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(54) SAFETY DEVICE FOR A PRESSURIZED GAS TANK AND METHOD FOR OPERATING SAID SAFETY DEVICE

(57) Safety device for a pressurized gas tank, comprising a support body (2) internally delimiting an evacuation channel (4), and a shutter (7) placed to intercept the evacuation channel (4), extended along a main extension axis (Y) and movable between a closed position, in which the shutter (7) is placed to close the evacuation channel (4) and an open position, in which the shutter (7) at least partially frees the evacuation channel (4). The shutter (7) comprises: a shaft (10) extended along the main extension axis (Y) and at least partially inserted within the evacuation channel (4); a closure head (8) placed at a first end (27) of the shaft (10); a spring (9) wound around the shaft (10) and interposed between the support body (2) and a contrast element (11) fixed to a second end (23) of the shaft (10), adapted to force the closure head (8) of the shutter (7) into the closed position; and a fusible element (14). The closure head (8) comprises a hollow sleeve (17) provided with a through hole (16) slidably traversed by the shaft (10) and delimiting a housing space (15) in which the fusible element (14) is housed; the shutter (7) comprises a retention element (21) fixed to the shaft (10) at its first end (27), which is pulled by the spring (9) against the fusible element (14).

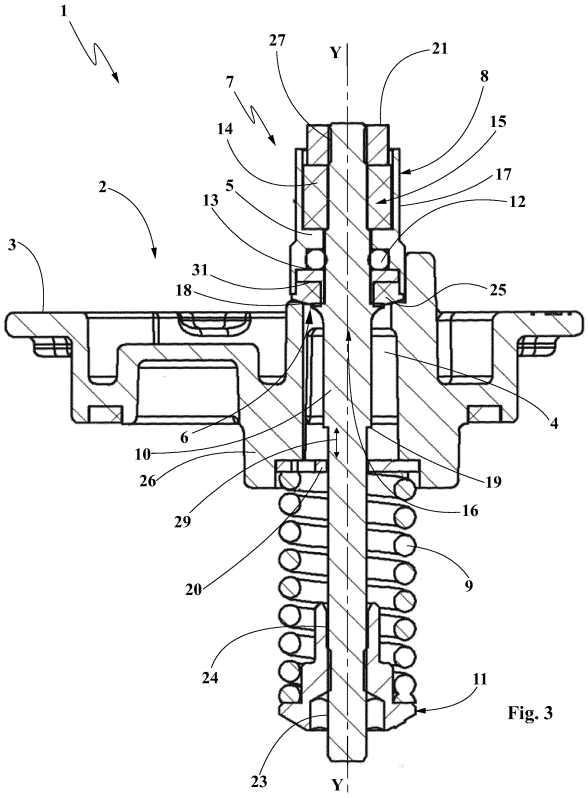

Fig. 3

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Description

Field of application

[0001] The present invention refers to a safety device for a pressurized gas tank and to a method for operating such safety device, according to the preamble of the respective independent claims.

[0002] The present safety device is intended to be installed at the containment wall (also known with the technical term skirt) of a tank containing pressurized gas, and in particular fuel gas for motor vehicles, in order to evacuate a gas flow in the presence of breakdowns, accidents or critical environmental conditions, i.e. when the pressure and/or the temperature of the gas contained inside the tank exceed pre-established threshold values.

[0003] The safety device and its operating method, object of the present invention, are therefore situated in the field of production of safety devices for pressurized gas tanks installed in plants for feeding fuel into motor vehicles and in particular in the industrial field of production of safety devices for over-pressure and over-temperature.

State of the art

[0004] As is known, the plants for feeding fuel gas into motor vehicles (such as cars or trucks) comprise a tank for storing fuel gas, normally liquefied petroleum gas (LPG), normally fixed to the support chassis of the motor vehicle.

[0005] Normally, the tank for storing fuel gas is hydraulically connected to the feed manifold of the internal combustion engine of the motor vehicle and therefore its filling and the physical characteristics of the gas contained therein are subjected to numerous laws in order to ensure the safety of the people on board the motor vehicle itself and of the people located in the vicinity thereof.

[0006] More in detail, one of the applicable laws provides that the tank be filled at most up to 80% of its maximum capacity, in order to prevent an excessive increase of the pressure of the gas contained therein.

[0007] LPG physical behavior generally or at least in first approximation follows the known laws of the state of ideal gases. The equation of state of the ideal gases provides that $pV = nRT$, in which p is the internal pressure of the gas, V is the volume occupied by the gas at the pressure p, n is the substance quantity, R is the gas constant and T is the gas temperature. By applying such general formula to the LPG contained in a tank, in first approximation, it is understood that with the increase of the temperature of the gas contained in the tank, also the internal pressure thereof increases proportionally (with proportionality constant equal to nR/V).

[0008] Therefore, in the case of prolonged exposure of the tank to a heat source, the latter can increase its temperature until it makes the gas contained therein reach critical pressure values, which could compromise the structural integrity of the tank itself. In particular, the currently applicable law provides that the maximum internal pressure of the LPG in a tank does not exceed 27 bar.

[0009] For the purpose of evacuating the gas contained in a tank following the attainment of the threshold value of its internal pressure, it has for some time been known in the field of production of safety devices to provide for a valve for the over-pressure, adapted to make the gas evacuate when the latter reaches the pressure threshold value. Such valve is normally positioned at an opening made on the skirt of the tank and is provided with a shutter placed to close the opening. This valve of known type is also provided with a containment jacket within which a spring is positioned, placed in abutment on one side against the shutter which is forced to close the opening, and on the other side against the internal wall of the containment jacket, which therefore acts as abutment against the elastic stress exerted by the spring.

[0010] With the increase of the pressure inside the tank, the gas pushes the shutter of the valve with always-greater force, such valve shutter forced to be moved away from the opening made on the skirt of the tank, overcoming the elastic force exerted by the spring. Once the shutter is moved from the opening, the gas is free to evacuate from the tank, and therefore the pressure within the latter decreases. A valve for the over-pressure of known type, considered in brief herein, is described in the patent US 1,686,875.

[0011] The same currently applicable law provides that the evacuation of the gas contained inside the tank be provided even in the case of only over-temperature. Indeed, if the tank is only partially filled, e.g. for a small part of the volume thereof, it can happen that - in the case of a fire or a prolonged exposure to a heat source - the thermal agitation of the gas molecules due to the heating is not sufficient for increasing the pressure inside the tank until it is brought above the aforesaid threshold value of 27 bar. Nevertheless, for example in the presence of a fire, it is still important to evacuate the gas contained in the tank regardless of its internal pressure, since it could explode. In particular, the law provides that upon reaching the threshold temperature of 120°C, the gas must be quickly released to the atmosphere.

[0012] For the purpose of evacuating the gas contained in a tank following the attainment of the threshold value of its temperature, an over-temperature valve has for some time been known in the field of production of safety devices, such valve for the over-temperature positioned at an opening made on the skirt of the tank and provided with a shutter placed to close such opening. The valve for over-temperature of known type is provided with a containment jacket within which an element made of fusible material is positioned, substantially placed to block the shutter which is therefore forced to maintain the opening made on the skirt closed. More in detail, the fusible material element is composed of an eutectic metal alloy that melts at low temperatures and is selected so

that it fluidifies at the aforesaid threshold temperature.

