July 22, 1969 R. G. HANSON ET AL 3,456,388

BALANCED DOOR HANGER AND CLOSURE

Filed Dec. 6, 1966 3 Sheets-Sheet 1

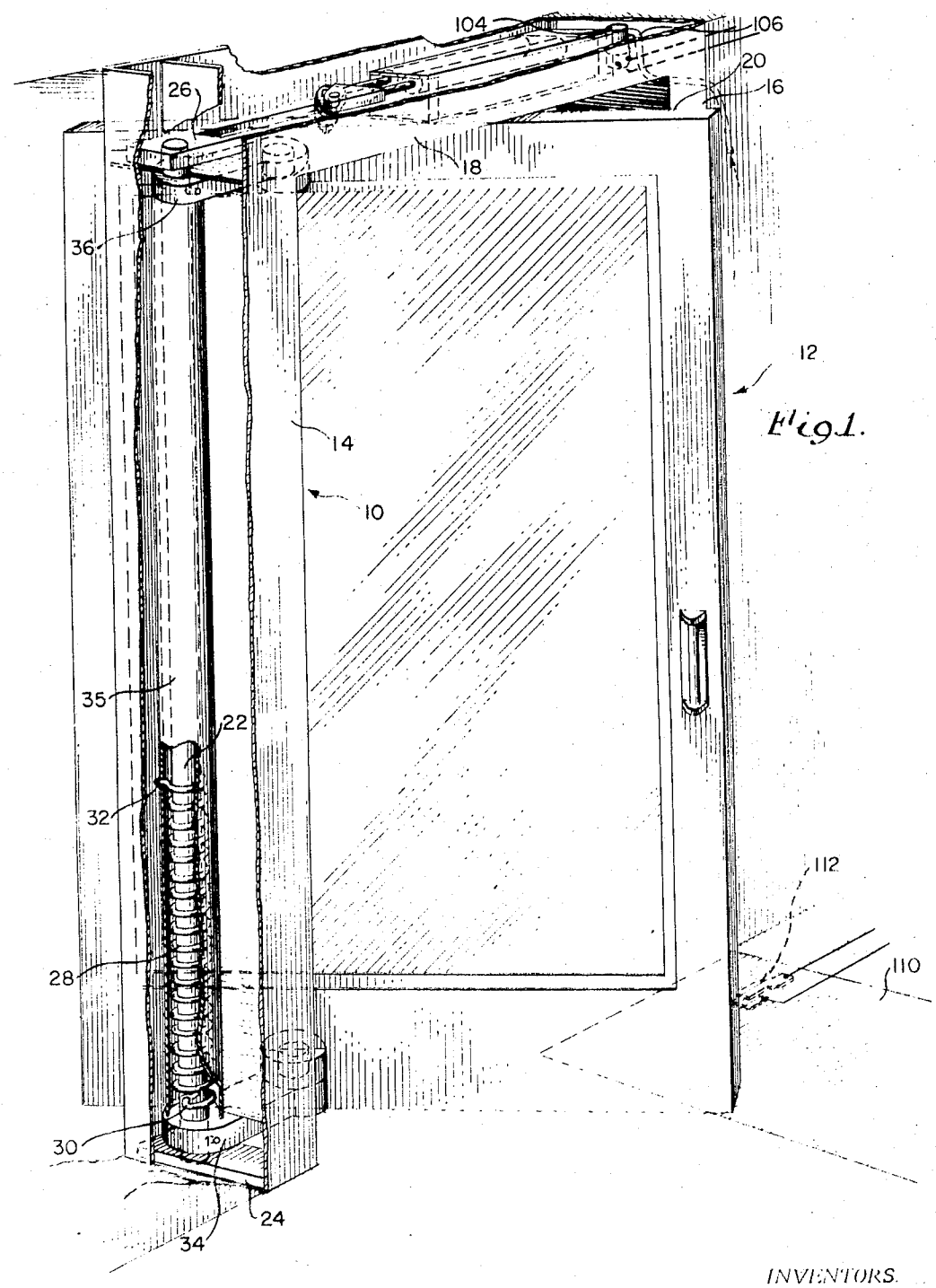


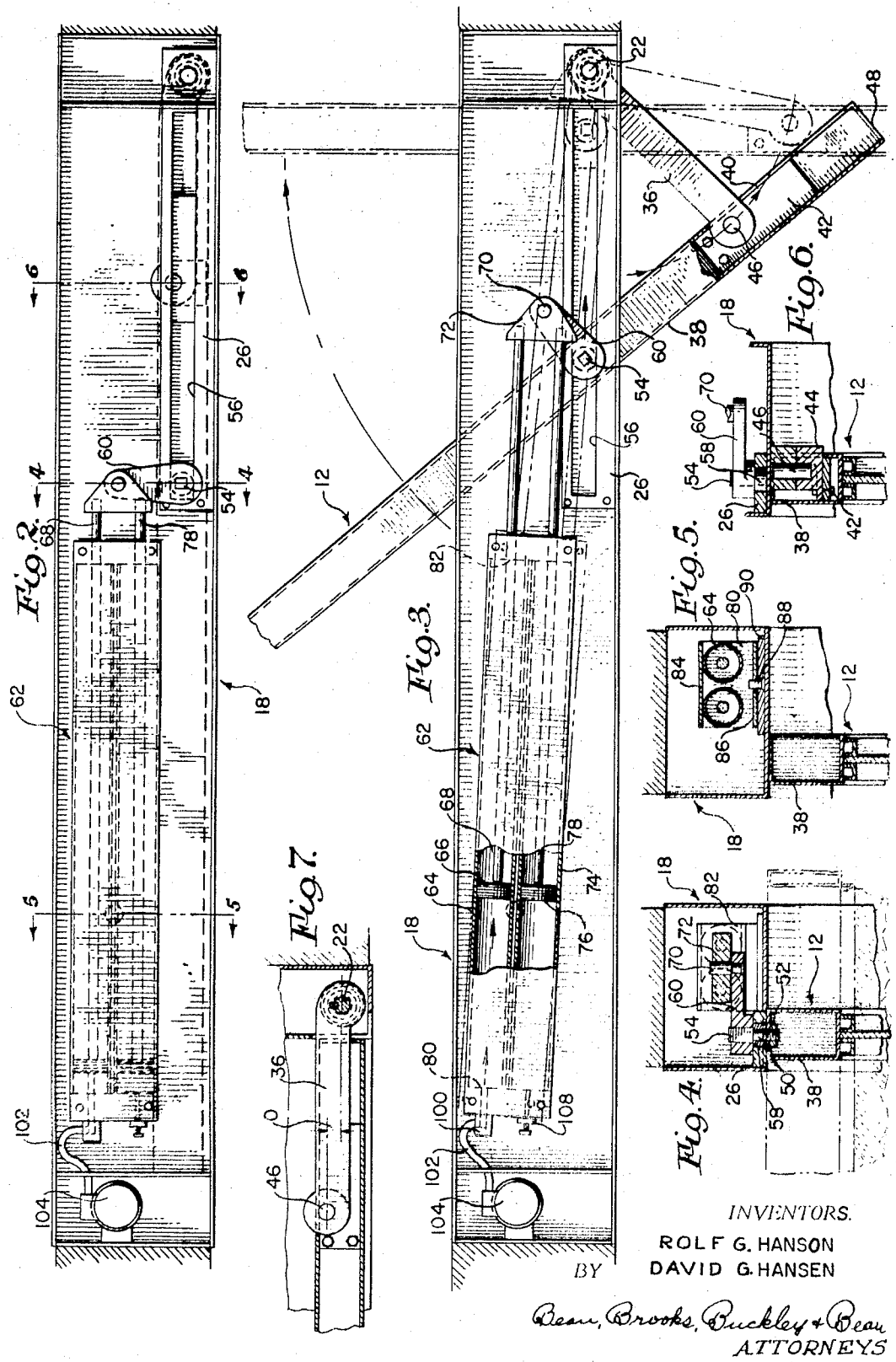
Fig 1.

