United States Patent [19]

Spear et al.

[11] **3,868,000**

[45] **Feb. 25, 1975**

[54] **CLOSURE SYSTEM**

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

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[52] **U.S. Cl.** **187/52,** 49/25, 200/61.43

[51] **Int. Cl.** **B66b 13/26**

[58] **Field of Search** ..... 187/52.56, 51, 48, DIG. 1; 49/25-28, 116-120, 366-370; 200/61.43

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Assistant Examiner—James L. Rowland
Attorney, Agent, or Firm—D. R. Lackey

[57] **ABSTRACT**

A closure system including a door mounted to open and close an entrance, a first object detector including a transmitter of radiant energy and a detector thereof, and a second object detector including a ribbon switch mounted on the edge of the door which leads upon closure thereof. A source of electrical potential energizes a translating device via the ribbon switch, until the ribbon is actuated, which deenergizes the translating device. The first object detector controls the operation of the door when an object interrupts radiant energy from the transmitter, and the translating device of the second detector controls the operation of the door when it is deenergized.

3 Claims, 7 Drawing Figures

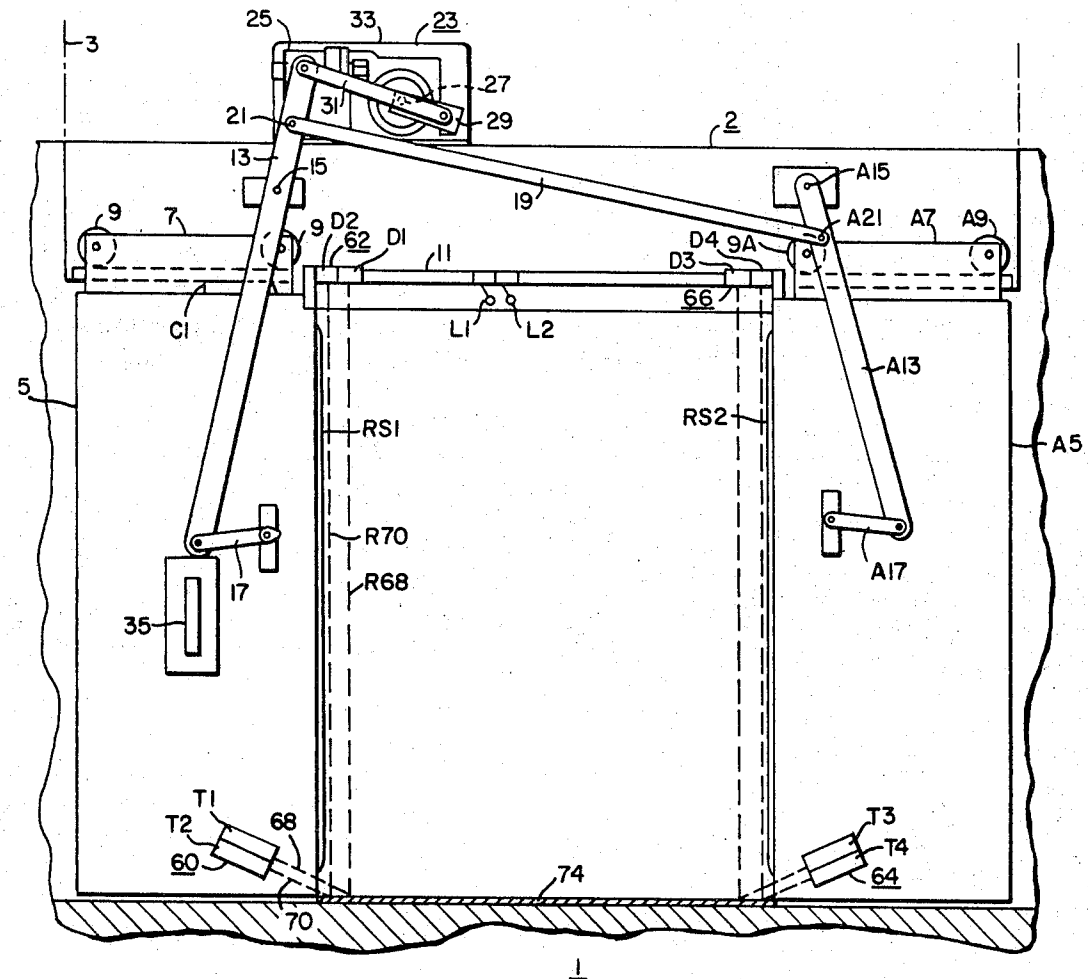


FIG. 2

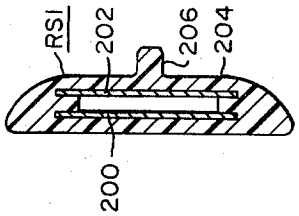


FIG. 3

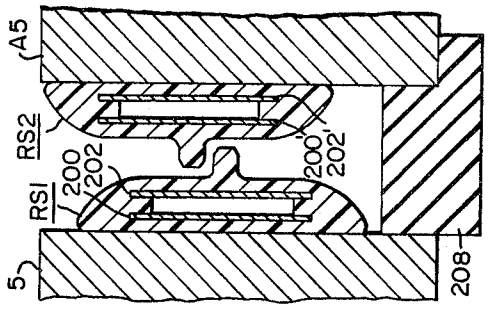
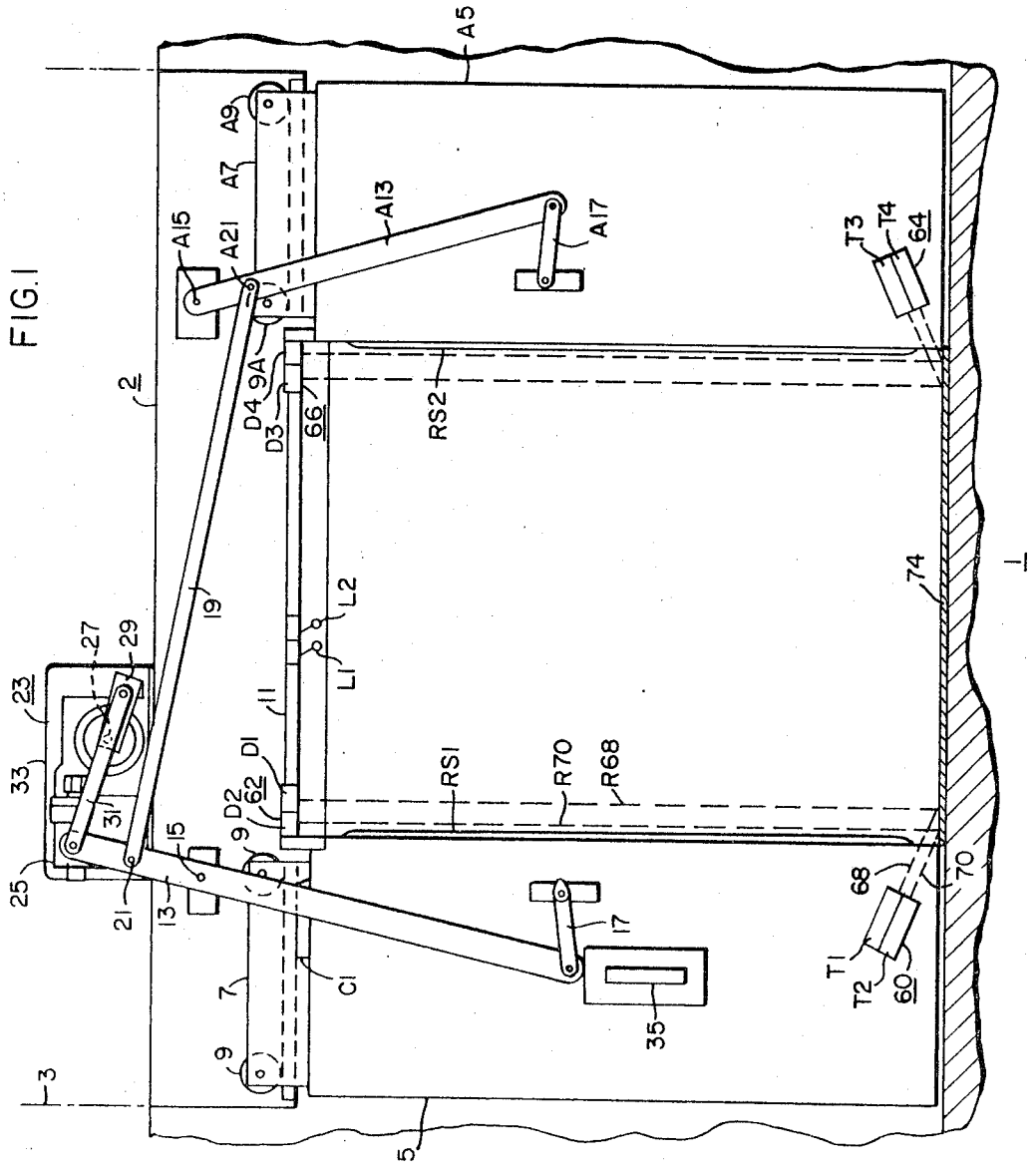


FIG. 1



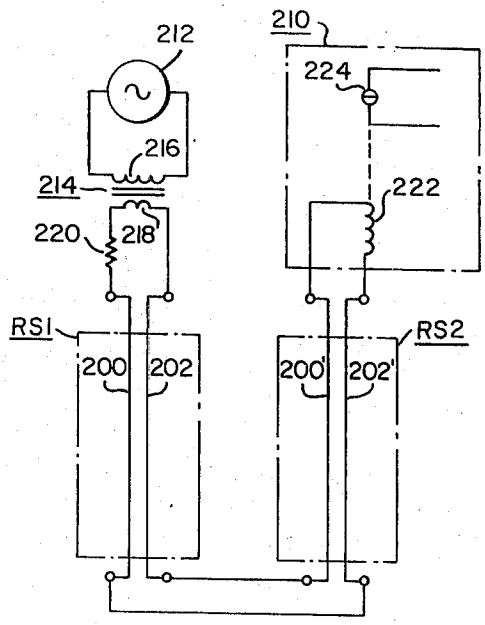

212
210
224
216
214
222
220
218
RS1
RS2
200
202
200'
202'