[0013] With the increase of the temperature of the skirt of the tank, the temperature melts the fusible element which keeps the valve shutter blocked, and such shutter is forced to be moved away from the opening made on the valve body fixed to the skirt of the tank, by means of the action of the gas, which is at a greater pressure than the atmospheric pressure and therefore is able to exert a force on the shutter in order to exit from the tank. An example of a valve for the over-temperature of known type, considered in brief herein, is described in the patent US 2,859,758.

[0014] Normally, both the valves for over-pressure and over-temperature of known type discussed herein up to now are mounted in parallel on the skirt of the tanks for the storage of liquefied petroleum gas, in order to ensure the safety required by the current applicable law in all situations.

[0015] Currently, several types of safety devices are present on the market, which are provided with a single support body on which the aforesaid over-pressure and over-temperature valves are mounted; such valves affect the same opening made on the skirt of the tank and are in the technical jargon of the field termed "multi-valves".

[0016] One example of a safety device provided with both the over-pressure and over-temperature valves is described in the patent IT 1315578 on behalf of the same applicant.

[0017] The safety device of known type and termed "multi-valve", described briefly above, has in practice proven that it does not lack drawbacks.

[0018] A first drawback lies in the fact that such known safety device is bulky, since each of the valves is provided with an autonomous gas discharge channel and therefore two separate internal ramifications of the device itself must be provided.

[0019] A further drawback of such known safety device lies in the fact that the mounting thereof at the skirt of the tank is long and arduous and therefore requires long operating times which translates into high mounting costs.

[0020] A further drawback of such known safety device lies in the fact that for its production, it is necessary to make a metallic support body of considerable mass in order to be able to obtain the provided seats of the various members and the provided passages for the gas. This involves the use of a considerable quantity of metallic material, in particular brass, whose cost is high and such to negatively affect the overall cost of production of the safety device.

[0021] The patent EP 1521022 describes a safety valve of known type which comprises a spring shutter in order to prevent over-pressures within the container, and a fusible element which is interposed between the spring of the shutter and a fixed cover of the valve, and is susceptible of melting (above a specific temperature) in a manner such to completely unload the spring, leaving the shutter free to be moved, such that it can be brought into open position by the gas inside the tank in order to allow the exit thereof in case of over-temperature.

[0022] Also the latter finding of known type has reliability and efficiency optimization limits, since it is in particular necessary that the spring of the shutter be completely unloaded in order to allow the latter to be opened in over-temperature conditions.

Presentation of the invention

[0023] The main object of the present invention is therefore that of overcoming the drawbacks manifested by the above-described prior art solutions by providing a safety device for a pressurized gas tank, which ensures optimal safety according to the current applicable laws.

[0024] Another object of the present invention is to provide a safety device for a pressurized gas tank, which is easy and quick to install.

[0025] Further object of the present invention is to provide a safety device for a pressurized gas tank, which maintains its mechanical characteristics unchanged over time and ensures constant and optimal safety.

[0026] Further object of the present invention is to provide a safety device for a pressurized gas tank, which is inexpensive and easy to make.

[0027] Further object of the present invention is to provide a method for operating a safety device for a pressurized gas tank, which allows obtaining high safety and reliability.

Brief description of the drawings

[0028] The technical characteristics of the finding, according to the aforesaid objects, can be clearly seen in the contents of the below-reported claims and the advantages thereof will be more evident in the following detailed description, made with reference to the enclosed drawings which represent a merely exemplifying and non-limiting embodiment of the invention, in which:

- figure 1 shows a top axonometric view of the safety device, object of the present invention;
- figure 2 shows a top plan view of the safety device, object of the present invention;
- figure 3 shows a sectional view, made along the trace A-A of figure 2, of the safety device, object of the present invention, in the closed configuration thereof;
- figure 4 shows a sectional view, made along the trace A-A of figure 2, of the safety device, object of the present invention, in a first open configuration thereof, due to the over-pressure;
- figure 5 shows a sectional view, made along the trace A-A of figure 2, of the safety device, object of the present invention, in a second open configuration thereof, due to the over-temperature;
- figure 6 shows a top plan view of a shutter of the safety device, object of the present invention;
- figure 7 shows a sectional view, made along the trace

B-B of figure 6, of the shutter of the safety device, object of the present invention;

- figure 8 shows an exploded axonometric view of the shutter of the safety device, object of the present invention.

Detailed description of a preferred embodiment

[0029] With reference to the set of drawings, reference number 1 overall indicates the safety device for a pressurized gas tank, object of the present invention.

[0030] The safety device 1 for a pressurized gas tank, object of the present invention, is intended to be installed on a containment wall of a tank, for example a fuel gas tank, not illustrated since it is well known to the man skilled in the art. Such containment wall defines the internal volume of the tank itself, in which the gas is intended to be stored.

[0031] Advantageously, the device 1 is intended to be installed on a tank containing liquefied petroleum gas (LPG) on board a motor vehicle, such as the tank of a car or truck in order to ensure a protection against over-pressure and/or over-temperature of the gas which can be encountered in case of irregularities, such as accidents or breakdowns.

[0032] More in detail, the safety device 1, object of the present invention, is intended to make the gas evacuate quickly from the tank if the pressure and/or the temperature reach predetermined threshold values, in order to prevent structural yielding of the containment wall of the tank with consequent explosion.

[0033] The safety device 1 for a pressurized gas tank comprises a support body 2 adapted to be fixed to the containment wall of a tank intended to contain pressurized gas. For such purpose, the support body 2 preferably comprises a perimeter flange 3 intended to be fixed to the wall of the tank by means of fixing means such as screws. The support body 2 internally delimits an evacuation channel 4, which is intended to place the internal volume of the tank in flow connection with the external environment, in order to allow the quick evacuation of the gas in case of over-pressure and/or over-temperature, as described in detail hereinbelow.

[0034] Preferably, the support body 2 is made of metallic material, e.g. hot-molded brass.

[0035] The safety device 1 also comprises a shutter 7 placed to intercept the evacuation channel 4 and extended along a main extension axis Y thereof.

[0036] Advantageously, the main extension axis Y is substantially orthogonal to the containment wall of the pressurized gas tank, once the device is installed on the tank.

[0037] The shutter 7 is movable between a closed position (illustrated in the enclosed figure 3), in which it is placed to close the evacuation channel 4 by hydraulically separating the interior of the tank from the external environment, and an open position (illustrated in the enclosed figure 4 in the case of over-pressure and in the enclosed figure 5 in the case of over-temperature), in which the shutter 7 at least partially frees the evacuation channel 4, allowing the pressurized gas contained in the tank to exit towards the external environment.

[0038] The shutter 7 of the safety device 1, object of the present invention, is provided with a shaft 10, which is extended along the main extension axis Y and is at least partially inserted within the evacuation channel 4. The shutter 7 is also provided with a closure head 8 placed at a first end 27 of the shaft 10 directed towards the external environment and with a spring 9 wound around the shaft 10 and interposed between the support body 2 and a contrast element 11 fixed to a second end 23 of the shaft 10 directed inside the tank. The spring 9 is adapted to force the closure head 8 of the shutter 7 into the closed position.

[0039] In particular, the spring 9 is compressed between the contrast element 11 (preferably placed outside the evacuation channel 4) and an abutment portion of the support body 2 arranged on an inner face thereof intended, during use, to be directed towards the interior of the tank.

[0040] Advantageously, the contrast element 11 of the safety device 1, object of the present invention, is provided with a threaded through hole 24 associated by means of coupling of screw-nut screw type to the second end 23 of the shaft 10, which has at least one threaded portion.

