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(54) Breathing apparatus with remote reading of high pressure in the source

(57) A breathing apparatus comprises a source of high-pressure air that supplies a breathing device (14) through pressure reducers (12 and 14). At the outlet of the source there is a non-compensated first pressure reducer (12) that provides medium pressure that is a preset function of the high inlet pressure. A second compensated reducer (15), near the breathing device (14) is connected through a pipe (13) to the outlet of the first reducer (12) to receive medium pressure therefrom, reduce the medium pressure to breathing pressure and send the medium pressure to the breathing device (14). A device (16) indicating the pressure of the source is connected between a first and second reducer to detect the medium pressure and provide, on the basis of the medium pressure detected and said preset function, an indirect measurement of the high pressure of the source.

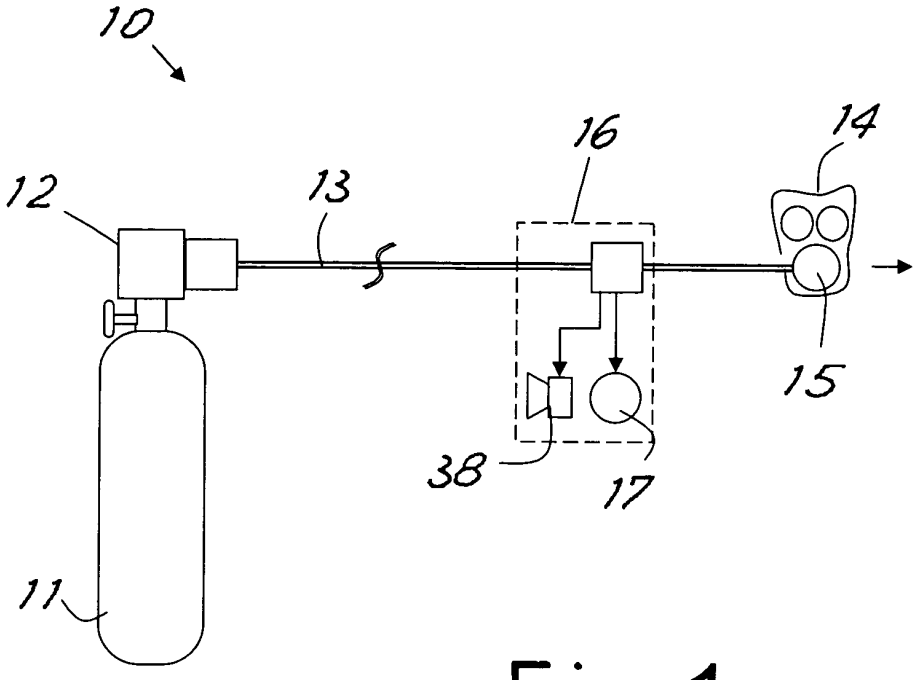

Fig. 1

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Description

[0001] The present invention relates to an innovative breathing apparatus with a remote reading device for reading the high pressure in the source.

[0002] International standards require self-contained breathing apparatuses to have a reading device for reading residual pressure in the cylinder, even if the standards do not indicate where the device has to be installed. In order to give the operator the indication of the high pressure gauge, in the prior art special costly and heavy high-pressure pipes are used (and which are obviously more hazardous than a simple medium-pressure pipe) or a measurement is taken near the cylinder by means of an electronic sensor and the electric signal is then taken to an indicator near the operator. This second solution has the drawback of requiring long electric cables from the cylinder to the operator and of being dependent on an electric supply source. It should be considered that the distance between the source of high-pressure air and the dispenser used by the operator may even be a hundred or more metres.

[0003] Systems have also been proposed with an adjuster on the cylinder that produces a sudden jump in pressure at a preset minimum pressure threshold in the cylinder so as to trigger a suitable alarm remotely that is sensitive to this sudden variation that is present near the operator. The operator is not, however, provided with any reading of the pressure in the cylinder.

[0004] The general object of the present invention is to overcome the aforesaid drawbacks by providing an innovative breathing apparatus that provides the operator with the remote measurement of the pressure of the cylinder without the need for high-pressure pipes or additional connections.

[0005] In view of this object, it was decided to devise, according to the invention, a breathing apparatus comprising a source of high-pressure air that supplies a breathing device through pressure reducers and is provided with a device indicating the pressure of the source, characterised in that at the outlet of the source it comprises a non-compensated first pressure reducer, near the source and that it provides at the outlet medium pressure that is a preset function of the high inlet pressure, and a second compensated reducer, near the breathing device and which is connected through a pipe to the outlet of the first reducer to receive therefrom the medium pressure, reduce the medium pressure to breathing pressure and send the breathing pressure to the breathing device, the device indicating the pressure of the source being connected between a first and second reducer to detect the medium pressure and provide, on the basis thereof and said preset function, an indirect measurement of the high pressure of the source.

[0006] In order to make clearer the explanation of the innovative principles of the present invention and the advantages thereof over the prior art, with the help of the attached drawings a possible embodiment applying these principles will be disclosed below. In the drawings:

- figure 1 shows a schematic view of a breathing apparatus according to the invention;
- figure 2 shows a sectioned schematic view of a pressure reducing unit of the apparatus in figure 1;
- figure 3 shows a sectioned schematic view of a first embodiment of a warning unit of the apparatus in figure 1;
- figure 4 shows a sectioned schematic view of a second embodiment of a warning unit of the apparatus in figure 1;
- figures 5 and 6 represent sectioned schematic views of the warning unit in figure 4 in two different operating statuses;
- figure 7 shows a sectioned schematic view of a third embodiment of a warning unit of the apparatus in figure 1;
- figures 8 and 9 represent sectioned schematic views of the warning unit in figure 7 in two different operating statuses.

[0007] With reference to the figures, in figure 1 there is shown schematically a breathing apparatus (generally indicated by 10) made according to the principles of the present invention.

