United States Patent

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[54] **PNEUMATIC DOOR OPERATOR**
10 Claims, 10 Drawing Figs.

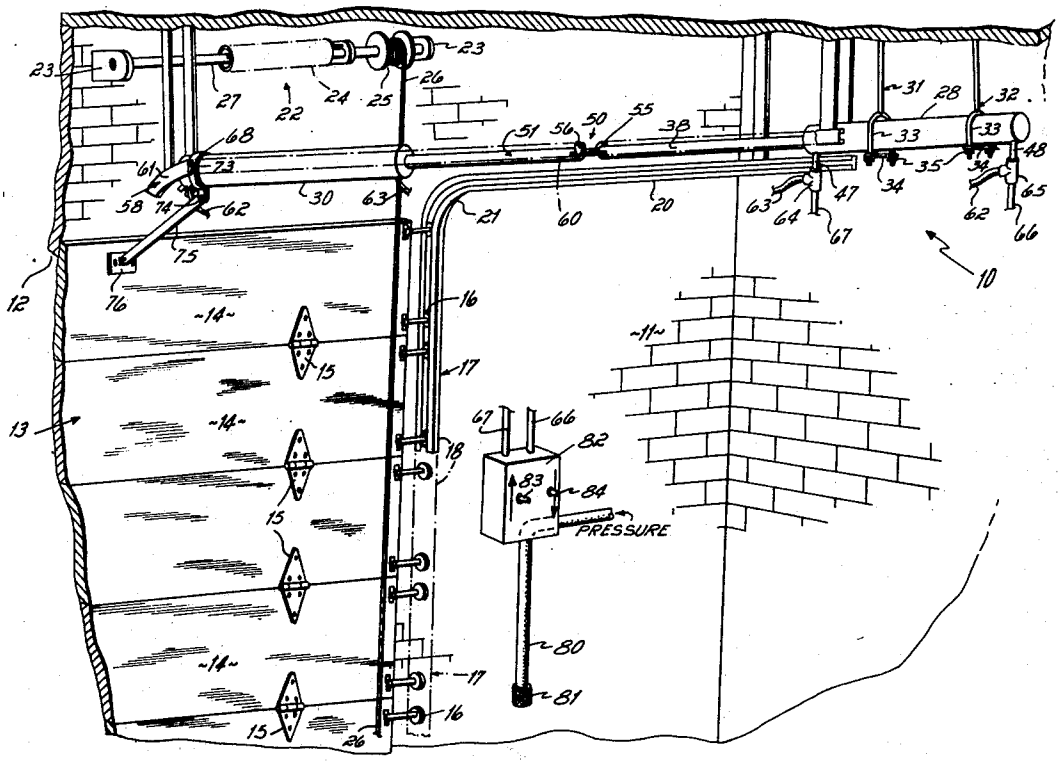
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[51] **Int. Cl.** **E05f 15/08**; E05f 17/00
[50] **Field of Search** ..... 160/188, 193; 91/173, 216, 217, 411; 92/152, 117(Cursory); 60/52(C.O.)

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ABSTRACT: A pneumatic operator for overhead and other doors. The operator includes two tandem-opposed hydraulic cylinders, a stationary rear cylinder and a movable forward cylinder. The forward cylinder is connected to the upper portion of the door by a rigid link. The piston rods of the front and rear cylinders are joined by a connector member. A track having a horizontal section and a curved forward section receives rollers joined to the connector member and forward cylinder. A source of pneumatic pressure is adapted to be connected to a first or second control line. The first control line communicates with the front end of the rear cylinder and the second control line communicates with the rear end of the front cylinder.



