United States Patent [19]

Kirsch

[11] **3,792,759**

[45] **Feb. 19, 1974**

[54] **ELEVATOR SYSTEM**

[75] Inventor: **Andrew F. Kirsch,** Edison, N.J.

[73] Assignee: **Westinghouse Electric Corporation,** Pittsburgh, Pa.

[22] Filed: **Dec. 22, 1972**

[21] Appl. No.: **317,881**

[52] **U.S. Cl.** .... **187/29 R**
[51] **Int. Cl.** **B66b 13/24**
[58] **Field of Search** 187/29

[56] **References Cited**

UNITED STATES PATENTS

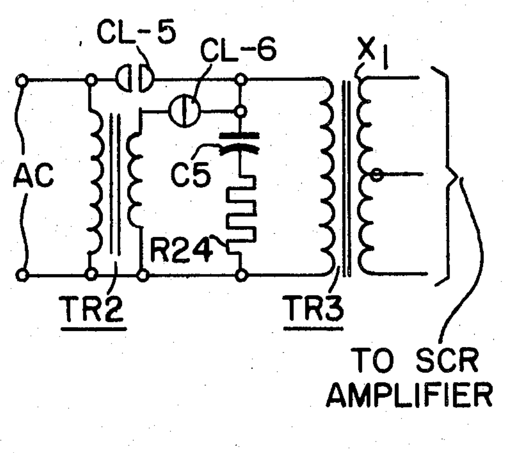
3,726,364 4/1973 Citrin et al. 187/29

Primary Examiner—Bernard A. Gilheany
Assistant Examiner—W. E. Duncanson, Jr.
Attorney, Agent, or Firm—D. R. Lackey

[57] **ABSTRACT**

An elevator system including first and second detectors arranged to modify the elevator control to take a predetermined course of action in the event of an earthquake. The first detector is highly sensitive to acceleration forces applied to the building, and it operates at a predetermined force level, selected to indicate the mere possibility of an earthquake. The first level detector, when actuated, stops the cars at a landing, and opens their doors. The elevator system is automatically put back into service if the second detector is not actuated, a predetermined period of time after the acceleration forces drop below a predetermined level. Operation of the second detector, which may be either responsive to a still higher level of accelerating forces, and/or to some other condition such as a specific type of mechanical damage, shuts the elevator system down and requires authorized personnel to put the system back into operation.

10 Claims, 3 Drawing Figures



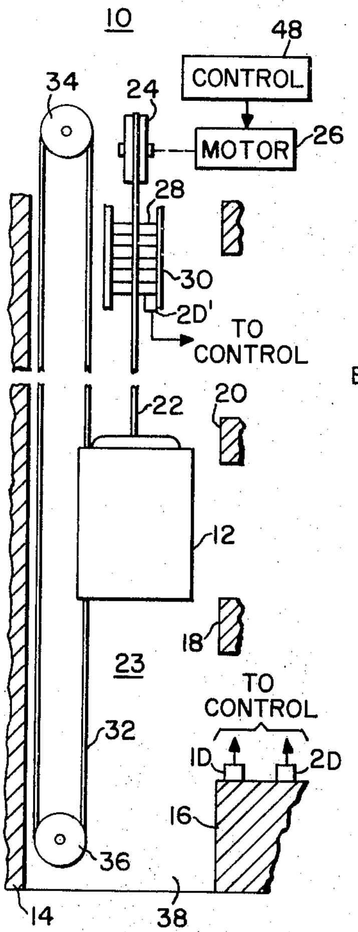


FIG. 1.

