Feb. 9, 1960 A. LEIMER ET AL 2,924,449

DOOR OPENING DEVICE

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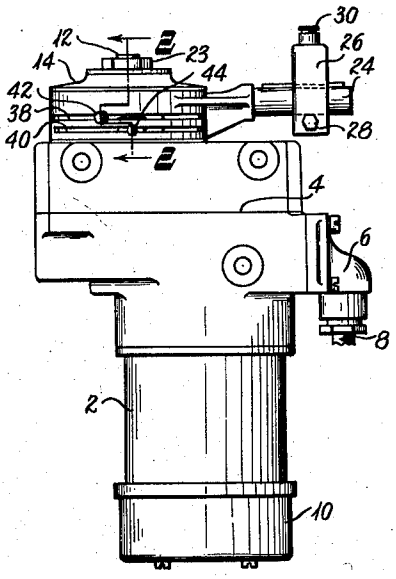


Fig. 1.

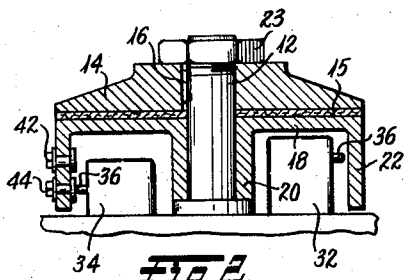


Fig. 2.

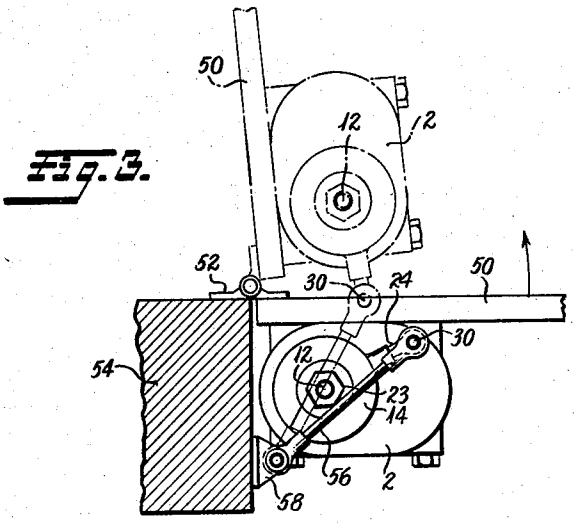


Fig. 3.

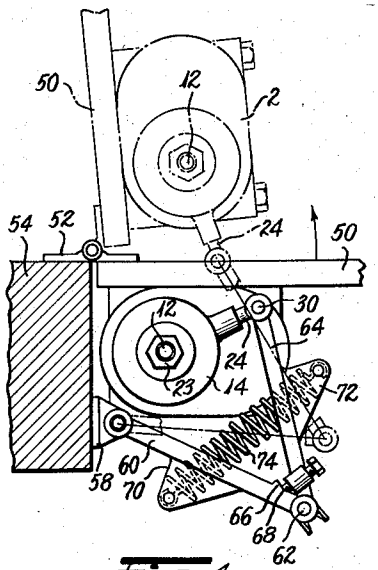


Fig. 4.

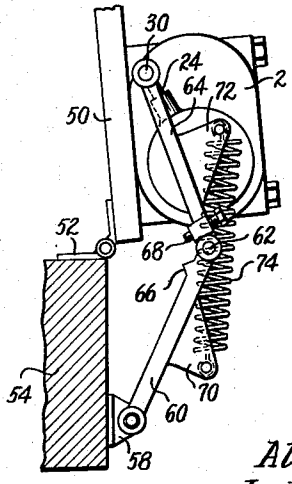


Fig. 5.

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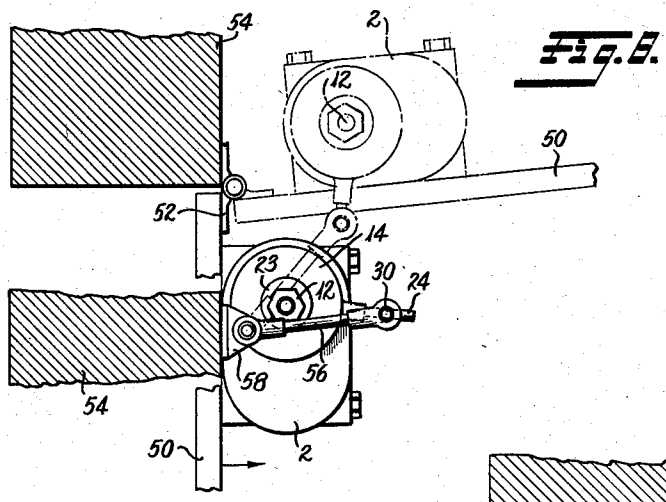


Fig. 6.