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BALANCED DOOR HANGER AND CLOSURE

Filed Dec. 6, 1966 3 Sheets-Sheet 2



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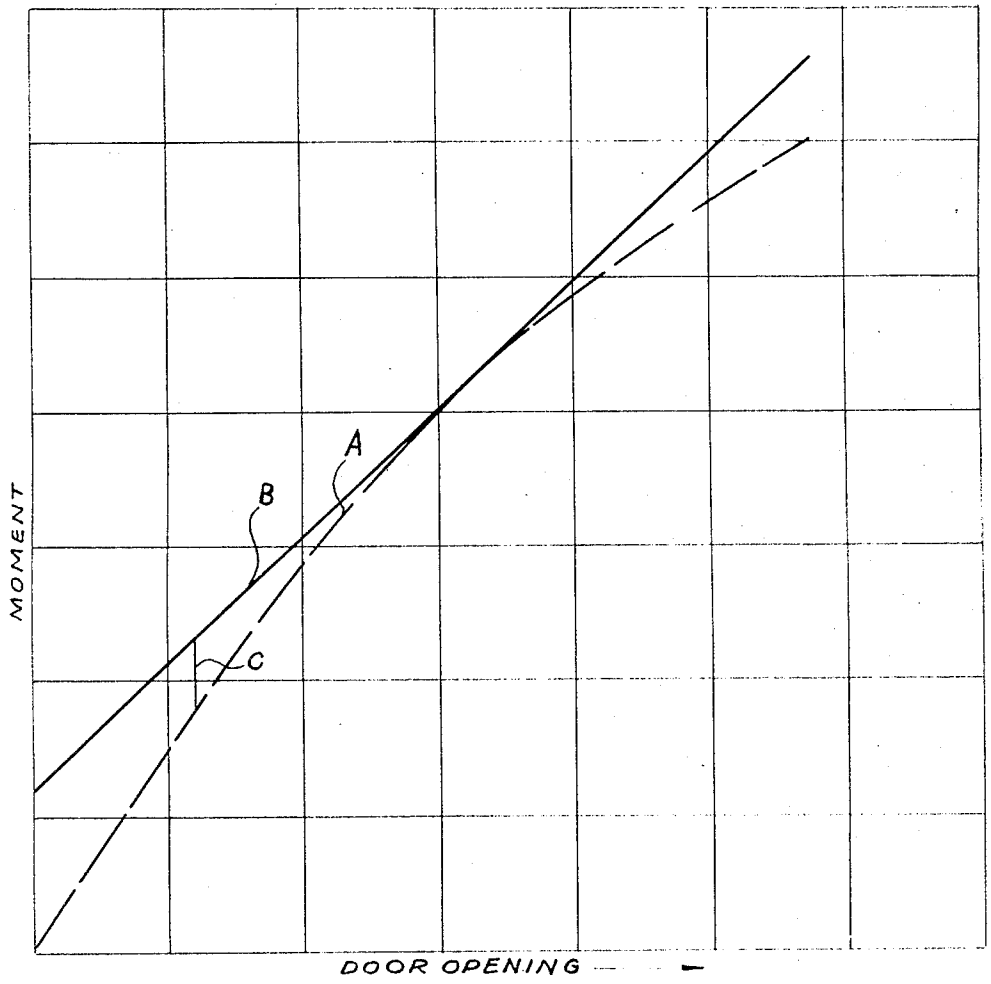
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BALANCED DOOR HANGER AND CLOSURE

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Fig. 8.



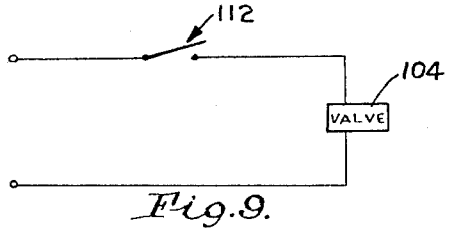


Fig. 9.

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BALANCED DOOR HANGER AND CLOSURE

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Int. Cl. E05d 15/30, 15/42, 15/44
U.S. Cl. 49—252 1 Claim

ABSTRACT OF THE DISCLOSURE

A swinging door having a return spring and a pneumatic check device. The check device is so arranged that it very nearly completely cancels the return spring action at any position of the door. In this way, very little effort is required to move the door open but at the same time, it is positively held in closed position against disturbances such as wind. A pneumatic power actuator may also be employed which, like the check device, very closely approximates the return spring force throughout the movement of the door.

