member on the outside surface. The passenger cage is mounted on this mounting frame 73 to provide a first contact-type guide means kept in contact with the guide rail 14.

Even with the contact-type guide means 70, as shown in Fig.13, the operation and effect identical to those of the above-mentioned embodiment are attained by mounting the second guide means 74 including a pair of electromagnets made up of yokes 75a, 75b and coils 76a, 76b on a mounting frame 73.

It will thus be understood from the foregoing description that according to the embodiments of the present invention, the guide load exerted on a passenger cage is reduced by being shared by two types of guide means and therefore each guide means is reduced in size thereby to decrease the mounting area on the passenger cage. Also, one of the guide means is operated exclusively for an offset load and therefore can be easily controlled for a reduced power consumption. Furthermore, even in the case of power failure during elevator operation resulting in the loss of the guiding function of one of the guide means, the passenger cage is guided successfully by the remaining guide means kept in contact with the guide rail, thereby preventing a component member of the passenger cage from coming into direct contact with the guide rail.

As explained above, according to the present invention, there is provided an elevator system in which the guide means is reduced in size, and the guide load exerted on the passenger cage is reduced at a saving of power consumption. At the same time, a running passenger cage is capable of being guided without any shock to the passenger cage even during a power failure.

CLAIMS

1. An elevator system comprising a passenger cage with guide means for guiding the passenger cage along at least a guide rail, characterized in that the guide means includes contact-type guide means kept in contact with the guide rail for guiding the passenger cage and non-contact type guide means kept out of contact in oppposed relationship with the guide rail for guiding the passenger cage.

2. An elevator system comprising a passenger cage with guide means for guiding the passenger cage along a guide rail, characterized in that the guide means includes contact-type guide means constructed kept in contact with the guide rail for mainly reducing the lateral vibratory force transmitted to the passenger cage and non-contact type guide means constructed for mainly reducing the offset load acting on the contact-type guide means.

3. An elevator system comprising a passenger cage with guide means for guiding the passenger cage along a guide rail, characterized in that the guide means includes roller-type guide means kept in contact with the guide rail through an elastic member for guiding the passenger cage and magnetic guide means for guiding the passenger cage by way of magnetic force.

4. An elevator system comprising a passenger cage with guide means for guiding the passenger cage along a

guide rail, characterized in that the guide means includes first guide means kept in contact with the guide rail for guiding the passenger cage and second guide means out of contact in opposed relationship with the guide rail for sharing a part of the guide load acting on the first guide means.

5. An elevator system comprising a passenger cage with guide means for guiding the passenger cage along a guide rail, characterized in that the guide means includes first guide means kept out of contact in opposed relationship with the guide rail and second guide means kept in contact with the guide rail for guiding the passenger cage and sharing a part of the guide load acting on the first guide means.

6. An elevator system comprising a passenger cage with guide means for guiding the passenger cage along a guide rail, characterized in that the guide means includes first guide means kept in contact with the guide rail for guiding the passenger cage and second guide means kept out of contact with the guide rail for guiding the passenger cage, said system further comprising means for changing the force for maintaining the clearance between the second guide means and the guide rail.

7. An elevator system as described in Claim 6, characterized in that the second guide means includes magnetic-type guide means for guiding the passenger cage by way of magnetic force, and the means for changing the

force for maintaining the clearance is one for changing the magnetic force against the guide rail.

8. An elevator system comprising a guide unit mounted on a passenger cage through an elastic member, which guide unit is constructed in contact with a guide rail to guide the upward and downward movement of the passenger cage, said system further comprising a pair of electromagnets in spaced relationship with the sides of the guide rail along the entrance and exit of the passenger cage, and means for controlling the magnetic force of at least one of the electromagnets in such a manner as to reduce the offset load acting on the guide unit.

9. An elevator system characterized by comprising first guide means for guiding a passenger cage through an elastic member, second guide means for sharing a part of the offset load acting on the first guide means and including a pair of electromagnets in opposed relationship through the guide rail, and excitation decision means for deciding which of the electromagnets is to be excited.

