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W. F. EAMES

2,900,521

DOOR CONTROL APPARATUS

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Fig. 1.

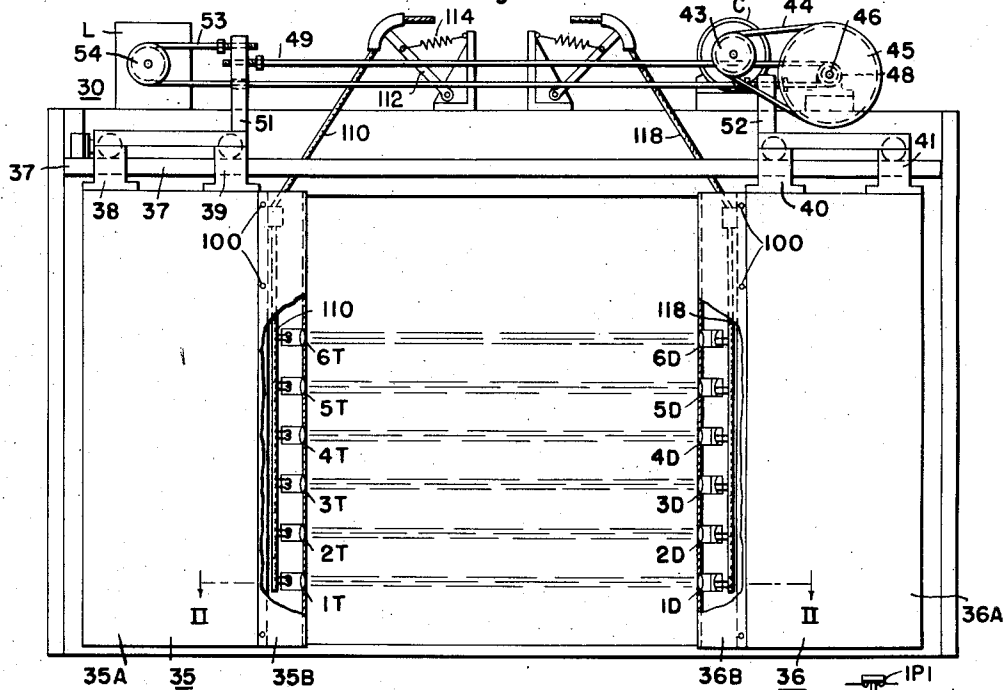


Fig. 2.

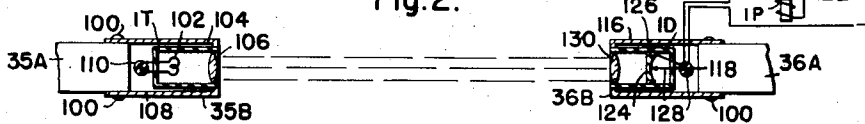


Fig. 3.

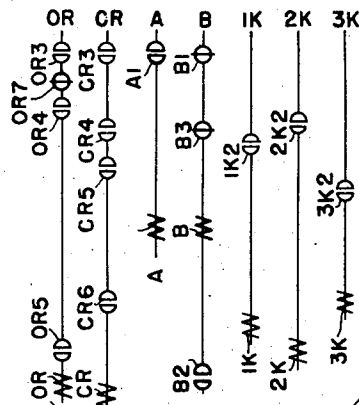
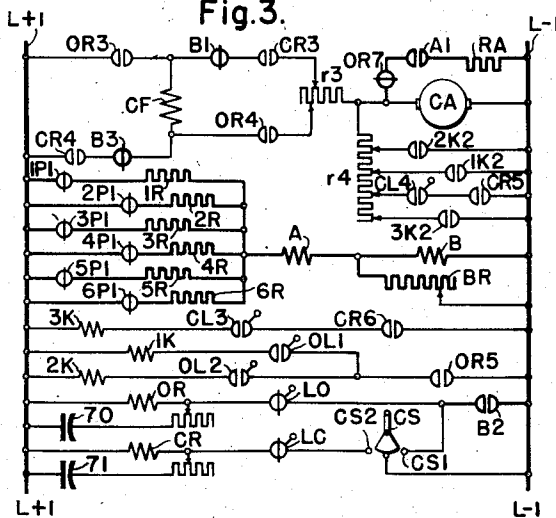


Fig. 3A. INVENTOR

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2,900,521

DOOR CONTROL APPARATUS

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10 Claims. (Cl. 250—208)

This invention relates to apparatus for detecting the presence of an object in space and it has particular relation to apparatus responsive to the presence of objects in the closing path of a door for controlling the operation of the door.

Although aspects of the invention may be employed for various applications wherein the presence of an object in space is to be detected, the invention is particularly desirable for the control of doors. The invention may be applied to manually-operated doors but it is especially suitable for power-operated doors such as those encountered in elevator systems.

