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(54) **CONTROL CIRCUIT FOR A PNEUMATICALLY ACTUATED VEHICLE DOOR**

(57) Control circuit for a pneumatically controlled vehicle door comprising a double-acting pneumatic cylinder (9) operable to open and close said door and having a first chamber (10) and a second chamber (11), a main pneumatic control block (5) having a first working port (7) and a second working port (8), a first line (12) connected to the first chamber (10) of the cylinder (9) and constituting a release line in a given movement direction of the cylinder (9) corresponding to a first movement direction of the door, and a second line (13) connected to the second chamber (11) of the cylinder (9) and constituting a filling line in said movement direction; circuit (1) comprises a safety device (42) configured to connect the first line (12) to the first working port (7) in normal operation and to connect the first line (12) to the second line (13) in response to a control signal identifying that the door is blocked by an obstacle in said first direction of movement of the door.

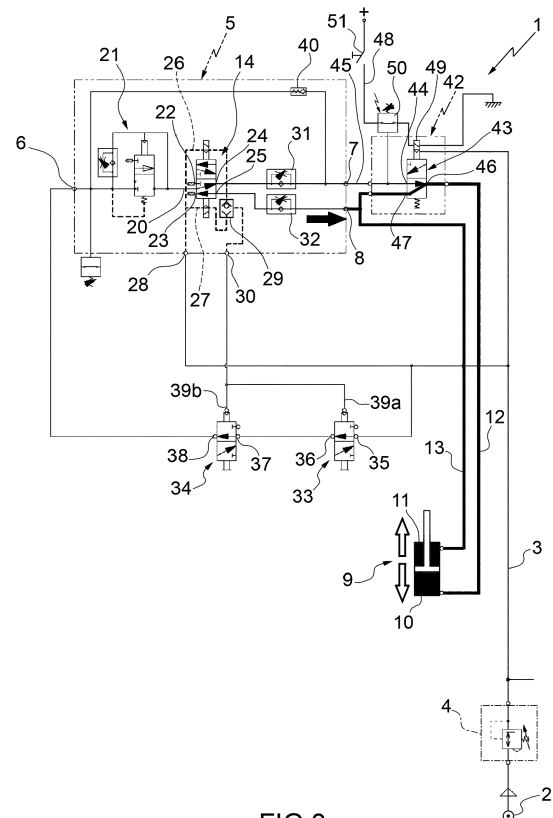


FIG.3

## Description

**[0001]** The present invention relates to a control circuit for a pneumatically actuated vehicle door.

**[0002]** The invention can be preferably, but not exclusively, used for controlling doors of passenger vehicles such as buses, trains or the like. This application will be referred to in the following for reference only, without any limitative effect.

**[0003]** Passenger vehicle doors are often controlled by pneumatic actuators. If a person or object lies in the trajectory of the door, significant impact can occur. For safety reasons, it is therefore desirable that in case of impact the door stops in order to avoid injury to passengers and/or damages. Also, it is desirable that the door, after such possible impact, can be manually controlled without too much efforts in order open or close it, depending on the direction of movement in which the impact occurred, in order to avoid that persons and/or objects can be released..

**[0004]** An object of the present application is to solve the above problems in a simple and cost-effective manner.

**[0005]** A further object of the present invention is to devise a solution that can be applied not only to new production vehicles, but also used to retrofit existing vehicles.

**[0006]** These objects are attained by a control circuit as claimed in claim 1 and a method as claimed in claim 4.

**[0007]** Two embodiments of the present inventions will be described hereinafter with reference to the attached drawings, in which:

Figure 1 is a pneumatic scheme of a circuit according to a first embodiment of the present invention;  
Figure 2 and figure 3 depict the circuit of Figure 1 one in two different operating conditions; and  
Figure 4 is a pneumatic scheme of a second embodiment of the present invention.

**[0008]** Referring to Figure 1, a control circuit for a vehicle door, e.g. a front bus single door, is indicated as a whole by numeral 1.