Brief summary and background of the invention

By the term "balanced door" as used herein is meant a door mounted by hinge arms and constrained by guide means movable in a rectilinear path so that, as the door is opened, that part of the door adjacent the hinge arms swings inwardly while the other part swings outwardly, there being spring return means to urge the door normally to closed position. Such an arrangement is entirely conventional and is well known materially to reduce the effort required to open the door. Consequently, balanced doors have come into wide usage particularly in public buildings where the requirement for massive exterior doors is encountered. It is also conventional to employ check means in a balanced door assembly to control the rate of closing movement of the door under the action of the spring return means. Ideally, the checking action would be tailored closely to the characteristics of the spring return means so that as the closing force exerted by the spring return means diminishes, the checking action would also diminish but not disappear during the terminal closing motion of the door. In this way, a positive and sure closing action would be permitted and the return spring would need only to be adjusted to exert that force necessary to retain the door closed against extraneous forces such as drafts or pressure differentials existing between the interior of a building and outside atmosphere as may be caused by ambient wind conditions.

It is, therefore, of primary concern in connection with this invention to provide an improved form of check or damping control arrangement for balanced doors.

It is also of primary concern to provide actuator means in conjunction with a balanced door which is effective either to open or to assist in opening the door when desired.

Generally speaking, it is an object of this invention to apply a checking and/or an actuating force in a balanced door assembly directly to the door at that point thereof which is guided for rectilinear movement. Insofar as checking action is concerned, this arrangement allows the aforesaid ideal checking action to be realized. Specifically, the checking action will vary generally in accord with the force exerted by the spring return means, and at the same time a small but finite checking action is obtained during the terminal closing motion of the door by the simple expedient of providing offset between the hinge axis and the path of movement of the guide means. Insofar as both checking action and the actuating force are concerned, said arrangement materially reduces the forces required in each case so that the fluid pressures encountered when using fluid pressure-operated devices for these tasks is relatively low. This latter, in addition to reducing power requirements also places less stress upon any seals used and further allows greater sensitivity of adjustment for the actuator.

More specifically, it is of concern in connection with this invention to provide an actuator arm in association with the balanced door guide member so that the power assist mechanism for opening or aiding in the opening of the door and/or checking or damping mechanism controlling closing movement of the door operates directly in conjunction with the guide mechanism.

A further object of this invention resides in the provision of a balanced door as aforesaid in which the entire actuating and/or check mechanism is conventionally housed within the frame structure for the door.

Still another object of this invention concerns the provision in a balanced door assembly, of a combined actuator and dashpot assembly mounted within the transom of the door frame structure and operating in conjunction with an actuating arm associated with rectilinear guide mechanism for constraining the pivotal motion of the door.

A still further object of this invention resides in the provision of a balanced door, as aforesaid, wherein the hinge arms are offset with respect to the centerline of the guide slot and, in association therewith, a dashpot operating upon an actuating arm associated with the guide member moving in such slot whereby dashpot action is practically non-existent or is at least substantially diminished at regions very near the closed position of the door so as to allow positive and sure terminal closing action of the door.

Other objects and advantages of the invention will be apparent from the following specifications and the accompanying drawing, wherein:

FIG. 1 is a perspective view partly broken away showing the door assembly constructed in accordance with the present invention and illustrating the door in partly opened postition;

FIG. 2 is a top plan view of the door frame assembly as shown in FIGURE 1;

FIG. 3 is a view similar to FIGURE 2 but illustrating the door in partly opened position in full lines and in fully opened position in phantom lines;

FIG. 4 is a vertical transverse section taken substantially along the plane of section line 4—4 in FIGURE 2 illustrating the guide mechanism and actuating arm;

FIG. 5 is a transverse section taken substantially along the plane of section line 5—5 in FIGURE 2 illustrating the mount for the power assist and dashpot assembly;

FIG. 6 is a transverse section taken along the plane of section line 6—6 in FIGURE 2 illustrating the hinge arm mounting;

FIG. 7 is a sectional view illustrating one of the hinge arms and showing the offset relative to the fixed pivot axis thereof;

FIG. 8 is a graph showing certain principles of the present invention; and

FIG. 9 is a schematic diagram illustrating the relationship of certain of the circuit components involved with the power mechanisms.

