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CA 2821172 C 2015/03/17

(11)(21) **2 821 172**

(12) **BREVET CANADIEN**
CANADIAN PATENT

(13) **C**

(22) **Date de dépôt/Filing Date:** 2006/08/22
(41) **Mise à la disp. pub./Open to Public Insp.:** 2007/03/16
(45) **Date de délivrance/Issue Date:** 2015/03/17
(62) **Demande originale/Original Application:** 2 556 590
(30) **Priorité/Priority:** 2005/09/16 (US11/227,096)

(51) **Cl.Int./Int.Cl.** ***B60T 13/66*** (2006.01), ***B60T 15/14*** (2006.01), ***B61H 13/20*** (2006.01)

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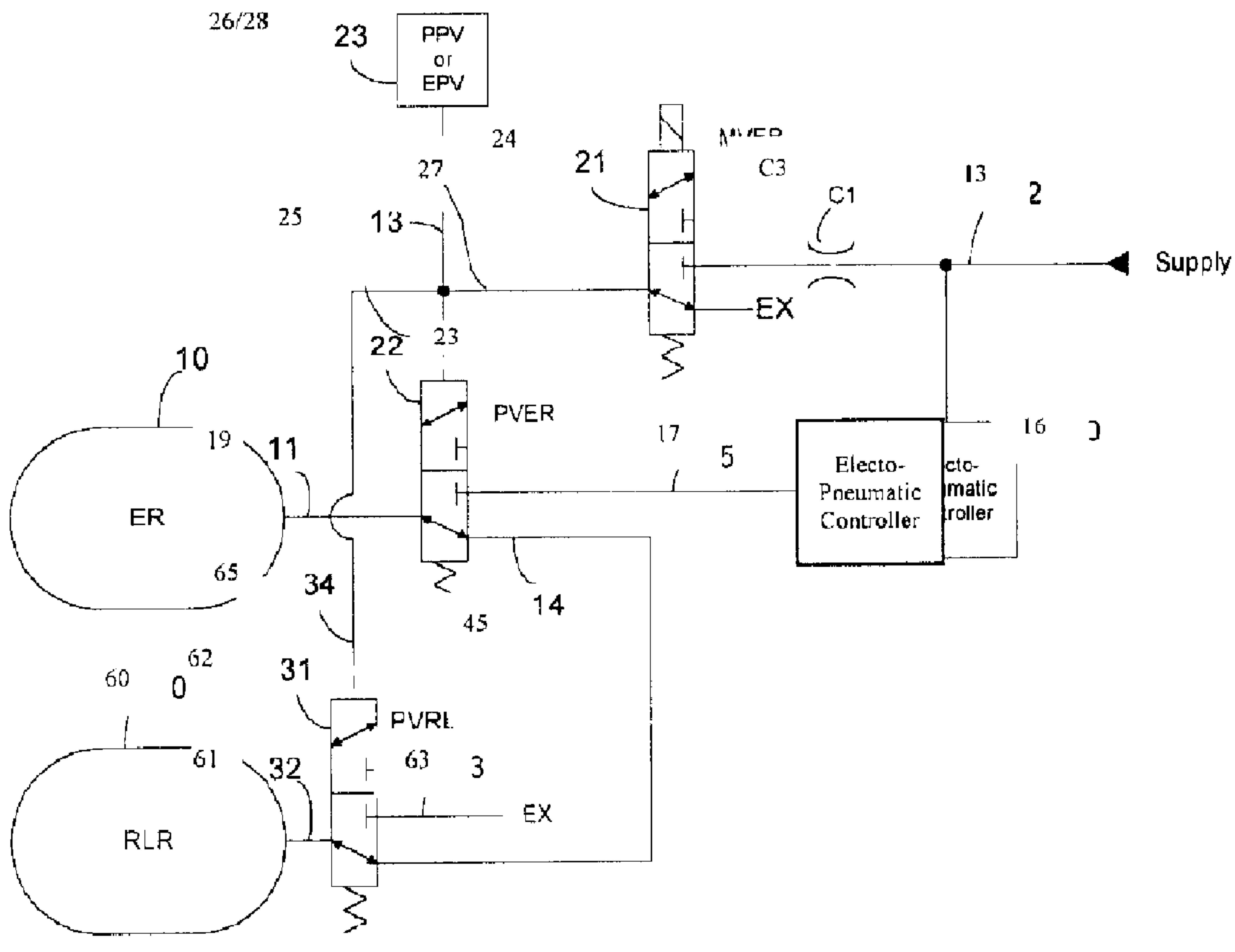
(54) **Titre : DISPOSITIF DE COMMANDE ELECTRONIQUE DE RESERVOIR DE COMPENSATION PAR SURPASSEMENT ET LIMITATION**

(54) **Title: ELECTRONIC EQUALIZING RESERVOIR CONTROLLER WITH PNEUMATIC PENALTY OVERRIDE AND REDUCTION LIMITING**



(57) **Abrégé/Abstract:**
A control system which allows electro-pneumatic control of an equalizing reservoir with the capacity to create penalty applications in a purely pneumatic manner. A controller for the equalizing reservoir includes an electro-pneumatic source of pressure or

(57) **Abrégé(suite)/Abstract(continued):**
atmosphere responsive to an electrical equalizing pressure control signal and a pilot valve selectively connecting the electro-pneumatic source or atmosphere to the equalizing reservoir in response to pressure in a pilot port of the first pilot valve. A magnetic valve is provided having a first input connected to a second source of pressure, a second input connected to atmosphere and an output connected to the pilot port of the first pilot valve. At least one penalty valve is connected to the pilot input of the first pilot valve and is responsive to a penalty signal to connect the pilot input to atmosphere. A fourth valve has a first input connected to the second input of the first pilot valve and an output connected to a third source of pressure lower than pressure in the equalizing reservoir prior to a penalty signal. The fourth valve connects its first input to its output in response to a penalty signal. A method of initializing the electro-pneumatic source of pressure or atmosphere responsive to an electrical equalizing pressure control signal

ABSTRACT

A control system which allows electro-pneumatic control of an equalizing reservoir with the capacity to create penalty applications in a purely pneumatic manner. A controller for the equalizing reservoir includes an electro-pneumatic source of pressure or atmosphere responsive to an electrical equalizing pressure control signal and a pilot valve selectively connecting the electro-pneumatic source or atmosphere to the equalizing reservoir in response to pressure in a pilot port of the first pilot valve. A magnetic valve is provided having a first input connected to a second source of pressure, a second input connected to atmosphere and an output connected to the pilot port of the first pilot valve. At least one penalty valve is connected to the pilot input of the first pilot valve and is responsive to a penalty signal to connect the pilot input to atmosphere. A fourth valve has a first input connected to the second input of the first pilot valve and an output connected to a third source of pressure lower than pressure in the equalizing reservoir prior to a penalty signal. The fourth valve connects its first input to its output in response to a penalty signal. A method of initializing the electro-pneumatic source of pressure or atmosphere responsive to an electrical equalizing pressure control signal

ELECTRONIC EQUALIZING RESERVOIR CONTROLLER WITH PNEUMATIC PENALTY OVERRIDE AND REDUCTION LIMITING

This application is a divisional application of co-pending application Serial No. 2,556,590, filed August 22, 2006.