**[0009]** Circuit 1 essentially comprises:

- a compressed air source 2,
- a feed line 3 connected to compressed air source 2 by a pressure regulator 4,
- a main control block 5 having an inlet port 6 and a first and second working ports 7, 8;
- a double-acting cylinder 9 having a first chamber 10 and a second chamber 11 respectively connected to the first working port 7 by a first line 12 and to the second working port 8 by a second line 13.

**[0010]** More specifically, main control block 5 comprises a main 5-way, 2-position solenoid valve 14 comprising:

- an inlet port 20 connected to inlet port 6 through a soft start device 21, per se known and not described in further detail;
- a first and second vent ports 22, 23; and
- a first and second line ports 24, 25 respectively connected to said first and second lines 12, 13.

**[0011]** Solenoid valve 14 is solenoid- and pilot-controlled, with pilot lines 26, 27 connected to an input pilot port 28 of main control block 5. Subject to an electric control signal on the respective control side of solenoid valve 14, pilot lines 26, 27 are connected to an AND valve 29, whose outlet is connected to an output pilot port 30.

**[0012]** Main control block 5 also includes a couple of unidirectional flow control valves 31, 32 on the first and second lines 7, 8 to regulate the speed of cylinder 9.

**[0013]** Circuit 1 also comprises an external emergency door opening valve 33 and an internal emergency door opening valve 34 (hereinafter "emergency valves 33, 34" for brevity).

**[0014]** Emergency valves 33, 34 are 3-way, 2-position valves which are series-connected. Emergency valve 33 has an inlet port 35 connected to feed line 3 and an outlet port 36 connected to an inlet port 37 of valve 34, whose outlet port 38 are connected to inlet port 6 of the main control block 5. Emergency valves 33, 34 are normally set in the open position (so that port 6 is connected to feed line 3) by respective pilot lines 39a, 39b connected to output pilot port 30 of main control block 5 (as will be described below), but can manually set to the vent position in case of emergency so as to enable door opening (respectively, from outside the vehicle and from inside the vehicle).

**[0015]** Main box 5 finally comprises a check valve 40 connecting first line port 7 to inlet port 6 for quick release in emergency.

**[0016]** According to the present invention, circuit 1 includes a safety device 42 including a three-way, two-position valve 43 on first line 12, having a first port 44 connected to the first working port 7 of the main control block 5 via a first portion 45 of the first line 12, a second port 46 connected to the first line 12 and a third port 47 connected to the second line 13.

**[0017]** Valve 43 is spring-biased in a position connecting the first port 44 with the second port 46, the third port 47 being closed.

**[0018]** Valve 43 is solenoid-actuable by an electric signal line 48 to switch to a second position connecting the second port 46 with the third port 47, the first port 44 being closed.

**[0019]** More particularly, a solenoid 49 of valve 43 is series-connected to a pressure-operated switch 50 and to a microswitch 51 along signal line 48, which is powered by the vehicle battery voltage. Pressure-operated switch 50 is pneumatically connected to connection passage 45 so as to act on signal line 48 in response to pressure in connection passage 45. Microswitch 51 is operable (in a conventional manner not shown in the drawings) by cyl-

inder 9 so as to disconnect line 48 just before door leaf (not shown) reaches a fully open position, and thus deactivate the safety device 42.

[0020] Operation of circuit 1 is as follows.

[0021] In normal conditions, i.e. in the absence of manual actuation of the emergency valves 33, 34 and of obstacles in the trajectory of the door, main control block 5 operates in a conventional manner.

[0022] When main solenoid valve 14 is excited by a closure signal (fig. 1), first line 12 is pressurized through valve 43 and cylinder 9 is displaced to or maintained in the door closure position (fig. 1).

[0023] When main solenoid valve 15 is excited by an opening signal (fig. 2), second line 13 is pressurized and cylinder is displaced to or maintained in the door opening position.