With reference now more particularly to FIGURE 1, the door assembly illustrated therein will be seen to consist essentially of a door frame structure indicated generally by the reference character **10** and an associated door indicated generally by the reference character **12**. The frame **10** includes a pair of uprights **14** and **16** disposed in horizontally spaced relationship and intercon-

nected by a transom **18**. The door itself may take any conventional form, it being appreciated that the opposite side edges of the door are disposed in close adjacency to the uprights **14** and **16** when the door is closed and with the top edge **20** of the door being disposed immediately below the transom **18** when in such position.

The two uprights **14** and **16** are preferably of hollow columnar form substantially as is shown for the upright **14** in FIGURE 1, being suitably fabricated from metal or the like. The upright **14** houses a vertical pivot rod **22** journaled at its lower end in a suitable foot plate **24** and at its upper end in a transom plate **26** hereinafter more particularly described. A coiled torsion spring **28** is disposed about the bar **22** and has one end **30** thereof anchored to the pivot bar **22** whereas the opposite end **32** is anchored to a tube **35** which extends concentrically of the pivot bar **22** and which is secured to the upright **14**. A pair of hinge arms **34** and **36** are pinned or otherwise removably affixed to the pivot bar **22** adjacent opposite ends thereof.

It will be seen, then, the rotation of the hinge arms **34** and **36** will carry the pivot bar **22** therewith so that the torsion spring **28** will resist such pivotal motion of the hinge arms. The free ends of the hinge arms **34** and **36** are pivotally connected to the door assembly **12** adjacent the bottom and top edges respectively thereof. In the particular construction shown, as will be seen more particularly by reference to FIGURES 3 and 6, the door includes a top frame member **38** of rectangular tubular form having an opening **40** in the forward side of the door and extending through the corner portion thereof as can be seen most clearly in FIGURE 3, there being a suitable mounting plate **42** fixed within the frame member **38** and which mounts a boss member **44** carrying a pin **46** by means of which the free end of the hinge arm **36** is pivotally attached to the door assembly. A similar construction prevails for the lower hinge arm **34** and its connection to the door **12**, it being appreciated that the vertical hinge axis established between the arms **34** and **36** and the door **12** is offset from the side edge **48** of the door substantially as is shown in FIGURE 3.

As can be best seen in FIGURE 4, the top frame member **38** of the door mounts a guide in upstanding relation to the top edge of the door. This guide may take the form of a stud **50** projecting through the top of the frame member **38** and secured thereto as by a nut **52**, the stud having a rectangular upper end portion **54**, see particularly FIGURE 3. The stud **50** extends through the transom plate **26**, such transom plate being provided with an elongate guide slot **56**, see particularly FIGURES 2 and 3, and a bushing or roller **58** is rotatably mounted on the stud **50** so that the guide is captive within the guide slot **56** and moves in rectilinear fashion therewithin to thus constrain the pivotal motion of the door. A partly opened position of the door is illustrated in full lines in FIGURE 3 whereas a fully opened position thereof is indicated by the phantom lines therein.

The upper end **54** of the stud **50** carries an actuating arm **60** which extends generally at right angles to the plane of the door in the direction of door opening movement, substantially as is shown. A combined actuator and dashpot assembly indicated generally by the reference character **62** is adapted to coact with the actuator arm **60** to control opening and closing movements of the door as hereinafter more particularly specified. The assembly **62** includes an actuating cylinder **64**, see particularly FIGURES 3 and 5, within which an actuator piston **66** is received, such piston having a rod **68** connected thereto and which projects from the cylinder for pivotal connection with the free end of the actuator arm at **70** through the medium of the connector head member **72**. The assembly **62** also includes a dashpot cylinder **74** having a piston **76** associated therewith, which piston is provided with a rod **78** also connected to the head member **72** substantially as is shown in FIGURE 3. The cylinders **64** and **74** are mounted between end plate members **80** and **82** to which the top and bottom housing plates **84** and **86** are attached. The entire assembly **62** is pivotally mounted to the transom assembly by means of the vertical stub shaft **88** carried by the base plate **90** fixed to the transom assembly **18** substantially as is shown in FIGURE 5.