[0041] Preferably, the shaft 10 of the shutter 7 is placed to traverse the evacuation channel 4 with its first end 27 positioned outside the evacuation channel 4 (in particular on an external side of the support body 2 intended, during use, to be directed towards the external environment) and with its second end also placed outside the evacuation channel 4 (in particular on an internal side of the support body 2 intended, during use, to be directed towards the interior of the tank).

[0042] The safety device 1 also comprises a fusible element 14 susceptible of melting in case of over-temperature, i.e. upon reaching a predetermined threshold value, in particular equal to 120°C in accordance with the currently applicable laws, in order to allow the quick evacuation of the gas contained in the tank and prevent the possibility of tank explosion.

[0043] Advantageously, the fusible element 14 is made of a eutectic alloy (i.e. a metal alloy whose melting temperature is lower than the melting temperature of the single components that form such alloy), and in particular it is preferably made of a lead and bismuth alloy, whose melting temperature is about 120°C.

[0044] Otherwise, the fusible element 14 can for example be made of an eutectic alloy of indium and tin, which nevertheless is well-known to be more costly than the aforesaid lead and bismuth alloy.

[0045] Of course, the material that composes the fusible element 14 can be of any type, selected based on the desired melting temperature, without departing from the protective scope of the present patent.

[0046] According to the idea underlying the present invention, the closure head 8 of the shutter 7 of the safety device 1 comprises a hollow sleeve 17 provided with a through hole 16 slidably traversed by the shaft 10, and internally delimits a housing space 15 in which the fusible element 14 is housed.

[0047] The shutter 7 also comprises a retention element 21 fixed to the shaft 10 at its first end 27 directed towards the external environment. Such retention element 21 is pulled by the spring 9 against the fusible element 14, in order to force the closure head 8 (and in particular the hollow sleeve 17) to obstruct the evacuation channel 4.

[0048] More in detail, the spring 9 - by abutting against the support body 2 - acts on the contrast element 11 fixed to the shaft 10 at its second end 23, forcing the same contrast element 11 and the entire shaft 10 therewith towards the internal volume of the tank along the main extension axis Y.

[0049] In this manner, the retention element 21, fixed to the first end 27 of the shaft 10, is also pulled along the axis Y (of the evacuation channel 4 and also of the shaft 10) towards the interior of the tank (i.e. downward with reference to the enclosed figures 3-5), forcing the same retention element 21 of the shutter 7 against the fusible element 14. In this manner, the shutter 7 (and in particular the hollow sleeve 17) is forced into the aforesaid closed position, obstructing the evacuation channel 4.

[0050] Advantageously, the fusible element 14 is arranged between a bottom wall 28 of the housing space 15 of the hollow sleeve 17 and the retention element 21 fixed to the shaft 10 of the shutter 7, in a manner such that, in particular, the retention element 21 (following the above-described action of the spring 9) abuts against the fusible element 14 which in turn is in abutment against the bottom wall 28 of the hollow sleeve 17.

[0051] Advantageously, the force exerted by the spring 9 is such to maintain the shutter 7 in the closed position during the normal operation of the pressurized gas tank and such to compress and move the shutter 7 into the open position if the pressure of the gas inside the tank itself exceeds a predetermined threshold pressure value, e.g. 27 bar, as prescribed by the currently applicable laws.

[0052] In accordance with the preferred embodiment illustrated in the enclosed figures, the closure head 8 of the shutter 7 comprises a first annular gasket 25 mechanically associated with the hollow sleeve 17.

[0053] More in detail, the hollow sleeve 17 is provided with an annular seat 31 in which the first annular gasket 25 directed towards the evacuation channel 4 is engaged and housed and preferably retained by means of a shaped washer 32 housed within the annular seat 31.

[0054] Preferably, the evacuation channel 4 has an annular extension around the shaft 10 and is delimited by an evacuation mouth 18 on which the annular gasket 25 of the closure head 8 is sealingly placed with the shutter 7 in the closed position, pulled by the elastic force of the spring 9.

[0055] Advantageously, the support body 2 comprises a cup-shaped portion 26 with at least one window, preferably transversely open with respect to the main extension axis Y, in order to allow the passage of the gas from the tank towards the evacuation channel 4 when the shutter 7 is in open position.

[0056] Advantageously, the closure head 8 of the shutter 7 comprises a second annular gasket 12 mechanically associated with the shaft 10, housed within the housing space 15 of the hollow sleeve 17 and preferably mounted interposed between the fusible element 14 and an internal mouth 13 which at least partially delimits the through hole 16 in which the shaft 10 of the shutter 7 is slidably inserted.

[0057] Preferably, between the second gasket 12 and the fusible element 14, a metallic annular portion 5 is interposed that is adapted to protect the gasket 12 following the melting of the fusible element 14 itself, in case of over-temperature. Such second annular gasket 12 is sealingly placed on the internal mouth 13 of the hollow sleeve 17 made along the through hole 16.

[0058] Such metallic annular portion 5 can be obtained in a single body with the hollow sleeve 17 via turning or with a separate metal washer.

[0059] Preferably, the first annular gasket 25 and the second annular gasket 12 are made of rubber.

[0060] In accordance with the preferred embodiment illustrated in the enclosed figures, the shaft 10 is provided with an end stop element 19, which interacts with an abutment portion 20 of the support body 2, with the shutter 7 in the open position.

[0061] In operation, when the fusible element 14 collapses, melting due to the exceeding of the threshold temperature, the shaft 10 is free to slide for an operating travel 29 (figure 3) with respect to the support body 2 until it abuts against the abutment portion 20 (figure 5) thereof.

[0062] More in detail, the operating travel 29 is equal to the distance measured along the main extension axis Y when the shutter 7 is in the closed position, between the end stop element 19 of the shaft 10 and the abutment portion 20 of the support body 2.

[0063] Advantageously, the end stop element 19 of the shaft 10 comprises a radially projecting annular shoulder, which is susceptible of abutting against a step of the abutment portion 20 of the support body 2, placed to intercept the end stop element 19 when the shutter 7 is moved from the closed position to the open position.

[0064] Advantageously, the height of the fusible element 14 along the main extension axis Y is greater than the operating travel 29, i.e. than the distance between the end stop element 19 and the abutment portion 20 when the shutter 7 is in closed position (and the fusible element 14 is not melted), in order to allow the exit of the gas from the tank even in the case of only over-temperature, as described in detail hereinbelow.

[0065] The gas that is located inside the tank is always

at a pressure higher than that of the external environment but it can have a pressure lower than the threshold pressure. In practice, if the tank is nearly empty, following a prolonged exposure of the latter to a heat source, the internal pressure of the gas might not reach the threshold value for compressing the spring 9 in order to move the shutter 7 from the closed position to the open position; nevertheless, the provided temperature threshold might be exceeded, such that there is the risk of tank explosion in this situation.

[0066] When the fusible element 14 is collapsed, being melted due to the exceeding of the threshold temperature, the shaft 10 is maintained by the action of the spring 9 with its end stop element 19 in abutment against the abutment portion 20 of the support body 2.

[0067] The gas nevertheless continues to push - from inside the tank towards the external environment - the closure head 8 (and in particular its hollow sleeve 17), which is slidably mounted on the shaft 10, freeing a passage between the same closure head 8 and the evacuation mouth 18 of the evacuation channel 4.

