Sept. 20, 1960 J. J. DREXLER 2,953,219

DOOR CONTROL APPARATUS

Filed Dec. 24, 1954

Fig.1.

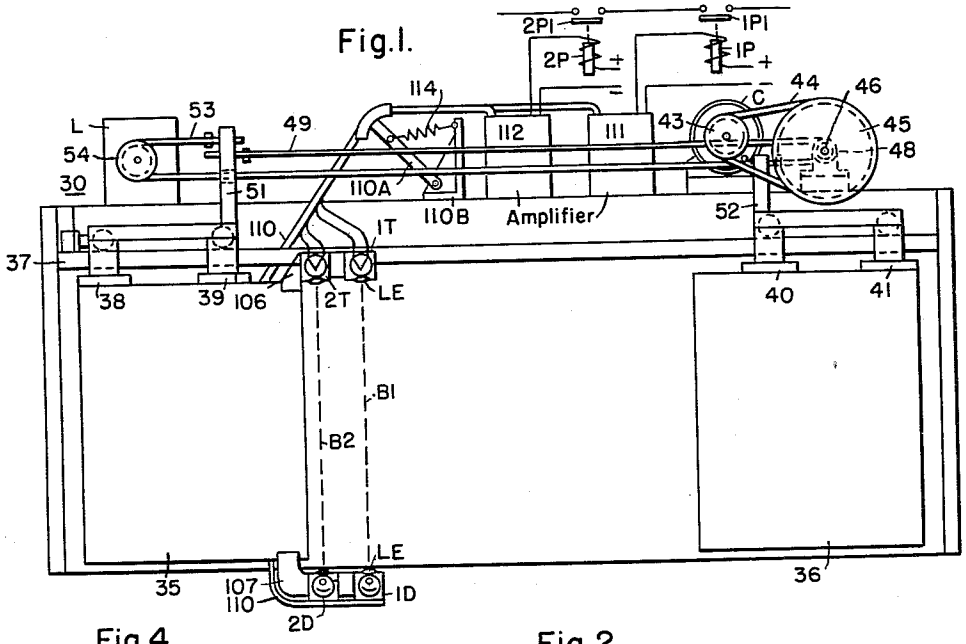


Fig.4.

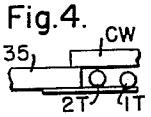


Fig.2.

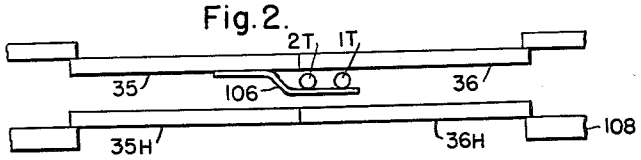


Fig.3.

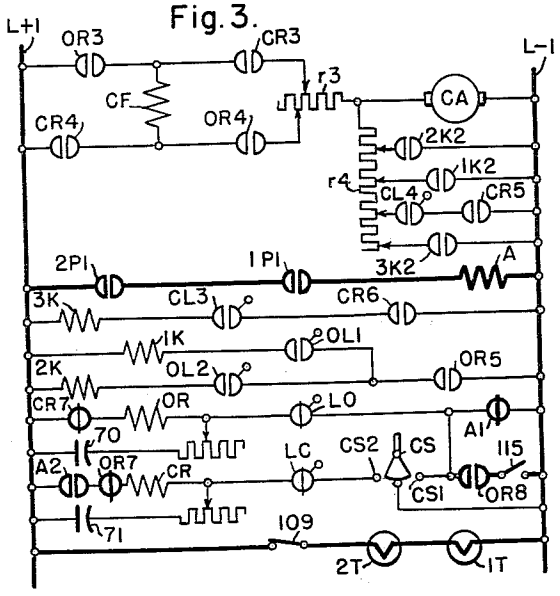
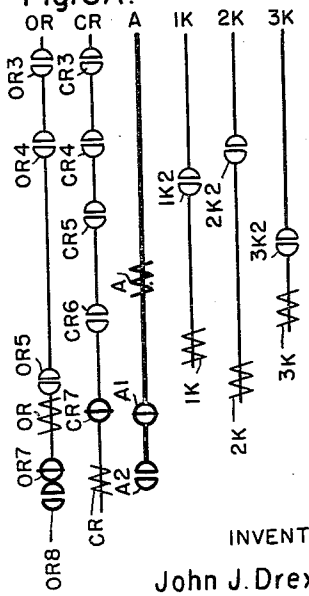


Fig.3A.



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DOOR CONTROL APPARATUS

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6 Claims. (Cl. 187—48)

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. This beam is moved across the opening which is closed by the door. If an object is positioned substantially in the closing path of the door, the beam is interrupted. Such interruption of the beam is employed for retarding closure of the door or interruption of the beam may result in reopening of the door.