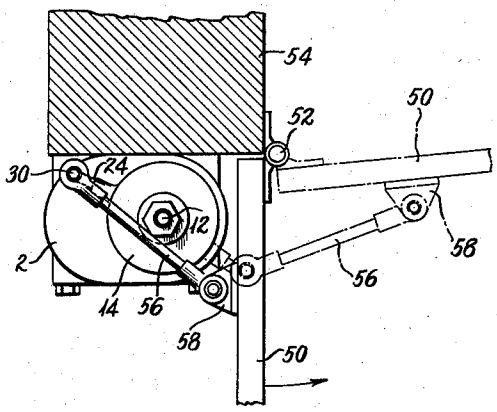


Fig. 8.

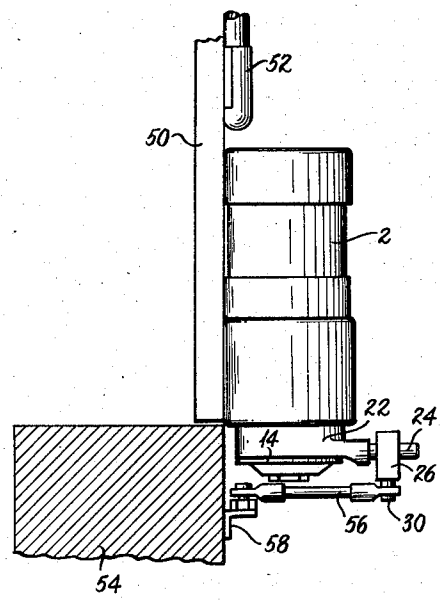


Fig. 7.

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Fig. 9.

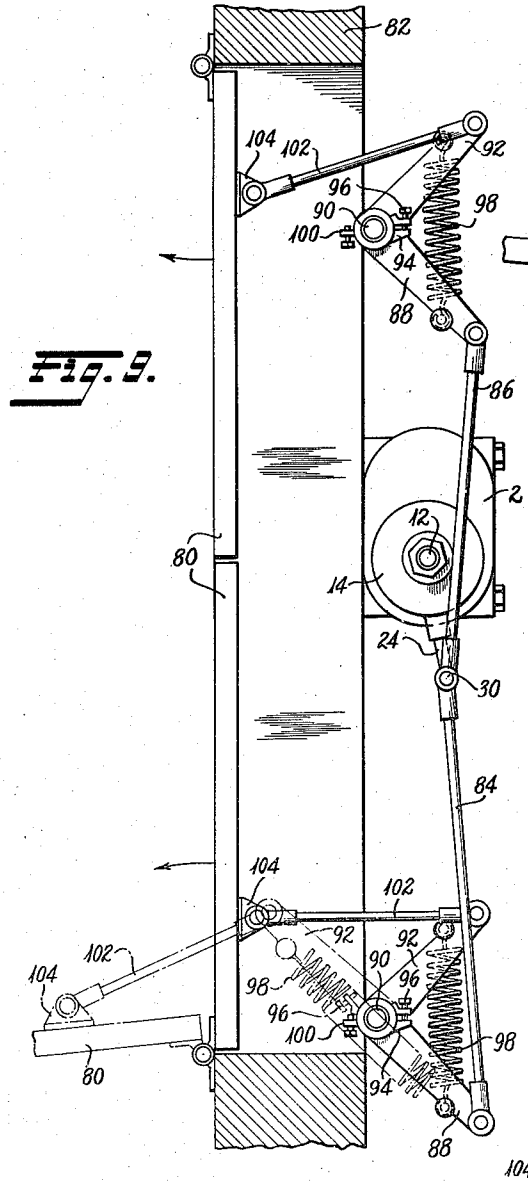
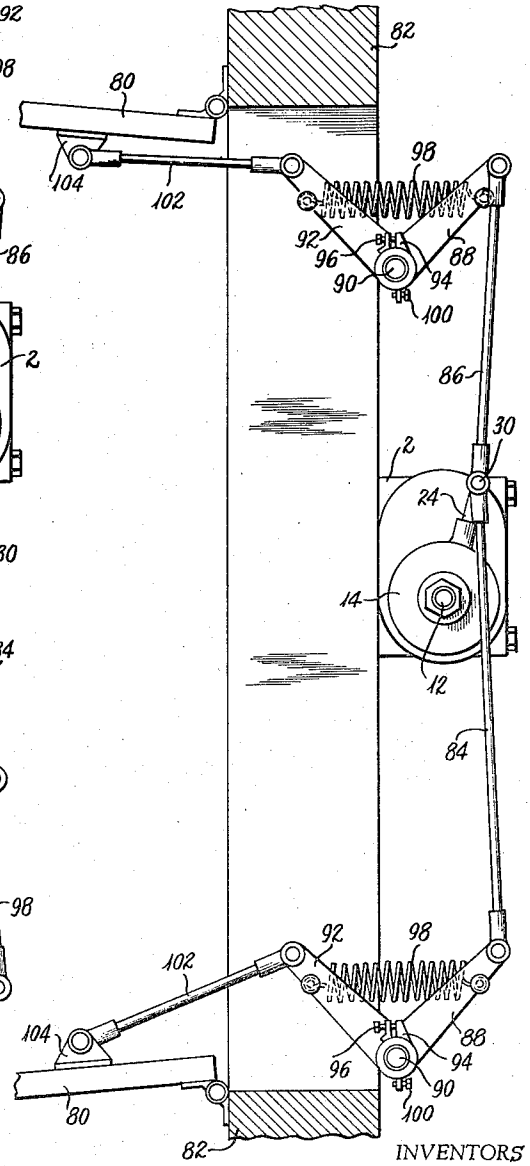


