United States Patent [19]

Hewitt

[11] **3,864,875**

[45] **Feb. 11, 1975**

[54] **SWING DOOR OPERATOR**

[75] Inventor: **Lew V. Hewitt,** Corpus Christi, Tex.

[73] Assignee: **Overhead Door Corporation,** Dallas, Tex.

[22] Filed: **Apr. 16, 1973**

[21] Appl. No.: **351,460**

[52] **U.S. Cl.** **49/115,** 49/264, 49/334, 49/340, 49/360

[51] **Int. Cl.** **E05f 17/00,** E05f 15/04

[58] **Field of Search** 49/115, 264, 334, 340, 49/360, 138, 139, 141

[56] **References Cited**

UNITED STATES PATENTS

2,458,402	1/1949	Myers	49/360 X
2,874,960	2/1959	Durbin et al.	49/334 X
2,893,725	7/1959	Katz	49/334 X
3,003,317	10/1961	Schroeder et al.	49/264 X
3,067,993	12/1962	Stretton	49/264 X
3,284,950	11/1966	Gute	49/340 X

FOREIGN PATENTS OR APPLICATIONS

836,429	6/1960	Great Britain	49/115

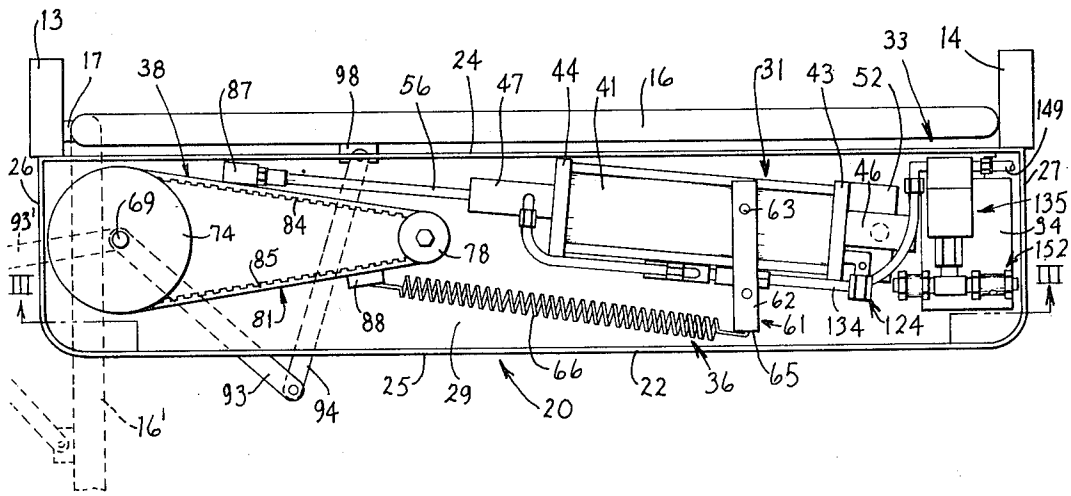
Primary Examiner—J. Karl Bell

Attorney, Agent, or Firm—Woodhams, Blanchard & Flynn

[57] **ABSTRACT**

A door operator for a door movable between open and closed positions. The operator includes an endless loop member supported for reversible orbital motion by a pair of spaced rotatable members. A linkage couples one rotatable member to the door. A pressure fluid cylinder has a piston rod connected to one reach of the endless loop member and is actuable in one direction for moving the endless loop member to open the door. Resilient tension return means are coupled to the other reach of the endless loop member and are responsive to cessation of actuation of the pressure fluid cylinder for causing the endless loop member to close the door. The pressure fluid cylinder includes means for decelerating door motion as the door approaches its open and closed positions, including enlarged cam portions on the piston rod thereof cooperating with valved pressure fluid inlet and outlet openings. A control circuit having a variable time delay responds to actuation of actuation and safety switches, by persons using the door, for controlling pressure fluid flow to the cylinder. By appropriate installation, the operator is usable with either right- or left-hand hinged doors and doors which open either inwardly or outwardly. A modified operator substitutes a direct drive connection for the linkage. Other modified operators are usable with sliding doors and with double swinging doors.

