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(54) System for mixing additive with liquid

(57) The present invention relates to a system for mixing pressurised liquid (5) with an additive (8), said system comprising:
a first conduit (12) for supplying pressurised liquid (5) from a source (9) to a discharge opening (11);
a vessel (13) that is adapted to contain said additive (8) that is to be mixed with said pressurised liquid (5);
a second conduit (20) for supplying pressurised liquid (5) to an inlet (21) of said vessel (13);
an outlet (23) from said vessel (13), wherein at least a portion of the outlet (23) has an at least partly vertical extension so that the flow of additive and pressurised liquid that flows in said outlet (23) is at least partly moved in an upwards direction in said outlet (23), and wherein said outlet (23) is connected to said first conduit (12);
and an air vent (40) provided to vent said vessel (13).

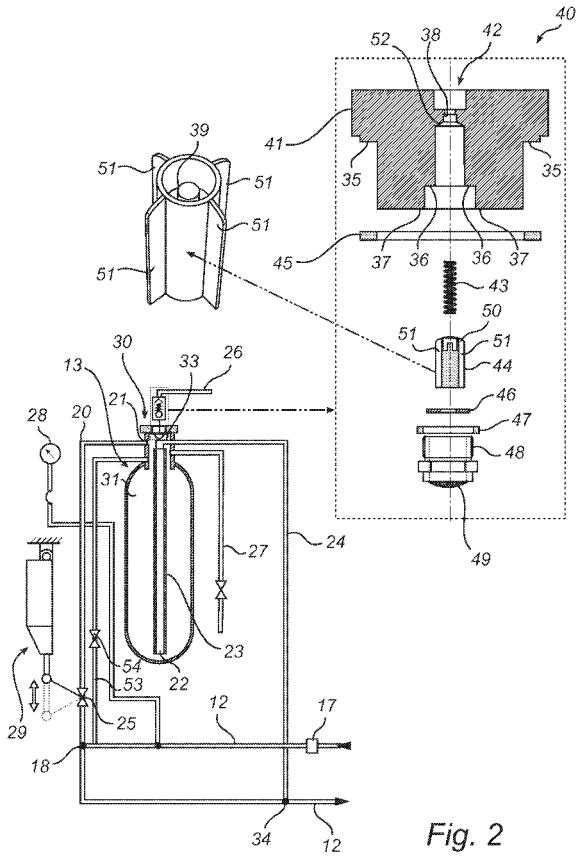

Fig. 2

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Description

Field of the Invention

[0001] The present invention relates to a system for mixing pressurised liquid with an additive. Said system comprises a first conduit for supplying pressurised liquid from a source to a discharge opening, a vessel that is adapted to contain said additive that is to be mixed with said pressurised liquid, and a second conduit for supplying pressurised liquid to an inlet of said vessel and an outlet from said vessel.

Background Art

[0002] There exists different applications in which pressurised fluid is to be mixed with an additive. One example of such applications is when a pressurised fluid is to be mixed with an abrasive in order to provide a high pressure jet for cutting or penetration of objects, e.g. in rescue service, military or policial applications or in water jet cutting.

[0003] In rescue service such as fire fighting, a system called cutting extinguisher has been developed. A cutting extinguisher comprises in general a pressure source for supplying pressurised liquid to a nozzle. Between the pressure source and the nozzle, a portion of the liquid is generally passed through a vessel containing additive in the form of abrasive. The pressurised liquid is generally supplied to the vessel and mixes with the abrasive as it moves downwards inside the vessel. If the inlet is not provided at the top of the vessel, the additive falls towards the bottom of the vessel under the influence of gravity and is thereafter mixed with the liquid at the bottom of the vessel. A mix of pressurised liquid and abrasive is then discharged from the bottom of the vessel. The discharged mix of liquid and abrasive is thereafter transferred back to the main flow of the liquid in order to be transferred to the nozzle. In order to regulate the amount of supply of abrasive to the vessel, a regulating valve is provided at a conduit between the outlet of the vessel and the conduit in which the main flow of the liquid flows. This regulating valve also has the purpose of preventing additive from falling out of the vessel, when supply of additive is not desired.

[0004] The above-mentioned system works well. However, it has for example been found that the abrasive may wear on the valve regulating the amount of abrasive mixed with liquid that is being discharged from the vessel. This wear may lead to difficulties in regulating the supply of abrasive, undesired discharging of additive and increased maintenance costs of the equipment. It is also difficult to control to the amount of abrasive that is being mixed with the liquid inside the vessel, hence leading to an uneven mix of abrasive and liquid. This may e.g. be because the abrasive that is supposed to fall towards the bottom of the vessel under the influence of gravity does not always do so in the desired manner. Furthermore, the previously known system must also comprise a non-return valve on the conduit leading to the vessel in order to prevent backflow from the vessel. This non-return valve is also subjected to wearing during use of the system. If it does not function properly, additive may exit the vessel through this conduit. This is not desired, and the equipment therefore requires maintenance so that the non-return valve is not worn out.

[0005] It is in certain applications also sometimes desired to mix other additives than abrasives to the pressurised liquid, e.g. gases or extinguishing foam or powder. The same problems with controlling the amount of additive being added is also present for these other additives.

[0006] There exist also other solutions for mixing abrasive with fluid. One such solution is presented in WO 95/29792. This solution comprises *i.a.* an inlet for supplying fluid, a pressure vessel, a jet pump and conduits connecting the pressure vessel and jet pump with each other and with the inlet for supplying fluid. The pressure vessel also comprises a flexible balloon diaphragm that is connected to a source of variable pressure. The function of this device is that pressurised fluid passes through the jet pump and enters into the vessel. When the pressurised fluid enters into the vessel, abrasive mixture is forced out through a conduit. The forcing of abrasive mixture out through the conduit can be emergency stopped by collapsing the balloon diaphragm. It can also be stopped by a valve that closes the supply of fluid. When the valve has been closed, some abrasive mixture is left in the conduit leading from the vessel. The jet pump will then be operated to draw liquid from the vessel and thus drain the conduit.

[0007] Another solution is presented in WO 00/52679. This solution also includes i.a. an inlet for supplying fluid, a pressure vessel, a jet pump and conduits connecting the pressure vessel and jet pump with each other and with the inlet for supplying fluid. The function of this device is similar to that presented above, i.e. pressurised fluid passes through the jet pump and enters into the vessel. When the pressurised fluid enters into the vessel, abrasive mixture is forced out through a discharge tube. When it is required to stop the flow out of the system, the jet pump will be operated to reverse the flow through the discharge tube, in order to clear the discharge tube from abrasive mixture. This function is intended to prevent formation of a plug of abrasive in the discharge tube. In order to function satisfactorily, this system also comprises several valves to regulate the flow through the system.

