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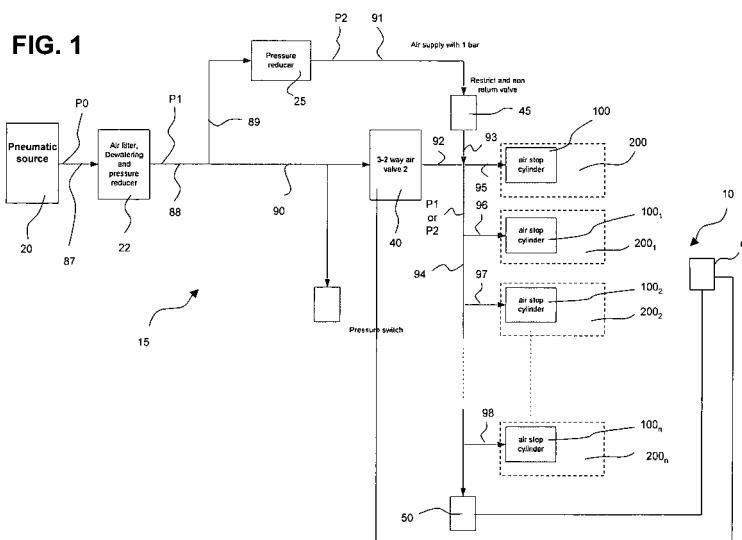
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(54) **Continuous compressed air leakage monitoring system and method**

(57) A monitoring system (10) monitors pressure in a pneumatic assembly (15) that supplies compressed air at a predetermined operating pressure (P1) from a pneumatic source (20) to at least one pneumatic load (100, 100₁, 100₂, ..., 100_n) actuatable thereby. The monitoring system includes a pressure reducing device (25) that reduces the pressure of the compressed air to a lower, leakage test pressure (P2). A switching device (40) has

a first switch position, in which the at least one pneumatic load is supplied with the compressed air at the leakage test pressure, and a second switch position, in which the at least one pneumatic load is supplied with compressed air at the operating pressure. A pressure sensor (50) continuously senses the pressure within a connecting piping (92-98) and outputs a warning signal in case the detected pressure falls below a predetermined threshold pressure (P3).



Description

Technical Field

[0001] The present disclosure refers to a monitoring system for monitoring a pneumatic arrangement or assembly comprising a piping or fluid communication path for supplying compressed air at a predetermined operating pressure to at least one load and/or device adapted to be driven by the compressed air. Furthermore, the present disclosure refers to a method for monitoring or determining whether a leak is present in such a piping or fluid communication path. In another aspect, the present disclosure refers to a monitoring system for monitoring or determining the amount or degree of leakage in such a piping or fluid communication path configured to supply compressed air, e.g., to an emergency stop device of at least one internal combustion engine, e.g., a diesel engine. The emergency stop device is driven or actuatable by the compressed air at a predetermined operating pressure.

Background

[0002] Various arrangements or systems are generally known that use compressed air at a predetermined operating pressure for operating or actuating a mechanical device such as, e.g., a pneumatic cylinder of an engine shutdown system.

[0003] Known diesel engines having mechanically-governed injection pumps are often pneumatically shut-off when the ignition key is turned off. Alternatively, under normal conditions, a shut-off of an engine is carried via an mechanical or electronic control unit. In an emergency case, an emergency shut-off is carried out via the mechanical or electronic control unit and a pneumatic emergency shut-off arrangement. However, if there is a defect or fault in the pneumatic arrangement or assembly, e.g., a leak in the compressed air fluid communication path or piping, the pneumatic shut-off function may no longer be guaranteed. Therefore, if a pneumatic driven device connected thereto, e.g., a pneumatic cylinder of an emergency shut-off system of a diesel engine, is required to be actuated, it may not be possible to properly shut-off the diesel engine in case the pneumatic cylinder can not be adequately driven due to a leak in the compressed air piping. Consequently, if the pneumatic load, i.e. the pneumatic cylinder in this example, cannot be adequately driven, the inability to timely shut-off the engine may be problematic.

[0004] More particularly, a known emergency shut-off arrangement comprises one or more pneumatic cylinders, which are extendable when a predetermined operating pressure is supplied to the pneumatic cylinder. This extension causes the fuel supply of an internal combustion engine, such as a diesel engine, to be cut-off. However, when an emergency shut-off is required, this known arrangement might fail if there is an undetected leak in

the compressed air piping connected to the at least one pneumatic cylinder. Thus, in the known emergency shut-off arrangement, an emergency shut-off of the associated engine cannot be guaranteed if there is a defect or leak in the piping.

[0005] US 5,322,041 discloses an supplemental emergency shut-off device for an internal combustion engine. This supplemental emergency shut-off device is provided in a filter head of the engine fuel filter and serves to shut off the fuel supply and thus shut down the engine in the event that the engine cannot be turned off by means of the ignition key. This may happen, for example, if the primary pneumatic shut-off system of a diesel engine has failed. The special positioning of this emergency shut-off device in the head of the fuel filter, which is placed in the upper region of the engine compartment to enable rapid changing of the filter, provides direct, unobstructed access to the emergency shut-off device. However, because this known arrangement requires an additional emergency shut-off device, this solution can be costly to implement.