[0024] If the door, during the opening movement, hits a person or obstacle and is blocked (figure 3), a sharp pressure decrease occurs in first line 12, that is detected by pressure switch 50 (being connection passage 45 in direct communication with first line 12 through safety valve 43), which enables control signal to valve 43. As a consequence, valve 43 switches to the second position, in which second port 46 is connected to third port 47 and therefore the second portion 47 of first line 12 is connected to second line 13 and pressurized, thereby connecting both chambers 10 and 11 of cylinder 9 which are thus both under pressure. Since pressure forces acting on the cylinder are balanced, the door opening movement is stopped, and the door can be displaced manually without significant efforts.

[0025] Normal operation can be reset by a closure command, which brings back the circuit to the condition of fig. 1.

[0026] In the closed position, door can be manually opened in emergency through external emergency valve 33 or internal emergency valve 34. Inlet port 6 of main control block 5 is vented and check valve 40 opens, releasing pressure from first line 12. Door can thus be manually opened.

[0027] Emergency valves 33, 34 are reset by opening control signal acting on main valve 14 (in conformity with Regulation ECE R107).

[0028] It is to be noted that manual operation of emergency valves 33, 34 is possible only when the vehicle is still. When the vehicle speed exceeds a predetermined, low threshold value, for example 5 km/h, a permanent closure signal acts on main valve 14, and therefore pilot signal on pilot lines 38, 39 is active too and pilot pneumatic force prevails on manual actuation.

[0029] Figure 4 depicts a circuit 100 according to a second embodiment of the present invention, which is configured for parallel control of two cylinders 9 controlling respective wings of a bus double door.

[0030] In this case, the whole circuit portion downstream of ports 24, 25 is simply doubled in parallel; each cylinder 9 has its own lines 12, 13, corresponding unidirectional flow control valves 31, 32 and check valve 40,

and its own safety device 42, which is configured release the respective door in case it is blocked by a person or obstacle during opening.

[0031] The advantages provided by the present invention are evident from an analysis of the features of circuits 1, 100.

[0032] In particular, safety device 42 allows the vehicle door to be stopped and manually controlled without significant efforts after an impact with a person or obstacle in their trajectory in a simple and cost-effective manner.

[0033] Also, safety device is a completely autonomous system that can be used in all kinds of door systems without any impact on door control logic or software. It can also be used to retrofit existing vehicles.

[0034] Obviously, modifications and variants of the circuit are possible, without departing from the scope of the appended claims.

[0035] In particular, safety device 43 can be configured to act on the closure stroke of the door, rather than on the opening stroke, depending on the door kinematics.

## Claims

1. Control circuit for a pneumatically controlled vehicle door comprising a double-acting pneumatic cylinder (9) operable to open and close said door and having a first chamber (10) and a second chamber (11), a main pneumatic control block (5) having a first working port (7) and a second working port (8), a first line (12) connected to the first chamber (10) of the cylinder (9) and constituting a release line in a given movement direction of the cylinder (9) corresponding to a first movement direction of the door, and a second line (13) connected to the second chamber (11) of the cylinder (9) and constituting a filling line in said movement direction, **characterized by** comprising a safety device (42) configured to connect the first line (12) to the first working port (7) in normal operation and to connect the first line (12) to the second line (13) in response to a control signal identifying that the door is blocked by an obstacle in said first direction of movement of the door.
2. Control circuit as claimed in claim 1, **characterized in that** said safety device includes a pressure switch (50) sensing pressure level in said first line (12), said control signal being enabled or disabled by said pressure switch (50) in response to the pressure level in said first line.
3. Control circuit as claimed in claim 1 or 2, **characterized in that** said safety device (42) includes a three-way valve (43) that is spring biased to connect said first line (12) to said first port (7) and solenoid-controllable through said control signal to connect said first line (12) to said second line (13) so as to balance air pressure in the two chambers of said cylinder.

4. Method of controlling a double-acting pneumatic cylinder (9) actuating a vehicle door, the cylinder (9) comprising a first chamber (10) connected to a first line constituting a release line in a given movement direction of the cylinder (9) corresponding to a first movement direction of the door, and a second chamber (11) connected to a second line (13) constituting a filling line in said movement direction, **characterized by** including the step of equalizing the air pressure in the two chambers (10, 11) of the cylinder (9) in response to a control signal identifying that the door is blocked by an obstacle in said first direction of movement of the door.