[0068] More clearly, the pressure of the gas forces the closure head 8 (and in particular the hollow sleeve 17) to slide with respect to the shaft 10, for a height equal to the difference between the height of the fusible element 14 and the operating travel 29 of the shaft 10, until the retention element 21 receives in abutment the bottom wall 28 of the hollow sleeve 17. In particular, in accordance with the example illustrated in the enclosed figures, the retention element 21 receives in abutment the metallic annular portion 5 (as illustrated in the enclosed figure 5).

[0069] Advantageously, the through hole 16 of the hollow sleeve 17 is provided with a cross section with respect to the main extension axis Y such to allow the passage of the retention element 21 during the movement of the closure head 8 (and in particular of the hollow sleeve 17) between the closed position and the open position (with the fusible element 14 collapsed).

[0070] Therefore, in the case of only over-temperature, for the purpose of moving the shutter 7 from the closed position to the open position, an evacuation slit 30 (figure 5) is defined between the closure head 8 and the evacuation channel 4, and in particular between the first gasket 25 and the evacuation mouth 18. Such evacuation slit 30 remains open even if the pressure of the gas inside the tank is lower than the threshold value, and the gas is free to quickly exit, ensuring the quick emptying of the tank even in the case of only over-temperature.

[0071] Preferably, the fusible element 14 has substantially annular form and is placed inside the housing space 15 and in particular is placed around the shaft 10 of the shutter 7.

[0072] Advantageously, the closure head 8 is provided with passage openings 22 (illustrated in figure 6) which are defined between the retention element 21 and the hollow sleeve 17 of the closure head 8 of the shutter 7.

[0073] In operation, the passage openings 22 are susceptible of being traversed by the liquefied fusible element 14 once the threshold temperature has been reached. The material which composes the fusible element 14 is forced to exit through the passage openings 22 from the hollow sleeve 17 towards the external environment due to the action of the spring 9 which pushes the retention element towards the bottom wall 28 and by action of the pressure exerted by the gas that pushes the hollow sleeve 17 towards the external environment.

[0074] Preferably, the retention element 21 comprises a nut screwed on the shaft 10 at its first end 27, which is provided with at least one externally threaded portion.

[0075] In this manner, the passage openings 22 are defined between the external perimeter walls of the nut of the retention element 21 and the internal face of the hollow sleeve 17, which is preferably of tubular form.

[0076] Also forming the object of the present invention is a method for operating the safety device 1 described up to now; for the sake of simplicity, the already-indicated reference numbers will be maintained hereinbelow.

[0077] The method for operating the device alternately or sequentially provides for a step of inoperative operation, i.e. when the shutter 7 is placed to intercept and close the evacuation channel 4 without over-pressure and over-temperature events being verified; a step of intervention for over-pressure, in which as reported above the pressure of the gas overcomes the contrast force of the spring 9, causing the exit of the gas, and a step of intervention for over-temperature in which - in the presence or absence of over-pressure - the melting of the fusible element 14 takes place.

[0078] The claimed method described hereinbelow refers to a step of intervention for over-temperature in the absence of over-pressure.

[0079] The method for operating the safety device for a pressurized gas tank, object of the present invention, therefore comprises in case of over-temperature and in the absence of over-pressure, initially a step of melting the fusible element 14, which is housed in the housing space 15 of the closure head 8. Such step is intended to be verified upon reaching a corresponding threshold value for the temperature of the fusible element 14.

[0080] Following the melting step, the fusible element 14 is found in liquid form or at least semi-liquid form and therefore is no longer able to act as a mechanical abutment for the retention element 21 pulled by the elastic action of the spring 9 and pushed by the pressure of the gas.

[0081] An emptying step then follows, in which the fusible element 14 exits from the hollow sleeve 17 of the closure head 8, by means of the force imparted by said spring 9 against the fusible element 14 imparted through the retention element 21, at least partially freeing the housing space 15.

[0082] Advantageously, the material which composes the fusible element 14 exits from the hollow sleeve 17, traversing the passage openings 22 which are defined between the retention element 21 and the hollow sleeve

17 itself.

[0083] The method for operating the safety device 1, object of the present invention, also comprises a consequent and successive step of releasing the spring 9, in which the spring 9 is expanded, forcing the shaft 10 to slide with respect to the hollow sleeve 17 until the end stop element 19 of the shaft 10 abuts against the abutment portion 20 of the support body 2.

[0084] Advantageously, following the step of releasing the spring 9, the shaft 10 of the shutter 7 is blocked with its end stop element 19 in abutment against the abutment portion 20 of the support body 2.

[0085] The operating method also comprises an opening step in which the shutter 7 reaches the open position, by means of the movement of the closure head 8. Such movement is susceptible of being actuated by the pressure of the gas contained inside the tank, which is adapted to move the closure head 8 itself towards the external environment, sliding on the shaft 10, at least partially freeing the evacuation channel 4 in order to allow the pressurized gas to exit from the tank.

[0086] More in detail, following the opening step, the first annular gasket 25 is released from the abutment against the evacuation mouth 18, between which a substantially annular evacuation slit 30 is defined that remains open even in the case of only over-temperature with pressure inside the tank lower than the threshold value.

[0087] Advantageously, in the step of releasing the spring 9, the shaft 10 slides with respect to the closure head 8 along the operating travel 29 equal to the distance along the main extension axis Y between the end stop element 19 and the abutment portion 20 with the shutter 7 in closed position.

[0088] The operating travel 29 traveled by the shaft 10 during such release step is smaller than the height of the fusible element 14 and therefore the retention element 21 is not yet abutted against the bottom wall 28 of the hollow sleeve 17, and in the particular case illustrated in the enclosed figures the retention element 21 is not yet abutted against the metallic annular portion 5 housed within the housing space 15, when the end stop element 19 abuts against the abutment portion 20.

[0089] Advantageously, in the opening step, the closure head 8 (and in particular the hollow sleeve 17) slides with respect to the shaft 10 by a length equal to the difference between the height of the fusible element 14 along the main extension axis Y and the operating travel 29, until the bottom wall 28 of the hollow sleeve 17 abuts against the retention element 21.

[0090] More in detail, the sum of the lengths traveled respectively by the shaft 10 in the step of releasing the spring 9 and by the closure head 8 during the opening step is equal to the height of the fusible element 14 along the main extension axis Y.

[0091] The safety device 1 and its operating method, both the object of the present invention, therefore ensure a quick evacuation of the gas contained inside the tank in case of over-pressure and in case of over-temperature. In particular, following the opening step, the evacuation slit 30 is defined between the evacuation mouth 18 of the support body 2 and the closure head 8 of the shutter 7 which allows the evacuation of the gas from the tank even in the case of only over-temperature with an internal pressure of the tank lower than the threshold value.

[0092] In particular, the claimed configuration of the spring 19, of the shaft 10, of the hollow sleeve 17 and of the fusible element 14 allows, in case of over-temperature, releasing the hollow sleeve 17 from the shaft 10 (in particular also without completely unloading the spring 19), in a manner such that it is sufficient to lift only the hollow sleeve 17 in order to allow the opening of the shutter 7.

[0093] The invention thus conceived therefore attains the pre-established objects.