[0006] A compressed air monitoring system for monitoring leakage of compressed air in a compressed air circuit is disclosed in US 6,711,507 B2. Herein, a flow meter is installed in a compressed-air supply line, which communicates with air-driven devices in a compressed air circuit. The flow meter measures the flow rate of the compressed air in the supply line. A monitor computer receives measured flow rate data from the flow meter. The monitor computer includes an operational state identifying means for identifying a current operational state of the air-driven devices from a plurality of categorized operational states of the air-driven devices. The monitor computer further includes an air leakage determining means for determining the level of leakage of compressed air in the compressed air circuit by comparing the measured flow rate data with a corresponding one of a plurality of master flow rates. The selected master flow rate corresponds to the current operational state of the air-driven devices identified by the operational state identifying means. It was asserted therein that such an arrangement makes it easy to categorize the operational states of the air-driven devices and to identify the current operational state of the air-driven devices. However, this known compressed air monitor system is expected to be quite expensive to implement due to the necessary flow meter and monitor computer.

[0007] AT 001 405 U1 discloses a method for monitoring or determining the amount or degree of leakage in a high pressure injection system of an internal combustion engine. In order to carry out this known method, the engine must be shut-off and the injection nozzles must be closed. Then, a high pressure region is filled with a low-pressure test gas. Thereafter, the periodic change of the pressure within the injection system is monitored and used for testing the air-tightness of the injection system. Thus, this known method is unsatisfactory, because it cannot be performed while the engine is running or op-

erating.

[0008] EP 1 439 295 A2 refers to a method for performing a controlled shut-off of an internal combustion engine such that the crankshaft stops in a predetermined angular position. However, this known method does not provide any teaching for solving the above-mentioned technical problem(s).

[0009] A further method for performing a rapid shut-off of a diesel engine is disclosed in DE 31 15 410 A1. Herein, a throttle rod of an injection pump is connected with a gas cylinder. The gas cylinder is connected to a pressure air pipe that supplies compressed air to a stop valve via an additional pipe. Such an arrangement might be useful to stop the internal combustion engine rather quickly, but it does not help to solve the above-mentioned technical problem(s).

[0010] In US 4,732,123, a safety air supply for diesel engine shutdown systems is disclosed. This safety air supply is used in combination with a type of pneumatic shutdown system that is connected to an existing air supply source. It cooperates via electromechanical control means with the fuel injectors of a diesel engine for moving the fuel injectors between operative and inoperative positions. The safety device comprises an air reservoir tank connected between the air supply source and the pneumatic cylinder of the shutdown system by means of heavy-duty armored conduit. A tee fitting is sealed in the top wall of the tank. A one-way check valve is secured in the top of the tee fitting and allows air to enter the tank from the existing air supply source up to a predetermined pressure. Thereafter, the valve closes to contain a supply of air within the tank, independent from the existing source. The outlet of the tee fitting is connected to the inlet of the existing pneumatic shutdown system. In the event of a failure of the air source or a ruptured or burned air line between the source and the pneumatic shutdown pneumatic cylinder, air will be supplied from the air tank to the shutdown pneumatic cylinder to maintain control, whereby the fuel injectors may be moved to the neutral position or inoperative position.

[0011] US 5,062,400 discloses a diesel engine shutdown device for stopping a diesel engine by actuating an engine shutdown mechanism with an actuator when an engine key switch is turned off. However, in this known diesel engine shutdown device, one or more of the above-mentioned technical problems may still arise.

[0012] Another diesel engine emergency shutdown system is disclosed in JP 06-002630 A, in which a selector valve is connected to an intake and to a discharge side of a fuel supply pump of the engine. This selector valve is switched by means of an emergency stop signal. However, one or more of the above-identified technical problems may also arise in this known emergency shutdown system.

[0013] A further emergency shutdown system for a diesel engine is disclosed in DD 80 588. Herein, a pneumatic way-valve is used to supply a pressurized medium, preferably pressurized air, into the inlet chamber of an injection pump such that the fuel within the intake chamber is forced into a return line and the fuel tank and, as a result, further fuel supply is stopped. Again, this known arrangement cannot solve the above-identified technical problems.

tion pump such that the fuel within the intake chamber is forced into a return line and the fuel tank and, as a result, further fuel supply is stopped. Again, this known arrangement cannot solve the above-identified technical problems.

Summary of the Invention

[0014] In accordance with a first aspect of the present disclosure, a monitoring system for monitoring a pneumatic arrangement or assembly is disclosed. The pneumatic arrangement may be used to supply compressed air at a predetermined operating pressure to at least one load and/or device configured to be driven or actuated by the compressed air at the operating pressure or higher. This monitoring system may be connectable to or may comprise a pneumatic source configured to supply compressed air at the operating pressure. A pressure reducing device is preferably utilized to reduce the pressure of the compressed air from the operating pressure to a lower, leakage test pressure. The monitoring system may also be connectable to or further comprise at least one pneumatic load and/or device configured to be operated or actuated by the compressed air at the operating pressure. A switching device is provided and has a first switch position and a second switch position. In the first switch position, the at least one pneumatic load may be supplied with the compressed air at the leakage test pressure and in the second switch position the at least one pneumatic load may be supplied with compressed air at the operating pressure. A piping or fluid communication path preferably connects two or more of the pneumatic source, the pressure reducing device, the switching device and the at least one pneumatic load or device. A pressure sensor may be adapted to continuously sense the pressure within the piping or fluid communication path and to output a warning signal in case the pressure within the piping or fluid communication path is or falls below a predetermined threshold pressure, e.g., less than the leakage test pressure.

[0015] According to a further aspect of the present disclosure, a method is provided for monitoring a pneumatic arrangement or assembly comprising at least one pneumatic load and/or device configured to be operated or actuated by compressed air at an operating pressure. The method may comprise one or more of the following method steps: supplying compressed air at the operating pressure into a piping or fluid communication path, reducing the pressure of the compressed air to a lower, leakage test pressure, thereafter monitoring the pressure within the piping or fluid communication path, and outputting a warning signal in case the monitored pressure is less than or falls below a predetermined threshold pressure, e.g., less than the leakage test pressure.