In a preferred embodiment of the invention, a beam of radiant energy which may be termed an advance beam is moved across the door opening in accordance with door movement during a closing operation of the door. The beam may precede the edge of the door which is the leading edge during a closing operation of the door by a predetermined distance for the purpose of detecting the presence of an object in the closing path of the door in sufficient time to permit stopping of the door before the door strikes the object.

Desirably, a plurality of beams of radiant energy may be employed for the purpose of providing complete protection for objects in the closing path of a door. In addition to the previously mentioned advance beam, a lead beam of radiant energy may be employed which is displaced slightly from that edge of the door which is the leading edge during a closing movement of the door. The lead beam preferably is close enough to the door edge to be interrupted by small objects such as the hand of a person in engagement with the door edge. Interruption of either of the beams is employed for modifying the operation of the car door.

It is, therefore, an object of the invention to provide

a protective device including a beam of radiant energy which is movable across an opening to be closed by a door.

It is a further object of the invention to provide a protective device including a beam of radiant energy which is movable substantially with a door and which leads the door during movement of the door in a closing direction.

It is another object of the invention to provide a protective device including a plurality of protective beams of radiant energy which are movable in succession across an opening for the purpose of detecting the presence of an object in the opening.

It is also an object of the invention to provide for a door a protective device including a beam of radiant energy associated with a door wherein the beam is positioned in advance of the edge of the door which is the leading edge during door closure and wherein the beam is displaced from the plane of the door.

It is an additional object of the invention to provide protective mechanisms for center opening doors which include a beam of radiant energy positioned to lead one of the doors during a closing movement of the doors and which is spaced from the plane of the associated door by a distance sufficient to clear the cooperating door when the two doors are moved into abutting relationship.

It is a still further object of the invention to provide an elevator system having an elevator car door and a hoistway door with a protective device including a beam of radiant energy which is positioned to lead the doors during a closing movement of the doors and which is positioned substantially between the planes of the doors.

It is still another object of the invention to provide apparatus as specified in any of the foregoing objects in combination with a door operator for opening and closing each of the doors and mechanisms responsive to interruption of a beam of radiant energy during closure of an associated door for controlling the associated door operator to reopen the associated door.

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 and having doors in open positions;

Fig. 2 is a view in top plan with parts broken away of the elevator car of Fig. 1 illustrated with closed doors and associated with hoistway doors;

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

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; and

Fig. 4 is a view in top plan of a portion of an elevator car illustrating a modified door construction.

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, 36—horizontally sliding center opening doors.
37—overhead track.
38, 39, 40, 41—hangers.
43—driving pulley or wheel.
44—driving belt.
45—driven pulley or sheave.
46—shaft.
48, 54—sprocket wheels.
49, 53—sprocket chains.
51, 52—brackets.
*r*3, *r*4—resistors.
70, 71—condensers.

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. The present drawing also illustrates a retarding relay A and relays 1P and 2P. An additional set of contacts CR7 is provided on the relay CR, and additional contacts OR7 and OR8 are provided for the relay OR.

During movement of the doors 35 and 36 in the closing direction from their open positions illustrated in Fig. 1, it is possible that an object or person may be located in the closing path of the door. To prevent the doors from striking the object, a beam of radiant energy illustrated by a broken line B1 is positioned to lead the door 35 by a substantial distance which may be of the order of five inches during the closing movement of the door. The lead distance preferably is sufficient to permit stopping of the door when the beam is interrupted before the door can strike the object responsible for the interruption of the beam.

Preferably, a second beam of radiant energy B2 is located adjacent the edge of the door 35 which is the leading edge during door closure. It will be noted that this leading edge and the beams B1 and B2 are substantially parallel to each other and extend in a vertical direction. The beam B2 leads the door 35 slightly during a door closing movement. However, the beam preferably is sufficiently close to the edge to assure substantial interruption of the beam by a small object such as the hand of a person which is in engagement with the edge of the door.

The radiant energy making up the beams B1 and B2 may have a frequency selected from a wide range. Preferably, the radiant energy is of a type which may be focussed into a beam. As examples of suitable radiant energy, reference may be made to light which may have a frequency within the visible spectrum or which may be of an invisible nature such as, for example, infrared radiant energy.

The advance beam of radiant energy B1 is located between two devices 1T and 1D. The leading beam of radiant energy B2 is located between two devices 2T and 2D. The beams may be established in various ways.

For examples of a detector device responsive to the radiant energy, reference may be made to a detector device of the photoemissive type, the photoconductor type, or the photovoltaic type. For present purposes, it will be assumed that a photoconductive cell is employed for detection purposes.

