Nov. 28, 1933. H. V. McCORNICK 1,937,029

ELEVATOR DOOR OPERATING MECHANISM

Filed June 13, 1929 6 Sheets-Sheet 1

Fig. 1.

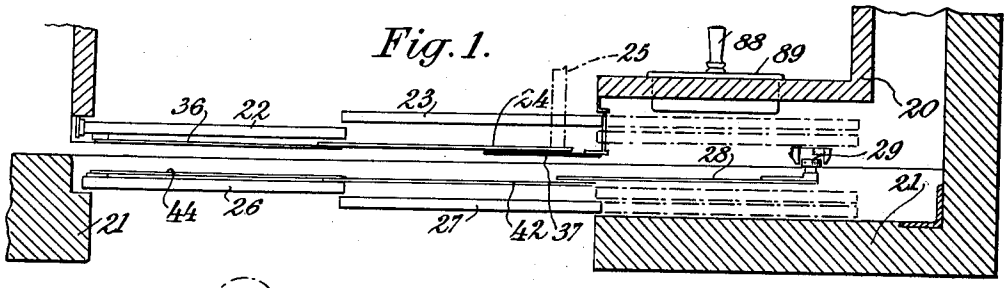
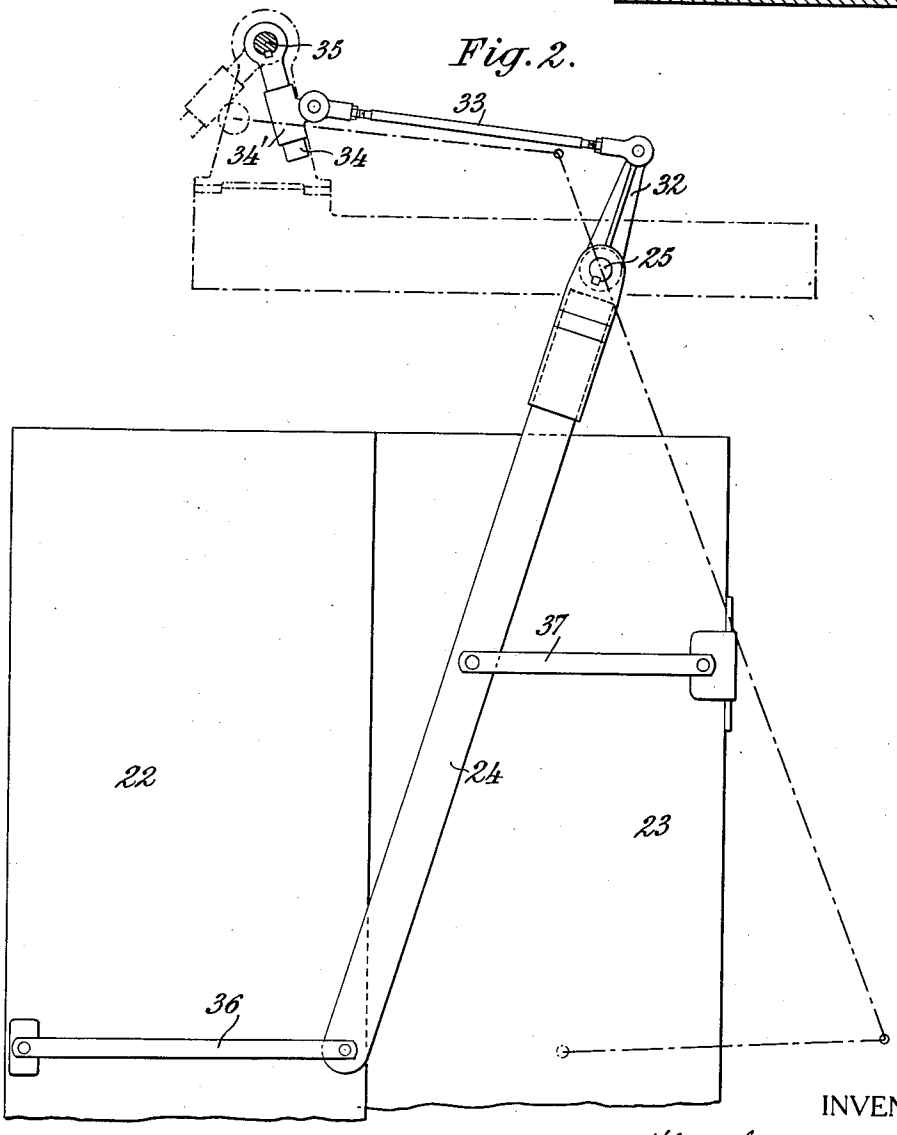


Fig. 2.



INVENTOR :

Harold V. McCormick,

By Attorneys,

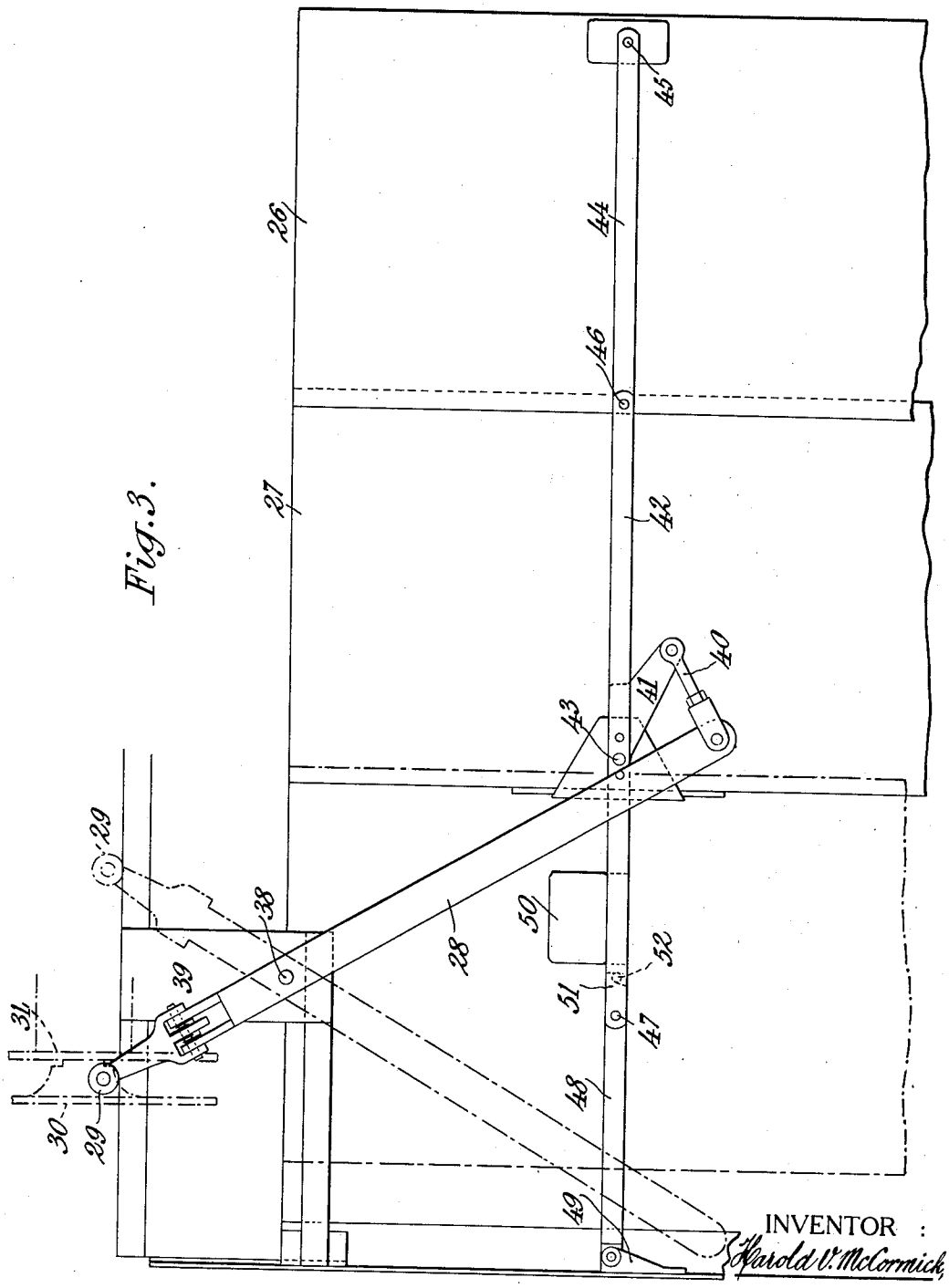
Fraser, Myers & Manley

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ELEVATOR DOOR OPERATING MECHANISM

Filed June 13, 1929 6 Sheets-Sheet 2

Fig. 3.