FIG. 4

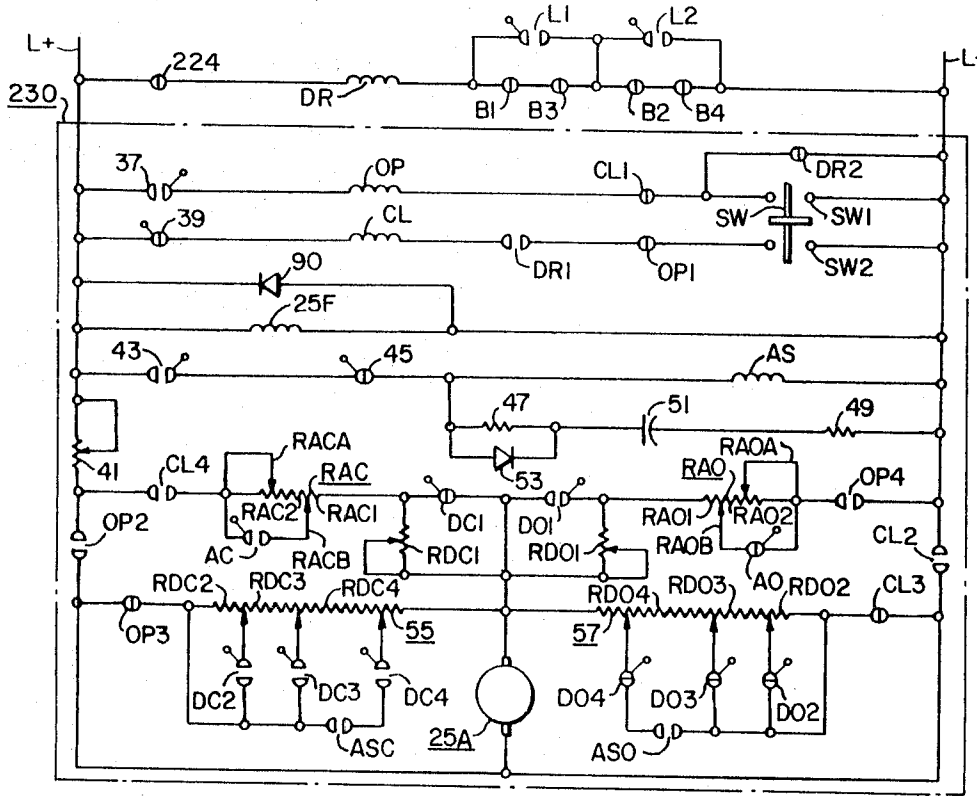

L+
L1
L2
L-
224
230
DR
B1
B3
B2
B4
37
OP
CL1
DR2
SW
SW1
39
CL
DR1
OP1
SW2
90
25F
43
45
AS
47
51
49
41
CL4
RACA
RAC
RAC2
RAC1
DC1
D01
RAO
RAOA
RAO1
RAO2
OP4
OP2
AC
RACB
RDC1
RDO1
RAOB
CL2
RDC2
RDC3
RDC4
RDO4
RDO3
AO
RDO2
CL3
OP3
55
57
DC2
DC3
DC4
D04
D03
D02
ASC
25A
ASO

FIG. 5

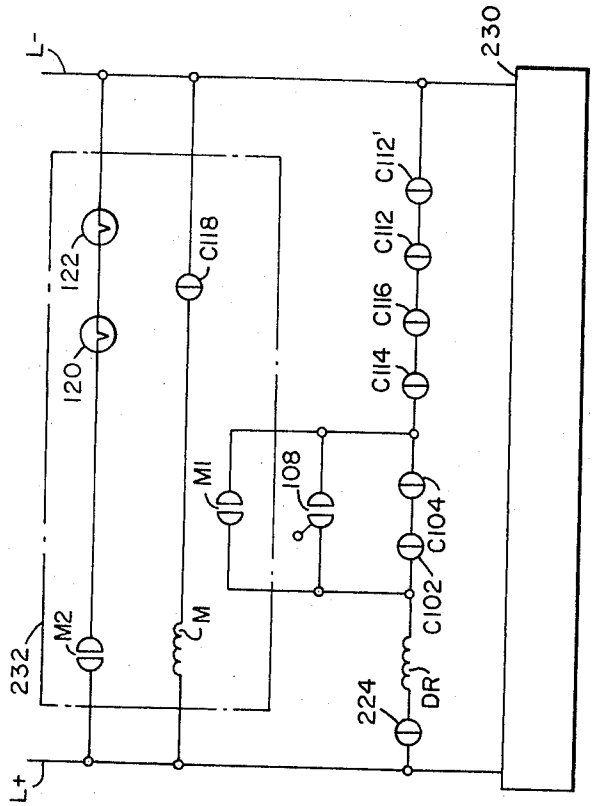

L-
230
C112'
C112
C116
C114
C118
122
120
M1
108
C104
C102
M2
M
232
224
DR
L+

FIG. 7

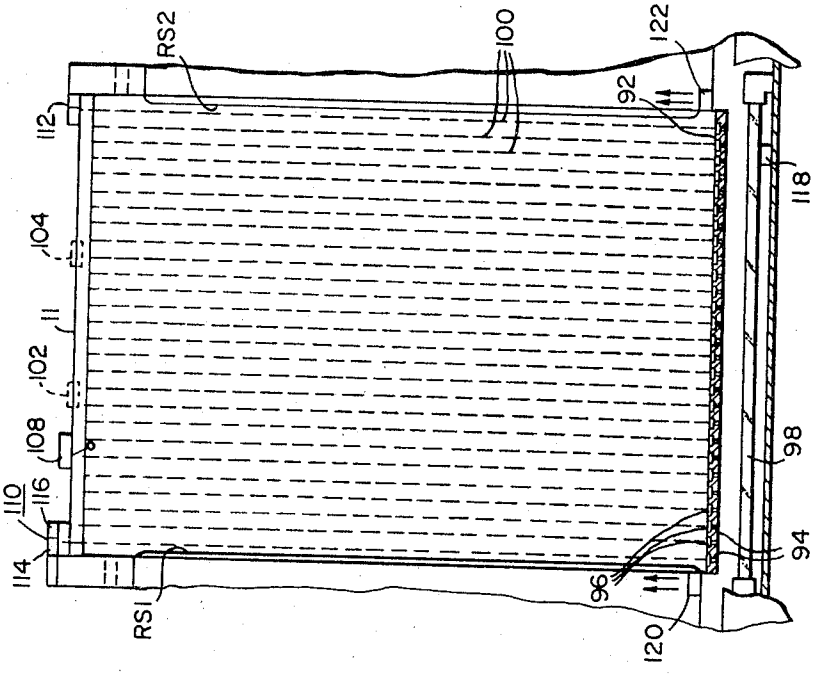

RS2
100
122
92
112
118
104
11
102
108
110
116
114
98
94
96
RS1
120

FIG. 6

CLOSURE SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates in general to closure systems, and more specifically to object detecting arrangements for closure or door control which are especially suitable for elevator systems.

2. Description of the Prior Art

In closure systems of the prior art, especially those used in elevator systems, it is common to provide some means for preventing the closure or door from striking an object in its closing path. One well known type of door protective device employs a beam of radiant energy which is projected across the elevator car opening. Interruption of the beam by an object disposed substantially in the closing path of the car and hoistway doors results in a modification of the door operation, such as by stopping and reversing the doors.

Another commonly used type of door protective device is the mechanical safety edge. When the mechanical safety edge, usually disposed on the car door, is depressed, limit switches are actuated which are connected in the door control circuits to effect a predetermined control action. U.S. Pat. No. 2,953,219, which is assigned to the same assignee as the present application, discloses a safety edge for the car door which is provided by disposing transmitters of radiant energy and detectors thereof on the car door, such that vertical beams of radiant energy are disposed along the edge of the car door to detect objects having a predetermined relationship with the edge of the door.