26 Claims, 15 Drawing Figures



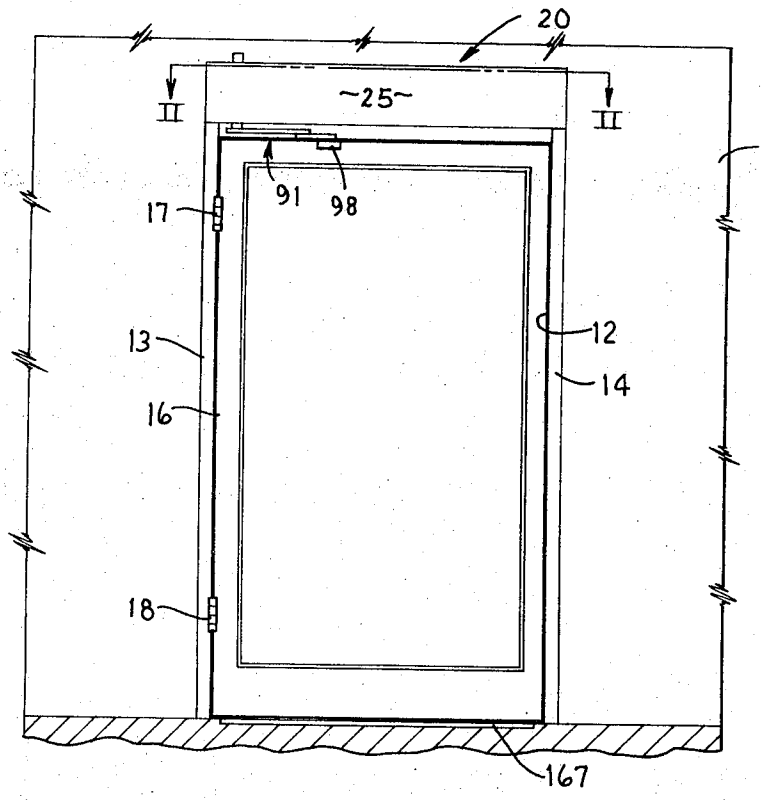


Fig.1

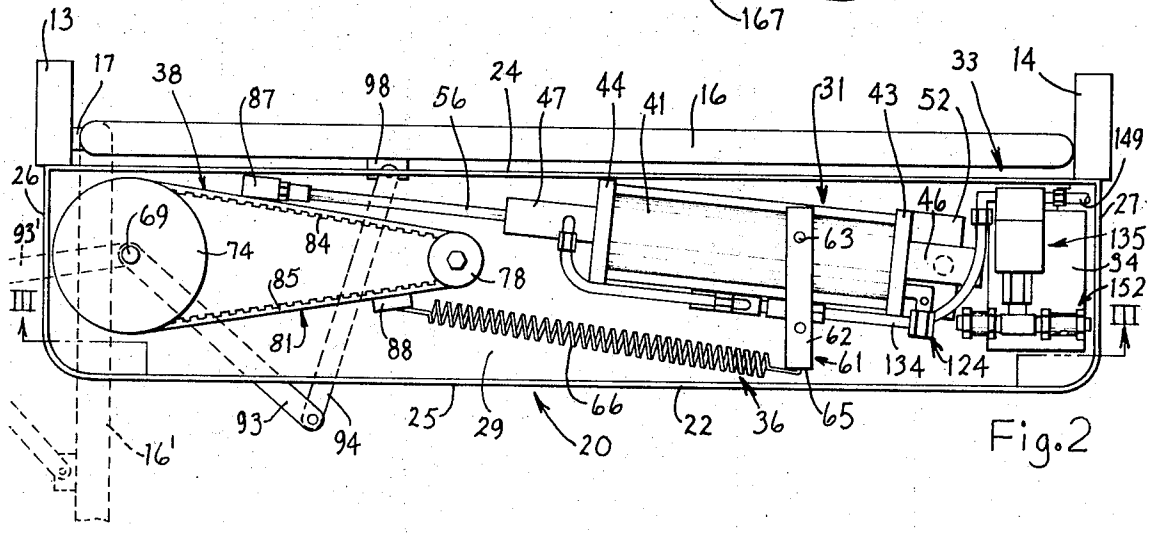


Fig.2

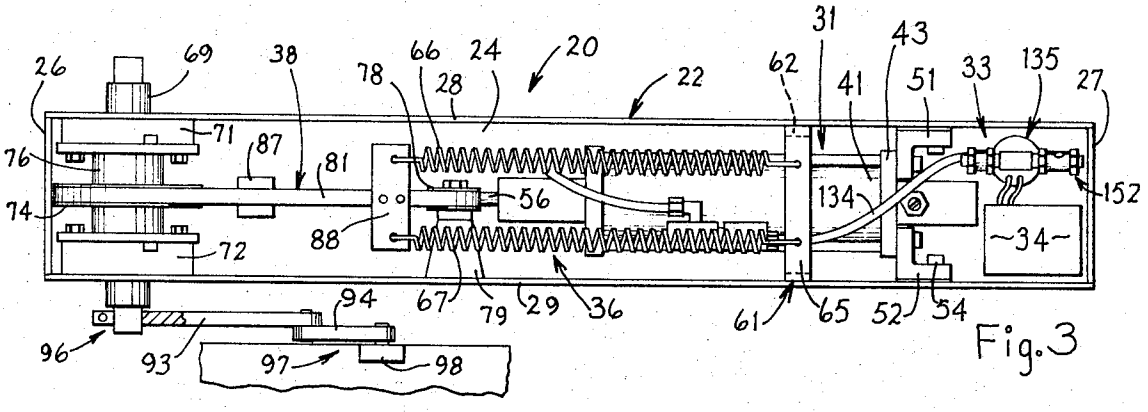


Fig.3

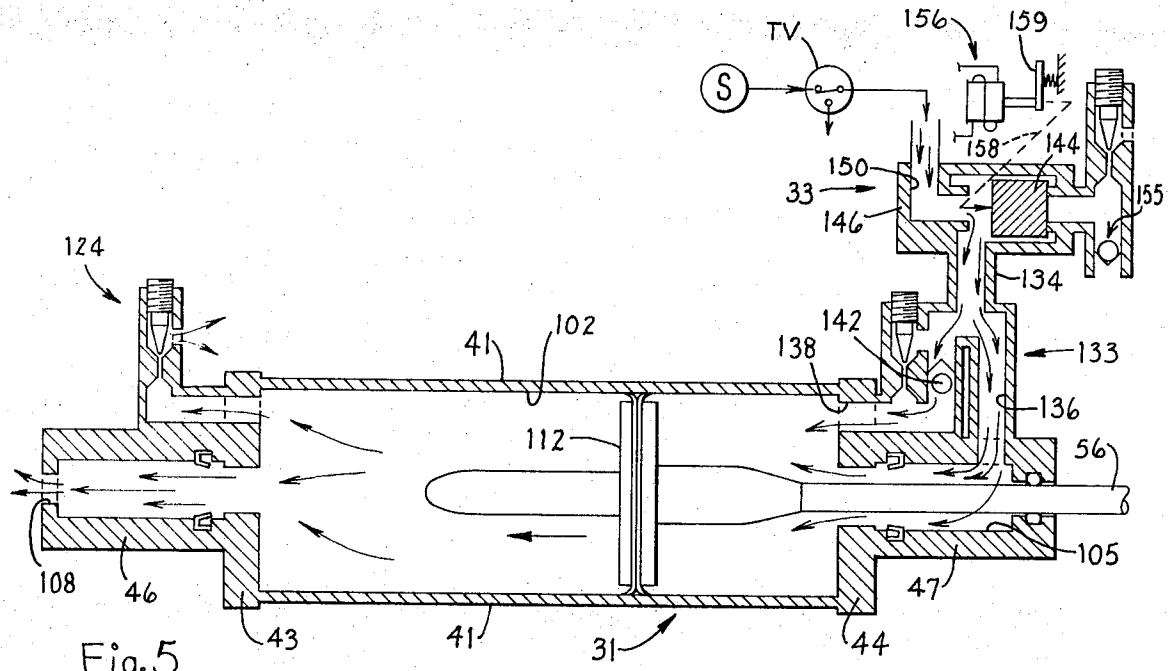

TV
S
156
159
158
144
150
33
146
155
124
134
142
138
133
41
102
136
112
56
105
108
46
47
43
41
31
44

Fig.5

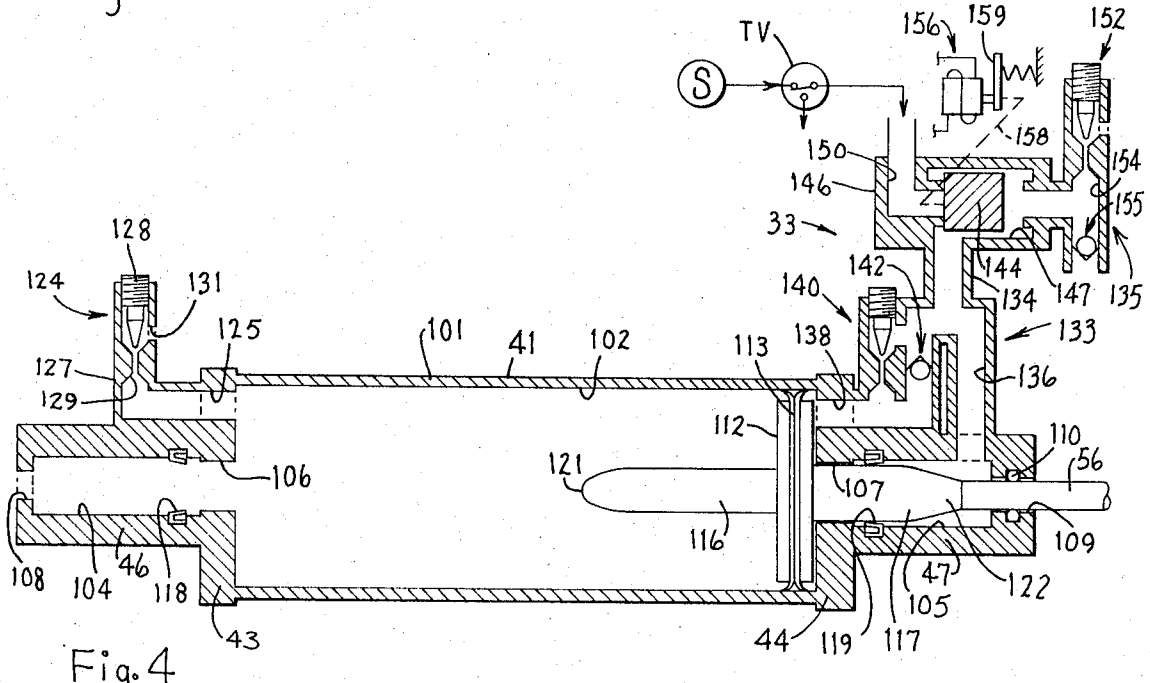

TV
S
156
159
152
158
150
154
146
155
33
144
147
135
142
140
134
133
124
131
128
125
101
41
102
113
138
136
127
129
112
110
121
56
107
106
116
109
108
104
46
118
47
105
122
43
44
119
117

Fig.4

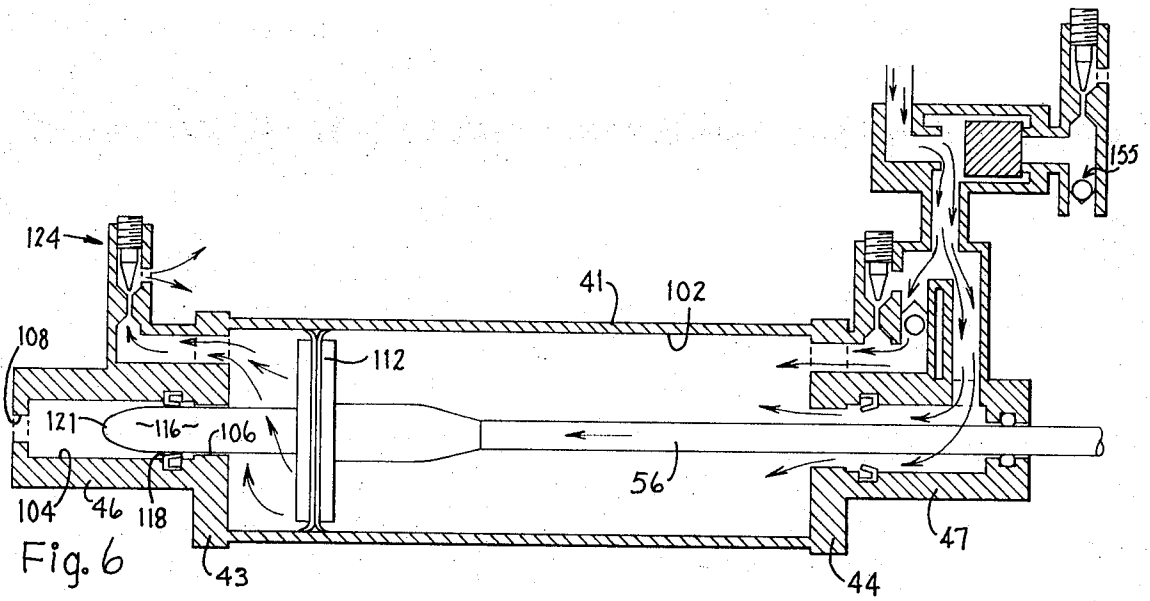

124
155
41
102
108
112
121
116
106
56
104
46
118
47
43
44

Fig. 6

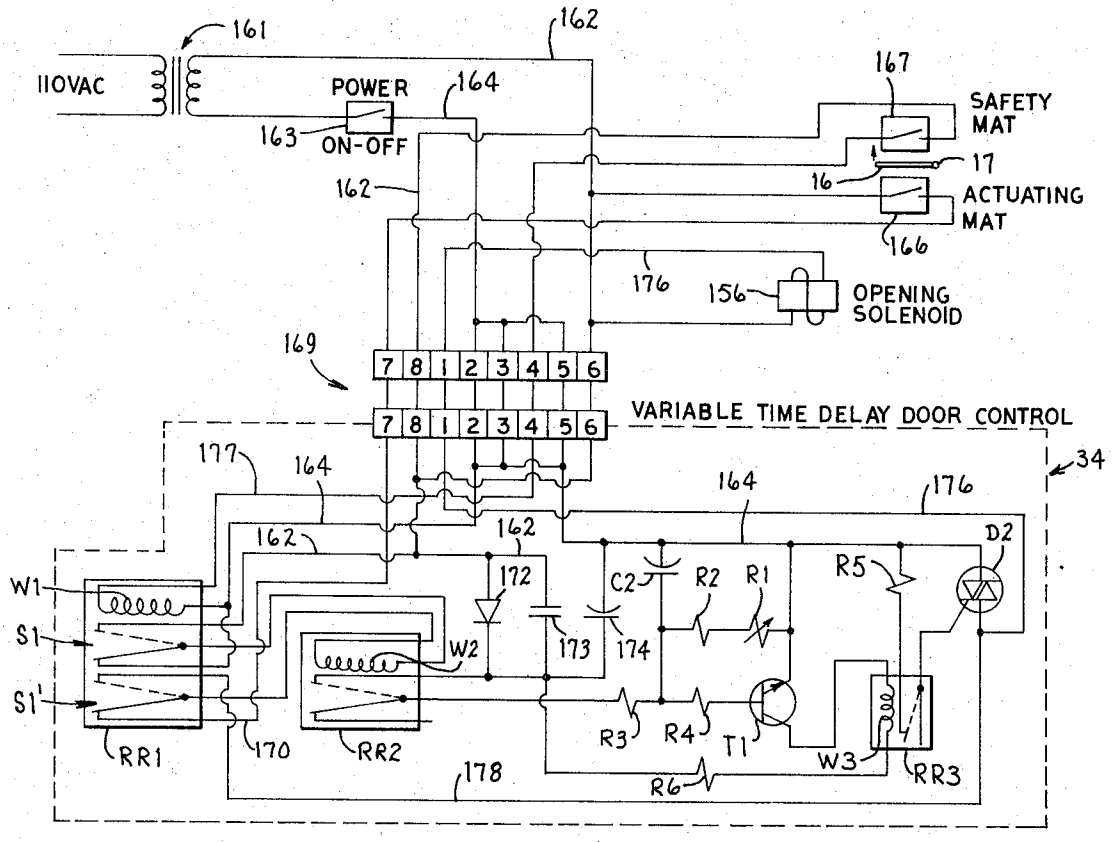

161
162
110VAC
POWER
164
163
ON-OFF
167
SAFETY MAT
17
16
ACTUATING MAT
166
176
156
OPENING SOLENOID
169
7 8 1 2 3 4 5 6
VARIABLE TIME DELAY DOOR CONTROL
34
177
164
176
162
D2
W1
S1
S1'
172
C2
R2
R1
R5
W2
173
174
R3
R4
T1
W3
RR3
RR1
170
RR2
178
R6