[0008] The apparatus comprises a source 11 of high-pressure air, in general a cylinder or group of cylinders, that supplies a pressure reducing unit 12 from which a flexible pipe 13 exits that feeds the medium-pressure air to a breathing device 14 (for example, a mask or other suitable dispensing device) provided with a known pressure reducer for reducing pressure from medium pressure to breathing pressure. The breathing device and this last reducer (generally indicated by 15 in figure 1) are substantially known and easily imaginable by those skilled in the art in the light of the explanations that follow. They are not therefore shown here or disclosed in greater detail.

[0009] Along the pipe 13, near the breathing device, there is a warning unit or indicating device 16 provided with a pressure indicator 17. The pipe 13 between the pressurised air source and the warning unit may be of any necessary length, for example, also a hundred metres or more. The warning unit is nevertheless sufficiently near the dispensing device as to be able to be consulted by the person who uses the dispensing device.

[0010] It is known that in the field of breathing apparatuses pressure reducers are compensated, i.e. they have a device that enables outlet medium pressure (MP) to be kept constant regardless of the inlet high pressure (HP). Constant medium pressure is deemed to be necessary to maintain the breathing resistance to the mask constant during the entire period of use.

[0011] According to the principles of the invention, the reducing unit 12 for reducing from high pressure to medium pressure is not provided with compensation and is made so that, in the absence of the compensator medium

pressure is a function of the inlet high pressure. Each outlet medium pressure from the adjusting unit 12 is matched by inlet high pressure to the unit. In particular, it has been found to be advantageous for the outlet pressure to be intended to increase progressively as the high pressure decreases in the cylinder.

[0012] Still advantageously, the medium pressure trend is linear with the high pressure variation.

[0013] From the knowledge of the medium pressure in the pipe 13 it is thus possible to ascertain the value of the high pressure in the cylinder 11. By exploiting the inverse proportion between high and medium pressure, it is sufficient to establish the maximum and minimum medium pressure and maximum and minimum high pressure values and size the adjusting unit 12 so that it enables the corresponding variation law to be obtained. As will be seen below, the medium pressure variation interval can be advantageously established so as to be able to trigger a minimum pressure alarm in the cylinder.

[0014] For example, it may be desired for medium pressure to have a value of 5.5 bar at 300 bar high pressure when the valve of the cylinder opens and, for example, 8 bar when there is residual pressure of 55 bar in the cylinder (with consequent activation of an exhaustion alarm).

[0015] As will be seen below, owing to the fact that the medium pressure increases as high pressure decreases, it is also useful for devising in a simple manner an exhaustion alarm.

[0016] The second adjuster 15 (provided with compensation) will be sized, according to the prior art, to absorb the medium pressure variations so that these variations do not interfere with comfortable breathing.

[0017] In some self-contained breathing apparatuses a compensation system is already in use even on the dispenser to avoid variations in resistance when the outlet pressure from the reducer varies suddenly so as to trigger an alarm system.

[0018] Substantially, the apparatus according to the invention comprising at the outlet of the high pressure 11 source a first non-compensated pressure reducer 12 to have reduced outlet medium pressure that is a preset function of the inlet high pressure and a second compensated reducer 15 that is connected to receive the medium pressure from the first reducer, reduce the medium pressure to breathing pressure and send the breathing pressure to the dispensing device. The pressure indicator 16 indicating the pressure of the source is connected between a first and second reducer to detect the medium pressure and to calculate therefrom the high pressure of the source, applying to the detection the opposite of the preset function. The variations in medium pressure are thus used for indirect measurement of the high pressure. For the sake of simplicity, it has been found convenient for the preset function that links high and medium pressure to be an inverse linear function.

[0019] The device 16 may advantageously comprise acoustic alarm means 38 that are triggered when the medium pressure reaches a value that corresponds to a high pressure value below a preset level.

[0020] An example of an embodiment of the first reducing unit 12 is shown in figure 2.

[0021] From the valve of the cylinder the air flows into the pressure reducing unit through a reduced port 18 formed by a shutter 19 on which an adjusting piston 20 acts that is pushed open by a suitable spring 21, and on the other side is pushed closed by the pressure downstream of the shutter so as to provide the desired reduction of pressure from high to medium pressure, with the desired inverse linear proportionality law.

[0022] It should be noted that when the cylinder dispensing opens, initially the air flows through the port 18, which is completely opened owing to the action of the spring 21 on the piston 20. The pressure that rises inside the reducer finally moves the piston 20, closing the shutter 19 against the seal seat. Movement occurs immediately at the first flow of air and this determines medium pressure downstream of the shutter that is equal to the maximum dispensable pressure, as occurs when the pressure lowers with the discharge hole of the cylinder. This could entail a reading error.

[0023] In order to avoid this, downstream of the shutter there is placed a valve 22 provided with a slideable piston 23 that is pushed by a spring 24 to close an outlet orifice 25. The seal between piston 23 and orifice 25 is only partial as the bottom of the piston has passage holes 26 of small diameter. When the cylinder is opened, the air that exits the reducer and enters the valve 22 finds the outlet orifice 25 closed by the piston 23, held in position by the weak spring 24. In this way, medium pressure reaches maximum value only inside the unit 12. In the piping 13, pressure on the other hand has the medium pressure value that is correctly a function of the pressure of the cylinder. In fact, the air, by flowing slowly through the piston 23 in closed position enables the system to return the pressure to the correct equilibrium status. When pressure starts to increase inside the conduit 13 the piston 23 is pushed by the pressure until it overcomes the thrust of the spring 24 and opens completely the outlet orifice 25, thus enabling the maximum flow of air to be used. In this manner, during the first opening transition of the air from the source the valve 22 prevents temporary overpressure at the outlet of the first adjuster 12.

[0024] As an example of sizing for obtaining a desired inverse linear function a S1/S2=98 proportion must be considered between respectively the sections S1 and S2 of the piston and of the passage hole of the seal seat of the reducer.