[0016] In another aspect of the present disclosure, the piping or fluid communication configured to supply compressed air to at least one pneumatic load is supplied with compressed air at a leakage test pressure that is

less than a minimum operating or actuating pressure of the at least one pneumatic load. By continuously supplying the compressed air at the leakage test pressure into the piping or fluid communication path, the air-tightness or sealing state of the piping or fluid communication path can be continuously monitored. The pneumatic load or device remains actuatable at any time by, for example, increasing the pressure of the compressed air within the piping or fluid communication path to at least the operating pressure. For example, compressed air at the operating pressure is preferably supplied through the piping to the at least one load only after switching a switching device, such as, for example, a 3/2-way valve or a switch at a pressure reducer device. Hence, any leakage in the piping can be easily determined or detected by, for example, a pressure sensor. If the at least one load is, for example, a pneumatic cylinder that is activated in order to shut-off the fuel supply of an internal combustion engine, in particular a diesel engine, it can be guaranteed that, if an emergency stop is required, the pneumatic cylinder can be adequately activated while the piping is being continuously monitored for leakage. Consequently, a leakage in the piping is not expected to lead to an inability to shut-off the fuel supply, in case an emergency stop of the internal combustion engine(s) is required.

[0017] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the disclosure.

[0018] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0019] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrates an exemplary embodiment of the disclosure and, together with the description, serve to explain the principles of the disclosure. In the drawings:

[0020] Fig. 1 is a schematic block diagram of a first exemplary embodiment of the present disclosure;

[0021] Fig. 2 is a schematic diagram of a further embodiment of the present disclosure; and

[0022] Fig. 3 is an arrangement according to the prior art.

Detailed Description

[0023] At first, a known pneumatic arrangement or system for supplying compressed air at an operating pressure to air cylinders of fuel pumps of one or more diesel engines is explained with reference to Fig. 3. This monitoring system of the present disclosure may optionally be retro-fitted into an existing pneumatic system or may be integrated in a newly-designed pneumatic system.

[0024] As shown in Fig. 3, a pneumatic source 20 is connected via a service unit 21 and a piping comprising

pipes 92, 94 and 95-98 to air stop cylinders 100, 100₁, 100₂, ..., 100_n. Each air stop cylinder 100, 100₁, 100₂, ..., 100_n is connected to a fuel pump configured to supply fuel to a respective diesel engine 200, 200₁, 200₂, ..., 200_n. The service unit 21 may comprise a dewatering device, e.g., a dehydrating and/or drainage device, a pressure reducer and an air filter. Furthermore, a control valve (not shown in Fig. 3) may be included in the service unit 21. In a first position, the control valve is preferably configured to supply no compressed air, i.e. shut-off the supply of compressed air to the air stop cylinders, and in a second position to supply compressed air at an operating pressure, e.g., equal to or greater than a minimum actuation pressure, of the air stop cylinders 100, 100₁, 100₂, ..., 100_n.

[0025] During normal operation of the fuel pumps and the respective diesel engine 200, 200₁, 200₂, ..., 200_n according to the known pneumatic system of Fig. 3, no compressed air is supplied to the air stop cylinders 100, 100₁, 100₂, ..., 100_n. Consequently, the fuel pumps of each engine 200, 200₁, 200₂, ..., 200_n operate in a normal operation mode. However, if for some reason one or all diesel engines 200, 200₁, 200₂, ..., 200_n must be stopped (e.g. "emergency stop"), the control valve within the service unit 21 is switched so that compressed air from the pneumatic source 20 is supplied via the piping 92, 94, 95-98 each respective air stop cylinder 100, 100₁, 100₂, ..., 100_n. As a result, each air stop cylinder 100, 100₁, 100₂, ..., 100_n extends and due to this actuation, the fuel supply to each of the associated fuel pumps is stopped. Due to this rapid shut-off of the fuel supply to each diesel engine 200, 200₁, 200₂, ..., 200_n, the diesel engines 200, 200₁, 200₂, ..., 200_n are immediately stopped.

[0026] Taking the above into consideration, it is apparent that, in case there is a leak in the piping 92, 94, 95-98, it may not be possible to supply compressed air at the minimum operating pressure to the air stop cylinders 100, 100₁, 100₂, ..., 100_n via the piping 92, 94, 95-98 due to a resulting drop of pressure caused by the leak. Hence, if for some reason an emergency shut-off of the diesel engines 200, 200₁, 200₂, ..., 200_n becomes necessary, the air stop cylinders 100, 100₁, 100₂, ..., 100_n may not adequately extend. As a consequence, an emergency stop of the engines 200, 200₁, 200₂, ..., 200_n can not be guaranteed. A thorough visual check of the piping 92, 94, 95-98 for leaks can only be conducted periodically in a cost-effective manner, for example once a month or even once a year. Therefore, a monitoring system as discussed below is particularly advantageous.

[0027] Reference will now be made in detail to the exemplary embodiments of the disclosure, examples of which are illustrated in the accompanying drawings. Wherever possibly, the same reference numbers will be used throughout the drawings to refer to the same or like parts. While the disclosure is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings

and will herein be described in detail. It should be understood, however, that there is no intent to limit the disclosure to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure as defined by the appended claims.

