PATENT SPECIFICATION

DRAWINGS ATTACHED

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Transpose Heading & Title

Control mechanism for elevator doors.

COMPLETE SPECIFICATION

We, OTIS ELEVATOR COMPANY, a corporation organized and existing under the laws of the State of New Jersey, United States of America, located at 260 Eleventh Avenue, New York 1, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The invention relates to control mechanism for power operated doors, especially doors of elevator installations.

In elevator installations in which the elevator cars are operated without attendants, it is common practice to provide mechanism to protect passengers against injury by closing doors. Among these mechanisms are arrangements in which antennae are provided along the leading edge of the elevator car door to detect the presence of a person within a certain distance of the door. The detection is accomplished by a change in capacity of an antenna to ground caused by the proximity of the person. This mechanism is utilized to stop the closing of the door or, if the door is in open position, to prevent its closing.

The British Patent No. 711,515 and the British Patent No. 734,471, are directed to arrangements of this type. In the arrangement of Patent No. 711,515, each antenna acts as a detector and causes firing of an electronic gaseous discharge tube when detection takes place. The tube, upon firing, acts to prevent or stop closing of the door. In the arrangement of patent No. 734,471, antennae are arranged so that unwanted operations are prevented by compensating for field disturbances due to elements, such as hoistway doors and door jambs, of the elevator installation itself. The present invention is directed to an improved arrangement for preventing unwanted operations of the detecting mechanism.

It is an object of the invention to provide detecting mechanism for elevator doors in which unwanted operations of the mechanism caused by irregularities in the configuration of the elevator installation itself are obviated.

Another object of the invention is to provide an improved detecting mechanism for use on elevator doors which mechanism is relatively insensitive to changes in the surrounding atmosphere.

With these objects in view, there is provided, according to the invention, an elevator system in which a closure is provided for controlling access to the elevator car, in which power mechanism is provided for operating said closure, in which detecting mechanism including a pair of antennae, each having a capacitive coupling to ground and mounted in spaced relation along the leading edge of said closure, is provided for detecting a person in the path of closing movement of said closure, and in which closure control means are provided which act when such detection occurs to prevent or stop the closing of the closure by said power mechanism, characterized in that there are provided a bridge circuit having said antennae directly connected to opposite ends of the bridge diagonal to form through their capacitive couplings to ground two arms of the bridge and having two impedances connected to said opposite ends of the bridge diagonal in the other arms of the bridge for balancing the bridge, a source of periodic input voltage for the bridge connected between ground and the junction of said other arms of the bridge, the diagonal of said bridge providing a periodic signal voltage and said bridge being balanced to prevent said signal voltage attaining a certain value when no person is in the field of influence of said antennae, an amplifier, and

transfer means for transmitting said periodic signal voltage to said amplifier to provide an amplified signal voltage, and in that said closure control means is responsive to said amplified signal voltage to prevent or stop the closing of the closure by said power mechanism when said signal voltage, due to a change in the capacitive coupling to ground of one antenna with respect to that of the other as a result of the proximity of a person to said antennae, attains or exceeds said certain value.

The antennae are arranged within a casing which is insulated from the closure and which has a potential applied thereto to shield the antennae from ground. At its forward end where the antennae are positioned, the casing is provided with a non-conducting cover, the surface of which has a high surface resistivity which quality is retained under humid conditions even when soiled as a result of handling by passengers or workmen. Thus, unwanted operations due to leakage from antennae to ground under normal usage are obviated.

In the drawings:

Figure 1 is a somewhate simplified view in front elevation of an elevator car with the car door and associated hoistway door and embodying the invention;

Figure 2 is a plan view of the arrangement of the car door and hoistway door of Figure 1;

Figure 3 is an enlarged detail in elevation of the protective mechanism along the front edge of the car door of Figure 1, illustrating the interior of the channel in which the antennae, amplifying tubes, adjusting condensers and other elements of the door detection circuits are mounted;

Figure 4 is an enlarged detail taken along the line 4—4 of Figure 3;

Figures 5 and 6, taken together, constitute a simplified schematic wiring diagram of that portion of the elevator power and control circuits which relate to the control of the doors;

Figure 7 is a key sheet for Figures 5 and 6, showing the electromagnetic switches in spindle form;

Figure 8 is a diagrammatic illustration of other arrangements of antennae;

Figure 9 is a simplified wiring diagram, similar to Figure 5 but further simplified, of an arrangement utilizing eight antennae; and

Figure 10 is a detail similar to Figure 4 of a construction which may be used in connection with flush hoistway doors.

Referring first to Figure 1, the elevator car 11 is illustrated as positioned at a landing 12. The car door 13 and hoistway door 14 for that landing are illustrated in closed position. While it is to be understood that the car door and hoistway doors may be operated in various ways, an arrangement has been illustrated in which these doors are power opened and spring closed. Two speed, side opening doors have been illustrated but it is also to be understood that the invention is applicable to other arrangements, especially center opening doors.

The car door and hoistway doors are operated by a door motor DM mounted on the car framework 21. This motor operates through a gear reduction arranged in casing 22 to drive an operating cam 24. This cam operates a lever 25 through the intermediary of a roller 26. Lever 25 is connected by chain 27 to a lever 30 for operating the car door operating arm 32. A spring 37 biases the car door to closed position. A pair of door checks 42 and 43 are connected to arm 32 for cushioning the final opening and closing movements of the car door.