INVENTOR :
Harold V. McCormick,

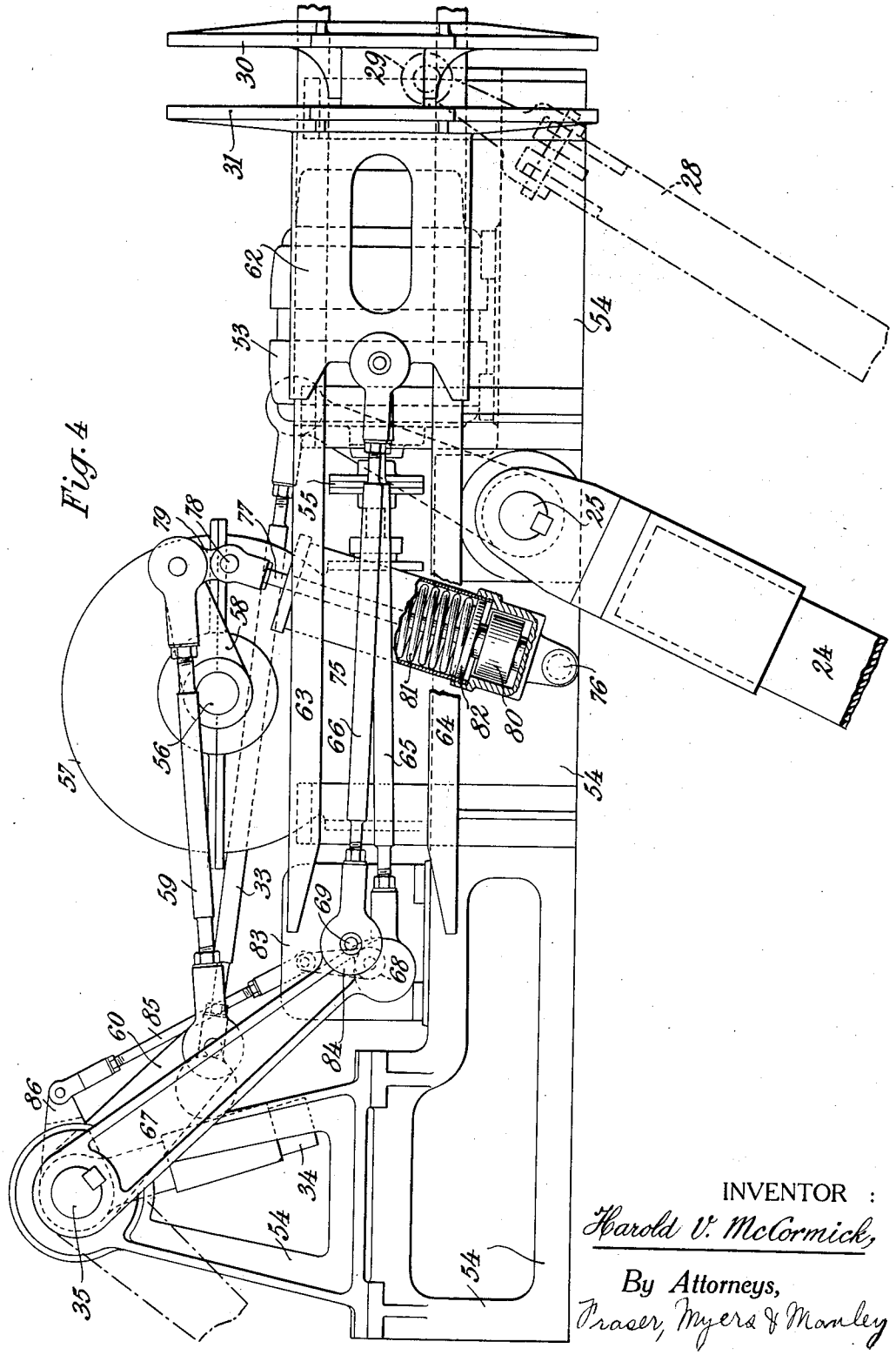
By Attorneys,
Fraser, Myers & Manley

Nov. 28, 1933. H. V. McCORNICK 1,937,029

ELEVATOR DOOR OPERATING MECHANISM

Filed June 13, 1929 6 Sheets-Sheet 3

Fig. 4



INVENTOR :
Harold V. McCormick,
By Attorneys,
Fraser, Myers & Manley

Nov. 28, 1933. H. V. McCORNICK 1,937,029

ELEVATOR DOOR OPERATING MECHANISM

Filed June 13, 1929 6 Sheets-Sheet 4

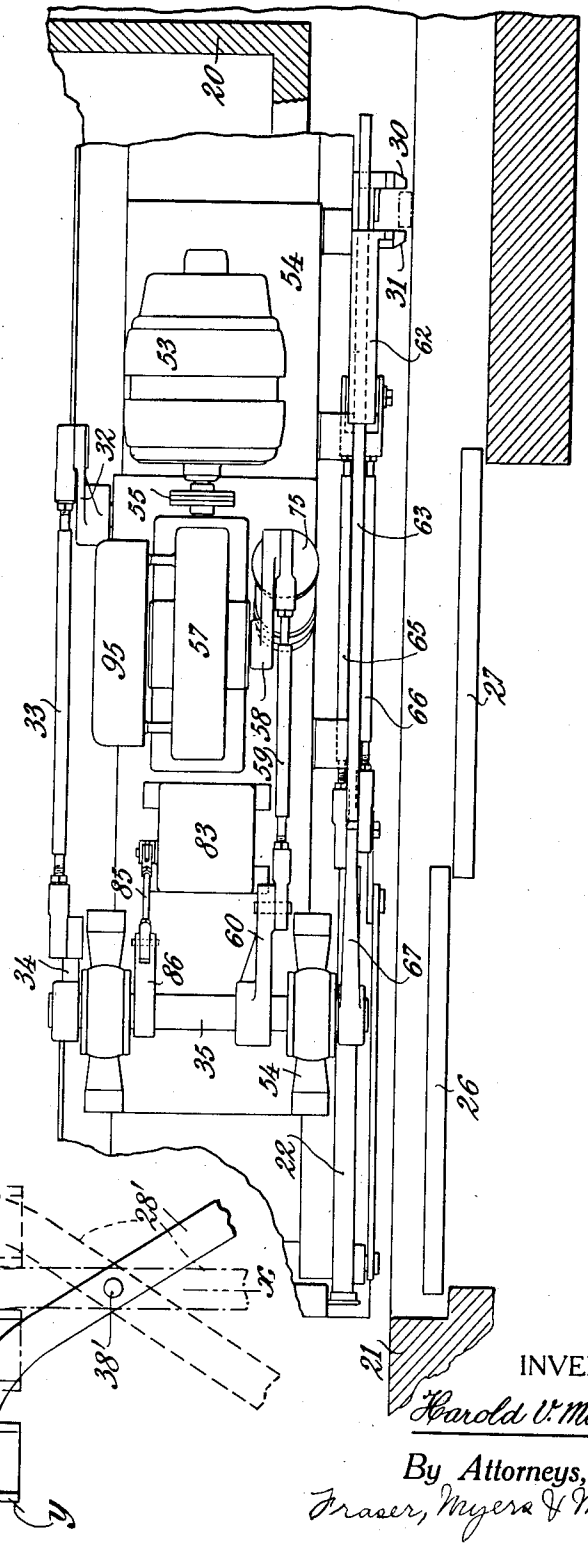


Fig. 5.

Fig. 9.

INVENTOR :
Harold V. McCormick,
By Attorneys,
Fraser, Myers & Manley

Nov. 28, 1933. H. V. McCORNICK 1,937,029

ELEVATOR DOOR OPERATING MECHANISM

Filed June 13, 1929 6 Sheets-Sheet 5

Fig. 6.