Fig. 7

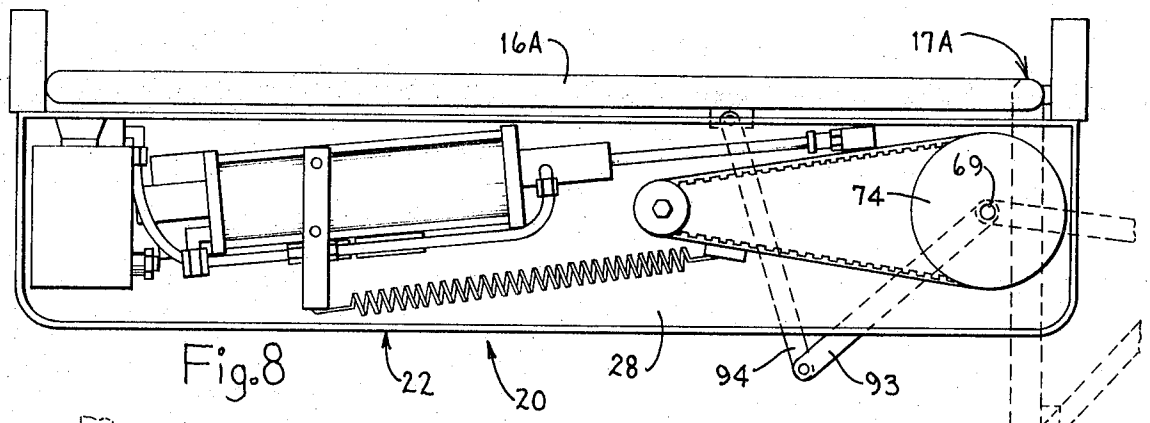

16A
17A
69
74
22
20
28
94
93

Fig. 8

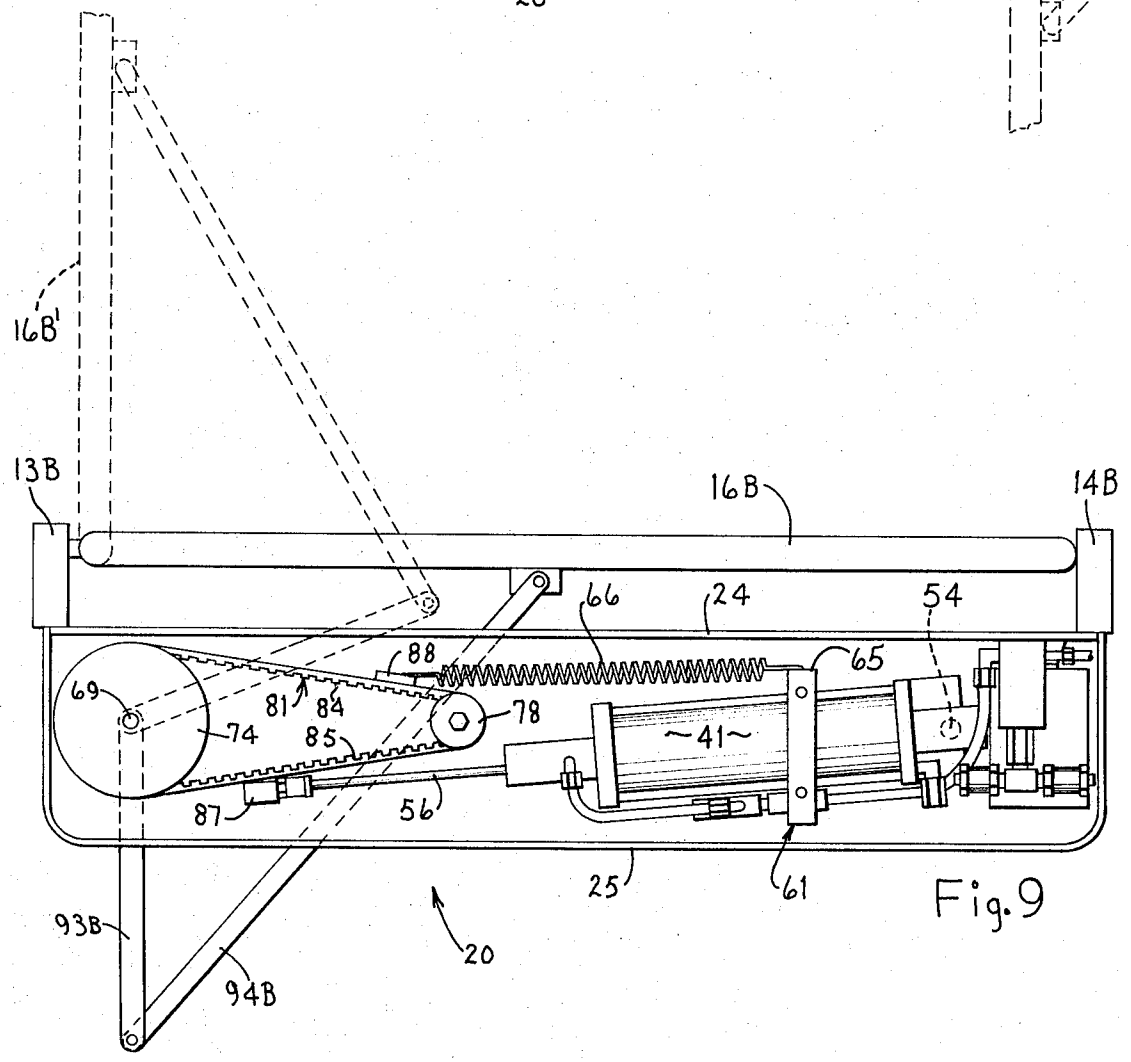

16B'
13B
16B
14B
66
24
54
88
65
69
81
84
74
85
78
~41~
87
56
25
61
93B
94B
20

Fig. 9

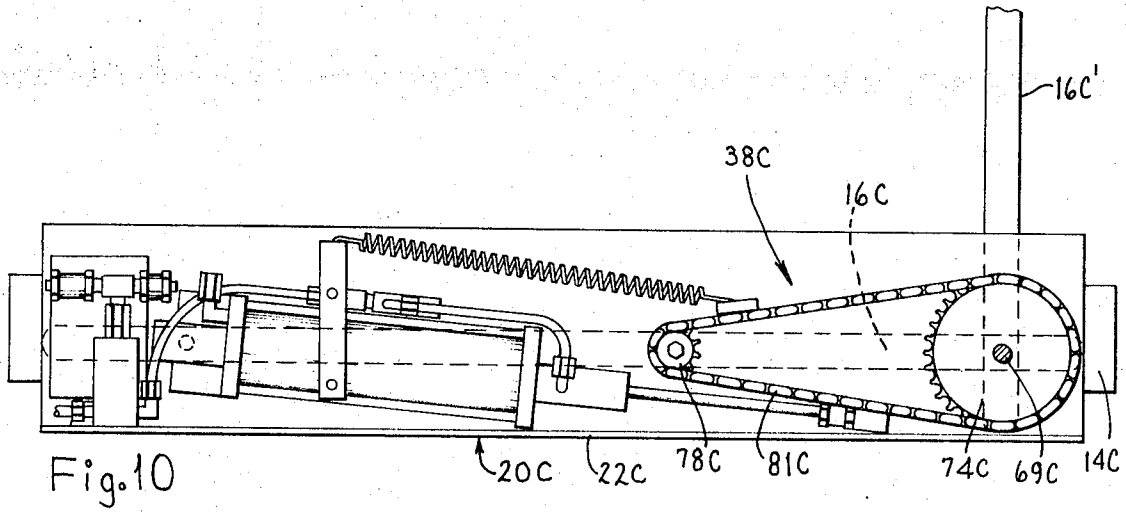

16C'
38C
16C
20C
22C
78C
81C
74C
69C
14C

Fig. 10

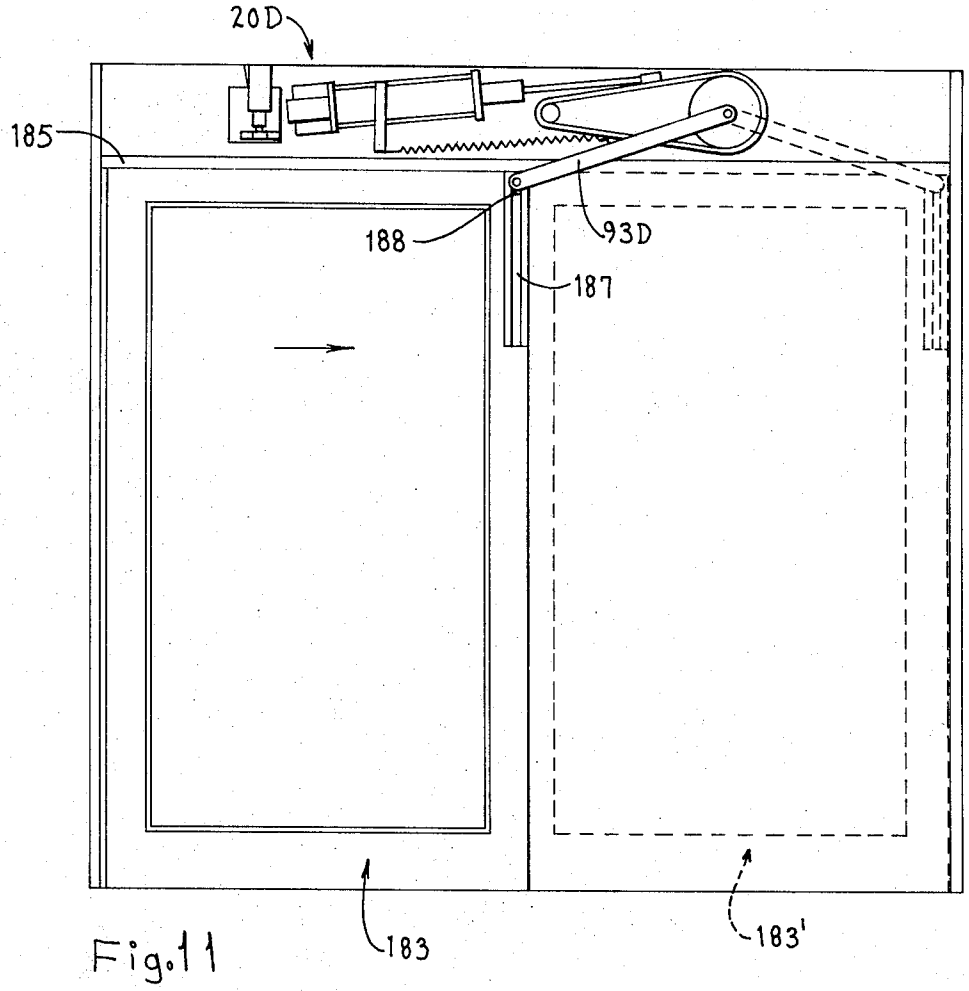

20D
185
188
93D
187
183
183'