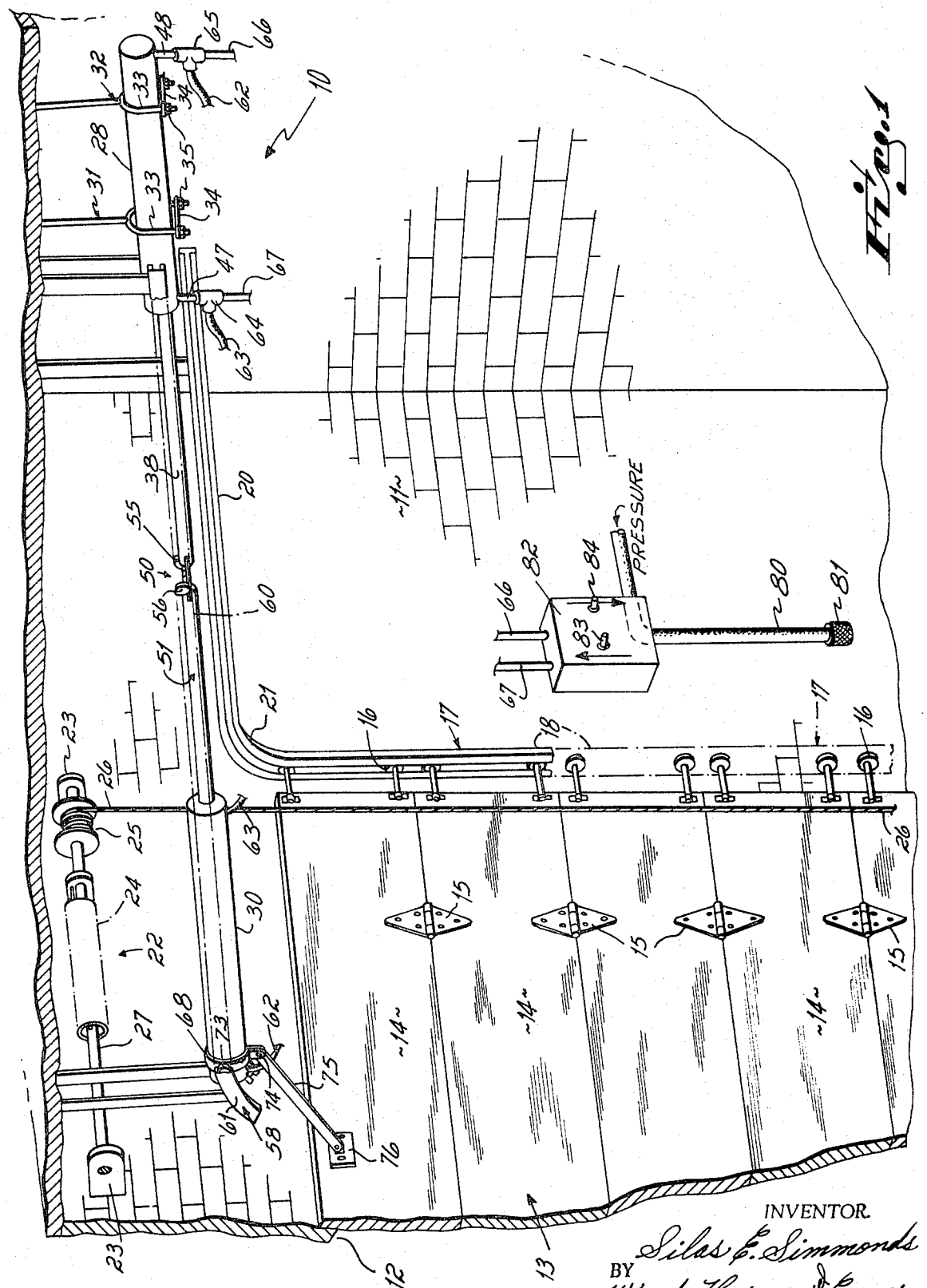


Fig. 1

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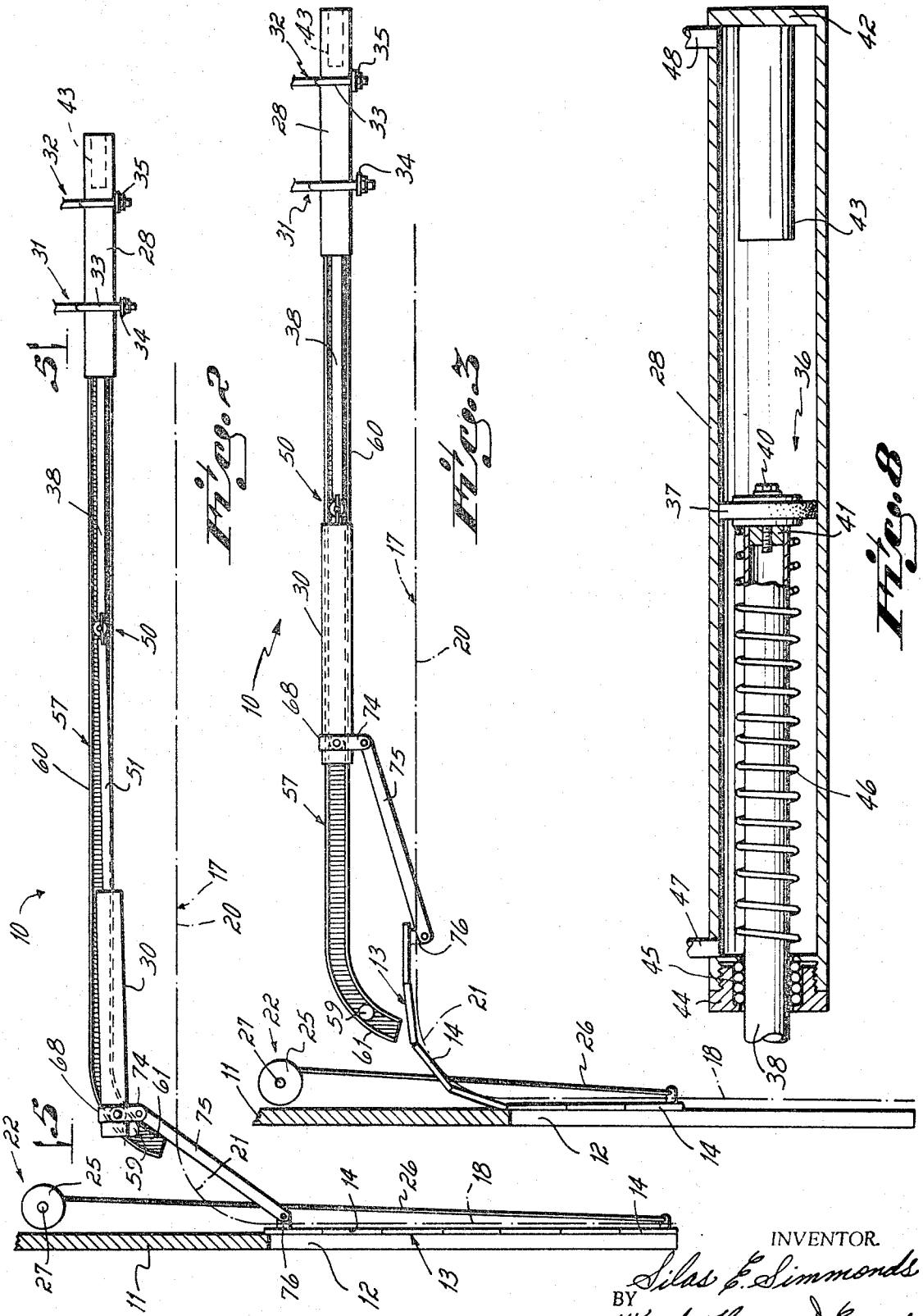