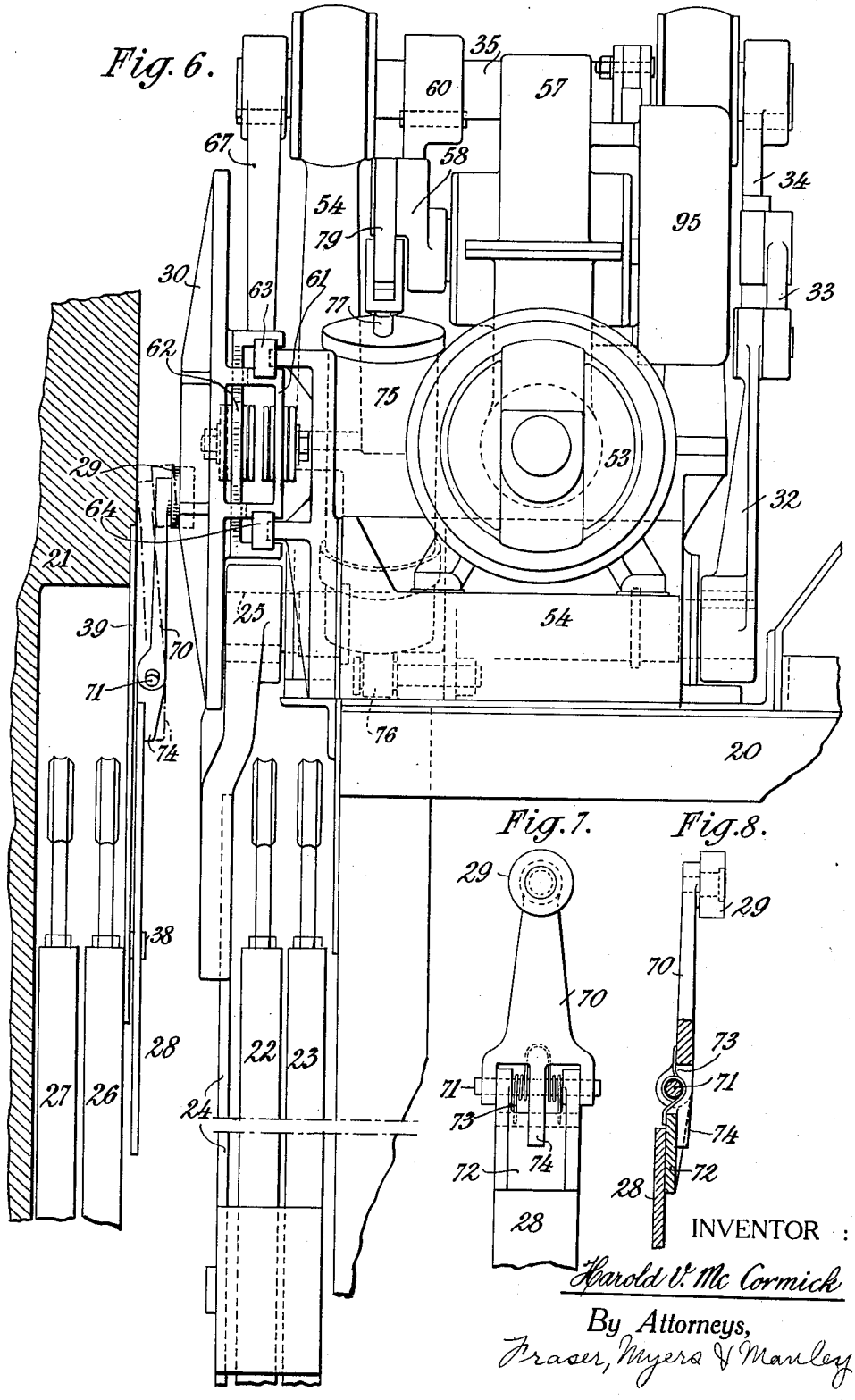


Fig. 7.

Fig. 8.

INVENTOR :

Harold V. Mc Cormick

By Attorneys,

Fraser, Myers & Manley

Nov. 28, 1933. H. V. McCORNICK 1,937,029

ELEVATOR DOOR OPERATING MECHANISM

Filed June 13, 1929 6 Sheets-Sheet 6

Fig. 10.

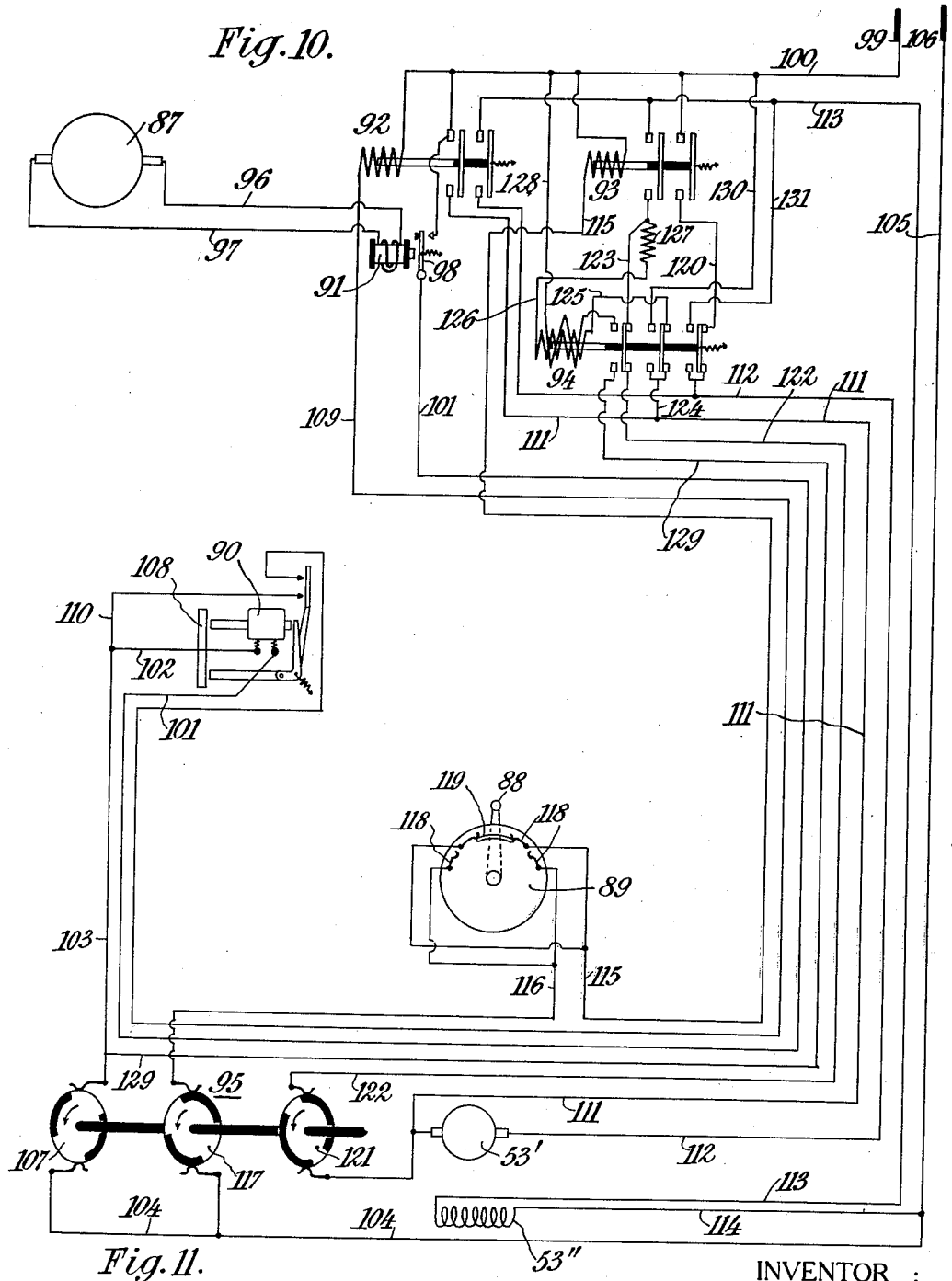
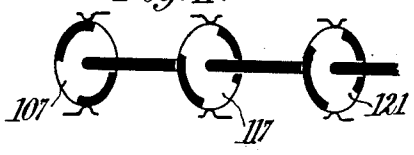


Fig. 11.



INVENTOR :

Harold V. McCormick,

By Attorneys,

Fraser, Myers & Manley

Patented Nov. 28, 1933 1,937,029

UNITED STATES PATENT OFFICE

1,937,029

ELEVATOR DOOR OPERATING MECHANISM

Harold V. McCormick, Long Beach, N. Y., assignor, by mesne assignments, to Westinghouse Electric Elevator Company, Chicago, Ill., a corporation of Illinois

Application June 13, 1929. Serial No. 370,554

9 Claims. (Cl. 187—52)

This invention relates to improvements in mechanism for opening and closing elevator doors and analogous devices. The various features of invention are specifically disclosed in the form of an apparatus comprising an electrically-controlled motor mounted on an elevator car and connections whereby said motor may open and close the doors of the elevator as well as the doors at the various landings of the elevator shaft in which the car travels.