Fig. 11

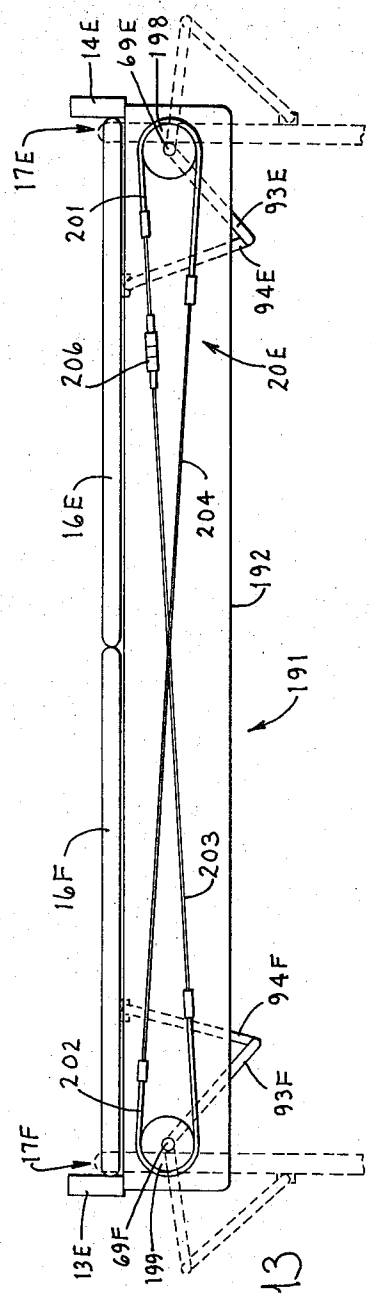

14E
69E
198
17E
201
93E
94E
206
20E
16E
204
192
191
16F
203
94F
202
93F
17F
13E
69F
199

Fig. 13

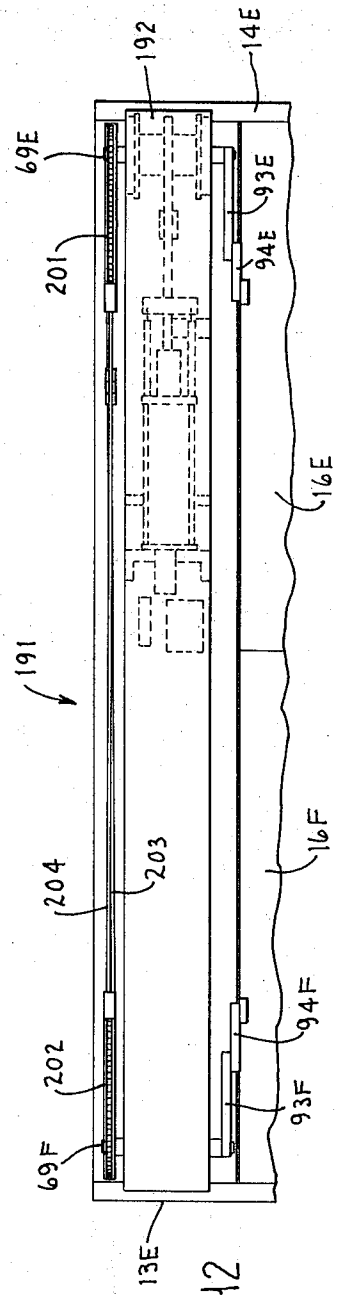

192
14E
69E
93E
201
94E
16E
191
16F
204
203
94F
202
93F
69F
13E

Fig. 12

Fig. 14

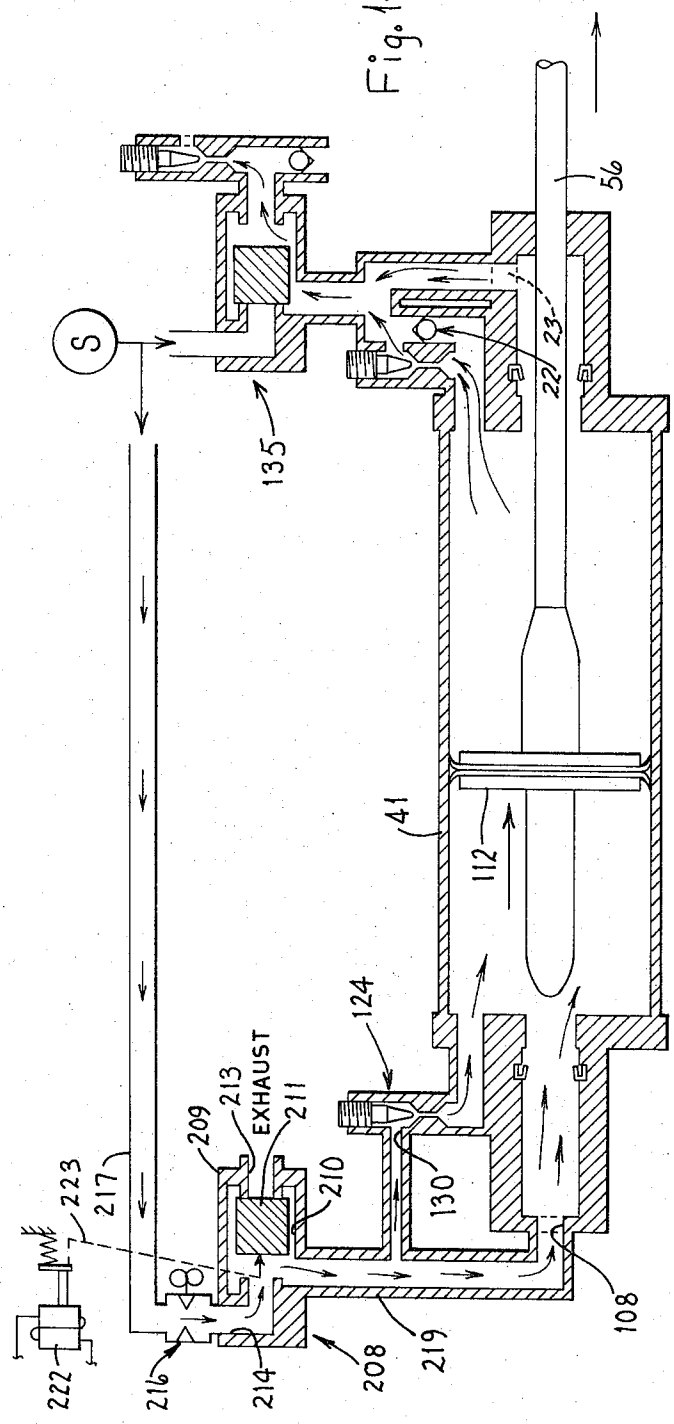
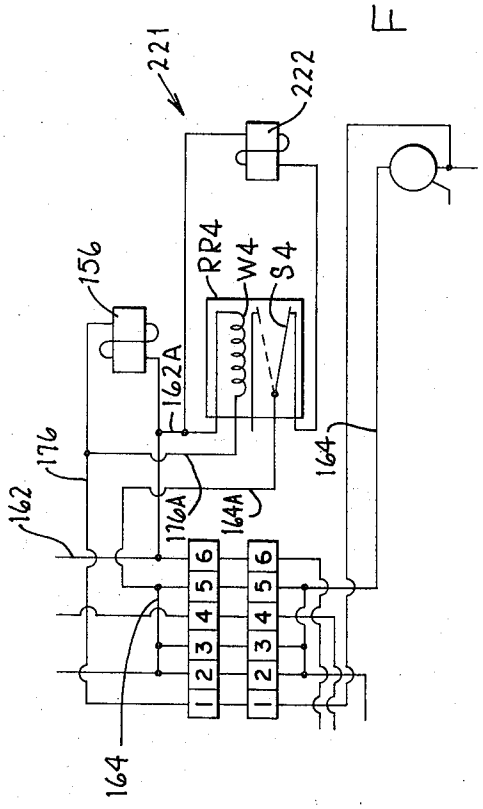

S
56
135
22
23
41
112
124
130
108
219
208
214
216
222
223
217
209
213
EXHAUST
211
210

Fig. 15


221
222
156
RR4
W4
S4
162A
164
176
162
176A
164A
164
1 2 3 4 5 6
1 2 3 4 5 6

SWING DOOR OPERATOR

FIELD OF THE INVENTION

This invention relates to a door operator and more particularly relates to a door operator for switch controlled opening and closing of a door, particularly a swinging door.

BACKGROUND OF THE INVENTION

The door operator embodying the present invention was developed to fulfill long felt needs in apparatus of this type. More particularly, although mat actuated power operated doors have long been known and a wide variety of door and operator systems has been proposed in the past, same have not proven entirely satisfactory for a variety of reasons. Many prior door operators have been of high mechanical complexity, resulting in high manufacturing and maintenance costs and unreliability in long-term use. Many prior door operators have not been versatile in application, being limited to use with a particular kind of door, e.g. swinging, sliding, etc. Swinging door operators have in the past further frequently been incapable of use with both leftwardly and rightwardly hinged doors or both inwardly and outwardly swinging doors or have required substantial modification or replacement of parts to accomplish a change-over from one type of swinging door to another, requiring large and costly inventories of disparate door operator models and replacement parts for each.

Accordingly, the objects of this invention include provision of:

1. A door operator of a simplified mechanical construction having relatively few parts and capable of use with little or no replacement of parts on a wide variety of door types.

2. A door operator, as aforesaid, usable with swinging doors, including bi-fold doors, and sliding doors as well.

3. A door operator, as aforesaid, usable with either right-handed or left-handed swinging doors without replacement of parts, simply by reorienting the door operator unit as a whole and repositioning the linkage by which it connects to the door.

4. A door operator, as aforesaid, usable with either inwardly or outwardly opening doors, by a minor rearrangement of parts therewith and, in some instances, by use of differing linkage lengths connected to the differing door types.

5. A door operator, as aforesaid, capable of use with either single or tandem doors and which is capable of maintaining synchronism of door opening in tandem door installations.

6. A door operator, as aforesaid, capable of connection to doors in several ways, e.g., through a linkage or directly through a rotating drive element.

7. A door operator, as aforesaid, which provides for deceleration of door movement to a fully opened or fully closed position, in a smooth and accurately controllable manner.

8. A door operator, as aforesaid, providing for reliable closing of the door automatically and despite power failures and the like, and also in case of fire and other specified events, so as to be usable as an automatically closing fire door.

9. A door operator, as aforesaid, which automatically prevents opening of a swinging door into a person or the like standing in the path thereof.

10. A door operator, as aforesaid, which is of modular type, divided into a number of major operating components, each quickly and readily replaceable as a unit.

Other objects and purposes of the invention will be apparent to persons acquainted with apparatus of this general type upon reading the following specification and inspecting the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partially broken elevational view of a door operator embodying the invention, mounted in operative relation with a left-hand hinged, inwardly swinging door.

FIG. **2** is an enlarged sectional view substantially taken on the line II—II of FIG. **1.**

FIG. **3** is a fragmentary sectional view substantially taken on the line III—III of FIG. **2.**

FIG. **4** is a diagrammatic central cross-sectional view of the pressure fluid cylinder of FIG. **2,** with associated valving, with the piston rod shown in the door-closed position.

FIG. **5** is a view similar to FIG. **4** but showing an intermediate position of the piston rod during door opening movement.

FIG. **6** is as view similar to FIG. **4** but showing the piston rod positioned as the door approaches its fully open position.

FIG. **7** is a schematic diagram of electrical circuitry which comprises a portion of the operator of FIG. **2.**

FIG. **8** is a view similar to FIG. **2** but showing the door operator reoriented for use with a right-hand hinged door.

FIG. **9** is a view similar to FIG. **2** but showing the operator arranged for use with an outwardly swinging door.

FIG. **10** is a view similar to FIG. **2** but showing a modified operator positioned directly above the door and arranged for direct drive opening thereof.

FIG. **11** is an elevational view disclosing a modification wherein the door is a sliding rather than swinging door.

FIG. **12** is a fragmentary elevational view of a door operator modified for synchronized opening of a pair of swinging doors.

FIG. **13** is a top elevational view of the apparatus of FIG. **12** and utilizing the operator of FIG. **2** as a portion thereof.

FIG. **14** shows a modification of the FIG. **4** apparatus.

FIG. **15** is a modified fragment of FIG. **7** related to FIG. **14.**

SUMMARY OF THE INVENTION

The objects and purposes of the invention are met by providing a door operator for a door movable between open and closed positions. The operator includes an endless loop member supported for reversible orbital motion by a pair of spaced rotatable members. A linkage couples one rotatable member to the door. A pressure fluid cylinder has a piston rod connected to one reach of the endless loop member and is actuable in one direction for moving the endless loop member to open the door. Resilient tension return means are coupled to the other reach of the endless loop member and are responsive to cessation of actuation of the pressure fluid cylinder for causing the endless loop member to close the door. The pressure fluid cylinder includes

means for decelerating door motion as the door approaches its open and closed positions, including enlarged cam portions on the piston rod thereof cooperating with valved pressure fluid inlet and outlet openings. A control circuit having a variable time delay responds to actuation of actuation and safety switches, by persons using the door, for controlling pressure fluid flow to the cylinder. By appropriate installation, the operator is usable with either right- or left-hand hinged doors and doors which open either inwardly or outwardly. A modified operator substitutes a direct drive connection for the linkage. Other modified operators are usable with sliding doors and with double swinging doors.

DETAILED DESCRIPTION

FIG. 1 discloses the interior face of a building wall **11** provided with a portal **12** defined in part by spaced, upstanding stiles **13** and **14.** The portal is occupied by an inwardly swinging door **16** pivotally supported by hinges **17** and **18** on the leftward stile **13.**

A door operator **20** is fixed on the interior face of the wall **11** above the door **16** for opening and closing said door, as hereinafter discussed.