BACKGROUND AND SUMMARY OF THE INVENTION

The present system relates generally to brake control systems and more specifically to a controller for an equalizing reservoir of a rail brake system, which includes a brake pipe controlled by a relay valve in response to pressure in the equalizing reservoir.

Prior rail brake systems have had either fully-pneumatic control of the equalizing reservoir (ER) or electro-pneumatic control of the ER. On systems which use fully-pneumatic ER control, penalty brake applications were created by exhausting a previously pressurized penalty pipe. This caused a subsequent pneumatic exhaust of the ER and brake application. On systems which use electro-pneumatic ER control, penalty brake applications are signaled to the brake system by electrical signals. The ER is then reduced to apply the brakes via electro-pneumatic control. Prior brake systems including ER controllers are illustrated in U.S. Patents 6,036,284 and 6,318,811.

To limit the penalty reduction of the equalizing reservoir, prior systems have used reduction limiting reservoirs. Penalty application valves connect the reduction limiting reservoir to the equalization reservoir for a penalty and cuts off the control from the brake valve. The pressure in the equalizing reservoir is reduced until the two reservoirs stabilize. After termination of the penalty, control is transferred back to the brake valve and the reduction limiting reservoir is emptied. Two such systems are shown in U.S. Patents 3,623,777 and 4,491,372

A control system which allows electro-pneumatic control of an equalizing reservoir with the capacity to create penalty applications in a purely pneumatic manner is described in U.S. Patent 6,746,087. The controller for the equalizing reservoir includes an electro-pneumatic source of pressure or atmosphere responsive to an electrical equalizing pressure control signal and a pilot valve selectively connecting the electro-pneumatic source or atmosphere to the equalizing reservoir in response to pressure in a pilot port of the first pilot valve. A magnetic valve is provided having a first input connected to a second source of pressure, a second input connected to atmosphere and an output connected to the pilot port of the first pilot valve. At least one penalty valve is connected to the pilot input of the first pilot valve and is responsive to a penalty signal to connect the pilot input to atmosphere. The pilot valve and the penalty valve pneumatically produce a brake application regardless of the state of the magnetic valve or its controller.

The present control system allows electro-pneumatic control of ER but with the capacity to create penalty applications in a purely pneumatic manner and reduction limiting. A controller for an ER includes an electro-pneumatic source of pressure or atmosphere responsive to an electrical equalizing pressure control signal and a first pilot valve selectively connecting the electro-pneumatic source or atmosphere at a first input or a second input to the equalizing reservoir in response to pressure in a pilot port of the first pilot valve. A magnetic valve is provided having a first input connected to a second source of pressure, a second input connected to atmosphere and an output connected to the pilot port of the first pilot valve. At least one penalty valve is connected to the pilot input of the first pilot valve and is responsive to a penalty signal to connect the pilot input to atmosphere. A fourth valve has a first input connected to the second input of the first pilot valve and an output connected to a third source of pressure lower than pressure in the equalizing reservoir prior to a penalty signal. The fourth valve connects its first input to its output in response to a penalty signal.

A method is disclosed for controlling pressure for an equalizing reservoir of a rail brake system which includes a brake pipe controlled by a relay valve in response to pressure in the equalizing reservoir and which includes an electro-pneumatic source of pressure or atmosphere having a closed loop system responsive to an electrical equalizing pressure control signal. The method includes measuring pressure in the equalizing reservoir after a penalty reduction of reservoir pressure; initially setting the electrical equalizing pressure control signal to the measured equalizing reservoir pressure after a penalty; and subsequently the activating closed loop system of the electro-pneumatic source of pressure or atmosphere to control the pressure of the equalizing reservoir to the electrical equalizing pressure control signals.

These and other aspects of the present invention will become apparent from the following detailed description of the invention, when considered in conjunction with accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a schematic of a controller for an equalizing reservoir of the prior art.

Figure 2 is a schematic of a controller for an equalizing reservoir illustrating a first embodiment of the present invention.

Figure 3 is a schematic of a controller for an equalizing reservoir illustrating a second embodiment of the present invention.

Figure 4 is a schematic of a controller for an equalizing reservoir illustrating a third embodiment of the present invention.

Figure 5 is a schematic of a control of the limiting magnetic valve of figures 3 and 4.

Figure 6 is a flow chart of the control of the equalizing reservoir after a penalty of the prior art.

Figure 7 is a flow chart of the control of the equalizing reservoir after a penalty according to the present disclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 is the equalizing portion of the controller for the equalizing resevior of U.S. patent 6,746,087. Where possible the same numbers will be used for sake of clarity. The controller for the equalizing reservoir is only part of a train brake control system, as illustrated in the previously mentioned patents. This equalizing controller may be used with systems other than those illustrated in the aforementioned patents.

As shown in the figures, an equalizing reservoir (ER) **10** is connected to and controls a brake pipe relay **12** via line **11**. The brake pipe relay **12** controls a brake pipe (BP). Also, connected to the brake pipe relay **12** is exhaust (EX) and a supply or main reservoir (MR) via line **13**. As is well known, the brake pipe relay **12** receives a reference signal **11** from the ER **10** and produces an appropriate pressure in the brake pipe (BP) using exhaust (EX) and pressure from the main reservoir (MR) via line **13**. Reduction in the pressure in the ER **10** produces a reduction in the pressure in the brake pipe (BP), which reflects a brake application. An increase in the pressure in ER **10** creates an increase in the pressure in brake pipe (BP), which is a brake release signal. The brake pipe cut off and charging circuit have been deleted for sake of clarity. How this is accomplished is well-known, as illustrated in the above-mentioned patents.

The main reservoir (MR) is also connected via line **13** to an electro-pneumatic source of pressure or atmosphere **16**, which is responsive to an electrical equalizing pressure control signal. The electro-pneumatic source **16** may include an electro-pneumatic or magnetic apply valve and an electro-pneumatic or magnetic release valve connected together at a common output **17** are shown in U.S. Patent 6,746,087. Even though a pair of valves may form the electro-pneumatic source of pressure or atmosphere **16**, a single valve may be used or any other electro-pneumatic control system to provide a desired equalizing reservoir pressure signal. The output **17** is connected to an equalizing reservoir transducer (ERT).

The output **17** is also provided as a first input to the equalizing reservoir pilot valve (PVER) **22**. The other input is from atmosphere or exhaust (EX) on line **45**. The output of the PVER **22** is provided on line **19** to the ER **10**. The pilot port or pilot line **23** of valve **22** is connected to an output 27 of an electro-pneumatic or magnetic valve **24**. A second pressure source at the input of **24** on line **21** is from the main reservoir (MR) and through a choke or restriction C3. The restriction C3 prevents the charging of the pilot port **23** when the penalty valve connects the pilot port **23** to exhaust (EX) or atmosphere.

The equalizing magnetic valve (MVER) **24** is shown in its deactivated condition, wherein the pilot port **23** is connected to exhaust (EX). Upon activation, the source is connected to the pilot valve **22** to move it from its shown exhaust position to its control pressure position connecting its output **19** to line **17**. The control of the electro-pneumatic source **16** determines the pressure provided through the open pilot valve **22** to the ER **10**. These connections and operations are well known in the prior art, as shown in the previously discussed patents.