[0028] Referring to Fig. 1, a first exemplary embodiment of a monitoring system 10 according to the present disclosure is explained in further detail. A pneumatic source 20 is connected to a device 22 for filtering and dewatering (e.g., dehydrating and/or draining liquid from) the compressed air and for reducing the pressure of the compressed air originating from the pneumatic source 20. A pipe 87 connects the pneumatic source 20 to the air filter, dewatering and pressure reducer 22. Additional pipes 88 and 90 connect the device 22 to a 3/2-way valve 40. The 3/2-way valve 40 is connected via pipes 92, 94 and 95-98 to a plurality of air stop cylinders 100, 100₁, 100₂, ..., 100_n of diesel engines 200, 200₁, 200₂, ..., 200_n. A further pipe 89 connects the device 22 to a pressure reducer 25. The pressure reducer 25 is connected via a pipe 91 to a restrict and non return valve 45. Valve 45 may also be known as a check valve, a check valve having a throttle, a one-way throttle and is generally intended to cover any type of valve which has an adjustable flow cross-section and only permits air flow in one direction. A pipe 93 connects the restrict and non return valve 45 to the pipe 94 and, accordingly, to the air stop cylinders 100, 100₁, 100₂, ..., 100_n via pipes 95-98, respectively.

[0029] A pressure sensor 50 is also connected to the pipe 94 and the control unit 60. The pressure sensor 50 is adapted to sense the pressure within the piping comprising at least one of the pipes 91-98.

[0030] The pneumatic source 20 supplies compressed air at a first pressure P0 into the pipe 87. In the device 22, the pressure of the compressed air originating from the pneumatic source 20 is reduced to an operating pressure P1, which may be for example at least a minimum pressure for operating and/or actuating the air stop cylinders 100, 100₁, 100₂, ..., 100_n. In this exemplary embodiment, the operating pressure P1 is lower than the first pressure P0. However, in one alternative, it is also possible for the pneumatic source 20 to supply compressed air, which is already at the operating pressure P1, to the air filter and/or dewatering device. In this alternative, the pressure reducer in device 22 may be omitted.

[0031] Depending on the switch position of the 3/2-way valve 40, the filtered, dewatered and pressure-reduced compressed air at the operating pressure P1 or at a leakage test pressure P2 is supplied into the piping 92-98. During normal operation of the engines 200, 200₁, 200₂, ..., 200_n, the 3/2-way valve 40 is in a position such that the pipe 90 is not in fluid communication with the pipe 92. Consequently, compressed air at the operating pressure P1 supplied through the device 22 flows through the pressure reducer 25. In the pressure reducer 25, the pressure of the compressed air is further reduced to the

leakage test pressure P2, which is lower than the operating pressure P1. The compressed air at the leakage test pressure P2 then flows into the piping 91-98. The air stop cylinders 100, 100₁, 100₂, ..., 100_n are preferably configured to be actuated or operative only when compressed air is supplied thereto at a higher (or relatively high) pressure, i.e. higher than the leakage test pressure P2, e.g., a pressure at or about the operating pressure P1. On the other hand, if compressed air at the lower leakage test pressure P2 is supplied, which occurs when the 3/2-way valve 40 is disposed in a first switch position, the air stop cylinders 100, 100₁, 100₂, ..., 100_n are configured to remain idle (i.e. not actuated).

[0032] Thus, during normal operation, the piping, including at least one of the pipes 91-98, is normally filled with compressed air at the leakage pressure P2. Hence, if the piping is air-tight (i.e. there are no leaks), the pressure within the piping should not change. Any changes in pressure within pipes 91-98 is thus preferably monitored by at least pressure sensor 50.

[0033] In case a leak develops in one or more of piping 91-98, compressed air at the leakage test pressure P2 will leak and, consequently, the pressure within the piping 91-98 will drop. In this case, the pressure drop within the piping 91-98 is detected by the pressure sensor 50 and a signal indicative of the pressure drop within the piping 91-98, e.g. a drop in pressure below a predetermined threshold pressure, such as the leakage test pressure P2, is outputted to the control unit 60. In one embodiment, the control unit 60 connected to the 3/2-way valve 40 may switch the valve 40 to the second switch position in response to the recorded pressure drop, whereby compressed air at the operating pressure P1 will be supplied into the piping comprising the pipes 92-98. As a result, the air stop cylinders 100, 100₁, 100₂, ..., 100_n are driven or extended, thereby shutting-off the fuel supply to the associated engines 200, 200₁, 200₂, ..., 200_n, as a precautionary measure, so that the leak(s) in the piping 92-98 can be repaired.

[0034] A more detailed schematic diagram of another exemplary embodiment of a monitoring system 10 is shown in Fig. 2. Herein, a pneumatic source 20 is connected to a dewatering device 22₁ arranged downstream of the pneumatic source 20. A first pressure reducer 22₂ is arranged downstream of the dewatering device 22₁. The pressure reducer 25 and the 3/2-way air valve 40 are connected via pipes 88, 89, 90, respectively, to the pressure reducer 22₂. The restrict and non return valve 45 is connected via the pipe 91 to the outlet of the pressure reducer 25. A pressure control valve 75 is connected to the pipe 91. The outlet of the restrict and non return valve 45 is also connected to the 3/2-way air valve 40. Furthermore, the pressure sensor 50 is connected to the pipe 92₂ which connects one outlet of the 3/2-way air valve 40 with a double check valve 70. The pipe 94 connects the air cylinders 100, 100₁, 100₂, ..., 100_n with the double check valve 70.