In an elevator system the doors of an elevator car may be under the supervision of a car attendant or they may operate automatically, no car attendant being provided. Devices for preventing a door from striking an object in the closing path of the door can be employed for elevator systems wherein an elevator car is provided with a car attendant, but they are even more desirable for an elevator system wherein no car attendant is provided for an elevator car.

In accordance with the invention, radiant energy is projected into space for the purpose of detecting the presence of an object. Preferably the radiant energy is capable of being concentrated or focussed into a beam and preferably the radiant energy is not in the portion of the spectrum visible to the eye. Infrared radiant energy is particularly suitable.

The invention further contemplates the provision of a detector which is responsive to the presence or absence of the radiant energy. Preferably the detector is responsive only to energy which is outside the visible portion of the spectrum. As previously pointed out, infrared radiant energy is particularly desirable and the detector may be responsive only to radiant energy in the infrared region of the spectrum.

Although a single beam of radiant energy may be employed, preferably a plurality of beams are established across an opening which is to be scanned. A separate detector is provided for each of the beams. In a preferred embodiment of the invention, interruption of a first number of the beams may be employed for retarding closure of a door which is intended to close the opening scanned by the beams. Interruption of a greater number of the beams is then utilized for further retarding or stopping or reversing the door.

The beams may be of fixed dimension for all conditions of door operation. Preferably the beams are arranged to shorten as the doors close. To this end, each transmitter device utilized for projecting a beam into the opening or each detector device utilized for detecting the presence or absence of the beam or both may be mounted for movement in accordance with movement of the door relative to the opening. In a preferred embodiment of the invention the devices are mounted on edges of the doors which are the leading edges during closing operations.

The door edge on which one or more of the devices

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may be mounted preferably is separable as a unit from the remainder of the door. For center-opening doors, a row of transmitter devices for projecting radiant energy may be mounted on the leading edge of one of the doors whereas a row of detector devices may be mounted on the leading edge of the remaining door.

It is therefore an object of the invention to provide improved object-detecting means employing non-visible radiant energy.

It is a further object of the invention to provide improved object-detecting means including a transmitter for producing a beam of infrared radiant energy and an infrared radiant-energy detector device located in the path of the beam.

It is a still further object of the invention to provide improved object-detecting apparatus including a transmitter unit for producing a plurality of spaced radiant-energy beams across an opening and a separate detector device responsive to such radiant energy in the path of each of the beams together with translating means having varying responses dependent on the number of beams which are interrupted.

It is an additional object of the invention to provide a door control mechanism including a transmitting device for directing a beam of radiant energy along the closure path of the door and a radiant-energy detector device in the path of the beam wherein the devices are mounted to approach each other as the door closes.

It is also an object of the invention to provide a door control mechanism wherein a plurality of beams of infrared energy are established across the closing path of the door and wherein a separate detector device is provided for detecting the presence or absence substantially of each of the beams together with mechanism responsive to the condition of the detector devices for retarding the closure of the door as a function of the number of beams which are interrupted.

It is another object of the invention to provide a door having a separable edge and having a plurality of devices for projecting or detecting radiant energy positioned along the separable edge.

It is still another object of the invention to provide center-opening doors having operating means for closing and opening the doors together with safety mechanism including a plurality of pairs of devices, each pair including a radiant-energy transmitter and a radiant-energy detector positioned to receive radiant energy projected by the transmitter device, one of the devices in each of the pairs being located on one of the center opening doors and the remaining devices being located on the remaining one of the center-opening doors.

It is still another object of the invention to provide a system as set forth in the preceding paragraph together with mechanism controlled by the detector devices and responsive to interruption of the beams for retarding closure of the doors to an extent dependent on the number of beams interrupted.

Other objects of the invention will be apparent from the following description taken in conjunction with the accompanying drawing, in which:

Figure 1 is a view in elevation with parts broken away of an elevator car embodying the invention;

Fig. 2 is a view in section with parts broken away taken along the line II—II of Fig. 1;

Fig. 3 is a schematic view in straight-line form illustrating control circuits associated with the elevator car of Fig. 1; and

Fig. 3A is a view of electromagnetic switches and relays employed in the circuits of Fig. 3. Corresponding contacts and coils in Figs. 3 and 3A are substantially in horizontal alignment.

The invention may be applied to any desired arrangement of doors. For example, the invention may be utilized for controlling the operation of side-opening, center-opening, single-speed or two-speed doors of types commonly encountered in elevator systems. In order to simplify its presentation, the invention is assumed to be applied to an elevator car employing center-opening doors as illustrated in the McCormick Patent 2,235,380. Insofar as is practicable, corresponding components of the McCormick apparatus and the apparatus shown in the attached drawing are illustrated similarly and bear similar reference characters. These corresponding components are as follows:

Apparatus list

L+1, L-1—Direct current source of electric energy
 OR—Door opening relay
 CR—Door closing relay
 CS—Car switch
 C—Car door motor having armature CA and field winding CF
 1K—First opening resistor relay
 2K—Second opening resistor relay
 3K—First closing resistor relay
 L—Controller
 LO—Limit switch on opening (operated by controller)
 LC—Limit switch on closing (operated by controller)
 OL1—First opening cam on door and gate (operated by controller)
 OL2—Second opening cam on door and gate (operated by controller)
 CL3—First closing cam (operated by controller)
 CL4—Second closing cam on gate only (operated by controller)
 30—Car
 35— } Horizontally sliding center opening doors
 36— }
 37—Overhead track
 38— }
 39— } Hangers
 40— }
 41— }
 43—Driving pulley or wheel
 44—Driving belt
 45—Driven pulley or sheave
 46—Shaft
 48— } Sprocket wheel
 54— }
 49— } Sprocket chains
 53— }
 51— } Brackets
 52— }
 r3— } Resistors
 r4— }
 70— } Condensers
 71— }

The components in the above list may be identical in the aforesaid McCormick patent and in the present drawing with the exception of the doors 35 and 36 and the door opening relay OR. In the present case, each of the doors is divided into two units or parts. For example, the door 35 is provided with a main part or unit 35A and an edge unit 35B which is separably attached to the unit 35A in any suitable manner as by means of screws 100. This edge unit 35B is located at the leading edge of the door during the closing movement of the door and may be referred to as a leading edge unit.

In an analogous manner the door 36 in the present case includes a door unit 36A and a leading edge unit 36B which is separably attached to the main door unit 36A. A set of break contacts OR7 is added to the door opening relay OR of the McCormick patent. With these exceptions, the components in the above list may be identical for the McCormick patent and for the present drawing. For this reason the following discussion will be

directed primarily to the additional subject matter herein presented. For a detailed discussion of the components in the above list, reference may be made to the McCormick patent.

During a closing operation of the doors 35 and 36, it is highly desirable that the doors be prevented from striking an object located in the closing paths thereof. To this end a transmitting device 1T is provided for projecting across the door opening radiant energy. A detector device 1D is located in the path of such radiant energy. By inspection of Fig. 1 it will be observed that the transmitting device 1T and the detector device 1D are located on opposite sides of the opening. These devices are shown on a larger scale in Fig. 2.

The radiant energy projected by the transmitter device 1T may have a frequency selected from a wide range. For example, the radiant energy may have a frequency in the ultrahigh radio frequency range if the objects entering the opening are opaque to such frequencies. Such objects may be constructed of an electroconductive material.

Preferably the radiant energy projected by the transmitter device 1T should be capable of being compacted or focussed into a compact beam. This not only improves the efficiency of the apparatus, but it prevents stray reflections of the radiant energy from objects which are outside the closing path of the doors.

If the objects entering the opening are of an inanimate nature, the radiant energy conceivably may be produced by a radioactive pellet constituting the transmitter 1T. However, if the objects comprise living cells or tissue, the radiant energy should be incapable of injuring such cells or tissue.

The transmitter device 1T may be designed to project visible light into the opening. However, since numerous sources of light are present, both within the elevator car and in the corridors served by the elevator car, the possibility of false operation of the apparatus due to the external sources is present and if an attempt is made to shield the detector device 1D from other light sources, it becomes difficult to clean and maintain the detector device. For these and other reasons, non-visible radiant energy is desirable.

Preferably the transmitter device 1T is designed to transmit a beam of infrared radiant energy. To this end, the transmitter device may include a heater or filament 102 which is located within a tube 104. A filament 102 may be constructed of a suitable resistance material such as nichrome which when heated by an electric current emits infrared radiant energy.

The end of the tube 104 through which the beam of radiant energy is transmitted preferably is closed by a lens which focusses the radiant energy into a compact beam which extends across the opening between the doors. It will be understood that the heater 102 need not be enclosed in a vacuum and may be of sturdy construction. If the heater generates radiation outside the desired range, a filter may be employed or the lens 106 may be constructed of a filter material for permitting the passage of only the desired radiant energy, in this case, infrared radiant energy.

The energy required for the heater 102 is quite small, and the infrared beam resulting may have such a low energy level that it is not perceptible by persons intercepting the beam. If desired, the energy level may be increased for the purpose of subjecting a person interrupting the beam to substantial heat. The resulting sensation of heat discourages a person from intentionally holding open the doors. However, in most applications, it will be assumed that the energy level is below the value producing heat substantially perceptible by a person.

By inspection of Fig. 2 it will be noted that the transmitter device 1T is located in the leading edge unit 35B. The leading edge unit 35B may be constructed of a channel 108 having an open end which is prop-

tioned to receive the edge of the door unit 35A, to which it is detachably secured by the screws 100. As shown in Fig. 2, the transmitter device is recessed in an opening provided in the web of the channel. Electric current for the heater 102 is supplied through a cable 110 which extends through the channel 108. By reference to Fig. 1 it will be noted that the cable 110 is of a flexible nature to permit movement of the door unit and may be attached to a lever 112 which is pivotally secured to the elevator car. The lever is biased by a spring 114 to maintain the cable 110 taut.

