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(54) ELEVATOR SAFETY APPARATUS

(71) We, HITACHI, LTD., a Corporation organised under the laws of Japan, of 5-1, 1-chome, Marunouchi, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an elevator safety apparatus.

As is well known, an elevator system provided in a building is a transportation system for serving a plurality of floors in response to hall calls from various floors of the building and cage calls from various cars of the elevator system, and a completely safe operation is required. Especially in view of its nature of vertical motion, safety measures are required even taking special conditions into consideration.

In a rope-suspended elevator system, an elevator car and a counter-weight are suspended on a hoist placed in a machine room. The rotation of the hoist causes upward and downward movement of the car and the counterweight. In order to reduce the working load of the hoist, the weight of the car when carrying about one half of the rated load thereof is rendered equal to that of the counter-weight, thereby minimizing the unbalanced turning effort of the hoist. In order to hold the elevator car in a stationary condition, an electromagnetic brake is provided with a holding power which is generally considered sufficient if the car carrying 125% of the rated load thereof can be held stationary.

In the case where elevator traffic demand is high such as in morning and evening rush hours, passengers more than the rated load may try to take an elevator car at a floor. To meet such a situation, a conventional system is such that when passengers equal to 110% of the rated load or more try to take the car, a buzzer is caused to sound to urge excess passengers to get off the car, while at the same time preventing the elevator operation, thereby securing elevator safety. Nevertheless, passengers as many as exceeding 125% of the rated load sometimes take the car ignoring the sounding buzzer, with a result that the car gradually slides down with its door held open. Then, usually, the available braking force has already been exerted and therefore the car cannot be stopped. Thus, it is possible that the car is undesirably gradually forced to slide down midway between the floor and the next lower floor, possibly leading to a personal injury or an accident in the building or elevator equipment.

The situation in which the car stops or slides up or down midway between two succeeding floors with its door held open takes place not only in the case where the actual load on the car exceeds the rated load, but also in the case where, for example, the car is decelerated to serve a floor and have its door opened thereafter, but it fails to stop at the destination floor and passes it.

Conceivable countermeasures against such troubles include (1) providing an emergency brake in addition to the above-mentioned electromagnetic brake to obtain a more powerful mechanical brake, and (2) endowing the motor in the hoist with a capability of generating a holding torque.

Any of these countermeasures against the undesirable excessive upward or downward movement of the car with the door thereof open, however, fails to provide a sufficient safety measure.

An object of the present invention is to provide an elevator safety apparatus eliminating the possibility of a personal injury due to the car operated with the door thereof held open.

According to the present invention, there is provided an elevator safety apparatus for an elevator system including at least one elevator car each serving a plurality of floors each provided with a hall door, the car having a door, the apparatus comprising means for detecting a situation in which the car is spaced from a floor level by a predetermined distance, and means for generating a command signal for closing the door of the car in response to the output from the detecting means irrespective of whether the associated hall door is open or closed.

The predetermined distance referred to herein is preferably a door-open zone, which is a region where the door-opened condition of the car is allowed and generally includes an upper region and a lower region extending from a floor level not more than about 300 mm. Outside of this door-open zone, it is generally impossible to automatically open the door. To meet the situation where the car whose door is held open within the door-open zone may leave the door-open zone as mentioned above, however, the car leaving the door-open zone is detected and a command signal for forcibly closing the door is issued. As a result, if the door of the car outside of the door-open zone is open, it is closed. If the door is already closed, no specific action is taken in response to the door-closing command signal.

Apparently, it is not always necessary to set the above-mentioned predetermined distance identical with the door-open zone, but it may be either widened or narrowed as desired, as explained later.

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

Fig. 1 is a side view showing a partial section of an elevator car hoistway;

Fig. 2 is a plan view of an elevator car, which is enlarged as compared with Fig. 1;

Fig. 3 is a diagram of a door control command circuit according to an embodiment of the elevator safety apparatus of the present invention; and

Fig. 4 is a diagram of a door control command circuit according to another embodiment of the invention.