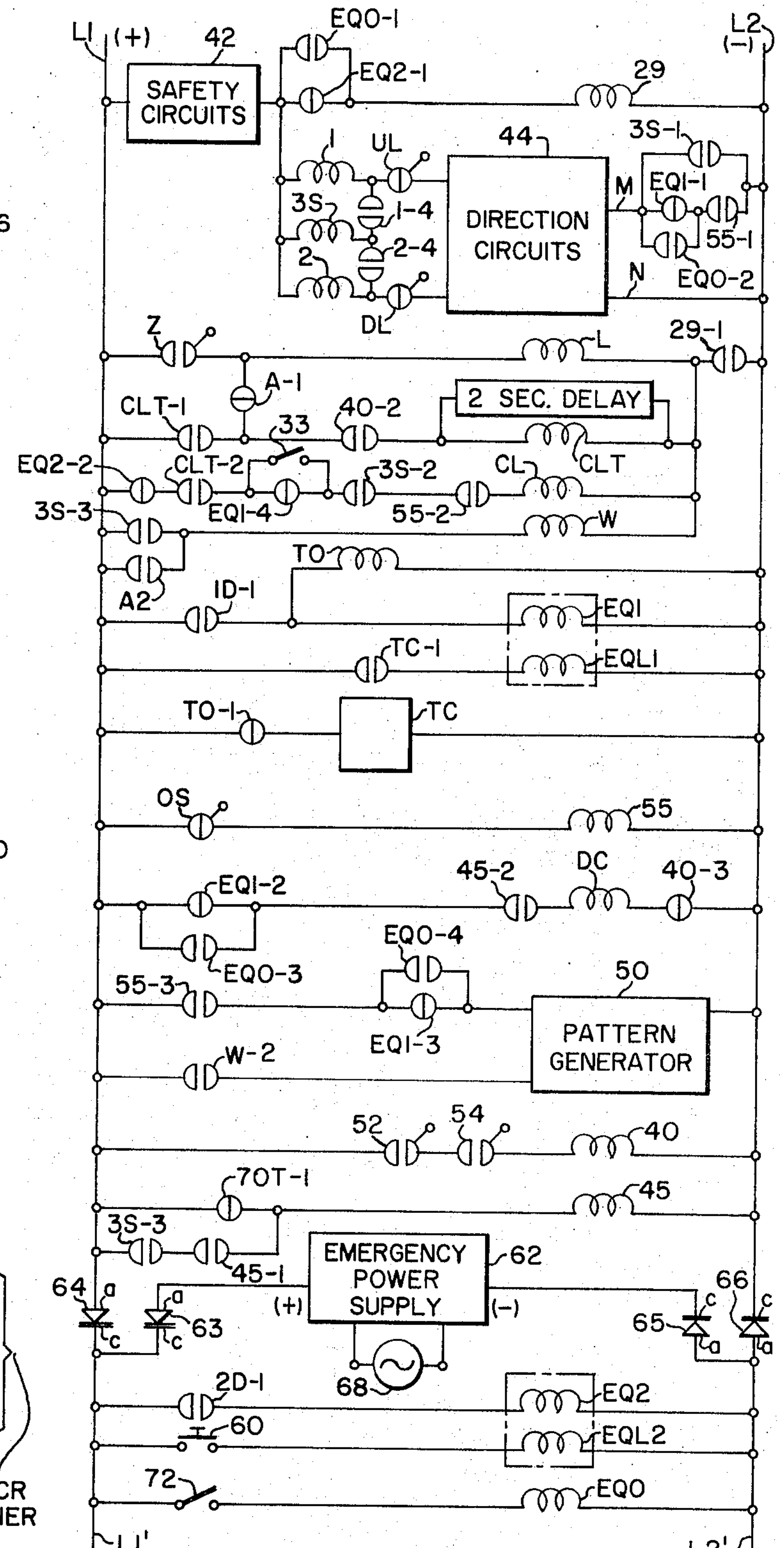


FIG. 2.

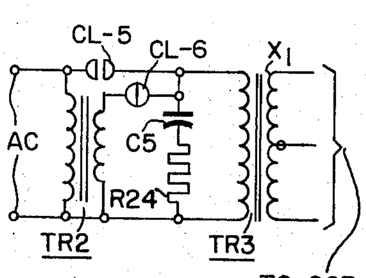


FIG. 3.

ELEVATOR SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates in general to elevator systems, and more specifically to elevator systems which include controls for detecting earthquakes.

Damaging earthquakes are likely to occur in certain well defined earthquake zones of the world. The need for earthquake detectors in certain elevator systems installed in an earthquake zone was recognized after the California earthquake in 1971.

Seismic earthquake detectors for elevator systems have been developed which are used to modify the elevator control to immediately shutdown the elevator system in the event of a significant earthquake. The elevator system may only be put back into operation by authorized maintenance personnel who first check for mechanical damage such as counterweight derailment and displacement of ropes from pulleys, before restarting the system.

SUMMARY OF THE INVENTION

Briefly, the present invention is a new and improved elevator system which may be used in structures located in an earthquake zone. The elevator system includes first and second detectors, selected and arranged to modify the elevator control to make the system highly sensitive to acceleration forces applied to the associated structure, without nuisance service outages which is highly sensitive system would ordinarily promote.