The operator **20** (FIGS. **2** and **3**) includes a housing **22,** of horizontally elongate and generally rectangular form, comprising a back wall **24,** front wall **25,** end walls **26** and **27,** a top wall **28** and bottom wall **29.** In the particular embodiment shown, the back wall **24** is preferably secured to the stiles **13** and **14** by any conventional means, such as screws not shown. At least a portion of the housing **22,** preferably including the front wall **25,** is removable for access to the contents of the housing.

The door operator **20** further includes within the housing **22** a pressure fluid motor unit **31** with associated valving **33,** a variable time delay control **34** for controlling such motor unit **31,** resilient return means **36** and an endless loop unit **38,** responsive to the motor unit **31** and return means **36,** for opening and closing the door **16.**

The motor unit **31** (FIGS. **2** and **3**) comprises a pressure fluid (here air) cylinder **41** having end walls **43** and **44,** respectively provided with bosses **46** and **47** extending coaxially therefrom. Angle brackets **51** and **52** are fixed to the cylinder end **43** and have horizontally extended portions pivotally secured to the top and bottom housing wall **28** and **29,** as by coaxial bolts **54,** so as to cantilever the pressure fluid cylinder within the housing **22** for horizontal pivoting thereof. An elongate piston rod **56** extends from within the pressure fluid cylinder **41** coaxially outwardly through the wall **44** and boss **47.**

The return means **36** comprises a reversible bracket **61** of generally U-shaped configuration, having upper and lower legs **62** removably affixed, by any convenient means such as screws **63,** to the top and bottom walls **28** and **29** of the housing. An upstanding bight portion **65,** preferably integrally extends between corresponding ends of the legs **62** and is near an intermediate portion of the cylinder **41.** Resilient tension means, here comprising a pair of substantially horizontally extending, coiled tension springs **66** and **67,** are fixed at one end to the bracket **61** and extend therefrom generally along the cylinder **41** and piston rod **56** toward the endless loop unit **38.**

The endless loop unit **38** comprises an upstanding actuating, or door drive shaft **69** (FIGS. **2** and **3**) located adjacent one end of the housing **22,** more particularly adjacent the hinged edge of the door **16.** The shaft **69** is rotatably supported by bearings **71** and **72** located within the housing and respectively fixed to the top and bottom walls **28** and **29** thereof. The ends of the shaft **69** extend out of the housing. A rotatable drive member **74** is fixed on the shaft **69** by a hub **76** in a conventional manner, between the bearings **71** and **72.** A rotatable idler member **78** of similar type but smaller diameter is supported in horizontal, coplanar relation with the member **74** adjacent and between the piston rod **56** and springs **66** and **67.** In the preferred embodiment shown, the idler **78** is rotatably secured atop a support **79** (FIG. **3**) carried by and fixed to the bottom wall **29** of the housing. An endless loop member **81** snugly encircles the members **74** and **78** and positively drives the former. The endless loop member **81** may be a conventional chain and the members **74** and **78** may be sprockets. However, in the particular embodiment shown, the member **81** is a toothed timing belt and members **74** and **78** are correspondingly toothed pulleys, the timing belt and pulleys being of known type. The free ends of the piston rod **56** and springs **66** and **67** are fixed to the outer surfaces of opposite reaches **84** and **85,** respectively, of the belt **81** between the pulleys **74** and **78** and by means of suitable clamps or brackets **87** and **88,** respectively.

A drive linkage **91** couples the lower end of shaft **69** to the door **16** and comprises a pair of pivotally connected links **93** and **94.** The free end of link **93** is removably fixed to the lower end of shaft **69** as generally indicated at **96** and by any convenient means. The free end of link **94** is pivotally secured at **97** to a bracket **98** fixed to the interior face of door **16** at the top thereof and is spaced inboard from the hinged edge thereof.

As generally indicated in FIGS. **4–6,** the pressure fluid cylinder **14** includes an elongate, hollow, cylindrical wall **101** extending coaxially between the end walls **43** and **44** and defining a hollow, elongate piston chamber **102.**

The bosses **46** and **47** are hollow and define a back check chamber **104** and a latch check chamber **105.** The chambers **104** and **105** communicate coaxially with the piston chamber **102** through guide openings **106** and **107,** respectively and open through the free ends of the bosses **46** and **47** via coaxial ports **108** and **109.** The port **109** is provided with an annular seal **110** sized for slideably receiving piston rod **56** therethrough.

The interior end (leftward in FIG. **4**) of piston rod **56** coaxially carries a radially enlarged piston **112** reciprocable between the ends of chamber **102.** Radially extending seal members **113** on the piston **112** slideably engage the cylinder wall **101** to prevent leakage past the piston **112.** The piston rod **56** further includes a pair of radially enlarged, coaxial cam portions **116** and **117,** which extend leftwardly and rightwardly from the piston **112** and are snugly but slideably receivable through guide openings **106** and **107,** respectively. Annular seals **118** and **119** are provided within the bosses **46** and **47,** adjacent the guide openings **106** and **107,** for sealingly engaging the cam members **116** and **117,** respectively, when the piston rod is respectively adjacent its leftward and rightward extremes of travel. The remote ends **121** and **122** of cam members **116** and **117** are tapered, the former being rounded at its end extremity.

A restrictive orifice unit **124** (FIG. 4) connects, by a passage **125** through the blind end wall **43** of the cylinder, with the chamber **102.** The restrictive orifice unit **124** here comprises a hollow casing **127** coupled to the passage **125** and having a restricted orifice **129,** flow through which is controlled by a threaded, axially adjustable needle valve **128.** An outlet opening **130** is provided on the needle valve side of the orifice **129** whereby the rate of air flow through the opening **130,** orifice **129** and passage **125** may be controlled by the setting of the needle valve **128.**

The valving **33,** as shown diagrammatically in FIG. **4,** includes a casing **133,** here shown as fixed to the end wall **44** and boss **47,** which through a conduit **134** communicates with a solenoid valve assembly **135.** The latch check chamber **105** communicates directly through a port **136** with conduit **134.** An eccentrically located passage **138** communicates between the piston rod (rightward in FIG. **4**) end of chamber **102** and conduit **134** and contains, in parallel, a restrictive orifice unit **140** and a one-way valve **142.** The restrictive orifice unit **140** is preferably similar to the restrictive orifice unit **124,** above described, including a similar restrictive orifice, needle valve and opening in series. The one-way valve **142** is oriented to allow free air flow from the conduit **134** therethrough into passage **138,** but to positively prevent reverse flow, and may, for example, comprise a conventional ball check valve.

The solenoid valve assembly **135** comprises a casing **146** having a chamber **147.** A reciprocable plunger, or valve element **144,** is slidable in the chamber **147.** The conduit **134** communicates with the chamber **147.** A source S of pressure fluid, of any conventional nature, here capable of supplying pressurized air at **40**psi, communicates through a conduit schematically indicated at **149** and a passage **150** with the chamber **147.** The passage **150** is, in the rest position of the apparatus, normally closed by the solenoid plunger **144.**

In the preferred embodiment shown, a conventional thermally actuable valve TV is interposed in the conduit **149** and is responsive to fire within the building for venting the passage **150** and preventing application of air pressure from the source S thereto. Normally however, the valve TV simply acts as a part of the conduit **149,** conveying pressurized air from the source S to passage **150.**

A further restrictive orifice unit **152,** preferably similar to the unit **128** above described, connects through a further passage **154** with the solenoid valve chamber **147.** A further oneway valve **155** (e.g. a ball check valve) connects between passage **154** and the atmosphere, to allow free air flow into passage **154** but block reverse flow therethrough. The passage **154** is closeable by the solenoid plunger **144** upon actuation of a solenoid **156** (as shown in FIG. **5**).

The solenoid **156,** as schematically indicated in FIGS. **4** and **5,** is of the electrically actuated, spring-return type and the valve element **144,** as shown by dotted line **158,** is preferably connected to, or forms a part of, the movable solenoid element **159.**

In the preferred embodiment shown, the door operator structure above described is controlled by electrical circuitry shown schematically in FIG. **7.** AC operating potential from any convenient source, for example a conventional 110 volt AC source, is applied through a voltage reduction and/or isolation transformer **161** to an AC line **162** and, through a main power on-off switch **163,** to a further AC line **164.** Conventional treadle, or mat, operated switches, comprising an actuating switch **166** and a safety switch **167,** are provided on opposite sides of the door **16,** the door **16** normally being arranged to swing over the safety mat and away from the actuating mat, as shown. The AC lines **162** and **164,** mat switches **166** and **167** and opening solenoid **156** are connected to the variable time delay door control circuit **34** preferably through a separable multiterminal connector **169.**

The control **34** includes a double-pole, double-throw relay RR1, incorporating a winding W1 and two double-throw switches S1 and S1′, each having a movable contact and upper and lower alternatively selectable fixed contacts. The control **34** further includes single-pole, single-throw relays RR2 and RR3 having actuatable windings W2 and W3. The movable contacts of switches S1 and S1′ are in their downward position shown and the contacts of relays RR2 and RR3 are open in the rest condition of the control. The AC line **164** connects to the winding W1 and lower fixed contact of switch S1. The movable contacts of switch S1 and switch S1′ connect across winding W2. The lower fixed contact of switch S1′ connects through a line **170,** and the actuating switch **166** to the other AC line **162.** Thus, closure of the actuating switch **166** completes a circuit through line **170,** switch S1′, the winding W2 and switch S1 to the AC lines, thus energizing winding W2.

A diode **172,** parallelled by a surge protector, **173** connects from AC line **162** to the fixed switch contact of relay RR2 and through a capacitor **174** to the other AC line **164.**

A transistor T1 is connected at its emitter to AC line **164** and at its collector through winding W3 and a resistor R6 to the cathode of diode **172** and thence to the other AC line **162.** Thus, DC potential is applied through this path to the transistor T1. The movable contact of relay RR2 connects through series resistors R3 and R4 to the base of transistor T1. A point between the resistors R3 and R4 connects through a capacitor C2, paralleled by a series resistor R2 and potentiometer R1, to AC line **164.** Thus, closure of the contacts of relay RR2 by actuation of the winding W2 applies positive bias from the diode **172** to the base of transistor T1, rendering same conductive through the winding W3 of relay RR3.

The normally open contact of relay RR3 connects in series with a resistor R5 from the AC line **164** to the gate of a triac D2. The main electrodes of triac D2 connect from the AC line **164** through a line **176** and the opening solenoid **156** to the other AC line **162.** Thus, upon actuation of the coil W3, the contact of relay RR3 applies gate potential from the AC line **164** to the triac D2, rendering same conductive through the solenoid **156** to energize the latter.

The winding W1 of relay RR1 connects from AC line **164** through a line **177** and safety switch **167** to the other AC line **162.** The AC line **162** also connects to the upper fixed contacts of switch S1 in relay RR1. A line **178** connects the upper contacts of switch S1′ to the lower end of triac D2.

OPERATION

To ready the door operator for operation, the power switch **163** (FIG. **7**) is closed, providing AC operating potential across lines **162** and **164.** The door **16** is nor-

mally closed and the remaining switches of the circuitry of FIG. 7 are in their solid-line positions shown. The piston rod **56** of the pressure fluid cylinder is in its extended position shown in FIGS. **4** and **2** and the solenoid **156** is in its unenergized state of FIG. **4.**

Considering the normal operation of the door operator, a person approaching the closed door **16** (FIG. **7**) from the outside steps on the actuating mat (preferably immediately in front of the door), closing the actuating switch **166.** This completes the circuit between the AC lines through switch S1', winding W2 and switch S1, thereby energizing winding W2 to close the contacts of relay RR2. Such closure supplies positive base bias from AC line **162** through diode **172** and resistors R3 and R4 to transistor T1. Transistor T1 then conducts from AC line **162** through diode **172,** resistor **R6,** the winding W3 and thence to the other AC line **164,** energizing winding W3. Closure of the relay RR2 contact also applies charging current to capacitor C2 causing the lower plate thereof to rapidly accummulate a positive charge.