Fig. 10.



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Fig. 11.

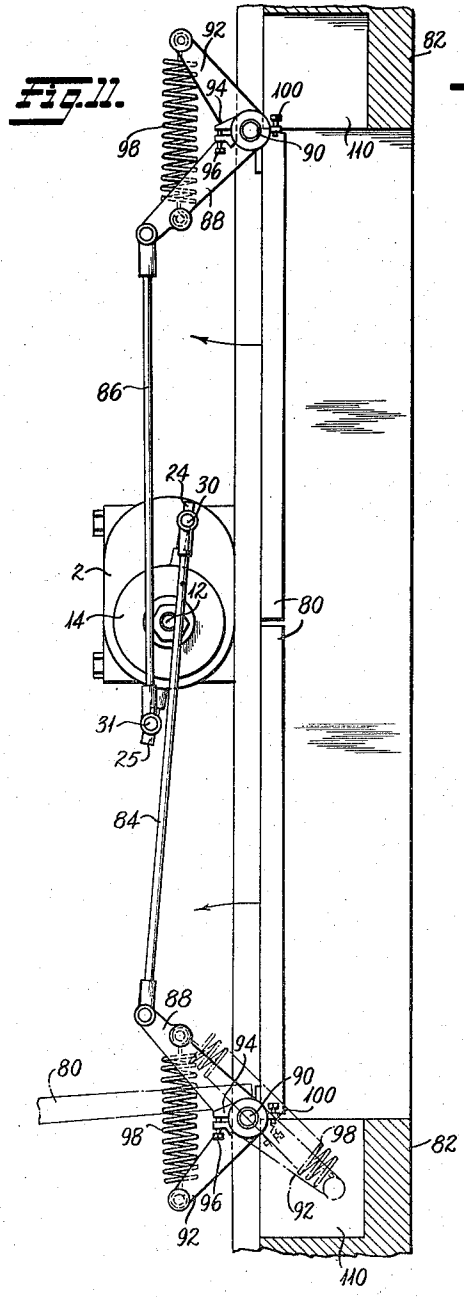
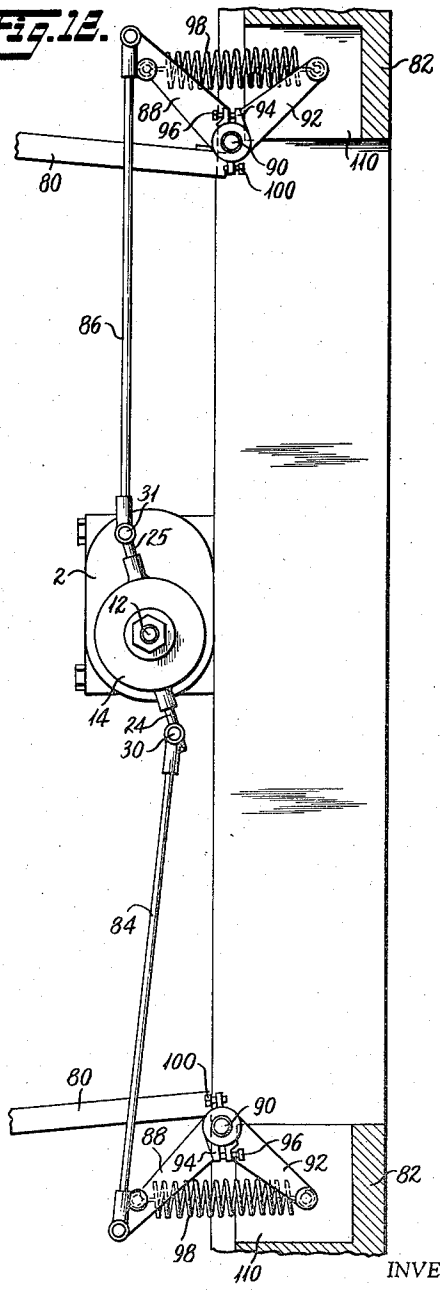


