

[54] ELEVATOR SYSTEM

[75] Inventor: James Lowry, Maplewood, N.J.

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

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[51] Int. Cl. .... B66b 13/14

[58] Field of Search ..... 187/51, 52, 56; 49/31, 49/138

[56] References Cited

UNITED STATES PATENTS

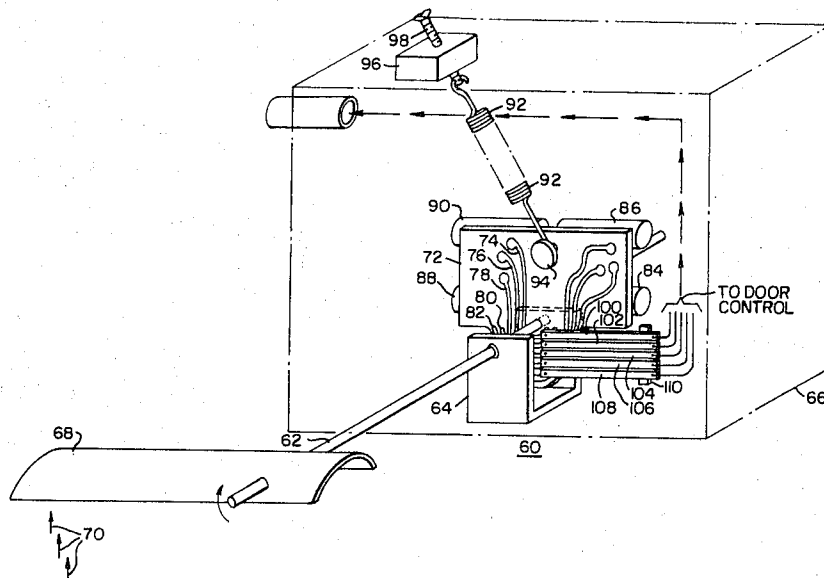
2,992,818 7/1961 Berkovitz et al. .... 49/138

Primary Examiner—Evon C. Blunk  
Assistant Examiner—James L. Rowland  
Attorney, Agent, or Firm—D. R. Lackey

[57] ABSTRACT

An elevator system including an elevator car having doors operable to a closed position according to a predetermined force pattern, and force modifying apparatus which increases the magnitude of the predetermined force pattern in response to the velocity of wind in the hoistway which applies a drag to the closing doors, to overcome the drag and close the doors without exceeding a predetermined resultant closing force.