The energized winding W3 closes the contact of relay RR3, applying gate potential to the triac D2 through resistor R5 from AC line **164** and rendering the triac conductive. The conductive triac D2 connects operating solenoid **156,** through line **176** across the AC lines **162** and **164,** thus energizing such solenoid.

Energization of solenoid **156** shifts the plunger **144** thereof rightwardly from its at rest position shown in FIG. **4,** to its position of FIG. **5.** Thus, pressurized air from source S enters the casing **146** through passage **150,** passes the solenoid plunger **144,** and moves through conduit **134** into the casing **133.** Such air then passes freely through one-way valve **142** and eccentric passage **138** into the rightward end of the chamber **102** to move the piston **112** leftwardly, retracting piston rod **156.** Such air from conduit **134** also passes freely through latch check port **136** and into the latch check chamber **105,** acting on the cam portion **117** to assist in driving the piston **112** leftwardly and removing the cam **117** from the latch check chamber. Air pushed leftwardly, ahead of the piston **112,** freely exits the chamber **102** through the free flow port **108,** and to an extent through the orifice unit **124.**

As the piston rod **56** nears the left end of its stroke, the nose **121** of cam **116** (FIG. **6**) passes through the guide opening **106** and seal **118** into the back check chamber **104,** at first partly, then completely, preventing air pushed ahead of the retracting piston **112** from exiting chamber **102** through the free flow port **108.** Thereafter, such air can only exit the chamber **102** at a controlled, low rate through the restrictive orifice unit **124.** This causes the retracting piston rod **56** to slow smoothly, over a substantial portion of its travel, until it comes to rest with the piston **112** adjacent the leftward, or blind, end of the cylinder **41.**

As seen in FIGS. **2** and **3,** such retraction of the piston rod **56** pulls the upper reach **84** of the belt **81** toward the idler pulley **78,** orbiting the belt **81** (clockwise in FIG. **2**) and moving the lower reach **85** of the belt leftwardly, pulling the clamp **88** leftwardly and tensioning and extending springs **66** and **67.** Such orbiting of the belt also positively rotates the guide pulley **74** and shaft **69** to rotate the link **93** clockwise to its broken line position **93'.** This in turn pulls the link **94** downwardly and leftwardly (FIG. **2**) to open the door **16.** Thus, as piston rod **56** decelerates gradually to a stop in its retracted position, the door **16** decelerates smoothly to its open position **16',** remote from a person standing on the actuating mat (FIG. **7**).

The apparatus will stay in its state last-mentioned, with the door open, while the person walks or stands on the actuating mat **166.** Normally, however, upon opening of the door, the person will advance through the open doorway and onto the safety mat **167.** As the person leaves the actuating mat, the switch **166** opens, deenergizing relay RR2. However, transistor T1 remains conductive for a delay period determined by the discharge time of capacitor C2 through resistor R2 and potentiometer R1. Thus, W3, triac D2 and solenoid **156** remain actuated during this delay. The length of the delay is adjustable by potentiometer R1. This delay gives the person a sufficient time to pass through the open doorway before the door **16** closes.

A person so passing through the doorway then normally steps on the safety mat, closing the switch **167** within such delay period. Thus, the winding W1 of relay RR1 is energized through safety switch **167** across AC lines **162** and **164** and shifts the contacts of switches S1 and S1' upwardly to their dotted line positions of FIG. **7.** In consequence, current flows through the AC line **162,** switch S1, winding W2, switch S1', line **178,** the still conductively biased triac D2 and the remaining AC line **164.** The resultant reenergizing of winding W2 closes the relay RR2 contact to reestablish the charge on capacitor C2, and continues to bias transistor T1 and thereby continue conduction of triac D2 while the safety switch remains closed. This continues energization of the solenoid **156** to hold the door open.

As the person leaves the safety mat, the safety switch **167** opens. Such removes AC potential from winding W1, allowing switches S1 and S1' to return to their solid line positions of FIG. **7** and deenergizing winding W2. After capacitor C2 discharges through the time delay period, transistor T1 shuts off, deenergizing winding W3, whereafter the triac D2 shuts off, deenergizing solenoid **156.** The delay period is sufficient to allow the person to move well beyond the safety mat and out of the path of the door **16.**

Upon deenergization of the solenoid **156,** the movable solenoid element returns to its rest position, by means of a suitable spring in a known manner, shifting the valve element **144** leftwardly to its position of FIG. **4,** preventing supply of pressurized air from source S to the conduit **134,** and opening the conduit **134** to the restrictive orifice unit **152.**

The piston rod **56** is then free to return rightwardly from its retracted position of FIG. **6.** The tension springs **66** and **67** (FIGS. **2** and **3**) then contact, pulling the lower reach **85** of belt **81** rightwardly, orbiting the belt **81** counterclockwise, and moving the upper reach **84** leftwardly. Such pulls, or extends, the piston rod **56,** rotating the drive pulley **74** counterclockwise to cause the link **93** to return the door **16** to its fully closed position.

During such piston rod extension, the piston **112** (FIGS. **4** through **6**) moves rightwardly, drawing air behind it into chamber **102,** primarily through the free flow port **108.** Air pushed ahead of the moving piston **112** flows freely through latch check chamber **105,** port **136,** conduit **134** and then, in a restricted manner, out the restrictive orifice unit **152.** Thus, the unit **152** limits the maximum closing speed of the door.

As the piston rod **56** nears full extension, the tapered nose **122** of cam **117** enters the guide opening **107**, the taper of the nose **122** progressively restricting air flow into the latch check chamber **105** and gradually decelerating the piston rod. After the nose **122** has passed the seal **119**, no further air can be pushed by piston **112** into the latch check chamber **105** and all air pushed ahead of the piston **112** must flow into port **138** and thence through restrictive orifice unit **140** (the one-way valve **142** being positively closed to air flow in this direction). Thus, restrictive orifice unit **140** further restricts exhaust air flow, further slowing and extending piston rod **56** and closing door so that the last increment of closing door movement is gradual. The chambers **104** and **105** (FIG. **4**) and corresponding cam members **116** and **117** are relatively long, compared to the total stroke of the piston rod **56** (here totalling about one-third of said stroke length), so that deceleration of the door as it approaches the ends of its travel is indeed gradual.

This completes the normal opening and closing cycle of the door operator of FIGS. **1** through **7**.

If, at any time during the opening and closing cycle of the door, the actuating switch **166** is again closed, the cycle immediately begins anew and proceeds in the manner above discussed.

To avoid the possibility of the door opening and striking a person in its path, the safety mat normally covers the area near and swept by the opening door. Thus, a person adjacent the closed door, standing in its path and on the safety mat, will close the safety switch **167**. With the apparatus of FIGS. **1** through **7** in its rest position shown (door closed, triac D2 off), closure of the safety switch **167** has no effect on the door. More particularly, closure of the safety switch **167** will energize winding **W1**, switching the contacts of switches **S1** and **S1'** to their dotted line positions, and thereby coupling winding **W2** in series with triac D2 across the AC line **162** and **164**. However, triac D2, being off, cannot supply current to winding **W2**. In consequence, transistor T1, relay RR3 and the triac D2 remain nonenergized and the door does not open. Further, while the safety switch **167** is closed, closing of actuating switch **166** has no effect since switch **S1'** no longer couples the line **170** to the winding **W2**. Thus, actuation of the safety switch **167** prevents subsequent closing of the actuating switch **166** from opening the door.

With the provision of the thermal valve TV, above discussed, the door **16** can be used as a fire door. More particularly, the door normally functions as an automatic door (as above described), but in case of fire would be relieved of air pressure from source S by the thermal valve TV, whereby the springs **66** and **67** would resiliently urge the door to its closed position and the door would no longer be opened by switches **166**. On the other hand, the door could be manually opened in such instances (or in any other instances wherein air pressure is not supplied to the conduit **134** from the source S) by manually pulling, or pushing, open the door **16** against the reslient force of the springs **66** and **67**, atmospheric pressure being maintained behind (to the right in FIG. **4**) the piston **112** by, for example, leakage through the check valve **155**.

For emergency use, an emergency switch, not shown, may be provided, for example in series with the solenoid **156** across the AC lines **162** and **164**, for energizing such solenoid to open the door.

The door operator embodying the invention can, in the absence of air supply to the cylinder **41**, be employed as a resilient door closer with a checking, or door decelerating, action toward the end of the door closing movement. Under such conditions, the door can be opened manually against the force of the springs **66** and **67**.

It may be desired, or required by local building codes, that the door requires no more than a specified maximum force to open in the event of failure of its automatic operator. Thus, should the timing belt **81** (FIG. **2**) become immobilized, the guide pulley **74**, in response to a preselected and greater than normal torque on the shaft **69** and door, will slip with respect to the belt, allowing opening or closing of the door. A similar effect can be achieved in FIG. **10**, hereinafter discussed, by providing a presettable slip clutch of conventional type (not shown) between the sprocket **74C** and shaft **69C**, for example.

If desired, the ratio of pressure fluid cylinder stroke and door opening angle can be varied, as for example by interposing a ratio changing gear train or the like between the driven pulley **74** and shaft **69**, or more simply, by changing the diameter of the pulley **74** or the length of link **93** or the location of bracket **98**.

MODIFICATIONS

The operator embodying the invention can be used with doors of either hand, that is, doors hinged at either their left or right sides. While FIG. **2** shown the operator **20** used with an inwardly swinging door **16** hinged at its left side, FIG. **8** discloses the operator **20** rearranged for operating a door **16A** hinged at its right side, as indicated at **17A**. Such is accomplished by rotating the door operator **20** about an axis perpendicular to the wall **11** through 180°, so that the drive pulley **74** is adjacent the hinge **17A**. The linkage **93, 94** is then connected to the other exposed end of the shaft **69**, now extending downwardly. Thus, the same operator **20** can be used with both left-hand and right-hand hinged doors simply by a rotation thereof and reconnection of the linkage **93, 94**.

As shown in FIG. **9**, the operator **20** can also be used with an outwardly swinging door **16B** of either hand, here for example left-hand hinged at **17B**. To accomplish this conversion, the bracket **61** is disconnected from the housing walls and rotated **180** degrees about a vertical axis and reconnected, to place the bight **65** thereof adjacent the housing back wall **24** instead of the front wall **25**. The springs **66, 67** and piston rod **56** are disconnected from belt **81**. The fluid cylinder **41** is then pivoted on pivot **54** toward the front wall **25** of the housing to place the piston rod **56** in front of idler pulley **78**. To facilitate such shifting, the idler pulley **78** may be temporarily removed. Thereafter, the springs **66, 67** are connected to the reach **84** (in back of the fluid cylinder **41**) and the piston rod **56** is connected to the front reach **85** of the belt. In this way, the retracting piston rod **56** and spring pair **66, 67** will rotate the drive pulley **74** in reversed directions as compared to their arrangement of FIG. **2**. Longer links **93B** and **94B** may replace the links **93** and **94** of FIG. **2**. Thus, retraction of piston rod **56** will still open the door **16B**, as in FIG. **2**, but by rotation of pulley **74** in the opposite direction.

It will be understood that the operator **20**, arranged as in FIG. **9**, can be rotated through 180° about an axis perpendicular to the building wall and with reposition-

ing arm **93B** at the other end of shaft **69**, can be used with right-hand hinged, outwardly swinging doors.