Among the several objects of the invention the following may be mentioned as of importance:

To provide a single operating device on a car having means for automatically causing said device to open a door when the car is at a landing, manually-controlled means whereby said device may be caused to close the door, and means connected with said device whereby it may be automatically conditioned for a door-closing or a door-opening operation as the door is opened and closed.

To provide a door-closing mechanism of which the effective closing force may be reduced after a closing movement has been initiated.

To provide a door-closing mechanism which will become automatically reversed if the door is subjected to an abnormal resistance when partly closed, whereby the door will be automatically reopened.

To provide a door-operating mechanism comprising a driving crank having a primary motor connected therewith and a secondary spring motor so connected with said crank as to be caused to store energy during an initial door-opening or door-closing movement and to restore such energy to the crank during the completion of a door-opening or door-closing movement.

To provide a door-operating mechanism having a crank and a cushion or buffer so connected with said crank as to tend to gradually check its movement at the end of either a door-closing or a door-opening operation of the mechanism.

To provide a door-operating mechanism having a driving crank and a pitman connecting said crank with a door opening and closing device, the relative disposition and ranges of movement of the parts of the mechanism being such that the crank-connected end of said pitman will move substantially at right angles to its longitudinal axis at the beginning and at the end of either a door-opening or a door-closing operation of the mechanism, and will move substantially parallel with its longitudinal axis when the crank is substantially midway between the beginning and end of a door-opening or door-closing movement.

To provide a door-operating mechanism having the above-described connection between a driving crank and a door opening and closing device in combination with the above-described connection between said crank and a spring motor, or between said crank and a cushion or buffer, or in combination with such a spring motor and buffer combined.

To provide a door-operating mechanism having a primary motor and a secondary spring motor of the above-described character in combination with means whereby the primary motor may be rendered passive after it has initiated a door-opening or a door-closing movement and after it has stored sufficient energy in the spring motor to insure the completion of the door-opening or door-closing movement of the mechanism after the primary motor has been rendered ineffective.

To provide an elevator car operating device comprising a driving mechanism on the car, a door opening and closing device at a landing, and a coupling comprising parts of said mechanism and device adapted to be brought into cooperative relation as the car moves to the landing, the parts of said coupling being so disposed that the working clearance by which they are separated will be materially reduced during an additional door-opening movement and will remain substantially constant throughout the remainder of the movement, so that the backlash will be reduced to a minimum at the time when the door-operating mechanism changes over from an accelerating mechanism to a retarding mechanism.

To provide an elevator car door operating mechanism comprising a driving mechanism on the car, a door-operating device at the landing, and a coupling comprising parts of said driving mechanism and operating device adapted to be brought into cooperative relation as the car moves to a landing, one of said coupling elements being so mounted as to be capable of being deflected in a direction other than that of its normal direction of movement, whereby it may be displaced by the other coupling element and permit the two elements to pass each other without damage if the car is moved to the landing when the two elements are not in their properly-aligned working relation.

In the accompanying drawings illustrating preferred and modified forms of the invention:—

Figure 1 is a plan view of the entrance portion of an elevator shaft and the adjacent portion of an elevator car, illustrating a shaft door and a

car door adapted to be operated by mechanism embodying the herein disclosed invention.

Fig. 2 is a diagrammatic view in elevation of the elevator car door and its door opening and closing device as it would be seen by one viewing the car door through the shaftway door.

Fig. 3 is an elevational view of a door at a shaftway and its opening and closing mechanism as it would be seen by one viewing the same from the inside of the shaft.

Fig. 4 is a front view of the door-operating mechanism indicated as being mounted on the top of the car.

Fig. 5 is a top view of the operating mechanism illustrated in Fig. 4.

Fig. 6 is an end view of the door-operating mechanism illustrated in Figs. 4 and 5.

Fig. 7 is a rear view of the upper end of the door-operating arm illustrated in Fig. 3.

Fig. 8 is a side view of the part of the mechanism illustrated in Fig. 7, a portion thereof being shown in cross-section.

Fig. 9 is a modified form of coupling through which the door opening and closing device at a landing may be operated by the mechanism on the car.

Fig. 10 is a conventional diagram of the electrical apparatus and connections whereby the movements of the driving motor for the door-operating mechanism are controlled.

Fig. 11 is a conventional view of a portion of the diagram illustrated in Fig. 10, the controller being indicated in a different position.

In Fig. 1 the entrance portion of an elevator car 20 is indicated in association with the entrance 21 at a landing of an elevator shaft. The doorway of the car is closed by a door herein disclosed as a double door comprising door elements 22, 23, having an opening and closing device 24 therefor connected by a driving shaft 25 with an operating mechanism mounted in any appropriate position on the car. The doorway at the landing is likewise indicated as being closed by a door herein disclosed as a double door comprising door elements 26, 27, having an opening and closing device 28 provided with an operating roller 29 adapted to form one element of a coupling by which the door opening and closing device may be connected with the above-described operating mechanism mounted on the car. The other element of the coupling may comprise a pair of shoes 30, 31, illustrated in broken lines.

The mechanism on the car by which the door opening and closing devices 24 and 28 are operated will be hereinafter more fully described.

Referring now to Fig. 2, the door elements 22 and 23 of the elevator car are indicated as being provided with an opening and closing device comprising a bar 24 fixedly secured to a shaft 25 rotatably mounted in the base of the door-operating mechanism on the top of the car. Fixedly secured at the opposite end of the shaft 25 is a rocker arm 32 connected by means of a rod 33 with a rocker arm 34 fixedly secured to a shaft 35 of the door-operating mechanism.

One end of the door-operating arm 24 is connected with the door element 22 by a connecting link 36, and the bar 24 is connected at a point intermediate its ends with the door element 23 by means of a link 37. The connections between the links 36 and 37 and the operating bar 24 may be so disposed as to cause the door element 22 to move with twice the velocity of the door element 23 when the arm 24 is swung about the center of the shaft 25 during a door-opening movement of the mechanism, thus causing the two door elements to be moved to the positions indicated in broken lines in Fig. 1 as the door is fully opened. A swing of the arm 24 in the opposite direction will cause the door to be closed.

The door opening and closing device of the door at a landing of the elevator shaft, best shown in Fig. 3, may comprise a lever 28 pivotally secured at 38 to a support 39 fixedly secured to any appropriate part of the elevator shaftway.

The lever 28, in the form of the mechanism herein disclosed, is connected by a link 40 with an arm 41 of a lever 42 pivotally connected at 43 to the door element 27.

The door element 26 may be connected with the lever 42 by a link 44, one end of said link being connected with the door as at 45 and the other end with the lever as at 46. The other end of the lever 42 may be connected at 47 by means of a link 48 with a bracket or other support 49 fixedly secured to any appropriate part of the shaftway.

The above-described toggle mechanism may, if desired, be balanced by means of a counterweight 50 secured to one end of the lever 42, and the link 48 may be extended beyond its pivotal connection 47 to provide a toe 51 adapted for engagement with a pin 52 on the lever 42, whereby the elements of the toggle mechanism may be brought to rest in relative positions of alignment.

The upper end of the lever 28 may be provided with a roller 29 adapted to serve as one element of a coupling whereby the door-operating device may be connected with the operating mechanism on the car when the car is at the landing. The other element of the coupling is herein illustrated in broken lines as comprising a pair of shoes 30, 31 so positioned as to come to rest at opposite sides of the roller as the car moves to the landing. This coupling element 30, 31 may be moved to the right, as illustrated in Fig. 3, by the operating mechanism on the car when the door is to be opened. It will be apparent that this movement of the coupling element will cause the lever 28 to be rotated in a clockwise direction as viewed in Fig. 3, thus causing the toggle mechanism to be broken, and a continuance of the movement of the lever to the position indicated in broken lines in Fig. 3 will cause the two door elements to be moved to the positions indicated in broken lines in Fig. 1. A reverse movement of the lever will cause the doors to be closed and locked in closed position by the toggle mechanism.

One form of door-operating mechanism embodying the invention is illustrated in Figs. 4, 5 and 6 of the drawings. This mechanism may comprise a primary motor, preferably an electric motor, 53, mounted in a suitable framework 54 supported preferably on the top of the car and connected by means of a friction clutch 55, or other suitable coupling means, with a rock-shaft 56 through appropriate gearing which may comprise a worm (not shown) driven by the shaft connected with the clutch 55 and a worm-wheel (not shown) enclosed in the gear case 57 mounted in the framework 54.