Also, connected to pilot port **23** of the PVER **22** are pneumatic penalty valve **26** and/or electric or electro-pneumatic penalty valve **28** via penalty pilot line **25**. Both of the valves **26** and **28** are responsive to a penalty input signal to connect their respective outputs to penalty pilot line **25** to exhaust (EX). This removes the pilot signal from pilot port **23** of the PVER **22** causing it to return to the shown position connecting its output **19** and the ER **10** to atmosphere or exhaust (EX). This causes the brake pipe relay **12** to reduce the brake pipe pressure causing a brake application.

The pressure value in the penalty pilot line **25** to pilot port **23** is monitored by a penalty pressure transducer (PT) via line 27. This may be used in controlling the ER **10** using the electro-pneumatic source **16** and indicates that a penalty valve has been activated connecting the penalty pilot line **25** to exhaust (EX).

A controller **50** is provided. This controller provides all of the control signals to the various electro-pneumatic or magnetic valves and receives feedback from each of the transducers. Controller **50** is illustrated as a single block and may be the controller of the brake system, which may be a single controller or may be plural distributive controllers. Portions of the controller **50** may be on a module, which includes the controller for the ER **10** as illustrated in Figure 9 of U.S. Patent 6,036,284 with other portions of the controller **50** being part of a system controller. Controller **50** is also shown controlling the electro-pneumatic penalty valves. Again, this would generally be performed by the brake system controller versus a distributive controller portion of the ER **10**.

As illustrated in Figure 2 of U.S. Patent 6,746,087, the penalty pilot line **25** may be connected to the input **21** of the MVER magnetic valve 24 instead of its input.

The operation of the system in Figure 1 provides a pneumatic actuated braking in response to a penalty condition whether it is an electro-pneumatically or pneumatically sensed penalty. The controller **50** prevents a continuous exhaust of MR out of an open penalty valve. The controller can detect a penalty condition via PT and act to de-energize (close) MVER valve **24**, thereby preventing any further exhaust of air. This also prevents a continuous exhaust of air when the controller (and magnetic valve **24**) are in a powered off condition. This would allow an unpowered locomotive to be hauled unmanned with an open foot valve, for instance.

Figures 2-4 show a modification to the equalizing reservoir system of Figure 1 to incorporate reduction limiting. While Figure 2 show the use of a reduction limiting reservoir and Figure 3 shows an additional reduction limiting magnetic valve, Figure 4 show a combination of both in series.

The line **45** of the first pilot valve (PVER) **22** is provided as a first input to a reduction limiting pilot valve (PVRL) **62**. The other input is line **63** which is from atmosphere or exhaust (EX). The output of the PVRL **62** is provided on line **61** to a reduction limiting reservoir (RLR) **60**. The pilot port or pilot line **65** of the PVRL **62** is connected to the pilot line **23** of the first pilot valve PVER **22**.

In response to a penalty input on line **25**, pilot line **65** is connected to exhaust. This removes the pilot signal of each the PVER **22** and the PVRL **62** causing each to be in the shown position. In the shown position, line **19** of the ER **10** is connected to line **45** from the PVER **22** to the input of the PVRL **62** and thus line **61** of RLR **60**. The pressure within ER **10** will reduce into the volume of RLR **60**. The pressure reduction within the ER **10** is proportionate to the volumetric size relationship of the ER **10** to the RLR **60**. This will cause ER **10** to reduce a prescribed amount due to a penalty and thus not fully to atmosphere, thereby causing a predetermined brake application instead of a full or maximum brake application.

As described in the prior art of Figure 1, upon activation of the equalizing magnetic valve **24** and closure of the penalty valve **26/28**, source pressure is connected to pilot lines **23** and **65 via** line **27**. The PVER **22** shall move from its shown penalty position to its control pressure position connecting its output **19** to line **17**. Upon connecting source pressure to pilot line **65**, the PVRL 62 shall change from its penalty position to connect its output line **61** to line **63** and exhaust (EX), thus depleting the pressure within the RLR **60** to restore full penalty reduction capability.

The use of a magnetic valve as the reduction limiting device is illustrated in Figure 3. The output line 45 of the pilot valve (PVER) **22** is provided as a first input to a penalty limiting magnetic valve (MVSP) **64**. The other input is line **67** which is from atmosphere or exhaust (EX). The penalty valve **26/28** is responsive to a penalty input to connect line **23** to exhaust and thus remove the pilot signal to the PVER **22** causing a response to the shown position. In the shown position, line **19** of the ER **10** is connected to line **45** from the PVER

22 to the input of the MVSP **64** and thus line **67** to atmosphere or exhaust (EX). The pressure within ER **10** will reduce to cause a braking.

Upon activation of the magnetic valve (MVSP) **64** input line **45** is disconnected from line **67** to atmosphere or exhaust (EX). The pressure within ER **10** will cease to reduce and thus maintain the brake application attained as long as the pilot valve **22** remains in the position shown or penalty.

Subsequent de-activation of MVSP **64** will reconnect to line **45** to exhaust, thus further reducing ER **10** and allow a greater brake application. Subsequent activation will cease reduction and maintain the brake application attained. By the activation control of MVSP **64** during the purely override penalty operation of the system, the brake application step increase may be controlled, maintained or fully applied.

The activation and deactivation of the MVSP **64** could be single source or various other designs. A simple method could be the activation of a timing relay by a pressure sensor within the pilot line **23** that would support a single step delay of equalizing reservoir prior to full exhaust. Another method could be that of a controller, that may be intelligent, to control the steps either over time or sensor feedback control.

A combination of the reduction limiting devices or systems of Figures 2 and 3 are shown in Figure 4. The magnetic valve MVSP **64** is connected to line **45** between the pilot valve PVER **22** and the pilot valve PVRL **62**. This provides the current limiting features of the current limiting reservoir **60** with the stepped or staged reduction and safety features of the magnetic valve MVSP **64**.

Figure 5 show the elements of a safety design through redundant controllers for the reduction limiting magnetic valve MSVP **64**.

The activation system includes two distinct, independent controllers 66 and **68**. The controllers are electronic and may be of solid state or microprocessor intelligent technologies. Significant are that these controllers are separate and independent with capable knowledge to control the activation of MVSP **64**. The controllers are arranged in series with the MVSP **64** in a manner that a failure of one would not prevent the other from deactivating the MVSP **64**. As shown in Figure 5 the MVSP **64** is deactivated. The electric source for activation must first be allowed to pass through controller **66**, as determined by its input requirements through closure of its switch, which may be solid state control or relay contacts, to the MVSP **64**, through the activation circuit of the MVSP (coil) and allowed to pass through controller **68** to attain source to return and thus activate the MVSP **64**. Controller **68** like controller **66** determines by its distinct input requirements the closure of its switch, which may be solid state control or relay contacts. Similarly, the controllers in series may activate a single relay to control MVSP **64**.

High level of safety is achieved in that the MVSP **64** must be activated to prevent the application of braking. The controllers **66** and **68** are redundant, that is each must be in the activation mode to activate the MVSP **64**. Failure of one in activation is overridden by the other. There would be several arrangements that would enhance the safety of the circuitry as the series addition of independent locomotive safety devices, such as cab signal, positive train control and vigilant systems. All to prevent the activation of the circuitry and thus allow braking to apply to the full potential.