[0035] During a normal operation mode of the engines

200, 200₁, 200₂, ..., 200_n, the compressed air at a high pressure supplied from the pneumatic source 20 passes through the pressure reducer 22₂ and its pressure is reduced to the operating pressure P1. While the 3/2-way valve 40 is in the position shown in Fig. 2, the pipe 92₁ is connected to or is in fluid communication with the pipe 92₂. Consequently, the compressed air within the pipe 89 passes through the pressure reducer 25, thereby reducing its pressure to the leakage test pressure P2. The compressed air at the leakage test pressure P2 passes through the restrict and non return valve 45, the 3/2-way valve 40 and the double-check valve 70. As a result, the pipe 92₂ is filled with compressed air at the leakage test pressure P2. The same applies to all of pipes 91, 92₁ and 94-98 (only 94 is shown in Fig. 2 for the purpose of clarity) leading to the respective air stop cylinders 100, 100₁, 100₂, ..., 100_n.

[0036] In the second switch position of the 3/2-way valve 40, the pipe 92₁ is disconnected from the pipes 92₂ and 94. Instead, the pipe 90 is connected to the pipe 92₂ such that compressed air at the operating pressure P1 flows through the pipe 92₂ and pipes 94-98 to the air stop cylinders 100, 100₁, 100₂, ..., 100_n. As a result, the air stop cylinders 100, 100₁, 100₂, ..., 100_n will extend and the fuel supply to the associated diesel engine 200, 200₁, 200₂, ..., 200_n will be immediately shut-off. The change-over or switching of the 3/2-way valve 40 may be initiated by a control unit 60 (not shown in Fig. 2 for the purpose of clarity) in the same manner as the embodiment of Fig. 1. The 3/2-way valve 40 may embody a switching device mentioned above.

[0037] In order to retract the air stop cylinders 100, 100₁, 100₂, ..., 100_n, the 3/2-way valve 40 is switched back into the position shown in Fig. 2. Consequently, the compressed air at the operating pressure P2 is exhausted via the double-check valve 70 and the compressed air in the piping comprising the pipes 92 and 94-98 returns to the leakage test pressure P2.

[0038] By placing the pressure sensor 50 in fluid communication with the pressure inside the pipe 92₂, a pressure drop within the piping 92 and 94-98 can be detected during the normal operation mode (i.e. when the leakage test pressure is being supplied to the pipes 92₂ and 94). In case a leak develops in the piping 92 and/or 94-98, the regulating valve 25 will automatically respond by attempting to increase the air volume flow rate in order to maintain the pressure within the piping 91-98 at the leakage test pressure P2. In this exemplary embodiment, because the compressed air at the leakage test pressure P2 passes through the restrict and non return valve 45, in particular through the reduced cross section of the restrict and non return valve 45, only a small volume of compressed air at the leakage test pressure P2 can flow into piping 92 and 94-98. Therefore, the pressure in the defective (i.e. leaking) piping 92-98 will drop to, for example, 0.5 bar, whereby the pressure sensor 50 detects the pressure drop below a preset threshold and outputs a warning signal to the control unit 60 shown in Fig. 1.

Industrial Applicability

[0039] Although the preferred embodiments of this invention have been described herein, improvements and modifications may be incorporated without departing from the scope of the following claims.

[0040] According to the exemplary embodiment shown in Figs. 1 and 2 of a monitoring system according to the present disclosure, the pressure limiting valve 75 monitors the valve 25. In case the valve 25 fails, the pressure in pipe 91 will increase. In this particular and exemplary embodiment, if the pressure becomes 1.5 bar or more, the pressure limiting valve 75 will open and prohibit an inadvertent extending or activation of the air stop cylinders 100, 100₁, 100₂, ..., 100_n.

[0041] It must be pointed out that the above pressure values are exemplary only. The operating pressure P2 may set to, e.g., about 7.5 bar or 10.0 bar and the leakage test pressure P2 may set to, e.g., about 1.0 bar. As an example, the air stop cylinders 100, 100₁, 100₂, ..., 100_n may be configured such that they are extended or actuated only if compressed air at an operating pressure of about, e.g., 2.0 bar is supplied thereto. However, the full extension of the air cylinders 100, 100₁, 100₂, ..., 100_n is reached in this exemplary embodiment only if compressed air at a pressure of 7.5 bar is supplied thereto. The air stop cylinders 100, 100₁, 100₂, ..., 100_n are preferably configured so that they do not extend or actuate if compressed air at a pressure below 2.0 bar is supplied thereto. However, it is well within the ordinary skill in the art to select other pressure values based upon the particular design that is implemented based upon the present teachings.

[0042] Furthermore, the present monitoring system may be used in connection with one or more air stop cylinders 100, 100₁, 100₂, ..., 100_n. However, such a monitoring system 10 can also be used with other pneumatic loads or devices, which may be modified such that the loads or devices can be activated only if compressed air at a pressure higher than a leakage test pressure is supplied thereto.

[0043] Although the term "shutdown" has been utilized herein to describe a stopping operation of an engine, it is noted this term is interchangeable with other similar concepts or actions such as cut-off, deactivation, power-down, power-off, de-energizing, etc. In addition, the term "piping" is interchangeable with pipe, channel, conduit, duct, fluid communication path, etc. Further, the term "operating pressure" is generally understood to mean a minimum pressure necessary to actuate or drive a pneumatic load or device, e.g. changing the pneumatic load or device from a first state to a second state, and thus necessarily includes pressures higher than the minimum pressure necessary for actuation.

[0044] The monitoring system and the method disclosed above, outlined in the attached claims and shown in the drawings attached may be used in all technical arrangements and monitoring systems in which pneu-

matic actuating means, e.g., a pneumatic cylinder, are used, e.g., for applying a force.