[0025] The formula that defines the medium pressure MP value in function of the high pressure HP when the piston 20 has a 33 mm diameter is MP=(839-HP)/98. From this formula it is deduced that the dependence between HP and MP is linear and that 5.5 bar of medium pressure corresponds to 300 bar of high pressure and 8 bar of medium pressure corresponds to 55 bar of high pressure.

[0026] In figure 3 there is shown a first embodiment of the warning unit 16, it comprises a pressure indicator made with a known electronic gauge 17 provided with a pressure transducer 30.

[0027] The warning unit is connected to the pipe 13 by means of a tee junction 31. Between the inside of the pipe 13 and the pressure transducer there is a single-acting valve 32 that opens in the direction of the gauge. The object of the valve is to eliminate disturbance fluctuations from the reading. In fact, during breathing the pressure in the conduit 13 fluctuates because the removal of air by the reducer is fairly consistent. This fluctuation would cause imprecise readings on the gauge. The single-acting valve 32 enables only maximum pressures to be reported, preventing air from escaping during the intake step, i.e. when air is removed therefrom. In this manner pressure oscillations due to breathing are cancelled. It is also possible to introduce a further electronic correction into the gauge to make the influence of MP oscillation during breathing insignificant.

[0028] The pressure variations detected by the gauge will then be, correctly, increasing MP values corresponding to decreasing HP values. Appropriate setting of the gauge scale (so as to apply to the display the inverse function to the function applied by the first reducer) enables the high pressure value of the source to be shown directly. The use of a linear function is of assistance therein.

[0029] It should be noted that when the cylinder is exhausted or the air valve is closed on the cylinder the medium pressure is discharged from the conduit 13 whilst in the gauge (owing to the single-acting valve 32), the residual pressure at the moment of interruption would remain. This would lead to a false pressure value being indicated on the gauge.

[0030] In order to avoid this drawback, the device 16 comprises a dump valve 39 connected between the gauge and check valve and discharged by the drop in inlet pressure of the check valve. Advantageously, the dump valve comprises a piston 33 that closes the passage 35 under the thrust of the pressure upstream of the check valve and against the action of a suitable discharge spring 34. During normal use, the piston 33 is kept in the closed position by the pressure in the conduit 13 that overcomes the force of the suitably sized spring 34.

[0031] In the absence of pressure, as after closure of the valve of the cylinder or at the end of the air reserve, when pressure drops in the pipe 13, the spring opens the passage 35 and the air imprisoned between the check valve 32 and the transducer 30 is discharged through a hole 36.

[0032] The acoustic alarm means is made by the digital gauge, which may be provided with an acoustic emitter 38 programmed for emitting an alarm sound when the pressure in the cylinder falls below a preset value. The acoustic emitter may also emit a signal for a few instants at the start of using the cylinder to indicate that the system is functioning. By using a digital gauge that is in itself known with microprocessor it is possible to program useful additional functions, as easily imaginable by those skilled in the art. For example, the management software in addition to activating an acoustic alarm system, can give information regarding the residual air reserve, work time that is still available, etc.

[0033] As shown by dotted lines in figure 3, on the discharge hole 36 a known acoustic air device 38b can also be placed (for example a whistle) operating with the air flowing out of the discharge hole. In this case, the device 38b will emit a useful acoustic signal at the moment of opening of the cylinder, which will indicate proper operation of the system and also when the residual air will be discharged at the end of the use of the self-contained breathing apparatus.

[0034] In figure 4 an alternative embodiment of the warning unit is shown, indicated in the figure by 116. For convenience, similar parts to those of the preceding embodiment will be indicated by the same numeration increased by 100.

[0035] There is thus a warning unit 11.6 provided with a gauge 117. The unit is connected to the pipe 13 by means of a tee junction 131. Between the inside of the pipe 13 and gauge 117 there is a single-acting valve 132 that opens in the direction of the gauge and has the object of eliminating reading disturbance fluctuations, as already described for unit 16. The gauge 117 is of mechanical type for the sake of simplicity, with the scale of the dial suitably designed to indicate directly the pressure in the cylinder, rather than the actual pressure in the conduit 13. In figure 4 is shown an example of a conversion scale for converting between detected medium pressure and the corresponding high pressure.

[0036] There is also a pressure dump valve 139 for discharging pressure in the gauge when there is a pressure fall in the conduit 13. The dump valve advantageously comprises a piston 133 that, with suitable circumferential seals, forms a sliding switch that is pushed to the right by a spring 134 and to the left by the pressure in the conduit 13.

[0037] The sliding switch is reached by an outlet 135 coming from the side downstream of the single-acting valve 132 and a discharge hole 136 leads away that is connected to a known air acoustic device 138 operating with the air jet exiting the discharge hole and which constitutes the acoustic alarm means.

[0038] Owing to the piston 133, the warning device 138 performs the dual function of discharging the residual pressure and acting as an exhaustion warning. When pressure in the conduit 13 is zero the piston 133 is pushed by the spring 134 so that the outlet 135 is connected to the discharge hole 136, as shown in figure 4. In this way, at the start of use of the cylinder and when the residual air is discharged a signal is obtained that indicates that the system is operating correctly.

[0039] The thrust of the spring is chosen so that when the pressure in the cylinder is comprised between maximum pressure (for example, 300 bar) and the pressure

at which the alarm has to intervene (for example 55 bar), the corresponding pressure in the conduit 13 takes the piston to an intermediate position, as shown in figure 5, so that the outlet 135 is isolated from the discharge hole 136 and the warning device 138 remains mute.

[0040] When the cylinder pressure falls below the value preset for the exhaustion alarm (for example, 55 bar) the thrust of the pressure on the piston 133 rises sufficiently to overcome the contrasting force of the spring 134 and the piston goes to the position in figure 6, opening the connection between the outlet 135 and the acoustic warning device 138, which will start to emit a warning sound.