Fig. 12.



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DOOR OPENING DEVICE

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Application December 12, 1955, Serial No. 552,627

4 Claims. (Cl. 268—65)

This invention relates to apparatus for opening and closing doors automatically by means of a novel electric motor and linkage assembly.

The door opening apparatus of this invention, to be known as "Electro Magic Door," comprises essentially a power train including a motor and a linkage driven thereby which incorporates a slipping device or "break-arm" connection to permit manual opening of the door without operating the driving motor.

A further feature of the invention resides in the provision of a slippable friction clutch between the motor and linkage to operate as a damping or restraining means or overrunning device to permit manual opening of the door, stopping of the door while the motor is operating and to function as a damping device to prevent slamming of the door. The motor includes a brake operable in response to energization of the motor so that the brake is always applied to hold the motor rotor stationary when no current is supplied to the motor.

The invention also includes limit switches responsive to rotary movement of a driven part of the power train and positively indicative of the position of the door for deenergizing the motor when the door reaches fully open and/or fully closed positions. The apparatus of the present invention comprises essentially an assembly of parts adapted for ready application to either single or double doors already installed or which may as readily be incorporated in new installations. The driving linkage connected to the motor includes an arrangement whereby the motor applies high opening force to the door at very low rates of movement when the door is at or near its fully open and fully closed positions and that same linkage inherently provides for the application of relatively low force at relative high rates of movement when the door is moving through intermediate portions of its total range.

It is therefore an object of this invention to provide a motor and linkage assembly adapted for use with either new or existing doors, whether they be single or double doors, for automatically opening and closing the same.

Another object of this invention is to provide such an assembly so designed as to permit manual opening of the door and holding the same in open position without operating the motor.

Still another object of this invention is to provide a door opening apparatus of the type set forth wherein temporary obstructions the door may encounter in its opening or closing movements will not cause damage to the mechanism or stalling of the motor.

A further object of this invention is to provide a motor driven door opening apparatus including a linkage assembly so arranged that the motor applies high forces to said door at low rates of movement at the start and end of its opening and closing movements and low actuating force at relatively high rate of movement during intermediate portions of the swinging movement of the door.

A still further object of this invention is to provide an apparatus of the type referred to including adjustable limit control means to deenergize the motor when the door reaches fully opened or fully closed position.

An additional object is to provide such an apparatus including a damping device to prevent slamming or overtravel of the door beyond its intended limits of movement.

Another additional object of this invention is to provide an apparatus attaining the above described objectives and which is simple in construction, economical to manufacture and reliable in operation.

Still other objects and advantages will become apparent to those skilled in the art as the description proceeds in connection with the accompanying drawings wherein:

Fig. 1 is a side elevational view of a motor device adaptable for use with all forms of the invention disclosed in subsequent figures.

Fig. 2 is a fragmentary sectional view on an enlarged scale taken substantially along the line 2—2 of Fig. 1.

Fig. 3 illustrates a simple embodiment of the invention wherein the motor is mounted on the hinged door.

Fig. 4 is a horizontal sectional view through an installation embodying a modified form of linkage from that shown in Fig. 3.

Fig. 5 is a view similar to Fig. 4 but showing the parts in different relative positions.

Fig. 6 is a view of apparatus corresponding to that of Fig. 3 but showing the motor mounted on the other side of the door from the side shown in Fig. 3.

Fig. 7 is a side elevational view of the installation shown in Fig. 6.

Fig. 8 is a view of apparatus like that of Fig. 3 but showing the motor mounted on the frame rather than on the door itself.