As illustrated in U.S. Pat. No. 3,063,516, which is assigned to the same assignee as the present application, it is also known, in a single closure system, to employ both the mechanical safety edge protection, which is effective when the door contacts or bears a certain predetermined relationship to an object, and protection for modifying the door action when an object is detected in the door opening irrespective of the location of the door relative to the object.

Copending applications Ser. Nos. 426,180 and 426,261, filed concurrently with the present application, and assigned to the same assignee as the present application, discloses new and improved closure systems for entranceways which utilize beams of radiant energy to provide safety edge protection on the leading edge of a closing door panel, eliminating the need for a mechanical safety edge. While a mechanical safety edge functions satisfactorily, it reduces the width of the door opening when the door, or door panels are open, or opening, the mechanical safety edge requires means for retracting the edge just before the door is fully closed, and since it is mechanical in nature it requires periodic maintenance due to wear and other mechanical problems. Should the radiant energy system which functions as a safety edge fail in a mode which permits the doors to continue to operate, some backup system should be present which will perform the function of a safety edge. Since the advantage of the radiant beam safety edge arrangements is in the elimination of the mechanical safety edge, it would defeat the purpose of these arrangements to provide a mechanical safety edge as backup protection.

SUMMARY OF THE INVENTION

Briefly, the present invention relates to new and improved closure systems, and especially to new and improved closure systems for elevators. An entranceway having a door mounted for movement to open and close the entranceway includes first object detecting means of the radiant beam type, wherein a transmitter of radiant energy and a detector thereof are arranged to detect an object disposed substantially within the entranceway when the radiant energy from the transmitter is prevented from reaching the detector due to the object. The first object detecting means preferably includes at least one radiant beam and detector thereof arranged to provide detection of an object having a predetermined relationship with the edge of the door which leads upon closure thereof. The detector is arranged to control the operation of the door when it does not receive radiant energy.

A second object detecting means provides a backup door edge object detecting function without resorting to a retractable, mechanical door safety edge device. The second object detecting means includes a ribbon or strip switch having normally separated electrically conductive elements, which is mounted on and along the edge of the door which leads upon closure. A source of electrical potential energizes a translating device via the electrically conductive elements of the ribbon switch. An object actuating the ribbon switch shunts the supply of electrical potential from the translating device, and the resulting deenergized condition of the translating device controls the operation of the door.

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 view in front elevation, with portions broken away, of an elevator car having a closure system embodying the teachings of the invention;

FIG. **2** is an enlarged cross-sectional view of a ribbon switch which may be used in the closure system of FIG. **1**;

FIG. **3** is a fragmentary cross-sectional view of the center opening doors of FIG. **1** shown in their fully closed position with ribbon switches mounted on the adjacent edges of the doors;

FIG. **4** is a schematic diagram illustrating the energization of a translating device via the normally separated elements of two serially connected ribbon switches;

FIG. **5** is a schematic diagram of door control apparatus suitable for operating the closure system of FIG. **1**;

FIG. **6** is a fragmentary view, in front elevation, of an elevator car having another closure system embodying the teachings of the invention; and

FIG. **7** is a schematic diagram of door control apparatus suitable for operating the closure system shown in FIG. **6**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

While the invention is applicable to closures designed for various applications, it is especially suitable for doors employed in elevator systems. Thus, the invention will be described with particular reference to elevator closures or doors. Further, the invention is appli-

cable to doors of various types, such as center opening, side opening, single speed, and two speed assemblies. For purposes of example, reference will be made to door assemblies of the center opening, power operated type, such as employed in elevator systems. In order to simplify its presentation, the invention is assumed to be applied to an elevator car employing the center opening, horizontally slidable doors, and controls therefor, as illustrated in U.S. Pat. No. 2,992,818, which patent is assigned to the same assignee as the present application. Only the portion of the controls of this patent necessary to understand the invention will be described. If the description of the complete control is desired, reference may be had to this patent for a detailed description.

Referring now to the drawings, and FIG. 1 in particular, there is shown an elevator system 1 which includes an elevator car 2 mounted for movement in the hoistway 3 of an associated building or structure to serve the landings or floors therein. FIG. 1 is a front elevational view of the elevator car 2 which is illustrated parked at a landing with its doors open. The associated hoistway or hatch doors which close and expose the opening to the hoistway from the associated landing are not shown in FIG. 1, for clarity.

The elevator car 2 includes center opening car doors, shown fully open, with the car doors comprising two sections 5 and A5. A number of similar components are employed for the door sections 5 and A5. Insofar as is practicable, a component for the door section A5 which is similar to a component for the door section 5 will be identified by the same reference numeral as is employed for the corresponding component associated with the door section 5 prefixed by the letter A.

The door section 5 is provided with a door hanger 7 on which door hanger wheels are mounted for rotation. The door hanger wheels for the door sections 5 and A5 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 5 is affected 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 5. 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 A15. 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 engine 23 which may include a reversible electric motor 25 coupled through suitable gearing to a shaft 27. The 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 5 and A5. When the door 1 is to be opened, the motor 25 is operated to rotate the arm 29 in a clockwise direction as viewed 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 1. 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 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.

The car door sections 5 and A5 are associated with hoistway door sections (not shown). The hoistway or hatchdoor sections are operable for opening and closing an entranceway to the hoistway. Although the hoistway door sections may be operated by any conventional door operator, the hoistway sections are preferably operated by the door operator 23 mounted on the elevator car 2 via cooperative vane and drive block members 35 and 36, respectively. The vane 35 is secured to the car door section 5 and is adapted for reception in a slot of the drive block 36, which is secured to the hoistway door section. A suitable linkage (not shown), similar to that disposed between the car door sections 5 and A5, or cable related, is provided between the two hoistway door sections. Thus, operation of the door operator mounted on the elevator car effects movement of both the cars and hoistway door sections in unison.

During the closing operation of the car and hoistway doors it is highly desirable that the door sections be prevented from striking an object located in the closing paths thereof. The invention utilizes a first object detector arrangement which includes a transmitter of radiant energy and detector thereof, and a second object detector arrangement which includes a ribbon switch. For purposes of example, two embodiments of the invention will be described using the object detector arrangements of the hereinbefore mentioned copending applications Ser. Nos. 426,261 and 426,180 for the first object detecting arrangements, but it is to be understood that other object detecting arrangements using beams of radiant energy may be used.