Another chain 44 is illustrated as connected to lever 25 from which it extends to a retiring cam 45. The cam is adapted when extended to engage roller 52 of bell crank lever 53 connected by tie rod 55 to a toggle lever 57 for operating the hoistway door. A spring 65 acts through the toggle lever to bias the door to closed position. A double acting door check 71 is connected for operation by lever 57 to cushion the final opening and closing movements of the hoistway door.

Limit switches are provided for controlling the operation of the door operating motor DM and of the detecting mechanism. For convenience it will be assumed that these switches are arranged in a casing 75 for operation as by cams rotated by the motor. These switches are shown in the wiring diagram, Figure 6. Car door and hoistway door contacts are not illustrated.

To open the doors, motor DM is energized for rotation in a direction to effect clockwise movement of cam 24. This pushes lever 25 clockwise which acts through chain 27 to pull lever 30 clockwise. Thus car door operating arm 32 is swung clockwise and acts through its link connections to the car door sections to open the car door. Lever 25 also acts through chain 44 to lift retiring cam 45. Bell crank lever 53 is thus swung in a direction to push upwardly on tie rod 55. Thus toggle lever 57 is operated to break the toggle and to pull the hoistway door to open position. As the doors reach open position, the door open limit switch in casing 75 causes deenergization of motor DM to bring it to a stop. The contour of cam 24 is such as to give the desired acceleration, speed, and retardation during opening movement of the doors. As the doors reach open position their stopping is cushioned by their checks.

During opening movement of the doors, tension is placed in springs 37 and 65 which act to close the doors upon motor DM being

energized for reverse rotative movement. Spring 37 acts directly on lever 32 to close the car door as reverse movement of motor DM takes place. Retiring cam 45 drops back as this reverse movement takes place which enables spring 65 to straighten out the toggle and thus close the hoistway door. Thus while the doors are spring closed, their closing movement can not take place any faster than permitted by motor DM. As the doors reach closed position, the door close limit switch opens to bring motor DM to a stop and the stopping of the doors is cushioned by their checks.

Referring now also to Figures 2, 3 and 4, the detecting mechanism will be described. In elevator construction, vertical members, known as sight guards, are provided at the leading edges of the car door and hoistway door to close the space between them. The hoistway door sight guard is designated HSG and the car door sight guard is designated CSG. The chassis for the detecting mechanism forms the car door sight guard and comprises a U-shaped channel 78 made up of an angle 80 and plate 81 which extend substantially the full height of the door. The outside of the channel 78 is covered with insulating material 82 which may, for example, be a plastisol which is sprayed on or sheet material adhered to the channel as by cementing, preferably additional insulating material being provided between angle 80 and the car door. Angle 80 is secured to the leading edge of the leading section 34 of car door at vertically spaced points by screws 83, being insulated from the door by washers 84 of insulating material. Plate 81 is secured to angle 80 at the rear by screws 85 and does not extend as far forward as the angle. At the forward edge, spacers 86 are provided and are secured to the angle and plate as by screws 87. The ends of channel 78 are closed by plates 88 welded to angle 80. A plurality of vertical antennae spaced about one inch apart and in the form of electrically conductive plates 90 are positioned near the forward edge of channel 78 to cover substantially the full height of the channel, four antennae covering a distance of about six feet having been found satisfactory. The edge 89 of each antenna is curved toward the hoistway door. The antennae are spaced from the forward edge of angle 80 to minimize leakage capacity between the antennae and the car door, and to avoid detection of passengers standing in the car near the car door. Adjacent their ends, the antennae are secured, as by screws, to mounting posts 93 of insulating material. These posts are adjustably mounted in blocks 94 of insulating material secured to angle 80 by screws 95. The forward edge of plate 81 is back of the face of the antennae to render the detector sensitive to passengers in front of the hoistway doors.

As will be seen from the wiring diagram of Figures 5 and 6 where the antennae are designated UA1, UA2, LA1 and LA2, the antennae are arranged in two of the arms of each of two capacity bridges. Various elements of the circuits such as adjusting condensers and fixed condensers in the other arms of the bridges, transformers TRB1 and TRB2 in the bridge diagonals and amplifying tubes AT1 and AT2 are mounted on frames FR1 and FR2. The connection of the antennae to these elements is by shielded cables, not shown, with a shielding potential applied to the cables. Each frame is supported through a multi plug and socket connection 100 on a bracket 101 secured to angle 80. Connecting wires (not shown) extend from the plugs and sockets to a terminal strip 102 secured to angle 80. Wires (not shown) extend from the terminal into cable connections 103, secured to the rear edge of channel 78. Shielding cables 104, supported by door operating arm 32, extend from connectors 103 to voltage supply box 105 supported on the car framework. One of these cables contains the current supply wires from the voltage supply box 105 and its shield is grounded. The other has a shielding potential applied to its shield. A shielding potential also is applied to the channel 78, the connection being made to the lug 106 secured to angle 80 by a mounting screw for strip 102. AS1 and AS2 are switches for enabling individual adjustments of the bridge networks to be made. These switches are mounted on the rear edge of channel 78.