The first detector is actuated when the building is subjected to greater than a first predetermined acceleration force, such as about 0.02g. This level is selected low enough to indicate the mere possibility of an earthquake, to provide a very early warning. The second detector may also be responsive to acceleration forces applied to the building, but it is not actuated unless a significant earthquake is occurring, such as about 0.2 to 0.4g. Actuation of the first detector stops all of the cars at a landing and opens their doors. If the second detector is not actuated, the elevator system is automatically placed back into service a predetermined period of time after the acceleration forces drop below a predetermined magnitude. Thus, the extremely sensitive setting of the first detector does not unduly hamper elevator service. If the second detector is actuated, the elevator system may be immediately shutdown, with the cars being stopped as quickly as possible without regard to their stopped positions relative to the landings. Ordinarily, the cars will already be at a landing with their doors open due to the prior operation of the first detector. However, if the operation of the second detector closely follows the operation of the first detector, the cars may not all be at a landing when the system is shutdown by the second detector. Alternatively, the second detector may be arranged to also stop the cars at a landing. Shutdown of the elevator system upon operation of the second detector enables authorized personnel to inspect for damage before placing the cars back into service. An emergency manually operated override in the car, the location of which may be known and accessible only to authorized personnel, may be provided for buildings, such as hospitals. The

override, when actuated, enables the car to be operated at reduced speed.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be better understood, and further advantages and uses thereof more readily apparent, when considered in view of the following detailed description of exemplary embodiments, taken with the accompanying drawings, in which:

FIG. 1 is a schematic view, in elevation, of an elevator system which may utilize the teachings of the invention;

FIG. 2 is a schematic diagram of elevator control constructed according to the teachings of the invention; and

FIG. 3 is a schematic diagram which illustrates an arrangement for reducing the elevator speed in response to predetermined conditions, which may be used in carrying out the teachings of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings, and FIG. 1 in particular, there is shown an elevator system **10** which may utilize the teachings of the invention. Elevator system **10** includes an elevator car **12** mounted for movement relative to a structure **14** having a plurality of landings, a few of which are indicated generally at **16, 18** and **20.** The elevator car **12** is supported by wire ropes **22** in a hatchway **23,** with the ropes **22** being reeved over a traction sheave **24** mounted on the shaft of a drive motor **26.** A counterweight **28,** guided by rails **30,** is connected to the other end of the rope **22.** A governor rope **32,** connected to the top and bottom of the elevator car **12,** is reeved over a governor sheave **34** located above the highest point of travel in the hatchway **23,** and about a pulley **36** located in the bottom or pit **38** of the hatchway.

The motor **26** drives the sheave **24** in response to elevator control, shown generally at **48.** According to the teachings of the invention, the control **48** is modified by first and second detectors **1D** and **2D**, or **1D** and **2D'**, when the detectors are actuated in response to predetermined conditions.

The first detector is responsive to acceleration forces applied to the structure or building **14,** particularly vertically applied forces, and as such it should be rigidly connected to the building **14,** such as on the floor of a basement landing. The *g* level of the forces applied to the building **14** which will actuate detector **1D** should be selected such that it provides an early indication of the possibility of an earthquake. This level is much lower and thus more sensitive than would be allowable for a detector which shuts the elevator system down with a manual reset remote from the car, such as in the penthouse, as the level will be such that it possibly may be triggered by acceleration forces due to causes other than an earthquake. A level of about 0.02g is an acceptable level, as it would not be reached by minor building disturbances, but it is still low enough that it would provide an early warning of an impending earthquake. This level, however, is merely stated for purposes of example, and is not meant to limit the invention, as other levels maybe used. An acceleration force detector which may be used for detector **1D** is the Kinemetric EST-1 Elevator Seismic Trigger marketed by Kinemetrics of San Gabriel, Calif.

The second detector may be similar to the first detector 1D, except for the g level at which it is actuated. If the second detector is an acceleration force detector, it is referred to as detector 2D, and it may be mounted adjacent to the first detector 1D. The acceleration force level at which detector 2D is actuated is selected to be high enough that its operation indicates a significant earthquake has occurred. A level in the range of about 0.2g to 0.4g may be used, as desired. While detectors 1D and 2D are referred to as being two separate devices, it is to be understood that a single detector which is arranged to provide signals at two different *g* levels may be used.

The second detector may not be related directly to *g* forces applied to the structure, but may be disposed to indirectly indicate such forces by detecting a specific type of mechanical damage to the elevator system. In this event, the second detector is referred to as detector 2D'. In FIG. 1, detector 2D' is illustrated as detecting counterweight derailment, but it may be disposed to detect displacement of ropes from the pulleys, and the like. Also, instead of a single damage detector, a group of damage detectors may be provided to check the most likely areas for damage, the operation of any one of which provides the second detector signal for modifying the elevator control.