The ends of the channel 108 may be left open to provide air circulation which carries heat from the transmitter device 1T. Additional ventilation may be provided in any suitable manner if so desired.

The detector device 1D is mounted in a channel 116 which is detachably secured to the edge of the door unit 36A. The construction is similar to that discussed for the mounting of the transmitter device 1T.

The detector device 1D may be of any type responsive to the radiant energy received from the transmitter device 1T. Thus for infrared radiant energy the detector device 1D may be of the photoemissive type, the photoconductive type or the photovoltaic type as desired. The terminals of the detector device are connected through a suitable cable 118 and through a suitable source of voltage, if employed, to two terminals 120 and 122. The cable 118 is similar to the cable 110 and may be similarly secured to the elevator car.

In a preferred embodiment of the invention, the detector device 1D comprises a small wafer 124 of germanium which is mounted in an electroconductive ring 126. The wafer has a dimple on one face in which a collector electrode 128 is located. The ring 126 and the collector electrode 128 constitute the terminals of the detector device. These terminals are connected in series with a suitable source of direct voltage represented by polarity markings + and - across the terminals 120 and 122.

The radiant energy received from the transmitter device 1T is applied to the face of the wafer 124 opposite the collector electrode 128. In this area, the wafer may have a thickness of the order of .003 of an inch. Preferably the radiant energy is focussed on the wafer by means of a suitable lens 130. If desired, a filter may be employed or the lens 130 may be constructed of a filter capable of transmitting only infrared radiant energy. This prevents excitation of the wafer 124 by visible light.

Any suitable translating device may be connected to the terminals 120 and 122. In the present case, a relay 1P has its coil connected directly across the terminals. If desired, an amplifier (not shown) may be inserted between the terminals 120 and 122 on the one hand and the relay 1P for the purpose of amplifying the energy received from the terminals. However, the germanium wafer detector device may be designed to provide sufficient output to operate the relay 1P directly.

As long as the detector device 1D is receiving infrared radiant energy, the relay 1P is energized and picked up and the break contacts 1P1 are opened. If the beam is interrupted in any way as by the presence of a person in the path of the beam, the relay 1P is dropped out and the break contacts 1P1 are closed. As hereinafter pointed out, the closing of the contacts 1P1 may be employed for retarding closure of the car doors.

If desired the transmitter device 1T and the detector device 1D may be mounted on portions of the elevator car adjacent the opening, but separate from the doors 35 and 36. However, it is desirable to mount the devices in such a manner that as the elevator car doors close, the distance between the devices decreases. Such decrease is assured by the mounting of one or both of the devices in the edges of the doors as herein set forth. The shortening of the distance between the devices makes it more unlikely that the detector device will be affected by reflected infrared radiant energy. Furthermore when

the elevator doors are completely closed, the lenses of the transmitter and detector devices are completely protected from possible abrasion and from the deposition of dust thereon. Furthermore by locating the device in a manner herein set forth, the lenses are completely available for cleaning.

Although a single beam may be helpful in protecting the opening between the doors 35 and 36, it is advantageous to provide a plurality of beams. To this end, a plurality of transmitter devices 1T, 2T, 3T, 4T, 5T and 6T may be located in a row along the leading edge of the door 35. These transmitter devices project a plurality of parallel beams across the opening. The transmitter devices may be spaced apart by any desired distance. It is contemplated that the distance between adjacent transmitter devices need not be less than 6 inches. Such a 6-inch minimum spacing is adequate for most elevator car installations.

All of the transmitter devices are mounted in the leading edge unit 35B in the same manner and are similarly energized through the cable 110. If it is necessary to service or replace the transmitter devices, the complete edge unit 35B containing all of the transmitter devices may be removed from the associated door unit 35A.

A separate detector device is provided for each of the transmitter units. Thus in Fig. 1 transmitter devices 1D, 2D, 3D, 4D, 5D and 6D are illustrated. These are all mounted on the leading edge of the door 36 in the same manner and their outputs are transmitted through the cable 118 to individual relays, each similar to the relay 1P, and identified by the letter P preceded by the numeral corresponding to the numeral prefix of the associated detector device. Since all of the detector devices are mounted on the leading edge unit 36B, they may be removed as a single assembly from the door unit 36A for servicing or replacement as desired.

Fig. 3 represents the control circuits shown in Fig. 5 of the aforesaid McCormick patent modified as shown in heavy lines. Since the invention may be described adequately as applied to the car doors, Fig. 3 does not disclose the circuits for controlling the hatchway doors. However, it is to be understood that if the hatchway doors of the McCormick patent are employed, they may be protected in the same manner discussed for the car doors.

Translating mechanism is provided which preferably has a response dependent on the number of beams which are interrupted. For example, the doors may be retarded to a degree dependent on the number of beams which are interrupted.