In Figs. 1 and 2, an elevator car 1 and a counter-weight 2 are connected by means of a rope 3, and through a pulley 7 mounted in a machine room 5 at the upper part of a housing 4 defining a hoistway for the car are operated between halls 81 to 83 by a hoist 6 in response to hall calls and/or cage calls. The car 1 with a load 17, upon arrival at one of the halls 81 to 83, opens the cage door (including right and left door units 91 and 92) and the corresponding one of the hall doors 101 to 103 for the halls 81 to 83 by means of a door operating device 13, thereby permitting a desired change of the load 17. Reference numerals 121 to 126 and 11 show detector elements provided on the housing and on the car respectively, which are relatively arranged to be engageable with each other to operate as a position detecting device during a running operation of the car.

A diagram of a door control command circuit in one embodiment of the elevator safety apparatus of the present invention is illustrated in Fig. 3. A door-closing command relay 51, when excited, issues a command signal for closing the door (in the directions shown by arrows 14 and 15 in Fig. 2), to the door operating device 13 (Figs. 1 and 2). A door-opening command relay 52, by contrast, issues a command signal for opening the door. A forcible door-closing command relay 53, when excited, issues a command signal for forcibly closing the door. CLSb denotes a normally-closed contact of a close limit switch relay excited upon completion of a closing of the door, OLSb a normally-closed contact of an open limit switch relay excited upon completion of an opening of the door, DSFb a normally-closed contact of a relay excited in response to the detection of an object caught at the door, numerals 60a and 60b contacts of a running relay which is excited with a start of the car and de-energized with the arrival of the car at a floor or a hall, and numerals $61b_1$ $61b_2$ and $61b_3$ contacts of a door-locking relay which is excited when the door 9 is completely closed and locked. This locked condition is cancelled only in the door-open zone. The other relay contacts are either normally open or closed and denoted by reference numerals resulting from additions of suffixes *a* or *b* to the reference numerals of the respective relays. Further, reference character DRC denotes a switch which is closed when the detector element 11 on the car is engaged with any one of the detector elements 121 to 126 on the housing. Character ALM denotes an alarm, and HR a manually-operable reset button.

It is assumed that the car arrives at the second floor so that the floor 16 of the car 1 or the cage floor 16 is flush with the second-floor level 82 as shown in Fig. 1. Under this condition, in Fig. 3, if the door is closed, the normally-closed contact OLSb of the open limit switch relay is also closed. Since the car is located within the door-open zone, the door locking relay 61 is de-energized, thereby closing the contact $61b_1$. Further, the door-closing command relay 51 is de-energized so that the contact 51b is closed. By de-energization of the running relay 60 to close the contact 60b, the door open command relay 52 is excited through a circuit including P-OLSb-$61b_1$-60b-51b-52-N. As a result, the cage door 91, 92 and the hall door 102 (Figs. 1 and 2) are opened by the door operating device 13. When the doors have completely opened, the contact OLSb of the open limit switch relay is opened, thereby de-energizing the door open command relay 52.

Thus, passengers and prospective passengers alight from and take the car respectively. Upon subsequent generation of a start command, the contact 60a is closed, thereby exciting the door closing command relay 51 through a circuit including P-CLSb-DSFb-60a-52b-51-N. The door operating device 13 shown in Figs. 1 and 2 now closes the cage door 9 and the hall door 102. When the doors have completely closed, the close limit switch relay contact CLSb is opened, thereby de-energizing the door closing command relay 51. At the same time, the car starts to run in a predetermined direction by a control circuit not shown.

It is possible that after passengers and prospective passengers have got off and in the car respectively at a hall floor with the cage door held open, the number of passengers in the car totals more than 125% of the rated load of the car 1 and the unbalanced turning effort exerted on the hoist 6 exceeds the holding power of the electromagnetic brake. Then, the car 1 undesirably gradually slides down with the hall door 102 and the cage door 9 held open.

When the difference between the floor levels of the car and the hall exceeds a predetermined distance, the detector element 11 on the car 1 is engaged with the detector element 123 on the housing 4. By this engagement, the switch DRC in Fig. 3 is closed. Since the door is held open and therefore the contact $61b_2$ is closed, the forcible door-closing relay 53 is energized through the circuit including P-DRC-$62b_2$-53-N, while at the same time the forcible door-closing by the relay 53 is self-held (stored) by the self-holding contact 53a. The manually-operable reset button HR is normally closed and serves to cancel the stored forcible door-closing.

Now, since by the excitation of the relay 53, the contact $53a_2$ is closed and both the contacts CLSb and DSFb have been already closed, the door-closing relay 51 is excited through the circuit including P-CLSb-DSFb-$53a_2$-52b-51-N.