[0008] Both the above-mentioned systems has a complex structure and requires a jet pump to function satisfactorily. Due to this, the systems are expensive.

Summary of the Invention

[0009] The object of the present invention is to obviate at least some of the above inconveniences and to provide a device that is reliable in use, that supplies additive in

a controllable manner, that is not as subjected to wear as some prior art systems and that is not as complex and expensive as some prior art systems.

[0010] The above-mentioned objects are achieved by a system for mixing liquid and additive of the kind defined in claim 1. Said system for mixing pressurised liquid with an additive comprises a first conduit for supplying pressurised liquid from a source to a discharge opening; a vessel that is adapted to contain said additive that is to be mixed with said pressurised liquid; a second conduit for supplying pressurised liquid to an inlet of said vessel; an outlet from said vessel, wherein at least a portion of the outlet has an at least partly vertical extension so that the flow of pressurised liquid and additive that flows in said outlet is at least partly moved in an upwards direction in said outlet, and wherein said outlet is connected to said first conduit; and an air vent provided to vent said vessel.

[0011] A system configured in the above-described manner has several advantages. It comprises few parts, and especially few complex parts, which give a simple and reliable system that may be produced at a lower cost than more complex systems.

[0012] At least a portion of the outlet is at least to some extent directed upwards. That the outlet has an at least partial vertical extension so that additive or mixture of additive and liquid in said outlet is moved upwards does not mean that it needs to have a straight vertical extension. It may for example be directed with an angle that gives a certain vertical component or have one straight vertical section and other sections with a different extension. Furthermore, the entire outlet does not need to have a vertical extension; it is sufficient that at least a part of the outlet has such an extension. The main purpose of the at least partly vertical extension is that the additive must be moved in an opposite direction as compared to if it was falling or being moved downwards under influence of gravity. Hence, the movement of the additive is effected by the pressure of the liquid acting on it. By this, the at least partly upward extension of the outlet creates a trap for the additive or mixture of additive and liquid that is to exit the vessel. Hence, material will not exit the vessel due to gravity but only when pressurised liquid is taken into the vessel and thereby exerts a pressure on said additive and forces it to move in an upwards direction inside the outlet.

[0013] Since the pressurised liquid and not gravity forces the additive towards the outlet from the vessel, the system provides for a more controlled discharging of additive, in terms of the amount of additive being discharged.

[0014] The above-described upwards movement of the additive or mix of additive and liquid that exits the vessel has the effect that there is no need for a regulating valve for controlling the flow of additive out of the vessel, as compared to some prior art systems, since additive will not be able to fall out of the vessel due to gravity. Hence, a component previously subjected to wear may be reduced, without compromising the function of the system.

[0015] It is possible that air or other gases becomes introduced into the vessel, e.g. during filling of additive into the vessel or if the supply of pressurised liquid runs out of liquid and supplies air instead. The air vent or air bleeder allows this air or other gases that has been introduced into the vessel to escape from the vessel, without having to exit through the outlet and into the conduit leading to the nozzle. This is beneficial since air contained in the vessel may, if it has to exit through the outlet, force additive out through the outlet as well, even after the supply of pressurised liquid has been turned off. This undesired forcing of abrasive into the outlet and perhaps even further to the conduit and a nozzle connected to the conduit may form plugs of additive or additive mixed with liquid. Hence, the air vent provides for a reliable system that is less susceptible of breakdowns due to formation of plugs of additive.

[0016] By connecting the outlet to the first conduit, the flow of pressurised liquid and additive will be transferred to the discharge opening together with the flow of pressurised liquid in the first conduit.

[0017] Suitably, said air vent comprises a movable closing element, wherein said closing element is biased towards an open position, and wherein it is adapted to move to a closed position when pressurised liquid is supplied to said vessel.

[0018] By this, air or other gases may be vented out through the air vent each time the system is started, i.e. each time the vessel is pressurised. However, when pressurised liquid enters into the vessel, the air vent will become closed. By this, there will be no discharging of liquid through the air vent.

[0019] The closing element may e.g. be biased towards an open position by a spring or other resilient means.

[0020] It may be suitable to provide the closing element as a body with projections and that space between the projections define channels for air to pass through. It may also be possible to provide the movable element with through holes.

[0021] It may be suitable to provide the closing element with an upper portion having a small radius. It may further be suitable to provide a seat for the closing element to be received in with a conical surface. With these geometries, a small area or surface of the upper portion of the closing element will come into contact with the seat when the movable closing element is in its closed position. This has the advantage that it creates an effective seal.

[0022] It may further be suitable that the movable closing element is adapted to be moved to the closed position due to a force exerted on to it by the pressurised liquid.

[0023] Suitably, said closing element is adapted to move to said closed position when it is subjected to pressure from said pressurised liquid.

[0024] By this, air or other gases may exit the vessel

through the air vent when the system is started, i.e. becomes pressurised, at the same time as it will become closed so that pressurised liquid cannot exit through the air vent.

[0025] Furthermore, an air vent provided in this manner does not require complex control means, which is beneficial in terms of cost and reliability.

[0026] Suitably, said air vent further comprises means for preventing additive from entering into said air vent.

[0027] If additive where to enter into the vent, it would be possible that the functioning of the vent should be compromised. Hence, it is beneficial to provide the inlet to the air vent, which is directed towards the vessel, with means preventing such entry. The means for preventing additive from entering into said vent may suitably be a fine-meshed net or other suitable means.

[0028] Suitably, said air vent is provided at the top portion of said vessel. This is beneficial since, at least in some applications such as water jet cutting and cutting extinguishers, the liquid such as water and the additive such as an abrasive material, is heavier than air. The air will therefore be positioned at the top of the vessel.

[0029] Suitably, control means for regulating the amount of supply of pressurised liquid to said vessel are provided at said second conduit.

[0030] With this system, the amount of additive being discharged from the vessel is in direct relation with the amount of liquid that is being supplied to the vessel. It may therefore be advantageous to be able to regulate the amount of liquid being supplied to the vessel, since it then regulates the amount of additive being discharged. By providing the control means for this regulation at the second conduit, through which pressurised liquid flows, the control means will not be subject to wearing from additive such as abrasive material. Hence, this position of the control means further improves the reliability of the system.