Fig. 2

Fig. 3

Fig. 8

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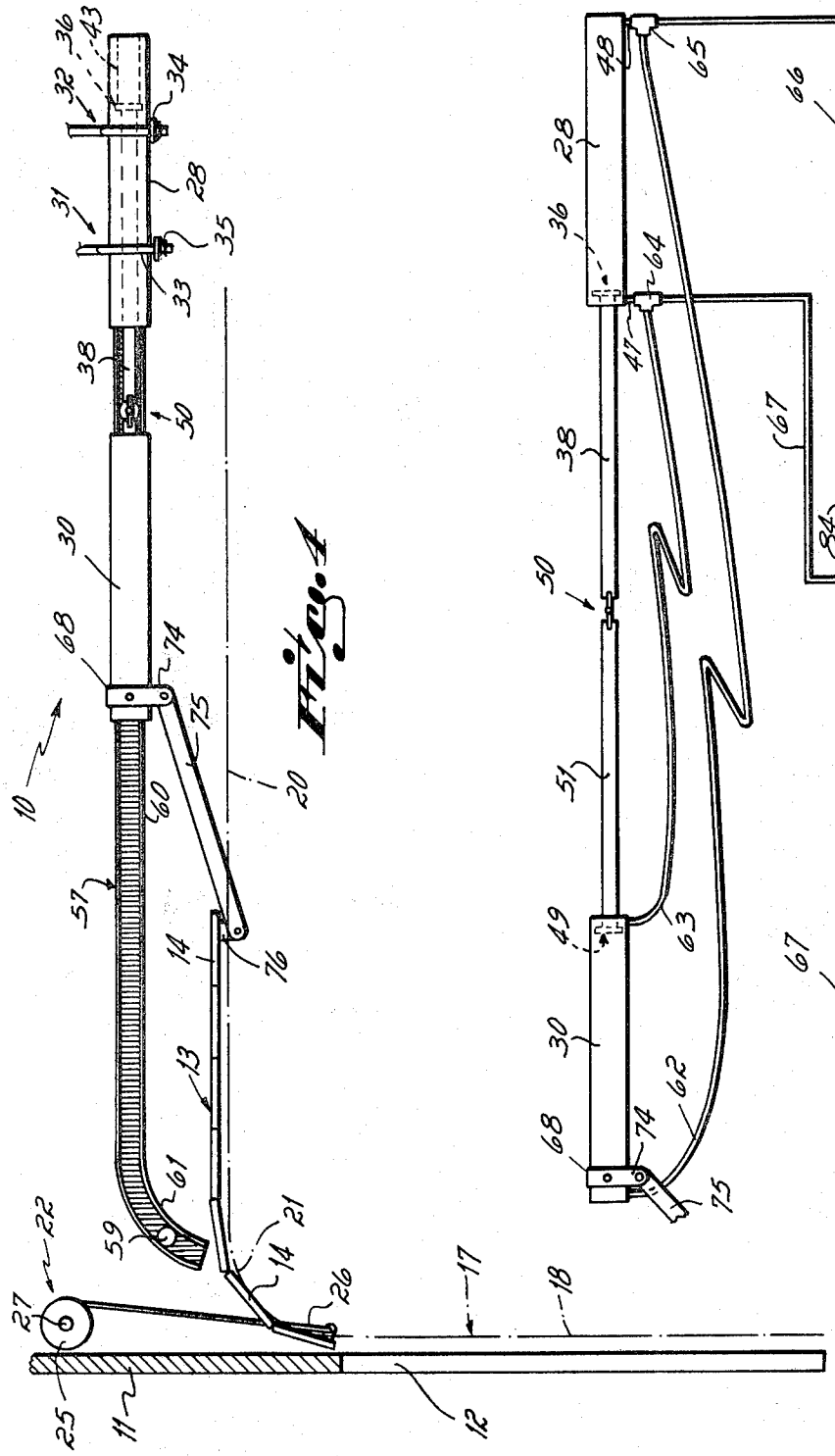