Claims

1. A monitoring system (10) for monitoring pressure in a pneumatic assembly (15) configured to supply compressed air at a predetermined operating pressure (P1) from a pneumatic source (20) to at least one pneumatic load (100, 100₁, 100₂, ..., 100_n), which is configured to be actuated by the compressed air at the operating pressure (P1), the monitoring system (10) comprising:

a pressure reducing device (25) configured to reduce the pressure of the compressed air at the operating pressure (P1) to a leakage test pressure (P2), which is lower than the operating pressure (P1);

a switching device (40) having a first switch position and a second switch position, the first switch position being configured to supply the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n) with the compressed air at the leakage test pressure (P2) and the second switch position being configured to supply the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n) with compressed air at the operating pressure (P1); a piping (92-98) configured to fluidly connect the pressure reducing device (25), the switching device (40) and the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n); and

a pressure sensor (50) configured to continuously sense the pressure within the piping (92-98) and to output a warning signal in case the pressure within the piping (92-98) is or falls below a predetermined threshold pressure (P3), which is less than the leakage test pressure (P2).

2. The monitoring system (10) of claim 1, further comprising a control unit (60) connected to the pressure sensor (50) and the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n), wherein the control unit (60) is adapted to output a control signal to the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n) in case the pressure sensor (50) outputs the warning signal to the control unit (60).

3. The monitoring system (10) of claim 1 or 2, further comprising:

a first pneumatic piping (88, 89, 90) configured to fluidly connect an outlet of the pneumatic source (20) with an inlet of the pressure reducing device (25) and with a first inlet of the switching device (40),

a second pneumatic piping (91, 92₁) connecting an outlet of the pressure reducing device (25) with a second inlet of the switching device (40), and

a third pneumatic piping (92₂, 94) configured to connect an outlet of the switching device (40) with an inlet of the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n),

wherein the first switch position of the switching device (40) is configured to provide a fluid communication path between the outlet of pressure reducing device (25) and the inlet of the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n) and to block fluid communication between first pneumatic piping (88, 89, 90) and the inlet of the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n), and the second switch position of the switching device (40) is configured to block fluid communication between the outlet of pressure reducing device (25) and the inlet of the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n) and to provide a fluid communication path between the first pneumatic piping (88, 89, 90) and the inlet of the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n).

4. The monitoring system of claim 3, further comprising a one-way restrictor (45), an inlet of the one-way restrictor (45) being connected to the outlet of the pressure reducing device (25) and an outlet of the one-way restrictor (45) being connected to the first inlet of the switching device (40).

5. The monitoring system of claim 3 or 4, further comprising a pressure relief valve (70) connected to the third pneumatic piping (92₂, 94).

6. The monitoring system of one of the preceding claims, wherein the switching device is a way valve, e.g., a 3/2-way valve (40).

7. The monitoring system of one of the preceding claims, wherein the ratio of the operating pressure (P1) to the leakage test pressure (P2) is within the range of about 2.0-20.0, preferably about 5.0-10.0, and more preferably about 7.0-8.0.

8. The monitoring system of one of the preceding claims, wherein the operating pressure (P1) is within the range of about 2.0-20.0 bar, preferably about 5.0-10.0 bar, and more preferably about 7.0-8.0 bar.

9. The monitoring system of one of the preceding claims, wherein the leakage test pressure (P2) is within the range of about 0.2-20 bar, preferably about 0.5-5 bar, and more preferably about 1.0-2.0 bar.

10. The monitoring system of one of the preceding

claims, wherein the pressure sensor (50) is arranged to monitor the pressure in the portion of the piping (92-98) that connects the pressure reducing device (25) with the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n).

- 11.** The monitoring system of one of the preceding claims, wherein the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n) is selected from the group of elements consisting of a pneumatic cylinder (), a pneumatic actuator, and a pneumatic adjusting means.

- 12.** The monitoring system of one of the preceding claims, wherein the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n) comprises an air stop cylinder of a fuel injection pump of a diesel engine.

- 13.** A pneumatic system comprising:
the monitoring system of any preceding claim, a pneumatic source (20) configured to supply compressed air at the predetermined operating pressure (P1) or higher, and
at least one pneumatic load (100, 100₁, 100₂, ..., 100_n) configured to be actuated by the compressed air at the operating pressure (P1), the monitoring system being configured to monitor the pressure within a fluid communication between the pneumatic source (20) and the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n).

- 14.** A method for monitoring a pneumatic assembly (15) having at least one pneumatic load (100, 100₁, 100₂, ..., 100_n) that is actuatable by compressed air at an operating pressure (P1), the method comprising:

supplying compressed air at the operating pressure (P1) into a piping (88-98);
reducing the pressure of said compressed air to a leakage test pressure (P2), which is less than the operating pressure (P1);
monitoring the pressure within the piping (88-98); and
outputting a warning signal in case the monitored pressure within the piping system (88-98) is less than or falls below a predetermined threshold pressure, which is less than the leakage test pressure (P2).

- 15.** The method according to claim 14, further comprising:

supplying compressed air at a pressure (P0) higher than the operating pressure (P1) from a pneumatic source (20), and
reducing the pressure (P0) of the compressed

air to the operating pressure (P1).

- 16.** The method according to claim 14 or 15, further comprising transmitting the warning signal to a control unit (60), wherein the control unit (60) thereafter shuts-off a device associated with the at least one pneumatic load (100, 100₁, 100₂, ..., 100_n).

- 17.** The method according to claim 16, wherein the device is at least one diesel engine (200, 200₁, 200₂, ..., 200_n).