Fig. 9 is a horizontal sectional view through a door installation illustrating a further modified form of the invention arranged to open double doors.

Fig. 10 is a view of the apparatus of Fig. 9 but showing the parts in different relative positions.

Fig. 11 is a view similar to Fig. 9 but illustrating a further modification of the apparatus; and

Fig. 12 shows the apparatus of Fig. 11 with the parts in different relative positions.

Referring first to Figs. 1 and 2, which illustrate a motor device adapted for use with each of the modifications to be described herein, a motor housing 2 houses any suitable type of electric motor and is provided with a portion 4 having a speed reducing gear train (not shown) therein. The motor housing 2 is provided with a fitting 6 through which suitable electrical conductors 8 extend to energize the motor and other control elements to be described. An extension 10 of the motor housing 2 contains a brake arrangement (not shown), which may be of any desired or well know type, wherein a brake is applied to the motor rotor to stop and hold the same stationary when the motor itself is deenergized. The brake may be normally spring set and electromagnetically released upon energization of the motor or it may be normally spring released and electromagnetically applied when current to the motor coils is cut off, it being only necessary that a suitable automatically engageable and releasable brake be provided to operate as suggested above. The speed reducing gears in housing portion 4 drive an output shaft 12 extending outwardly of the housing 4. A driving friction member 14, having a facing of friction material 15 thereon, is keyed to the shaft 12 by means of a key 16 or the like whereby the member 14 is positively driven in rotation with the shaft 12 but is free for axial movement thereon. A driven clutch member 18 may be in the form of a hollow drum, as shown, having a hub 20 journalled on the shaft 12 and an outer peripheral

flange 22 radially spaced from the hub. A nut 23 threaded to the shaft 12 may be adjusted to regulate the pressure between the friction facing 15 and driven clutch member 18 to thereby regulate the maximum torque the shaft is capable of delivering to a linkage to be described. The driven clutch member 18 includes a radial crank arm 24 rigid therewith and constituting a driving crank for the apparatus. A bracket 26 is slideably adjustable on the radial crank arm 24 and is provided with a clamping screw 28 whereby it may be fixed in any selected position of adjustment along the crank arm. The bracket 26 is provided with a crank pin 30 for a purpose to be described hereinafter.

As previously stated, the driven clutch member 18 is preferably in the form of a hollow drum and overlies a pair of motor-control switches 32 and 34, each having a movable switch operating element 36 positioned adjacent the inner periphery of the flange 22. The flange 22 is provided with a pair of generally parallel circumferential slots 38 and 40 (see Fig. 1). A switch actuating member 42 is adjustable along the slot 38 and a similar switch actuating member 44 is adjustably mounted in the slot 40. A evident from Fig. 2, the switch actuating means 36 on the respective switches 32 and 34 are at different elevations whereby the switch 32 responds only to contact with the switch actuating member 42 whereas the member 44 is the only one that can actuate motor controlling switch 34. Preferably the switches 32 and 34 are positioned on generally opposite sides of the shaft 12 and the members 42 and 44 are positioned relatively close to each other so as to both be accessible for adjustment at the same time. The switches 32 and 34 are so arranged in the motor circuits that upon actuation of either switch by its corresponding member 42 or 44, a circuit carrying current to the motor will be opened and the motor thus deenergized. The adjustment and functioning of the motor control arrangement just described will be further described in greater detail later.

Referring now to Fig. 3, which shows a door 50 hingedly mounted, by means of suitable hinges 52, on a stationary frame 54, the motor housing 2 is securely mounted on the inner face of the door 50. A thrust link 56 is pivoted at one end thereof on a bracket 58 secured to the frame 54 and is pivoted at its other end to the crank pin 30 previously described. It is to be noted that with the door 50 in a closed position as shown in full lines in Fig. 3, the axis of shaft 12, the pivot axis of link 56 on bracket 58 and the axis of crank pin lie nearly in straight line relationship. It is preferred, however, that they do not assume a straight line relationship but that the axis of shaft 12 be offset laterally from a line joining the ends of link 56, as shown.