[0041] In figure 7 there is shown a third embodiment of a warning unit according to the invention. For convenience, parts that are similar to those of the embodiment in figure 3 will be indicated by the same numbering increased by 200.

[0042] There is thus a warning unit 216 provided with a gauge 217. The unit is connected to the pipe 13 by means of a tee junction 231. Between the inside of the pipe 13 and gauge 217 there is a single-acting valve 232 that opens in the direction of the gauge and eliminates the disturbance fluctuations of the reading. Also in this case the gauge is mechanical, with a scale that is suitably designed to provide directly the desired reading of the pressure in the cylinder.

[0043] Unlike the preceding embodiment, there are two dump valves 239a and 239b for discharging the pressure downstream of the check valve. Advantageously, the two dump valves comprise pistons, respectively 233a and 233b, that constitute two sliding switches. The two pistons are pushed upwards by the pressure in the conduit 13 and in the opposite direction by respective springs 234a and 234b.

[0044] Each sliding switch is joined by an outlet 235a, 235b coming from the side downstream of the single-acting valve 232 and a discharge hole 236a, 236b leads away that is connected to a known air acoustic device 238.

[0045] The position of the circumferential seals on the two pistons and the size of the springs are such as to provide the piston 233a with the function of final discharge and to alert to proper initial function and to provide the piston 233b with the function of exhausted air reserve alarm.

[0046] By suitably sizing the springs, at the pressure in the conduit comprised between 0 and 5.5 bar (corresponding in the cylinder to pressure comprised between 0 and 300 bar), the system is in the position shown in figure 7, with both the pistons retracted because they are held in position by the respective springs. In these conditions the piston 233a enables the air to pass through (activating the acoustic alarm that indicates in this case the good operation of the system) until the pressure in the piping reaches the preset normal operation value with a full cylinder (approximately 5.5 bar). The piston 233b on the other hand prevents the passage of air.

[0047] When the preset pressure of 5.5 bar has been reached, the piston 233a moves, interrupting the acoustic alarm supply. At the operating pressure comprised between the pressure corresponding to full cylinder and the pressure corresponding to minimum threshold (for example, respectively 5.5 bar and 7.8 bar, corresponding to the cylinder pressure comprised between 300 and 55 bar) the system is thus as in figure 8, with both pistons that prevent the passage of air. This is the normal operating situation.

[0048] When the pressure in the conduit reaches and then exceeds the value that warns of entry into the reserve (8 bar, corresponding to cylinder pressure values below 55 bar) the piston 233b overcomes the resistance of the calibrated spring 234b and moves upwards, enabling the air to reach the acoustic alarm, which in this case indicates exhaustion of the air reserve (figure 9).

[0049] Although this system has two distinct elements rather than one, it is easier to devise. In fact, the calculation of two separate springs is simpler, the first for the intervention between 0 and pressure (5.5 bar) corresponding to a full cylinder and the second (8 bar) corresponding to the exhausted cylinder alarm, than the embodiment of just one spring, which compressed cannot meet both needs.

[0050] At this point it is clear how the preset objects have been obtained, devising a self-contained breathing apparatus without the traditional mechanical or electronic high-pressure reading gauge, with significant economic and practical constructional advantages. The constructional simplicity of the system according to the invention minimises operating problems and makes the apparatus extremely light and easy to handle.

[0051] Owing to the invention, the need to use costly high-pressure pipes and any hazard induced by the need to carry high pressure along pipes as far as the operator are avoided.

[0052] Naturally, the above description of an embodiment applying the innovative principles of the present invention is provided merely by way of example of such innovative principles and must not therefore be considered to limit the protective scope of what is claimed herein. For example, depending on the specific practical needs, in the various embodiments shown herein the gauge may be selected from those of electronic or mechanical type. The mechanical gauge has the example of being able to be applied with simplicity by suitably drawing the scale on the dial, the law of proportion chosen between high and medium pressure and the lack of need for an electric power supply. The electronic gauge has the advantage of greater operational flexibility, it being possible to program many additional functions therein.

[0053] If an acoustic alarm warning is desired but not the warning that the apparatus has been switched on, the air acoustic device may be connected to the pressurised air only in the former case, separating (as easily imaginable by those skilled in the art) the simple discharge outlet from the one that goes to the warning de-

vice.

[0054] Although an embodiment of the first adjuster has been found to be useful with a function that is inversely proportional between inlet pressure and outlet pressure, as is easily imaginable by those skilled in the art, an adjuster can also be devised with a direct function, i.e. with a decrease in inlet pressure that is matched by a corresponding decrease in outlet pressure. The indicating device will thus be made (as easily imaginable by those skilled in the art) to provide the correct indirect measurement of high pressure and possible alarm warnings at preset values of said pressure.

Claims

1. Breathing apparatus comprising a source of high-pressure air that supplies a breathing device (14) through pressure reducers and provided with a device indicating the pressure of the source, **characterised in that** at the outlet of the source it comprises a non compensated first pressure reducer (12), near the source and that provides outlet medium pressure that is a preset function of the inlet high pressure, and a second compensated reducer (15), near the breathing device (14) and which is connected through a pipe (13) to the outlet of the first reducer for receiving the medium pressure therefrom, reducing the medium pressure to breathing pressure and sending the breathing pressure to the breathing device (14), the device (16) indicating the pressure of the source being connected between a first and second reducer to detect medium pressure and provide, on the basis thereof and said preset function, an indirect measurement of the high pressure of the source.

2. Apparatus according to claim 1, **characterised in that** said preset function of medium pressure compared with high pressure is inverse linear.

3. Apparatus according to claim 1, **characterised in that** the indicating device comprises acoustic alarm warning means (38, 138, 238) that is sensitive to the medium pressure entering the device to be triggered when the medium pressure reaches a value that corresponds to a preset low value of the high pressure.