7 Claims, 5 Drawing Figures





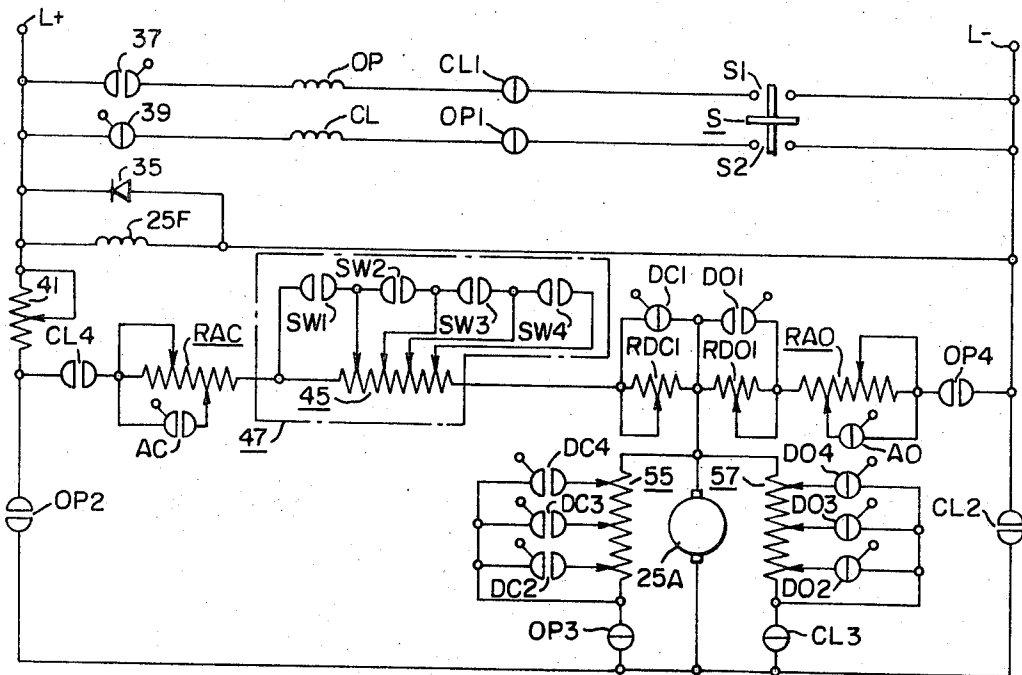


FIG. 2

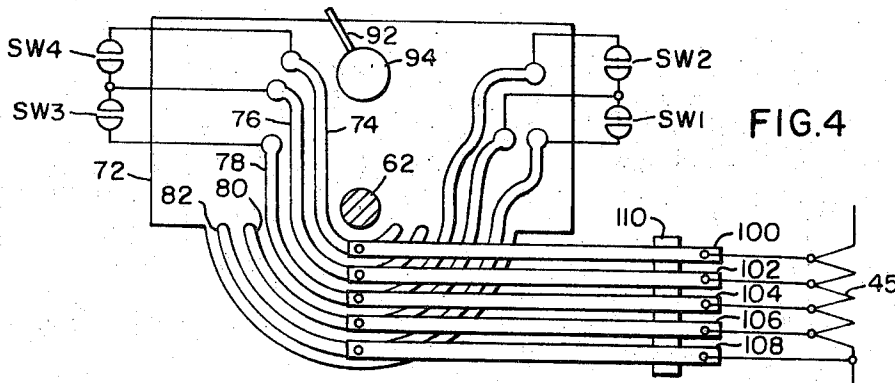


FIG. 4

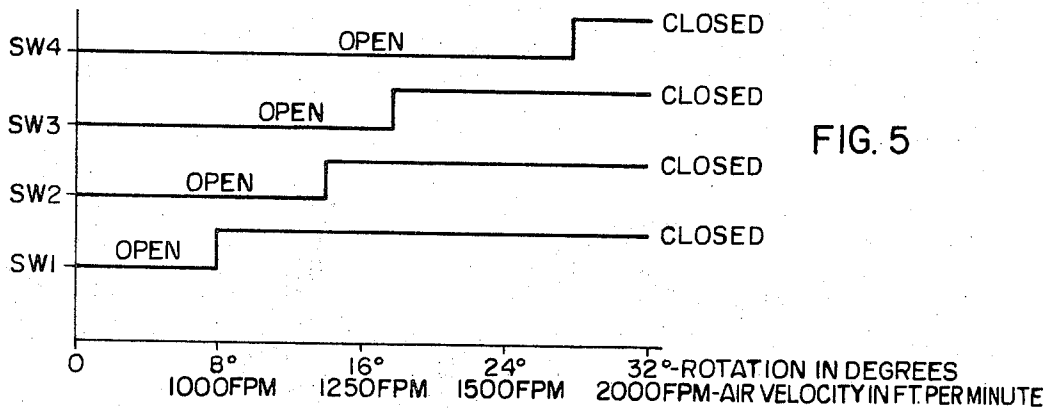
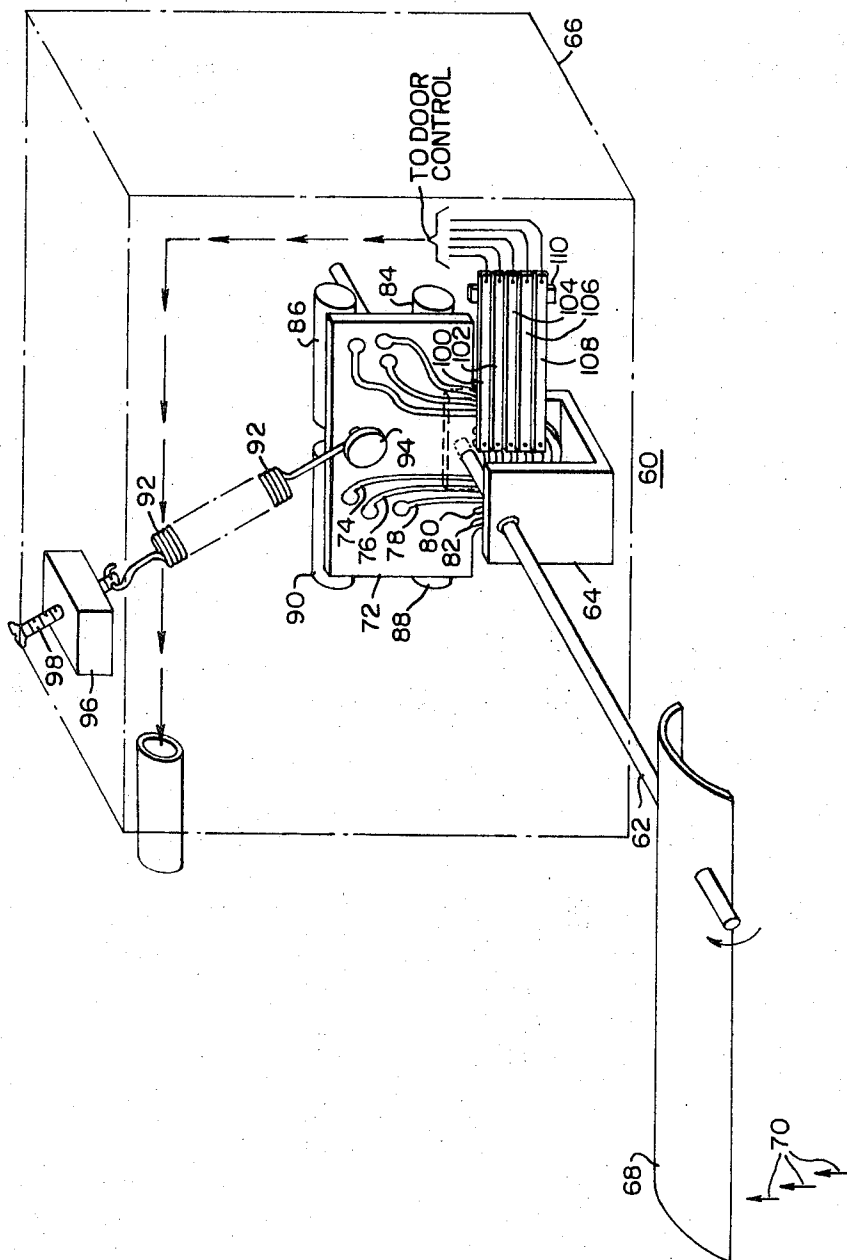


