# United States Patent [19]

**Daugirdas**

[11] **3,916,567**

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[54] **OBSTRUCTION SENSOR FOR PNEUMATIC DOOR OPERATOR**


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[73] Assignee: **Vapor Corporation,** Chicago, Ill.



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[52] **U.S. Cl.** ..... **49/28**

[51] **Int. Cl.²** ..... **E05F 15/06**

[58] **Field of Search** ..... 49/27, 28, 24



[56] **References Cited**

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| 1,134,608 | 4/1915 | Gottschalk | 49/27 |
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| 1,849,516 | 3/1932 | Forman | 49/24 |
| 2,782,028 | 2/1957 | Almond | 49/27 |



*Primary Examiner*—Kenneth Downey

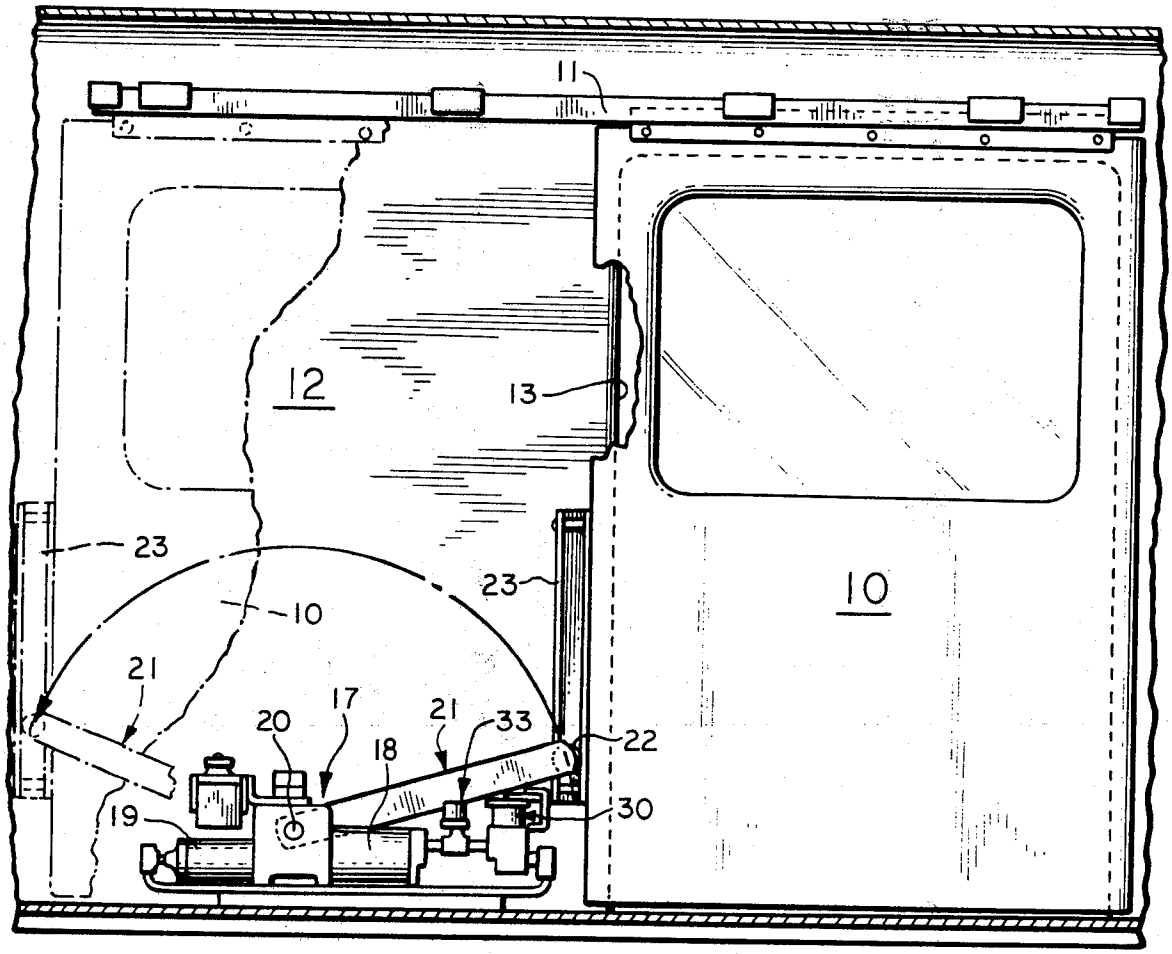
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[57] **ABSTRACT**

A differential pneumatic door actuator, including pneumatic and electrical controls wherein the actuator is drivingly connected to a door and provided with large and small air cylinders, and a pressure responsive switch monitors the pressure in the large cylinder to actuate a reversing cycle relay when a given pressure is detected during the closing cycle.