Upon excitation of the door-closing relay 51, the door-operating device 13 in Figs. 1 and 2 closes the cage door 9 in the directions shown by the arrows 14 and 15. When the forcible door-closing command relay 53 is excited, the alarm ALM is immediately actuated through the circuit including P-$53a_1$-HR-$61b_3$-ALM-N. In this way, the passengers including prospective passengers are warned that the door is being closed for safety so that no article or person be caught at the door units of the cage door 9 being closed.

As described above, when the car with the door thereof held open moves a predetermined distance away from a floor level, the door is forcibly closed to prevent passengers in the car from falling in the hoistway.

When the predetermined distance is set greater than the length of the door-open zone, since the cage door 9 disengages from the hall door 102 when the car 1 leaves the door-open zone, the hall door is then automatically closed by a spring restoration system.

In view of the fact that the relay 53 is maintained energized until the reset button HR is depressed, this relay may be used to inform a caretaker, so that he takes steps for an emergency operation of the car to make the cage floor level flush with a hall floor level. Thus, the doors 9 and 102 are opened and the passengers can escape from the car.

If a passenger were caught at the door units when the cage door 9 is being closed, the contact DSFb would be opened and therefore the relay 51 is de-energized. The door operating device 13 stops closing, and the relay 52 is energized by the circuit including P-OLSb-$61b_1$-60b-51b-52-N, thus causing the door-operating device 13 to open the door. With the door completely open, the contact OLSb is opened and the relay 52 is de-energized, so that the relay 51 is again actuated, re-starting the door-closing operation.

The position detecting elements 11 and 121 to 126 are so located as to be engageable with each other when the difference between the cage floor 16 and one of the hall floors 81 to 83 exceeds a predetermined distance. Accordingly, they are engaged also during a normal operation of the car when the difference between the cage floor level 16 and one of the hall floor levels 81 to 83 reaches a predetermined distance and the car is decelerated.

It is well known that an elevator car in deceleration generally runs, opening its door when it reaches the door-open zone just before arrival at a destination service floor. Under this condition, it may be that the position detecting elements 11 and 121 to 126 are engaged with each other and the relay 53 is excited, with a result that the door is forcibly closed, thereby delaying the door-opening operation even at the normal arrival of the car at the destination floor. In such a case, the positions where the position detecting elements 11 and 121 to 126 are located for mutual engagement are set preferably somewhat outside of the door-open zone. By doing so, when the position detecting elements 11 and 121 to 126 are engaged mutually, no "door-open running" command is yet given and therefore the door 9 is still kept closed, so that the contact $61b_2$ is open. As a result, the circuit including P-DRC-$61b_2$-53-N fails to be formed. Hence, the relay 53 is not excited, and therefore the door-opening operation is not delayed at the arrival of the car at the destination floor.

Further, there might be some danger also in a case where the hall door and the cage door are held open until the car departs from the door-open zone, namely, about 300 mm away from a hall floor level. To avoid such a danger, the door may alternatively be closed when the car has moved away from any of the floor levels 81 to 83 by, say, about 250 mm.

In the above-mentioned embodiments, position detecting elements are additionally provided on the car and on the housing. However, various elements for detecting the position of the car conventionally provided at and in the vicinity of the floors and may be used as the position detecting element referred to in the above embodiments, thereby economically eliminating the need for the provision of additional position detecting elements.