4. Apparatus according to claim 3, **characterised in that** the acoustic alarm warning means comprises a piston (133, 233b) that is pushed against the action of a spring (134, 234b) by the medium pressure entering the indicating device to move, upon reaching a preset medium pressure value corresponding to a preset low value of the high pressure, to a connection position of an air-driven acoustic warning device (138, 238), so as to activate said acoustic warning device.

5. Apparatus according to claim 1, **characterised in that** the pressure indicating comprises a gauge (17, 117, 217) with scale conversion between detected medium pressure and corresponding high pressure and connected to the medium pressure through a check valve (32, 132, 232).

6. Apparatus according to claim 5, **characterised in that** between the gauge (17, 117, 217) and check valve (32, 132, 232) there is connected a dump valve (39, 139, 239a) that is discharged by the pressure drop upstream of the check valve (32, 132, 232).

7. Apparatus according to claim 6, **characterised in that** to the outlet of the dump valve (39, 139, 239a) there is connected an acoustic warning device driven by the air exiting the discharge hole.

8. Apparatus according to claim 6, **characterised in that** the dump valve comprises a piston (33, 133, 233a) closing the discharge hole, which is pushed to the open discharge position by means of a spring (34, 134, 234a) and towards the opposite closed position by means of the medium pressure entering the indicating device.

9. Apparatus according to claim 6, **characterised in that** the dump valve comprises a shutter piston (133), which is pushed against the action of a spring (134) by the medium pressure entering the warning device to reach with a first preset medium pressure value a first discharge position, and with a second preset medium pressure value a second discharge position whilst with medium pressure values comprised between the first and second value the discharge hole remains closed; in at least the second discharge position the discharge being sent to an air acoustic warning device (138) so as to activate the acoustic warning device, the medium pressure between the first and second pressure value being preset for normal use of the apparatus and exceeding the second pressure value corresponding to reaching a preset low value of the high pressure.

10. Apparatus according to claim 1, **characterised in that** the pressure-indicating device comprises an electronic gauge (17) provided with an acoustic warning device (38) programmed to emit an acoustic alarm warning when the medium pressure detected reaches a value that corresponds to a preset low value of the high pressure.

11. Apparatus according to claim 1, **characterised in that** the first adjuster (12) is mounted directly on the source and the second adjuster (15) is mounted directly on the breathing device (14).

12. Apparatus according to claim 2, **characterised in**

that the first adjuster (12) comprises a shutter (19) closing the passage of air from the source, which shutter is pushed closed, against the action of a spring (21), by the pressure downstream of the shutter (19) that acts on an adjusting piston (20) connected to the shutter, so as to provide a reduction in the pressure leaving the adjuster with said inverse linear function, after the shutter (19) a valve (22) being positioned that is provided with a slideable piston (23) that is pushed by a second spring (24) to close partially an outlet orifice (25) of the first adjuster, during an opening transition of the air from the source, so as to avoid momentaneous overpressure at the outlet of the first adjuster (12).