The cylinder **64** is provided with an inlet connection **100** by means of which compressed air or other pressurized fluid is introduced into the interior of the cylinder by means of the conduit **102** extending to a suitable solenoid valve **104** which is connected, as by conduit **106** (FIGURE 1), to a suitable pressurized fluid source not shown. The solenoid valve **104** is operative to connect the cylinder **64** to the source of pressure through the conduit **106** and **102** but the normal position of the valve vents the cylinder **64**. Whereas the cylinder **64** is open or at least vented at its piston rod end, the other cylinder **74** is preferably closed at both ends. In this respect, it is preferred that the cylinder **74** and its piston be constructed as a hydraulic shock absorber employing the principles of the so-called tubular type of automotive shock absorber. In the present case, it is preferred that the internal valve construction is such that substantially the same checking action is obtained in both directions of movement so that the same damping or rate-responsive resistance to movement occurs in the door opening as well as the door closing direction. The check device may, however, be provided with an external control **108** so as to adjust the resistance exerted by the device. External control means (not shown) is provided to adjust the pressure of the fluid introduced to the cylinder **64** through the conduit **102**, it being understood that the pressure may be such either merely to assist in door opening movement or to actually effect door opening movement without the requirement of external force being applied to the door. The solenoid valve **104** may be controlled in any suitable fashion, as for example photoelectric cell devices or the like, but for the purpose of clarity, as shown FIGURE 1, a suitable mat device **110** is provided beneath which a switch **112** is disposed so that when a person nears the doorway, the power assist mechanism will come into play. Such switch mechanism or its equivalent, of course, would normally be provided on both sides of the door. To clarify this point, the diagram of FIG. 9 is included herein. In this figure it will be apparent that the switch **112**, whatever form it may take, operates when closed to control the valve **104** to pressurize the cylinder **64**. The valve **104** will vent the cylinder **64** when the switch **112** is opened.

One of the most significant aspects of the present invention involves the point at which the door control is applied. It will be appreciated that the return spring **28** exerts a moment upon the arms **34** and **36** which is directly proportional to the angle through which the arms have been swung by the door. This moment, then, is linear and its magnitude at any instant is dependent upon the angle of the arms, as aforesaid, the rate or spring constant of the spring **28**, and the amount of preload on the spring when the door is closed (some preload is essential at any rate and it may be desirable to provide means for varying the preload to accommodate variations in wind load, etc.). The force exerted by the piston **66** in cylinder **64** is, on the other hand, substantially constant, i.e., is equal to the pneumatic pressure times the area of piston **66**. However, since the constant force exerted by the piston **66** is acting on the linkage system at the sliding guide means **50**, it produces a moment on the arms **34**, **36** which is nearly linear and which, like the moment produced by the return spring **28**, is essentially proportional to the angle of the arms **34**, **36**. As a consequence, the action of the return spring **28** and of the power mechanism **64**, **66** may be very closely matched at any position of the door. This is illustrated in FIGURE 8 wherein the lines A and B respectively indicate the moments produced by the actuating mechanism and by the return spring. In the particular case shown, the power actuating mechanism is adjusted

(as by the presence of air applied to cylinder **64**) so that the user must exert some force to open the door, the magnitude of which is the difference between the lines A and B as indicated for example by line C. Conversely, the door if freed cannot exert any substantial "bump" from behind upon a person passing through the doorway.

Still further, the coordination of the control mechanism with the guide means, as aforesaid, permits relatively low pressures to be used in the cylinder **64** even when the control is set to automatically open the door without assistance from the user (line A shifted above line B in FIGURE 8).

Insofar as the door checking action is concerned, it will be appreciated that the piston and cylinder arrangement **74, 76** exerts a restraining force proportional to the rate of movement of the guide means **50**. It will also be appreciated that, given a fixed rate of angular movement of the arms **34, 36**, the rate of movement of the guide means **50** decreases as the door is closing. This in itself is desirable since it is advantageous to more or less match the checking action with the force or moment exerted by the door spring. However, the rate of movement of the guide means during the last inch or so of door closing movement tends to be very small.