Another embodiment with these points in view will be described with reference to Fig. 4 showing a modification of the door control circuit shown in Fig. 3. The circuit of Fig. 4 is identical with that of Fig. 3 except that section X is replaced by section Y in Fig. 4. In Fig. 4, SDP shows a switch for one of the conventional position detecting elements used at the time of car deceleration. Generally, decelerated conditions are detected by detecting element in several stages in the vicinity of each hall floor for a higher degree of accuracy of detection of the position of the car arriving at the floor. In this embodiment, one of the elements in such a stage as to be within a door-open zone. The contact 90a has been closed since generation of a deceleration command signal. When the corresponding position detecting switch SDP is closed, a speed control relay for deceleration such as a speed-down command relay 21 for the last stage is excited, with a result that a predetermined deceleration command is generated, thereby causing the car to decelerate and stop at a corresponding floor. The relay 53, as in the preceding embodiment, is a forcible door-closing command relay energized by the deceleration position detector switch SDP and the contacts OLSa and $61b_2$. In other words, the forcible door-closing relay 53 is energized only when the position detection switch SDP is actuated with the contacts OLSa and $61b_2$ closed or with the door completely opened. If the car enters the door-open zone in normal deceleration for arrival at a floor, the door lock is released and the contact $61b_2$ is closed. At this time, the "door-open running" condition, under which the car runs with its door being opened, starts, and immediately after that, the switch SDP is closed for a short period of time but the door is not yet completely open. Therefore, the forcible door-closing relay 53 is not likely to be energized, and such a trouble as undesirable prevention of the "door-open running condition" is not caused at the time of normal deceleration for arrival at a floor. In the event that the car which has arrived at a given floor slides down with its door held open, the circuit including P-SDP-OLSa-$61b_2$-53-N is formed, so that the relay 53 is energized for forcible door-closing operation. Further, since the door is forcibly closed within the door-open zone, the engaged condition between the cage door 9 and the hall door 102 enables the door-operating device 13 to close both the doors simultaneously, thus further improving the safety of the elevator system.

In the embodiment of Fig. 4, if a deceleration command switch operated outside of the door-open zone is used as the switch SDP, the contact OLSa is not required so that the same operation is achieved as that in the embodiment of Fig. 3.

Further, the above-described position-detecting elements for the open-door zone may be utilized. For example, in place of the deceleration position detecting switch SDP in Fig. 4, a switch may be inserted corresponding to the position detecting elements for the door-open zone. Also in this case, under the "door-open running condition" with the door-open zone detected, the relay 53 is not generally excited. It is excited to close the door only after service of a floor when the level difference between the cage floor and the hall floor exceeds the door-open zone with the cage door held opened.

WHAT WE CLAIM IS:—

1. An elevator safety apparatus for an elevator system including at least one elevator car each serving a plurality of floors each provided with a hall door, the car having a door, the elevator safety apparatus comprising means for detecting a situation in which the car is spaced from a floor level by a predetermined distance,

and means for generating a command signal for closing the door of the car in response to the output from the detecting means irrespective of whether the associated hall door is open or closed.

2. An elevator safety apparatus according to claim 1, in which the detecting means includes a plurality of first detector elements disposed at predetermined positions corresponding to the respective floors in a hoistway, and a second detector element disposed on the car, the arrangement being such that the first detector elements are engageable with the second detector element.

3. An elevator safety apparatus according to claim 1 or 2, further comprising means for detecting a situation in which the door of the car is opened and means for closing the door of the car in response to simultaneous operation of the two detecting means.

4. An elevator safety apparatus according to claim 3, in which the means for detecting the situation in which the door of the car is opened is arranged to detect a situation in which the door is not completely closed.

5. An elevator safety apparatus according to claim 3 or 4, further comprising a relay element actuated in response to the two detecting means, means for holding the operation of the relay element, and a manual switch for clearing the held condition.

6. An elevator safety apparatus according to any of the preceding claims further comprising door operating means mounted on the car for opening and closing the door, door-open zone detector means for detecting a situation in which the car is within a predetermined distance from a floor level, and means for permitting actuation of the door operating means in response to operation of the door-open zone detector means, the first-mentioned car spacing detecting means being arranged so as to be responsive to non-operation of the door-open zone detecting means.

7. An elevator safety apparatus according to any of claims 1 to 5, further comprising door operating means mounted on the car for opening and closing the door, door-open zone detector means for detecting a situation in which the car is within a predetermined distance from a floor level, and means for permitting actuation of the door operating means in response to operation of the door-open zone detector means, the first mentioned car spacing detecting means being arranged so as to be operative within the door-open zone.

8. An elevator safety apparatus according to claim 7, in which the door opening detecting means is arranged so as to operate with a predetermined width of opening of the door.

9. An elevator safety apparatus according to any of the preceding claims, further comprising position detector means provided for each of the floors for controlling the deceleration of the car for arrival at any one of the floors, the first-mentioned car spacing detecting means being arranged so as to be responsive to operation of the position detector means.