Fig. 4

Fig. 9

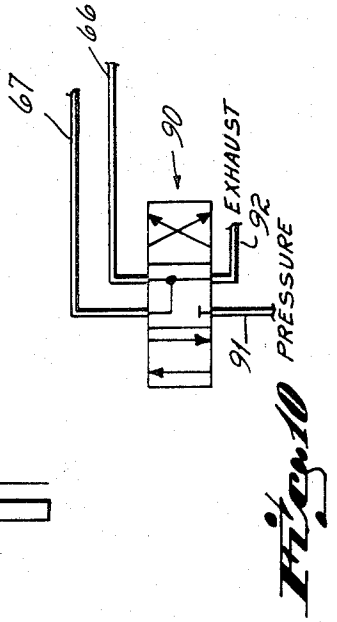


Fig. 10

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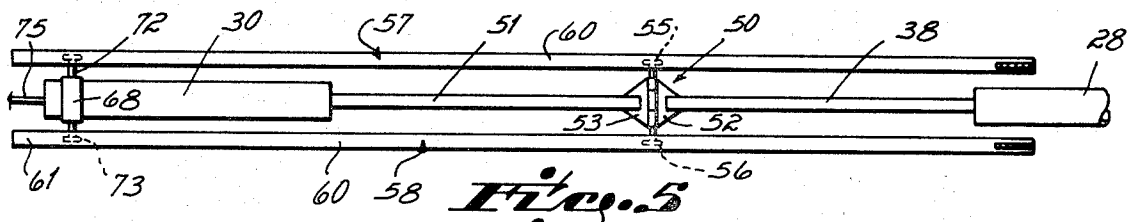


Fig. 5



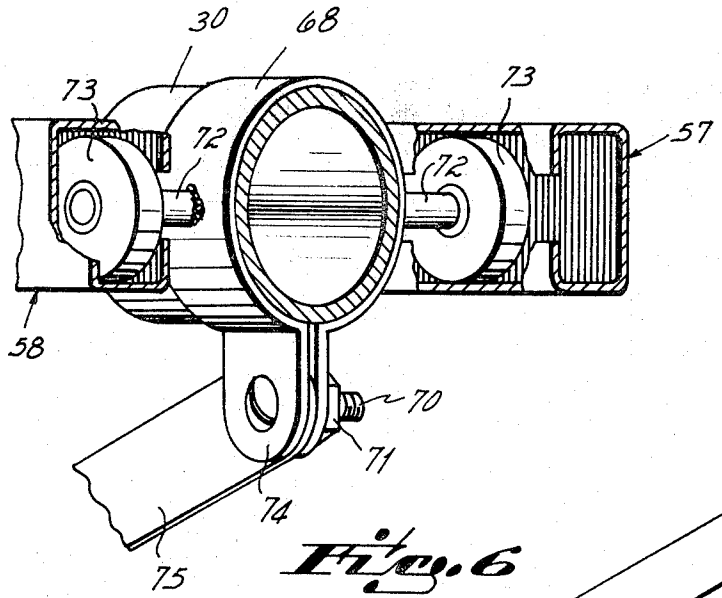


Fig. 6

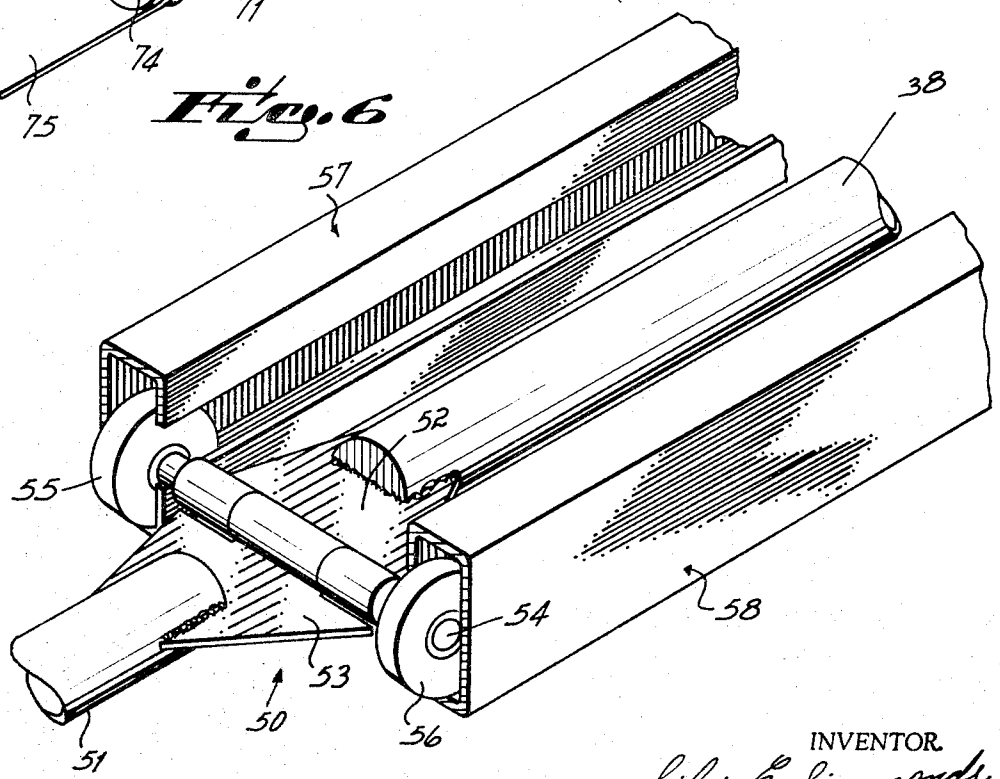


Fig. 7

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PNEUMATIC DOOR OPERATOR

BACKGROUND OF THE INVENTION

This invention relates to door actuators and is particularly directed to a pneumatic actuator for opening and closing overhead garage doors and the like.