FIG. 5

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 closure or door control for elevator systems.

## 2. Description of the Prior Art:

U.S. Pat. No. 2,992,818, which is assigned to the same assignee as the present application, discloses a closure control mechanism for elevator systems which provides a predetermined force pattern to the car and hatch doors. The closure control reduces the closing force applied to the elevator car door at predetermined deceleration or check points, and if the door does not fully close within a predetermined period of time following the final check point, an additional closing force is provided to close the door.

In high rise buildings, considerable drag is applied to the car and hatch doors, which opposes the closing force applied to the doors, at floors which have an opening to the outside of the building, such as at the main or lobby floor. This drag is due to the air rushing into the hoistway when the elevator car is located at this main or lobby floor with its car and hatch doors open, due to "chimney effect." The higher the velocity of the air entering the hatch door opening and proceeding up the hoistway between the elevator car and the open hatch door, the more drag applied to the doors upon the closing thereof. On extremely windy days, the drag may exceed the magnitude of the closing force applied to the doors, and the doors will not close completely. The hereinbefore mentioned U.S. Pat. does not solve this wind drag problem, as the anti-stall feature of this patent is effective only when the door is close to near fully closed position. The closing doors may stall at positions prior to the point at which the anti-stall feature of the hereinbefore mentioned patent is activated.

Permanently increasing the magnitude of a certain portion of the force pattern used to close the doors of the car and hatchway, to accommodate the greatest magnitude of drag due to wind which may be encountered, is not an acceptable solution to the problem. The resultant closing force, i.e., the force applied to the door less drag, must not exceed a predetermined magnitude, which magnitude is set by safety codes. For example, Rule 112.3a of the American Standard Safety Code for Elevators, ANSI A17.1-1971, states that "the force necessary to prevent closing of a horizontally sliding car door or gate from rest shall be not more than 30 pounds." Thus, to increase the force pattern to the value necessary to close the car and hatch doors on an extremely windy day, would cause the resultant closing force to exceed acceptable limits on a calm day.