Thus, the same door operator assembly can accommodate all of the four possible combinations of door hinging and opening directions, i.e., right-hand hinge, left-hand hinge, interior opening, and exterior opening.

In FIG. **10**, a modified door operator **20C** is disposed in a space in the wall between stiles **13C** and **14C** and in overlapping fashion above the door (indicated in a broken line at **16C** in its normal closed position). The operator housing **22C** is fixedly located, for example by securement to stile **13C** and **14C**, by any convenient means not shown. The modified door **16C** is of the type pivotally supported by coaxial shaft offset inboard from the edge of the door and extending vertically upwardly and downwardly therefrom, the shafts being pivoted, for example, in a suitable socket, not shown, in the building floor and/or in the area directly above the door. In the particular embodiment shown, the upwardly extending door pivot shaft connects to or is in extension of a shaft **69C**, rotatably supported by the housing **22C** as in FIG. **3**. Thus, rotation of the shaft **69B** rotates the door **16C** to and from its open position shown in **16C'**, in response to rotation of the drive member **74C**.

The door operator **20C** of FIG. **10** is further modified in that members **74C** and **78C** comprise sprockets and the endless loop member **81C** comprises a chain.

It should be noted that the direct drive arrangement of FIG. **10** requires a lesser angle of rotation by drive member **74C** to affect a given angle (for example 90°) of door pivotal motion, the angle of rotation of the drive member **74C** and door being the same in FIG. **10**. In contrast, the drive member **74** of FIGS. **2, 8** and **9** may traverse an angle between 90° and 180° for a 90° opening movement of the corresponding door. Thus, a pressure fluid cylinder of shorter stroke or a larger drive member diameter may be employed in the modified FIG. **10** apparatus.

FIG. **11** discloses a modified door operator **20D** similar to the operator **20** but adapted for use in opening and closing a sliding door **183**. The operator **20D** is located above the upper track **185** of the sliding door and except as in hereinafter discussed basically comprises the door operator **20** as shown in FIG. **8** but rotated about its length axis through an angle of 90° and so that the drive shaft **69D** is horizontal and has one end thereof forwardly overhanging the front face of the door **183**. The door **183** has fixed to its upper rightward face a vertical track element **187** having a longitudinal undercut groove. A link **93D** is fixed to the exposed end of shaft **69D** and extends therefrom into pivotal connection with a slider **188** vertically slidable within the track element **187**. Thus, upon counterclockwise rotation of the shaft **69D**, the link **93D** swings, thus simultaneously sliding downward along the track element **187** and causing the door **183** to slide rightwardly along its track to its open position indicated in broken lines at **183'**. Reversal of the rotation of the shaft **69D** reverses the sliding motion of the door **183** to return same to its closed solid line position of FIG. **11**.

The operator **20** can thus also be arranged to actuate gates and folding doors, in the latter instance, for example, either panel of a conventional, hinge connected bi-fold door pair.

FIGS. **12** and **13** disclose a modified door operator system **191** for opening and closing a double, or tandem, door arrangement, comprising a pair of doors **16E** and **16F**. Such doors **16E** and **16F** when closed are substantially coplanar and are hinged at **17E** and **17F** at their remote side edges on stiles **14E** and **13E**, respectively. The double door operator **191** includes an elongate housing **192** mounted on the stiles **13E** and **14E**, as in FIG. **2**. A single door operator unit **20E**, arranged as in FIG. **8**, is provided at one end of the housing **192**, here the rightward end as diagrammatically indicated in broken lines. The door operator **20E** is arranged within the housing **192** and opens and closes the door **16E** in the same manner above described with respect to FIGS. **2** through **9**.

In addition, however, a dislike synchronizing member **198** is fixed to the upper end of the shaft **69E** for rotation therewith. In the particular embodiment shown, member **198** is a sprocket. The lower end of the shaft **69E**, as in FIG. **8**, is connected through links **93E** and **94E** to the door **60E**.

A similar shaft **69F** is rotatably supported at the opposite end of housing **192** by suitable bearings not shown, as in FIG. **3**. The lower and upper ends of shaft **69F** extend beyond the top and bottom walls of the housing **192** and respectively fixedly carry a link **93F** (which as in FIG. **2** connects through a further link **94F** to door **16F**) and a further synchronizing member, or sprocket **199**, preferably identical to the member **198**. Flexible positive drive elements **201** and **202**, here lengths of chain, partially encircle sprockets **198** and **199**, respectively and are in positive driving relation therewith. Crossed cables **203** and **204** join the diagonally opposed ends of chains **201** and **202** to provide a closed loop of "Figure-eight" configuration which is maintained under moderate tension, hereby a turnbuckle **106** in cable **203**.

Thus, rotation of shaft **69E** by the door operator **20E**, by rotation of sprocket **198**, orbiting of chains **201, 202** and cables **203, 204** effects equal and opposite rotation of sprocket **199** and hence of shaft **69F**. Thus, shafts **69E** and **69F** rotate in opposite directions and in synchronism to effect a shychronized opening or synchronized closing of their corresponding doors **16E** and **16F**.

If desired, in cases where for example the doors **16E** and **16F** are relatively heavy or have relatively high pivot friction, an additional operator, not shown, arranged in a manner of operator **20** of FIG. **2**, may be provided at the left end of housing **192** to rotatably drive the shaft **69F** for opening and closing door **16F**, the synchronizing apparatus **198** through **206** maintaining synchronous opening and closing of the two doors despite the use of two separate operators.

FIGS. **14** and **15** disclose a modification providing for power assisted door closing and usable, for example, in high stack pressure situations wherein the normal springs **66** and **67** (FIG. **3**) may be insufficiently strong as to close the door. Such modification can be either factory or field installed.

FIG. **14** discloses a piston rod **56** of cylinder **41** in an intermediate position of door closing movement and is modified from the structure shown in FIGS. **4–6** as follows.

A further solenoid valve assembly **208** comprises a casing **209** containing a chamber **210**. A reciprocable valve element **211** is slidable in the chamber **147** to alternatively close an exhaust port **213** (during door closing movement, as shown in FIG. **14**) and a pressure

fluid inlet port **214** (during door opening movement). The exhaust port **213** may vent directly to the atmosphere. The inlet port **214** connects through an adjustable orifice, or valve **216**, control valve **16**, and a conduit **217** to the source S of pressurized air, as schematically indicated in FIG. **14**. A conduit or passage **219**, connects the chamber **210** to the free flow port **108** of cylinder **41**, above described, and also to the port **130** of the restrictive orifice unit **124**, above described.

FIG. **15** discloses a fragment of the circuit of FIG. **7** modified by the addition of a closing solenoid circuit **221**. Such circuit **221** includes a relay **RR4** having a winding **W4** energizable for opening a single-pole, single-throw switch **S4**. The winding **W4** connects through lines **176A** and **162A** across the opening solenoid **156** above discussed with respect to FIG. **7**. A line **164A** connects from AC line **164** through switch **S4**, a closing solenoid **222** and line **162A** to the other AC line **162**. The closing solenoid **222** is suitably mechanically connected, as schematically indicated by broken line **223** in FIG. **14**, to the valve element **211**.

Thus, when the opening solenoid **156** is energized (to open or hold open the door) as above discussed, the winding W4 is similarly energized to open switch **S4**, whereby closing solenoid **222** is deenergized. When such solenoid is deenergized it locates the valve element **211** in its leftward position (FIG. **14**) closing the pressurized air inlet **214** and opening the exhaust port **213**. Thus, air pushed ahead of the leftwardly moving (FIG. **14**) piston **112** escapes the cylinder **41** through port **108**, and to a lesser extent through restrictive orifice unit **124**, and thence through passage **219** past the valve element **211** and out exhaust port **213**.

On the other hand, when opening solenoid **156** is deenergized so also is winding W4 (FIG. **15**) and switch S4 is closed, energizing closing solenoid **222** by connecting same across the AC line **164** and **162**. The energized solenoid **222**, through the connection **223** (FIG. **14**) shifts the valve **211** to its rightward position shown in FIG. **14**, closing exhaust port **213** and opening the passage **214**. Air then flows from the pressurized source S through conduit **217**, at a rate controlled by the speed control valve **216**, and thence through port **214** and passage **219** to the port **108** (and to the lesser extent through restrictive orifice unit **124**) and thereby into the leftward (FIG. **14**) end of the cylinder **41** to assist the springs **66** and **67** (FIG. **3**) in extending the piston rod **56**, so as to close the door.

Although particular preferred embodiments of the invention have been disclosed in detail for illustrative purposes, it will be recognized that variations or modifications of the disclosed apparatus, including the rearrangement of parts, lie within the scope of the present invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a door operator for a door movable between an opened position and a closed position, the combination comprising:

a flexible endless loop member and door drive shaft means direct driven in opposite directions thereby for opening and closing said door;

motor means engaging a reach of said endless loop member and actuable for moving said endless loop member in one orbital direction;

return means also engaging a reach of said endless loop member and responsive to disabling of said motor means for closing said door through moving said endless loop member in the opposite orbital direction;

whereby said motor means and return means oppositely orbit said endless loop member to move said door between open and closed positions.

2. The apparatus of claim **1** in which said door drive shaft means includes a door drive shaft and a rotatable drive member fixed thereon and including a freely rotatable idler spaced therefrom by said reaches, said flexible endless loop member encircling said idler and drive member and positively engaging and rotatably driving said drive member, said motor means and said return means respectively comprising a pressure fluid cylinder energizable for retraction and a tension spring, each of which has an end directly connected to said endless loop member intermediate said drive member and idler, and means coupling said rotatable drive member to said door for opening and closing same upon opposite orbital movement of said loop member by said cylinder and spring.

3. The apparatus of claim **1** in which said motor means includes a pressure fluid cylinder having a retractable piston rod connected to said endless loop member for moving said door, a piston on said piston rod and responsive to pressure on one side thereof for moving said piston rod in one direction, oppositely directed cam means on said piston rod and chamber means at opposite ends of said cylinder gradually blockable by respective cam means for gradually initially decelerating the piston rod before nearing the ends of its stroke, and valve means controllable for applying pressure fluid to said piston rod to move same in said one direction.

4. The apparatus of claim **3** including first restrictive orifice means paralleling the said chamber means at one end of said cylinder for further decelerating said piston as it approaches said end of said cylinder in the final part of its stroke, valve unit means at the opposite end of said cylinder and a conduit in communication with said valve unit means, said valve unit means including a second restrictive orifice and a one-way valve both connected in parallel between said conduit and said opposite cylinder end, said one-way valve allowing free fluid flow from said conduit to said piston but positively blocking return flow thereby except return flow through said second restrictive orifice, said valve unit means further including a passage communicating between said conduit and the adjacent other said chamber means in parallel with said second restrictive orifice and one-way valve.

5. The apparatus of claim **4** including a pressure fluid source and third restrictive orifice means alternatively communicable with said conduit past said controllable valve means, said controllable valve means including a plunger movable for alternately blocking said source and third restrictive orifice means.

6. The apparatus of claim **1** including electrically energizable means for actuating said motor means, control circuit means responsive to actuation of an actuating switch for energizing said electrically energizable means and for maintaining said energization for a predetermined delay time following the deactuation of said actuating switch.

7. The apparatus of claim 6 including switch means responsive to actuation of a safety switch for causing said control circuit means to hold said door open in response to prior actuation of said actuating switch occurring within said delay time but for preventing opening of said door in response to a subsequent actuation of said actuating switch.