Claims

1. Safety device (1) for a pressurized gas tank, comprising:

   - a support body (2) intended to be fixed to the containment wall of a tank, and internally delimiting an evacuation channel (4), which is intended to place the internal volume of the tank in flow connection with the external environment;
   - a shutter (7) placed to intercept said evacuation channel (4), extended along a main extension axis (Y) and movable between:

     - a closed position, in which said shutter (7) is placed to close said evacuation channel (4) in order to hydraulically separate the interior of the tank from the external environment;
     - an open position, in which said shutter (7) at least partially frees said evacuation channel (4), in order to allow the pressurized gas contained in the tank to exit towards the external environment;

   said shutter (7) being provided with:

     - a shaft (10) extended along said main extension axis (Y) and at least partially inserted within said evacuation channel (4);
     - a closure head (8) placed at a first end (27) of said shaft (10) intended to be directed towards the external environment;
     - a spring (9) wound around said shaft (10) and interposed between said support body (2) and a contrast element (11) fixed to a second end (23) of said shaft (10) intended to be directed inside the tank, said spring (9) being adapted to force the closure head

(8) of said shutter (7) into said closed position;

- a fusible element (14);

said safety device (1) being **characterized in that**:

- said closure head (8) comprises a hollow sleeve (17) provided with a through hole (16) slidably traversed by said shaft (10) and delimiting a housing space (15) in which said fusible element (14) is housed;
- said shutter (7) comprises a retention element (21), which is fixed to said shaft (10) at said first end (27), and is pulled by said spring (9) against said fusible element (14).

2. Safety device (1) for a pressurized gas tank according to claim 1, **characterized in that** said shaft (10) is provided with an end stop element (19), which is adapted to interact with an abutment portion (20) of said support body (2), with said fusible element (14) fused.

3. Safety device (1) for a pressurized gas tank according to claim 2, **characterized in that** the height of said fusible element (14) along said main extension axis (Y) is greater than the distance between said end stop element (19) and said abutment portion (20) with said shutter (7) in closed position.

4. Safety device (1) for a pressurized gas tank according to any one of the preceding claims, **characterized in that** said closure head (8) of said shutter (7) comprises a first annular gasket (25) mechanically associated with said hollow sleeve (17); said evacuation channel (4) having an annular extension around said shaft (10) and being delimited by an evacuation mouth (18) on which said annular gasket (25) of said closure head (8) is sealingly placed, with said shutter (7) in closed position.

5. Safety device (1) for a pressurized gas tank according to any one of the preceding claims, **characterized in that** said closure head (8) of said shutter (7) comprises a second annular gasket (12) mechanically associated with said shaft (10); said second annular gasket (12) being sealingly placed on an internal mouth (13) of said hollow sleeve (17) made along said through hole (16).

6. Safety device (1) for a pressurized gas tank according to any one of the preceding claims, **characterized in that** said fusible element (14) has substantially annular form and is placed inside said housing space (15) and around said shaft (10) of said shutter (7).

7. Safety device (1) for a pressurized gas tank according to any one of the preceding claims, **characterized in that** said closure head (8) is provided with passage openings (22) which are defined between said retention element (21) and said hollow sleeve (17) of said closure head (8).

8. Method for operating a safety device (1) for a pressurized gas tank according to claim 1, comprising the following operating steps:

- a step of melting said fusible element (14) housed in the housing space (15) of said closure head (8), once the threshold temperature value for the temperature of said fusible element (14) has been reached;

- an emptying step, in which said fusible element (14) exits from said hollow sleeve (17) of said closure head (8), by means of the force exerted by said spring (9) and by the pressure of the gas against said fusible element (14) through said retention element (21), at least partially freeing said housing space (15);

- a step of releasing said spring (9), in which said spring (9) is expanded, forcing said shaft (10) to slide with respect to said hollow sleeve (17) until an end stop element (19) of said shaft (10) abuts against an abutment portion (20) of said support body (2);
- a consequent opening step, in which said shutter (7) reaches said open position, by means of the movement of said closure head (8) due to the pressure of the gas contained inside the tank, which moves said closure head (8) towards the external environment, sliding on said shaft (10), at least partially freeing said evacuation channel (4) in order to allow the pressurized gas to exit from the tank.

9. Method for operating a safety device for a pressurized gas tank according to claim 8, **characterized in that** in said release step, said shaft (10) slides with respect to said closure head (8) for an operating travel (29) equal to the distance along said main extension axis (Y) between said end stop element (19) and said abutment portion (20) with said shutter (7) in closed position;
in said opening step, said closure head (8) sliding with respect to said shaft (10) by a length equal to the difference between the height of said fusible element (14) along said main extension axis (Y) and said operating travel (29).

10. Method for operating a safety device for a pressurized gas tank according to one of the claims 8 or 9,

characterized in that following said opening step, an evacuation slit (30) is defined between said evacuation mouth (18) and said closure head (8) which allows the evacuation of the gas from the tank in case of over-temperature and at pressure lower than a threshold pressure value.