The forward edge of the channel is provided with a cover 110 extending the full height of the door. This cover is in the form of an angle, one leg 111 extending from the forward edge of plate 81 to which it is secured by screw 109 and the other leg 112 extending in front of the faces of the antennae and over a portion of the leading edge of the car door to which it is secured by screws 113. This cover 110 is composed of insulating material which has and which retains a high surface resistivity. It has been found that certain materials change their surface resistivity markedly either under humid conditions alone or after having been handled by certain workmen or servicemen or touched by certain users of the elevator when humid conditions prevail. This change in resistivity may be sufficiently large to change the capacity to ground of an antennae and to cause unwanted operations. There is some uncertainty as to what causes some materials to resist loss of their high resistance surfaces while others do not. While a high gloss surface does not insure this retention property, in all tested cases the property was not found

to exist on roughened or dull surfaces. Certain plastics, such as those made of cellulose acetate butyrate or polytetrafluoroethylene, known commercially as Tenite Butyrate (Registered Trade Mark) and Teflon (Registered Trade Mark) respectively, have been found satisfactory in this respect and also have a sufficiently high impact strength to minimize breakages. Other plastics when covered with such material would also be satisfactory. It is also preferred to form the hoistway door sight guards HSG of this material, in the form of an angle as illustrated in Figure 2. When made of cellulose acetate butyrate the cover 110 and sight guards HSG are formed by extrusion.

A monitoring antenna MA may also be provided. This antenna is in the form of a short angle member, secured by screws 116 to the two centrally located mounting posts 93 so as to span the two centrally located antennae. It is connected by wires, not shown, by way of terminal strip 102 and the shielding cable 104 containing the current supply wires to box 105 and casing 75.

Reference may now be had to Figures 5 and 6 which illustrate diagrammatically the various circuits for controlling the operation of door motor DM. The circuits are shown in "straight" or "across-the-line" form, in which the coils and contacts of the various switches are separated in such manner as to render the circuits as simple and direct as possible. The relationship of the coils and contacts may be seen from Figure 7 where the switches are arranged in alphabetical order and shown in spindle form. The coils and contacts in the wiring diagram are in horizontal alignment with the corresponding coils and contacts on the spindles. The invention is applicable to various forms of elevator control systems. The circuits have been considerably simplified and it is to be understood that modifications may be made to adapt them to the particular elevator installation.

The electromagnetic switches employed in the circuits shown in Figures 5 and 6 are designated as follows:

DC—Door close switch
DE—Door speed switch
DO—Door open switch
DP—Detector relay
DR—Door control switch
DT—Door time switch
H—Field and brake switch
NT Hall time switch
XNT Auxiliary hall time relay

Throughout the description which follows, these letters will be applied to the coils of the above designated switches. Also, with reference numerals appended thereto, they will be applied to the contacts of these switches, as, for example, contacts DC1. The electromagnetic switches are illustrated in deenergized condition. Switch DR is a latching type and is illustrated in reset condition.

The door operating circuits of Figure 6 are illustrated as having direct current supply lines designated + and −. The door motor armature is designated DMA while its field winding is designated DMF. Resistors RDM are speed control resistors for door motor DM; resistors RDM3 and RDM4 being in series with door motor armature and serving for the door opening operation, and resistors RDM1, RDM2 and RDM5 acting as a voltage divider to control the voltage applied to the door motor armature for the door closing operation. Resistor RDMF serves to control the strength of the door motor field. EDB is a rectifier which serves dynamically to brake the door operating motor to bring it to a stop in response to operation of the detecting mechanism. DL3, DL4, DOL, DCL2, DCL3 and DEL are limit switches operated by the door motor. These limit switches are located in casing 75, Figure 1, as previously indicated. DCB is a door close button. Resistor RXNT and condenser QXNT control the timing of relay XNT. Resistor RNT1 and RNT2 and condenser QNT control the timing of switch NT. Resistor RDT and condenser QDT control the timing of switch DT. Resistor RDR is a current limiting resistor.

The manner in which the doors are controlled may vary considerably, depending upon the characteristics of the particular installation. In particular circuits illustrated, the doors open automatically as a stop is made at a landing and close automatically upon the expiration of a given time interval. In order that this may be understood, assume that the car is in operation and is nearing a landing at which a stop is to be made. Relay XNT and switch NT are both operated during the running of the car, the circuit for the coil of relay XNT being through contacts H3 and the circuit for the coil of switch NT being through contacts XNT2. As the car arrives at the landing at which the stop is being made, switch H drops out and in so doing engages contacts H4 and separates contacts H3. The separation of contacts H3 disconnects the coil of relay XNT from the supply lines. This relay does not drop out immediately, however, being delayed by the discharge of condenser QXNT. The engagement of contacts H4 completes a circuit by way of contacts XNT1 for the set coil of switch DR. This switch operates and latches itself in operated condition. As a result of the operation of switch DR, contacts DR2 engage, completing a circuit by way of door open limit switch DOL for the coil of door

open switch DO. This switch engages contacts DO5 and DO6 and separates contacts DO4, establishing a circuit for the armature DMA for the door operating motor through resistors RDM3 and RDM4 for causing the operation of the door operating mechanism to open the car door and also the hoistway door at the floor at which the stop is being made. Switch DO also separates interlock contacts DO2 in the circuit for the coil of door close switch DC. As the doors move a certain distance from closed position, door speed limit switch DEL closes to complete a circuit for the coil of switch DE. This switch engages contacts DE3 to short circuit resistance RDMF in circuit with the door motor field winding DMF and engages contacts DE4 to short circuit resistance RDM4 in circuit with armature DMA of the door operating motor. This gives the desired control of the door operating motor for the particular door operating mechanism illustrated. As the doors near open position, limit switch DEL opens. However, the circuit for the coil of switch DE is maintained by way of contacts DO1 and DE1. As the doors reach open position, door open limit switch DOL opens, breaking the circuit for the coil of switch DO. This switch drops out to break the circuit for armature DMA of the door operating motor. It also breaks the circuit for the coil of switch DE which drops out, engaging contacts DE5 to establish a short circuit for armature DMA to bring the door operating motor to a stop.