FIG. 1

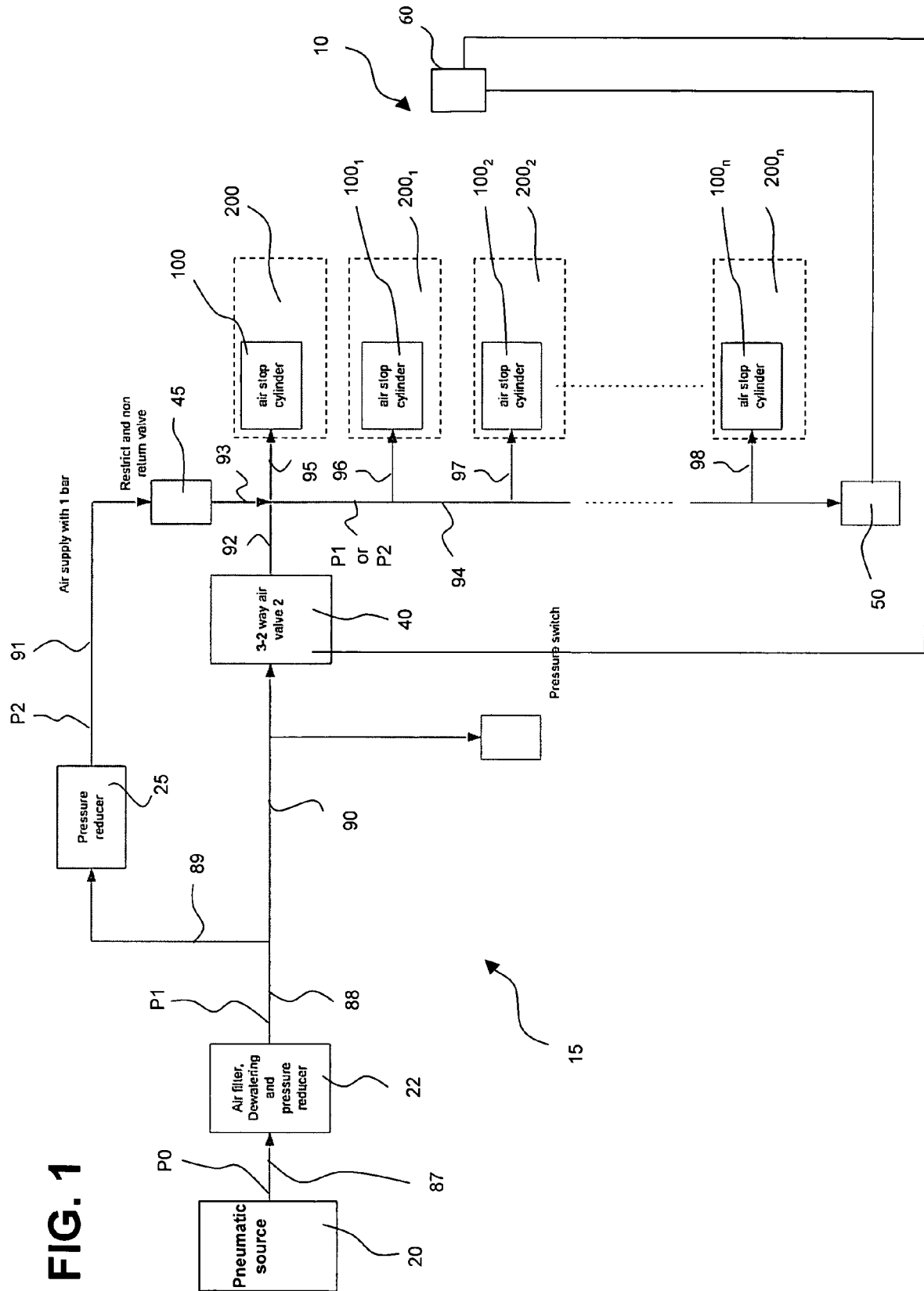


FIG. 2

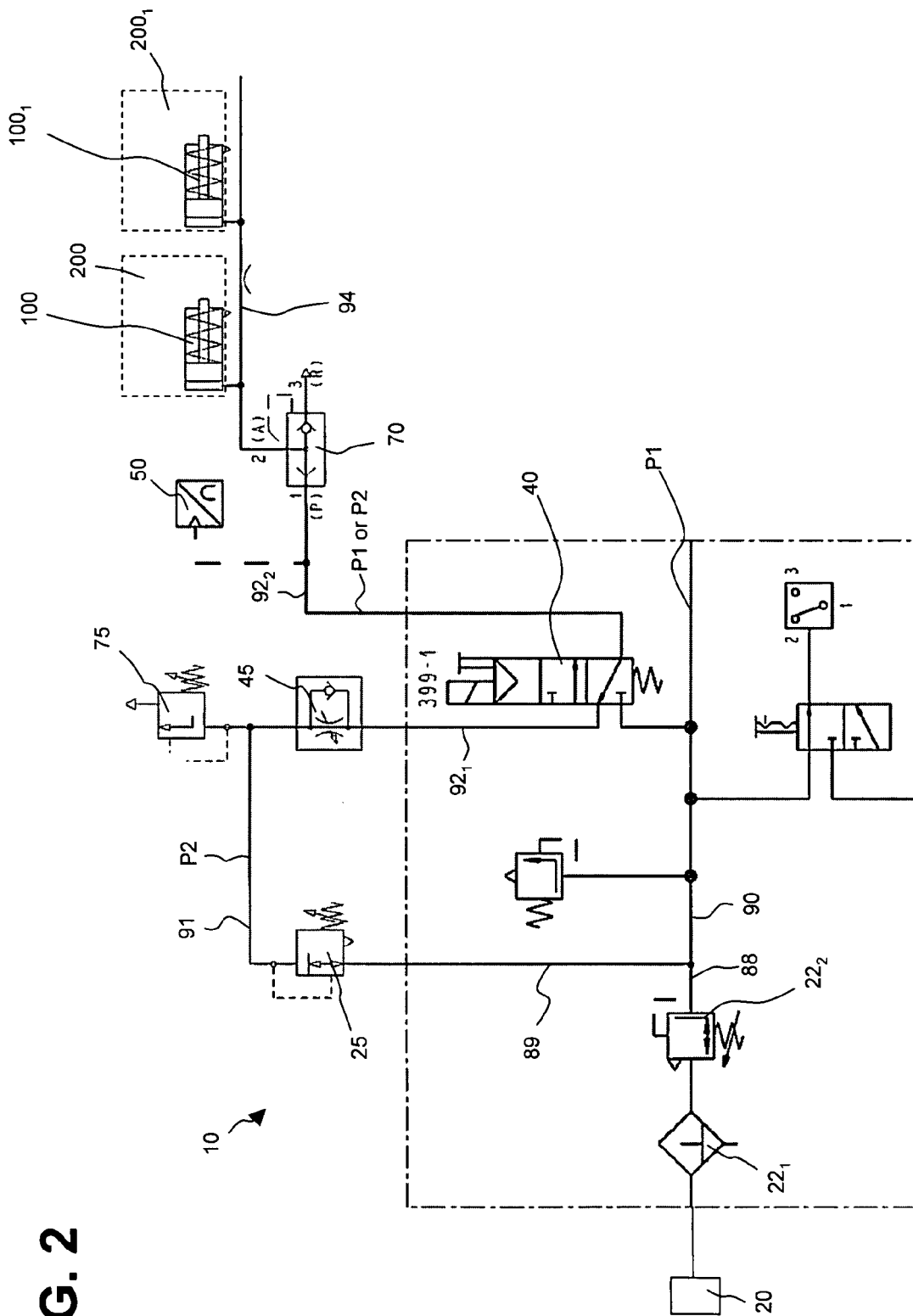