More specifically, the closure system of FIG. 1 utilizes the object detector arrangement of application Ser. No. 426,261, with the reference numerals of FIG. 1 being the same as in FIG. 1 of this copending application to facilitate reference to the copending application should a more detailed description of the arrangement be desired. The first object detecting means includes transmitter means 60 and detector means 62 associated with the left hand car and hoistway door sections, as viewed in FIG. 1, and transmitter means 64 and detector means 66, associated with the right hand car and hoistway door sections. Since the arrangement and operation of the object detecting means is similar for the left and right hand door sections, only the object detecting means for the left hand door sections will be described in detail.

Transmitter means 60 is mounted on car door section 5, preferably towards the bottom thereof, and adjacent

to the leading edge of the door with reference to the closing direction of the door. Transmitter means **60** is arranged to provide at least one beam of radiant energy, and preferably at least two, as illustrated, with first and second radiant beams **68** and **70** being provided by transmitter devices T1 and T2, respectively.

Transmitter devices T1 and T2 are positioned to direct or project the radiant beams **68** and **70** across the small opening between the elevator car **2** and the hoistway wall to the sill **74** associated with the hoistway entrance. At least one of the beams, such as beam **68**, is directed to strike the sill **74** on the corridor side of the hoistway door as opposed to the hoistway side, and the other beam is projected to strike the sill substantially adjacent to the edge of the hoistway door. The beams **68** and **70** of radiant energy are directed to predetermined spots or locations on the sill **74**, which locations will move across the sill **74** with movement of the car doors and their associated hatch door sections. In order to project the beams of radiant energy across the opening between the elevator car and hoistway wall to the corridor side of the sill **74**, it may be necessary to remove a small portion of the sight guard (not shown) which blocks the view into the space between the car **2** and hoistway wall **3**. However, since it is only necessary to remove the sight guard close to the floor level, it will not be noticeable to prospective passengers.

It is important to note that at least the portions of the sill **74** to which the beams **68** and **70** of radiant energy are directed throughout movement of their associated car door section, be formed of a material which has a non-specular surface and which will not become polished or specular during use. A sill constructed of a fairly rough bronze, i.e., unpolished, has been found to be satisfactory, but any material may be used which will scatter the reflection of the beam of energy from its surface, instead of reflecting the beam with a sharply defined projection. A sill formed of a metallic grit, such as aluminum oxide, held together with a suitable binder, such as epoxy resin, is also suitable, as the small metallic particles uniformly scatter the reflection of the beam of radiant energy from its surface.

Detector means **62**, which is sensitive to the level of the reflection which will be received from the sill **74**, includes the same number of detector devices as there are radiant beams to detect. In other words, when two transmitters, T1 and T2 are used to transmit two beams **68** and **70**, detector means **62** will include two detectors D1 and D2. Detector means **62** is mounted for movement with car door section **5**, and each detector device of detector means **62** is aimed to intersect a beam of radiant energy at the sill **74**. A suitable detector is Photo-bell's side sensitive receiver type RPS3R.

Detector means **62** is mounted at the top of the car door **5** with detector device D1 spaced from the edge of the door **5** such as about 3 inches, and with detector device D2 spaced from the edge of the door **5**, such as about one half inch. The reflection path from the sill **74** to detector device D2, indicated by beam R70 in FIG. **1**, proceeds past the edge of the hoistway door about one half inch therefrom. Therefore, an object such as a hand placed on the edge of the hoistway door **34** will interrupt the reflection from the sill **74** to detector D2, and this interruption initiates a control action in the door control circuit to retard further closing movement, and to reverse the doors, if desired. The reflection path from the sill **74** to detector D1, indicated by beam R68 in FIG. **1**, proceeds past the edge of the hoistway door, about 3 inches therefrom, and extends the object detection zone out to the point where detection of an object provides time for the closing door to stop without contact with the person or object interrupting this reflection.

The object detecting means for the right hand door sections are similar to those for those for the left hand door sections, with the transmitter means including transmitter device T3 and T4, directed to sill **74**, and the detector means **66** includes detectors D3 and D4 aimed to the sill such that their line of sight intersects the beams of transmitter devices T3 and T4 at the sill **74**.

Detector devices **62** and **66** are offset from one another to permit them to pass upon closure of the doors. The "3 inch" detectors D1 and D3 are rendered ineffective by a limit switch L1 disposed to cutout these detectors just before they would detect an interruption of the reflected energy due to normal door closure, and the "½ inch" detectors D2 and D4 are rendered ineffedctive by a limit switch L2.

Preferably, the transmitting device **60** is designed to transmit a beam of infrared radiant energy. Such devices are well known in the art. The detecting device **62** may be of any type responsive to the radiant energy received from the transmitting device **60**. Thus, for infrared radiant energy the detecting device **62** may be of the photoemissive type, the photoconductive type or the photovoltaic type, as desired. Such detecting devices also are well known. Reference may be made to U.S. Pat. No. 2,900,521 for construction details of suitable radiant energy transmitting and detecting devices.

Should the first object detector arrangement of FIG. **1** fail in a mode which permits the doors to continue to open and close, there would be no door edge protection for objects in the closing paths of the door sections. Backup door edge section is provided, according to the teachings of the invention, by providing strip or ribbon switches on the car and/or hoistway doors. For purposes of example they will only be described as being applied to the car doors, as the same arrangement can be used for the hoistway doors. More specifically ribbon switches RS1 and RS2 are disposed on the edges of the movable car door sections **5** and A5, respectively, which edges are the leading edges of the door sections during closure thereof. A ribbon switch, such as the ribbon switches available from Tapeswitch Corporation of America, Farmingdale, N.Y., has a thickness dimension of only about 0.25 inch, including an actuation bead, and a width dimension of about 0.75 inch, and they are obtainable in lengths suitable for protecting the complete lengths of a door edge of an elevator car. The ribbon switches may be held in place by a suitable adhesive applied to the back side of the switch, or a plastic mounting channel may be secured to the edge of the door, with the ribbon switch being mounted in the mounting channel. A contact pressure of only about **8** ounces, applied anywhere along the length of the ribbon switch, will actuate the switch.