In many buildings, such as automotive repair garages and warehouses for example, entrance to the building is gained through a relatively large opening adapted to be closed by a sizable door. The door for such a building is often of the order of from 12—20 feet high and requires a power operator. In many such installations, the presence of paint fumes or some other explosive atmosphere renders it undesirable to utilize an electric motor door operator. At the same time, many of these buildings have readily available a source of pneumatic pressure.

Accordingly, the principal object of the present invention is to provide a pneumatic door operator effective to positively open and close overhead doors particularly the large doors of this type commonly employed in garages, warehouses and other commercial buildings. It will be appreciated that the achievement of this objective is rendered considerably more difficult in the case of an overhead door because the door moves in at least two perpendicular planes, *i.e.* the door first moves upwardly in a vertical plane and then horizontally away from the wall.

Another object of the present invention is to provide a pneumatic door operator which is reliable in operation and has no tendency to bind or jam despite the fact that it is operating a heavy door requiring a relatively long travel.

A still further object of the present invention is to provide a pneumatic door actuator which is effective to stop the door almost immediately in any intermediate position between its fully open and fully closed position and is likewise effective when reactuated to shift the door to a fully open or closed position from any intermediate position in which it has been stopped.

An additional object of the present invention is to provide a door operator which is substantially less expensive than an electric operator for the same size door and which is considerably lighter in weight so that the operator imposes a considerably smaller load on the ceiling or other support structure.

More particularly, the present invention is predicated upon the concept of providing a pneumatic door actuator comprising tandem, opposed pneumatic cylinders having the free ends of their pistons hingedly joined by a connector member. One of the two pistons, the rear piston remote from the door, is mounted in a stationary position while the forward piston is mounted for guided movement along a track which includes a substantially horizontal portion and a forward downwardly sloping portion. The connector member joining the two piston rods is also guided along this same track.

The forward piston is interconnected to the upper end of the door by a rigid link pivotally connected to the door and to the forward piston. Each of the pistons and cylinders is double-acting with the forward end of the rear cylinder and the rearward end of the forward cylinder being joined to a common first control air line. Similarly, the forward end of the forward cylinder and the rear end of the rear cylinder are connected to a common second control air line. Means are provided for selectively connecting a source of air pressure to either the first or second control air line while at the same time venting the other line.

When the door is to be raised, the source of pressure is applied to the first control line so that pressure is simultaneously applied to the forward end of the rear cylinder and the rear end of the forward cylinder. The rear piston starts to retract while the forward cylinder starts to shift rearwardly over its piston. As the rear piston retracts, it moves upwardly along the curved portion of the track raising the door along the door tracks. Subsequently, the piston shifts the upper edge of the door in a horizontal plane as the door continues to be shifted to its completely open position.

To lower the door, the source of air pressure is applied to the second control line which causes pressure to be simultaneously applied to the frontportion of the forward cylinder and the rearward portion of the rear cylinder. The application of this pressure causes the rear piston to be advanced toward the door while the forward cylinder is advanced forwardly over its own piston rod. As a result, the door is pushed forwardly with the bottom portion of the door shifting downwardly along its track.

As the door approaches its completely closed position, the forward cylinder is tilted downwardly as its rollers enter the forward downwardly curving portion of its track. The door can be stopped in any intermediate position by merely removing the source of pressure from both control lines.

I have empirically determined that one of the advantages of the present control system is that it is extremely trouble-free despite the fact that the door travels a relatively long distance and is moved in two planes. This is due to the use of the tandem cylinders having their rods hingedly interconnected by a member which is guided along a track and by the provision of a track which is effective to tilt the forward cylinder as it approaches the end of its forward movement.

Another advantage of the present door operator is that the door can be quickly stopped in any intermediate position and can be either opened or closed from this intermediate position. Thus, if a car should start to drive under a door as it is being closed, the door can be stopped before the car is damaged. Also, the door can be stopped when it has been raised a sufficient distance to clear the particular vehicle passing through so that the door need not be opened 13 feet, for example, to permit passage of a 5 feet sports car.

A still further advantage of the present invention is that the actuator is effective to shift the door in a relatively rapid manner from its open to its closed position. The speed of movement of the door is increased by the simultaneous operation of the tandem pistons and cylinders. Moreover, the present pneumatic door operator is very smooth in operation.

An additional advantage of the present invention is that the actuator is located in a completely out of the way position. The actuator itself does not include any cables or other cumbersome devices located close to ground level where they might become caught in equipment or the like causing the mechanism to jam.

These and other objects and advantages of the present invention will be more readily apparent from a consideration of the following detailed description of the drawings illustrating a preferred embodiment of the invention.

In the drawing:

FIG. 1 is a perspective view of a typical overhead door fitted with a pneumatic operator embodying the present invention.

FIG. 2 is a side elevational view of the present operator with the door in its lowered position.

FIG. 3 is a view similar to FIG. 2 showing the door in a partially elevated position.

FIG. 4 is a view similar to FIG. 2 showing the door in a raised position.

FIG. 5 is a top plan view of the present pneumatic door operator taken along line 5–5 of FIG. 2.