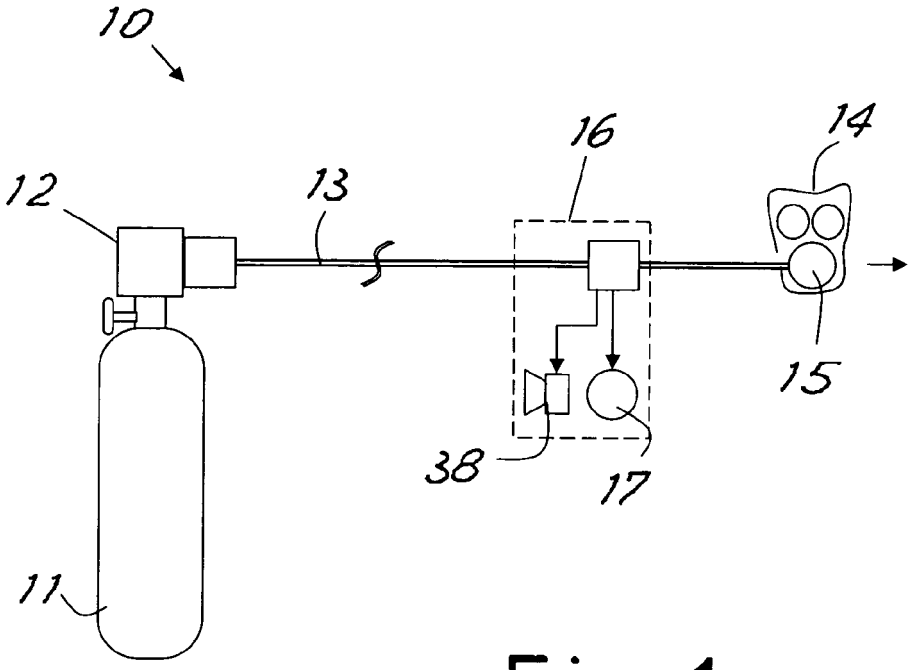

Fig.1

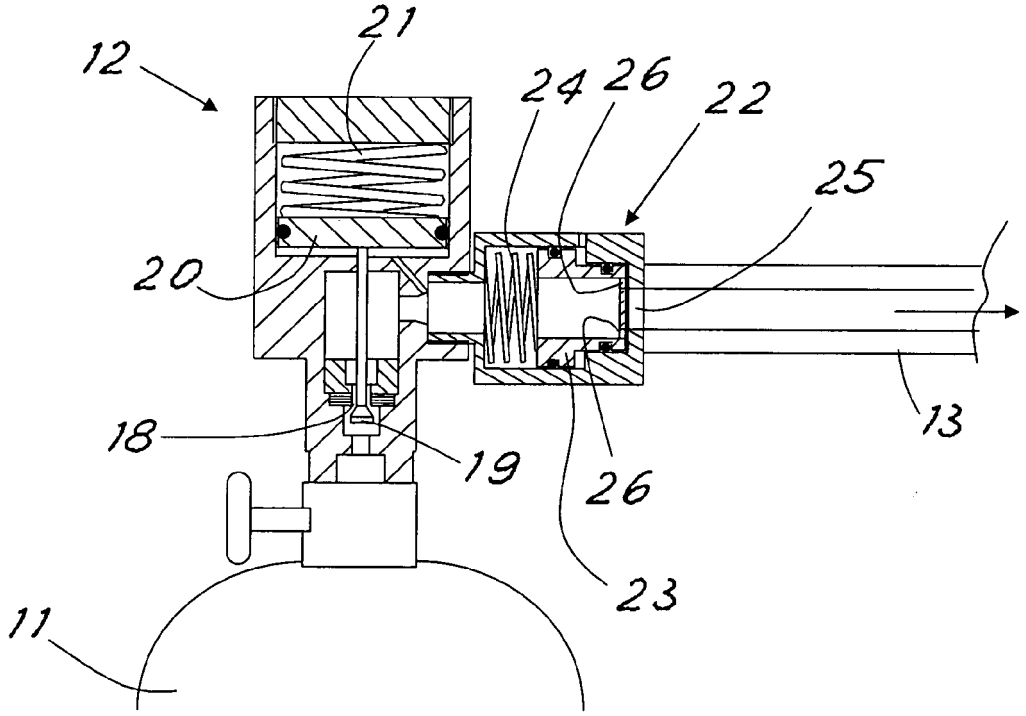

Fig.2

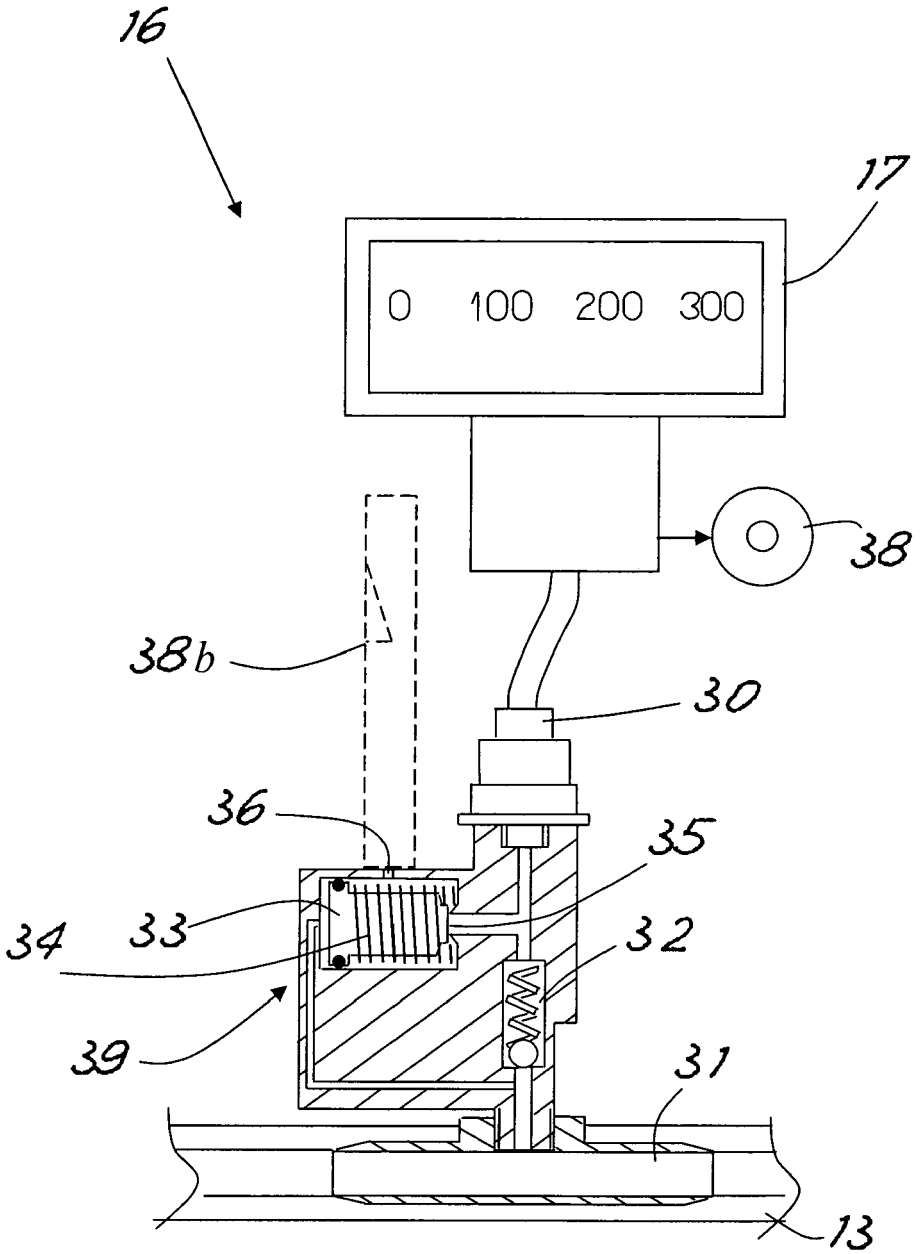

Fig.3

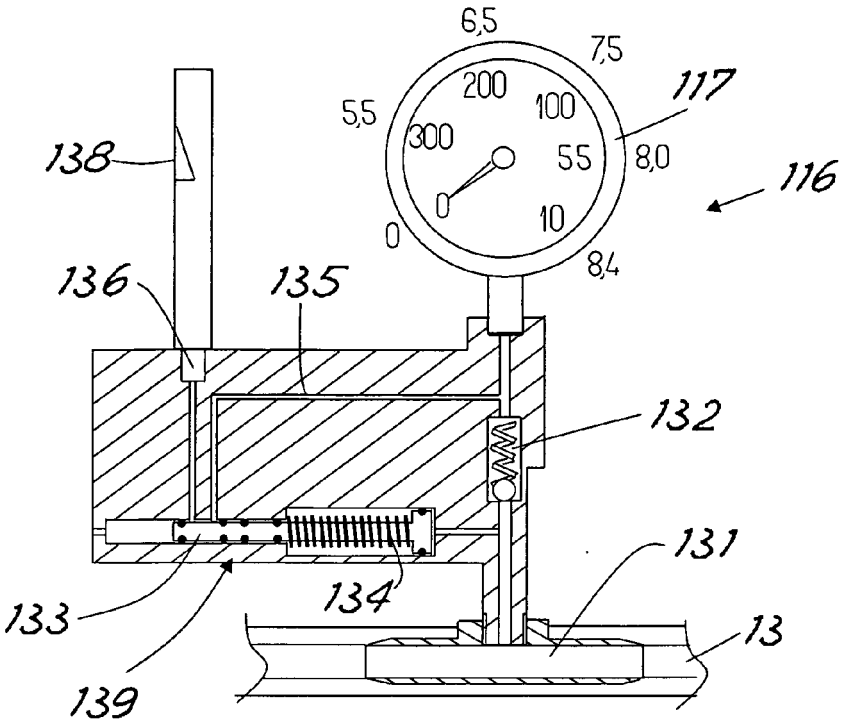
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Fig.4