## SUMMARY OF THE INVENTION

Briefly, the present invention is a new and improved elevator system, and closure control mechanism therefor, which solves the wind drag problem without increasing the resultant closure force of the car and hatch door beyond an acceptable limit. Control means is provided for developing an acceptable force pattern for closing the car and hatch doors when there is little or no drag on the doors due to wind. The control means also includes force modifying means which modifies the force pattern in response to wind velocity in the

hatchway. When the doors are fully open, the wind velocity is sensed and the force pattern is modified, if necessary, to increase the force applied to the doors by an amount proportional to the velocity of the wind entering the hatchway from the landing at which the car is located. As the doors start to close, the wind velocity increases due to the venturi effect and the amount of force modification is increased. As the doors approach their fully closed position, the drag due to wind is reduced because the wind velocity is decreased and the amount of force modification is reduced, preventing the predetermined acceptable force limit from being exceeded, and preventing objectionable slamming.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be better understood, and further advantages of 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 an elevational view, with portions broken away, of an elevator system having a closure constructed according to the teachings of the invention;

FIG. 2 is a schematic diagram of an electrical control system for operating the closure shown in FIG. 1;

FIG. 3 is a perspective view, shown partially in phantom, of force modifying means which is responsive to wind velocity, which may be used to practice the teachings of the invention;

FIG. 4 is a partially schematic view of a portion of the force modifying means shown in FIG. 3, which more clearly illustrates its structure and function; and

FIG. 5 is a graph which illustrates the operation of the force modifying means shown in FIG. 3.

## DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings, and FIG. 1 in particular, there is shown an elevator system 1 which may utilize the teachings of the invention. Elevator system 1 is illustrated as being of the traction type, having an elevator car 2 and a counterweight 3 interconnected via hoisting roping 4 reeved over a traction sheave 5. Drive means 12 is connected to sheave 5, to move the car 2 and counterweight 3 in guided paths up and down the hoistway of an associated structure or building to enable the elevator car 2 to serve the landings therein.

The elevator car 2 includes a door 6 for opening and closing an elevator car entranceway 7 through which load may enter and leave the car. The elevator car door 6 may be of any desired conventional construction, such as a center-opening or a side-opening door or a double or a single door. For purpose of illustration, it will be assumed that the door is a center-opening door mounted for horizontal sliding movement.

A door operator mounted on the elevator car is employed for opening and closing the car door to expose and to close the entranceway 7. Such an operator is shown in FIG. 1 and now will be described

The center-opening car door 6 comprises two sections 8 and A8. In FIG. 1 the door is shown in its fully open position. A number of similar components are employed for the door sections 8 and A8. Insofar as is practicable, a component for the door section A8 which is similar to a component for the door section 8 will be identified by the same reference numeral as is employed for the corresponding component associated with the door section 8 prefixed by the letter A.

The door section 8 is provided with a door hanger 9 on which door hanger wheels 10 are mounted for rotation. The door hanger wheels for the door sections 8 and A8 are positioned for movement along a horizontally-mounted track 11 in a conventional manner. The track 11 is secured to the elevator car by any suitable means.

Movement of the door section 8 is effected by a lever 13 pivotally mounted on the elevator car by means of a pin 15. The lower end of the lever 13 is pivotally connected to one end of a link 17, the other end of the link being pivotally connected to the door section 8. The lever 13 is coupled to the lever A13 by a link 19, the ends of which are pivotally attached to the levers 13 and A13 by pivots 21 and A21, respectively. The pivot 21 is positioned above the pin 15, whereas the pivot A21 is located below the pin 15. Consequently, rotation of the lever 13 to close the door section 5 moves the link 19 in the proper direction to close the door section A5.

The lever 13 preferably is operated by a suitable door operator 23 which may include a reversible electric motor 25 coupled through suitable gearing to a shaft 27. Shaft 27 carries an arm 29 which is pivotally connected to one end of a link 31, the remaining end of the link 31 being pivotally connected to the lever 13. Consequently, the motor 25 may be energized in a conventional manner for the purpose of opening and closing the door sections 8 and A8. When the door 6 is to be opened, the motor 25 is operated to rotate the arm 29 in a clockwise direction to the position shown in FIG. 1. In order to reclose the door, the electric motor is reversed.