FIG. 6 is an enlarged perspective view partially broken away of the forward cylinder.

FIG. 7 is a perspective view of the piston rod connector.

FIG. 8 is a longitudinal sectional view through the rear cylinder.

FIG. 9 is a schematic view of the pneumatic door operator.

FIG. 10 is a schematic circuit diagram of a modified form of door operator control.

One typical installation of a pneumatic door operator **10** is shown in FIG. 1. As there shown, one wall **11** of a building, such as a garage, warehouse or the like, is provided with a conventional door opening **12**. The door opening is adapted to be closed by a vertical folding door **13**. In the embodiment shown, this door comprises a plurality of panels **14** which are hingedly interconnected as by means of hinges **15**. Each side of the door carries a plurality of rollers **16** which track in

channel-shaped tracks 17 disposed at opposite sides of the door.

It will be appreciated that in a conventional installation, tracks 17 include a vertical run 18 extending from a point adjacent to the floor to a height slightly above the height of opening 12 and a horizontal section 20, the two sections being interconnected by a curved section 21. The weight of door 13 is substantially counterbalanced by a torsion spring assembly 22. This assembly includes shafts 27 carried by brackets 23, a torsion spring element 24, a drum 25 and a flexible cord 26 which is wound around the drum and is secured to the bottom portion of the door.

This much of the door construction is conventional and is described merely to provide a more complete understanding of the utility of the present pneumatic operator. It is to be understood that this door construction is merely exemplary and that the present operator could be utilized with different types of overhead doors or with horizontal sliding doors if desired.

The pneumatic operator 10 comprises tandem pneumatic cylinders 28 and 30. One of these cylinder—rear cylinder 28—is mounted in a stationary position in a generally horizontal plane remote from the door opening 12 by means of spaced hanger members 31 and 32. These hanger members are preferably in the form of inverted U-bolts 33 having a cross piece 34 drawn up against the cylinder as by means of bolts 35. The cross piece of the rear hanger member 32 is preferably tightened rigidly against the rear cylinder, while the cross piece of the forward hanger member is left slightly loose to provide a slight freedom of pivotal movement of the cylinder 28 to accommodate any misalignment of the cylinder.

As is shown in FIG. 8, rear cylinder 28 is fitted with a piston 36 having a peripheral rubber sealing member 37. The piston is secured to an elongated piston rod 38 as by means of a bolt 40 threadably engaging a plug 41 rigidly mounted inside piston rod 38. The rear end of the cylinder is closed in any suitable manner, such as by means of a rear wall 42, and is preferably provided with an inwardly extending abutment member, such as a section of pipe 43 effective to limit rearward movement of piston 36. The forward portion of the cylinder 28 is sealed in any suitable manner, such as, for example, by means of a threaded plug 44 which is carried by the end of the tubular cylinder and is effective to compress a suitable gasket material, such as a plurality of O-rings 45 against a stationary ring and washer so that the O-rings provide a seal between the cylinder and piston rod 38. A cushioning spring 46 is disposed over the piston rod 38 to cushion and limit forward movement of the piston 36. Cylinder 28 is provided with air connections at both its front and rear ends. The forward end of the piston is connected to air line 47 while the rear end of the cylinder is connected to air line 48.

The piston rod 38 is preferably of a length approximately equal to half the height of door opening 12. The forward, or free, end of this piston rod is welded or otherwise secured to a piston rod connector 50. This connector is effective to establish a pivotal connection between piston rod 38 of the rear cylinder and piston rod 51 of forward cylinder 30. Piston rod 51 is preferably substantially equal in length to piston rod 38. As shown in FIG. 7, connector 50 is generally like a hinge and includes leaf members 52 and 53 which are pivotally carried by a transverse pin 54. The ends of this pin, or shaft, carry rollers 55 and 56 which track in channel-shaped tracks 57 and 58. Tracks 57 and 58 extend parallel to one another from the forward end of the rear cylinder 28 into close proximity to the front wall 11. Tracks 57 and 58 include generally horizontal sections 60 and a downwardly curving forward section 61.

Piston rod 51 is joined to a piston 49 mounted within cylinder 30. It is to be understood that the internal construction of cylinder 30 and piston 49 are substantially identical with cylinder 28 and piston 36. Accordingly, cylinder 30 and piston 49 will not be described in detail.

Cylinder 30 is provided with connections at its front and rear portions to air lines 62 and 63 respectively. As is shown in FIG. 9, line 63 connected to the rear end of cylinder 30 is joined through tee 64 to line 47 connected to the front end of cylinder 28. Similarly, line 62 leading to the front end of cylinder 30 is connected through tee 65 to line 48 leading to the rear end of cylinder 28. Lines 62 and 48 are in turn connected to control line 66, while lines 63 and 47 are connected to control line 67. The manner in which these lines are connected into the pneumatic air system is described below in connection with the description of FIGS. 9 and 10.