It will be assumed for present purposes that each of the beams is produced by a separate lamp and that each of the beams is associated with a separate photocell. Thus, the beam B1 is produced by the transmitter device 1T which comprises a lamp. In a similar manner, the transmitter device 2T constitutes a lamp capable of producing the beam B2. Lenses LE may be associated with the lamps to assist in directing the radiant energy in a compact beam.

The beam of radiant energy B1 transmitted by the transmitter device 1T is received by the photocell 1D. A similar beam of radiant energy B2 is transmitted by the transmitter device 2T and is received by the photocell represented by the detector device 2D. Lenses LE may be employed for the purpose of focussing each of the beams on its associated photocell.

The two transmitter devices 2T and 1T are mounted on a bracket 106 which is secured to the upper edge of the door 35. The two detector devices 1D and 2D are mounted on a bracket 107 which is secured to the lower part of the door 35. Consequently, the beams B1 and B2 are mounted for movement with the door 35.

The horizontal location of the beams may be selected in accordance with requirements. In Figs. 2 a preferred location for the beams is illustrated. In Fig. 2 the doors 35 and 36 in their closed positions are shown associated with two hatchway or hoistway doors 35H and 36H, respectively. It will be understood that a pair of doors similar to the doors 35H and 36H is located at each floor which the elevator car is intended to serve. When the elevator car is positioned at a floor, the doors 35 and 35H are moved to the left from closed positions and the doors 36 and 36H are moved to the right for the purpose of exposing the passage through which the passengers enter and leave the elevator car. If a conventional master operator is employed, the doors 35 and 35H move as a unit and the doors 36 and 36H also move as a unit. For present purposes, it will be assumed that a master operator is employed. However, as pointed out in the aforesaid McCormick patent, the hoistway doors may be operated independently of the elevator car doors. The hoistway doors 35H and 36H close an opening in a hoistway wall 108 in a conventional manner.

By inspection of Fig. 2, it will be noted that the transmitter devices 1T and 2T and, consequently, the beams produced thereby are displaced from the plane of the doors 35 and 36 sufficiently to clear the door 36 when the doors 35 and 36 are in abutting relationship. If beams also are associated with the door 36, they also may be displaced from mechanisms associated with the door 35 for the purpose of clearing in a similar manner such mechanisms of the door 35.

If hoistway doors are provided, the transmitter devices 1T and 2T preferably are located to transmit the beams of radiant energy between the car doors and hoistway doors to control the closing of all of the doors. However, if desired, similar beams may be associated with one or each of the hoistway doors for the purpose of providing independent protection for these doors.

In Fig. 4, the door 35 is assumed to be a side opening door which cooperates with the wall CW of the elevator

car to complete an enclosure for persons within the elevator car. In such a case, the transmitter devices 1T and 2T and the beams produced thereby may be located substantially in the plane of the door 35. Since the door 35 is displaced from the car wall CW, the beams are displaced sufficiently from the car wall to prevent interference thereby.

Returning to Fig. 1, it will be noted that the lamps 1T and 2T are energized through conductors which extend through a flexible cable 110 to a suitable source of energy which may be the buses L+1, L—1 of Fig. 3 and which will be discussed further below. The flexible cable 110 is secured to one end of a link 110A which has its other end pivotally associated with a bracket 110B on the elevator car. A spring 114 extends between the link 110A and the bracket 110B secured to the car for the purpose of maintaining tension on the cable 110. With this construction, the cable 110 permits free movement of the associated door.

The photocells 1D and 2D have their electrodes connected to conductors which also extend through the cable 110. If the outputs of the detector devices 1D and 2D are sufficient, they may be applied directly to relays such as the relays 1P and 2P. For present purposes, it will be assumed that each of the photocells is connected to the input terminals of a suitable amplifier capable of producing an amplified output representative of the energization of the photocell. Thus, the photocell 1D is connected to the input terminals of a suitable amplifier 111. The output terminals of the amplifier are connected in series with the winding of the relay 1P and a suitable source of direct current represented by polarity markings + and —. In a similar manner, the detector is associated with an amplifier 112 and the relay 2P.

The connections are such that as long as radiant energy reaches the detector devices 1D and 2D, the relays 1P and 2P, respectively, are picked up. If either of the beams of radiant energy is interrupted, the associated relay 1P or 2P drops out.

These relays or the relay A controlled thereby (described also) may be connected in a conventional manner to any suitable door-operator system for retaining or reversing closing doors when one of the relays operates in response to interruption of one of the beams.

Figure 3 represents the control circuits shown in Fig. 5 of the McCormick patent modified as shown in heavy lines. Since the invention may be applied adequately to the car doors, Fig. 3 does not disclose the circuits for controlling the hatchway or hoistway 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 as discussed for the car doors.