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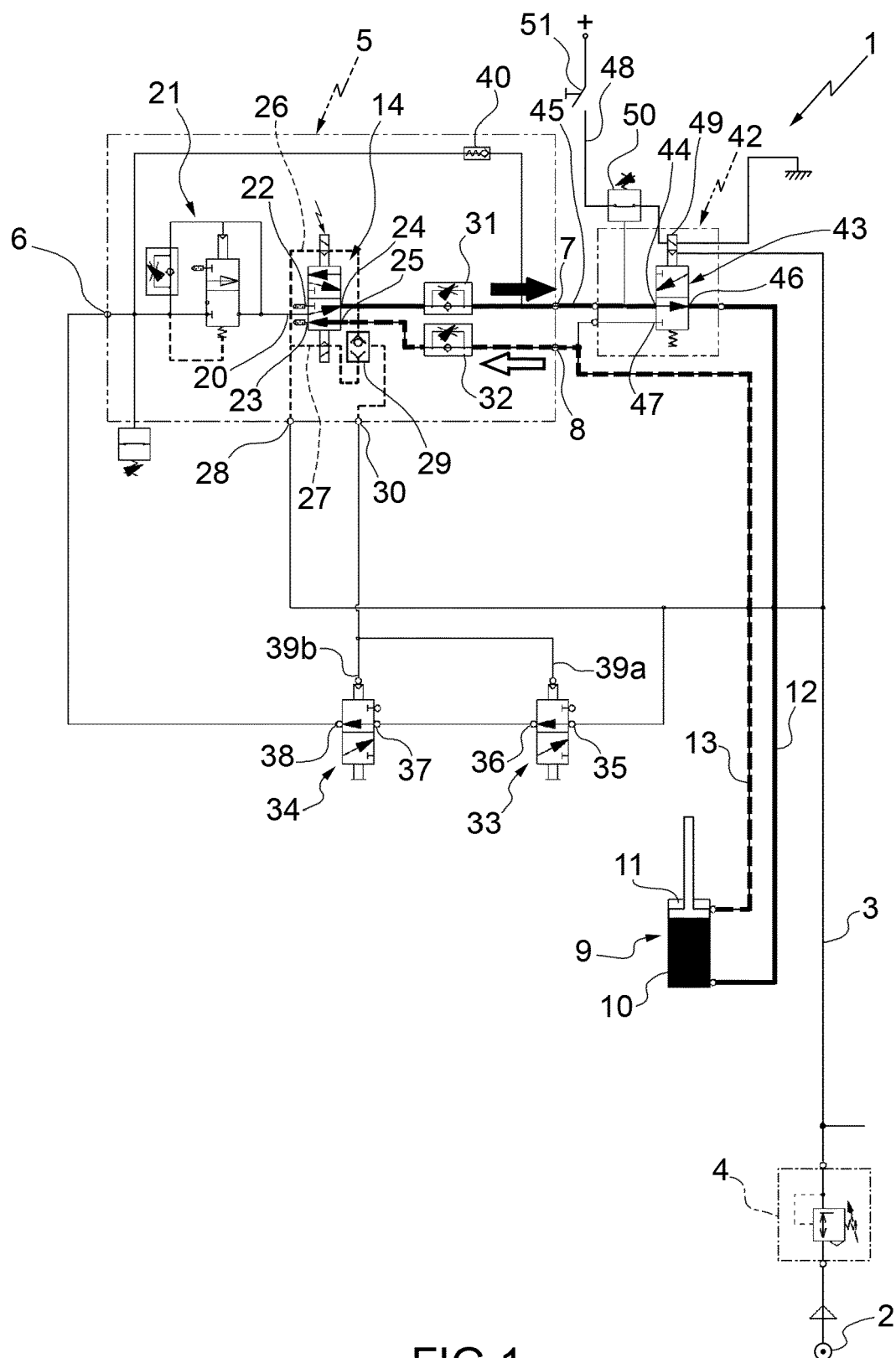