**9 Claims, 4 Drawing Figures**



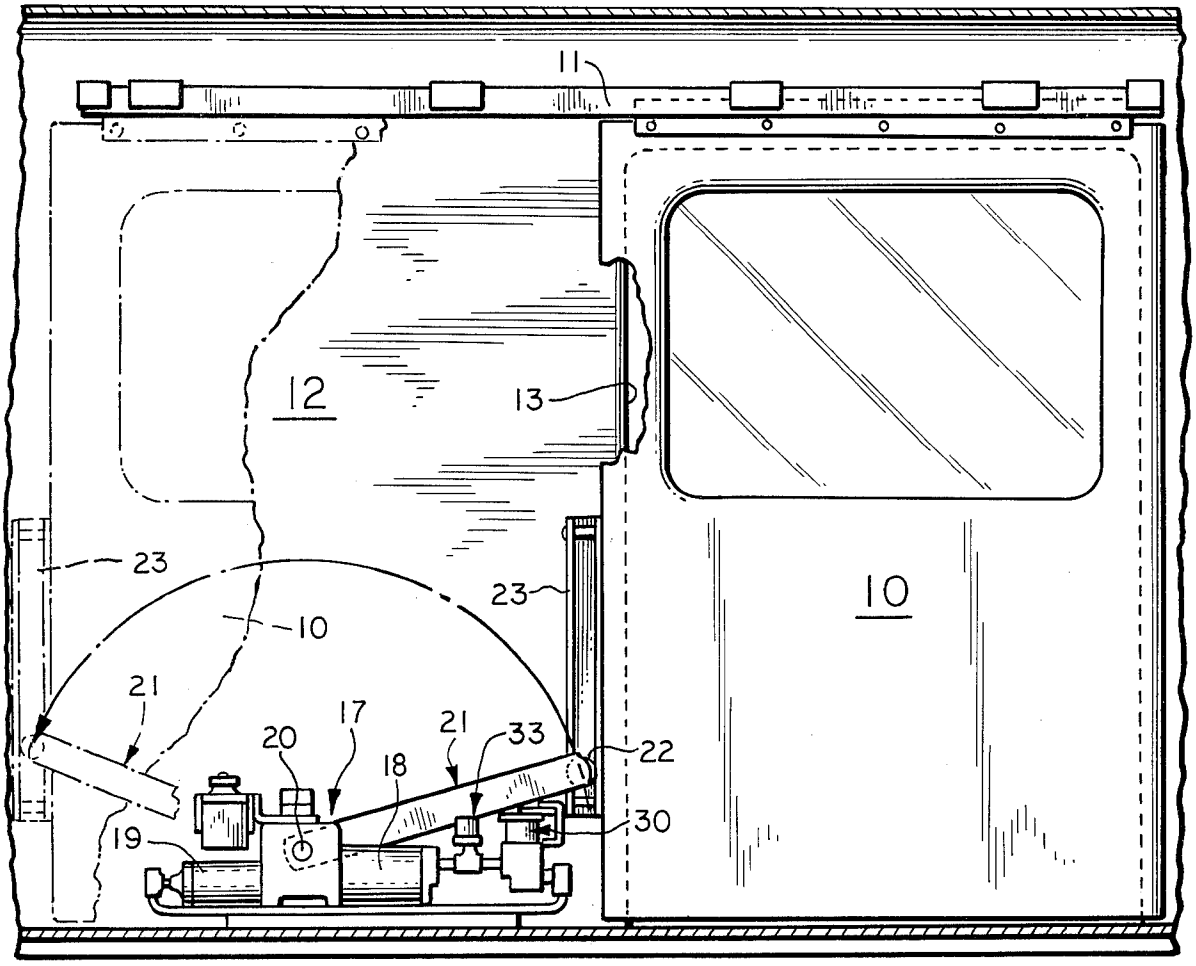

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30
19

FIG. 1

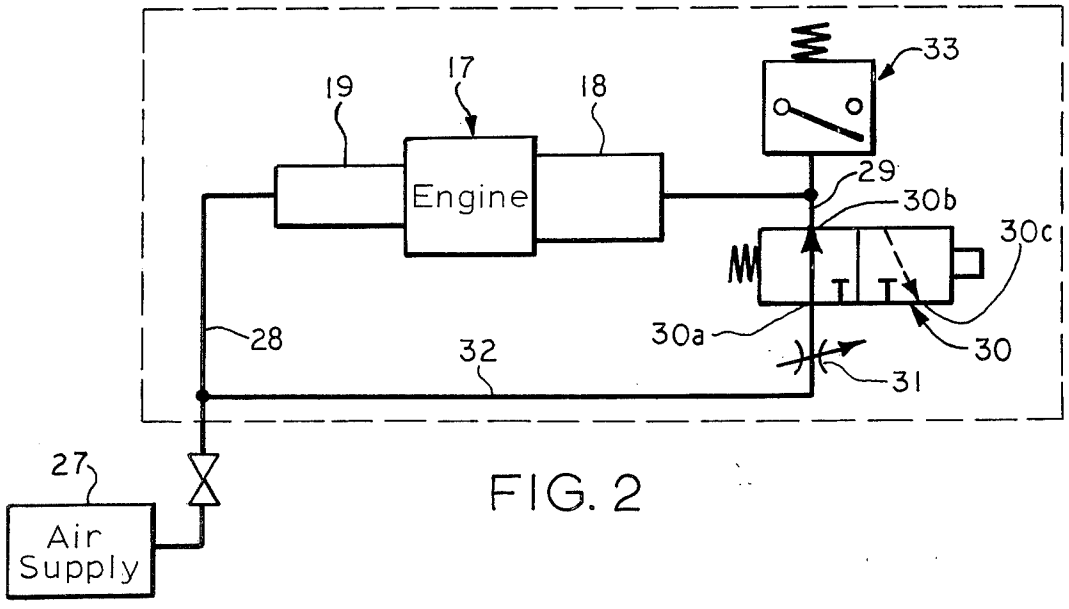

19
17
18
33
Engine
29
30b
30c
T
T
28
32
30a
30
31
27
Air Supply