The first detector 1D is set to be triggered or actuated by a very low acceleration force, which provides the earliest possible warning of an earthquake, without plaguing the system with undue service outages, as its actuation is not used to shut the system down such that maintenace personnel are required to place the elevator system back into service. Operation of the first detector is used to modify the elevator controls such that all of the cars stop at the closest floor at which they can make a normal stop, and they open the doors at the landing. The stopping of the cars may be made at a reduced speed, if desired. Assuming for the moment, that the second detector was not actuated, once the accelerating forces applied to the building fall below a predetermined level, which level may be the same level at which the detector was actuated, or at a lower level, as desired, timer means is actuated to time out a predetermined time interval, such as thirty seconds. If the acceleration forces do not go above the level of the first detector during this time, the elevator system is automatically placed back into service.

Operation of the second detector shuts the elevator system down, requiring a manual reset by authorized personnel at a point remote from the car, such as in the control room located in the penthouse. If the second detector operates a sufficient period of time after the first detector operates, the cars will all be at a landing with their doors open in response to the first detector. If the second detector operates quickly after the operation of the first detector, or substantially simultaneously therewith, it may be arranged to stop the cars without regard to their stopped positions relative to a landing, as it may not be desirable to operate the cars after the second detector operates, especially if the second detector is responsive to actual damage in the system or, especially when the building does not have an express zone, the operation of the second detector may be arranged to stop the cars at a landing. In certain types of buildings, such as hospitals, it may be more important to move a car to a predetermined landing than the damage that operating the car after actuation of the second detector may cause. In this event, a manually operated override is provided which, when actuated, enables the car to be operated at reduced speed notwithstanding the operation of the first and second detectors. This manually operated override would normally be placed at a location in the car known only to certain personnel, or it may be accessible or operable only by a key.

FIGS. 2 and 3 are schematic diagrams of a portion of an elevator control system embodying the invention. The control of any elevator system may be modified to operate according to the teachings of the invention. For purposes of example, the elevator control disclosed and described in co-pending application Ser. No. 198,199, filed Nov. 12, 1971, in the name of W. Caputo, which application is assigned to the same assignee as the present application, will be used to illustrate the invention. Only the parts of FIGS. 2 and 3 of application Ser. No. 198,199 which are necessary to understand the invention are shown in the present application, as reference may be had to this co-pending application for additional information if required.

The relay contacts in FIGS. 2 and 3 of the present application are identified by hyphenated reference characters. The portion of the reference character before the hyphen identifies the relay with which the contacts are associated, and the number after the hyphen identifies the contacts on the associated relay. All of the relay contacts are shown in their normal position when the relay is deenergized. For example, in FIG. 3, the make contacts CL-5 are open when the relay CL is denergized and closed when the relay is energized. On the other hand, the break contacts CL-6 are closed when relay CL is deenergized and open when the relay is energized.

As an aid to understanding the drawings, the relays and switches are identified as follows:

A - Brake Monitor Relay
CL - Current Limiter Relay
CLT - Current Limiter Delay Relay
DC - Door CLose Solenoid - Closes Doors when Energized
DL - Down Travel Limit Switch
EQ1 - Set Coil For First Level Signal Relay
EQL1 - Reset Coil For First Level Signal Relay
EQ2 - Set Coil For Second Level Signal Relay
EQL2 - Reset Coil For Second Level Signal Relay
EQ0 - Override Relay
L - Pattern Leveling Zone Relay
OS - Overspeed Switch
TC - Timer
TO - Relay
UL - U Travel Limit Switch
W - Pattern Selector Relay
Z - Pattern Leveling Zone Switch
1 - Up Direction Relay
1D - First Level Acceleration Force Detector
2 - Down Direction Relay
2D - Second Level Acceleration Force Detector
2D' - Damage Detector
3S - Running Relay
29 - Safety Circuit Relay
40 - Car Door Relay - Energized Only When Doors Are Closed
45 - Door Control Relay - Controls Opening And Closing Of Doors When Energized And Deenergized, Respectively

55 - Overspeed Relay
70T - Non-Interference Time Relay

The first level signal relay EQ1 includes break contacts EQ1-1, EQ1-2, EQ1-3, and EQ1-4, the second level signal relay EQ2 includes a break contacts EQ2-1 and EQ2-2, and the override relay EQ0 includes make contacts EQ0-1, EQ0-2, EQ0-3, and EQ0-4, which will be hereinafter described.

The safety circuit relay 29 is connected between buses L1 and L2 via the conventional elevator safety circuits, shown generally at 42, and through either the break contacts EQ2-1 of the second level signal relay EQ2, or through the make contacts EQ0-1 of the override relay EQ0. The safety circuit relay 29 has make contacts 29-1 which enable the operaton of relays L, CLT, CL and W.