Mechanically, forward cylinder 30 is free to move over its piston rod 51. Specifically, the forward end of cylinder 30 is mounted in a collar member 68 which is secured around the cylinder member and is tightly bolted in place as by means of bolts 70 and nuts 71. Collar 68 carries horizontally extending shafts 72 which in turn support rollers 73. These rollers track in tracks 57 and 58. Collar member 68 also includes two depending flanges 74 which receive between them a link 75, the link being pivotally mounted upon bolt 70. The opposite end of link 75 is pivotally secured to a bracket 76 mounted upon the upper edge of door 13 preferably adjacent to the center portion thereof. It is to be understood that the axis of cylinders 28 and 30 and tracks 57 and 58 extend in a plane normal to wall 11 and are preferably transversely positioned near the center of door 13.

The interconnections to the pneumatic cylinders 28 and 30 are best shown in FIG. 9. As there shown, the door actuator system includes a source of compressed air 77, for example, a motor driven compressor. This source of compressed air is connected to a conventional pressure reducer 78 which reduces the pressure of the compressed air to a suitable working pressure, for example 35 lbs. per square inch. The pressure reducer is in turn connected through suitable conduits to a flexible hose 80. This hose is provided with a female coupling 81 of the self-closing type, *i.e.* when coupling 81 is not in engagement with a male coupling member, hose 80 is sealed. As shown in FIG. 1, the hose is carried by a control housing 82 which also supports male fittings 83 and 84. These fittings are connected to the ends of lines 67 and 66 respectively. The male fittings 83 and 84 are constructed such that when female fitting 81 is snapped over them as shown in FIG. 9, a substantially airtight connection is made, and the male fittings open the internal valve in fitting 81 so that compressed air flows from compressor 77 through hose 80 and coupling 81 into the line connected to the associated male fitting. The construction of each of the male fittings is such that when it is not engaged by female coupling 81, its associated line 66 or 67 is vented to atmosphere.

In operation, the operator raises or lowers the door by coupling member 81 over the appropriate male fitting 83 or 84, depending upon whether he intends to open or close the door. For example, suppose that the door is in its down position as shown in FIG. 1. To open the door, female coupling 81 is snapped over male coupling 83. As a result, air pressure is introduced through lines 67, 63 and 47 simultaneously to the front end of rear cylinder 28 and the rear end of front cylinder 30. The forward cylinder 30 is thus urged rearwardly over its piston rod 51, while the rear piston and piston rod 38 are drawn rearwardly pulling with them piston rod 51 and piston 30.

As a result, the forward cylinder 30 starts to shift rearwardly toward stationary cylinder 28. Collar 68 is shifted upwardly along the curved portion 61 of tracks 57 and 58 and link 75 draws the upper end of the door upwardly over its curved track sections 21. As the piston rod 40 of the rear cylinder 28 continues to move rearwardly and forward cylinder 30 is forced rearwardly over its piston rod 51, the rollers 73 connected to the collar member 68 travel onto the horizontal section 60 of tracks 57 and 58 so that cylinder 30 is brought into a horizontal plane and the upper end of the door starts to move horizontally inwardly away from the door opening 12 as shown in FIG. 3. During this movement the connector member 50 between piston rods 40 and 51 is, of course, tracking horizontally along tracks 57 and 58. As the rear piston rod 38 continues to retract, the forward piston 30

simultaneously continues to move rearwardly over its piston rod **51**. This action continues until the door is completely opened as shown in FIG. **4**.

In this position the rear piston **36** is in engagement with the abutment **43** and the forward piston **49** is preferably fully retracted. The pressure of the system is such that no damage occurs even though the pressure connection is maintained after the door is fully opened. During the opening movements of the door, the air is exhausted from the rear portion of piston **28** and the forward portion of piston **30** through lines **62**, **48** and **66** and through rear fitting **84**. Since the cross-sectional area of this exhaust conduit is small in relation to the diameter of the pistons, a damping or smoothing effect is exerted on the operation of the actuator.

In order to close, or lower, the door, the operation is reversed, *i.e.* connector **81** is joined to male nipple **84**. This causes pressure to be applied through lines **66**, **48** and **62** to the rear portion of rear cylinder **28** and the forward portion of cylinder **30**. As a result, the rear piston and its piston rod **38** are urged forwardly toward wall **11**, while cylinder **30** is simultaneously urged forwardly over its piston rod **51**. Connector **50** tracks along the horizontal track section **57** as does the collar connection to piston **30**. Link **75** forces the door forwardly from the position shown in FIG. **4** to the position shown in FIG. **3**. If the pressure connection is maintained to line **66**, rear piston rod **38** and forward cylinder **30** continue their forward movements. As the door nears its closed position, the forward end of piston **30** is canted downwardly as the rollers **73** carried by collar **68** enter the downwardly curving portion **61** of tracks **57** and **58**. The door is thus firmly urged downwardly into its completely lowered position. A stop **59** is provided in tracks **57** and **58** to limit forward movement of cylinder **30**.

If at any time during the raising or lowering operation it is desired to stop the door, it is only necessary to disconnect female coupling **81** from male coupling **83** and **84**. When this is done, the pressure previously applied to cylinders **28** and **30** is immediately vented through the open lines and the door stops immediately, for example, within a travel of an inch or so. The door remains in any position in which it is stopped until pressure is reapplied to raise or lower the door by reconnecting coupling **81** to couplings **83** or **84**.