[0031] Suitably, said system further comprises a branch, wherein said first and second conduits are connected to said branch, so that pressurised liquid from said first conduit can be diverted to said vessel through said second conduit.

[0032] It is possible to provide the first and second conduit so that the second conduit is coupled to the first conduit at a junction. The pressurised liquid flowing in the first and second conduits may thereby be provided from the same supply and pressurised by the same pressure source. If the first and second conduits are connected to each other so that the second conduit leading to said vessel is branched from said first conduit, the pressure in the second conduit will be somewhat higher than the pressure in the first conduit at the point where the outlet from said vessel is connected to the first conduit. This is because of a slight pressure drop in the first conduit from the point where the second conduit is diverted to the point where the outlet from said vessel, or a conduit leading from said outlet, is connected. This is beneficial because the pressure in the second conduit is the pressure by which additive is forced through the outlet and into the first conduit, and it is therefore beneficial if that is higher than the pressure from the first conduit to the vessel.

[0033] However, it is also possible to provide the first and second conduits as separate conduits that are connected to different pressure sources and/or liquid supplies. In this case, since the two conduits are in communication with each other through the vessel and the outlet from the vessel, it is beneficial to provide that the pressure of the liquid in the second conduit is higher than the pressure in the first conduit, for the same reason as given above.

[0034] Suitably, control means for regulating the amount of supply of pressurised liquid to said vessel are provided at said second conduit between said branch and said vessel.

[0035] With this system, the amount of additive being discharged from the vessel is in direct relation with the amount of liquid that is being supplied to the vessel. It may therefore be advantageous to be able to regulate the amount of liquid being supplied to the vessel, since it then regulates the amount of additive being discharged. By providing the control means for this regulation at the second conduit, through which pressurised liquid flows, the control means will not be subject to wearing from additive such as abrasive material. Hence, this position of the control means further improves the reliability of the system.

[0036] Suitably, said outlet is connected to said first conduit downstream of said branch.

[0037] It is possible to have the first and second conduits connected so that the pressurised liquid in the second conduit is being diverted from the first conduit. It is then beneficial if the discharge of pressurised liquid and additive from the outlet is connected to said first conduit downstream of this connection so that no additive enters into the second conduit and further into the vessel.

[0038] The outlet may be either directly connected to the first conduit or through another conduit leading from the outlet to the first conduit.

[0039] Suitably, an intake is provided at a lower portion of said at least partly vertically extending outlet. By this, the flow of pressurised liquid and additive will be moved in an upward direction in the outlet.

[0040] It may be beneficial if the intake is positioned at the lowermost portion of the outlet. This may for example be achieved by providing the outlet as a pipe having an opening at its lowermost portion.

[0041] The intake may e.g. be facing towards the bottom of the vessel and have the outlet extending above.

[0042] Suitably, said outlet has a generally vertical extension in said vessel, and said intake is provided at a distance of between 0,5 to 3 cm from a bottom surface of said vessel.

[0043] It is preferred to have the intake positioned close to the bottom of the vessel in order to be able to utilise as much of the additive as possible in the vessel. The above-mentioned range has proven to be a benefi-

cial value in terms of additive utilisation and flow conditions.

[0044] The distance between the intake and bottom surface may depend on the specific application of the system. It may therefore in certain applications be more preferred to have the intake provided at a distance of 0,5 to 1,5 cm from the bottom surface of the vessel.

[0045] Suitably, said intake is positioned vertically below said inlet. It is beneficial if the inlet to the vessel is positioned above the intake to the outlet. By this, the pressurised liquid will act on the additive and force it downwards towards the bottom of the vessel, and into the intake to the outlet. By not depending on gravity moving additive towards the intake, a more controlled discharging of additive may be achieved.

[0046] Suitably, said intake has a diameter of approximately 5 to 20 mm. Suitably, said outlet has a diameter of approximately 5 to 20 mm.

[0047] This values of the intake and the outlet has proven to be beneficial diameters for obtaining good flow conditions of the pressurised liquid and additive being discharged from the vessel. The diameter of the outlet is dependent on the desired flow rate of pressurised liquid in the system. The flow rate of pressurised liquid effects the amount of additive being discharged for a given time period. Hence, with a high flow rate, i.e. more additive being discharged, the intake and outlet may be designed with a larger diameter, in order not to create a too high flow rate in the outlet.

[0048] Suitably, said outlet exits said vessel at approximately the same vertical position as said inlet is provided in said vessel.

[0049] Suitably, said inlet is provided at the upper portion of said vessel. Suitably, said outlet exists the vessel at the upper portion of said vessel. It is also conceivable that the outlet exits the vessel at a position below where said inlet is provided, but that the vertical extension of said outlet extends to the same height as where the inlet is provided.

[0050] Having the inlet and the end of the vertical extension of the outlet provided at the same height is beneficial in terms of controlled discharge of additive from the vessel.

[0051] The amount of pressurised liquid and additive being discharged from the vessel through the outlet is preferably equal to the amount of pressurised liquid being supplied to the vessel through the inlet.

[0052] The present invention may be suitable to use in a system for penetration of objects, and wherein said additive is an abrasive material.

[0053] In systems for penetration of objects, such as cutting extinguisher systems or water jet cutting systems, it is important with a controlled and reliable mixing of abrasive particles with pressurised liquid, such as the mixing provided by this system.

Brief Description of the Drawings

[0054] The present invention will now be described, for exemplary purposes, in more detail by way of embodiments and with reference to the enclosed drawings, in which:

Fig 1 is a schematic perspective view of an application in which the present invention may be used;

Fig 2 is a schematic drawing illustrating the main components of the present invention and with an enlargement of an air vent shown in a cross-sectional exploded view and a closing element of said air vent in perspective view; and

Figs 3a and 3b are cross-sectional views of an air vent.

Detail Description of Preferred Embodiment

[0055] The invention will now for exemplary purposes be described in a currently preferred embodiment that is intended for rescue service work.

[0056] The general outline of the rescue service system will first be described with reference to figure 1. When making a hole by cutting in or penetrating a surface 1, e.g. a roof, walls, doors etc. using cutting extinguishing equipment generally designated 2 in case of fire 3 in spaces 4 in such constructions as different types of buildings, cisterns, tanks and containers for various purposes and vehicles, trains, ships etc. for fire fighting, this making of the hole by cutting or penetration occurs by means of a pressurised extinguishing liquid 5 which after penetration is injected into the space 4 on fire in the form of a jet 6, which is quickly evaporated and assists in extinguishing the fire 3.