FIG. 2

FIG. 3

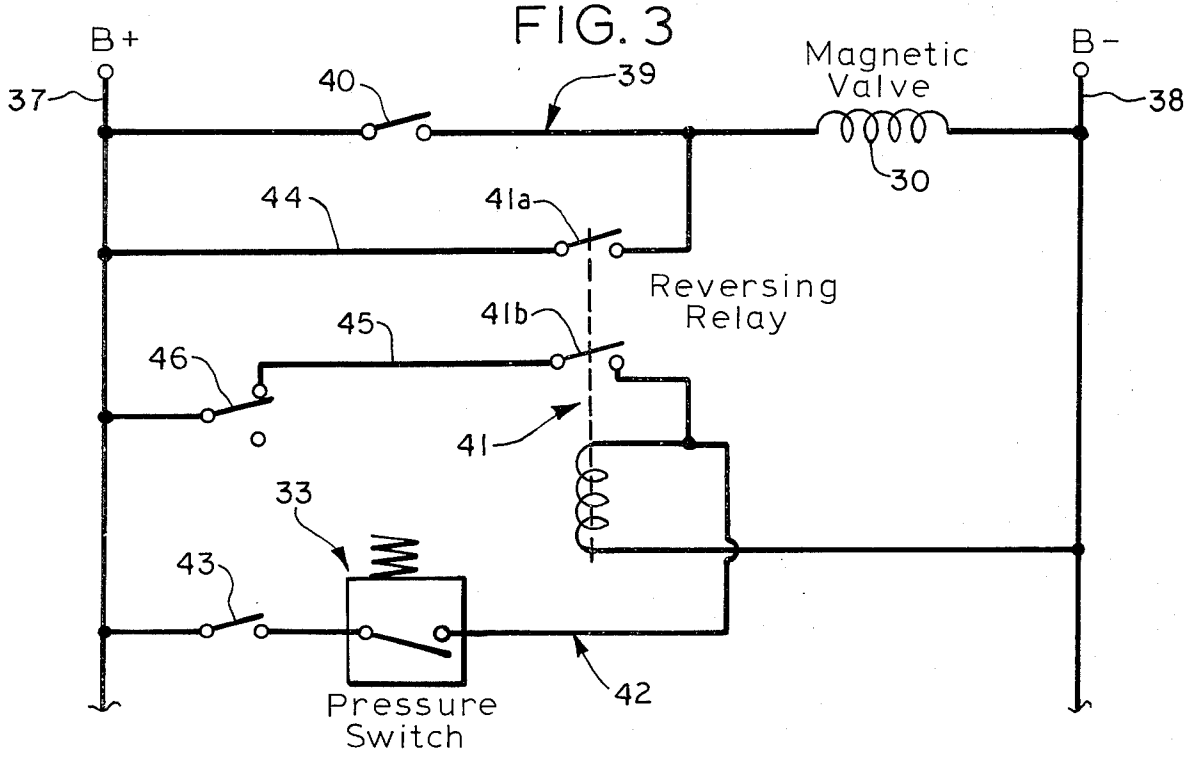
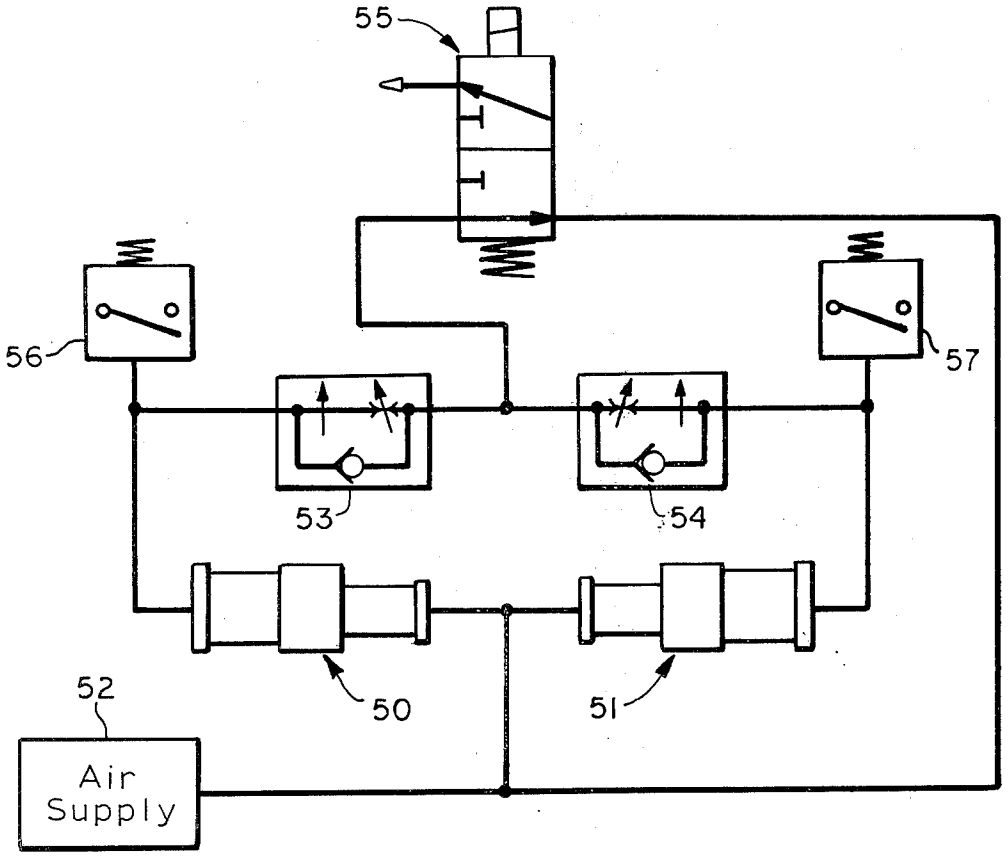

B+
37
40
39
Magnetic Valve
B-
38
30
44
41a
Reversing Relay
45
41b
46
41
33
43
42
Pressure Switch

FIG. 4


55
56
57
53
54
50
51
52
Air Supply

# OBSTRUCTION SENSOR FOR PNEUMATIC DOOR OPERATOR

This invention relates in general to pneumatic door operators for opening and closing doors in a vehicle or a building, and more particularly to an obstruction sensor for a differential pneumatic door engine.