In the modification shown in Fig. 3 and in other modifications to be described hereafter, the means for initially energizing the motor 2 may be of any desired or known type. It is contemplated that the motor may be initially energized by a hand switch, by a photo cell, by sound waves, by an electric field, or by means of a contact carpet or contact step. Generally automatically operable doors are caused to open by mere proximity of a person to the door. Such proximity may cause the door to operate by virtue of interruption of a light beam, distortion of an electric field or by the actual physical closing of a switch by contact with the person or in response to the weight of the person approaching the door. Whatever means are employed to energize motor 2, the motor 2 commences operation in such manner as to rotate the crank arm 24 in a clockwise direction as seen in Fig. 3 at a substantially uniform rate. From the arrangement of the parts shown in full lines in Fig. 3 it will be evident that when the door is in closed position the initial rotation of the crank arm 24 and the relationship of that crank arm to the link 56 is such that a relatively high compressive force is applied to the link 56 with a resultant reactive force being applied to the door 50 but at a relatively low rate of movement to thereby facilitate acceleration of the door from a standstill. As the door swings to mid-open position the crank 24 assumes a position generally perpendicular to the link 56 at which time the force transmitted to link 56 is at a minimum but the rate of movement of the door is at a maximum. As the door approaches and reaches fully open position, as shown by dotted lines in Fig. 3, the crank pin 30 again approaches the straight line defined by a line joining the axis of shaft 12 and the pivotal mounting for the link 56 so that the rate of movement of the door decreases and the controlling force on link 56 increases to thus decelerate the door before it reaches fully open position even though the crank arm 24 rotates at a substantially uniform speed. This feature of the invention enables a relatively light inexpensive motor to be employed and yet be effective to operate a relatively heavy door.

It will be obvious that the switch actuating members 42 and 44 described in connection with Figs. 1 and 2 may readily be adjusted in their respective slots to deenergize the motor 2 when the door 50 reaches its closed position and to again deenergize the motor after the door has been swung to substantially its fully open position.

By virtue of the inclusion of the friction clutch shown in Fig. 2 in the motor drive, the door 50 may be manually pushed to fully open position without energizing or operating the motor. The friction clutch would merely slip under those conditions to permit the door to be pushed open. Upon swinging the door to fully open position, the friction clutch is effective to hold the door open. This is possible since any tendency of the door to close is resisted by the friction clutch and crank arm 24 and the motor itself since the motor rotor is held stationary by the brake previously described.

Referring now to Figs. 4 and 5, the motor 2 is considered identical to that previously described and is provided with the same crank arm 24 and driving shaft 12. The linkage connecting the crank pin 30 and bracket 58 is somewhat different in this modification. The first link 60 is pivotally mounted on the bracket 58 and is pivotally joined at its other end on an axis 62, to a connecting rod or link 64. The other end of the rod 64 is pivotally connected to the crank pin 30. The link 60 and rod 64 are provided with cooperating abutments 66 and 68, the latter of which may be adjustable, acting to limit pivotal movement of 64 relative to 60 in a counter clockwise direction as seen in Fig. 4. It will be apparent that rotation of the crank arm 24 in a clockwise direction will tend to swing rod 64 counter clockwise relative to link 60 but such movement is prevented by the abutments 66 and 68 so that the link and rod assembly acts as a single rigid member to transmit force from the crank pin 30 directly to the bracket 58 and thus cause the door to open to the dotted line position shown. Under those conditions the apparatus functions as if a single rigid straight link extended directly from the crank pin 30 to the bracket 58.

The link 60 and the rod 64 are each provided with outwardly directed ears 70 and 72 respectively. Each of the ears 70 and 72 forms an anchor for one end of a tension spring 74. The tension spring 74 is so arranged and pretensioned that its line of action extends to one side of the pivot axis 62 and the spring thus acts to normally hold the abutments 66 and 68 in engagement as shown in Fig. 4. It will be evident that, when the door is in the open position shown in dotted lines, reverse rotation of the motor 2 to effect closing of the door will tend to separate the abutments 66 and 68, but that tendency is resisted by the spring 74 and the spring itself transmits the necessary force to initiate closing movement of the door.

Fig. 5 illustrates the relative positions of the parts, after the door has been manually swung to open position without energizing the motor 2. By reference again to Fig. 4 it will be noted that the crank pin 30 lies quite close to the door 50 when the latter is closed as shown in full lines. As seen in Fig. 5, the crank pin 30 remains in the same

position relative to the door and motor since the crank has not been driven by the motor. Nevertheless, the door has been swung to full open position by virtue of the pivotal connection between link 60 and rod 64. To so manually open the door it was only necessary to overcome the tension of spring 74 and swing the link 60 and rod 64 relative to each other to the position shown in Fig. 5. It is to be noted that upon manual opening of the door 50 to the position shown in Fig. 5, the line of action of the spring 74 moved across the axis 62, by virtue of the lateral extension of the ears 70 and 72 and the spring 74 now tends to swing the abutments 66 and 68 away from each other. In other words, as shown in Fig. 5, the spring 74 has passed to an over-center position and functions to hold the door in the open position shown.