The up direction relay 1 is connected to be energized through the safety circuits 42, through the upper travel limit switch UL, through the direction circuits 44, which are shown in application Ser. No. 198,199, and through the M or N outputs of the direction circuits 44. The N output, which is only used during leveling, is connected directly to bus L2. The M output is connected to bus L2 either through make contacts 55-1 of the overspeed relay 55 and break contacts EQ1-1 of the first level signal relay EQ1, or through make contacts 3S-1 of the running relay 3S. Contacts EQ1-1 are shunted by make contacts EQ0-2 of override relay EQ0. Thus, when the overspeed relay 55 is energized and relay EQ1 is deenergized, relay 1 may be energized, which picks up the running relay 3S via contacts 1-4. Contacts 3S-1 then close to hold relays 1 and 3S energized despite the opening of contacts EQ1-1 or contacts 55-1. Thus, if the first level signal relay EQ1 is energized and its associated car is not running, the car cannot be started. However, once the car is started with relay EQ1 deenergized, subsequent pick up of relay EQ1 will not drop out relays 1 and 3S.

In like manner, the down direction relay 2 is initially energized through the safety circuits 42, through the down limit switch DL, through the direction circuits 44 and through either contacts 3S-1 or through the serially connected contacts EQ1-1 and 55-1.

The leveling zone relay L is energized when make contacts 29-1 of the safety relay 29 are closed, and switch Z is closed, indicating the car is within the leveling zone of a landing.

The current limit delay relay CLT is energized through contacts 29-1 when the car doors close and the car is stopped at a landing, indicated by contacts 40-2 of the car door relay 40, contacts A-1 of the brake monitor relay A, and leveling zone switch Z all being closed. When relay CLT picks up, its contacts CLT-1 close to maintain relay CLT energized as long as the doors remain closed. Relay CLT also has contacts in the circuit of the current limiter relay CL. It will be noted that relay CLT has a two second delay in drop out, which may be provided with an RC circuit connected across the relay coil.

The current limiter relay CL is energized through contacts 29-1 when relay 55 is energized indicating the overspeed circuit has not been actuated, the running relay 3S is energized, relay EQ1 is deenergized or its contacts EQ1-4 are shunted by a switch 33, the current limiter delay relay CLT is energized, and the second level signal relay EQ2 is not energized, indicated by contacts 55-2, 3S-2, EQ1-4, CLT-2 and EQ2-2 all being closed. Relay CL has make and break contacts CL-5 and CL-6, respectively, connected to reduce the car speed when relay CL is deenergized, as will be hereinafter explained when describing FIG. 3.

The pattern selector relay W is energized through contacts 29-1 when the running relay 3S is energized via contacts 3S-3, and it remains energized until the brake is applied, indicated by contacts A-1 of the brake monitor relay A opening. Relay W has make contacts W2 connected in the circuit of the pattern generator 50.

The pattern generator 50, which is shown in detail in application Ser. No. 198,199, energizes solenoids which lift pawls clear of the floor stops located in the pattern generator. The stop relay (not shown) breaks this circuit when energized to stop the car at a landing. The overspeed relay 55 has contacts 55-3 which opens when relay 55 drops out to drop the pawls and thus stop the car at the closest landing at which the car can make a normal stop. The first level signal relay EQ1 has break contacts EQ1-3 connected to drop the pawls in the pattern generator 50 when relay EQ1 is energized. Contacts EQ1-3 ar shunted by contacts EQ0-4 of the override relay EQ0.

Contacts W-2 of the pattern selector relay are also connected to the pattern generator 50, in the circuit which normally opens when the floor stop of a pattern generator is captured by a dropped pawl. If the safety relay 29 is deenergized, relay W drops to open contacts W-2, which simulates the capturing of a floor stop by a pawl, stopping the car without regard to its location relative to a landing.

The overspeed relay 55 is energized through the overspeed switch OS, which opens at a predetermined percentage of overspeed, such as 10 percent. The overspeed relay has contacts 55-1 in the circuits of relays 1, 2 and 3S, contacts 55-2 in the circuit of relay CL, and contacts 55-3 in the solenoid circuits of the pattern generator 50, as hereinbefore described.