Fixedly secured to one end of the shaft 56 is a rock-arm 58, connected by means of a pitman 59 with a rock-arm 60, fixedly secured to the shaft 35 mounted in the framework 54.

The shaft 35 is connected with the opening and closing device for the car door by the lever 34 and pitman 33, as already described, and the shaft may be connected with the shoes 30, 31, by which

the operating mechanism may be connected with the opening and closing device of a door at a landing, by means which will now be described.

As best illustrated in Figs. 4 and 6, the shoe 30 is provided wtih a rear guide-block 61 (Fig. 6), and the shoe 31 is provided with a front guide-block 62, the two guide-blocks being adapted to slide, each independently of the other, along a pair of guideways 63, 64.

The guide-blocks 61 and 62 are respectively connected by means of pitmen 65, 66 with a rock-arm 67 fixedly secured to the shaft 35. The pivotal connections 68, 69 between the rock-arm 67 and the pitmen 65, 66 are, for reasons to be hereinafter explained, at slightly different radial distances from the center of the shaft 35, and the connection 68 is spaced slightly in advance of the connection 69 as to its angular relationship with the center of the shaft 35.

The pair of shoes 30, 31 comprise a coupling element intended to cooperate with the rollers on levers 28 of door-opening and door-closing devices at the various landings of the elevator shaftway. In order that they may do this without conflict, notwithstanding the slight lateral swaying movement of the car with respect to its guides, it is important that a relatively ample working clearance be allowed between the inner surface of each shoe and the adjacent surfaces of the rollers. The invention, therefore, provides for a material reduction of the clearance between the shoes and the rollers during the initial part of the door-opening movement, whereby ample clearance may be allowed without resulting in undue backlash during an opening movement of a door at the time when the door has reached its maximum velocity of movement and the opening device ceases to be an accelerating means and commences to act as a retarding means. This is accomplished by the above-described mechanism, from an examination of which it will be apparent that the trailing shoe 30 connected with the rock-arm 67 at the point 68 will move somewhat faster during an initial part of a door-opening movement than the leading shoe 31 connected with the rock-arm 67 at the point 69. This acceleration of the trailing shoe with respect to the leading shoe is due both to the angular spacing of the points 68 and 69 and to the greater angular distance of the point 68 from the center of the shaft 35. The connection of the pitmen 65 and 66 with the arm 67 substantially as indicated in Fig. 4 of the drawings will cause the variation of movement between the shoes 30 and 31 to gradually decrease, so that the movement of the two shoes will become substantially uniform before the rock-arm has moved to a vertical position, and the movement of the two shoes will remain substantially uniform thereafter until the rock-arm attains its maximum movement to the left, at which time the door-opening movement is completed. In view of the somewhat greater radius of the pivotal connection 68 as compared with that of the connection 69, this substantially uniform movement of the shoes at the end of the door-opening operation of the mechanism may be attained even though the rock-arm move to an angular position to the left substantially equal to that to which it moves to the right in closing the door, as indicated in broken lines in Fig. 4.

It will be obvious that the relative positions of the pivotal connections 68, 69 between the connecting rods 65, 66 and the rock-arm 67 may be varied in accordance with variations of the respective angular positions to which the rock-arm is intended to be moved at the beginning and end of a door-opening movement. For example, if the angular inclination of the rock-arm at the beginning of its movement to the right of the vertical line passing through the center of the shaft 35 is greater than its inclination at the end of the movement to the left of such vertical line, the radial distance of the center 68 as compared with that of the center 69 might be decreased, or the former might even be made equal to the latter, since under such circumstances the relative speed of movement of the shoes 30, 31 would be substantially equal during the swing of the arm 67 throughout the arcs of movement of substantially equal angles at opposite sides of the vertical line, where as the velocity would be caused to vary more rapidly throughout the additional arc of movement of the arm to the right of the vertical line.

As a means of avoiding accidental damage to the mechanism, should the car approach the landing when the coupling element comprising the shoes 30, 31 and the coupling element comprising the roller 29 are not in their normal alignment, provision is made whereby one of these elements may be deflected in a direction substantially perpendicular to its normal direction of movement, thereby permitting the two coupling elements to pass each other without unduly straining any part of the mechanism. One form of mechanism for accomplishing this result is illustrated in Figs. 7 and 8. As there disclosed, the upper end of the door-operating lever 28 consists of an extension 70 pivotally connected as at 71 to a bracket 72 firmly secured to the upper end of the lever. Any appropriate form of spring 73 may be provided to maintain the extension 70 in its upright position, and its movement in a clockwise direction about the pivotal connection 71, as indicated in Fig. 8, may be limited by means of a downwardly-extending toe 74, which is brought into contact with the rear face of the bracket 72 when the extension 70 is in its normal working position.

As indicated in Fig. 6, the shoes 30, 31 are gradually tapered at their upper and lower extremities on the faces directed towards the adjacent wall of the elevator shaft so as to form a cam-like element. Should the relative positions of the lever 28 and the coupling element comprising the shoes 30, 31 be displaced when the car approaches the landing either from above or from below, so that one or the other of the shoes is in alignment with the roller instead of passing clearly to one side thereof, the approaching gradually-beveled surface of the shoe will engage the face of the roller 29 and cause it and the extension 70 of the lever 28, in which it is mounted, to be rocked slightly about the pivotal connection 71, as indicated in broken lines in Fig. 6. This will permit the shoe to pass the roller without damage, after which the spring 73 will cause the roller and its mounting element to be restored to their normal positions, as indicated in full lines in Fig. 6.

In the preferred form of the invention, means, hereinafter to be described, may be provided for rendering the primary motor 53 inactive after it has rotated the crank 58 (Fig. 4) through slightly more than half its door-opening or door-closing movement, and an auxiliary spring motor is provided to insure the completion of such motion. As indicated in Fig. 4, this spring motor may be combined with a hydraulic buffer of any

appropriate type. More specifically described, the spring motor and buffer best adapted for use as a part of the herein-disclosed invention comprise a cylinder 75, pivotally connected at one end as at 76 to the base or frame 54, and a piston-rod 77 pivotally connected at one end as at 78 to an extension 79 forming a part of the end of the pitman 59, the piston-rod 77 being connected at its opposite end to a piston 80 adapted to move into and out of a restricted portion of the cylinder of suitable form to serve as a dash-pot. A spring 81 may be confined between the upper head of the cylinder 75 and a spring-retaining element 82 secured to the piston-rod 77 above the piston 80.

It will be observed that the direction of movement of the crank-connected end of the pitman 59 at the beginning and at the end of a door-opening or door-closing movement is substantially perpendicular with respect to the longitudinal axis of the pitman, whereas the direction of movement of the crank-connected end of the pitman 59 when the crank is substantially midway between the extreme ends of the door-opening or door-closing movement is substantially parallel with the longitudinal axis of the pitman. On the other hand, the direction of movement of the crank-connected end of the piston-rod 77 at the beginning and at the end of a door-opening or door-closing movement is substantially parallel with its longitudinal axis, whereas the direction of movement of the same end of the piston-rod 77 when the crank is midway between the ends of a door opening or closing movement is approximately at right angles to the longitudinal axis of the piston-rod. This relationship is of importance in that it enables the crank to very gradually accelerate and retard the opening and closing movements of the door; to restore energy more rapidly in the spring motor at the commencement of an opening or closing movement when the resistance offered by the spring is least; and to permit the spring to complete an opening or closing movement of the door at a time when its mechanical advantage is greatest.

The relative position of the upper end of the door-operating lever 28 with respect to the coupling element comprising the shoes 30, 31, when the car is at a landing, is best illustrated in Figs. 3, 4 and 6. In Fig. 3 the shoes and adjacent portions of the coupling element are indicated in broken lines, and in Fig. 4 the upper end of the lever 28 is indicated in broken lines.

In order that the elevator on which the apparatus embodying the invention is installed may not be started while the doors are open, the car-operating mechanism may be subjected to the control of an interlock switch of any appropriate character, which may be enclosed in a switch-box 83 mounted on the framework 54, as indicated in Fig. 4. The switch may be opened and closed by a rock-arm 84, connected by a rod 85 with a rock-arm 86, fixedly secured to the shaft 35. Preferably, as indicated in Fig. 4, the relative positions of the rock-arms 84 and 86 with respect to the connecting rod 85 and the shafts to which the arms are secured are such that the movement of the arm 86 in its clockwise direction during the initial part of the door-opening movement will impart a rapid lengthwise movement to the connecting rod 85, and such that each increment of lengthwise movement of the rod 85 will impart a relatively rapid angular movement to the rock-arm 84, thus causing the switch terminals (not shown) in the box 83 to be quickly opened, after which the retardation of the movement of the switch member is of no material consequence. This arrangement of the rock-arms and connecting rod by which the interlock switch is operated is of importance also because it insures the separation of the switch elements until the door has been almost completely closed.