As illustrated most clearly in FIG. **2**, which is an enlarged cross sectional view of ribbon switch RS1, the ribbon switch includes two spaced electrically conductive elements or spring conductors **200** and **202**, surrounded by a plastic or rubber jacketing structure **204** which may incllude an integral bead **206** on the side of

the switch which is to be subjected to an actuating force.

The edges of the electrically conductive elements **200** and **202** are held apart to provide a normally open circuit configuration, with actuation providing electric contact between the elements, which contact is released when the actuating force is removed from the switch, due to the resiliency of the spring-like material from which the elements **200** and **202** are formed. Thus, the strip or ribbon switch RS1 has no moving parts other than the slight flexing of one or both of the elements **200** and **202,** when the switch is subjected to a contact pressure or force. Further, this switch does not require a retraction mechanism, it requires little or no maintenance, and it occupies only about 0.25 inch of the door opening.

FIG. **3** illustrates a fragmentary plane view, in section, of doors **5** and A**5,** with the relative placement of the ribbon switches being such that the ribbon switches RS1 and RS2 function as an astragal on the meeting stiles of the center opening doors. The switches RS1 and RS2 are arranged relative to one another such that their beads overlap when viewed in a direction perpendicular to the major planes of the doors, thus blocking a view between the adjacent edges of the closed doors. A spacer **208** is fixed to one of the doors, such as near the top of door A**5,** which prevents the doors from closing to the point where one ribbon switch would actuate the other.

FIG. **4** is a schematic diagram of a ribbon switch arrangement using the ribbon switches RS1 and RS2 shown in FIGS. **1** and **3.** This schematic arrangement is also applicable to a door having a single section or panel, thus having a single ribbon switch, instead of the two switches required for the double, center opening doors illustrated in FIG. **1.**

A translating device **210** is connected to a source **212** of electrical potential via electrically conductive elements of the ribbon switches RS1 and RS2. The ends of the elements **200** and **202** of switch RS1 are connected to ends of the elements **200'** and **202',** respectively. The free ends of elements **200** and **202** are connected to the source **212** of electrical potential, and the free ends of elements **200'** and **202'** are connected to the translating device **210.** The magnitude of the source **212** of electrical potential may be stepped down to the desired voltage level via a transformer **214,** having a primary winding **216** connected to source **212** and a secondary winding **218** connected to the ribbon switch RS1 via a resistor **220.** The alternating potential output of secondary winding **218** may be rectified, if desired, or the alternating potential may be applied directly to the serially connected ribbon switches, as illustrated. Transplanting device **210** may be an electromagnetic relay of the alternating or direct current type, depending upon the characteristic of the voltage applied to the device via the ribbon switches. Device **210** includes an electromagnetic coil **222** connected to the ribbon switch RS2 and a normally open contact **224.** Translating device **210** may also be a solid state relay, as desired. Device **210** is connected to be continuously energized from source **212** via the serially connected elements of the ribbon switches RS1 and RS2, until one of the ribbon switches is actuated. When either of the ribbon switches RS1 or RS2 is actuated, causing its electrically conductive elements to contact one another, the source **212** is shunted from device **210,** with resistor **220** being selected to limit the current magnitude to a predetermined maximum value during this period of time. The shunting of the source potential from translating device **210** causes it to switch or change to its de-energized condition, opening its contacts **224.** A failure of source **212,** or a discontinuity of the circuit between source **212** and device **210,** will also cause device **210** to become de-energized, opening its contact **224.** The circuit effect of contact **224** will now be described, with reference to FIG. **5,** which is a schematic diagram for door control apparatus which may be used to operate the door controller **33** shown in FIG. **1.** Except for the addition of contact **224,** the circuit diagram of FIG. **5** is the same as the circuit diagram shown in FIG. **4** of copending application Ser. No. 426,261.

More specifically, FIG. **5** illustrates an armature **25A** and a field winding **25F** of the door operating motor **25** shown in FIG. **1.** Electrical energy for the control circuit is derived from a pair of direct-current buses L+ and L−. It will be observed that the motor field winding **25F** is connected directly across the buses L+ and L−. In parallel with the field winding **25F** is a rectifier **90** of a conventional type, such as silicon. Current flows through the rectifier **35** in the direction indicated by its circuit symbol. Thus the rectifier **90** 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 buses L+ and L−.

The motor **25** is energized to open or to close the car door by operation of a switch SW. 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, upward movement of the operating member of the switch SW, as viewed in FIG. **4,** to close its contacts SW**1,** 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 buses 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.**

Downward movement of the operating member of the switch SW results in closure of its contacts SW2 to complete, with a limit switch **39** and break contacts OP1 of the door opening relay OP, a circuit connecting the door relay CL across the buses 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 therethrough 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. 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. **4.**

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. 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 DO1 through DO4 in sequence similarly control door deceleration during a door opening operation.

Make contacts ASC and ASO are disposed in series circuit relationship with the cam-operated contacts DC4 and DO4, respectively. These contacts are associated with an anti-stall or checkback relay AS. If a pair of limit switches **43** and **45** both are in closed condition, the relay AS is connected for energization across the buses L+ and L−. In parallel with the coil of the relay AS is a resistor-capacitor network comprising serially connected resistors **47** and **49** and a capacitor **51.** In parallel with the resistor **47** is a rectifier **53** of a conventional type such as silicon. Current flows through the rectifier **53** in the direction indicated by its circuit symbol in FIG. **4.** Thus, when both of the limit switches **43** and **45** are in their closed condition, the capacitor **51** charges through the resistor **49** and the rectifier **53,** which, in effect, then shorts the resistor **47.** When one of the limit switches **43** or **45** is opened, the capacitor **51** discharges through the resistors **45** and **49** and the coil of the anti-stall relay AS. Since the length of times of charge and discharge of the capacitor are dependent upon the RC network time constant, the rectifier **53** effects a fast charge of the capacitor **51** and a relatively slow discharge thereof.