Application Ser. No. 198,199 does not show door circuits, but certain door circuits have been added to FIG. 2 in order to illustrate the effect of the invention on the operation of the car doors. The door circuits shown in FIG. 2 include car door relay 40, door control relay 45, and a door close solenoid DC. The door relay 40 is energized when limit switches 52 and 54 are closed, indicating the car and hatch doors are closed. Door control relay 45 is energized when the non-interference time expires, indicated by contacts 70T-1 closing, and it seals itself in through its contacts 45-1 and contacts 3S-3 of the running relay 3S. Relay 45 controls the opening and closing of the doors via contacts disposed in the door opening and door closing solenoid circuits. The door closing solenoid DC is energized when the doors are open, indicated by contacts 40-3 being closed, the door control relay 45 is energized, indicated by contacts 45-2 being closed, and through break contacts EQ1-2 of the first level signal relay EQ1. Thus, when relay EQ1 is energized, the door solenoid DC will not be energized at the end of the normal non-interference time, and the doors cannot be closed once they are opened at a floor or landing. Contacts EQ1-2 however, are shunted by make contacts EQ0-3 of the override relay EQ0, enabling the doors to be closed notwithstanding the energization of relay EQ1, by energizing the override relay EQ0.

According to the teachings of the invention, the first level signal relay EQ1, which is of the latch type, has a set coil EQ1 and a reset coil EQL1. When coil EQ1 is energized, the relay picks up and maintains the picked up condition until its reset coil EQL1 is energized. Coil EQ1 is connected between conductors L1 and L2 via make contacts 1D-1 of the first level accelerating force detector 1D shown in FIG. 1.

A relay TO is also connected to be energized via make contacts 1D-1 of the first level detector 1D. Relay TO includes break contacts TO-1.

An "on" delay timing relay TC is provided, which is of the type which starts timing a predetermined time interval in response to a contact closure, and at the end of the timed period closes make contacts TC-1. Power removal resets the timer TC.

Reset coil EQL1 of the first level signal relay is connected to be energized through the break contacts TO-1 of relay TO, and make contacts TC-1 of timer TC. Timer TC is connected between buses L1 and L2 via contacts TO-1 of the relay TO. Thus, when the first level detector 1D is actuated to close contacts 1D1, the first level signal relay EQ1 is energized which opens its contacts EQ1-1 to prevent restarting the car once it stops, it opens its contacts EQ1-4 to deenergize relay CL, if switch 33 is open which reduces the car speed via its contacts CL-5 and CL-6 shown in FIG. 3, and it opens its contacts EQ1-3 in the pattern generator circuit 50 to drop the pawls and stop the car at the closest floor at which it can make a normal stop. It will be noted that the reduction of car speed when relay EQ1 operates its optional. Contacts EQ1-2 also open to prevent the doors from reclosing once they open at a landing. If switch 33 is closed the car will run at normal speed to the nearest landing at which it can make a normal stop.

FIG. 3 illustrates a circuit arrangement for reducing the car speed when relay CL drops, which arrangement is shown in detail in application Ser. No. 198,199. It is sufficient for purposes of this application to illustrate that the source of alternating potential applied to the SCR amplifier which generates the field current for the generator, which in turn supplies the voltage for the elevator drive motor 26, is reduced by the dropping of relay CL. When relay CL is energized, make contacts CL-5 connect the alternating current source to the SCR amplifier via a transformer TR3. When relay CL is deenergized, contacts CL-5 open and break contacts CL-6 close to contact transformer TR2 between the source of alternating potential and transformer TR3. Transformer TR2 is a step-down transformer, reducing the magnitude of the alternating potential applied to transformer TR3, which in turn reduces the field current in the generator field winding, resulting in a reduced voltage being applied to the drive motor 26.

Returning to FIG. 2, when contacts 1D1-1 of the first level detector close, relay TO is picked up. When the accelerating forces which triggered the first level detector 1D drop below a predetermined magnitude and contacts 1D-1 open, relay TO drops out to close its contacts TO-1. The opening and reclosing of contacts TO-1 start the timing sequence of timer TC. After the predetermined timing interval of timer TC, such as about 30 seconds, sor example, contacts TC-1 close to energize reset coil EQL1, resetting the first level signal relay EQ1. Thus, contacts EQ1-1 close to enable a direction relay 1 or 2, and running relay 3S, to pick up. Contacts EQ1-4 close which, if manual switch 33 is open, enable relay CL to pick up, assuming the other conditions for energizing relay CL are satisfied. If switch 33 is closed, relay CL is not disabled by relay EQ1 and contacts EQ1-4 have no circuit effect. Contacts EQ1-3 close to pick up the pawls in the pattern generator 50. Contacts EQ1-2 also close, which enables the door close solenoid DC.