FIG.1

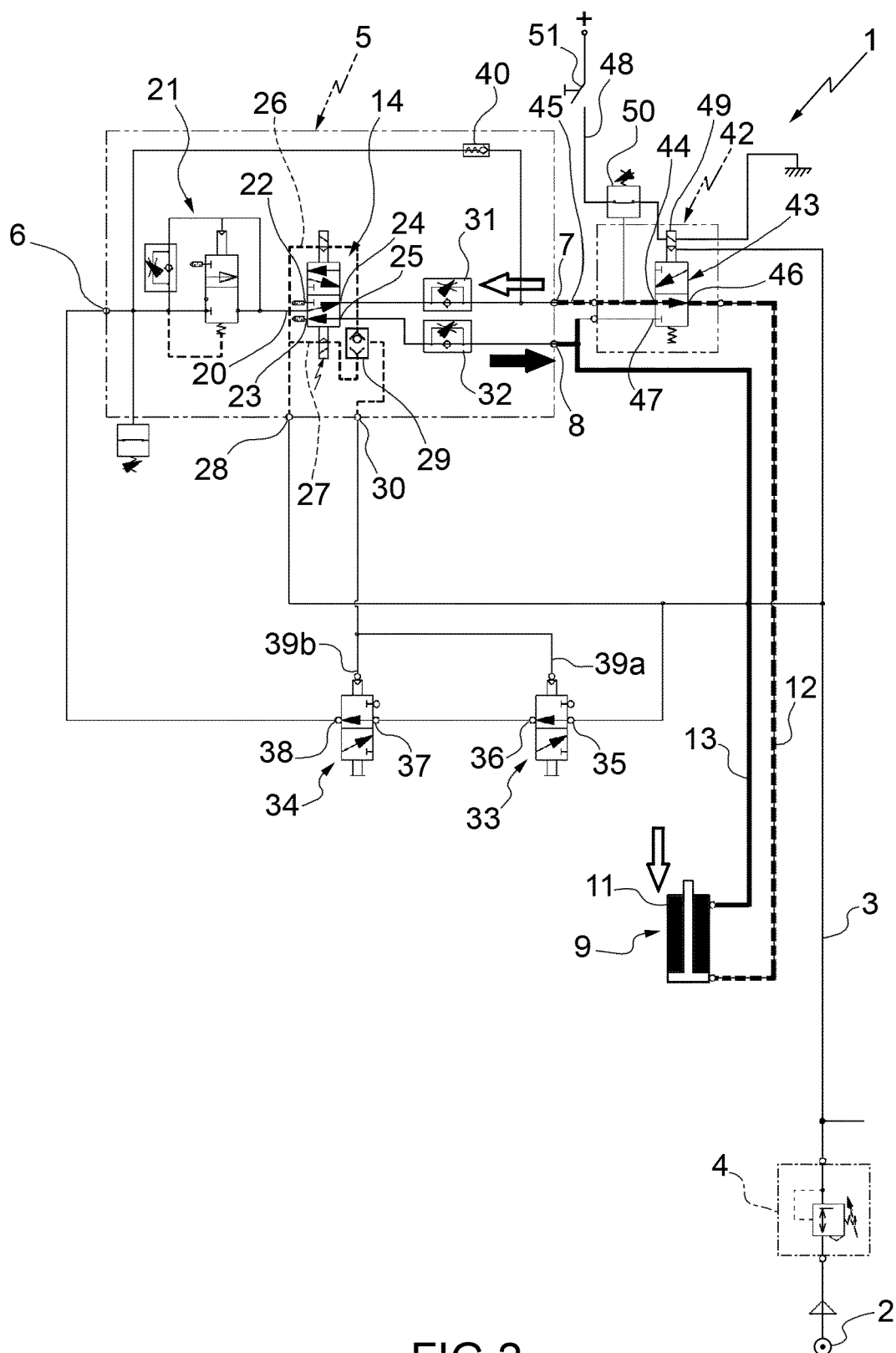


FIG.2

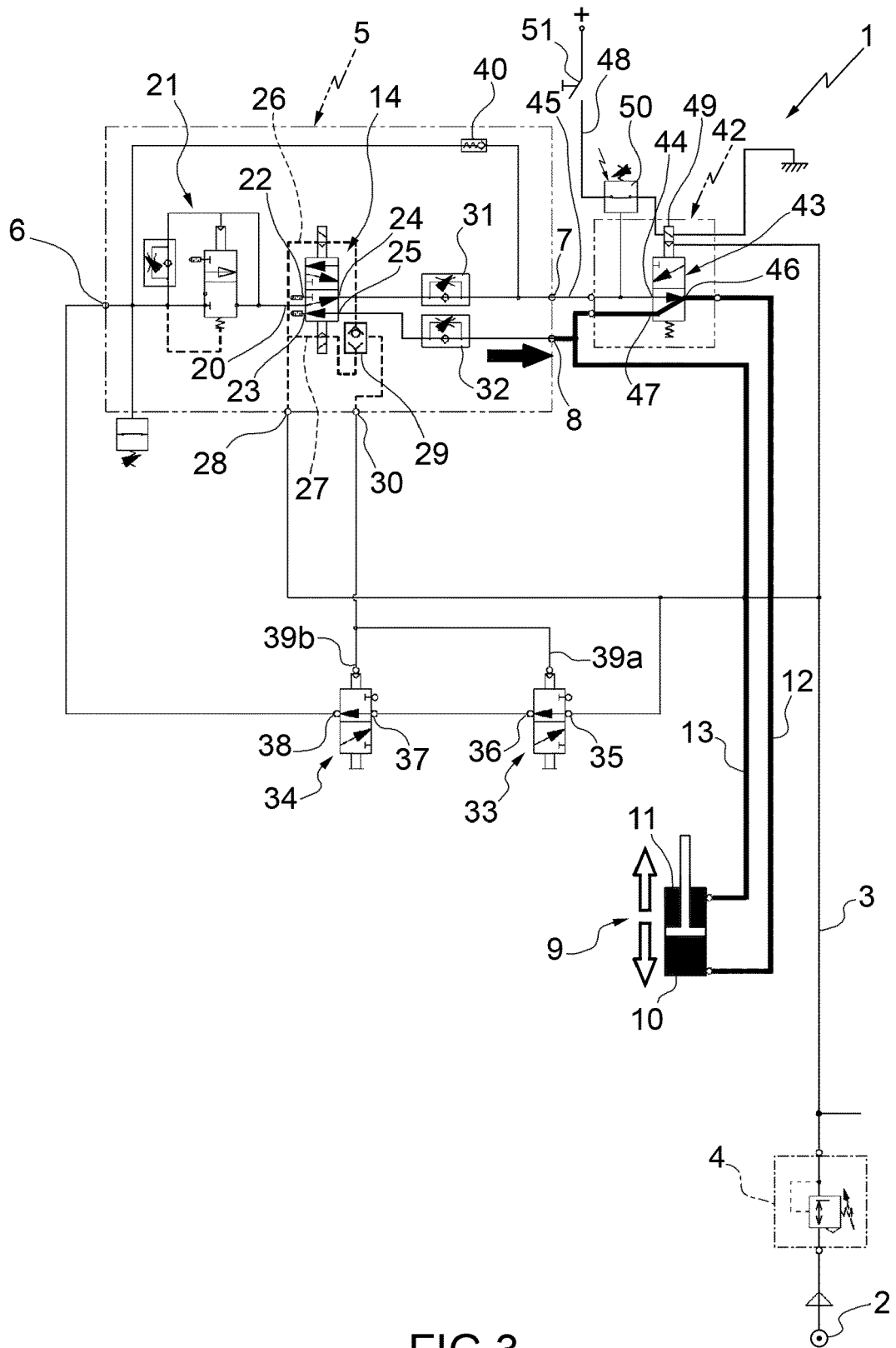


FIG.3

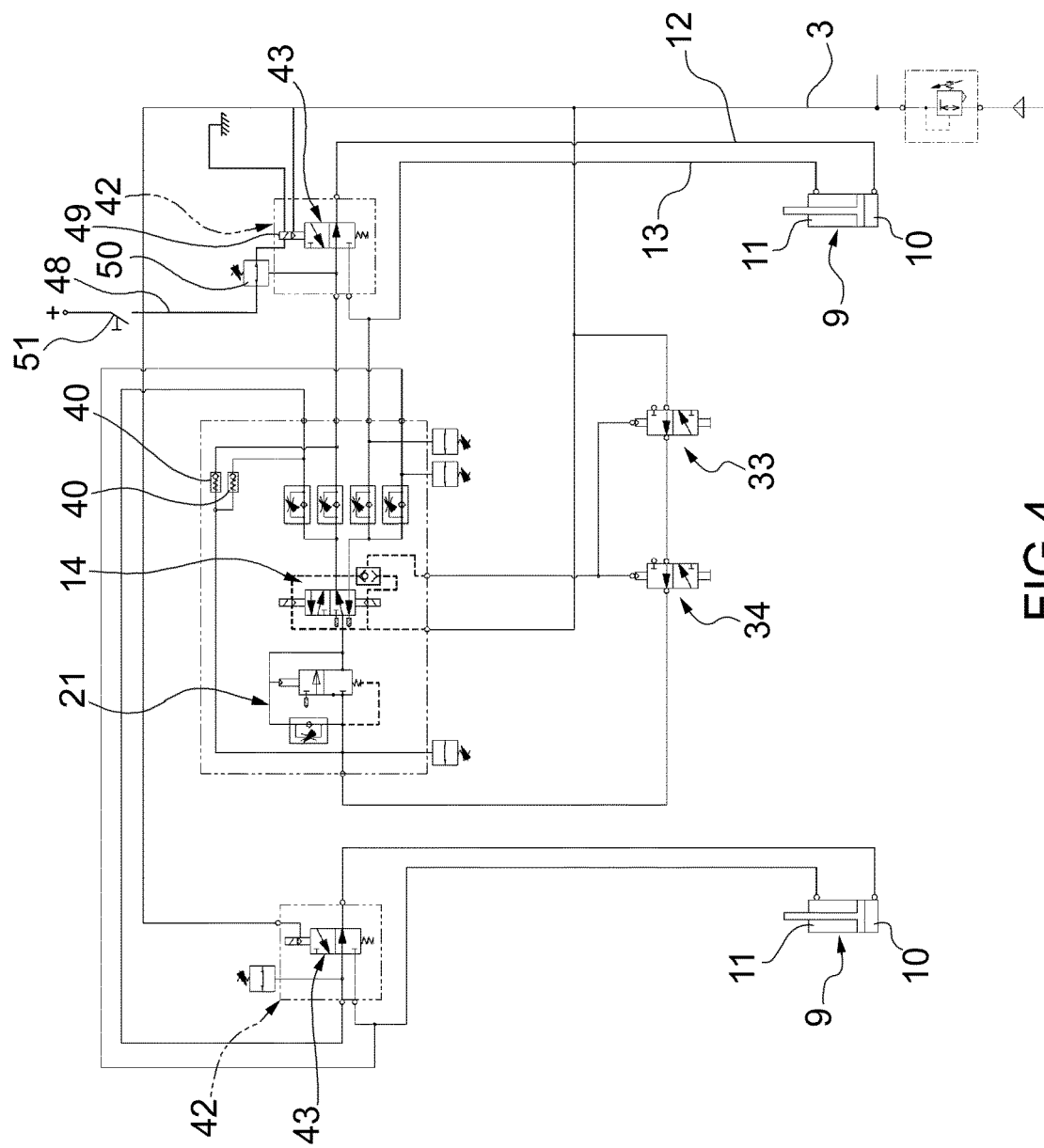


FIG.4



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Application Number  
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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                   |                                                      |                                                                        |
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| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                                                                                                     | Relevant to claim                                    | CLASSIFICATION OF THE APPLICATION (IPC)                                |
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| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                                                                                                                                                                                   |                                                      |                                                                        |

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