In order to provide for necessary adjustments between the door opening and closing devices and the operating mechanism on the car, the connecting rod 33 (Fig. 2) need not be directly connected with the rock-arm 34. On the contrary, the connecting rod may be pivotally secured to a sleeve 34', which may be radially movable along the arm 34 and adjustably secured thereto in any appropriate manner. Further adjustment between the different parts of the mechanism may be provided, if desired, by threading the opposite ends of the connecting rods 33, 59, 65, 66 and 85, right hand and left hand respectively, whereby the effective lengths of the rods may be increased by rotation in one direction and decreased by rotation in the other direction, after which they may be firmly secured in adjusted position by means of lock-nuts.

It will be obvious that the variation of the clearance space between the parts of the coupling between the operating mechanism on the car and the opening and closing device at a landing may be effected in various ways. In Fig. 9, for example, is illustrated a modified form of coupling having a single driving element 30' and having a pair of rollers 29' at the upper end of the lever 28' to be engaged by the driving element. When using this form of the mechanism, if it is desired to have the lower end of the lever 28' swing through equal angles to the right and left of a vertical line x—x passing through the axis of its pivotal connection 38' throughout its complete door-opening and door-closing movements, the upper end of the lever may be bent to an angle such that the rollers 29' will still be to the left of the vertical line x—x when the lever is substantially midway between the beginning and end of its complete range of movement. The bend in the upper end of the lever 28' may also be such that the rollers 29' at the end of a door-opening movement will have been moved to the right of the vertical line x—x a distance substantially equal to that which they occupy at the left of the line when the lever is in its mid-position. It will be apparent from an analysis of this mechanism that, as the driver 30' moves the upper end of the lever from the position indicated at A to the position indicated at B during the first half of a door-opening movement, the clearance between the rollers 29' and the flanges 31' on the driving member 30' will be rapidly decreased, due to the change in the angular relations between the line y—y passing through the centers of the rollers and the vertical surfaces of the flanges 31' of the driving element. During the movement of the driving element from its position B to its position C, the change of angular relation between the line y—y and the vertical flanges of the driving element is relatively small, and, throughout this part of the movement, the change in clearance space between the rollers and the flanges is proportionately small. It will be clear, therefore, that a relatively large clearance may be provided between the rollers and the flanges of the driving element when in their normal positions as indicated at A, thus allowing for the necessary lateral movement of the car as it travels up and down the shaftway without causing

the rollers to conflict with the vertical movements of the driving element. After the car is brought to rest at a landing and the driving element is moved towards the right during the initial part of a door-opening movement, the clearance between the rollers and the flanges of the driving element will be materially reduced, so that, when the door has reached its maximum velocity of movement and the driving element ceases to act as a driving member and commences to act as a retarding member, the clearance between the rollers and the flanges of the driving element may be small, thus permitting a minimum amount of jar or backlash.

The preferred and modified forms of the invention thus far disclosed illustrate but two of the many ways in which the clearance between the driving and driven elements of the coupler may be reduced during the initial part of a door-opening movement by variations of the proportions and points of connection of the links of the mechanism.

In Fig. 10 are illustrated diagrammatically the electrical apparatus and circuit connections by means of which the operation of the primary motor 53 is controlled. On this diagram 87 represents the armature of the operating motor of the elevator car, the movements of which are dependent upon the position of the handle 88 of an appropriate controller 89 mounted in the car. The primary motor 53 (Fig. 5) of the door-operating mechanism may be of the series wound type indicated in the diagram as having an armature 53′ and a field winding 53″. The movements of this motor, as will be hereinafter more fully explained, may be made dependent upon the operation of a relay 90 mounted on the car, relays 91, 92, 93 and 94 mounted in the elevator penthouse or in any other available position in the building in which the elevator is installed, and a controller 95 which may be mounted on the end of the shaft 56 (Fig. 4) and enclosed in a casing secured to the gear casing 57.

The relay 91 (Fig. 10), which may be designated a master relay, may have its energizing coil connected in a circuit comprising conductors 96, 97, including the armature 87 of the car-operating motor or so much of the winding of that armature as may be necessary to keep the relay 91 energized and its armature pulled up so long as the armature 87 is in rotation. When the armature 87 comes to rest, the relay 91 will be de-energized, thus causing its armature 98 to fall back and close a circuit from one terminal 99 of any suitable source of electromotive force through conductor 100, contact members of relay 98, conductor 101, the winding of relay 90, conductors 102, 103, element 107 of controller 95, and conductors 104 and 105, to the other terminal 106 of the source of electromotive force. This circuit is controlled not only by the master relay 91, but also by the element 107 of the controller 95. Included in the circuit just traced is the energizing coil of the relay 90, which is designed to control the door-opening movement of the motor 53.

In order that the door may not be opened by the energizing of the master relay 91 unless the car is at the landing, the magnetic circuit of the relay 90 is divided into two portions of which one portion 108 is mounted at the landing. When the car is between landings, there is a gap in the magnetic circuit of the relay 90, and until this gap is closed its physical and electrical characteristics are such that it will not draw up its armature even though the circuit of its energizing coil is closed by the master relay 91. When the car reaches the landing, the gap in the magnetic circuit of the relay 90 is closed by the part of the circuit 108 mounted in an appropriate location in the elevator shaft, thus causing the characteristics of the relay to be changed, as a result of which the relay attracts its armature and closes a circuit from conductor 100 through the energizing coil of relay 92, hereinafter referred to as the door-opening relay, conductors 109, 110, 103, 104 and 105, thus causing the door-opening relay to attract its armature and establish an energizing circuit for the motor 53. This circuit may be traced as follows: terminal 99, conductor 100, left-hand contacts of relay 92, conductor 111, motor armature 53′, conductor 112, right-hand contacts of relay 92, conductor 113, field winding 53″, and conductors 114 and 105 to terminal 106. This energizing circuit causes the door-operating motor to be operated in a door-opening direction, and during such rotation the controller 95 connected to shaft 56 (Fig. 4) of the operating mechanism is rotated in the direction indicated by the arrows in Fig. 10.

When the door-operating mechanism is in its door-closing position, the contacts of the controller element 107 are connected by conductive material so as to close the circuits for the landing relay 90 and the door-opening relay 92. The controller element 107, however, is provided with insulating elements so positioned as to break the circuit between conductors 103 and 104 at an intermediate point of the door-opening movement of the motor, thus de-energizing the landing relay 90 and door-opening relay 92, after which the motor is de-energized and becomes passive or inactive. The insulating portions of the controller element 107 are so disposed with respect to the conductor portions as to interrupt the circuits of the relays 90 and 92 after the opening movement of the door has been well initiated and the spring 81 (Fig. 4) of the secondary motor has been sufficiently energized to insure the completion of the door-opening movement. Preferably, this interruption of the motor circuit will take place after the crank 58 (Fig. 4) has made slightly more than one-half its complete door-opening movement. The energizing circuit of the relays 90 and 92 will be maintained in an open-circuit condition by the controller element 107 throughout the remainder of the door-opening movement of the motor until the motor and the connected controller come to rest with the controller in the position indicated in Fig. 11, which may be referred to as its open-door position.

When the controller 95 is in its open-door position as distinguished from its closed-door position, a circuit may be established through the energizing coil of the relay 93, which may be regarded as a door-closing relay. This circuit may be traced as follows: terminal 99, conductor 100, relay-energizing coil, conductor 115, the contact members 118 and 119 of the car switch, conductor 116, controller element 117, conductor 104 and conductor 105 to terminal 106. This door-closing motor circuit may be closed, when the door is open, by any appropriate switch mechanism in the car. Such switch mechanism, as herein disclosed, comprises switch terminals 118 which may be provided in pairs in the controller 89, the terminals being so disposed as to be closed by a contact element 119 connected with the con-

troller handle 88, by which it may be moved into a bridging relation with respect to one pair of contacts when moved in one direction to cause the car to ascend, and to bridge the other pair of terminals when moved in the opposite direction to cause the car to descend. The contacts 118 may be connected in parallel relation, as indicated, so that the circuit of the door-closing relay 93 will be closed irrespective of the direction of movement of the controller handle.