10. An elevator system as described in Claim 8 or 9, characterized in that each of said electromagnets has a channel-shaped yoke with the ends of the channel legs mounted in opposed relationship to each other through the guide rail, said yoke leg ends having opposite magnetic polarities.

11. An elevator system as described in Claim 9, characterized in that said excitation decision means includes a displacement sensor for detecting the change in the clearance between the electromagnets and the guide rail and a decision circuit operated on the basis of the output of the displacement sensor.

12. An elevator system characterized by comprising elastic guide means for guiding a passenger cage through an elastic member along a guide rail, magnetic guide means for guiding the passenger cage by way of magnetic force along the guide rail, and means for changing the response rate of the magnetic force of the magnetic guide means.

13. An elevator system characterized by comprising at least two types of guide means having different frequency characteristics to be reduced.

14. An elevator system characterized by comprising a passenger cage including two types of guide means having three guide elements in opposed relationship with three continuous surfaces of a guide rail for guiding the passenger cage.

15. An elevator system characterized by comprising two types of guide means for guiding a passenger cage along a guide rail, wherein the lateral vibration transmitted to the passenger cage is reduced mainly by one of the guide means and the offset load mainly by the other guide means.

16. A method for controlling an elevator system comprising contact-type guide means for guiding a passenger cage by keeping a guide unit in contact with a guide rail and non-contact type guide means arranged in opposed relationship with the guide rail for guiding the passenger cage, characterized in that the rigidity of the support spring of the non-contact type guide means is controlled to increase when the passenger cage is stationary and to decrease while the passenger cage is running.

17. A method for controlling an elevator system comprising elastic guide means for guiding a passenger cage through an elastic member along a guide rail and magnetic guide means for guiding the passenger cage by magnetic force along the guide rail, characterized in that the response rate of magnetic force of the magnetic guide means is decreased when the passenger cage is running and increased while the passenger cage is stationary.

18. A method for controlling an eleavator system as described in Claim 17, characterized in that the response rate of magnetic force while the passenger cage is running is decreased progressively with the increase in the running speed and increased with the decrease in the running speed of the passenger cage.

19. A method for controlling an elevator system characterized in that one of the two guide elements in

opposed relationship to each other with a guide rail therebetween is controlled to keep the clearance constant between the passenger cage and the guide rail.

20. A guide apparatus for an elevator system characterized by comprising a pair of electromagnets fixed on a passenger cage in opposed relationship to each other with a guide rail held therebetween from the direction of the passenger cage entrance and exit, selection means for selecting one of the electromagnets to be excited, and command means for issuing a selection decision command to the selection means.

21. A guide apparatus for an elevator system comprisnig a pair of electromagnets fixed on a passenger cage in opposed relationship to each other with a guide rail held therebetween from the direction of the passenger cage entrance and exit, characterized in that said electromagnets include a fixed magnetic flux generator and a variable magnetic flux generator, said variable flux generator on one of said electromagnets being constructed in such a manner as to generate magnetic fluxes to be added to the fixed magnetic fluxes of said fixed magnetic flux generator, the variable magnetic flux generator on the other of said electromagnets being constructed in such a manner as to subtract the fixed magnetic fluxes of the fixed magnetic flux generator, said system further comprising current supply means for supplying an excitation current to each

of said electromagnets.

22. A guide apparatus of an elevator system characterized by comprising magnetic guide means for guiding a passenger cage through magnetic force along a guide rail and means for changing the response rate of magnetic force of the magnetic guide means.

23. An elevator system substantially as herein described with reference to and as illustrated in Figs. 1 to 6 or Figs. 1 to 6 as modified by any one of Figs. 8 to 13 of the accompanying drawings.

24. A method for controlling an elevator system substantially as any one herein described with reference to the accompanying drawings.

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Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES: WPI

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Documents considered relevant following a search in respect of claims 1-8, 12-15

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
P	GB 2248600 (HITACHI) whole document	1-8, 12-15
Y	GB 1030728 (OTIS) whole document	1-8. 12-15
Y	US 4754849 (MITSUBISHI) whole document	1-8, 12-15

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