Recovery of the pressure in the pilot port **23** results in the pilot valve PVER **22** disconnecting the equalizing reservoir ER **10** from atmosphere and connecting it to the electro-pneumatic source of pressure **16**. When pressure in the ER is actively in the stage of reducing and when a penalty override terminates, an abruptly reconnect to the electro-pneumatic source **16** may cause an undesirable effect. The prior art options is to 1) stop the reduction from occurring any further or 2) delay the recovery of the pilot port pressure till full application of braking. Option 1 is not desirable as full application may not have been attained and removes the selection of adding more braking through the control of the electro-pneumatic source **16**. Option 2 is not desired as the time for assurance of full braking capability would be a restriction to the overall operating system or control of the locomotive. The present design allows for the connection of ER **10** to the electro-pneumatic source **16** with no degradation to braking ability, expectation of the operator or inhibit to further application braking. The present design is applicable to any of the equalizing reservoir control system with an electro-pneumatic control including but limited to those illustrated in Figures 1-4.

In the prior art, the controller **50** has a responsibility in the recovery of a penalty application. As described above, recovery of a penalty requires the restoration of supply pressure to pilot line **23**. Supply source pressure is not available unless the controller **50** has activated the MVER **24** to connect source line **13** to pilot line **23**. The PPV or EPV **26/28** must be activated to disconnect the pilot line **23** from atmosphere or exhaust. Only then may the pilot line **23** be allowed to develop pressure and activate the PVER **22**. The activated PVER **22** disconnects exhaust or reduction limiting line **45** and connects the ER **10** line **19** to line **17** and thus the electro-pneumatic controller **16**.

As illustrated in Figure 6, a determination is made at step **70** whether recovery is possible. If so the, controller **50** would delay activation of the MVER **24** through its logic to assure that the ER **10** has reduced sufficiently to assure a reliable application of braking. Prior to activation of MVER **24** at step **74**, the controller **50** disconnects each the supply and exhaust of the electro-pneumatic controller **16** from line **17** at step **72**. Thus on the activation of the PVER **22** due to the development of pressure within line **25**, the ER **10** would neither increase or decrease pressure, thereby maintaining the level of braking achieved.

The controller **50** would monitor the feedback level sensor PT and determine the activation state of the PVER **22** at step **76**. Once the activation was determined and on command of the operator to fully release braking at step **78**, then the controller **50** would allow the electro-pneumatic controller **20** to increase, maintain and control pressure within line **17** and thus ER **10** at steps **82** and **84**.

In the present system as illustrated in Figure 7, the controller **50** still has the responsibility in the recovery of a penalty application. As described in the prior art, the controller **50** activates the MVER 24 at step **74**, disconnects each the supply and exhaust of the electro-pneumatic controller **16** at step **72**, and monitors the feedback level sensor PT to determine the activation state of the PVER **22** at step **76**. Next the system allows the electro-pneumatic controller **16** to maintain, decrease or control pressure within line **17** and thus ER **10** without the requirement of the operator to fully release braking as in step **78**.

The controller **50** monitors the feedback level sensor PT to determine the activation state of the PVER **22** at step **76**. The controller **50** determines whether the ER **10** is in connection via line **19** and PVER **22** to line **17** and thus to the electro-pneumatic controller **16**. If so, the electro-pneumatic controller **16** has an integrated feedback level sensor that the controller **50** determines the pressure on line **17** and thus the pressure within the ER **10** from the transfer ERT of the electro-pneumatic controller **16** at step **86**. The controller **50** then sends a target ER signal to the electro-pneumatic controller **16** equal to the feedback level sensor value at step **88**. However electro-pneumatic control **16** does not allow connections to source or exhaust to be made. This preconditions the closed loop control of the electro-pneumatic controller **16**. The controller **50** determines the desired braking request from the locomotive at step **82**, which includes the operator and other logical requirements as the continuance of the penalty brake due to recovery needs. The electro-pneumatic controller **16** closed loop control is actuated at step **84** to selecting connect to source and/or exhaust to line **17** to establishing full electro pneumatic control of braking.

This method provides a seamless transition from the override of ER control function back to operator control, fully under the requirements and rules of the standards well known in the industry. The safety of the override features are not compromised but enhanced as the disconnection of source and exhaust at the electro-pneumatic controller prevent the possibility of the undesired effects of pressure leakage. The operator is not confused by a difference in operation and is less likely to over react that could result in undesirable heavy braking effects. Although the present invention has been described and illustrated in detail, it is to be clearly understood that this is done by way of illustration and example only and is not to be taken by way of limitation. The scope of the present invention is to be limited only by the terms of the appended claims.

CLAIMS:

1. A method of controlling pressure for an equalizing reservoir of a rail brake system which includes a brake pipe controlled by a relay valve in response to pressure in the equalizing reservoir and which includes an electro-pneumatic source of pressure or atmosphere having a closed loop system responsive to an electrical equalizing pressure control signal, the method comprising:

measuring pressure in the equalizing reservoir after a penalty reduction of reservoir pressure;

initially setting the electrical equalizing pressure control signal to the measured equalizing reservoir pressure after a penalty; and

subsequently activating the closed loop system of the electro-pneumatic source of pressure or atmosphere to control the pressure of the equalizing reservoir to the electrical equalizing pressure control signal without requiring a command to fully release braking.

2. A controller for an equalizing reservoir of a rail brake system which includes a brake pipe controlled by a relay valve in response to pressure in the equalizing reservoir, the controller comprising:

an electro-pneumatic source of pressure or atmosphere responsive to an electrical equalizing pressure control signal;

a first pilot valve selectively connecting the electro-pneumatic source of pressure or atmosphere at a first input or connecting a second input to the equalizing reservoir in response to pressure in a pilot port of the first pilot valve;

a first magnetic valve having a first input connected to a second source of pressure, a second input connected to atmosphere and an output connected to the pilot port of the first pilot valve;

a penalty valve connected to the pilot port of the first pilot valve and responsive to a penalty signal to connect the pilot port to atmosphere;

a fourth valve having a first input connected to the second input of the first pilot valve and an output connected to a third source of pressure lower than pressure in the equalizing reservoir prior to a penalty signal, the fourth valve connecting the fourth valve's first input to the fourth valve's output in response to a penalty signal;

wherein the electro-pneumatic source of pressure or atmosphere includes a pressure transducer to measure the pressure in the equalizing reservoir and a closed loop system to control the pressure of the equalizing reservoir to the electrical equalizing pressure control signal; and

wherein the electrical equalizing pressure control signal is initially set to the measured equalizing reservoir pressure after a penalty before activating the closed loop system without requiring a command to fully release braking.

3. The controller according to Claim 2, wherein the third source of pressure is a second reservoir.

4. The controller according to Claim 3, wherein the fourth valve has a second input connected to atmosphere and the fourth valve connects the fourth valve's second input to the fourth valve's output in the absence of the penalty signal.

5. The controller according to Claim 2, wherein the third source of pressure is atmosphere.

6. The controller according to Claim 2, wherein the penalty valve and the fourth valve are responsive to at least one of an electric penalty signal and a pneumatic penalty signal.