[0057] The extinguishing liquid 5 is usually ordinary water to which one or more liquid and/or pulverulent additives 8 are added to improve the penetration and/or extinguishing effect. Such an additive 8 is an abrasive, for example a sandblasting agent with sand or some other abrasive material, which increases the penetration speed through the surface 1. Another additive can be an extinguishing foam or an extinguishing powder or the like, which during injection of the extinguishing liquid 5 into the space 4 on fire in combination with the fine mist, that is formed by the microdroplets created by the pressurised liquid when being sprayed into the space on fire, quickly cools the fire gases 7 and, thus, additionally promotes the effective fire fighting.

[0058] The equipment 2 as illustrated in the drawing comprises as main components a pressure source 9 for providing the pressurised extinguishing liquid 5, a lance 10 with an extinguishing nozzle 11 for discharging the extinguishing liquid, a conduit or tubing 12 between the pressure source 9 and the extinguishing nozzle 11 for supplying the extinguishing liquid 5. A vessel 13 that con-

tains the additive 8 to be added to the extinguishing liquid is also provided. As will be explained in greater detail with reference to figure 2, the vessel 13 is connected to the pressure source 9 and the conduit 12. The equipment also comprises means, not shown in figure 1, for turning on and off, and also for regulating, the supply of the extinguishing liquid.

[0059] In the shown embodiment, the pressure source 9 is suitably a high pressure pump fixedly mounted in a fire fighting vehicle 14. To the outlet of the high pressure pump, the tubing 12 is connected, which preferably is arranged to be unwound from and wound onto a reel 15 which is suitably also mounted in the fire fighting vehicle 14. At its other end, the tubing 12 is connected to the lance 10 and its extinguishing nozzle 11.

[0060] The lance 10 and the associated extinguishing nozzle 11 is in the illustrated embodiment supported and operated by an operator, usually a fireman, to perform the making of the hole and the fire fighting. However, it is not necessary that the nozzle 11 is provided at a handheld lance, it may e.g. be mounted at an arm that is connected to e.g. a fire fighting vehicle.

[0061] Figure 2 illustrates schematically a currently preferred embodiment of the system for mixing a pressurised liquid with an additive in accordance with the present invention.

[0062] The system comprises a vessel 13 having an outer circumferential surface 30 defining a chamber 31 of said vessel. The chamber 31 is adapted to receive the additive 8 that during use of the system is to be mixed with the pressurised liquid 5. The vessel 13 comprises an inlet 21 for connection to the source of pressurised liquid and an outlet 23 for discharging additive from the vessel. The outlet 23 is in the illustrated embodiment a pipe with a substantially vertical extension inside the chamber 31. The opening of the pipe, i.e. the intake 22 to the outlet 23 is positioned at the lower portion or bottom of the pipe 23, and is positioned approximately 1,5 cm from the bottom of the chamber 31. In the preferred embodiment, the diameter of the intake 22 is approximately 7 mm, but other values are also conceivable.

[0063] At the upper portion of the vessel 13 is an air valve or vent 40 provided over a top opening 33 of the vessel 13. The venting valve 40 comprises a main body 41, which has outer dimensions so that it covers the opening 33 when it is connected to the vessel 13. In the preferred embodiment, the main body is made of stainless steel.

[0064] The main body is provided with a through hole 42 that extends from the upper end to the lower end of the main body 41, when the main body is provided at the vessel 13. As is seen in figs 2, 3a and 3b, the through hole has a non-cylindrical shape and is provided with seats or abutments for receiving a spring 43, a closing element 44, washers 46, 47 and a filter plug 48, that are comprised in the air vent 40. The air vent 40 also comprises a washer 45.

[0065] The closing element 44 has a generally cylindrical shape with a conical upper portion having a small radius, i.e. the upper portion has a rounded tapering with a small radius. Furthermore, the closing element is provided with four projections or wings 51, equally spaced around the body of the closing element. The wings 51 also have upper surfaces having a small radius, following the radius of the upper surface of the closing element 44. Between adjacent wings 51 is a space or channel through which air may pass. The wings 51 do also have the purpose of centering the closing element 44 in the through hole 42. The closing element 44 also has a seat 39 adapted to receive the spring 43. The main body 40 has a corresponding seat 38 for receiving the spring. The spring 43 biases the closing element 44 downwards, so that air may pass in the space between the wings 51 and out through the vent 40. The washer 46 is provided to prevent the closing element 44 to be moved too far downwards. The washer 46 is adapted to abut a corresponding seat 36 of the main body, and to be held by the filter plug 48. The filter plug 48 is a plug that at its lower portion is provided with a fine-meshed net 49. The purpose of the net 49 is to prevent abrasive from entering into the vent 40. The washer 45 is a sealing means and is adapted to abut a corresponding seat 35 at the main body 40. The washer 47 is also a sealing means and is adapted to abut a surface 37.

[0066] The closing element 44 is in the preferred embodiment made of a shape memory material, such as PEEK. Shape memory material has the advantage that it strives to return to its original form, i.e. if for example abrasive material would enter through the filter plug 48 and into the through hole 42 where the closing element 44 is positioned, the abrasive material would be able to enter into the plastic material, without damaging the shape of the closing element.

[0067] The vent 40 may be removably connected to the vessel in any suitable manner. It is for example possible to provide the main body 41 with threads and the vessel 13 with corresponding threads so that the vent may be threadedly connected to the vessel. The vent 40 is connected to a drain or conduit 26 through which discharged air may be lead away.

[0068] The system for mixing pressurised liquid with an additive also comprises a conduit system connecting the vessel 13 with the source of pressurised liquid and the nozzle or outlet 11. A first conduit 12 is connected to the pressure source (not shown in figure 2) and to the nozzle (not shown in figure 2). The conduit 12 is provided with a valve or other means 17 for regulating the supply of pressurised liquid from the pressure source to the conduit 12. At a point along the conduit 12 a branch 18 is provided and a second conduit 20 is connected to the first conduit 12. The second conduit 20 is provided with a second valve 25 for regulating the amount of pressurised liquid being diverted from the first conduit 12. The valve 25 is controlled by manoeuvring means 29, which for example may be an electrically controlled cylinder for opening and closing the valve 25. The valve 25 may

thereby be completely closed, i.e. preventing liquid from being diverted to the vessel 13, or be manoeuvred to different levels of openness so that a desired amount of liquid is being diverted to the vessel 13. The second conduit 20 is connected to the inlet 21 of the vessel 13. A third conduit 24 connects the outlet 23 of the vessel 13 to the first conduit 12, at a connection point 34, which is arranged downstream of the branch 18 as seen in the flow direction of the pressurised liquid 5 in the conduit 12.