The second level signal relay EQ2 is connected between buses L1 and L2 via make contacts 2D-1 of the second level acceleration force detection 2D, or contacts 2D-1 may represent one or more parallel connected make contacts which are responsive to one or more damage detectors, such as damage detectors 2D′ shown in FIG. 1. When the second level detector is actuated, contacts 2D-1 close to energize coil EQ2. The reset coil EQL2 of the second level signal relay is connected to be energized via a pushbutton 60 located outside of the car, such as in the penthouse. Thus, relay EQ2 cannot be reset from within the car, requiring authorized maintenance personnel to reset the relay. Before resetting this relay, however, the maintenance personnel will check the elevator system for possible damage.

Relay EQ2 has break contacts EQ2-1 connected in the circuit of the safety relay 29. When contacts EQ2-1 open, relay 29 drops out, opening its contacts 29-1. Relays L, CLT, CL and W all drop out, and contacts W-2 in the speed pattern generator circuit 50 open to stop the elevator car without regard to its stopped location relative to a landing. Relay EQ2 also has break contacts EQ2-2 in the circuit of relaY CL, the purpose of which will be hereinafter explained. If it would be desirable to stop the cars at landings when relay EQ2 operates, contacts EQ2-1 and EQ0-1 would not be required, but relay EQ2 would require break contacts connected in series with contacts EQ1-1, and break contacts connected in series with contacts EQ1-3. Contacts EQ0-2 would thus shunt contacts EQ1-1 and the contacts from relay EQ2, and contacts EQ0-4 would shunt contacts EQ1-3 and the contacts from relay EQ2.

As illustrated in FIG. 2, an emergency power supply 62, such as a battery and a battery charger, may be connected to buses L1 and L2 via diodes 63, 64, 65 and 66, to insure a power supply for relay EQ2. Diode 64 has its anode electrode a connected to the bus L1 and the anode electrode a of diode 63 is connected to the positive output of power supply 62. The cathode electrodes *c* of diodes 63 and 64 are connected together and to a bus which may be called bus L1′. Diode 66 has its cathode electrode *c* connected to bus L2, the cathode electrode *c* of diode 65 is connected to the negative terminal of power supply 62, and the anode electrodes a of diodes 65 and 66 are connected together and to a bus which is referred to as bus L2′. Relay EQ2 is connected between buses L1′ and L2′. The power supply 62 may be maintained in a charged condition by connecting the battery charger to a source 68 of alternating potential.

In certain types of buildings it may be necessary to operate an elevator car notwithstanding possible damage to the system by an earthquake which caused the operation of the second level signal relay. For example, in a hospital, it may be of the utmost importance to be able to move a car which stopped due to the operation of the second level detector relay while transporting a critically ill or injured patient to a predetermined floor for treatment or surgery. If this function is essential, an override relay EQ0 is provided having a manually operated switch 72 located within the car. The location of the switch would normally only be disclosed to certain personnel. Relay EQ0 includes make contacts EQ0-1 which shunt contacts EQ2-1, to enable safety relay 29 to be energized. It also includes make contacts EQ0-2, EQ0-3 and EQ0-4 which shunt contacts EQ1-1, EQ1-2, and EQ1-3, respectively. Contacts EQ0-2, when closed, enable the car to run. Contacts EQ0-3, when closed, enable the car doors to be closed. Contacts EQ0-4, when closed, enable the floor stop pawls to pick up.

Break contacts EQ2-2 are connected in the circuit of relay CL, to prevent relay CL from being energized after relay EQ2 has been triggered. Thus, the elevator car will operate at reduced speed when the second level signal relay EQ2 is overriden by energizing the emergency override relay EQ0.

In the operation of the elevator system 10 according to the teachings of the invention, it will first be assumed that only the first level detector 1D is triggered. Relay EQ1 is picked up and latched in, opening its contacts EQ1-1, EQ1-2, EQ1-3 and EQ1-4. The opening of contacts EQ1-1 have no effect on a running car, but they prevent restarting of the car once it stops at a landing. The opening of contacts EQ1-3 in the circuit of the pattern generator 50 stops the car at the closest landing at which it can make a normal landing, if it is not already at a landing, by dropping the pawls to engage the next floor stop. Running relay 3S drops when the car is within a predetermined zone adjacent the landing, contacts 3S-3 open and door control relay 45 drops to energize the door open solenoid (not shown). The doors now remain open as long as contacts EQ1-2 in the door close solenoid circuit, which includes solenoid DC, are open. When contacts 1D-1 close, they also energize relay TO. When the acceleration forces which triggered detector 1D drop below a predetermined magnitude and contacts 1D-1 open, relay TO closes its contacts TO-1 to start timer TC. When timer TC times out and closes its contacts TC-1 for a predetermined short period of time, the reset coil EQL1 is actuated to reset the first level signal relay EQ1.