By inspection of Fig. 3 it will be noted that two relays A and B are added to the control circuits of the McCormick patent. These relays will be referred to respectively as the first retarding relay and the second retarding relay. The relays A and B are connected between the buses L+1 and L-1 for energization through a parallel circuit having 6 arms in parallel. Each of the arms includes a resistor and a separate one of the relays associated with the detector devices 1D to 6D. For example one arm includes a resistor 1R and the break contacts 1P1 for the relay 1P. A second arm includes a resistor 2R and break contacts 2P1. It will be understood that the break contacts 2P1 are open when the detector device 2D receives an infrared radiant energy beam and are closed when the beam is interrupted. Thus each of the arms in the parallel circuit is controlled by a separate one of the detector devices 1D to 6D.

The relay A is designed to pick up when it is energized through a predetermined number of the associated parallel arms. For present purposes it will be assumed that the relay A picks up when it is energized through any one of the associated parallel arms.

The relay B is designed to pick up when it is energized through a number of arms of the associated parallel circuit larger than the number required to pick up the

relay A. In the present case, it will be assumed that the relay B picks up when it is energized through any two arms of the associated parallel circuit. If desired the relays A and B may be of similar construction but the difference in pickup may be provided by a resistor BR which is connected in shunt with the coil of the relay B. By adjusting the value of the resistor BR, the number of parallel arms of the associated parallel circuit through which the relay B must be energized for the relay to pick up may be adjusted.

The first retarding relay is designed to introduce a first retarding effect in the door closure of the elevator car. To this end, pickup of the relay A is accompanied by closure of the make contacts A1 to connect through break contacts OR7 a resistor RA across the armature CA of the car door motor C. Such connection of the resistor decreases the current flowing through the armature and increases the current flowing through the field winding CF to decrease the rate at which the doors close. Consequently if a person attempts to prevent closure of the doors by interrupting one of the beams with his hand the doors will still continue to close but at a slower rate of movement. Break contacts OR7 are added to the door opening relay OR of the aforesaid McCormick patent.

Furthermore, if one of the transmitter devices or one of the detector devices become inoperative, the doors of the elevator car can still operate but at a slower rate of movement until the defective device is repaired or replaced.

Pickup of the second retarding relay B is intended to produce a further retarding effect on the closure of the doors. Such a retarding effect may cause the doors to close at a still slower rate, it may stop the doors completely or it may reopen the doors.

As shown in the preferred embodiment, the relay B in picking up opens its break contacts B1 and B3 to interrupt the closing circuit for the field winding CF and the armature CA. At the same time the make contacts B2 close to establish an opening circuit for the door opening relay OR. Consequently, the pickup of the relay B is accompanied by reopening of the car doors.

The operation of the system now may be set forth. For the first operation it will be assumed that the retarding relays A and B both remain deenergized. Under these circumstances the car doors operate in the same manner discussed in the McCormick patent and may be set forth as follows:

It will be assumed that the car is in operation and is slowing down to a stop at the third floor. The controller switches CL4, CL3 and LO are closed by reason of the position of the controller L.

As the car comes into the third floor, it is assumed that the attendant throws the car switch CS to open the car doors 35 and 36. The closing of the contact members CS1 energizes the door opening relay OR by the circuit L+1, OR, LO, CS1, L-1.

The closing of the contact members OR3 and OR4 energizes the field winding CF and the armature CA of the car door motor to move the car doors to their open position, through the circuit L+1, OR3, CF, OR4, r3, CA, L-1. The energized motor moves the chains 49 and 53 to open the car doors and the action of the chains rotates the controller L to restore its limit switch contact members LC to their closed position. By the time the doors are approximately one inch open, the chains rotate the controller to restore its contact members CL4 to their open position. When the doors are, say, four inches open, the controller restores its contact members CL3 to their open position. As the car doors continue their travel toward their open position and are, say, four inches from their full open position, the controller L closes its first decelerating contact members OL1, thereby energizing the first opening resistor relay 1K which, in turn, closes its contact members. The closing of the contact members

1K2 inserts a predetermined portion of the resistor r4 in parallel with the armature CA of the car door motor to decelerate that motor to slow down the car door as it nears its full open position. As the doors arrive at, say, one inch from their full open position, the controller L is operated to close its second decelerating switch OL2, thereby energizing the second opening resistor relay 2K to close its contact members by the circuit L+1, 2K, OL2, OR5, L-1. The closing of the contact members 2K2 inserts a predetermined portion of the resistor r4 in parallel with the armature CA of the car door motor to decelerate that motor to slow down the car doors so that they move softly into their full open position.

In the diagram of Fig. 3, the resistor r4 is shown as connected at various points by adjustable arrows controlled by opening and closing switches. It should be understood that in actual practice the circuits controlled by the opening and closing switches may be connected to the resistor at any point or points selected by the elevator engineer and that it is common practice to make these connections when the elevator is installed and to change or modify them in any manner desired to secure smooth operation of the car door motor in opening and closing the doors with which they are associated.