The present invention is particularly concerned with door actuating systems where the doors are power driven between open and closed positions in relation to doorways through which persons are moving between the inside and outside of a vehicle, a building, or the like.

It has been well known to provide obstruction sensors for door operators which reverse the closing cycle to open a door or which otherwise stop a closing cycle. It has also been well known to utilize pneumatic door engines in door operators. In recent years, increased emphasis on more efficient operation of mass transit vehicles has made entry and exit of passengers a critical operation. Door systems have become highly complicated and require more rapid door operation to satisfy these requirements, door operators are necessarily designed to generate greater forces in order to achieve the higher door speeds.

Possibilities for injury to passengers passing through the newer door system are substantially increased by rapid operation and greater force characteristics. For example, a passenger can be struck by the moving door edge, and may be injured at the point of contact or in a subsequent fall from the vehicle. A more serious situation arises when a passenger is caught in the door and dragged as the vehicle begins to move.

These factors have placed increased emphasis on obstruction sensing in order to allow door operation in a reasonable time while minimizing possibilities for injury to passengers. This is best done by rapidly sensing the buildup or rate of change of force due to an obstruction in the door path and quickly removing the force by reversing the door motion.

The present invention concerns an obstruction sensor for a differential pneumatic door engine of the well known type such as shown in U.S. Pat. No. **1,849,516.** It has also been well known to provide obstruction sensors for such an engine responding to engagement between an obstruction and the door edges which actuate controls, such as in U.S. Pat. No. **2,832,588.** It is further known to provide door edges with electrical switches connected in the controls for a pneumatic door engine. All such door edge sensors require connections with the door engine controls.

The present invention provides an obstruction sensor for a differential pneumatic engine which is built into the controls of the engine and remote from the door edge and depends only on the force-time relationship of the door during the closing cycle when an obstruction is encountered. More specifically, a pressure sensing switch monitors the closing pressure of an engine during a door closing cycle such that when the closing pressure rises above a given level due to the door encountering an obstruction, activation of the pressure sensing switch causes the door to stop and move to a fully open or partially open position as desired before again commencing the closing cycle.

It is therefore an object of the present invention to provide an improved obstruction sensor for a differential pneumatic door engine which responds to the closing pressure of the engine during the closing cycle.



Another object of the present invention is to provide a door obstruction sensor for a differential pneumatic door engine wherein the pressure of the large cylinder is monitored during the closing cycle and, if rising to a given value, will actuate a pressure responsive switch to reverse the movement of the door, and in so doing limit the closing force developed by the door edge in both magnitude and duration, greatly reducing possibilities of injury to passengers who might be struck or caught by the door during the closing cycle.

Other objects, features and advantages of the invention will be apparent from the following detailed disclosure, taken in conjunction with the accompanying sheets of drawings, wherein like reference numerals refer to like parts, in which:

FIG. **1** is a somewhat diagrammatic view of a door engine operating a door and which includes the obstruction sensor according to the present invention;

FIG. **2** is a piping schematic diagram of the pneumatic controls for the door engine shown in FIG. **1**;

FIG. **3** is an electrical schematic diagram of the controls for the door engine; and

FIG. **4** is a piping schematic diagram of the pneumatic controls for a pair of door engines operating biparting doors.

Referring now to the drawings and particularly to FIG. **1**, a door **10** is illustrated as being suspended from a track **11** for sliding movement therealong in a side wall **12** of a vehicle or building having an opening **13.** A differential pneumatic door engine **17** is illustrated as being mounted laterally of the door opening for driving the door **10** between open and closed positions.