In Fig. 6, in which all parts of the apparatus may be identical to those shown in Fig. 3, the motor is shown as mounted on the outer side of the door 50 rather than on the inside thereof as shown in Fig. 3. The method of mounting the motor in Fig. 3 permits mounting the same at any position intermediate the top and bottom edge of the door 50. In the arrangement of Fig. 6 on the other hand, the motor must necessarily be mounted adjacent either the top or bottom edge of the door so that link 56 and/or crank 24 may extend across the plane of the door during the opening movement toward the bracket 58 mounted on the frame 54.

Fig. 7 illustrates the installation of Fig. 6 in side elevation and needs no further detailed description.

Fig. 8 again shows the apparatus of Fig. 3 but in an installation wherein the motor 2 is mounted directly on the frame 54 rather than on the door 50, and necessarily the bracket 58 is secured to the door rather than the frame. In all other respects the structure and operation of the type of installation shown in Fig. 8 are the same as that of Fig. 3.

Figs. 9 and 10 illustrate a different form of installation in which a single motor 2 and crank arm 24 are arranged and adapted to simultaneously open a pair of doors 80 hingedly mounted in an opening in frame 82. In this form of the invention a pair of connecting rods 84 and 86 are independently pivoted to the crank pin 30 and each connecting rod is pivotally connected at its outer end to corresponding and identical links 88. Each of the links 88 is pivotally mounted on a pin 90 mounted in fixed relation to the frame 82. A second link 92 is pivotally mounted on each pin 90 for pivotal movement thereon independently of the links 88. The links 88 and 92 of each pair are provided with cooperating abutments 94 and 96, respectively, to engage each other to limit relative pivotal movement of the links to the position shown in full line in Fig. 9. Of course the links are free to pivot relative to each other in a direction to separate their abutments 94 and 96. A spring 98 is provided for each pair of links 88 and 92 and acts to hold the abutments 94 and 96 in contact with each other. The line of action of each spring 98 is to the right of its associated pivot axis at 90 as seen in Fig. 9. Each of the links 92 is provided with a further abutment 100 positioned substantially diametrically opposite its abutment 96. Preferably the abutments 96 and 100 are made adjustable. The outer end of each of the links 92 is pivotally connected to a rod 102 which is in turn pivotally connected to its corresponding door 80 by means of a suitable bracket 104. As will be obvious from an inspection of Figs. 9 and 10, and particularly Fig. 10, rotary movement of the crank arm 24 from the position of Fig. 9 to the position of Fig. 10 in a counter clockwise direction transmits movement to the links 88 through connecting rods 84 and 86. The forces transmitted to the links 88 are in such direction that they firmly press abutments 94 and 96 together and act through links 88 and abutments 94 and 96 and links 92 to apply compression forces to links 102 and thereby open the doors 80 to the positions shown in Fig. 10. When the doors reach the open position the motor control switches

32 and 34, previously described, are actuated to stop rotation of the motor.

As shown by the dotted line in Fig. 9, either door 80 may be manually swung to open position by overcoming the force of its spring 98 upon swinging link 92 about pin 90. The abutment 100 on link 92 engages the rear side of abutment 94 of link 88 to limit the manual opening movement of the door. It is also to be noted that the line of action of spring 98 moves across the axis of pin 90 to hold the door 80 in open position.

In the modification shown in Fig. 11 the motor 2 is the same as that described herebefore but the crank means comprises a driven clutch member 18 having a pair of diametrically opposed crank arms 24 and 25 thereon. The crank arm 24 is provided with a crank pin 30 as previously described and crank arm 25 is provided with a crank pin 31 similar to the crank pin 30. The connecting rods 84 and 86 correspond to the connecting rods bearing the same reference numerals in Fig. 9 and are respectively connected to links 88 which may be identical to those described in the previous embodiment. The links 88 and 92 of this embodiment are identical in construction to those previously described and are also provided with springs 98 in the same relationship. The modification of Fig. 11 differs from that of Fig. 9 further in that the pins 90 upon which links 88 and 92 are mounted constitute the hings pins for the doors 80. In other words, the common axis about which links 88 and 92 may independently rotate is coincident with the hinge axis of the doors. This form of device eliminates links 102 of the previous embodiment since the links 92 herein are rigidly fixed to the doors 80 by any suitable means. It will be noted that the motor 2 and operating linkage is positioned on the outside of the doors 80, whereas in Fig. 9 the motor and linkage arrangement are on the inside. In other respects the two modifications are similar except that the frame 82 of Fig. 11 is provided with recesses 110 to provide clearance for the links 92 when the doors 80 are moved to open position. It will be obvious that either of the doors 80 of Fig. 11 may be manually opened without actuating the motor 2, and the links 88 and 92 respond thereto and function in exactly the same manner as described in connection with Fig. 9.