As the car doors reach their open position, the controller L is operated to open its limit switch LO to deenergize the opening relay OR. However, inasmuch as this relay is associated with its condenser 70, it stays energized for a very short time to give the door motors time to complete their opening movement after the limit switch opens and also causes the doors to be held in their full open position momentarily against their bumpers to absorb their rebound. The opening of the contact members OR3 and OR4 deenergizes the field winding CF and the armature CA of the car door motor, thereby stopping that motor. The opening of the contact members OR5 deenergizes the first opening and the second opening resistor relays 1K and 2K to open their contact members for disconnecting the resistor r2 from the circuits for the armature CA.

It will be assumed now that the passengers have entered or left the car and that the car attendant moves the car switch CS in a clockwise direction to effect the closing of the car doors. The movement of the switch closes its contact members CS2, thereby energizing the door closing relay CR through the circuit L+1, CR, LC, CS2, L-1.

The closing of the contact members CR3 and CR4 energizes the car door motor C through the circuit L+1, CR4, B3, CF, B1, CR3, r3, CA, L-1. The energized car door motor moves the car doors toward their closed position and in doing so causes the chains 49 and 53 to rotate the controller L so that it restores the limit switch LO to its closed position. As the car door moves, say, one inch away from its open position, the controller restores its switch OL2 to its open position, and as the car door moves, say, four inches away from its open position, the controller restores the switch OL1 to its open position, to prepare them for closing at the proper time in the opening sequence of the doors.

As the doors arrive at, say, four inches from their closed position, the controller L closes its switch CL3, thereby completing the circuit for energizing the first closing resistor relay 3K to close its contact member 3K2. The closing of the contact members 3K2 inserts a predetermined portion of the resistor r4 in parallel with the armature CA of the car door motor to cause that motor to decelerate and thus slow down the movement of the car door as it nears its fully closed position.

As the car door gets within, say, one inch of its closed position, the controller L closes its switch CL4, thereby inserting a predetermined portion of the resistor r4 in parallel circuit with the armature CA to positively check the car door motor as the car door reaches the desired predetermined distance from its full closed position.

When the doors are about one-half inch from their fully closed position, the controller opens its limit switch LC, thereby opening the circuit for the door closing relay CR but the condenser 71 on this relay maintains it in its energized condition for a time sufficient for the motors to move the doors to their fully closed position and also causes the motors to hold the doors momentarily against their bumpers to absorb the rebound therefrom. When the relay CR becomes deenergized, it opens its contact members. The opening of the contact members CR3 and CR4 deenergizes the car door motor. The opening of the contact members CR5 removes a predetermined portion of the resistor r4 from the circuit of the armature CA of the car door motor. The opening of the contact member CR6 deenergizes the first closing resistor relay 3K which restores its contact member 3K2 to its open position.

Next it will be assumed that one of the devices such as the transmitter device 1T has an open circuit and fails to produce a beam of radiant energy. Under such circumstances, the source of radiant energy is removed from the detector device 1D and the relay 1P drops out to close its break contacts 1P1.

As shown in Fig. 3 closure of the break contacts 1P1 completes the following energizing circuit for the retarding relays: L+1, 1P1, 1R, A, B and BR in parallel, L-1. Such energization is insufficient to pick up the second retarding relay B but it is sufficient to pick up the first retarding relay A. The relay A closes its make contacts A1 to connect through the contacts OR7 the resistor RA across the armature CA. This reduces the closing speed of the doors but permits closure of the doors at the reduced speed until the defective transmitter device is replaced or repaired.

Let it be assumed next that a passenger attempts to prevent closure of the doors by advancing his foot to interrupt the radiant energy transmitted by the transmitter device 1T. The effect of such interruption is to prevent radiant energy from reaching the transmitter device 1D and the relay 1P drops out to close its break contacts 1P1. Consequently during the closing operation of the doors, the first retarding relay A is picked up through the following circuit: L+1, 1P1, 1R, A, B and BR in parallel, L-1. Such energization is insufficient to cause pickup of the relay B.

The closure of the make contacts A1 connects the resistor RA through the break contacts OR7 across the armature CA to reduce the speed of closure of the doors. Consequently the doors continue to close at a reduced rate and tend to force the foot of the person away from the door. Because of the slow rate of movement of the door the person can remove his foot completely before the doors close.

Finally let it be assumed that during a closing operation of the doors a person enters the opening and interrupts at least the beams transmitted from the transmitter devices 1T and 2T. As a result of such operation, the relays associated with the detector devices 1D and 2D both drop out and close their break contacts 1P1 and 2P1, to establish the following circuit: L+1, 1P1 and 1R in parallel with 2P1 and 2R, A, B and BR in parallel, L-1.