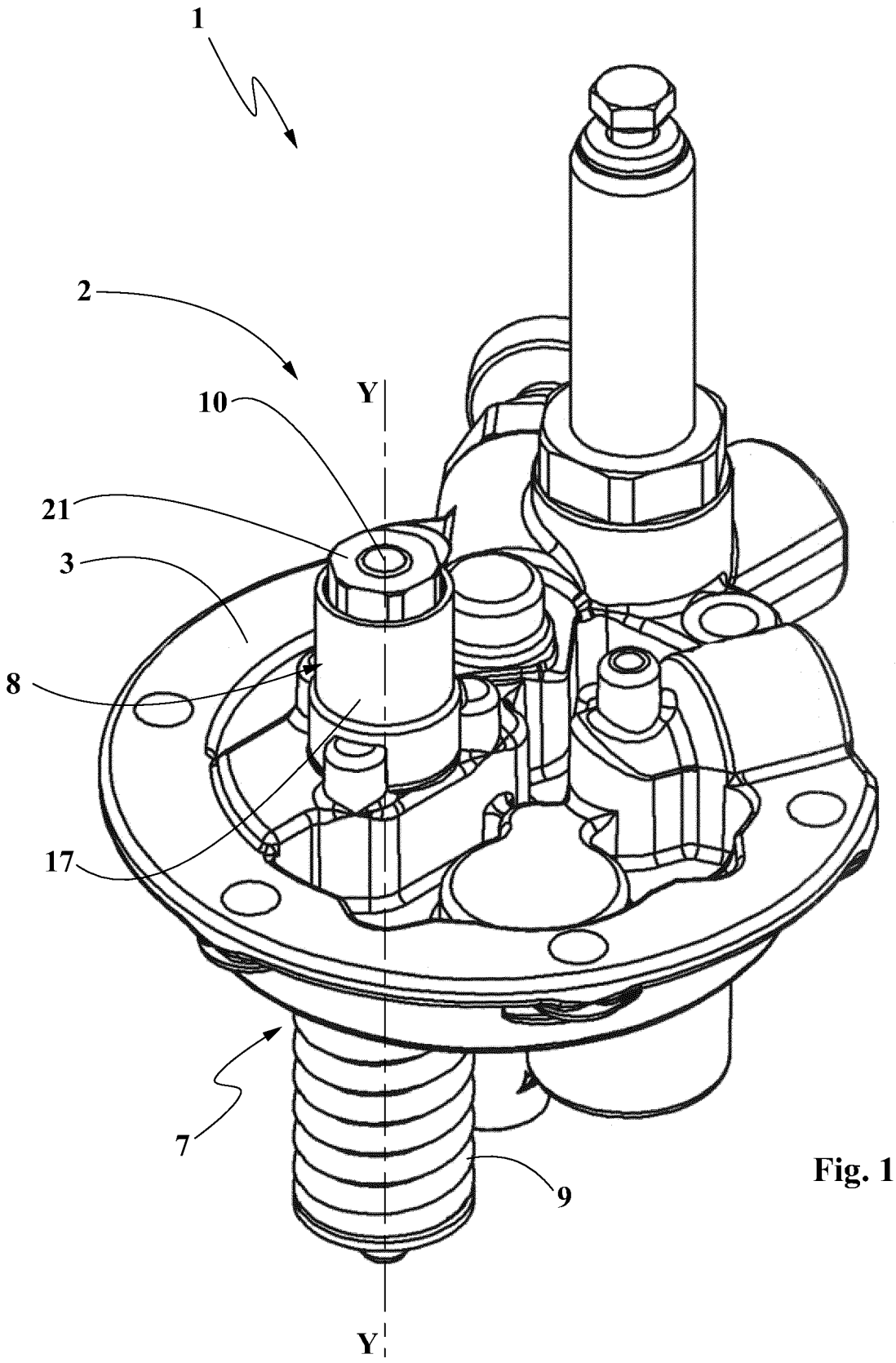


Fig. 1

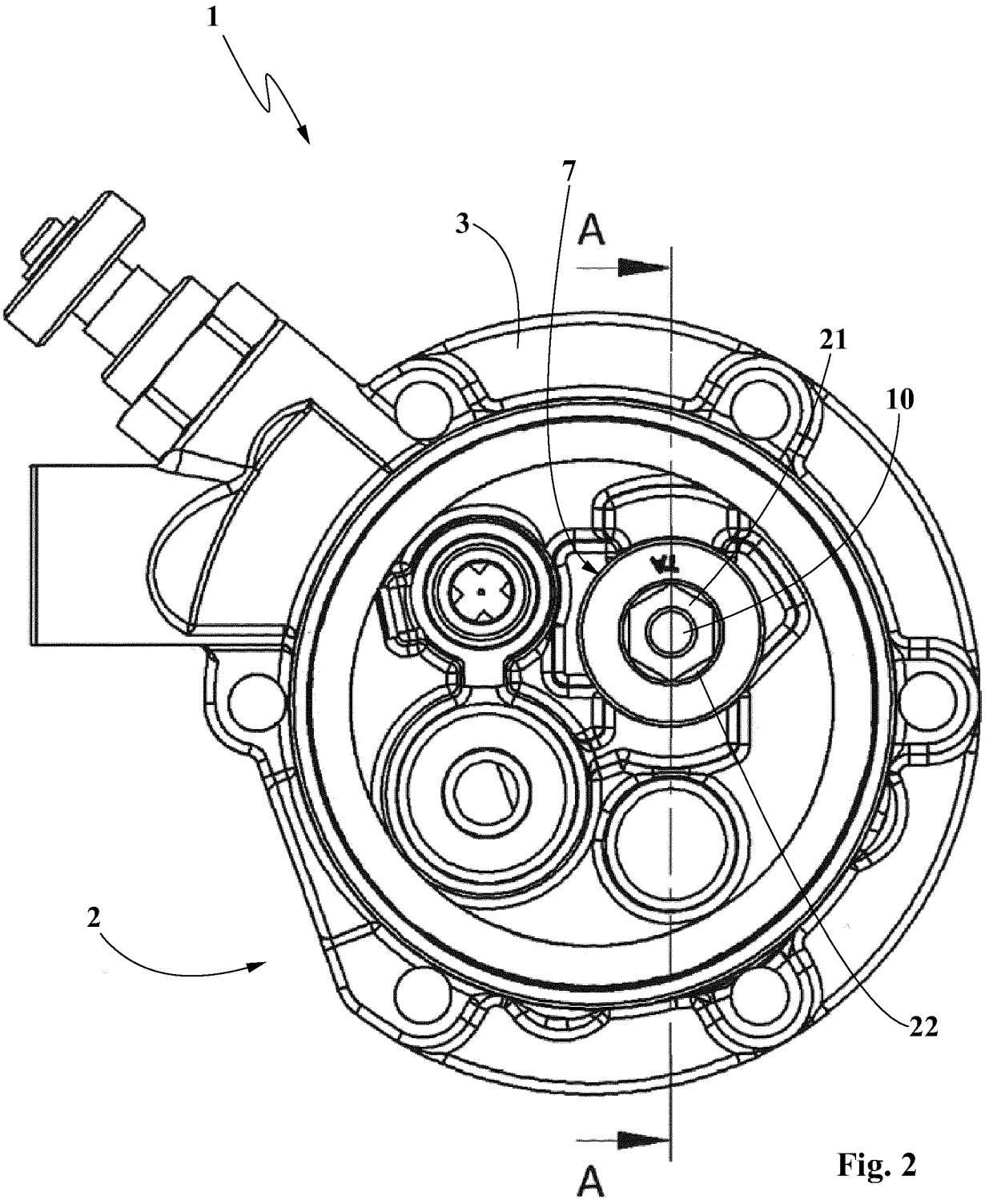


Fig. 2

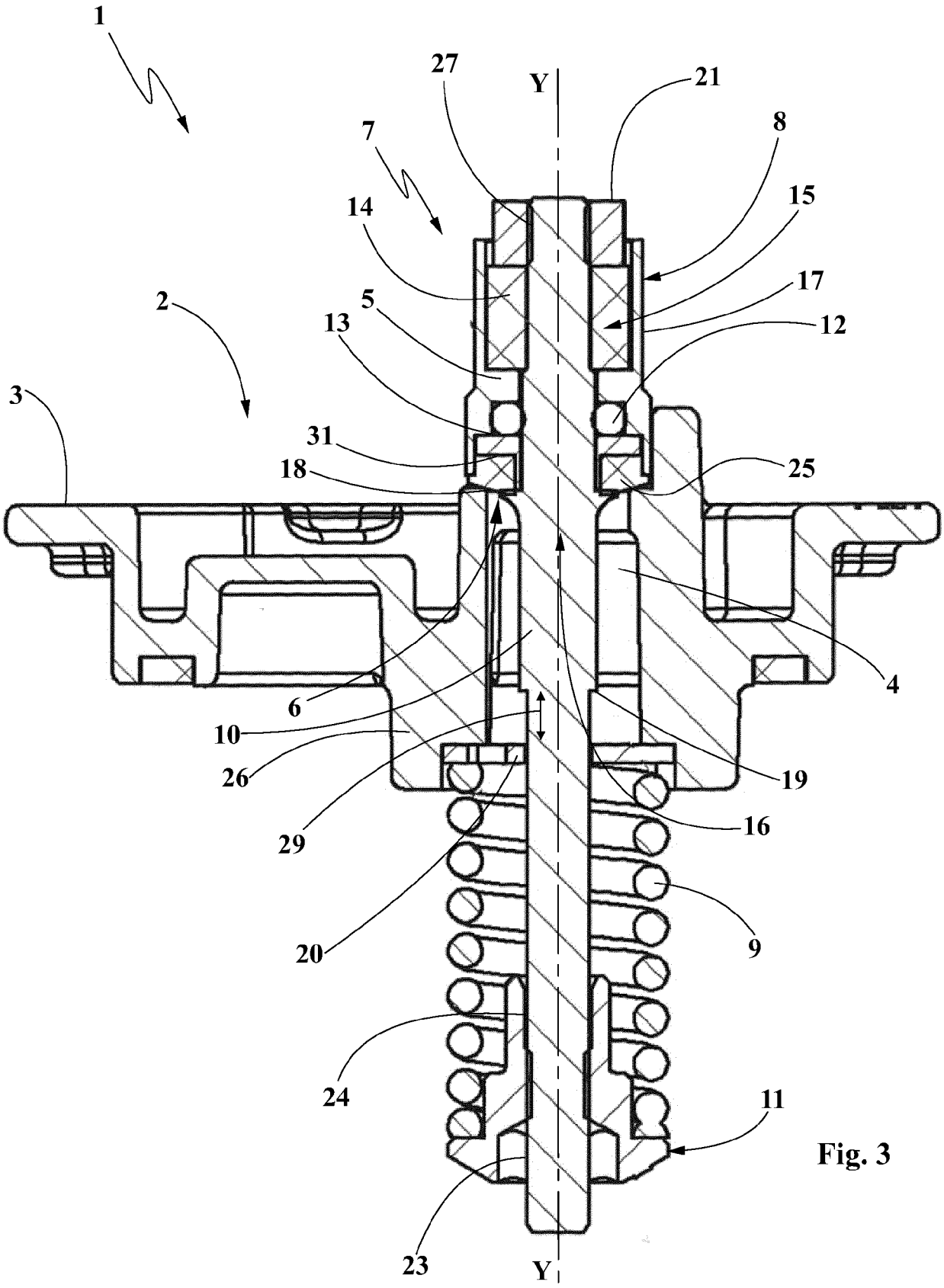


Fig. 3

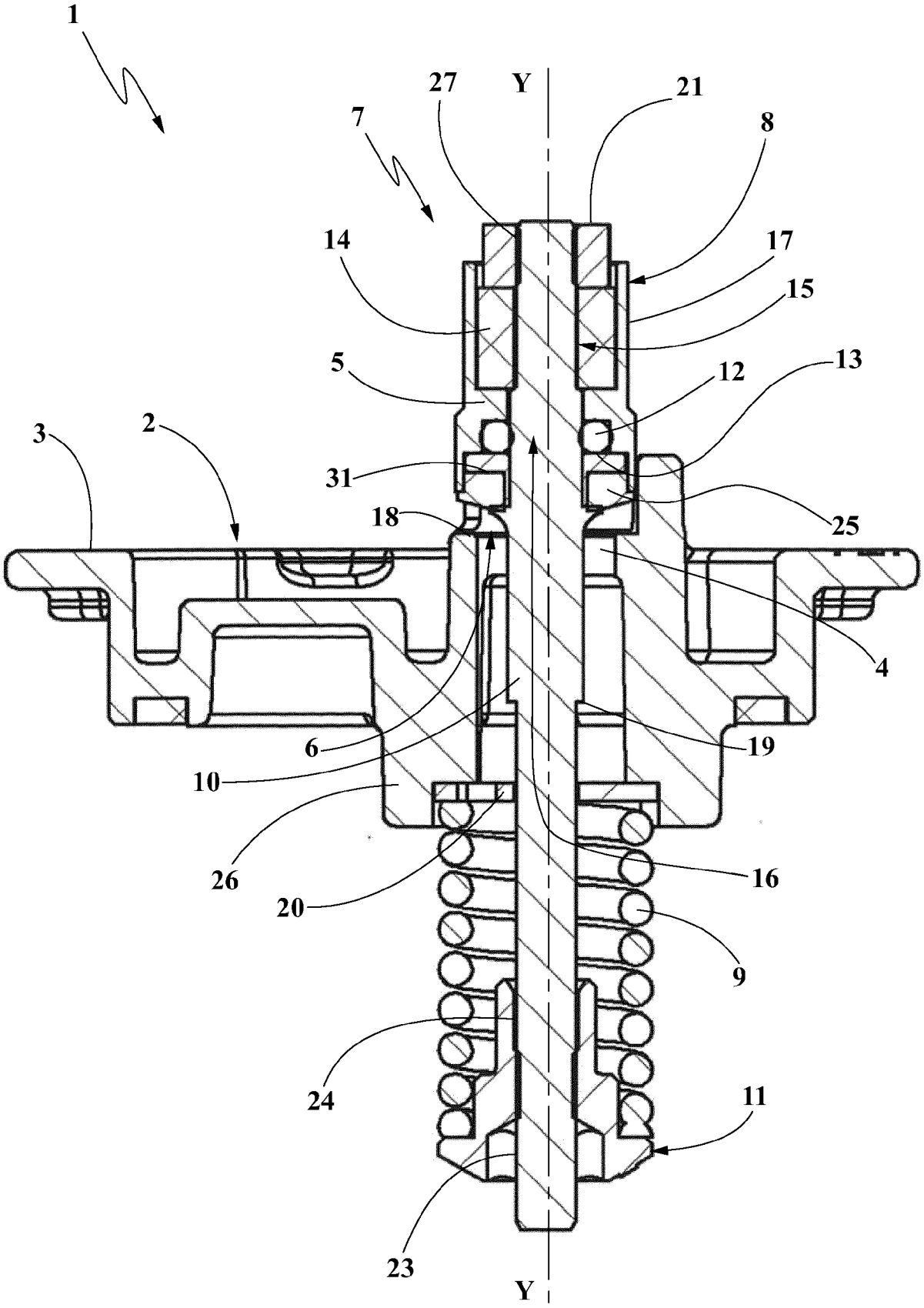