The door engine **17** is of the well known type as shown in U.S. Pat. No. **1,849,516,** wherein it includes large and small cylinders **18** and **19** and an output shaft **20** driven by the cylinders. The output shaft is suitably drivingly connected to the door **10,** wherein it includes a lever arm **21** connected at one end to the shaft **20** and provided with a roller **22** at the other end engaging in a vertical track **23** connected to the trailing edge of the door **10.** The position of the lever arm **21,** as shown in solid lines, disposes the door **10** in closed position relative the opening **13** and, as shown in dotted lines, where the arm has oscillated counter-clockwise disposes the door in open position relative to the door opening.

The invention concerns the door leading edge encountering an obstruction during the closing cycle, so that the door closing cycle can be reversed to prevent injury to the obstruction or damage to the door operating system, especially where it may be a person, and where reversing the closing cycle will allow the person to move from the path of the door before the door is driven through another closing cycle. The obstruction sensor of the invention is built into the controls for the door engine such that there is no need to mount any detector in the leading edge of the door.

The pneumatic piping circuit for the door engine **17** and applicable for the installation shown in FIG. **1** is illustrated diagrammatically in FIG. **2,** wherein a suitable air supply or source **27** is directly connected to the small cylinder **19** by a line **28.** The large cylinder **18** is connected through a line **29** to a three-way normally open magnet valve **30,** which is in turn connected through a speed control valve **31** and line **32** to the air supply **27.** The closing speed of the engine may be ad-

justed by the speed control valve. A pressure switch **33** is connected to the line **29**, thereby monitoring the pressure in the large cylinder **18**. The manner in which the well known differential engine **17** operates is conventional in that when the magnet valve **30**, which includes a port **30***a* connected to the speed control valve, a port **30***b* connected to the line **29** and the large cylinder **18** and port **30***c* connected to atmosphere, is deenergized as illustrated in FIG. **2**, ports **30***a* and **30***b* are connected to interconnect the air supply to the large cylinder **18** which overcomes the force generated in the small cylinder **19** to either cause a closing cycle if the door had been in open position or to maintain the door in closed position, as illustrated by the parts in solid lines in FIG. **1**. Energization of the magnet valve **30** interconnects the port **30***b* to port **30***c* for exhausting the air pressure from the large cylinder **18** wherein the force generated in the small cylinder **19** will cause a door opening cycle. During the closing cycle when the magnet valve is de-energized, as illustrated in FIG. **2**, should the door encounter an obstruction sufficient to cause the pressure in the large cylinder to rise above a given point according to the adjustment of the pressure switch **33**, the pressure switch **33** will be activated to cause the reversing cycle as will be more clear following the description of the electrical diagram in FIG. **3**. While the pressure switch may be adjusted to activate or trigger at any given level, it is preferably set to trigger at about sixty percent of the line pressure from the air supply.

Referring now to FIG. **3**, an electrical schematic diagram for controlling the magnet valve is illustrated which includes a suitable power supply connected across lines **37** and **38**. The magnet valve **30** is connected at one end to line **38** and at the other end to a manually operable door control line **39**, having a switch **40** which, when closed, will energize the magnet valve and cause a door opening cycle and which, when opened, will de-energize the magnet valve and cause a door closing cycle.

A reversing relay **41** is connected to cause energization of the magnet valve **30** and reversal of the door closing cycle in the event the pressure switch **33** is triggered during a door closing cycle. The relay is connected at one end to the line **38** and at the other end to the pressure switch line **42** having the pressure switch **33** and a limit switch **43** therein. The limit switch **43** is suitably actuated by a cam (not shown) on the output shaft of the door engine such that the limit switch is open, as illustrated when the doors are in closed position, to prevent the pressure switch **33** with its closed contacts from triggering the reversing relay, as the pressure in the large cylinder will build up to line pressure when the door is in closed position. During the opening cycle of the door, when the pressure in the large cylinder is exhausted to atmosphere, the pressure switch will open and the limit switch **43** will be closed. Accordingly, the limit switch **43** will be closed during the closing cycle of the door until the door reaches fully closed position when it will then open.

The reversing relay **41** includes switch contacts **41***a* and **41***b*. Contacts **41***a* are in a reversing line **44**, while contacts **41***b* are in a "stick circuit" line **45**. Additionally, limit switch **46** is in line **45** and operable to open when the door reaches fully open position or any partial open position if desired.