[0069] The system also comprises a pressure gauge 28 for measuring the pressure in the conduit 12, upstream of the branch 18, as seen in the flow direction of the pressurised liquid 5 in the conduit 12.

[0070] The system will now be described in use. Pressurised liquid 5 is supplied from the pressure source 9 and flows in conduit 12. A user may operate the manoeuvring means 29 for the valve 25 so that a desired amount of pressurised liquid is being diverted to the second conduit 20. The pressurised liquid that is being diverted flows through the second conduit 20 and enters the first chamber 31 of the vessel 13 through the inlet 21. The first chamber 31 of the vessel 13 is pre-filled with additive 8, which in the preferred embodiment is abrasive, or a mix of abrasive material and liquid. As the pressurised liquid enters the first chamber 31, it exerts a pressure on the abrasive material, and forces the abrasive material to move into the pipe 23, i.e. the outlet of the vessel 13. The abrasive material, which at least to some extent now is mixed with pressurised liquid 5, is moved inside the pipe 23 and out of the vessel through the conduit 24. The conduit 24 is, as described above, connected to the conduit 12 at a connection point 34, which is arranged downstream of the branch 18 as seen in the flow direction of the liquid 5 in the conduit 12. The mix of abrasive material and liquid from the vessel 13 is thereby mixed with more pressurised liquid in the conduit 12 and is transferred to the nozzle 11 where it is ejected out of the nozzle and e.g. towards a surface in order to cut or penetrate the surface.

[0071] As described above, the conduit 24 is connected to the conduit 12 at the connection point 34. Because of this connection, pressurised liquid 5 in the conduit 12 will, when no additive or mix of additive is transferred from the vessel 13 through the third conduit 24, move into the conduit 24 and pipe 23. However, due to a pressure drop of the pressurised liquid 5 in the conduit 12, this pressure is lower than the pressure of the pressurised liquid 5 being supplied to the vessel 13 by the conduit 20. Hence, the pressure acting on the abrasive 8 in order to move the abrasive material 8 into the outlet 23 is capable of overcoming the pressure exerted by the liquid in the third conduit 24, and the abrasive material may thereby be moved out of the vessel 13 when pressurised liquid is being diverted to the vessel 13 through the second conduit 20. The pressure drop in the first conduit 12 may e.g. be achieved by arranging the first conduit with bends, such that the pressurised liquid in the first conduit is moved in e.g. a U-shape.

[0072] With reference to figures 3a and 3b, the function of air vent 40 will now be described. When the pressure source 9 is inactive, there is no increased pressure in the system, and air will not flow out through the air vent 40, due to the fact the pressure is the same in the vessel 13 as in the surrounding environment. However, when the system is turned on, i.e. when the pressure source 9 is started and provides a pressure in the system, air will be vented out. Figure 3a shows this situation. The spring 43 biases the closing element 44 downwards and air contained in the vessel 13 may pass through the filter plug 48 and through the space between the wings 51 of the closing element and out through the through hole of the main body 41 of the air vent 40. The spring 43 is adapted to bias the closing element 44 downwards with a force that is able to withstand the pressure of air flowing out through the vent 40.

[0073] However, a short while after the system has been started, pressurised liquid is being supplied to the vessel 13 in order to mix it with additive 8 and the volume of material being contained in the vessel 13, i.e. additive and liquid, is increased. The fine-meshed net 49 prevents additive 8 from moving into the air vent 40, but the pressurised liquid may pass trough the filter plug 48 and exert a force on the closing element 44 that overcomes the spring force biasing the closing element 44 downwards. Hence, when the system is in use, the closing element 44 becomes positioned in the position shown in figure 3b. By this, the outer surface of the upper portion 50, or due to the rounding of this surface, a part of this surface, comes into contact with a surface 52 of the through hole 42. The space between the wings 51 is when the closing element is in this condition no longer in communication with the upper portion of the through hole 42, meaning that no air or other material from the vessel 13 may pass through the trough hole. The surface 52 of the main body, i.e. the seat for receiving the closing element 44 has a conical shape. The upper surface of the closing element 44 has, as given above, a small radius. Due to these geometries, the force the closing element 44 exerts on the seat 52 will be limited to a small surface, and the pressure force will reach a high magnitude at this surface. This creates a strong sealing.

[0074] Due to the pressure in the first conduit 12 and in the third conduit 24 and into the vessel 13 from the third conduit 24, the air vent 40 will become closed also when the system is operating with the control means 25, 29 closed. Hence, even when no pressurised liquid 5 is being taken in to the vessel from the second conduit 20, the pressure in the vessel will move the closing element 44 to its closed position. This is because the pressure in the vessel 13 increases due to the pressure in the third conduit 24.

[0075] When the pressure source 9 is turned off, the pressure in the vessel 13 will exit through the outlet 23 and the third conduit 24 and finally through the nozzle 11. When the excess pressure has been removed from the vessel 13, the movable closing element 44 will return

to the open position, as illustrated in fig 3a, under the influence of biasing spring 43, and air may once again exit through the air vent 40 when the system is restarted.

[0076] If air is contained in the vessel 13, there may occur undesired discharging of abrasive from the vessel when the system is turned off, i.e. when the pressure source 9 is turned off. This is because the pressurised air will then be depressurised and hence expands it volume and thereby exert a force on the additive, which will be moved into the outlet 23. By venting the vessel 13 each time the system is started, this undesired discharging of additive might be minimized.

[0077] After the system has been used in accordance with the description above, the vessel 13 comprises liquid or a mix of water and additive. It is possible to refill the vessel with new additive so that it may be used again. In order to fill new additive 8 into the chamber 31, a user may, when the system is not in use, remove the air vent 40 from the top opening 33 of the vessel 13 and thereafter pour the additive 8 through the top opening 33 and into the chamber 31. However, when new additive 8 is filled into the vessel 13, the liquid in the vessel must be removed. The vessel 13 is therefore also provided with a drain or conduit 27 at an upper portion of the vessel. The drain 27 has manoeuvring means 32 for opening and closing the drain. A user may thereby open the drain 27 and when additive is filled into the vessel, it will sink to the bottom of the chamber 31 and liquid in the vessel will be moved upwards inside the chamber 31 and be discharged through the drain 27. The liquid discharged through drain 27 does not have to be pure liquid; it may also be liquid mixed with additive.