7. The controller according to Claim 2, wherein the fourth valve is a second pilot valve having a pilot port connected to the pilot port of the first pilot valve.

8. The controller according to Claim 7, including a second magnetic valve selectively connecting the first input of the first pilot valve to the second input of the fourth valve.

9. The controller according to Claim 2, wherein the fourth valve is a second magnetic valve, the third source of pressure is atmosphere and the fourth valve connects its first input to its output when de-energized.

10. The controller according to Claim 9, including a pair of controls that must be active at the same time to energize the second magnetic valve.

11. The controller according to Claim 1, wherein the pressure transducer is connected to the first input of the first pilot valve.

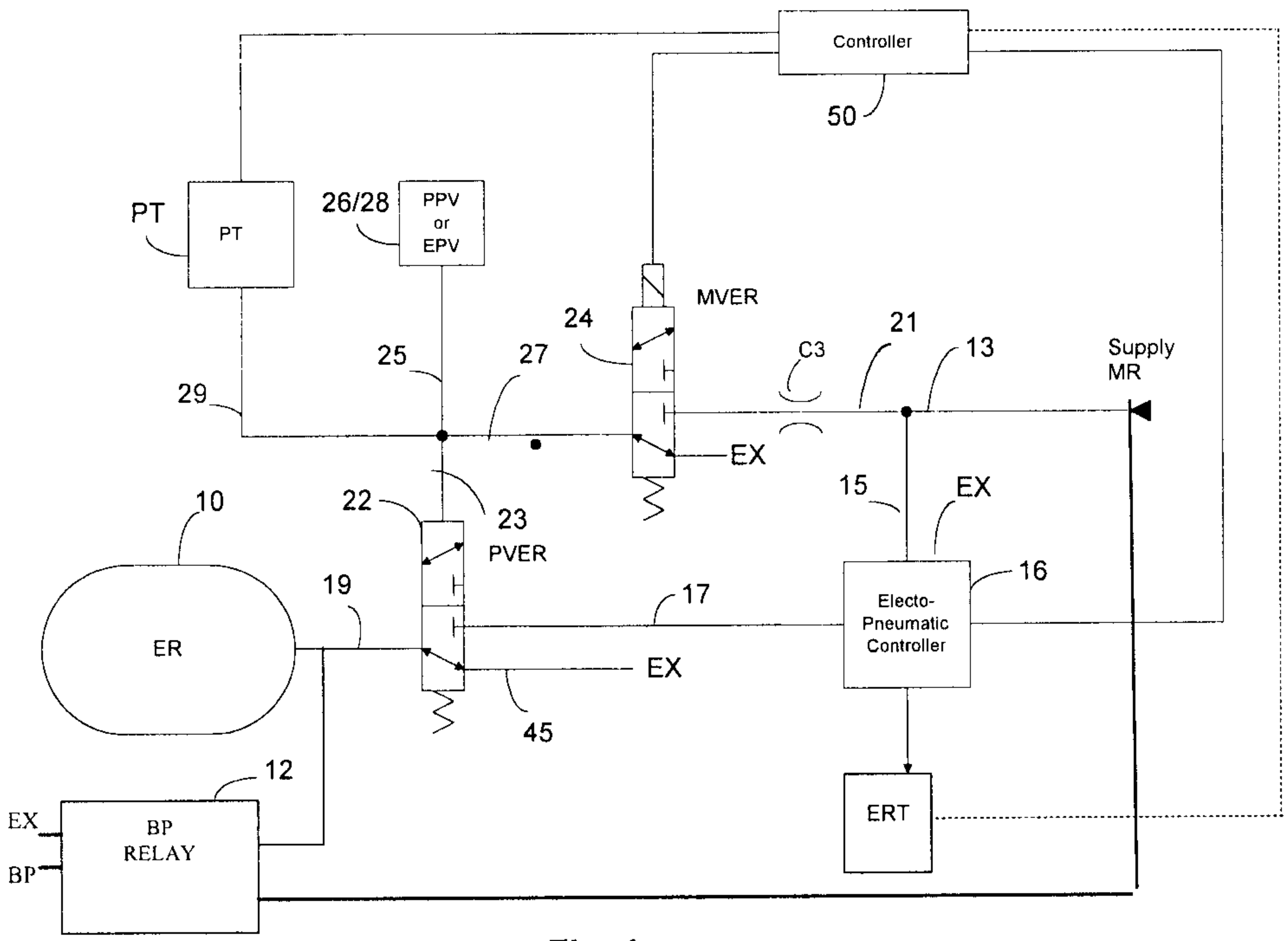


Fig. 1

PRIOR ART

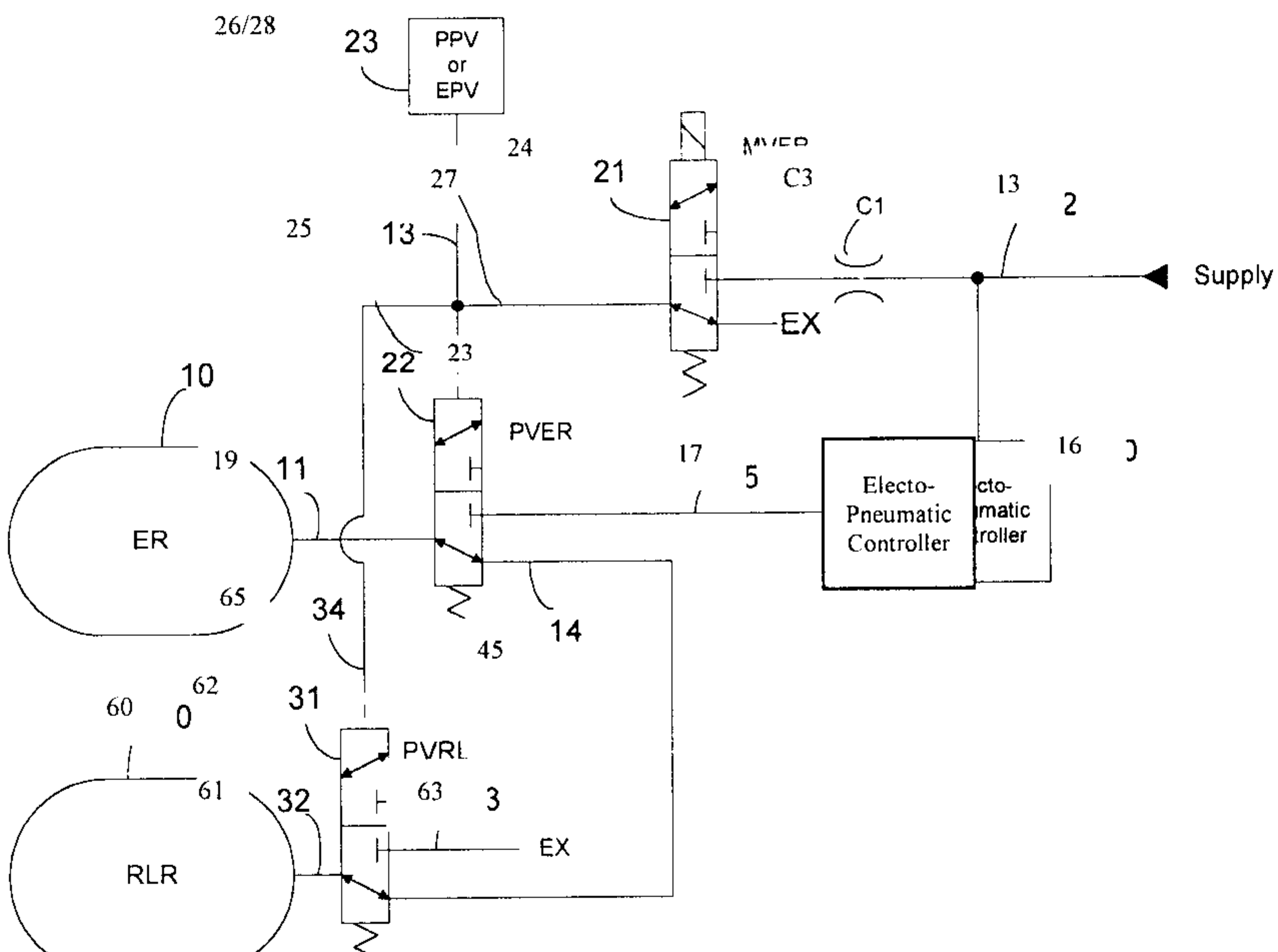