The contacts shown in FIG. **3** are illustrated in their positions when the door is fully closed. In operation, normal opening and closing of the door is accomplished by actuation of the switch **40** for energizing the magnet valve **30** to cause an opening cycle and de-energizing the magnet valve to cause a closing cycle. When the doors are in fully opened position and normally during the closing cycle, the limit switch **43** will be closed and the pressure switch contacts will be open. During the closing cycle, the pressure in the large cylinder is less than line pressure and less than that which would cause triggering of the pressure switch due to the pressure drop across the speed control valve. The limit switch contacts **46** would be open at the full open position or any partial open position as desired. During the closing cycle when the switch **40** is open, should an obstruction be encountered by the door thereby stopping or nearly stopping the door in the closing cycle, pressure will build up in the large cylinder **18** and at the given pressure value of the pressure switch **33** cause triggering of the pressure switch to close the contacts and energize the reversing relay **41** to reverse the closing cycle and cause the door to move toward the open position. The forces produced at the door edge, when encountering an obstacle, therefore, have a controlled buildup and can easily be held to a safe maximum value. Also, the duration of the peak force is only a few milliseconds since the reversal relay and magnetic valve **30** operate in milliseconds to exhaust the large cylinder and open the door. It can be appreciated that since chances of injury to passengers struck by or caught in the door while exiting a vehicle is greatly minimized by the rapid decrease of door edge force. Energization of the reversing relay energizes the magnet valve **30** to exhaust the air from the large cylinder **18** whereby the pressure in the small cylinder **19** will cause the opening cycle. The contacts **41***b* close the stick circuit line **45** so that as the pressure switch releases and opens its contacts in the opening cycle, the reversing relay will be maintained in energized position to continue the opening cycle until the limit switch **46** is opened. Thereafter, de-energization of the reversing relay and the magnet valve will again allow the door to move to closed position. If the obstruction is then removed from the path of the door, it will continue until it is in fully closed position.

It will be appreciated the controls for sensing the obstruction, while described above as applicable to a single door engine for a single door, can also be applied to biparting doors where each is driven by a door engine. A piping diagram illustrating the pneumatic circuit for such an arrangment is illustrated in FIG. **4** wherein door engines **50** and **51** have their small cylinders connected directly to an air supply **52** and their large cylinders connected to the air supply through flow control valves **53** and **54** and a three-way normally open magnet valve **55**. The flow control valves **53** and **54** are essentially the same as the speed control valve **31** in the embodiment of FIG. **2**, while the magnet valve **55** is essentially the same as that illustrated in the embodiment of FIG. **2**. Pressure sensing switches **56** and **57** respectively monitor the pressure in the large cylinders of the door engines **50** and **51**. The circuit of FIG. **3** would be modified by merely including another pressure switch line for the additional pressure switch and which would be in parallel with the pressure switch line **42**. A limit switch would also be provided in the addi-

tional pressure switch line and it can be appreciated that one of the pressure switch lines would relate to the pressure switch **56**, while the other would relate to the pressure switch **57**. Further, it can be appreciated that the door engines would operate together pursuant to the operation of the single magnet valve **55** and should one of the biparting doors sense an obstruction thereby triggering one of the pressure switches, the reversing relay would cause the magnet valve to reverse the closing cycle of both doors being driven by the door engines **50** and **51**. It can be appreciated that any number of door engines may be included responding to a single magnet valve and for obstruction sensing a pressure switch would monitor the pressure in each of the large cylinders of the door engines.

It may be appreciated that adjustment of the pressure switches will permit reversal of the door closing cycle responsive to any given obstruction force. Preferably, the switch is adjusted to close and reverse the door closing cycle when the pressure in the large cylinder of the engine is approximately sixty percent of available line pressure. It may therefore be seen that the present invention provides a foolproof and economical arrangement for sensing door obstruction and reversing the door closing cycle.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention, but it is understood that this application is to be limited only by the scope of the appended claims.