8. The apparatus of claim 1 including a housing supporting said endless loop member, motor means and return means adjacent said door, said door drive shaft means comprising a shaft rotatably supported in said housing and having both ends thereof extending from said housing, means connecting one extended end of said shaft to said door for opening and closing said door upon opposite rotations of said shaft, said door operator being usable with both rightwardly and leftwardly hinged doors by rotation of said housing through 180° about an axis transverse to the plane of the closed door and using of the opposite extended shaft end for opening and closing connection to said door.

9. The apparatus of claim 1 including a housing carrying said endless loop member and motor means and return means, said housing being offset vertically of said door width-wise of the door opening, said motor means including an elongate reciprocable member secured to said endless loop member, said return means comprising an elongate resilient member secured to said endless loop member, said endless loop being longitudinally extended lengthwise of said housing, said reciprocable member and said resilient member end engaging said endless loop member and extending along said reaches and longitudinally of said endless loop member to opposite ends secured to the housing remotely of said endless loop member for urging said reaches of said endless loop member in opposite rotational directions.

10. The apparatus of claim 9 in which said resilient member comprises an elongate tension spring and including bracket means on said housing and spaced from said endless loop member, said resilient member being secured adjacent its free end to said bracket means for rotating said endless loop member when tensioned and in the absence of actuation of said motor means.

11. The apparatus of claim 10, in which said motor means comprises a pressure fluid retraction cylinder, said reciprocable member comprising the piston rod thereof, said cylinder being located remotely of said endless loop member and including means pivotally mounting the free end of said cylinder on said housing for permitting pivotal movement of said pressure fluid cylinder during retraction of said piston rod.

12. The apparatus of claim 11 in which said bracket means is reversibly mounted on said housing, said pressure fluid cylinder and spring normally extending substantially in parallelism along and beyond opposite reaches of said endless loop member, said reaches extending substantially longitudinally of said housing, whereby said door operator is adaptable to use with either inwardly or outwardly swinging doors by reversal of said bracket means on said housing and pivoting of said pressure fluid cylinder to allow reversed securement of said piston rod and spring to said endless loop means.

13. The apparatus of claim 12 in which said endless loop member is secured to said spring and piston rod ends on opposite reaches thereof, said door drive shaft means including a rotatable drive member and the shaft thereof rotatably supported on said housing and spaced away from said spring and rod ends, said shaft being driven by said endless loop member directly through said rotatable drive member and fixedly carrying a first link, a second link pivotally engaging said first link and said door, whereby rotation of said shaft results in opening and closing movement of said door, the length of said links being variable for adapting said operator to either inwardly or outwardly swinging doors.

14. The apparatus of claim 1 including a spaced pair of rotatable members around which said endless loop member orbits, said endless loop member being in positive driving engagement with one said rotatable member, a housing disposed directly above said door, said door drive shaft means incorporating said one rotatable member, a shaft fixedly engaging said door on the hinge axis thereof and extending rotatably and upwardly into said housing, said shaft fixedly engaging said one rotatable member, whereby orbiting of said endless loop member opens and

15. The apparatus of claim 1 in which said door is a sliding door, said endless loop member being supported in a substantially vertical plane above said sliding door and including a rotatable idler, said door drive shaft means consisting of a shaft and a rotatable drive member carrying said endless loop member in cooperation with said idler, said endless loop member directly driving said rotatable drive member, a link fixed to said shaft and a substantially vertical guide track on said door slidably engaging said link, whereby rotation of said drive member slides said door between open and closed positions.

16. The apparatus of claim 1 in which said door comprises a pair of substantially alignable door panels hinged at remote side edges thereof, said door operator including a housing adjacent the tops of said door panels, a pair of rotatable synchronizing members on said housing adjacent opposite ends thereof, one said synchronizing member being fixed on said door drive shaft means, an elongated loop twisted to define substantially a "figure-eight" configuration and passing around said rotatable synchronizing members for constraining said members to rotate in synchronism and in opposite rotational directions, a first operator unit comprising said endless loop extending from said drive shaft means in overlapping relation with said "figure-eight" loop, said motor means and return means respectively comprising respective powered and resilient elongate retractable members extending from the reaches of said endless loop member below said "figure-eight" loop.

17. The apparatus of claim 16 including a second door operator unit of similar kind and reversed orientation having a positive driving connection to the other of said synchronizing members and door panel.

18. The apparatus of claim 5 including a further one-way valve connected in parallel with said third restrictive orifice means to said controllable valve means and oriented to positively block pressure fluid flow therethrough from said controllable valve means but to freely allow fluid flow therethrough toward said controllable valve means, whereby, when said controllable valve means is positioned to block communication between said source and said conduit, and said piston is moving toward said one end of said cylinder, said further one-way valve maintains atmospheric pressure behind said piston.

19. The apparatus of claim 3 including further valve means controllable for applying pressure fluid to said piston rod to move same in said opposite direction for assisting said return means and including a solenoid controlled valve having a valve element shiftable for alternatively allowing exhaust fluid movement out of said cylinder ahead of the piston rod as the latter moves in said one direction for opening the door and for applying pressure fluid to said piston to assist moving same in said opposite direction during door closing movement.

20. The apparatus of claim 19 in which said controllable valve means includes an opening solenoid energizable for causing pressure fluid to move the piston rod in said one direction and in which said further valve means includes a closing solenoid and a relay for controlling actuation of said closing solenoid, said relay being connected in parallel with said opening solenoid and adapted to energize said closing solenoid in alternative relation to energization of said opening solenoid.

21. The apparatus of claim 19 in which said further valve means includes a speed control valve in series with said solenoid controlled valve.

22. The apparatus of claim 9 including pivot means for securing said opposite ends of said reciprocable member and resilient member in said housing and a freely rotatable idler, said endless loop member having extremities orbitally supported by said idler and drive shaft means, said pivot means and door drive shaft means being spaced in opposite directions longitudinally of the housing from said idler, said reciprocable member comprising longitudinally extended linear actuator means actuable for retraction and said resilient member comprising a tension spring, the first mentioned ends of said retractable linear actuator means and spring being fixed to opposite reaches of said endless loop means and extending therealong away from said drive shaft means for alternatively tensioning said loop means around said door drive shaft means.

23. The apparatus of claim 3 including valving means connected to the one of said cylinder ends approached by the piston rod moving in said one direction for controlling fluid flow to and from said one chamber means, a valve unit at the other end of said cylinder, and means defining a flow path between said valving means and said valve unit (1) for traveling fluid to said one cylinder end to facilitate movement of said piston away therefrom in response to urging of said return means and (2) for alternatively traveling fluid to said valve unit at said other cylinder end during piston movement away from said other cylinder end.

24. The apparatus of claim 3 including valving means connected to the one of said cylinder ends approached by the piston rod moving in said one direction for controlling fluid flow to and from the chamber means at said one cylinder end, a valve unit at the other end of said cylinder, and means defining a flow path between said valving means and said valve unit (1) for traveling fluid to said one cylinder end to facilitate movement of said piston away therefrom in response to urging of said return means and (2) for alternatively traveling fluid to said valve unit at said other cylinder end during piston movement away from said other cylinder end.

25. In a door operator for a door movable between an opened position and a closed position, the combination comprising:

endless loop means movable in opposite directions for opening and closing said door;

motor means coupled to said endless loop means and actuable for moving said endless loop means in one direction, said motor means including a pressure fluid cylinder having a retractable piston rod connected to said endless loop member for moving said door, a piston on said piston rod and responsive to pressure on one side thereof for moving said piston rod in one direction, oppositely directed cam means on said piston rod and chamber means at opposite ends of said cylinder gradually blockable by respective cam means for gradually initially decelerating the piston rod before nearing the ends of its stroke, and valve means controllable for applying pressure fluid to said piston rod to move same in said one direction;

return means coupled to said endless loop means and responsive to disabling of said motor means for moving said endless loop means in the opposite direction;

whereby said motor means and return means act through said endless loop means to move said door between open and closed positions.

26. In a door operator for a door movable between an opened position and a closed position, the combination comprising:

endless loop means movable in opposite directions for opening and closing said door;

motor means coupled to said endless loop means and actuable for moving said endless loop means in one direction;

return means coupled to said endless loop means and responsive to disabling of said motor means for moving said endless loop means in the opposite direction;

electrically energizable means for actuating said motor means, control circuit means responsive to actuation of an actuating switch for energizing said electrically energizable means and for maintaining said energization for a predetermined delay time following the deactuation of said actuating switch, switch means responsive to actuation of a safety switch for causing said control circuit means to hold said door open in response to prior actuation of said actuating switch occurring within said delay time but for preventing opening of said door in response to a subsequent actuation of said actuating switch;

whereby said motor means and return means act through said endless loop means to move said door betwen open and closed positions.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3 864 875 Dated February 11, 1975

Inventor(s) Lew V. Hewitt

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 16, line 21; after "and" insert ---closes said door.---.

Col. 17, line 3; change "said" to ---the---.

Col. 17, lines 40 through 51; please cancel Claim 23.

Col. 18, after line 60; add the following claim:

---27. In a door operator, for a door pivotable between an open position and a closed position, the combination comprising:

a housing fixedly mountable above and adjacent said door and extending substantially the width of the door opening;

a drive shaft extending through at least a bottom wall of said housing and rotatably supported on opposed top and bottom housing walls and means connecting said drive shaft to said door at least adjacent a pivot axis of said door for rotating said door between open and closed positions upon rotation of said drive shaft;

a rotatable disklike drive member fixed on said shaft

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
U.S. GOVERNMENT PRINTING OFFICE : 869-930

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3 864 875 Dated February 11, 1975

Inventor(s) Lew V. Hewitt

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

and located in said housing;

a freely rotatable idler fixedly located in said housing remote from said drive member and an endless loop member encircling said drive member and idler in positive and toothed driving connection with said drive member for rotating said shaft synchronously with orbiting of said endless loop member, said endless loop member having first and second reaches on opposite sides of a common diametrical line between said idler and said drive member;

an elongate resilient tension member and means releasably fixedly securing one end thereof to said housing remotely from said endless loop member and means fixedly securing the other end thereof to one reach of said endless loop member;

a pressure fluid cylinder adjacent said resilient member having a piston rod extending from one end thereof into fixed engagement with the other reach of said endless loop member,

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
U.S. GOVERNMENT PRINTING OFFICE: 869-930

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3 864 875 Dated February 11, 1975

Inventor(s) Lew V. Hewitt

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

the other end of said cylinder being pivotally supported on said housing, said cylinder including means at the ends thereof incorporating controllable restrictive orifices and coacting means on said piston rod for providing controlled deceleration of said piston rod at the ends of its stroke;

a solenoid controlled valve and a variable time delay control circuit carried by said housing, said solenoid control valve being responsive to said control circuit for alternatively applying pressure fluid to said one end of said pressure fluid cylinder for retracting said piston rod and for exhausing said last-mentioned end of said cylinder at a controlled rate;

switches on opposite sides on said door and means coupling same to said control circuit for opening said door in response to actuation of one said switch, holding said door open for a controlled delay period in response to subsequent actuation of the other said switch within a similar delay

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
U.S. GOVERNMENT PRINTING OFFICE : 869-930

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3 864 875 Dated February 11, 1975

Inventor(s) Lew V. Hewitt

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

period after actuation of said one switch, and for preventing opening of the door in response to sole actuation of said other switch.---.

Signed and Sealed this

nineteenth Day of *August 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

USCOMM-DC 60376-P69
U.S. GOVERNMENT PRINTING OFFICE : 869-930