Fig. 12 shows the mechanism of Fig. 11 after the motor 2 has been operated to open the doors 80. It will be noted that the motor in this modification drives the shaft 12 in a clockwise direction to effect opening of the doors whereas the shaft 12 of the Fig. 9 form is rotated in a counter clockwise direction.

Although a number of specific embodiments of the invention have been shown and described herein it is to be noted that the essential features of the invention are present in all modifications. In each form the motor and crank structure along with the motor control switches 32 and 34 is essentially the same and is as described in connection with Figs. 1 and 2. In each case a suitable motor brake is provided and the motor drives its crank structure through an adjustable pressure friction clutch. In each form the crank pin or pins are so positioned, when the door or doors are closed, that the link or connecting rod driven thereby transmits force from the crank pin in a direction extending closely adjacent the motor shaft 12 to thus provide an arrangement wherein high torque or forces are transmitted to the linkage at a low rate of movement during the initial portion of the door opening cycle and at the end thereof, whereas the intermediate portion of the cycle is accomplished by applying relatively light forces to the door at a relatively high rate of movement. In all forms shown the door may be manually opened in the event of power failure or for any other reason, without operating or energizing the driven motor and is held in open position.

By providing radially adjustable crank pins, as described, and by properly selecting the point of securement

of the door operating link relative to the door hinge, each installation can be made and adjusted so that a complete cycle of operation requires crank arm movement of less than 180° within a range such that the parts never assume a "dead center" relationship.

It is to be noted that if and when friction clutch slippage occurs, in all modifications described, during a motor operating cycle, no effect is produced in or by the switches **32** and **34** because operation of those switches is dependent only upon actual door position.

Obviously the particular control employed to initiate operation of the motor to open the doors must energize the motor independently of the switches **32** and **34**. Thus the switches **32** and **34** may be arranged in "holding" circuits closed by initial energization of the motor.

Closing of the doors described may be effected in any desirable manner. For instance, any suitable time-controlled switch may be employed to energize the motor for reverse rotation a predetermined length of time after it reaches fully opened position. On the other hand, the door closing cycle could be initiated by means similar to those employed to initiate door opening.

It is to be further noted that, in the forms shown in Figs. 4, 9 and 11, after a door has been manually opened, subsequent operation of the motor through a full cycle in a door opening direction is necessary to effect automatic closing of the thus manually opened door. Obviously, however, a manually opened door may thereafter be manually closed without operating the motor.

In the forms shown in Figs. 3, 6 and 8 the motor control circuits may be so arranged that a manually opened door is immediately conditioned for automatic closing (provided there is no power failure) or those circuits may be so arranged that manual opening of the door renders all motor controls inoperative until after the door has been manually returned to closed position.

The modifications illustrated herein are merely illustrative of the invention which is not to be limited thereto but which encompasses other modifications falling within the scope of the appended claims.

We claim:

1. In apparatus for opening and closing a door hingedly mounted on a frame, an electric motor device having a housing, a linkage device and means drivingly connecting said linkage device to said motor device, one of said devices being secured to said door and the other device being secured to said frame, said means drivingly connecting said motor to said linkage device including a hollow rotary member driven by said motor, a pair of motor deenergizing switches on said housing and within said rotary member, switch actuating elements carried by said rotary member and projecting inwardly thereof, and independent means, accessible from outside said rotary member, mounting said elements on said member for angular adjustment there-around whereby said elements may be adjusted to deenergize said motor when said door reaches predetermined selected positions during its opening and closing movements.

2. Apparatus as defined in claim 1 including means for restraining continued movement of said door after deenergization of said motor.

3. Apparatus as defined in claim 1 wherein said rotary member comprises the driven member of a friction clutch.

4. Apparatus as defined in claim 1 wherein said hollow rotary member is an open cup-shaped member arranged with its open side facing said housing, at least one circumferential slot through the side wall of said member, one of said independent means being adjustable along said slot.

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