The invention is hereby claimed as follows:

**1.** In a system for operating a door between open and closed positions and reversing a door closing cycle upon sensing an obstruction at the door, a differential pneumatic door engine having large and small cylinders and an output shaft driven by the cylinders and drivingly connected to the door, an air supply, means connecting the air supply directly to the small cylinder, an electrically operable valve for selectively interconnecting the large cylinder to the air supply to close the door or to atmosphere to open the door, flow control means between the air supply and the large cylinder, a normally open pressure switch monitoring the pressure in the large cylinder and responding to an obstruction encountered by the door, a reversing cycle relay having contacts for operating the valve to interconnect the large cylinder to atmosphere, and said pressure switch having contacts for operating said relay to close the valve contacts and cause the valve to interconnect the large cylinder to atmosphere for a door opening cycle, wherein said pressure switch and said flow control means coact with each other to respond to a predetermined pressure in the large cylinder caused by an obstruction encountered by the door.

**2.** In a system as defined in claim **1**, which further includes means for disabling the pressure switch when the door is in closed position.

**3.** In a system as defined in claim **2**, which further includes means for maintaining the relay conditioned to hold the valve contacts closed until the door has opened to a predetermined position.

**4.** In a system for operating a door between open and closed positions and reversing a door closing cycle upon sensing an obstruction at the door, a differential pneumatic door engine having large and small cylinders and an output shaft drivingly connected to the door, an air supply connected directly to the small cylinder, a two-position three-way normally open exhaust-type magnet valve having a first port connected to the large cylinder, a second port connected to the air supply, and a third port connected to atmosphere, wherein the valve when de-energized interconnects said first and second ports causing the engine to close the door and when energized interconnects said first and third ports causing the engine to open the door, a normally open pressure switch connected to monitor the pressure of said large cylinder, flow control means between said air supply and said valve, a reversing cycle relay having contacts for energizing the magnet valve, and said pressure switch having contacts for energizing said relay upon detecting a given pressure in the large cylinder during the door closing cycle, wherein said pressure switch and said flow control means coact with each other to respond to a predetermined pressure in the large cylinder caused by an obstruction encountered by the door.

**5.** In a system for driving a door between open and closed positions having a differential pneumatic door engine, an air supply for driving said engine, said engine having an output shaft and large and small cylinders driving said shaft, and means drivingly connecting the outputshaft to the door, the improvement being in control means for said engine which senses a door obstruction and reverses the door closing cycle, said control means including means connecting the small cylinder directly to the air supply, a three-way magnet valve connected between the air supply and large cylinder interconnecting the large cylinder to the air supply when de-energized to cause a door closing cycle and to the atmosphere when energized to cause a door opening cycle, a reversing cycle relay having normally open contacts which close upon energization thereof to cause energization of the magnet valve, a pressure sensing switch monitoring the pressure in the large cylinder having contacts which close in response to a given pressure to cause energization of the reversing relay, and flow control means between the air supply and the large cylinder, wherein said pressure switch and said flow control means coact with each other to respond to a predetermined pressure in the large cylinder caused by an obstruction encountered by the door.

**6.** In a system as defined in claim **5**, wherein said control means further includes a limit switch in series with the contacts of the pressure sensing switch, and means for opening the limit switch when the door reaches fully closed position.

**7.** In a system as defined in claim **6**, wherein said control means further includes a "stick circuit" having contacts which close upon the energization of the reversing relay and a normally closed limit switch and means for opening same during the door opening cycle to de-energize the reversing relay and cause a door closing cycle.

**8.** In a system as defined in claim **7**, wherein the pressure sensing switch is set to operate and close its contacts in response to detection of about sixty percent line pressure.

**9.** In a system for driving a door between open and closed positions having a differential pneumatic door engine, an air supply for driving said engine, said engine having an output shaft and large and small cylinders driving said shaft, and means drivingly connecting the output shaft to the door, the improvement being in control means for said engine which senses a door ob-

struction, limits the door edge force in accordance with the resistance of the obstruction before the large cylinder develops maximum force and reverses the door closing cycle, said control means including orifice means between said air supply and said large cylinder, valve means for selectively interconnecting the large cylinder to the air supply to close the door or to atmosphere to open the door, and a pressure responsive means monitoring the pressure in the large cylinder for controlling operation of said valve means, whereby said pressure responsive means and said orifice means coact with each other to respond to a predetermined pressure in the large cylinder caused by an obstruction encountered by the door.

* * * * *