Upon the expiration of a given time interval, relay XNT drops out, separating contacts XNT1 and XNT2. The separation of contacts XNT1 is without effect as switch DR is latched in operated condition. The separation of contacts XNT2 disconnects the coil of switch NT from the supply lines. This switch does not drop out immediately, being delayed by the discharge of condenser QNT. Upon dropping out, switch NT engages contacts NT1 to establish a circuit by way of contacts DR1 for the reset coil of switch DR which is restored to unlatched condition. Contacts NT1 also complete a circuit by way of door close limit switch DCL3 and contacts DP3 and DO2 for the coil of door close switch DC to initiate the door closing operation. A time interval is thus provided, namely the interval of relay XNT, say three seconds, plus the interval of switch NT, say a half second, from the time that the stop is made before the closing of the doors is initiated. The time delay on switch NT may in certain instances be omitted, as by omitting the discharge current of condenser QNT. Switch DC upon operation engages contacts DC2 and DC4 and separates contacts DC3 to complete a circuit for the armature DMA of the door operating motor for effecting operation of the door operating mechanism to close the car door and hoistway door. During the closing operation, limit switch DEL is again closed completing a circuit for the coil of switch DE which short circuits motor field resistance RDMF and in addition separates contacts DE6 to remove a short circuit for a position of resistor RDM5, giving the desired control of the door operating motor for the particular door operating mechanism illustrated. As the doors near closed position, switch DEL is opened but the circuit for the coil of switch DE is maintained by way of contacts DE2 and DC1. As the doors reach closed position, limit switch DCL3 opens, breaking the circuit for the coil of switch DC which separates contacts DC2 and DC4 to break the circuit for the door motor armature DMA and separates contacts DC1 to break the circuit for the coil of switch DE. This switch drops out to re-engage contacts DE5 to establish a short circuit for armature DMA to bring the door operating motor to a stop.

Referring now especially to Figure 5, antennae UA1 and LA1 are arranged in the arms of one bridge and antennae UA2 and LA2 are arranged in the arms of the other bridge. Inasmuch as the arrangement is the same for each bridge, the circuits associated with but one of them, namely those subject to antennae UA1 and LA1 will be described in detail. In the other arms of the bridge are a fixed condenser C3 and an adjustable condenser C1, the bridge being balanced by adjustment of condenser C1. Connected across the diagonal of the bridge and between UA1 and LA1 is the primary winding of transformer TRB1. The secondary winding of this transformer is connected to the input wires of amplifier AM1. One of the input wires is connected to current supply line BO. The amplifier is indicated by block outline and includes amplifying tube AT1 which is illustrated as a dual triode vacuum tube. The anodes of the tube are connected by way of load resistors LR1, LR2 and adjusting switch AS1 to supply line B+. The anode of the right half of the tube is connected through voltage doubler VD1 and potentiometer P1, indicated by blocks to the input of amplifier AM3, also indicated by a block. The voltage doubler VD transforms the unbalance signal from an alternating to a unidirectional character and potentiometer P provides a ready way to adjust and correlate the amplification or "gain" of one amplifier with that of another. Both VD and P may be of any standard design so long as they are stable in operation. Fixed condenser C4, adjustable condenser C2, transformer TRB2, amplifier AM2 including tube AT2 and load resistors LR3 and LR4, switch AS2, voltage doubler VD2 and poten-

tiometer P2 are similarly provided for the other bridge, the output from potentiometer P2 also being connected to amplifier AM3. As a practical matter it may be advisable to provide a capacitive shunt to ground at each end of the conductor between the input of amplifier AM3 and the potentiometers P in order to minimize "hum" or "noise" pickup in this path. In the output circuit of amplifier AM3 is connected the coil of detector relay DP, current for this coil being provided from alternating voltage supply lines AC1 and AC2 which are isolated from the usual common A.C. supply ground. Amplifier AM3 is also connected to line BO to complete its input circuit. An alternating voltage source, indicated by block OSC, is connected from line BO to ground G, and may be an oscillator providing voltage of a certain frequency, 230 volts of 1,000 cycles per second having been found satisfactory. A resistor SR is connected between the source OSC and ground G. This resistor is rendered effective by door limit switch DCL1 as the doors near closed position to reduce the sensitivity of the detector. A shield SH, formed by channel 78, for the antennae is indicated by a dotted line and is connected to line BO to provide a shielding potential. The monitor antenna MA is connected through door limit switches DL1 and DL2 in parallel to line BO. Limit switches DCL1, DL1 and DL2 are located in casing 75, Figure 1. Potentiometers P1, P2, amplifier AM3, relay DP, source B+, BO, source OSC, and resistor SR are located in voltage supply box 105, Figure 1.

The antennae form capacitance couplings to ground in the bridge circuits. Thus ground G and line BO form two junctions of the arms of each bridge and source OSC applies periodic voltage between these points of the bridges. Shield SH isolates the antennae from the adjacent ground potential of the car door to prevent unwanted operations. It also partially shields the antennae from the hoistway doors. The capacitance couplings formed by antennae and each hoistway door, which is at ground potential, are balanced out in the bridge circuits. With perfect alignment of the hoistway doors and car door, there will be no voltage across the diagonals of the bridges due to the hoistway doors. However, in some elevator installations, a certain amount of misalignment may exist between certain of the hoistway doors and the car door. Thus at such points of misalignment the impedance to ground of one antennae of each bridge will be less than that of the other. Each bridge is adjusted by its adjusting condenser C1, C2 so that under normal conditions there will be insufficient voltage across the diagonal of that bridge to cause operation of detector relay DP as a result of such misalignment. This may result in voltages being present across the diagonals of the bridges even where a hoistway door is exactly aligned with the car door. due to the adjustment to prevent an unwanted operation by a misaligned hoistway door. However, by proper adjustments, these diagonal voltages are kept sufficiently low to obviate unwanted operations. Voltage may also be present across the bridge diagonals due to unbalanced loading of the elevator car. However, here again, the adjustments are such as to prevent sufficient voltages across the diagonals to cause unwanted operations.