Fig. 2

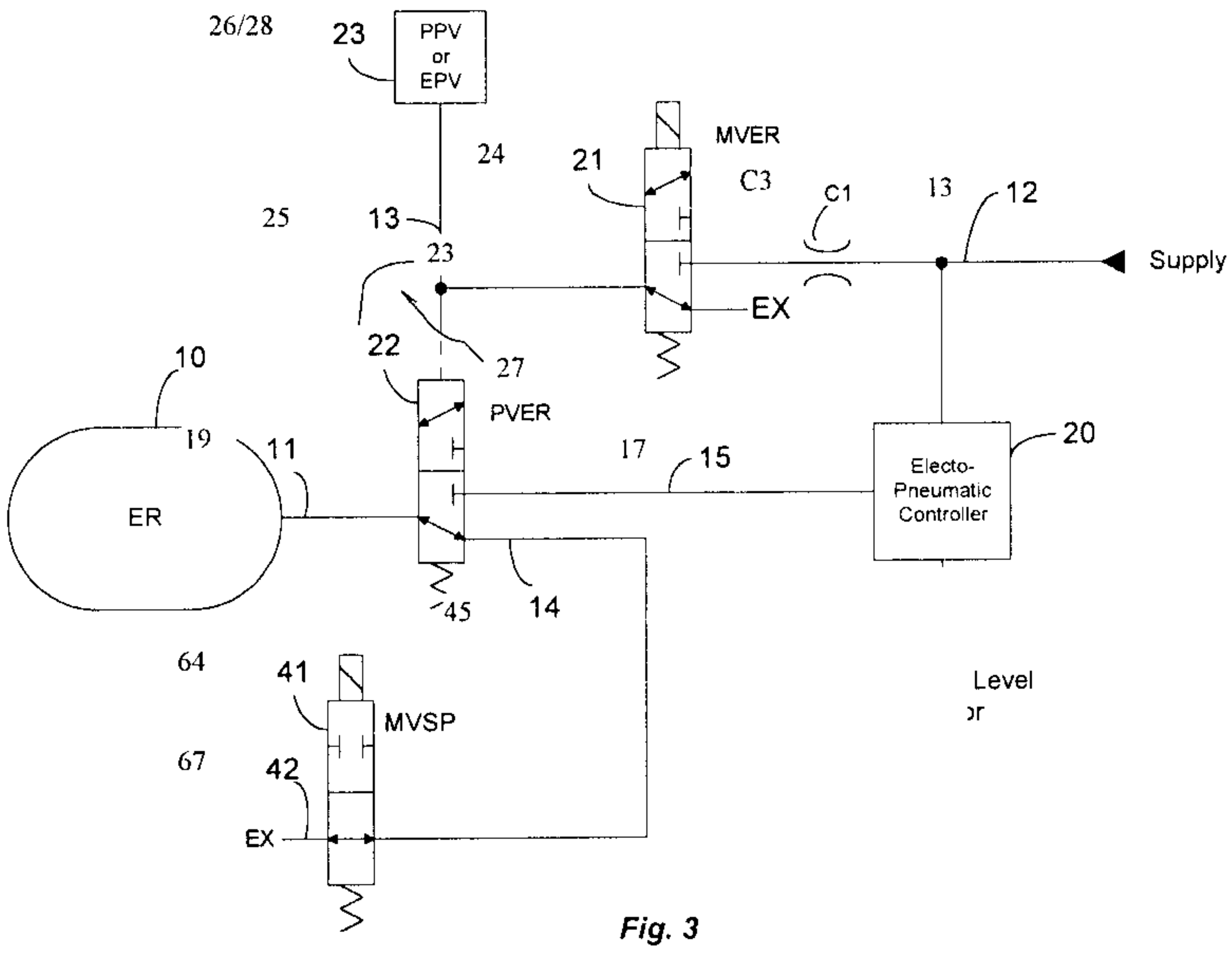


Fig. 3

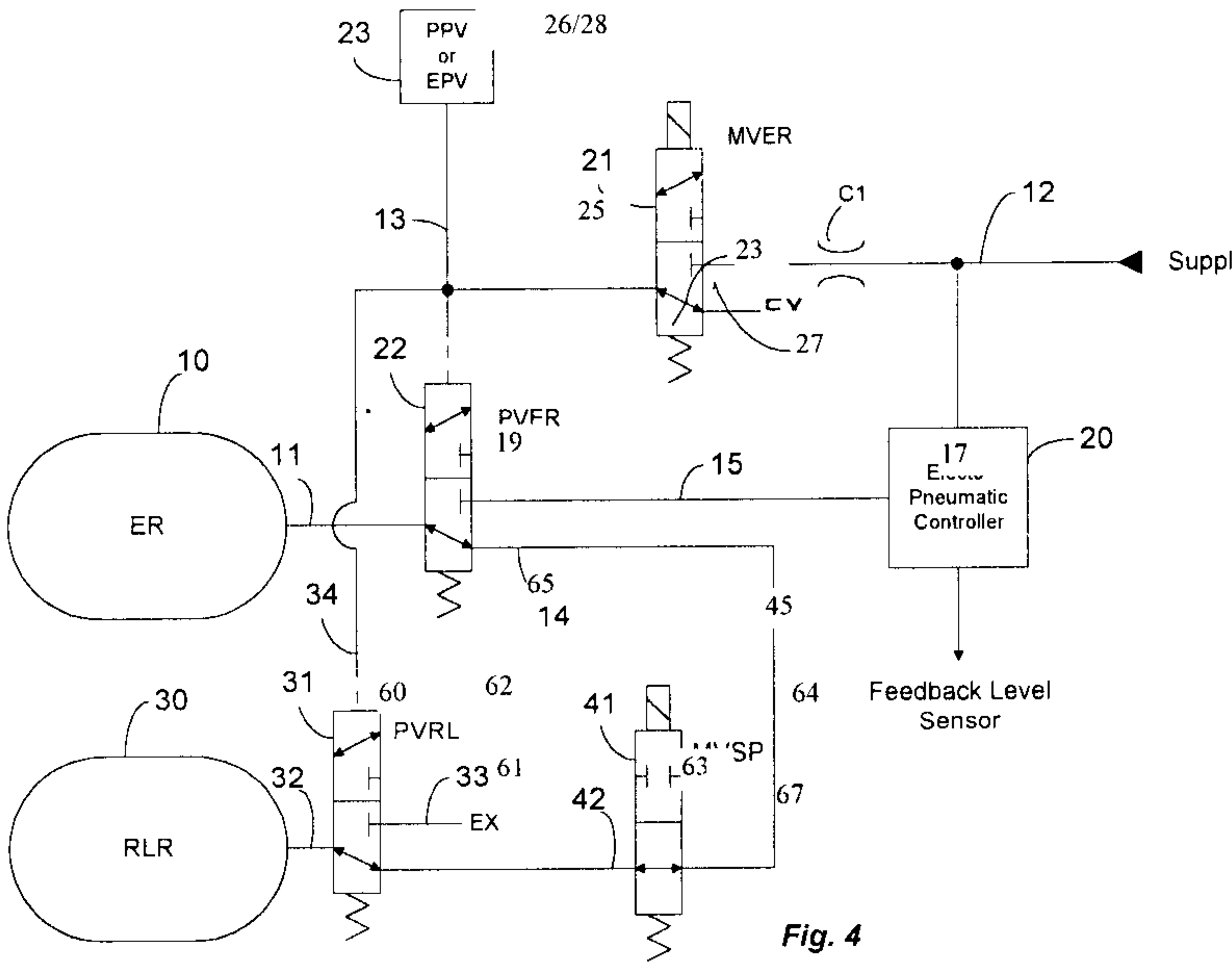


Fig. 4

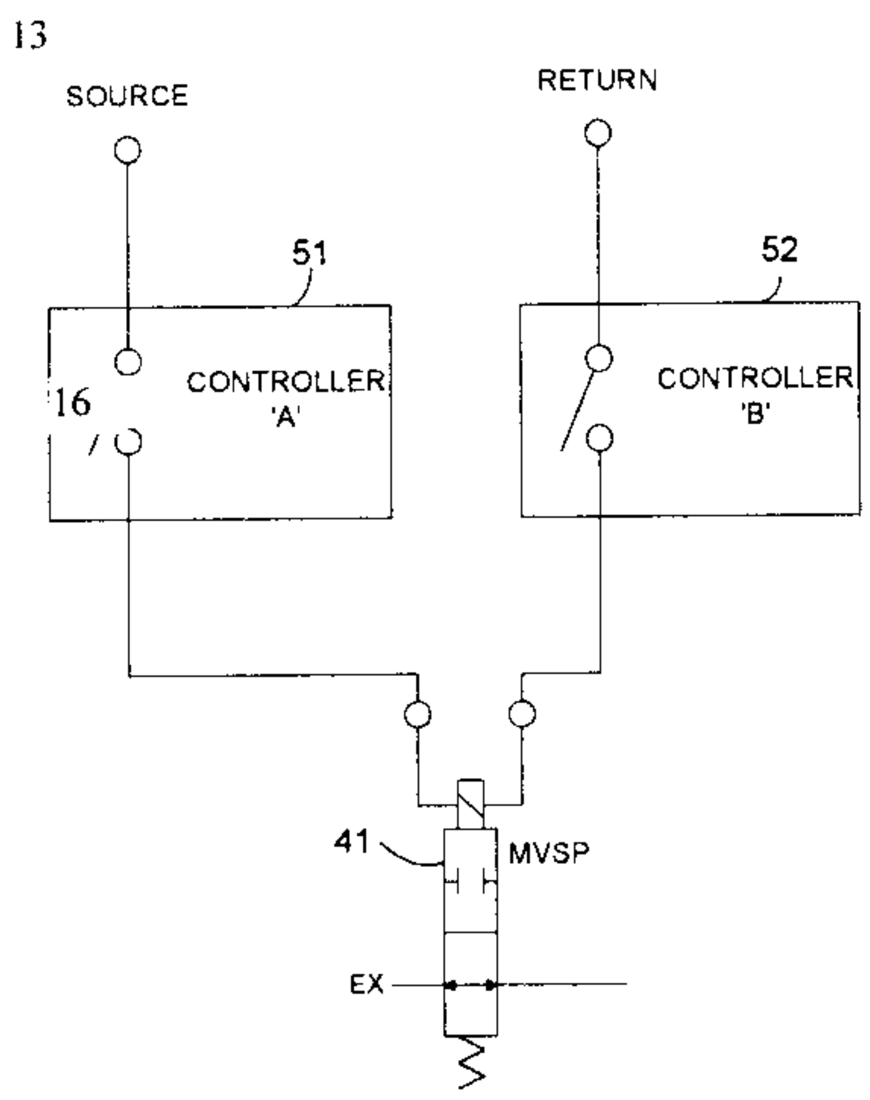


Fig. 5

66 68

64

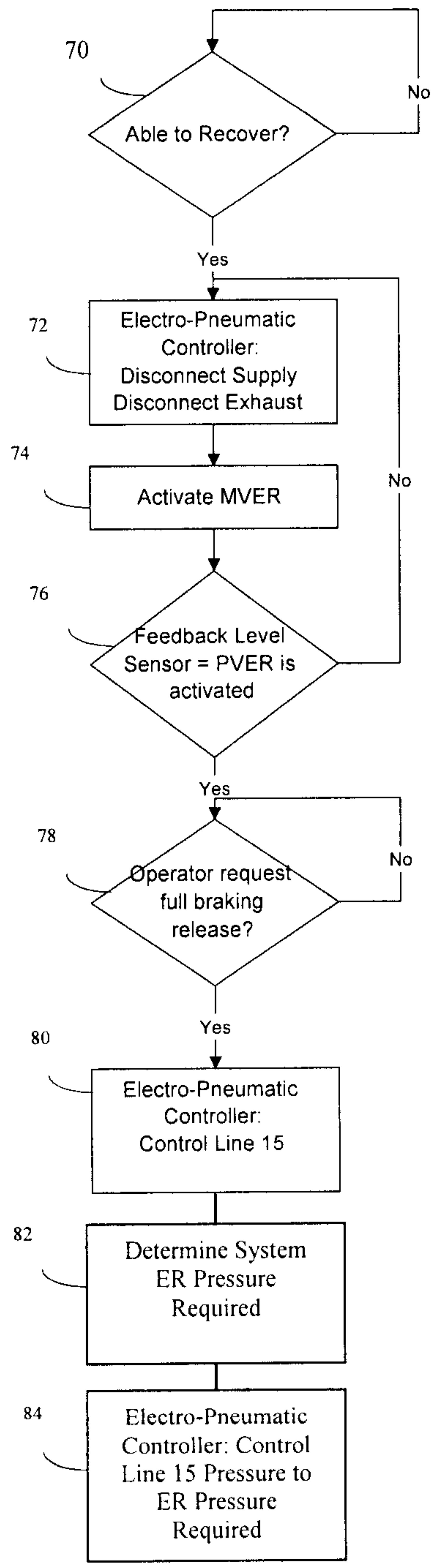


Fig. 6

PRIOR ART

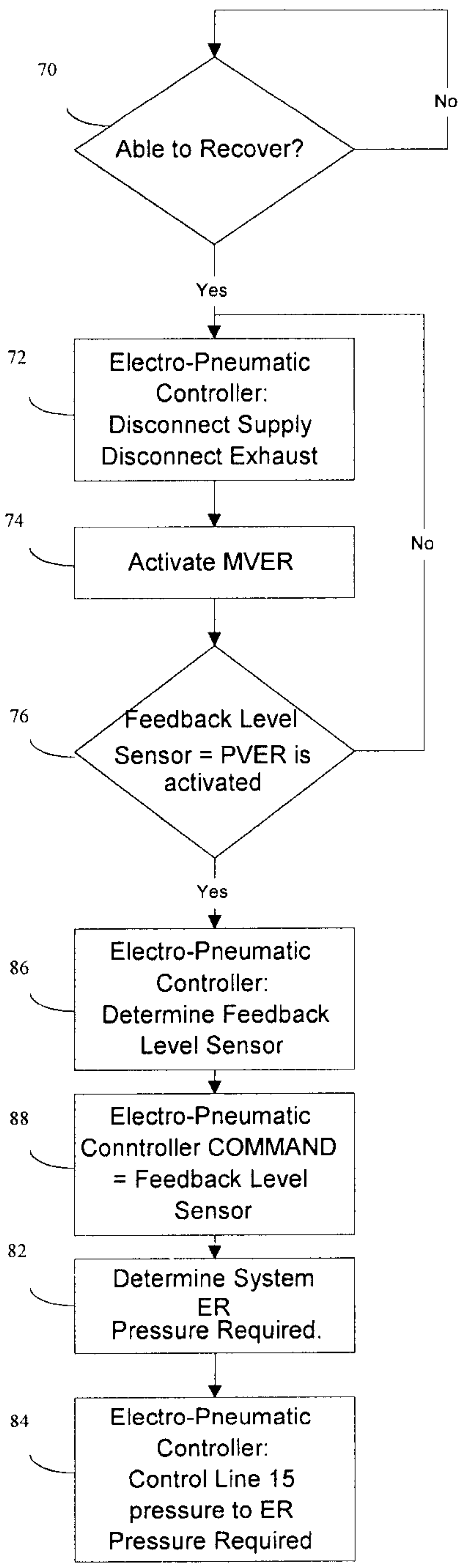
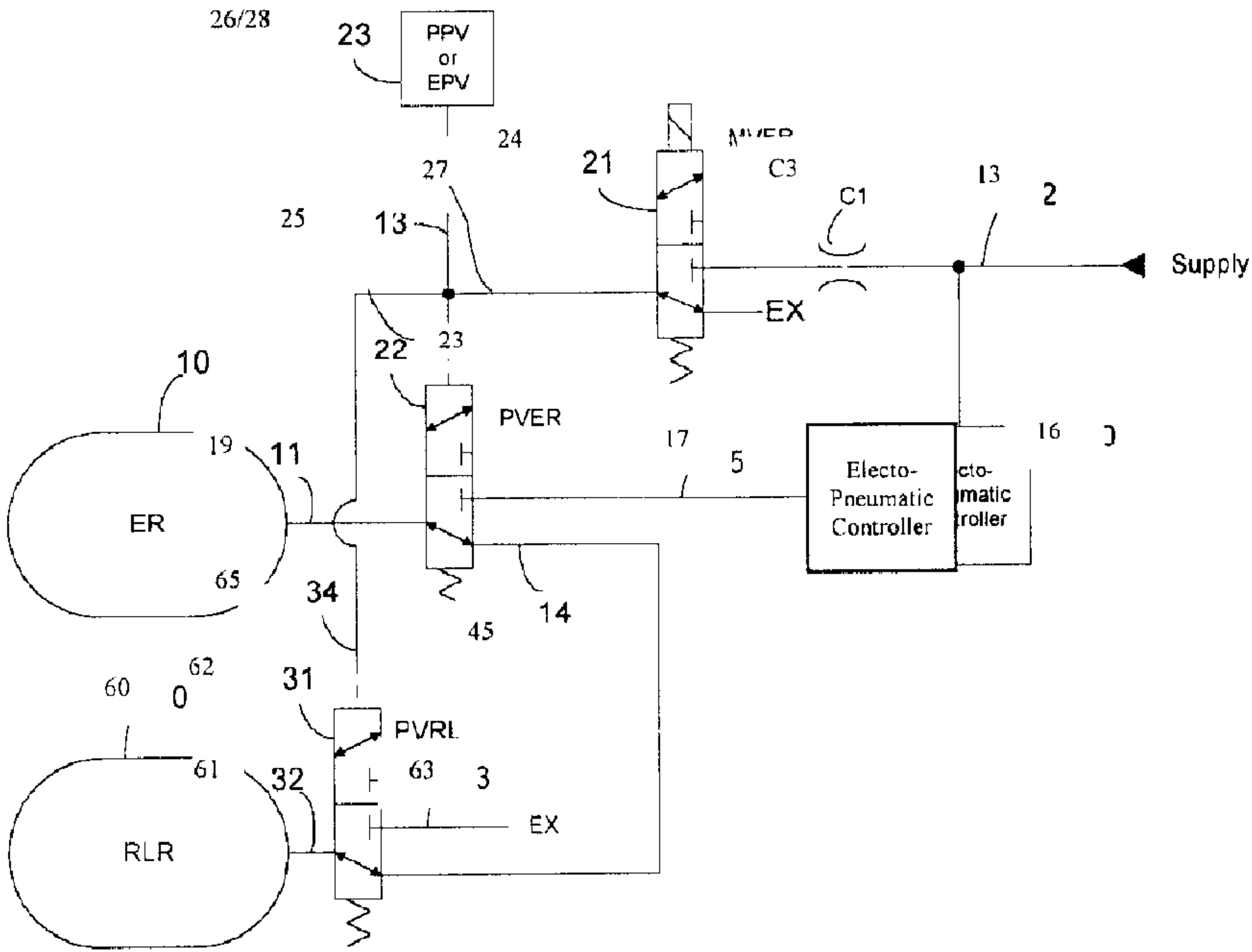

70
Able to Recover?
No
Yes
72
Electro-Pneumatic Controller: Disconnect Supply Disconnect Exhaust
74
Activate MVER
No
76
Feedback Level Sensor = PVER is activated
Yes
86
Electro-Pneumatic Controller: Determine Feedback Level Sensor
88
Electro-Pneumatic Conntroller COMMAND = Feedback Level Sensor
82
Determine System ER Pressure Required.
84
Electro-Pneumatic Controller: Control Line 15 pressure to ER Pressure Required

Fig. 7



26/28
23
PPV
or
EPV
24
MVER
27
21
C3
C1
13
2
25
13
Supply
EX
22
23
10
PVER
19
11
17
16
5
Electro-
Pneumatic
Controller
cto-
matic
troller
ER
65
34
14
45
62
60
0
31
PVRL
61
63
3
32
EX
RLR