10. An elevator safety apparatus substantially as hereinbefore described with reference to the accompanying drawings.

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FIG.1

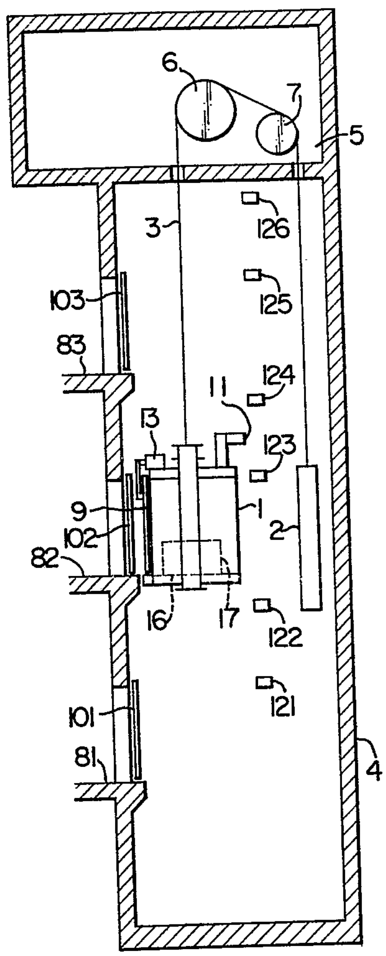

FIG.2

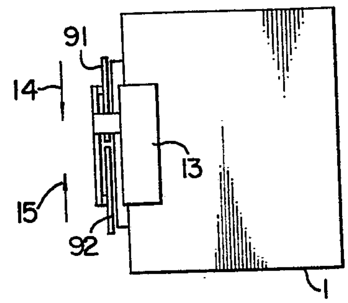
91
14
13
15
92
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FIG.3

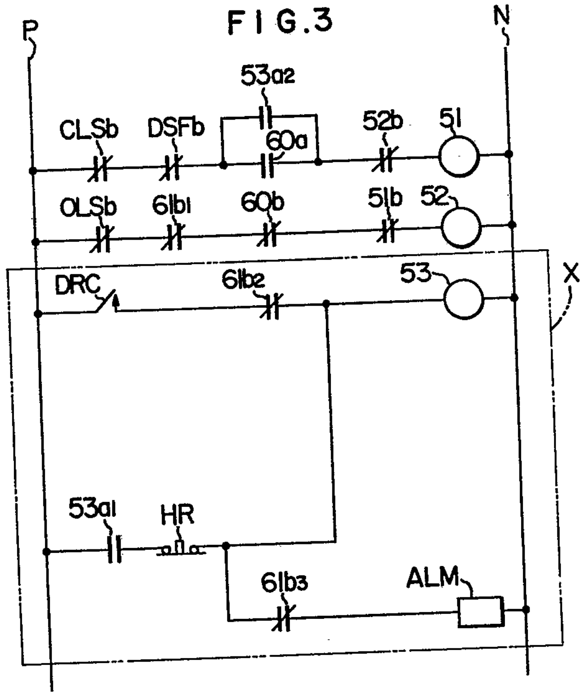
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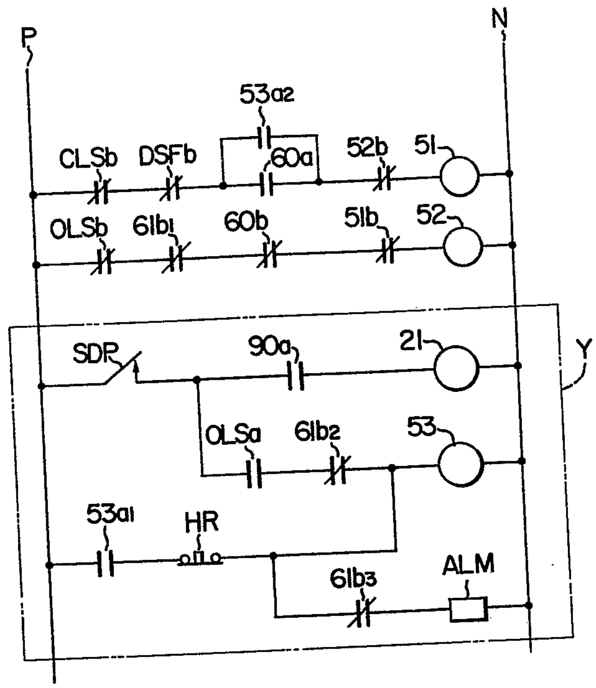
FIG. 4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53
53a1
HR
61b3
ALM