The bridge circuits are adjusted individually. To adjust either bridge, the circuits controlled by the other bridge, are disconnected from line B+. For example, to adjust the bridge circuits controlled by antennae UA1, LA1, switch AS2 is thrown to its other position, disconnecting amplifier AM2 from line B+. At the same time, switch AS2 connects resistor AJR2 across voltage source B+, BO. The value of this resistance is such that it passes about the same current as the circuits with switch AS2 in its upper position. In this way the load on the source and thus the source voltage remains about the same, enabling accurate adjustments to be made. In practice the elevator car is positioned at a floor of the building and each bridge is adjusted individually to produce minimum voltage across winding TRB as measured at the potentiometer output. This adjustment is repeated for the other bridge or bridges, after which the potentiometers of the respective bridges are adjusted to give equal output in the presence of a known "target" or object to be detected. The car is then moved from floor to where the output of each bridge is measured with the doors in their normal positions in insure that no irregularity exists of sufficient magnitude to produce an unbalance voltage that approaches too close to the control voltage required to actuate amplifier AM3 and operate detection relay DP. In the unlikely event this control voltage is approached or the operating margin is desired to be increased it is possible to readjust the offend- ind doors or in the alternative to "build them out" such that compensating ground coupling is provided for the conjugate antenna of the bridge.

When an object such as a person's body comes into proximity with the antennae, it affects the antennae differently. Due to its irregularity, it increases the antenna to ground capacitance, thus decreasing the antenna to ground impedance, of the antennae nearer the person more than that of the others. As a result, an unbalance of considerable extent of one or both bridges occurs, causing a signal voltage to appear in the transformer primary TRB1 or TRB2

across the diagonal of the bridge of sufficient value to cause, when amplified, operation of detector relay DP. Assume that the doors are closing as operation of relay DP takes place. Upon operation, relay DP separates contacts DP3 to break the circuit for the coil of door close switch DC. Switch DC in dropping out breaks the circuit for armature DMA of the door operating motor as previously described. In addition it engages contacts DC3 which completes a shunt circuit for armature DMA through braking rectifier EDB. This acts in effect as a short circuit for armature DMA and brings the doors to a quick stop. Relay DP also engages contacts DP4 to complete a circuit for the coil of door open switch DO, causing the immediate reopening of the doors. It also engages contacts DP2 which complete a circuit for the set coil of switch DR. As the doors move away from the person, relay DP drops out. Switch DO is maintained energized through contacts DR2 after contacts DP4 separate.

Upon the operation of switch DO to cause the door reopening operation, contacts DO3 engage to complete a circuit for the coil of switch NT, causing this switch to operate. This circuit is maintained operated through contacts DO3 until the doors reach open position. Thus switch NT can not drop out to initiate a reclosing operation until the doors reach open position. Thus the time interval that the doors remain open under such conditions is that due to switch NT alone and is of short duration. In this connection, it is to be noted that in case of congestion when the passenger transfer cannot be effected quickly, so long as any person is sufficiently within the zone of influence of the antennae to decrease sufficiently its impendance to ground there will be repeated operations of relay DP until this condition ceases to exist.

As the doors near closed position, the sensitivity of the detector is reduced. This is effected by means of door close limit switch DCL1 and resistor SR. The door close limit switch is set to open when the doors come within say four inches of closed position. This inserts resistor SR in circuit with source OSC, thus reducing the value of voltage applied to the ends of the bridges. This prevents insufficient voltage appearing across the diagonals of the bridges to cause unwanted operation of relay DP due to misalignment of the door jambs with the car door. However, the reduction of voltage is not sufficient to prevent response to a hand placed on the leading edge of the car door. Thus should a passenger grasp the car door after it has reached the four inch zone, he is still able to cause operation of relay DP to bring the door to a stop and reopen it, thereby enabling passenger transfer to be made.

As the doors reach closed position, door close limit switches DCL2 and DCL3 open, preventing reopening of the doors even though the detector relay DP operates because of the proximate ground potential of the jamb. Limit switch DCL2 prevents the completion of the circuit for the set coil of switch DR by the engagement of detector relay contacts DP2. Thus contacts DR2 remain separated, preventing the completion of one energizing circuit for the coil of door open switch DO. Limit switch DCL3 breaks the other energizing circuit by way of contacts DP4 for the coil of switch DO, thus preventing operation of switch DO to reopen the doors.