[0078] The pressure source 9 in the present system is preferably capable of delivering pressurised liquid at a pressure in the order of 150 - 400 bar, preferably 300 bar, and at a flow rate in the order of 15 - 60 l/min, preferably 25 - 60 l/min. In some applications the pressure may exceed the values above and amount to say 400 bars or more, and also the flow rate may exceed that mentioned above and amount to say 100 l/min or more.

[0079] The amount of liquid being diverted from the conduit 12 to the conduit 20 in the branch 18 depends on the specific application, i.e. the desired amount of additive to be mixed with pressurised liquid before the mix of additive and liquid is discharged through the nozzle. The conduit 20 and the valve 25 are therefore adjusted to provide a flow that gives a desired discharge of additive.

[0080] Of course, the invention must not be considered to be limited to the shown and described embodiment and the alternatives mentioned, but can be modified and supplemented optionally within the scope of the appended claims.

[0081] It is for example possible to provide a collection unit at the bottom of the chamber 31. The collection unit may e.g. be in the form of a cone, into which the additive is collected as it falls or is moved downwards inside the chamber 31. The intake 22 of the outlet 23 may then be positioned at the desired distance, e.g. 0,5 - 3 cm, from the bottom portion of the cone.

[0082] It is also possible to provide the system with a fourth conduit 53 that, as the second conduit 20, supplies pressurised liquid to the vessel 13. This fourth conduit 53 may, as the second conduit 20, being branched from the first conduit 12, or be connected to a separate pressure source and/or supply of liquid. By having two conduits supplying pressurised liquid into the vessel it is may be easier to control or regulate the amount of additive being discharged from the vessel 13 and into the first conduit 12. The control means 25, 29 for controlling the amount of pressurised liquid 5 to the vessel 13 through the second conduit 20 may then be able to be operated between an on and an off condition. The second conduit 20 may be adapted in diameter so that the pressurised liquid being discharged from the nozzle 11 contains e.g. 2 % or 4 % additive, when the control means 25, 29 are in the on position. The fourth conduit 53 may be provided with a needle valve 54 or other means for controlling and regulating the amount of pressurised liquid flowing through this conduit and to the vessel 13. This needle valve 54 may e.g. be manually operated. In a situation where much additive is needed, e.g. when cutting in difficult materials, an operator may manoeuvre the valve 54 so that more pressurised liquid is supplied to the vessel, hence increasing the amount of abrasive being discharged. In a situation where not as much additive is needed, e.g. in penetration of materials that is easier to penetrate, an operator may adjust the valve 54 so that less or no pressurised liquid flows through the fourth conduit 53. Hence, less abrasive is being discharged from the vessel in this situation and the supply of additive in the vessel lasts for longer operation times. It may for example be possible to regulate the amount of additive so that the pressurised liquid and additive being discharged from the nozzle 11 contains between 2 and 10 % of additive.

[0083] The present invention has been described in a preferred embodiment that is intended for use in rescue service equipment, with the purpose of first penetrating a surface and thereafter spraying extinguishing liquid into a space on fire. However, other applications of the inventive concept are also conceivable. It is for example possible to use the present invention in e.g. military or policial equipment in which it is desirable to first penetrate a surface and thereafter spray gases or other substances, e.g. pulverulent material, through the penetrated surface and into a space. In these cases, another liquid than water may be used and other additives than abrasive material may be used. Furthermore, it is also possible to use the present invention in water jet cutting, in which high pressure water and abrasive material is mixed and used for cutting in a material, but without the purpose of later injecting fluid into a space.

Claims

1. A system for mixing pressurised liquid (5) with an additive (8), said system comprising:

   a first conduit (12) for supplying pressurised liquid (5) from a source (9) to a discharge opening (11);
   a vessel (13) that is adapted to contain said additive (8) that is to be mixed with said pressurised liquid (5);
   a second conduit (20) for supplying pressurised liquid (5) to an inlet (21) of said vessel (13);
   an outlet (23) from said vessel (13), wherein at least a portion of the outlet (23) has an at least partly vertical extension so that the flow of pressurised liquid and additive that flows in said outlet (23) is at least partly moved in an upwards direction in said outlet (23), and wherein said outlet (23) is connected to said first conduit (12);
   and an air vent (40) provided to vent said vessel (13).

2. A system according to claim 1, wherein said air vent comprises a movable closing element (44), wherein said closing element (44) is biased towards an open position, and wherein it is adapted to move to a closed position when pressurised liquid (5) is supplied to said vessel (13).

3. A system according to claim 2, wherein said closing element (44) is adapted to move to said closed position when it is subjected to pressure from said pressurised liquid.

4. A system according to any one of the preceeding claims, wherein said air vent (40) further comprises means (49) for preventing additive (8) from entering into said air vent (40).

5. A system according to any one of the preceeding claims, wherein said air vent is provided at the top portion of said vessel (13).

6. A system according to any one of the preceeding claims, wherein control means (25, 29) for regulating the amount of supply of pressurised liquid (5) to said vessel (13) is provided at said second conduit (20).

7. A system according to any one of the preceeding claims, wherein said system further comprises a branch (18), and wherein said first and second conduits (12, 20) are connected to said branch (18), so that pressurised liquid (5) from said first conduit (12) can be diverted to said vessel (13) through said second conduit (20).

8. A system according to claim 7, wherein control means (25, 29) for regulating the amount of supply of pressurised liquid (5) to said vessel (13) are provided at said second conduit (20) between said branch (18) and said vessel (13).

9. A system according to any one of claims 7 or 8, wherein said outlet (23) is connected to said first conduit (12) downstream of said branch (18).

10. A system according to any one of the preceeding claims, wherein an intake (22) is provided at a lower portion of said at least partly vertically extending outlet (23).

11. A system according to any one of the preceeding claims, wherein said outlet (23) has a generally vertical extension in said vessel (13), and wherein an intake (22) to said outlet (23) is provided at a distance of between 0,5 to 3 cm from a bottom surface of said vessel (13).

12. A system according to any one of the preceeding claims, wherein an intake (22) to said outlet (23) is positioned vertically below said inlet (21).

13. A system according to any one of claims 10 to 12, wherein said intake (22) has a diameter of approximately 5 to 20 mm.

14. A system according to any one of the preceeding claims, wherein said outlet (23) exits said vessel (13) at approximately the same vertical position as said inlet (21) is provided in said vessel (13).

15. A system according to any one of the preceeding claims, wherein said system is adapted to be used in a system for penetration of objects, and wherein said additive is an abrasive material.