The limit switches **43** and **45** are located in the control assembly **33** and are operated by cams disposed therein. In a preferred embodiment of the invention, the cam associated with the switch **43** operates to open the switch simultaneously with the opening of the control contacts DC4 by its associated contact cam. The limit switch **45** is opened by its cam simultaneously with the opening of the control contacts DO4 by its associated contact cam. Each of these limit switches remains in open condition from the time of its opening to the time when the door reaches the same position in a door movement opposite in direction to that in which the door was moving when the respective limit switch was operated by its associated cam.

The coil of a door safety relay DR is connected between buses L+ and L− via serially connected contacts **B1, B3, B2, B4,** and **224.** Contacts **B1, B3, B2** and **B4** are associated with detectors **D1, D3, D2** and **D4,** respectively with these contacts being directly controlled by and suitable translating device associated with the detectors. Such a translating device may take the form of relays whose energizing coils are not shown. Contacts **B1, B2, B3** and **B4** are closed as long as its associated detector device is receiving radiant energy form the spot on the sill **74** to which it is aimed. Limit switches **L1** and **L2** are connected to shunt or short contacts **B1** and **B3,** and **B2** and **B4,** respectively, to render these contacts ineffective when the doors close. Contact **224,** as hereinbefore explained, is closed as long as translating device **210** shown in FIG. **4** is energized. Actuation of ribbon switch **RS1** or **RS2** deenergizes devices **210** and contacts **224** open.

Door safety relay DR includes a make contact **DR1** which is connected in series with the energizing coil of the closing relay CL, and break contacts **DR2** connected to shunt contacts **SW1** of switch SW. It should be noted that the contacts **DR1** and **DR2** are shown in the condition when buses L+ and L−. are deenergized. When the door is closing and no obstruction is detected by any of the detectors, relay DR will be energized. Thus, contacts **DR1** will be closed to enable the closing coil CL to be energized, and contacts **DR2** will be open, and they will thus have no circuit affect on the door open relay OT. Should reflection of radiant energy to any of the detector devices be interrupted, its associated contact would be open, such as contact **B1,** which drops out the door safety relay DR. Contacts **DR1** open to deenergize the coil CL of the closing relay and stop the closing motion of the car and hoistway doors, and contacts **DR2** close to energize the door open relay OP. Should it only be desired to stop the closing of the doors upon interruption of radiant energy from the sill to one of the detectors, instead of reversing the doors, contacts **DR2** would not be required. When the doors reach the point during closing where reflection from the sill will be interrupted by the opposite door section, limit switches **L1** and **L2** successively operate to first disable the 3-inch detectors, and then the ½ inch detectors. It is to be understood that while these detectors are referred to as the 3-inch and ½-inch detectors, that their locations may be changed from these dimensions, if desired.

If the radiant energy detector function should fail in a mode which permits the doors to operate, the ribbon switch provides back-up protection, functioning to open the circuit of the door safety relay DR when slight pressure is applied to either ribbon switch, thus controlling the doors in a manner similar to that responsive to a beam of radiant energy being interrupted by an object, while the contact **224** is not illustrated as being shunted when the doors are closed, it may be shunted by limit switch **L2** along with the ½-inch detectors, if desired.

FIG. **6** is a fragmentary view of the car door sections **5** and **A5** shown in FIG. **1,** except modified to include the radiant energy object detector disclosed in copending application Ser. No. 426,180 FIG. **6** is similar to FIG. **1** of this copending application, except modified to include the ribbon switches **RS1** and **RS2,** as hereinbefore described relative to FIG. **1.**

Specifically, the closure system shown in FIG. **6** employs a sill **92** disposed at the entrance of the elevator car **1,** which extends substantially across the width dimension of the entrance. The sill **92** includes a plurality of openings **94** in the entrance portion of the sill, which openings may extend in spaced relation across the entranceway in a single row. The openings are preferably

formed by drilling counterbored holes, and protective transparent or translucent, glass or plastic, lenses **96** are disposed therein, such as with a suitable adhesive. The protective lens need not be of the focusing type. The sill **92** is disposed to cover a recess or compartment in the forward portion of the floor of the elevator car, immediately adjacent the entrance to the car **1.** A source **98** of radiant energy is disposed in this recess or compartment, just below the underside of the sill **92** through which the openings **94** are disposed. This arrangement provides a plurality of vertically oriented beams **100** of radiant energy spaced horizontally across the entranceway to the elevator car. The source **98** is preferably an electric lamp, such as an incandescent resistance lamp, or a mercury vapor lamp, such as a fluorescent lamp. The wavelength of the electromagnetic radiation from source **98** may be selected from a wide range, and may be in the visible or invisible spectrums. Radiant energy visible to the human eye has the added advantage of highlighting the sill, and is thus the preferred embodiment, but infrared or ultraviolet wavelengths may be used if desired.

The first type of object detection which may be provided using the source **98** and plurality of beams **100** of radiant energy is the arrangement, once activated during the door open cycle, which is independent of the position of the door. For this arrangement, one or more detecting devices responsive to the radiant energy used are disposed in the ceiling or transom of the elevator car. For purposes of example, for a 42-inch center-opening door two detector devices **102** and **104,** spaced about 12 inches apart, will provide satisfactory object detection. However, any number of devices may be used. The detection devices should be rendered ineffective just prior to their detecting the door as the door closes, in order to prevent false triggering thereof. When two symmetrically located detectors **102** and **104** are used, as illustrated in FIG. **1,** a single cam **106** and limit switch **108** may be used to render devices **102** and **104** ineffective at a predetermined point in the door close cycle.

The detector devices **102** and **104** may be of any type responsive to the wavelength of the radiant energy source. For example, they may be of the photoemissive, photoconductive, or photovoltaic type, as desired. The detecting devices **102** and **104** may be connected to each control a separate relay having a contact which is closed as long as the detector is receiving radiant energy from source **98.** Upon interruption of this radiant energy to a detector, the contact of its associated relay would open to effect some predetermined control action, such as stopping or reversing the doors.