The system is arranged so that if due to the detecting mechanism the doors fail to close after a certain period, say fifteen seconds, the detecting mechanism is rendered ineffective and the doors are closed at a slow speed. Switch DT is utilized for this purpose. This switch is energized during running of the car, the circuit through its coil being completed by way of contacts H1, H2, door limit switch DL4 and contacts H3. When a stop is made at a landing, contacts H1, H2 and H3 separate and the coil of switch DT is disconnected from the supply lines. This switch is delayed in dropping out for the prescribed period by the discharge of condenser QDT into its coil by way of contacts DT1 and DP1 and limit switches DL3, DL4 as will be explained later. Upon dropping out, switch DT separates contacts DT2 and DT5 to render the detector relay ineffective by its contacts DP2 and DP4 to cause reopening of the door. It also engages contacts DT3 to reset switch DR and to complete a circuit by way of contacts DT4, by-passing contacts DP3, for the coil of door close switch DC to effect closing of the doors. Switch DT also engages contacts DT6 to short circuit a portion of resistance RDM across motor armature DMA, causing the door closing operation to take place at a slow speed so that, if anyone is hit, he will not be injured but gently pushed out of the way, an operation known as "nudging".

Testing circuits may be provided and have been illustrated. Monitoring antenna MA is utilized for this purpose, and is rendered effective during each initial door opening operation to cause sufficient decrease in impedance of one antenna of each bridge to ground to cause operation of relay DP. By means of door limit switches DL1 and DL2, the monitoring antenna is connected to line BO while the doors are closing, are in closed position and while in their open position thereby rendering the monitoring antenna ineffective to cause operation of relay DP during this time. During the initial

door opening operation when the car stops at a floor, these limit switches disconnect the monitoring antenna from line BO, enabling the antenna by means of the capacitance coupling to ground of its wire in grounded cable 104 to bring ground potential sufficiently near the center antenna UA2 and LA1 in different bridges to cause operation of relay DP.

Operation of the detector relay by the monitoring antenna is utilized in the circuits of time switch DT to determine whether the detecting mechanism is functioning properly. While the car is running, the coil of switch DT is connected to the supply lines as above pointed out. When the coil is disconnected from the supply lines, it is maintained energized by the discharge of condenser QDT, provided relay DP is operated to close contacts DP1 before limit switch DL4 opens. Limit switches DL1 and DL3 are toggle switches which open when the doors reach say one-quarter inch of fully closed position and remain open until the doors reach say one-quarter inch of their full open position, at which point they close and remain closed until the doors again reach one-quarter inch of fully closed position. Limit switch DL2 is set to open say at one-half inch of door opening movement and close as the doors arrive at say within one-half inch of their full open position. Limit switch DL4 is set to open at say one inch of door opening movement and close as the doors arrive at say within one inch of open position.

When the doors start to open at a floor at which a stop is being made, limit switch DL2 opens, disconnecting antenna MA from line BO. Assuming that the detecting mechanism is functioning properly, this causes operation of relay DP to engage contacts DP1. These contacts by-pass limit switches DL3 and DL4 so that the subsequent opening of switch DL4 is without effect to break the initial energizing circuit or condenser discharge circuit for the coil of switch DT. As the doors near open position, switch DL4 recloses. Thus the subsequent reclosing of limit switches DL1 and DL2 to reconnect antenna MA to line BO and thus cause the dropping out of detector relay DP to separate contacts DP1 is without effect. Switches DL1 and DL3 now respectively maintain antenna MA connected to line BO and condenser QDT connected across coil DT until the doors reach closed position. Thus antennae UA1, UA2, LA1 and LA2 are effective during this period and switch DT is maintained operated either until the doors reach closed position or its time interval expires.

Should the detector relay DP fail to operate upon the opening of limit switch DL2 in the initial door opening operation, upon the opening of limit switch DL4, switch DT is deenergized and drops out immediately. The subsequent closing of switch DL4 does not cause reoperation of switch DT as contacts DT1 are now separated. As a result of the engagement of contacts DT6 the doors close at slow speed, advising that the detecting mechanism is not functioning properly.

While the invention has been described in an arrangement having two pairs of antennae, other arrangements may be utilized. A few possible arrangements are diagramatically illustrated in Figure 8. Only the antennae and their pairings are shown, the antennae being indicated by vertical lines spaced from each other and their pairings by dotted lines. Combinations of four, five, six and eight antennae are shown, the number of antennae being indicated in each case at the bottom. The four antennae arrangement is that already described in connection with Figure 5. In the five antennae arrangement, there are three pairs of antennae, the center antenna being common to two pairs. In the sixth antennae arrangement shown on the left, there are three pairs of antennae, while in the other six antennae arrangement there are four pairs, each of the two center antennae of such other arrangement being common to two pairs. In a similar manner, three different arrangements utilizing eight antennae may be had, the one on the left providing four pairs, the center one five pairs and the one on the right six pairs.

The various arrangements may control bridge circuits corresponding in number to the number of pairs, or various pairs may be grouped to control the same bridge circuits. As an example, an eight antennae, two bridge circuit arrangement is shown in Figure 9. Here the antennae are designated A1 to A8 inclusive. Antennae A1 and A8 are connected in parallel in the upper arm of bridge BR1, antennae A3 and A6 are connected in parallel in the lower arm of bridge BR1, antennae A2 and A7 are connected in parallel in the lower arm of bridge BR2, and antennae A4 and A5 are connected in parallel in the upper arm of bridge BR2. This arrangement has the advantage that the change of impedance of the antennae of each arm of each bridge acts to balance more effectively the change of impedance of the antennae of the other arm of that bridge in case of hoistway door and door jamb misalignments. Resistance SR and switch DCL1 are shown in the connection to ground. This is matter of precaution and may be omitted.