The second retarding relay B is now energized sufficiently to pick up. This relay opens its break contacts B1 and B3 to interrupt the closing circuit for the field winding CF and the armature CA. Consequently, the elevator car doors come to a stop.

At the same time, the second retarding relay B closes its make contacts B2 to establish the following opening circuit for the door opening relay: L+1, OR, LO, B2, L-1. Since the door opening relay OR now is energized, it operates in a manner previously described to open the doors.

The relay A also picks up and closes its make contacts A1. However, the opening of the break contacts OR7 renders the make contacts A1 ineffective to control the

speed of the car door motor and the doors open at full speed.

When the opening again is cleared, the relays A and B drop out to permit a normal door closing operating of the elevator car doors.

In the embodiment of Fig. 3 opening and closing of the doors are controlled by a car switch. As previously pointed out, the doors may be controlled to open automatically as the car stops and to close automatically a predetermined time after they open or to close in response to registration of car or corridor calls for elevator service. Such automatic operation of doors is well known in the art.

Although the invention has been described with reference to certain specific embodiments thereof, numerous modifications falling within the spirit and scope of the invention are possible.

I claim as my invention:

1. In a closure system, a structure having an opening, a door, means mounting the door for movement to close and expose said opening, and object-detecting means responsive to the presence of an object substantially in the path of said door, said object-detecting means comprising a plurality of transmitters each positioned to direct a separate beam of radiant energy other than visible light substantially across said opening, said beams being spaced from each other in a direction parallel to the plane of the opening, separate detecting means responsive to such radiant energy positioned in the path of each of said beams for controlling the operation of said door, motive means for moving the door relative to said structure, and translating means controlled by the detecting means for conditioning the motive means to retard movement of the door by the motive means as a function of the number of said beams which are interrupted, said translating means being responsive to the change in condition of the detecting means following interruption of at least a predetermined first number of said beams for retarding movement of the door in a closing direction by the motive means, said translating means being responsive to the change in condition of the detecting means only if a second number of said beams larger than said predetermined first number of said beams are interrupted for further retarding movement of the door.

2. In a closure system, a structure having an opening through which objects may enter and leave the structure, a door, means mounting the door for movement to close and expose said opening, motive means effective when operated for moving the door to close and expose the opening, and object-detecting means responsive to the presence of an object in a space substantially in the path of the door during movement of the door in a first direction by the motive means for retarding movement of the door in said first direction by the motive means, said object-detecting means comprising a plurality of separate transmitters each positioned to direct a separate beam of infrared energy substantially across said opening, said beams being spaced from each other in a direction parallel to the plane of the opening, and separate infrared detecting means positioned in the path of each of said beams at a position spaced substantially from the associated transmitter along the associated beam for controlling the movement of the door in said first direction said detecting means including means modifying the movement of the door differently for a plurality of different conditions of interruption of said beams.

3. In a closure system, a structure having an opening, a door, means mounting the door for movement to close and expose said opening, and object-detecting means responsive to the presence of an object substantially in the path of said door, said object-detecting means comprising a transmitting device for directing radiant energy into a predetermined area, and a detecting device responsive to said radiant energy, a first one of said devices being mounted on a portion of said structure other than

said door in position to be approached by a leading edge of said door during closing movement of the door, the second one of said devices being mounted on the leading edge of said door to approach the first one of said devices as the door closes, said transmitting device directing radiant energy across said opening when the door is open towards the detecting device for detection by the detection device, whereby presence of an object between the devices in the path of said radiant energy interrupts the detection of radiant energy by said detecting device.

4. In a closure system, a structure having an opening, first and second doors having leading edges adjacent each other when the doors are in position to close said opening, means mounting the doors for simultaneous movement towards and from each other relative to the structure to close and expose the opening, and object-detecting means responsive to the presence of an object substantially in the path of either of said doors, said object-detecting means comprising a transmitting device mounted on the first door adjacent the leading edge of the first door for directing radiant energy across the opening substantially towards the leading edge of the second door, and a detecting device mounted on the second door adjacent the leading edge of the second door to receive said radiant energy, said detecting device being responsive to said radiant energy for operation from a first to a second condition, whereby blocking of said radiant energy by an object positioned substantially between said doors places the detecting device in said first condition.

5. In a closure system, a structure having an opening, first and second doors having leading edges adjacent each other when the doors are in position to close said opening, means mounting the doors for simultaneous movement towards and from each other relative to the structure to close and expose the opening, and object-detecting means responsive to the presence of an object substantially in the path of either of said doors, said object-detecting means comprising a transmitting device mounted on the first door adjacent the leading edge of the first door for directing radiant energy across the opening substantially towards the leading edge of the second door, a detecting device mounted on the second door adjacent the leading edge of the second door to receive said radiant energy, said detecting device being responsive to said radiant energy for operation from a first to a second condition, whereby blocking of said radiant energy by an object positioned substantially between said doors places the detecting device in said first condition, and motive means for opening and closing said doors, said motive means being operable with said detecting device in said second condition to effect a predetermined closure of the doors, and said detecting device when operated to said first condition being effective for retarding closure of the doors.