The pulling-up of the armature of relay 93 will establish two circuits for the motor of the door-operating mechanism, one of relatively high resistance and one of relatively low resistance. The circuit of relatively low resistance may be traced as follows: terminal 99, conductor 100, right-hand contacts of relay 93, conductor 120, right-hand pair of right-hand contacts of relay 94, conductor 112, motor armature 53', controller element 121, conductor 122, right-hand pair of left-hand contacts of relay 94, conductor 123, left-hand contacts of relay 93, conductor 113, motor field winding 53'', conductor 114 and conductor 105 to terminal 106.

The circuit of relatively high resistance uses a part of the circuit connections of the circuit of relatively low resistance, and may be traced as follows: terminal 99, conductor 100, right-hand contacts of relay 93, conductor 120, right-hand pair of right-hand contacts of relay 94, conductor 112, motor armature 53', conductor 111, right-hand pair of the central group of contacts of relay 94, conductor 125, energizing coil of relay 94, conductor 126, resistance coil 127, left-hand contacts of relay 93, conductor 113, field winding 53'', conductor 114 and conductor 105 to terminal 106.

The above-described motor circuits differ from the motor circuit established by the door-opening relay 92 in that they cause current to pass through the armature 53' in the opposite direction, while the current is caused to pass through the field winding 53'' in the same direction. The motor is thus reversed and conditioned for a door-closing movement of the operating mechanism.

So long as the door-closing circuits of the motor are closed at the controller elements 117 and 121, as indicated in Fig. 11 representing the position of the controller when the doors are open, a relatively low resistance motor circuit will be established, causing the motor to exert its normal torque during the initial part of a door-closing movement. After the closing movement of the door has been well initiated and the door has been say approximately one-third closed, the insulating portion of the controller element 121 will break the low resistance motor circuit between conductor 122 and the field winding 53'', after which the motor will be energized through the high resistance circuit including resistance coil 127, thus causing the torque of the motor to be materially reduced, so that the movement of the door could be more readily stopped should a person become accidentally caught between the leading edge of the door and the door jamb.

The purpose of the relay 94, which may be regarded as an emergency relay, is to provide an additional safeguard against injury to a person who might be caught by the door as it is being closed. As already explained, this relay has an energizing coil in the circuit comprising conductors 124, 125, 126 and resistance coil 127, said conductors being a part of the high resistance door-closing motor circuit. The characteristics of the relay 94 are such that it will not be sufficiently energized by the current in the motor circuit to operate its armature so long as the door-closing load on the motor is normal. The characteristics of this relay are such, however, that it will be sufficiently energized to pull up its armature if the current in the motor circuit is materially increased, as would be the case if the motor were subjected to an overload as a result of an abnormal obstruction to the closing of the door. Under such circumstances, the pulling-up of the armature of the relay 94 would cause it to open the three circuits already traced through the right-hand pairs of its three groups of contacts and to close new circuits through the left-hand pairs of the same groups of contacts.

In order that the armature of the relay 94 may not be caused to move back to its normal position by the breaking of its energizing circuit through the right-hand pair of its intermediate group of contacts, the relay is provided with a second energizing winding in a holding circuit which is established through the left-hand pair of its left-hand contacts, which may be traced as follows: terminal 99, conductor 100, conductor 128, holding coil for relay 94, left-hand pair of left-hand contacts of relay 94, conductor 129, controller element 107, conductor 104 and conductor 105 to terminal 106.

The pulling-up of the armature of the relay 94 will break the normal door-closing motor circuits at the right-hand pairs of its three groups of contacts, and will establish a reversing motor circuit, which may be traced as follows: terminal 99, conductor 100, conductor 130, left-hand pair of the middle group of contacts of relay 94, conductor 124, conductor 111, motor armature 53', conductor 112, left-hand pair of right-hand contacts of relay 94, conductor 131, conductor 113, field winding 53'', conductor 114 and conductor 105 to terminal 106. The resistance offered to the closing of the door by one who might be so unfortunate as to be caught between the approaching edge of the door and the door jamb would thus cause the motor circuit to be reversed through this new set of connections established by the pulling-up of relay 94 and thus cause the door to be quickly opened.

The opening of the door as a result of the operation of the emergency relay 94 will continue until the holding circuit of the relay is broken by the insulating portion of controller element 107, after which the armature of the relay 94 will be restored to its normal position. The door will remain open provided the handle 88 has been restored to its normal position, so as to break the energizing circuit of the door-closing relay 93, and the parts of the mechanism will again be in condition for a normal door-closing operation of the mechanism on movement of the controller handle 88.

If the door is normally closed, the insulating portion of controller element 117 will open the circuit of the door-closing relay 93 after the door-closing movement has been initiated and the spring motor 81 sufficiently energized to complete the movement. The opening of the energizing circuit of relay 93 will cause its armature to be restored to normal position, thus opening the motor circuits, after which the motor will be ineffective during the completion of the door-closing movement by the spring motor.

To avoid the unintentional direct connection of the field winding 53'' across the terminals 99, 106, thus short-circuiting the armature 53', the

insulating portions of the controller elements 107, 117 should be so disposed that the circuit through element 107 will be broken before the circuit is established through element 117 during a door-opening movement, and so that the circuit through controller 117 will be broken before a circuit is established through controller element 107 during a door-closing movement.

It will be understood that, by proper adjustment of the armature spring of the relay 91 and the winding of its exciting coil, the time element between the stopping of the rotation of the armature 87 and the operation of the relay armature 93 may be adjusted to accord with the conditions to be met. If it is desired to have the car doors commence to open as the car is being brought to rest at the landing, this may be effected by using a relay having a relatively open magnetic circuit and a spring capable of causing its armature to fall back before the current in its exciting coil has been reduced to zero. On the other hand, if it is desired to delay the opening of the doors until slightly after the time when the car arrives at the landing, this may be accomplished by interlinking, with the magnetic circuit of the relay, a short-circuited coil of low electrical conductivity in association with its exciting coil, in a well-known manner, which will tend to maintain the excitation of the magnetic circuit of the relay after the current in its exciting coil has ceased to be effective.

The mode of operation of the above-described mechanism may now be readily explained. As an elevator car having the invention applied thereto comes to rest at a landing, the magnetic circuit of relay 90 mounted on the car will be closed by the metal bridging element 108 mounted in the elevator shaft, so that, as soon as the armature 87 of the car-operating motor comes to rest and the master relay 91 is permitted to release its armature, relay 90 will establish an energizing circuit for the door-opening relay 92, which, in turn, will establish the door-opening circuit for motor 53 (Fig. 5). The motor 53 will then commence to rotate and will, through the clutch 55 and the worm and worm-wheel in the gear case 57, commence to rotate the crank 58 in a counter-clockwise direction as indicated in Fig. 4. This movement of the crank and the connected door-operating mechanism comprising the connecting rod 59, rock-arm 60, rock-arms 67 and 34, connecting rods 65, 66 and 33, and door-operating levers 24 and 28, will gradually accelerate the car door as well as the door at the landing, and will at the same time commence to store energy in the spring motor 81. This initial movement of the crank and associated mechanism will also cause the interlock switch in the switch-box 83 to be quickly opened as soon as the door starts to move, thereby making it impossible to start the car either upwardly or downwardly until the door has again been closed. After the door has received from the motor 53 a sufficient impulse to insure the completion of the opening movement with the aid of the energy which has been stored in the spring 81, the motor circuit is opened and the motor is rendered powerless throughout the remainder of the door-opening movement.

The opening of the motor circuit is effected by the controller secured to the shaft 56, the element 107 of which will at the proper time cause the relays 90 and 92 to be de-energized, after which the controller element 117 will be conditioned for the closing of circuits whereby the motor may be driven in a reverse direction when the doors are to be closed. The insulating portions of the controller will preferably be so disposed as to delay the opening of the motor circuit until after the crank 58 has completed more than half its door-opening movement, at which time it will have passed its dead-center relationship with respect to the spring motor 81. Under normal circumstances the inertia of the doors and door-operating mechanism might be relied upon to complete the opening movement. Since the operation of the mechanism under such ideal conditions could not be relied upon in practice, the spring motor 81, in which energy is stored throughout the first half of the door-closing movement, has been supplied as a means of completing such movement, the doors being gently brought to rest by means of the cushion or buffer in the end of the spring cylinder 75.