Fig. 4

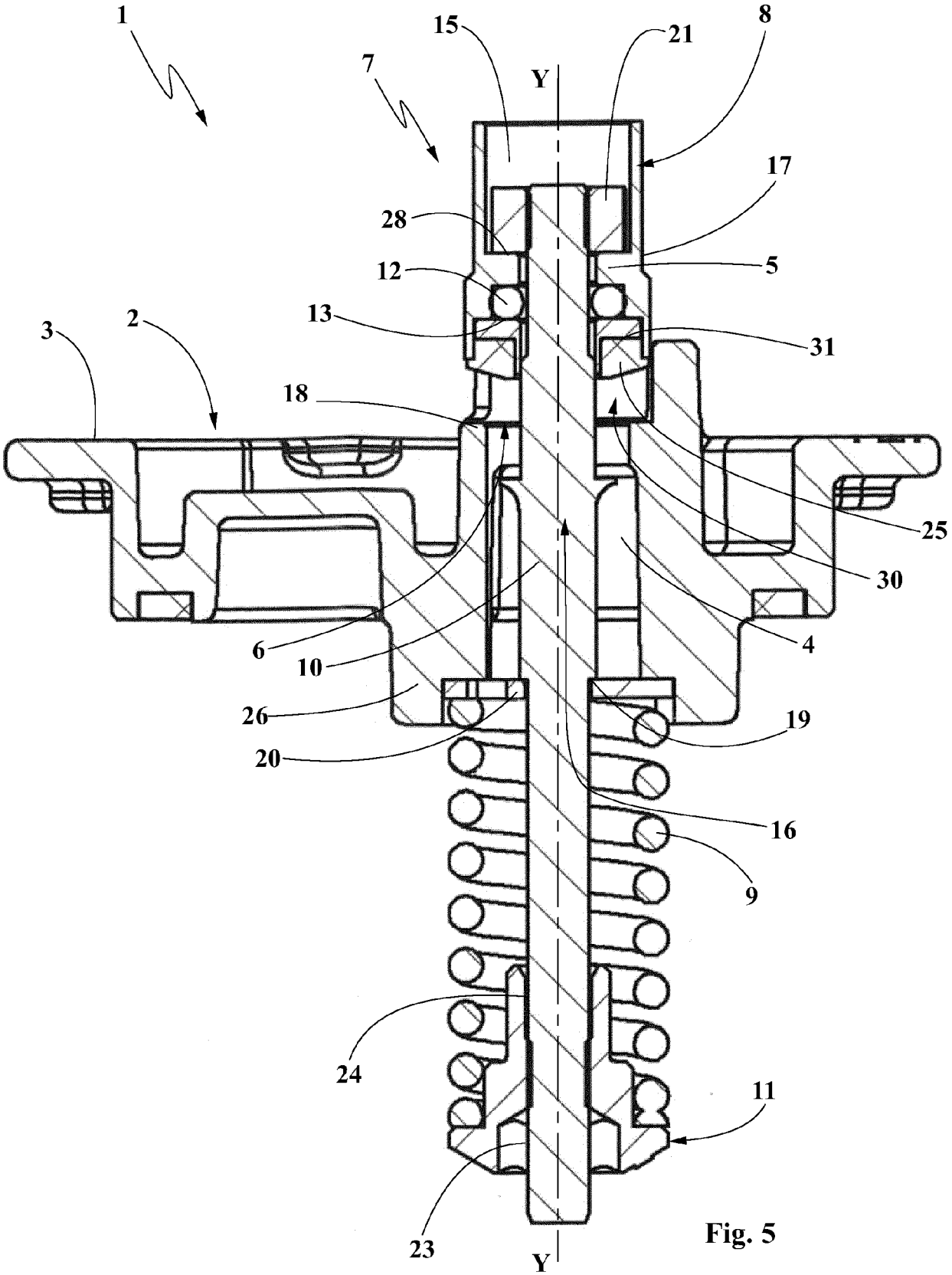


Fig. 5

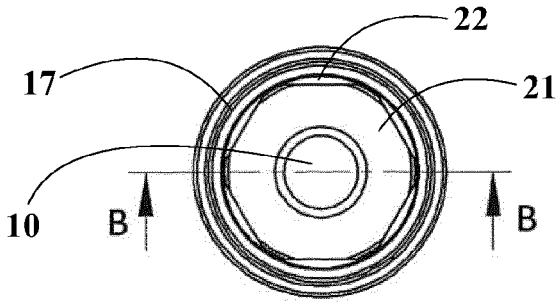
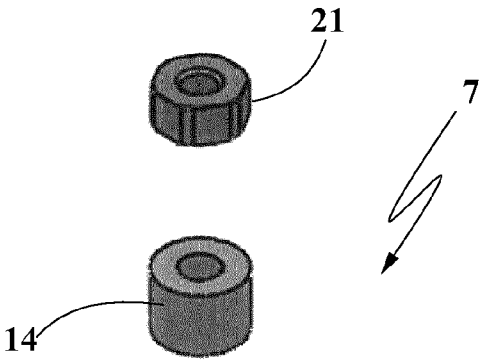


Fig. 6



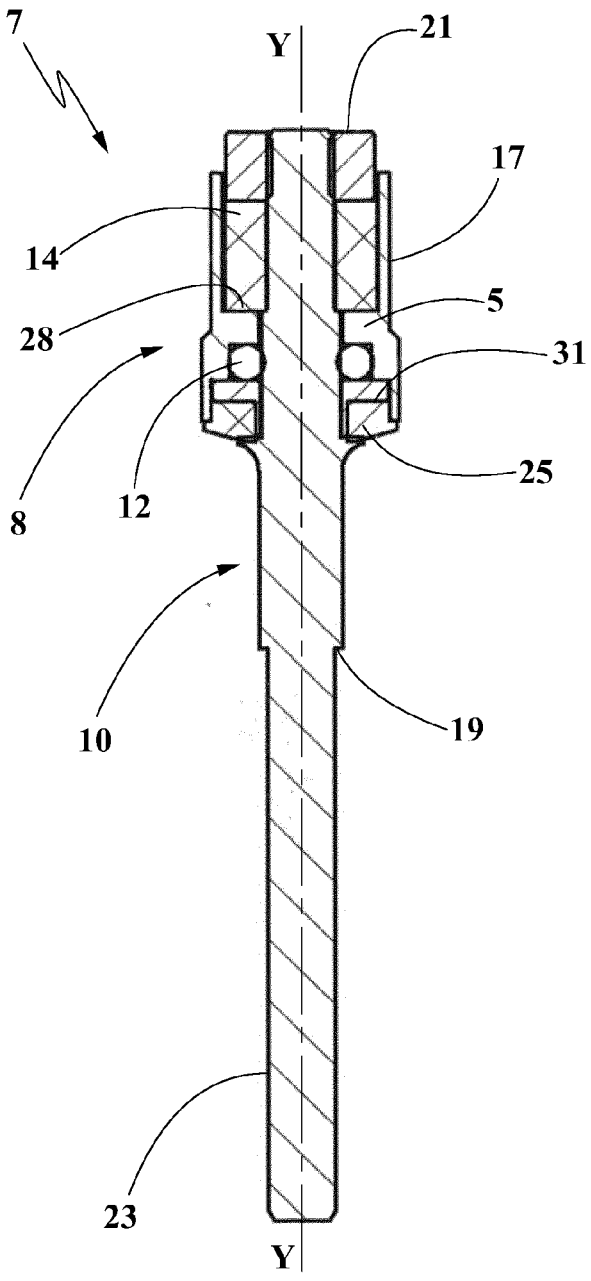