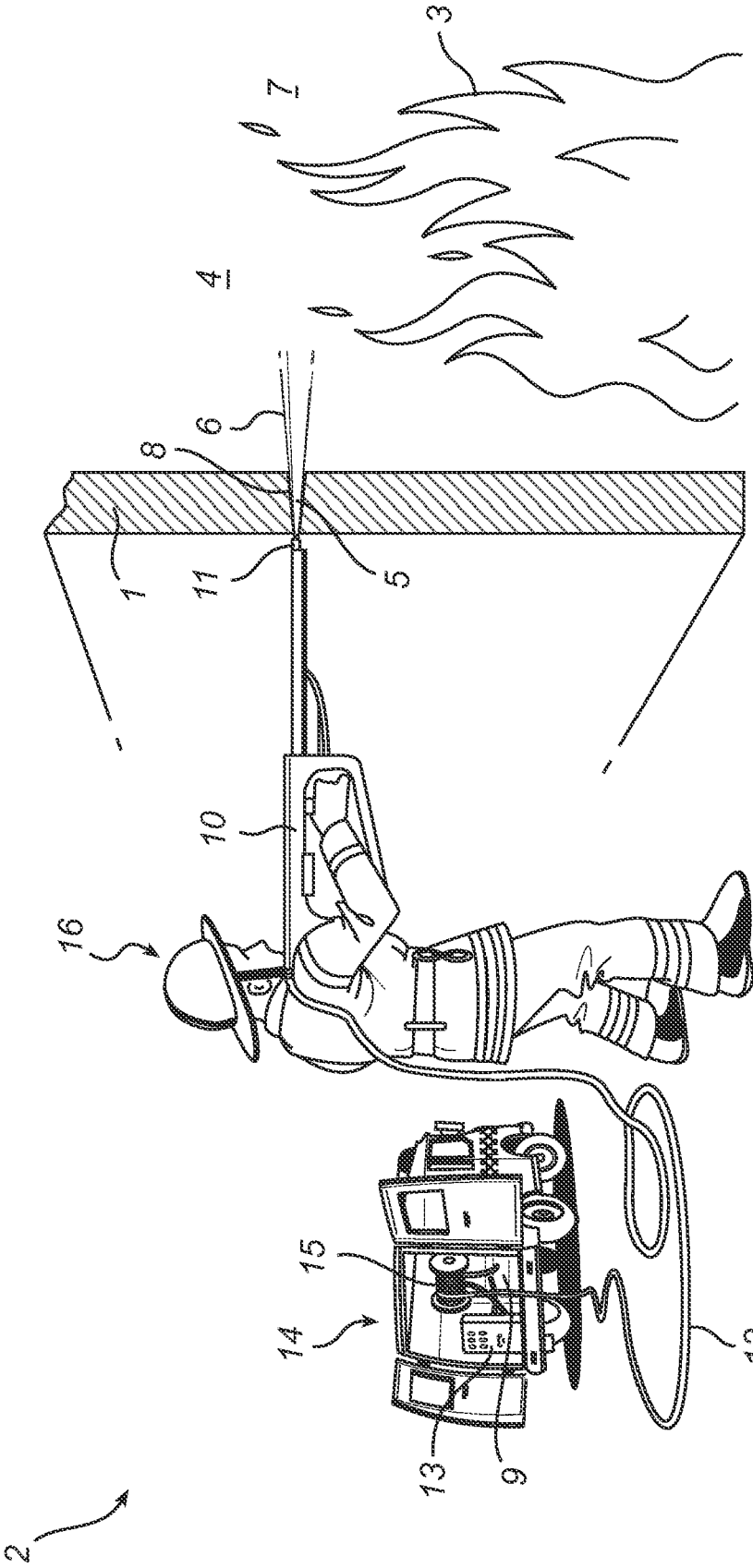

Fig. 1

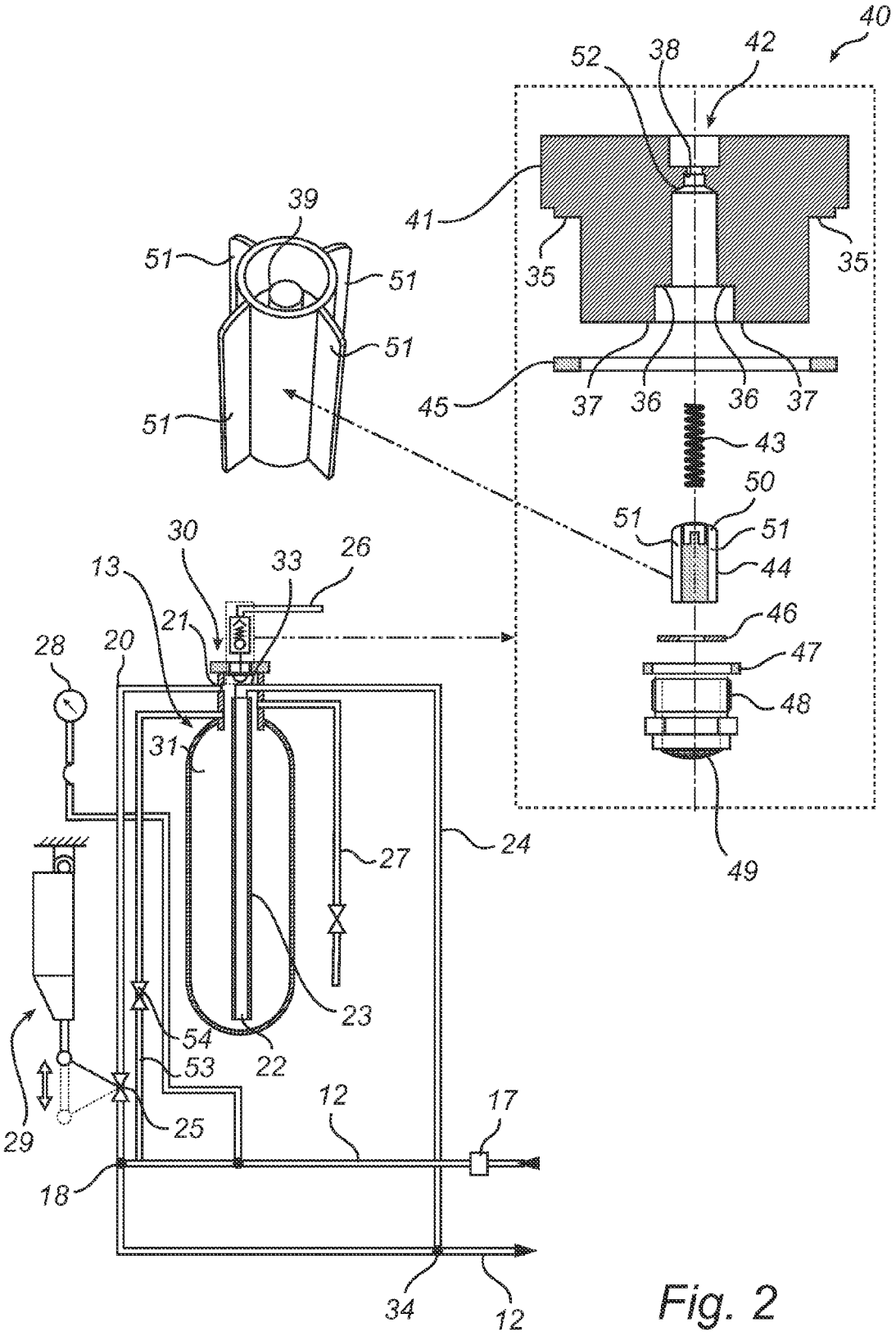
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Fig. 2