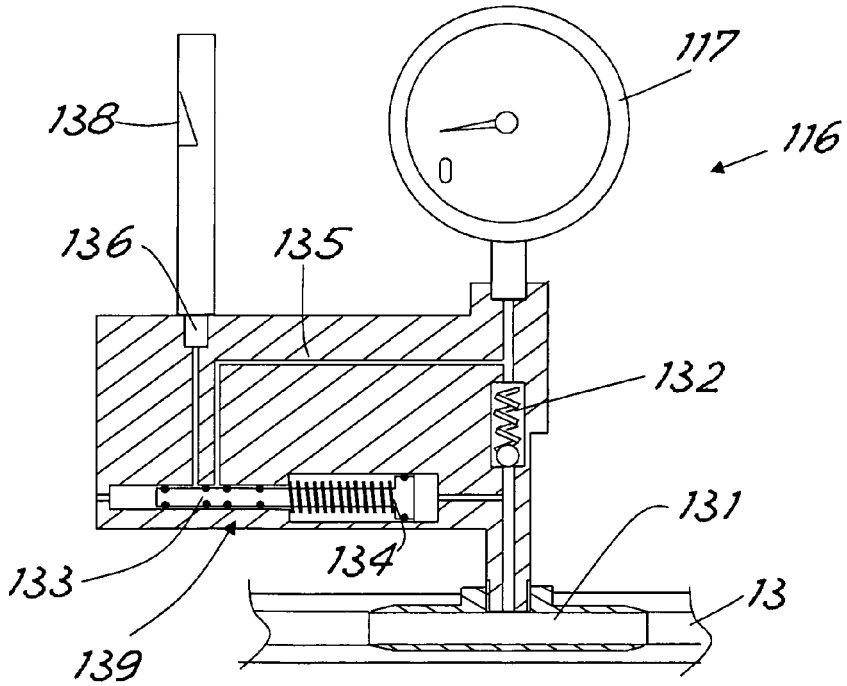
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Fig.5

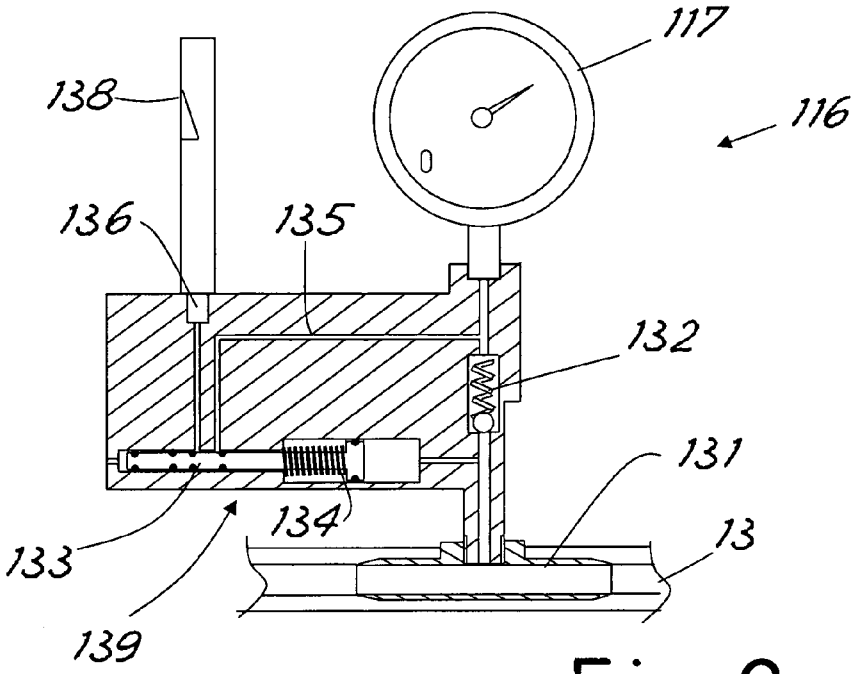
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Fig.6