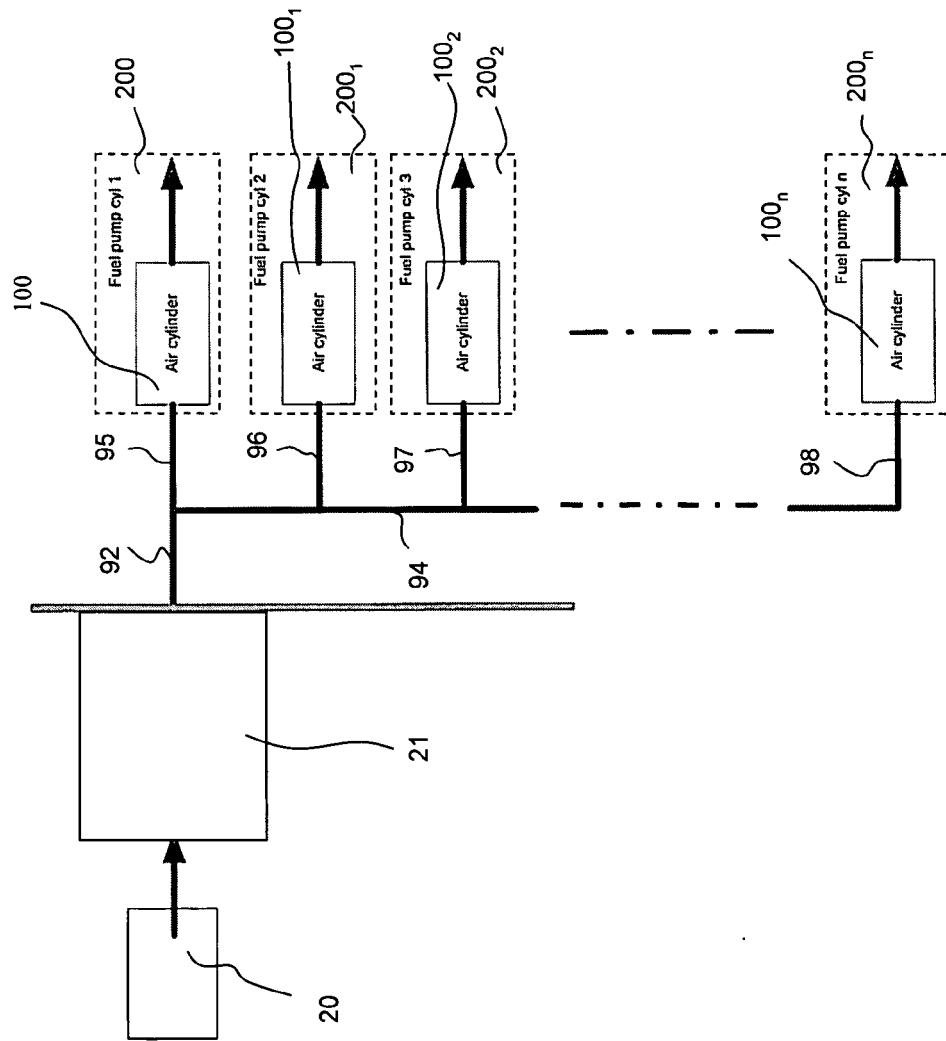


FIG. 3 PRIOR ART





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