A control assembly 33 is mounted on the elevator car adjacent the motor 25. Positive driven contact cams located in the control assembly 33 control the rate of acceleration and deceleration of the door 6 as will be described below. The control assembly also houses control contacts and control resistors. The contact cams are keyed to the gearing associated with the motor 25 and operate the control contacts for predetermined distances of travel of the arm 29 to vary motor armature circuit resistance, thus controlling the door's rate of acceleration and of deceleration. Each cam is symmetrical and operates two spring-closed contacts, one contact being located on each side of the cam. For each direction of door movement, a separate and identical set of contacts is actuated, one for the opening movement of the door, the other for the closing movement of the door. Such arrangement is well known in the art.

In order to illustrate suitable operation of the door controller 33, a schematic control diagram is shown in FIG. 2. In this diagram, the armature 25A and the field winding 25F of the door operating motor 25 (FIG. 1) are illustrated. Electrical energy for the control circuits is derived from a pair of direct-current busses L+ and L-. It will be observed that the motor field winding 25F is connected directly across the busses L+ and L-. In parallel with the field winding 25F is a rectifier 35 of a conventional type, such as silicon. Current flows through the rectifier 35 in the direction indicated by its circuit symbol in FIG. 2. Thus the rectifier 35 provides a path for induced current as a result of the collapse of the motor field winding's magnetic field in the event that power is removed from the busses L+ and L-.

The motor 25 is energized to open or to close the car door by operation of a switch S. Although this may be a manually operated switch, in a preferred embodiment of the invention this switch represents the contacts of a relay or relays employed in any conventional door operating system to initiate an opening or a closing operation of the door. Thus, movement of the operating member of the switch S up, as viewed in FIG. 2, to close its contacts S1 completes, with a limit switch 37 and break contacts CL1 of a door closing relay CL, a circuit connecting a door opening relay OP across the busses L+ and L- for energization. The limit switch 37 is opened as the door arrives at its fully open position by a cam located in the control assembly 33.

Movement of the operating member of the switch S down results in closure of its contacts S2 to complete, with a limit switch 39 and break contacts OP1 of the door opening relay OP, a circuit connecting the door closing relay CL across the busses L+ and L- for energization. The limit switch 39 is opened as the door arrives at its fully closed position by a cam located in the control assembly 33.

The break contacts CL1 prevent energization through of the door opening relay OP when the door closing relay CL is energized. The break contacts OP1 operate in a similar manner in the circuit of the door closing relay CL. By inspection of FIG. 2, it will be seen that also associated with the relay OP are make contacts OP2 and OP4 and break contacts OP3. Associated with the relay CL are make contacts CL2 and CL4 and break contacts CL3. These contacts control energization of the motor armature 25A, the circuits for energization of the armature being located in the lower portion of FIG. 2.

Associated with the armature 25A are a plurality of adjustable resistors and a plurality of cam-operated control contacts for controlling acceleration and deceleration of the motor 25. These resistors and contacts, together with the contact cams for the latter, are located in the control assembly 33 as above described.

It will be noted that the adjustable resistor 41 is disposed in series circuit relationship with the armature 25A in the bus L+. The remainder of the adjustable resistors associated with the armature 25A bear identifying symbols which are indicative of their functions. Thus, the adjustable resistor RAC is employed to effect acceleration of the motor during a door closing operation while the adjustable resistor RAO is employed for accelerating the motor during door opening movement. Similarly, the resistor RDC1 is used for decelerating the motor and thereby the door during a door closing movement while the adjustable resistor RDO1 effects deceleration of the motor during door opening movement. Likewise, the cam operated control contacts bear identifying symbols which are indicative of their control functions. For example, the contacts AC and AO are effective for accelerating the door during closing and door opening movements, respectively. The contacts DC1 through DC4 effect deceleration of the door during door closing movement and operate sequentially in the order of their suffix numerals. The contacts D01 through D04 in sequence similarly control door deceleration during a door opening operation.