The single source **98** and perforated sill **92** may also be used to provide object detection relative to the leading edge of a closing door panel, by mounting detector means on the door panel, or panels, adjacent the edge or edges thereof which lead upon closure of the door. The detector means is spaced from the edge of its associated door panel to provide the desired detection zone, and as illustrated in FIG. **6** detector means **110** and **112** are provided for car door sections **5** and **A5** which preferably have a least two detector devices, such as detector devices **114** and **116** which form a part of the detector means **110.** Detector device **114,** which is closest to the leading edge of the door panel **5** upon closure thereof, is adjusted such that a hand placed upon the door will interrupt a beam from source **98** to the detector, and thus functions in a manner similar to the mechanical safety edge. If the detector device **114** is spaced about one-half inch from the edge of the door, it will satisfactorily perform this function. The second detector **116** is spaced from the door edge by a greater dimension. This dimension is preferably selected to enable the detector **116** to detect an object in the closing path of the door and to stop the car door before striking the object. A dimension of about 3 inches has been found to be satisfactory, but it is not critical. Since the detector means **110** moves with the door, it is important that the number of openings **94,** the diameter of the openings, the spacing of the openings and thus the horizontal spacing of the resultant vertically oriented beams **100,** and the lens on the detector device, all be selected such that the detector lens will span two adjacent beams **100** to maintain continuous contact with the radiant energy, in the absence of an object interrupting the radiant energy, as the door moves from its open to its close position. One-half inch diameter openings disposed on ¾-inch centers has been found to be satisfactory but other suitable dimensions may be used.

A detector **118** responsive to the radiant energy provided by source **98** may be disposed in the recess with source **98.** This detector may include a relay having contacts connected to render detectors **102** and **104** ineffective, and to energize auxiliary radiant energy transmitter devices **120** and **122,** should the source **98** fail to provide radiant energy of a predetermined level. Transmitter devices **120** and **122** are aimed at detector means **110** and **112,** respectively, to continue door edge object detection until source **98** can be serviced.

Suitable back-up door edge protection may be provided, according to the teachings of the invention, by ribbon switch control which may be used with, or in place of the detector **118,** relay M and transmitters **120** and **122.** As illustrated in FIG. **7,** which is a schematic diagram of suitable door control apparatus for operating the closure system shown in FIG. **6,** the door safety relay DR is connected across buses L+ and L− via contacts C**102** and C**104** of radiant energy detectors **104** and **104** disposed in the transom of the elevator car **1,** contacts C**114** and C**116** of detector means **110** which is mounted for movement with the door panel **5,** contacts C**112** and C**112′** of detector means **112** which is mounted for movement with door panel A**5** and contacts **224** of the translating device **210** shown in FIG. **4.** These serially connected contacts are associated with relays responsive to detectors **102** and **104,** and to detector means **110** and **112,** and these contacts are closed as long as its associated detector device is receiving radiant energy from source **98.** Contacts **224** are closed as long as the translating device limit switch **108** is disposed to shunt contacts C**102** and C**104** when it is in its closed position, to render these contacts ineffective just before the radiant energy received by detectors **102** and **104** would be interrupted by the closing door panels.

Relay M is a monitor relay responsive to contact C**118** of detector **118** shown in FIG. **6,** which detector will maintain contact C**118** closed and relay M energized as long as the source **98** provides radiant energy. Relay M includes break contacts M**1** and M**2.** Contacts M**1** are connected across contacts C**102** and C**104,** and contacts M**2** are serially connected across buses L+ and L− with transmitter devices **120** and **112,** which

are also shown in FIG. **6.** Should source **98** fail to provide radiant energy of the proper level, contacts M1 will close and render the detectors **102** and **104** ineffective, and contacts M2 will close to energize radiant energy transmitters **120** and **122,** in order to retain the door edge object detection function. This portion of the circuit is shown within a broken line rectangle **232** to indicate that it is not essential, when the back-up door edge protection provided by the ribbon switches RS1 and RS2 is utilized. The portion of the circuit shown generally at **230** in FIG. **7** is the same as the detailed circuit illustrated within the broken line rectangle **230** shown in FIG. **5,** and the effect of deenergizing the door safety relay DR is the same as described relative to FIG. **5.**

In summary, there has been disclosed new and improved closure systems especially suitable for elevators, which include object detector means of the radiant energy type, and door safety edge detector means which provides a back-up object function in the event the radiant energy object detection system fails in a mode which allows the doors to continue to function. The disclosed back-up protection includes ribbon or strip switches mounted on the edges of the movable door sections which edges lead upon closure thereof. The disclosed closure system requires no mechanical safety edge, no retraction mechanisms, little or no maintenance, and takes up an insignificant space between the stiles of the door sections.

We claim as our invention:

1. An elevator system, comprising:

a structure having a hoistway, and a landing having an opening to the hoistway,

an elevator car mounted for movement in the hoistway of said structure to serve said landing,

said elevator car having an opening therein which is in registry with the opening to the hoistway when said elevator car is at said landing,

a car door mounted for movement to open and close the opening of said elevator car,

a hoistway door mounted for movement with said car door to open and close the opening of the hoistway,

first object detector means including transmitter means providing at least one beam of radiant energy, and detector means responsive to such energy,

a sill at the landing adjacent the opening to the landing, said sill having a non-specular surface,

said transmitter means being mounted on the car door for movement therewith and positioned to direct a beam of radiant energy at said non-specular surface of the sill,

said detector means being mounted on said car door for movement therewith and aimed to intersect the beam of radiant energy at said sill,

said detector means being responsive to an interruption of the reflected radiant energy from said sill for controlling the operation of the car and hoistway doors,

and second object detector means including a source of electrical potential, translating means, and ribbon switch means, said ribbon switch means being mounted on an edge of at least one of said doors, which is the leading edge upon closure thereof, said translating means being energized by said source of electrical potential via said ribbon switch means until an object actuates the ribbon switch means, which deenergizes said translating means, said translating means being connected to control the operation of said car and hoistway doors when it is in its deenergized condition.

2. The elevator system of claim **1** wherein the transmitter and detector means are oriented such that reflected radiant energy from the sill to the detector means is spaced from and substantially parallel to the leading edge of the hoistway door upon closure thereof.

3. The elevator system of claim **1** wherein the ribbon switch means includes a ribbon switch mounted on an edge of both the car and hoistway doors.

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