6. In a closure system, a structure having an opening, first and second doors having leading edges adjacent each other when the doors are in position to close said opening, means mounting the doors for simultaneous movement towards and from each other relative to the structure to close and expose the opening, and object-detecting means responsive to the presence of an object substantially in the path of either of said doors, said object-detecting means comprising a plurality of first devices mounted substantially in a row along the leading edge of the first door, a plurality of second devices mounted substantially in a row along the leading edge of the second door, said devices being arranged in a plurality of pairs each including a separate one of the first devices and a separate one of the second devices, the devices in each of said pairs comprising respectively a transmitting device for transmitting radiant energy in a beam across the opening between the doors and a detecting device responsive to the radiant energy received from the asso-

ciated transmitting device for operation from a first to a second condition.

7. In a closure system, a structure having an opening, first and second doors having leading edges adjacent each other when the doors are in position to close said opening, means mounting the doors for simultaneous movement towards and from each other relative to the structure to close and expose the opening, and object-detecting means responsive to the presence of an object substantially in the path of either of said doors, said object-detecting means comprising a plurality of first devices mounted substantially in a row along the leading edge of the first door, a plurality of second devices mounted substantially in a row along the leading edge of the second door, said devices being arranged in a plurality of pairs each including a separate one of the first devices and a separate one of the second devices, the devices in each of said pairs comprising respectively a transmitting device for transmitting radiant energy in a beam across the opening between the doors and a detecting device responsive to the radiant energy received from the associated transmitting device for operation from a first to a second condition, the first door including a first door unit and a first edge unit detachably secured to the leading edge of the door unit, said first devices being mounted on the edge unit for attachment or separation as a complete assembly relative to the first door unit, and the second door including a second door unit and a second edge unit detachably secured to the leading edge of the second door unit, said second devices being mounted on the second edge unit for attachment or separation as a complete assembly relative to the second door unit.

8. In a closure system, a structure having an opening, first and second doors having leading edges adjacent each other when the doors are in position to close said opening, means mounting the doors for simultaneous movement towards and from each other relative to the structure to close and expose the opening, object-detecting means responsive to the presence of an object substantially in the path of either of said doors, said object-detecting means comprising a plurality of first devices mounted substantially in a row along the leading edge of the first door, a plurality of second devices mounted substantially in a row along the leading edge of the second door, said devices being arranged in a plurality of pairs each including a separate one of the first devices and a separate one of the second devices, the devices in each of said pairs comprising respectively a transmitting device for transmitting radiant energy in a beam across the opening between the doors and a detecting device responsive to the radiant energy received from the associated transmitting device for operation from a first to a second condition, motive means for operating the doors, and common translating means responsive to the operation of any of said detecting devices from the second to the first condition for modifying the operation of the doors by the motive means.

9. In a control system, a structure having an opening, means for establishing a plurality of spaced beams of radiant energy in said opening, first and second translating means having different responses to the interruption of said beams of radiant energy for exercising different control functions in said system, said first translating means being responsive to a predetermined change in the condition of at least a predetermined first number of said beams, and said second translating means being responsive to a predetermined change in the condition of said beams only if the number of beams having said predetermined change is larger than the first number.

10. In an elevator system, an elevator car having a door opening through which objects may enter and leave the elevator car, a door, means mounting the door for reciprocation in a substantially straight path to close and expose the opening, an energizing circuit, motive means effective when energized through said energizing circuit

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for moving the door in said path to close and expose the opening, object-detecting means responsive to the presence of an object in a space substantially in the path of the door during a closing movement of the door by the motive means for retarding closing movement of the door by the motive means, said object-detecting means comprising a transmitting device for directing across said space a beam of radiant energy, said radiant energy being focussed into a beam which is parallel to the closing direction of the door and which is confined substantially to said space, a detecting device in the path of the beam of radiant energy after the beam has crossed said space, said detecting device being responsive to interruption of the beam for operation from a first condition to a second condition, means responsive to operation of the detecting means to said second condition during a door-closing operation of the motive means for decreasing the closing energy supplied to the motive means by said

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energizing circuit, and means mounting one of said devices for movement towards the other of said devices during a door-closing operation, whereby the spacing of the devices decreases as the effective door opening decreases.

References Cited in the file of this patent

UNITED STATES PATENTS

1,822,152	Kinnard et al. -----	Sept. 8, 1931
1,929,273	Crago -----	Oct. 3, 1933
1,947,079	Ellis -----	Feb. 13, 1934
2,082,941	Burnside -----	June 8, 1937
2,149,177	Miller -----	Feb. 28, 1939

OTHER REFERENCES

Walker: "Photoelectric Cells in Industry," Pitman Pub. Corp., New York, 1948, page 189. (Copy in Patent Office Technical Library TK 7872.P5W3.)