As a result, the checking action right at the jamb is normally practically nil so that the spring device must be preloaded a substantial amount to prevent annoying oscillations of the door at closed position. However, according to this invention, the checking action during this terminal movement of the door is increased by reversing the motion of the guide means **50** during this terminal movement so that rate of movement of the tip of the arm **60** will be greater at the instant of closing than it otherwise would be. This is achieved by providing an offset disposition of the pins **46**, or more particularly of the pivot axis established between the arms **34** and **36** and the door **12**, with respect to the stud **50** of the guide member. Such offset is shown in FIGURE 7, it being appreciated that the guide slot **56** may, if desired, be disposed such that the path of rectilinear movement of the guide stud **50** intersects the center of the hinge bar **22**. Such a relationship is shown in FIGURE 7 and the net offset as aforesaid is indicated at **0** in FIGURE 7. The purpose of this construction is to cause reverse movement of the guide stud **50** just before the instant the door is closed so that the later instant of door closing will witness an increased rate of movement of the tip of the actuating arm **60** so that a small but significant damping effect is present at the terminus of the door closing movement.

While the unit shown includes a power actuator, it is obvious that the power cylinder and associated mechanisms can be dispensed with, but retaining the dashpot cylinder and its piston and rod connected to the actuator arm to check and control the closing operation of the door. In the latter case, the door would be pulled open by the conventional handle.

It is also clear that the door can be fully powered to open, or that the power controls can be arranged so that on manually pulling on the door handle, a switch is operated to activate the power unit and either complete the opening of the door or furnish partial power as an assist to manual opening of the door.

We claim:

1. A door assembly comprising in combination, a frame structure including a pair of spaced uprights and a transom, a door normally disposed in closing relation to the opening defined by said frame structure with opposite side edges and top edge of the door closely adjacent to the respective uprights and transom, a bar provided within one of said uprights and defining a vertical pivot axis, a coil spring surrounding said bar with one end thereof fixed to said one upright and its other end fixed to said bar to normally urge said door to its closed position, a pair of hinge arms connected at one end to said bar and having their opposite ends pivotally connected to said door on a vertical hinge axis parallel to that side edge of the door normally adjacent said one upright but offset therefrom toward the other side edge of the door, said hinge axis including hinge pins, guide means in said transom including an elongated guide slot extending longitudinally in the transom, an upstandign guide stud mounted on the top edge of said door at a point offset from said vertical hinge axis toward said other side edge of the door, said guide stud being received in said guide slot for constraining the door to follow a fixed path in moving between its normally closed position and an open position with respect to said frame structure, an actuator and checking assembly comprising two parallel piston rods fixedly connected to a connector head member, said head member being pivotally with respect to the plane of the door in the direction guide stud in such manner as to permit pivotal movement of said actuator arm around its pivotal connection to the head member, means pivotally mounting said actuator and checking assembly on the base of said transom so as to permit the longitudinal axis of said assembly to describe an arcuate motion intersecting the center line of said guide slot, said actuator arm being fixed to said door through said guide stud and projecting from the guide stud laterally with respect to the plane of the door in the direction of its opening movement, said guide stud cooperating with said actuator arm and with the pivotal connection of the latter to said head member so that during initial increments of the door opening movement the door pivots around the guide stud only, said piston rods and said actuator arm cooperating with said guide slot and with said pivotal connection of the actuator arm to said head member so that after the initial opening movement the door pivots around said hinge axis and said pivot axis and said guide stud while gliding along said guide slot toward its fully open position, and damping means opposing the door closing force exerted by said coil spring in the final closing movement of the door comprising an offset disposition of said vertical hinge axis to that side of a straight horizontal line between said vertical pivot axis and said guide stud which side lies in the direction of the door opening movement when the door is closed, so that the hinge axis crosses said straight line from one side to the other to impart a reverse movement to said guide stud and an increased rate of movement to the pivoted end of said actuator arm and connector head number just before the door is fully closed for obtaining an effective damping action at that moment.

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U.S. Cl. X.R.

49—386