It will be noted that an adjustable resistor 45 is connected in series between resistor RAC and resistor RDC1, and that contacts SW1, SW2, SW3 and SW4

are connected such that each contact, when closed, shorts a predetermined portion of resistor 45. The adjustable arms of resistor 45 are set or adjusted such that as contacts SW1 through SW4 close in sequence, the closing of each contact will short out a predetermined portion of resistor 45 and add it to any portion shorted out by a previously closed contact. The contacts SW1 through SW4 are responsive to the velocity of the wind in the hoistway, as will be hereinafter explained. For the present, it is sufficient to state that contact SW1 closes when the wind velocity reaches a predetermined magnitude, such as 1,000 feet per minute, contact SW2 closes when the wind velocity reaches a predetermined higher magnitude, such as about 1,200 feet per minute, contact SW3 closes when the wind velocity reaches a predetermined higher magnitude, such as about 1,400 feet per minute, and contact SW4 closes when the wind velocity reaches a predetermined still higher magnitude, such as about 1,880 feet per minute. The operation of these contacts at these wind velocities is illustrated graphically in FIG. 5. The contacts SW1 through SW4 and adjustable resistor 45 provide a force modifying means 47 for modifying the conventional closing force pattern in response to wind velocity in the hoistway.

In order that the invention may be fully understood, typical door operations now will be considered. The conditions of various control contacts and limit switches in FIG. 2 are shown as they appear in actual operation when the door is in its fully open position, as is illustrated in FIG. 1. It first will be assumed that the operating member of the switch S is moved down as viewed in FIG. 2. Closure of the switch contacts S2 results in energization and pickup of the door closing relay CL since the limit switch 39 is in closed condition. Pickup of the relay CL results in opening of its break contacts CL1 and CL3 and closure of its make contacts CL2 and CL4. Closure of the make contacts CL2 and CL4 results in energization of the armature 25A of the motor 25 through the following circuit:

L+, 41, CL4, RAC, 45, RDC1, 25A, CL2, L-

Opening of the break contacts CL3 prevents the flow of current through the adjustable resistor 57.

Energization of the armature 25A results in counterclockwise rotation of the shaft 27 (FIG. 1) to initiate closing movement of the door sections 8 and A8. The resistor 41 is adjusted to control the over-all speed of the motor during door opening and door closing movements. The adjustable resistor RAC has an arm which is adjusted to control the initial torque developed by the motor 25. As the door begins to close, the contact cam associated with the control contacts AC closes the contacts AC to short out a portion of resistor RAC. Since the total resistance in series with the armature 25A now has decreased, armature current increases to accelerate the motor 25 and thereby the door sections 8 and A8. An arm of the resistor RAC is adjusted to control the magnitude of this acceleration.

As the door sections continue to move, the control contacts DC1 are opened by their associated contact cam to insert a portion of the adjustable resistor RDC1 in series with the armature 25A. Armature current thus decreases to decelerate or check the motor and thereby the door sections. The resistor RDC1 is adjusted to obtain the desired amount of deceleration at this point.

Further movement of the door and operation of contact cams and their associated control contact re-

sults in the sequential closing of the control contacts DC2, DC3 and DC4 to short out portions of the adjustable resistor 55. Since the resistor 55 is in parallel with the armature 25A, the sequential shorting out of various portions thereof results in the shunting of the armature by successively lower resistances. As the total resistance shunting the armature decreases, more current is drawn away from the armature through the shunt path, resulting in increased deceleration of the motor and thereby of the door sections 8 and A8. The arms of the resistor 55 are adjusted to obtain the desired magnitude of deceleration of the door sections at each deceleration or check point, as determined by operation of the control contacts DC2, DC3 and DC4.

The value of resistor 45 and the setting of resistor RAC are selected to provide the proper value of initial closing force on the doors when there is little or no drag on the doors due to wind. When the wind velocity past the doors is sufficient to exert considerable drag on the doors, such as might be caused by an air velocity of 1,000 feet per minute, contact SW1 closes to short out a portion of resistor 45, increasing the armature current through armature 25A, and increasing the closing force applied to the doors. A higher air velocity will short out still more of resistor 45, as shown in FIG. 5. As the doors close and reduce the size of the opening 7, the wind velocity will decrease and the closed switches will reopen in reverse order to their closing sequence, again as illustrated in FIG. 5, to reinsert resistance into the armature circuit and reduce the closing force applied to the doors in response to the drop in wind velocity past the doors. Thus, the wind drag is compensated for without ever compensating, which over compensation might increase the actual closing force of the doors above the code limit. The normal decelerating contacts DC1 through DC4 will then close in sequence to slow the doors as they reach their fully closed position. The anti-stall feature of U.S. Pat. No. 2,992,818, although not shown in FIG. 2, may be used if desired to insure full closure of the doors.