The above described constructions are particularly suitable for installations having the customary distance of about five inches between the car door and the hoistway

doors. They are also suitable for the so-called "flush" type door installations in which the sliding hoistway doors are mounted considerably closer to the car door. This is especially true of the eight antennae arrangement of Figure 9. There are certain modifications desirable in the flush type arrangement which are illustrated in Figure 10. The leading portion of the car door is cut out as at 120 to provide room for the detector, enabling the doors to be brought close together. No hoistway door sight guard is provided as the doors are already close together. The plate 81 is extended forward toward the leading edge of the car door to increase the shielding of the detector from the close hoistway door. To minimize a decrease in sensitivity of the detector as a result of the extension of plate 81, the antennae 90 are moved forward closer to cover 110. Also the antennae are spaced a little farther from the car door to minimize leakage to the car door. This arrangement is especially suitable for the four antennae arrangement of Figure 5 and is also of advantage where a greater number of antennae are utilized including the arrangement of Figure 9.

Detecting mechanism embodying the invention has many advantages. It is silent, highly sensitive and instantaneous in operation. Also, it is simple, economical in construction and reliable in operation. It has no dead spots as a hand placed on the leading edge of the door opposite any antenna or at any of the spaces between antennae will cause a detecting operation to take place. Assume for example that a hand is placed at a point between antennae UA1 and UA2 of Figure 5. If it equally affects both antennae, both bridges will be unbalanced an amount to provide a signal voltage sufficient to cause operation of detector relay DP. If the hand is not placedy symmetrically with respect to the antennae, say more opposite antenna UA1, at least the upper bridge will provide sufficient signal voltage to cause operation of relay DP. Ample signal voltage in the case of detection of persons is assured. A detecting operation is had by a hand placed on the car door as the door nears closed position, without causing unwanted operation by the door jambs. Unwanted operations due to phase differences in the voltages at the ends of the bridge diagonals, or as a result of change in humidity or due to a certain amount of misalignment of the hoistway doors are obviated.

The invention, while described as applied to side opening doors, is equally applicable to center opening doors, in which case both leading sections are provided with the detecting mechanism. Various changes may be made in the circuits. For example, other forms of amplifiers may be employed. While the detecting mechanism has been described as acting to stop the closing movement of the doors and return them to open position, it may be used to slow the doors. Where the doors are merely brought to a stop, various other ways of controlling the doors after they have been stopped may be utilized. It is not intended to set forth all the variations which may be made but many changes and different embodiments could be made without departing from the scope of the invention. Therefore, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

WHAT WE CLAIM IS:

1. An elevator system in which a closure is provided for controlling access to the elevator car, in which power mechanism is provided for operating said closure, in which detecting mechanism including a pair of antennae, each having a capacitive coupling to ground and mounted in spaced relation along the leading edge of said closure, is provided for detecting a person in the path of closing movement of said closure, and in which closure control means are provided which act when such detection occurs to prevent or stop the closing of the closure by said power mechanism, characterized in that there are provided a bridge circuit having said antennae directly connected to opposite ends of the bridge diagonal to form through their capacitive couplings to ground two arms of the bridge and having two impedances connected to said opposite ends of the bridge diagonal in the other arms of the bridge for balancing the bridge, a source of periodic input voltage for the bridge connected between ground and the junction of said other arms of the bridge, the diagonal of said bridge providing a periodic signal voltage and said bridge being balanced to prevent said signal voltage attaining a certain value when no person is in field of influence of said antennae, an amplifier, and transfer means for transmitting said periodic signal voltage to said amplifier to provide an amplified signal voltage, and in that said closure control means is responsive to said amplified signal voltage to prevent or stop the closing of the closure by said power mechanism when said signal voltage, due to a change in the capacitive coupling to ground of one antenna with respect to that of the other as a result of the proximity of a person to said antennae, attains or exceeds said certain value.

2. An elevator system according to claim 1, characterized in that said impedances in the other arms of the bridge are capacitors, at least one of which is adjustable.

doors. They are also suitable for the so-called "flush" type door installations in which the sliding hoistway doors are mounted considerably closer to the car door. This is especially true of the eight antennae arrangement of Figure 9. There are certain modifications desirable in the flush type arrangement which are illustrated in Figure 10. The leading portion of the car door is cut out as at 120 to provide room for the detector, enabling the doors to be brought close together. No hoistway door sight guard is provided as the doors are already close together. The plate 81 is extended forward toward the leading edge of the car door to increase the shielding of the detector from the close hoistway door. To minimize a decrease in sensitivity of the detector as a result of the extension of plate 81, the antennae 90 are moved forward closer to cover 110. Also the antennae are spaced a little farther from the car door to minimize leakage to the car door. This arrangement is especially suitable for the four antennae arrangement of Figure 5 and is also of advantage where a greater number of antennae are utilized including the arrangement of Figure 9.

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The invention, while described as applied to side opening doors, is equally applicable to center opening doors, in which case both leading sections are provided with the detecting mechanism. Various changes may be made in the circuits. For example, other forms of amplifiers may be employed. While the detecting mechanism has been described as acting to stop the closing movement of the doors and return them to open position, it may be used to slow the doors. Where the doors are merely brought to a stop, various other ways of controlling the doors after they have been stopped may be utilized. It is not intended to set forth all the variations which may be made but many changes and different embodiments could be made without departing from the scope of the invention. Therefore, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

WHAT WE CLAIM IS:

1. An elevator system in which a closure is provided for controlling access to the elevator car, in which power mechanism is provided for operating said closure, in which detecting mechanism including a pair of antennae, each having a capacitive coupling to ground and mounted in spaced relation along the leading edge of said closure, is provided for detecting a person in the path of closing movement of said closure, and in which closure control means are provided which act when such detection occurs to prevent or stop the closing of the closure by said power mechanism, characterized in that there are provided a bridge circuit having said antennae directly connected to opposite ends of the bridge diagonal to form through their capacitive couplings to ground two arms of the bridge and having two impedances connected to said opposite ends of the bridge diagonal in the other arms of the bridge for balancing the bridge, a source of periodic input voltage for the bridge connected between ground and the junction of said other arms of the bridge, the diagonal of said bridge providing a periodic signal voltage and said bridge being balanced to prevent said signal voltage attaining a certain value when no person is in field of influence of said antennae, an amplifier, and transfer means for transmitting said periodic signal voltage to said amplifier to provide an amplified signal voltage, and in that said closure control means is responsive to said amplified signal voltage to prevent or stop the closing of the closure by said power mechanism when said signal voltage, due to a change in the capacitive coupling to ground of one antenna with respect to that of the other as a result of the proximity of a person to said antennae, attains or exceeds said certain value.

2. An elevator system according to claim 1, characterized in that said impedances in the other arms of the bridge are capacitors, at least one of which is adjustable.



3. An elevator system according to claim 1 or 2, in which a plurality of antennae are mounted in spaced relation along the leading edge of said closure, characterized in that there are provided a plurality of such bridge circuits, each having arms formed by a different pair of said antennae, with the antennae of each pair having another antenna positioned between them in their relationship along the leading edge of the closure, that an amplifier is provided for each bridge circuit to which the signal voltage of that bridge circuit is transmitted and that the closure control means is responsive to the amplified signal voltage of any of said bridge circuits to prevent the closing of the closure by said power mechanism when the signal voltage of the diagonal of that bridge circuit attains or exceeds said certain value.

4. An elevator system according to claim 3, characterized in that there is positioned between the antenna of each pair one antenna of at least one other pair.

5. An elevator system according to claim 3 or 4 in which the closure is a door on the elevator car, characterized in that but two bridge circuits are provided, one antenna of each bridge being positioned along said door edge between the antennae of the other bridge.

6. An elevator system according to any of claims 3 to 5, in which the closure is a door on the elevator car and in which the antennae are vertical and arranged in vertical succession along the leading edge of the car door, characterized in that the bridge circuits are a pair of alternating current bridge circuits, the antenna at one end of the car door being directly connected to one end of the diagonal of one of said bridges, the next succeeding antenna being directly connected to one end of the diagonal of the other of said bridges, the next succeeding antenna being directly connected to the other end of the diagonal of said one bridge and the next succeeding antenna being directly connected to the other end of the diagonal of said other bridge to form arms of said bridges.

7. An elevator system according to any of claims 3 to 6, in which the closure is a door on the elevator car, in which the antennae are arranged along the leading edge of the car door and in which but two bridge circuits are provided, characterized in that each bridge circuit has as one arm thereof two of said antennae directly connected to one end of the diagonal of that bridge and as another arm thereof two other of said antennae directly connected to the other end of the diagonal of that bridge, the antennae connected in one bridge being not the same as those connected in the other.

8. An elevator system according to claim 7, characterized in that eight like antennae are carried by the leading edge of the car door, counting from top to bottom, the first and eighth antennae being connected directly to one end of the diagonal of one bridge to form one arm thereof, the second and seventh antennae being connected directly to one end of the diagonal of the other bridge to form one arm thereof, the third and sixth antennae being connected directly to the other end of the diagonal of said one bridge to form another arm thereof, and the fourth and fifth antennae being connected directly to the other end of the diagonal of said other bridge to form another arm thereof.

9. An elevator system according to claim 7 or 8 in which a hoistway door is provided at each landing served by the elevator car, characterized in that the capacitive coupling of the antennae of each arm of each bridge to any adjacent hoistway door balances substantially that of the antennae of the other arm of that bridge to such hoistway door, even though said hoistway doors are differently misaligned with said car door.

10. An elevator system according to claim 9 in which the power mechanism operates the car door and also the hoistway door at each landing at which the car is stopped, and in which the closure control means acts to prevent or stop closing movement of both doors by said power mechanism.

11. An elevator system according to any of the preceding claims in which the closure is the elevator car door and in which the car door is provided with a door jamb, characterized in that there are provided means responsive to arrival of said door within a certain distance of said door jamb in closing for decreasing the effectiveness of the bridge circuit or circuits to such extent that the closure control means is not operable in response to the approaching proximity of said jamb but is operable in response to the placing of the hand of a person on said leading edge of said door.

12. An elevator system according to claim 11 in which the elevator car serves a plurality of landings, each of which has a hoistway door, and in which each of said hoistway doors has a door jamb, characterized in that said means for decreasing the effectiveness of the bridge circuit or circuits is likewise responsive to arrival of said hoistway doors within a certain distance of their respective door jambs in closing.

13. An elevator system according to any of the preceding claims in which a casing open at its forward edge is mounted along the leading edge of said closure, said casing being insulated from said closure, in which at least one antenna is provided and mounted within said casing at said forward edge, and in which a cover is provided for said open

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forward edge of said casing, characterized in that said cover is of an insulating material having a high surface resistivity which is unaffected by humidity under normal usage.

14. An elevator system according to claim 13, in which said casing is U-shaped in cross section and is mounted along the leading edge of said closure with its open edge forward, in which a plurality of antennae are mounted within said casing at said open edge, and in which means are provided for applying potential to said casing to shield it from ground, characterized in that said cover for said open edge of said casing is a plastic cover made with cellulose acetate butyrate.

15. An elevator system according to claim 1 substantially as hereinbefore described with reference to the accompanying drawings.

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