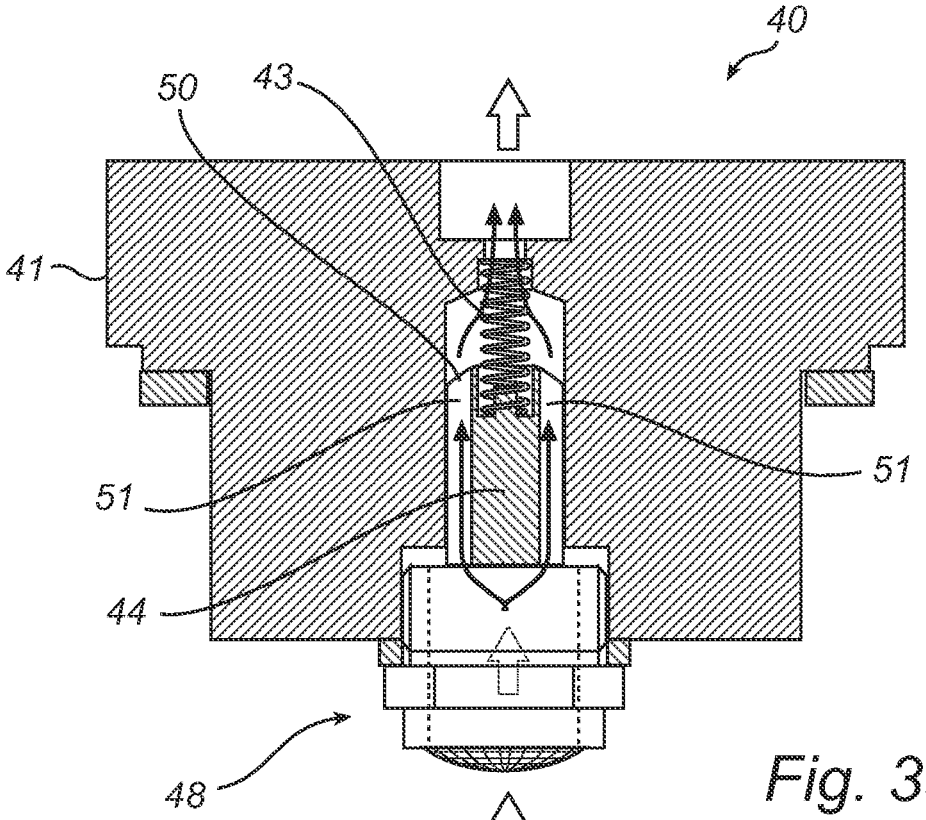

Fig. 3a

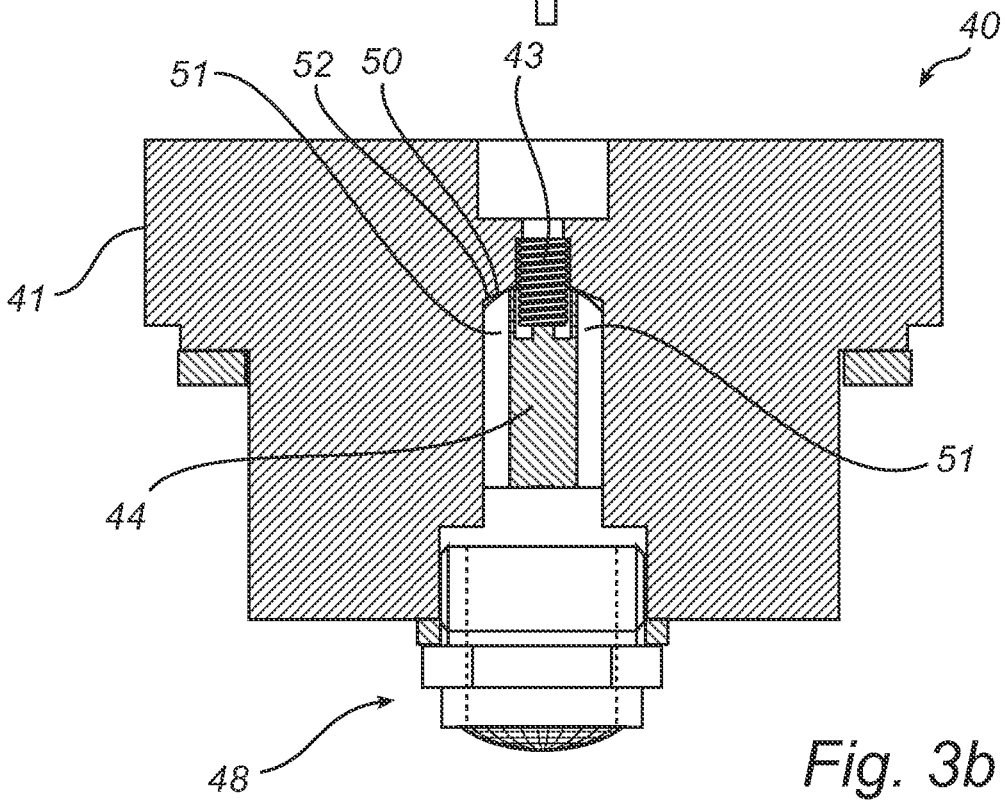

Fig. 3b

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EUROPEAN SEARCH REPORT

Application Number
EP 08 16 5381

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Place of search	Date of completion of the search	Examiner
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CATEGORY OF CITED DOCUMENTS

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