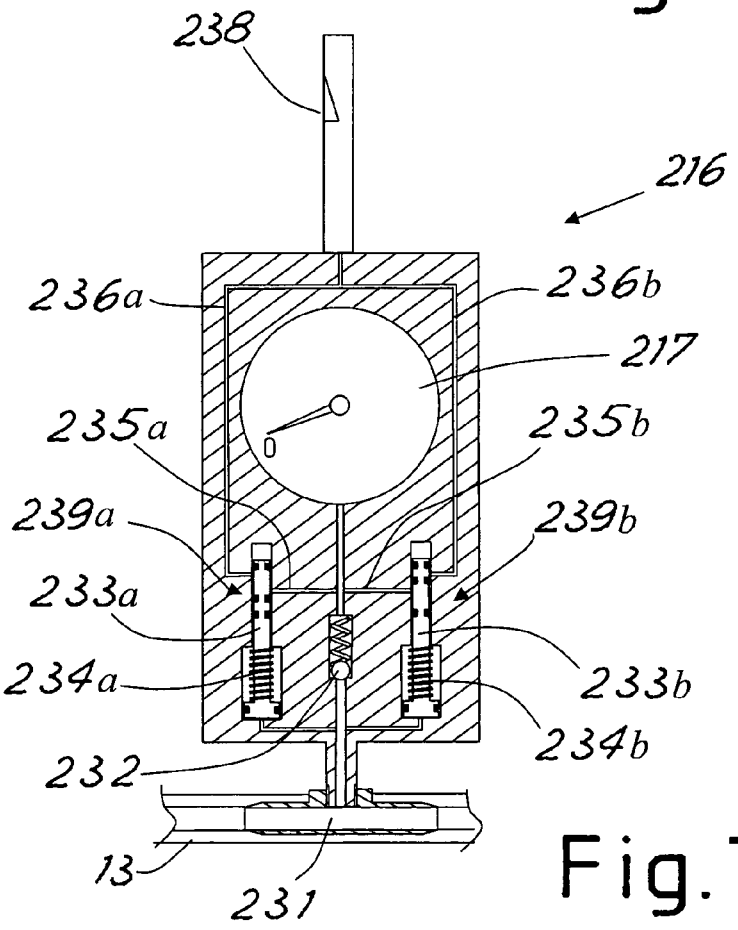
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Fig.7

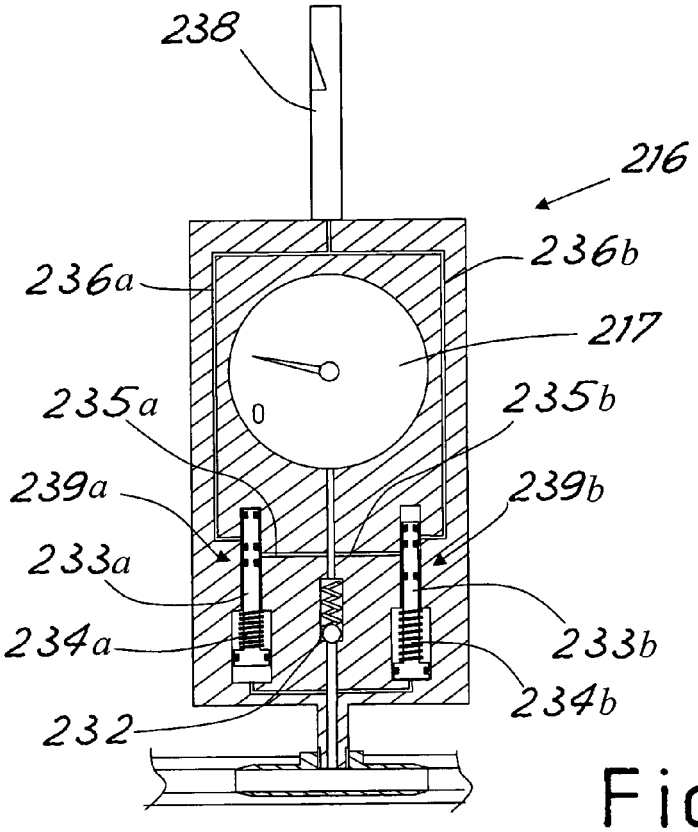
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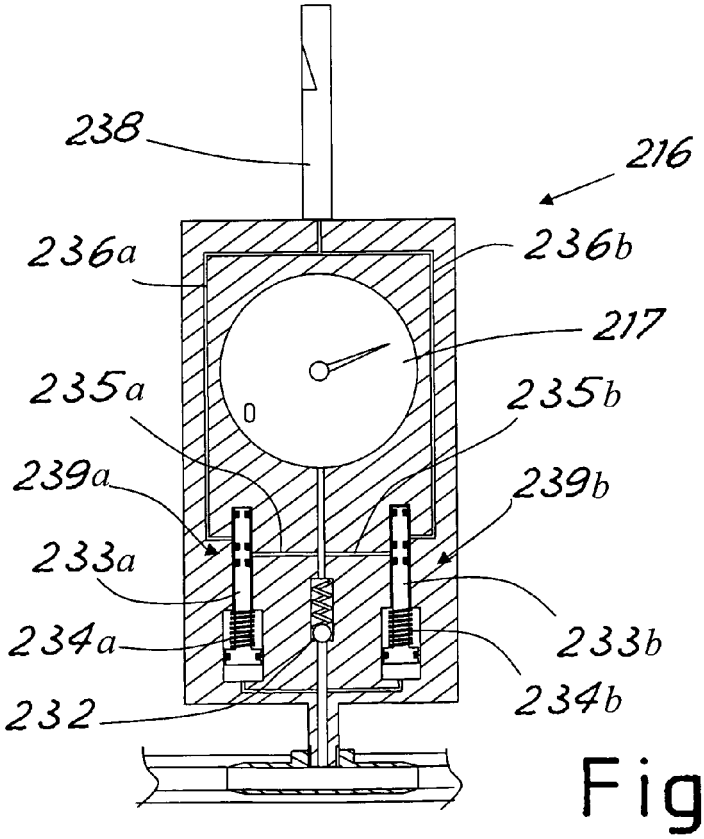
Fig.8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233b
234a
234b
232

Fig.9

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 02 2177

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	25 March 2008	Paul, Adeline

CATEGORY OF CITED DOCUMENTS

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