The closing of the car door and the door which has been opened at a landing may be effected at the will of the car operator by movement of the controlled handle 88 in one direction if he desires to cause the car to ascend, and in the opposite direction if he desires to cause the car to descend. This movement of the handle 88 of the controller will have no immediate effect upon the car-operating mechanism, which is rendered ineffective by the interlock switch in box 83 so long as the doors are open, but it will establish a circuit as a result of which the door-closing relay 93 will be energized, and the relay will, in turn, establish circuits through which the door-operating motor may be driven in its door-closing direction. The circuits established by relay 93 include one of relatively low resistance dependent upon a conductive path through controller element 121 by which the motor may be caused to exert its maximum torque during the initiation of a door-closing movement. After the door has been approximately one-third closed, and has attained the greater part of its acceleration in a door-closing direction, the low resistance motor circuit is opened by the controller element 121 and the motor is then energized through the high resistance circuit including the resistance coil 127. This change of circuits results in a material reduction in the driving torque of the motor, thus making it possible for one who might be caught by the door to bring it to rest without being seriously injured. The emergency relay 94 is provided as an additional safeguard. This relay becomes effective as a result of the overloading of the motor due to an abnormal obstruction to the closing movement of the door. With this feature of the invention embodied in the mechanism, a person who might be caught by the door would cause the relay 94 to be energized, thereby establishing a reversing circuit through the door-operating armature, thus causing the door to be immediately reopened. The complete opening of the door breaks a holding circuit for the emergency relay through controller element 107, thus restoring the relay circuit to normal condition, after which, if the doorway is clear, the door may be closed by a normal operation of the mechanism by again moving the handle 88 of the controller in the proper direction.

One feature of the invention which is of material importance is that a single auxiliary spring motor is relied upon to complete the closing movement of the door as well as to complete the opening movement of the door, and a single cushioning device or buffer is employed to bring the door to rest at the end of its movement in both direc-

tions. The operating connections between the primary motor, the spring motor, the buffer and the door opening and closing devices, are also of special merit in that they are such as to cause the door to be very gradually accelerated by the primary motor; to cause energy to be stored in the spring motor most rapidly at the time when the spring affords the least resistance, and more slowly as the resistance of the spring increases; and to cause the spring to exert its greatest mechanical advantage at the end of a door-opening or door-closing movement so as to fully complete the same notwithstanding the retarding influence of the buffer.

If the moving car passes a landing without stopping, the door-operating mechanism is not affected since, although the magnetic circuit of the relay 90 is closed as the relay passes the metal element 108 at the landing, the energizing coil of said relay remains dead for the reason that the electromotive force across the terminals of the master relay 91 is maintained by the rotation of the armature 87 of the car-operating motor, thus preventing the master relay 91 from releasing its armature. As the car passes the landing, the shoes 30 and 31 of the door-operating mechanism pass at opposite sides of the rollers 29 of the door opening and closing devices at the different landings, ample clearance being allowed to provide for the lateral swaying movement of the car in its guides. However, should the car be caused to pass a landing when the normal positions of the shoes and rollers have been so displaced as to not bring a roller and shoe into alignment, the yieldable mounting of the roller in the extension 70 of the lever 28, as indicated in Figs. 7 and 8, would permit the roller to be slightly deflected by the gradually-inclined face of the shoe so as to cause the shoe to pass the roller without injuring any part of the mechanism.

Although it is necessary to provide a relatively large amount of clearance space between the rollers 29 and the shoes 30, 31, to permit the car to pass freely up and down the shaftway, this clearance space is materially reduced during the initiation of a door-opening movement and before the acceleration of the door by the door-opening device has been completed, so that, after the door-opening device has attained its maximum velocity and commences to retard the opening movement of the door, the clearance between the roller and the shoes will be relatively small so as to permit a negligible amount of backlash at the time when the door overruns the operating mechanism as the latter is changed in function from an accelerating device to a retarding device.

The conventional form of controller indicated in Fig. 11 and at the lower left-hand corner of Fig. 10 is fairly representative of a controller adapted for use in the specific form of door-operating mechanism illustrated in Fig. 4, in which the crank 58 is intended to make a complete door-opening or door-closing rotation of an extent of something less than 180°. Should the mechanism be such as to require the complete movement to equal or slightly exceed 180°, the form of controller indicated by the above-mentioned figures of the drawings would not be satisfactory, since the electrical conditions at the end of the corresponding movement of the controller would be the same as at the beginning of the movement. It will be apparent, however, that the actual controller might be made in some other suitable form, such, for example, as a drum having the opposite contact elements located in different planes so that the relative lengths of insulating strips and conductive strips might be properly proportioned to suit any desired degree of rotation.

The invention is not intended to be limited to the specific forms in which it is herein disclosed for purposes of illustration, but should be regarded as covering modifications and variations thereof within the scope of the appended claims.

What is claimed is:

1. An elevator door operating mechanism comprising an opening and closing device for a door at a landing, an operating device therefor including a plurality of links carried by the car, and a coupling, including a pair of shoes, for said devices comprising a portion of each, said portions being so disposed as to be brought into effective power-transmitting relation by the movement of the car to the landing, the respective portions of said coupling being of dimensions differing sufficiently to provide a free working clearance when in the positions which they normally occupy as the car travels up and down its shaftway, the links of the mechanism connecting the said shoes to different points on the operating device to reduce the clearance between the respective portions of the coupling during the initial door-accelerating portion of a door-opening movement.

2. An elevator door operating mechanism, as defined by claim 1, of which one portion of its coupling comprises a roller and the other a pair of relatively movable spaced roller-engaging shoes, said shoes being connected with the linkage of which they form a part at different points so as to be moved at different rates of speed during the initial door-accelerating movement of the mechanism, the points selected being such as to cause the trailing shoe to move slightly faster than the leading shoe and thereby reduce the amount of clearance between the shoes and the roller.

3. An elevator door operating mechanism, as defined by claim 1, having a roller as the part of the coupling which comprises a portion of the door opening and closing device and a pair of relatively movable spaced roller-engaging shoes as the part which constitutes a portion of the operating device, said operating device comprising a crank and a pair of links connecting the respective shoes therewith at angularly-spaced points with respect to its center of rotation.

4. The combination with an elevator car and a door to be opened only when said car is at a landing of its shaftway, of an operating device for said door having an electrical controlling circuit and a relay therefor of which the magnetic circuit consists of separable metal elements, mounted respectively on said car and at said landing in relative positions such as to close the magnetic circuit of the relay and reduce its reluctance when the car is at the landing, the magnetic, electrical, and mechanical characteristics of the relay being such that it will not be rendered effective to close its controlling circuit when electrically energized except when its magnetic circuit is closed.

5. An elevator door operating mechanism, as defined by claim 4, having an electrical circuit in which the energizing coil of its relay is connected, a master relay to open said circuit when energized and close it when de-energized, and electrical connections whereby the energizing coil of the master relay may be connected with the armature of the elevator operating motor, whereby the master relay will be energized whenever the armature is rotating and de-energized only when it is at rest.

6. The combination, with a door-closing device, and an electric motor therefor, of means for energizing said motor comprising two circuits one of higher resistance than the other, and a controller connected with said device whereby the circuit of relatively high resistance may be shunted by the circuit of lower resistance throughout the initial part of a door-closing operation and whereby the low resistance circuit may then be opened so as to reduce the driving power of the motor throughout the remainder of the closing movement.

7. The device defined by claim 6, having, in combination therewith, an emergency relay of which the energizing coil is included in the motor circuit of relatively high resistance and means controlled by said relay whereby the motor circuit may be reversed, the characteristics of said relay being such that it will not be rendered effective unless the motor current is materially increased above that necessary to drive the motor when subjected to its normal door-closing load.

8. The combination, with a door-closing device, and an electric motor therefor, of means comprising circuit connections whereby said motor may be caused to rotate in a door-closing direction, a motor-reversing relay having its energizing coil connected with said motor circuit, and means comprising circuit connections controlled by said relay whereby said motor may be caused to rotate in a door-opening direction, the characteristics of said relay being such that the current in the motor circuit will not cause it to be operated to effect a change in the motor circuit connections so long as the door-closing load on the motor is normal, but such that an increase in the current in the motor circuit due to an overload of the motor as a result of an abnormal obstruction to the closing of the door will cause the relay to be operated, thereby effecting a change of circuit connections such as to reverse the direction of rotation of the motor.

9. The combination, defined by claim 8, including additional circuit connections controlled by the motor-reversing relay, whereby, when said relay is once effectively energized, it will remain energized after its original energizing circuit is opened.

HAROLD V. McCORMICK.