Since the invention is concerned with door closing, and since the door opening control contacts and adjustable resistors associated with the armature 25A are in all respects symmetrical with the door closing control contacts and adjustable resistors associated therewith, except a counterpart of resistor 45 is not used in the door opening circuit, it is unnecessary to describe them in detail.

FIG. 3 is a perspective view, shown partially in phantom, of a wind responsive device 60 which may be used to change the portion of resistor 45 connected in the armature circuit of motor 25 in response to wind velocity in the hoistway.

Device 60 includes a shaft 62 mounted for rotation about its longitudinal axis such as on the outwardly extending arms of a U-shaped bracket or support member 64. Support member 64 is disposed within an enclosure 66, shown in phantom, with one end of shaft member 62 extending outwardly from the enclosure 66 through a suitable opening therein. A vane 68 is fixed to the end of shaft 62 which is outside enclosure 66. Vane 68 is oriented such that its longitudinal axis is substantially horizontal when there is little or no upward flow of air against the underside of vane 68. The underside of vane 68 may be concave in cross-section, as illustrated in FIG. 3, to increase its responsiveness to upward air flow, indicated by arrows 70. The shaft 62

is fixed to the vane 68 near one end thereof, such that clockwise rotation of vane 68 about the longitudinal axis of shaft 62 results in angular or rotational movement of shaft 62 in direct response to the velocity of the air flow.

A printed circuit board 72 is securely fixed to shaft 62, such as between the upwardly extending spaced extensions of the U-shaped support member 64. One side of the board 72 has printed thereon a plurality of spaced, arcuate electrically conductive surfaces 74, 76, 78, 80 and 82. FIG. 4 is an elevational view of the board 72, which more clearly illustrates the electrically conductive surfaces disposed thereon. Four mercury switches 84, 86, 88 and 90 are fastened to the side of board 72 which is opposite to the side on which the electrically conductive surfaces are disposed. Mercury switches 84, 86, 88 and 90 have contacts SW1, SW2, SW3 and SW4, respectively, shown in FIGS. 2 and 4, which close and open as the position of its associated mercury switch is changed. Mercury switches 84, 86, 88 and 90 are oriented on the board 72 such that each operates its contacts at a different angular position of the board 72. For example, as shown in FIG. 5, switch 84 may be oriented to close its contact SW1 when the board rotates 8° from its "at rest" position, switch 86 may be oriented to close its contact SW2 at the 14° position, switch 88 may be oriented to close its contact SW3 at the 21° position, and switch 90 may be oriented to close its contact SW4 at the 28° position, corresponding to different velocities of air movement past the vane 68.

The board 72 is biased to a predetermined "at rest" position when there is no air flow past the vane, such as by utilizing a tension spring 92 which is disposed between a post 94 on the board 72 and a mounting block 96 fixed to the enclosure 66. The distance between the block 96 and the post 94 may be made adjustable by disposing a screw 98 through the block 96 and disposing one end of the spring 92 through an opening disposed in the end of the screw. Thus, the other end of the spring 92 may be removed from post 94, and the screw 98 turned to lengthen or shorten the amount of spring extension, and then reattach the spring to the post 94, to achieve the desired bias. A counterbalancing weight with an adjustable torque arm may be used as the bias means, instead of the tension spring, if desired.

Electrically conductive, spring-like fingers 100, 102, 104, 106 and 108 are mounted on an insulating post member 110 and biased against the electrically conductive surfaces 74, 76, 78, 80 and 82, respectively. Contact SW1 of switch 84 is electrically connected between surfaces 80 and 82, contact SW2 of switch 86 is electrically connected between surfaces 78 and 80, contact SW3 of switch 88 is electrically connected between surfaces 76 and 78, and contact SW4 of switch 90 is electrically connected between surfaces 74 and 76. The contact fingers rest against the arcuate electrically conductive surfaces as the board 72 rotates about the longitudinal axis of shaft 62, maintaining electrical contact therewith through the rotational range of board 72.