While the control arrangement shown in FIG. **9** is advantageous because of its extreme simplicity and economy, it is obvious that the same control operation can be obtained through the use of a valve, such as a manually operated three-position, four-connection valve shown diagrammatically in FIG. **10**. As there shown, the valve **90** is a manually operated valve which is effective to provide exactly the same operating conditions provided in the circuits shown in FIG. **9**. Valve **90** is connected to lines **67** and **68** and to a pressure line **91** which is permanently connected to pressure regulator **78**. The valve is also connected to an exhaust line **92** vented to atmosphere. When the valve is in the center position as shown in FIG. **10**, the pressure line **91** is closed and lines **67** and **68** are both connected to atmosphere. When the valve is shifted to the right, the door will be opened since line **67** will be connected to pressure line **91** and line **68** will be connected to exhaust line **92**. This is functionally the same as connecting coupling **81** to male coupling **83**. Similarly, when the valve is shifted to its extreme left position, the door will be lowered since pressure will be applied to line **68** and line **67** will be vented to atmosphere. This is functionally the same as connecting coupling **81** to coupling **84**.

From the foregoing disclosure of the general principles of the present invention and the above disclosure of a preferred embodiment, those skilled in the art will readily comprehend various modifications to which the invention is susceptible. Specifically, as was mentioned above, while the present door operator is particularly advantageous for use with overhead doors it can also be utilized with other types of doors, such as sliding doors, particularly where long movements are involved. Moreover, while the preferred embodiment includes two pneumatic motors which are connected in opposed tandem relationship, *i.e.* with their pistons connected together, and while this provides certain additional advantages, it is also contemplated that in some installations the motors can be connected in tandem relationship with the front motor reversed from the position shown. In this arrangement the cylinder of the forward motor is connected to the piston rod of the rear motor while the piston rod of the forward motor is connected to the door through a pivoted link. In this modification the pneumatic circuit is also slightly modified in that the first control line **66** is connected to the rear ends of both cylinders, while the second control line **67** is connected to the forward ends of both cylinders.

I claim:

1. A pneumatic actuator for overhead doors of the type having hinged sections guided along a door track having a vertical and horizontal leg, the actuator comprising:

front and rear pneumatic motors, the rear motor being disposed remote from the door, the front motor being disposed adjacent to the door, each of said pneumatic motors comprising two relatively movable elements, one of said elements being a cylinder, the other of said elements being a piston rod;

means mounting the cylinder of the rear motor in a stationary position;

means interconnecting the piston rod of the rear motor to a first of the two relatively movable elements of the front motor;

rigid link means pivotally interconnecting the second element of said front motor to the door;

actuator track means for guiding the first member of said front motor, said track means also guiding the second member of the front motor and the piston rod of the rear motor;

first and second control lines, the first said control line being connected to the forward portion of said rear motor cylinder and a portion of said front motor cylinder so that pressure in said line is effective to cause said first member to be moved rearwardly, the second line being connected to the rear portion of the rear cylinder and a portion of the front cylinder so that pressure in said line is effective to cause said first member to be moved forwardly; and

means for selectively applying pressure to either of said first or second control lines while venting the other said control line.

2. The pneumatic actuator of claim **1** in which said actuator track means includes a horizontal section substantially parallel to the horizontal section of the door track and a downwardly curved section adjacent to the door.

3. A pneumatic actuator for overhead doors of the type having hinged sections guided along a door track having a vertical and horizontal leg, the actuator comprising:

front and rear pneumatic motors, the rear motor being disposed remote from the door, the front motor being disposed adjacent to the door, each of said pneumatic motors comprising two relatively movable elements, one of said elements being a cylinder, the other of said elements being a piston rod;

means mounting the cylinder of the rear motor in a stationary position;

coupling means pivotally interconnecting the piston rod of the rear motor to the piston rod of the front motor;

rigid link means pivotally interconnecting the cylinder of said front motor to the door;

actuator track means for guiding the cylinder of said front motor, said track means also guiding the piston rods of the front and rear motors;

first and second control lines, the first said control line being connected to the forward portion of said rear motor cylinder and a rearward portion of said front motor cylinder, the second line being connected to the rear portion of the rear motor cylinder and a forward portion of the front motor cylinder; and

control means for selectively applying pressure to either of said first or second control lines while venting the other said control line.

4. The pneumatic actuator of claim 3 in which said actuator track means includes a horizontal section substantially parallel to the horizontal section of the door track and a downwardly curved section adjacent to the door.

5. The pneumatic actuator of claim 3 in which said coupling means carries a member guided by said actuator track means.

6. The pneumatic actuator of claim 5 in which said forward motor cylinder carries a follower adjacent its forward end, said follower being in engagement with said actuator track means.

7. The pneumatic actuator of claim 3 in which said control means comprises male couplings secured to the ends of the first and second control lines, a flexible conduit connected to a source of compressed air, and a self-closing female coupling mounted on the end of said flexible conduit.

8. The pneumatic actuator of claim 3 in which said control means comprise a three-position, four-connection valve, the valve having a center position in which both of said control lines are vented and the pressure line is sealed.

9. The pneumatic actuator of claim 4 in which said coupling means comprises a hinge member including leaves secured to each of said piston rods and a pivot pin, a roller on said pivot pin in engagement with said actuator track means.

10. The pneumatic actuator of claim 9 in which a collar is secured around said forward cylinder adjacent to the forward end thereof, said rigid link means being pivotally connected to the collar, said collar also carrying a roller in engagement with said track means.