If the second level detector 2D, or 2D′, is actuated a sufficient period of time following the actuation or triggering of detector 1D, all of the cars will be at a landing when the system is shutdown by the dropping out of relay 29. If relay EQ2 is triggered substantially simultaneously with the triggering of relay EQ1, or sufficiently close thereto, and relay EQ2 has contacts in the safety relay circuit which are effective, i.e., contacts EQ2-1, one or more of the cars may not be at a landing when the system is shutdown. Once relay EQ2 is actuated, it would not usually be advisable to run the cars any further than necessary. Therefore, the 29 relay circuit is used to stop the cars without regard to their location relative to a landing. However, as hereinbefore stated the second level signal relay may have its contacts connected to stop the cars at a landing in the same manner as relay EQ1. An override relay EQ0 may be provided for moving a car, or cars, at reduced speed to a landing, when the nature of the use of the building is such that certain emergency conditions may dictate the movement of an elevator car after an earthquake.

In summary, there has been disclosed a new and improved elevator system which is highly sensitive to the possibility of an earthquake, without incurring nuisance shut downs which requires authorized personnel to place the elevator system back in service. The elevator system includes a two level detector arrangement, with the first level detector being highly sensitive to acceleration forces applied to the building, and the second level detector may be responsive to higher acceleration forces, or to other conditions, such as predetermined damage in the system. Operation of the first detector, without operating the second detector, causes only a momentary delay in elevator service, as the cars are all brought to a landing, and their doors are opened. If the acceleration forces which triggered the first detector drop below a predetermined magnitude for a predetermined period of time, without the second level detector being triggered, the elevator system is automatically put back into operation. If the second level detector is actuated, the elevator system is then shutdown, as the possibility of damage to the elevator system is very great, and may be placed back into operation only by authorized personnel. The invention also features an emergency override arrangement, which in certain instances allows the operation of the second detector to be overriden to move the cars, when the use of the building is such that movement of an elevator car after an earthquake is more important than the possible damage which car movement may cause to the system.

I claim as my invention:

1. An elevator system comprising:

a structure having a plurality of landings,

an elevator car mounted for movement relative to the structure,

first control means for starting, moving and stopping said elevator car to serve the landings,

and second control means for modifying the operation of said first control means in response to predetermined conditions,

said second control means including:

a. first detector and signal means for modifying said first control means to stop said elevator car in response to predetermined acceleration forces applied to said structure,

b. second detector and signal means for modifying said first control means to stop said elevator car in response to a predetermined condition which indicates further operation of said elevator car may be hazardous, and

c. timer means actuatable in response to said first detector and signal means which, in the absence of an operation by said second detector and signal means, automatically enables restarting of the elevator car a predetermined period of time after the detected acceleration forces have dropped below a predetermined magnitude.

2. The elevator system of claim 1 wherein the elevator car includes doors operable by the first control means, and wherein the first detector and signal means modifies the first control means to stop the elevator car at a landing and to prevent the elevator doors from closing when the elevator car stops at a landing and opens its doors due to said first detector and signal means, at least until the operation of the timer means enables restarting of the elevator car.

3. The elevator system of claim 1 wherein the first detector and signal means modifies the first control

means to stop the elevator car at the closest landing that it can make a safe stop.

4. The elevator system of claim **1** wherein the second detector is responsive to predetermined acceleration forces applied to said structure, which predetermined acceleration forces are greater than the predetermined acceleration forces which actuate the first detector and signal means.

5. The elevator system of claim **4** wherein the predetermined acceleration forces to which the first and second detector and signal means are responsive to are about 0.02g and 0.4g, respectively.

6. The elevator system of claim **1** wherein the second detector and signal means is responsive to mechanical damage suffered by the elevator system, and wherein the second detector and signal means modifies the first control means to stop the elevator car without regard to whether its stopped position is in registry with a landing.

7. The elevator system of claim **1** including a counterweight mounted for movement in guide means, and means interconnecting the elevator car and said counterweight, wherein the second detector is responsive to dislocation of the counterweight relative to the guide means.

8. The elevator system of claim **1** wherein the second detector and signal means includes relay means actuatable from a first to a second condition when the predetermined condition it is responsive to is detected, and including manually operable reset means disposed remotely from the elevator car for resetting the relay means to its first condition.

9. The elevator system of claim **8** including manually operable override means located within the elevator car which modifies the first control means to enable operation of the elevator car at reduced speed notwithstanding the relay means of the second detector and signal means being in its second condition.

10. The elevator system of claim **1** including emergency power supply means for operating said second detector and signal means.

* * * * *