By inspection of Fig. 3, it will be noted that a relay A is added to the control circuits of the McCormick patent. The relay A is connected across the buses L+1 and L—1 through the make contacts 1P1 and 2P1 of the relays 1P and 2P illustrated in Fig. 1. In addition, the lamps of the transmitter devices 1T and 2T are connected across the buses L+1 and L—1 through a suitable switch 109. For present purposes, it will be assumed that this is a manual switch which is maintained in its closed condition during operation of the elevator car.

The operation of the system now may be set forth. Inasmuch as the lamps of the transmitter devices 1T and 2T are illuminated, the relays 1P and 2P are picked up and the relay A is energized. Consequently, the make contacts A2 are closed and the break contacts A1 are open.

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, CR7, OR, LO, CS1, CS, 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 positions through the circuit L+1, OR3, CF, OR4, *r*3, 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 *r*4 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 *r*4 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 *r*4 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 adsorb 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 *r*2 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, A2, OR7, CR, LC, CS2, CS, L—1.

The closing of the contact members CR3 and CR4 energizes the car door motor C through the circuit L+1, CR4, CF, CR3, *r*3, 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 *r*4 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 *r*4 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 adsorb 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 *r*4 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 as the doors are closing the beam of radiant energy from one of the devices such as the transmitter device 1T is interrupted. Under such circumstances, the source of radiant energy is removed from the detector device 1D and the relay 1P drops out to open its make contacts 1P1.

As shown in Fig. 3 opening of the make contacts 1P1 interrupts the energizing circuit for the retarding relay A. This relay opens its make contacts A2 to deenergize the door closing relay CR. The relay CR opens its contacts CR3 and CR4 to stop the closing movement of the door. Also contacts CR5, CR6 and CR7 are reset.

The retarding relay A also closes its break contacts A1 to establish, when the contacts CR7 close, the following opening circuit for the door opening relay: L+1, CR7, OR, LO, A1, L—1. Since the door opening relay OR now is energized, it operates in a manner previously described to open the doors. The extent of the reopening of the door may be controlled as desired. Thus, the relay A may have a delay in pickup sufficient to assure full reopening of the door even though the beam interruption is brief. For present purposes, it will be assumed that the relay A picks up fairly promptly when energized.

Full door reopening also may be assured by closing the manual switch 115 to connect the make contacts OR8 across the contacts A1. When an opening operation of the door is initiated the make contacts OR8 close to shunt the contacts A1 and the door open contacts of the switch CS until the door is fully open.

When the beam again is cleared, the relay A picks up to permit a normal door closing operation of the elevator car doors.

Interruption of the beam B2 during a door closure operation results in deenergization of the relay 2P and consequently of the relay A. The relay A then operates in the manner previously discussed to reopen the 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 mounted for movement relative to the structure substantially in accordance with movement of the door and responsive to the presence of an object substantially in the path of said door, said object-detecting means comprising a plurality of transmitter devices each positioned to direct a separate beam of radiant energy substantially parallel to an edge of the door, said beams being spaced from each other in a direction parallel to the plane of the opening, and a separate detector device responsive to such radiant energy positioned in the path of each of said beams for controlling the operation of said door.

2. A system as claimed in claim 1 in combination with motive means for moving the door relative to said structure, and translating means responsive to the change in condition of the detector devices following interruption of at least a predetermined first number of said beams for retarding movement of the door by the motive means.

3. A system as claimed in claim 2 wherein said translating means is effective to retard movement of the door in only one direction of travel.

4. 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 mounted for movement relative to the structure substantially in accordance with movement of the door and 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 transmitter mechanism positioned to direct a plurality of separate beams of radiant energy in a direction substantially along an edge of the door which is the leading edge during a door-closing movement, said beams being spaced at different distances in advance of the door during a door closure, said detector means responsive to interruption of any of said beams for controlling the movement of the door in said first direction.

5. In a closure system, a structure having an opening, a pair of first and second doors having leading edges adjacent each other when the doors are in position to close said opening, a pair of third and fourth doors spaced from the first pair of doors for closing and exposing the opening, means mounting the doors of each of said pairs for 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 at least one of said doors, said object-detecting means comprising transmitting means for establishing a plurality of radiant energy beams extending from first points to second points substantially along the leading edge of the first door, said beams moving substantially with the first door and leading the

first door by different distances during a closing movement of the first door, and radiant energy detector means responsive to interruption of either of said beams during door closure for modifying the operation of the doors.

6. A system as claimed in claim 5 in combination with motive means for operating the doors, and common translating means responsive to the operation of said radiant-energy detector means from a second to a first condition for modifying the operation of the doors by the motive means.

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