The electrically conductive contact fingers 100, 102, 104, 106 and 108 are each connected to a different electrical conductor, and the electrical conductors are connected to different adjustable arms of resistor 45 in the door control. FIG. 4 schematically illustrates the

connection of the contact fingers to resistor 45, as well as schematically illustrating the connection of the electrically conductive surfaces on board 72 to the contacts of the switches 84, 86, 88 and 90.

Wind responsive device 60 is mounted on the elevator car 2 in a position to be responsive to the velocity of the wind rushing into hoistway from a landing when the car is sitting at the landing with its car and hatch doors open. As illustrated in FIG. 1, the device 60 is preferably mounted on top of the elevator car, directly above the hatch and car door opening, with the vane 68 disposed to detect upward air movement pass the front of the car into the hoistway. The upward air movement rotates vane 68 clockwise, as viewed in FIGS. 1 and 3, and when the angular rotation of vane 68 reaches about 8°, corresponding to a predetermined air velocity, such as 1,000 feet per minute, switch 84 reaches a position which causes its contact SW1 to close. When contact SW1 closes, a portion of resistor 45 is bypassed through the circuit which includes contact finger 108, conductive surface 82, switch contact SW1, contact surface 80 and contact finger 106. Higher velocity air flow will close switch contacts SW2, SW3 and SW4, in the recited order, as the angular rotation of the board 72 reaches the value at which the associated mercury switches are oriented to operate. The closing of each switch contact removes still more resistance from the armature circuit of motor 25, increasing the armature current and thus increasing the closing force applied to the doors, to offset the drag on the car and hatch doors due to wind. The amount of additional force applied to the doors is just enough to offset the drag. Thus, the resulting closing force of the doors does not exceed code requirements. As the doors close and the wind drag drops in magnitude, the vane 68 rotates counterclockwise to open the contacts SW4, SW3, SW2 and SW1 in the recited order and add resistance to the armature circuit, to reduce the closing force applied to the doors and insure that the resultant closing force of the doors is not increased as the wind drag is reduced.

While the wind responsive device 60 operates to add and remove resistance in the armature circuit in a step-like manner, it is to be understood that the device 60 may be connected to operate a continuously adjustable potentiometer in the armature circuit, if desired.

I claim as my invention:

1. An elevator system comprising:

a structure having a hoistway and a landing,  
an elevator car,

means mounting said elevator car for movement in said hoistway from a position displaced from the landing to a predetermined position adjacent the landing,

said elevator car having an opening,

closure means for controlling access to the car through the opening in said elevator car at said landing,

closure operating mechanism for said closure means to open and close said opening when the car is in the predetermined position,

control means operable in cooperation with said closure operating mechanism to close said closure means with a predetermined force pattern,

said control means including means modifying said force pattern in response to wind velocity in said hoistway.

2. The elevator system of claim 1, wherein the means modifying the force pattern increases and decreases the magnitude of the force pattern in response to increasing and decreasing wind velocity in the hoistway, respectively.

3. The elevator system of claim 1, wherein the means modifying the force pattern changes the magnitude of the closing force to overcome drag applied to the closure means by wind in the hoistway, while maintaining the resultant closing force below a predetermined magnitude.

4. The elevator system of claim 1, wherein the means modifying the force pattern increases and decreases the magnitude of the closing force in a plurality of steps in response to increasing and decreasing wind velocity in the hoistway, respectively.

5. The elevator system of claim 1, wherein the means modifying the force pattern increases the closing force above that called for by the force pattern in response to wind velocity while maintaining the resultant closing force of the closure means below a predetermined magnitude.

6. The elevator system of claim 1, wherein the closure means includes a hoistway door at the landing and a car door mounted on the elevator car, and the means modifying the force pattern is carried by the elevator car in a location such that it is responsive to the magnitude of the velocity of the wind flowing into the hoistway through the hoistway door when the elevator car is at the landing with the hoistway and car doors open to allow access to the elevator car.

7. The elevator system of claim 1, wherein the means modifying the force pattern includes rotatable means pivotally mounted and biased such that its angular position is responsive to the magnitude of the velocity of the wind which creates a drag in the closure means as it is operated from its open to its closed position, and switching means operable at predetermined angular positions of said rotatable means, said switching means being connected to said control means to modify said force pattern in response to the condition of said switching means.

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