Fig. 7

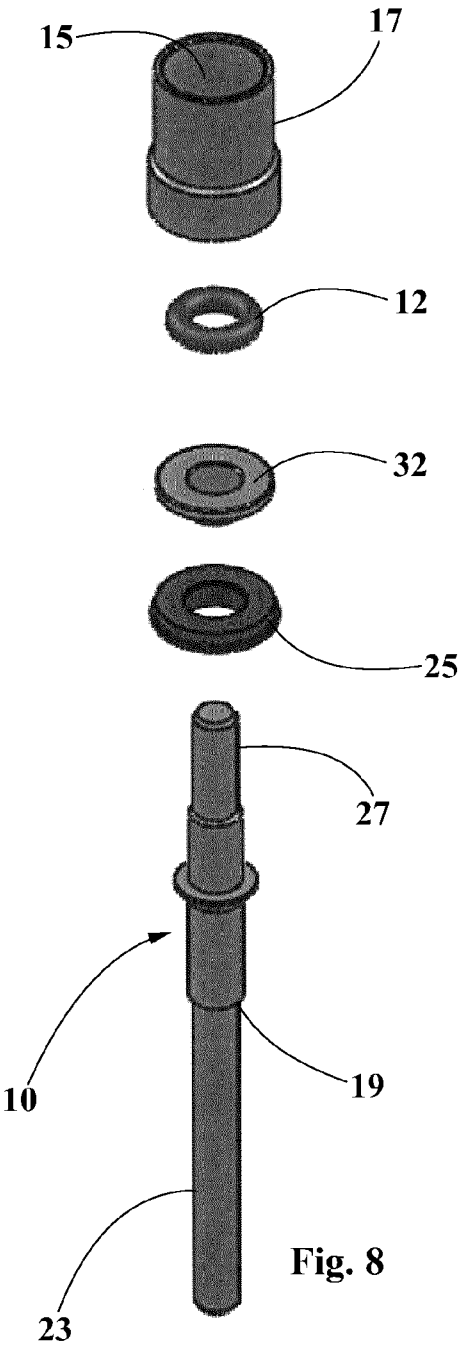


Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 18 15 4522

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	WO 2012/091522 A2 (CIJ CO LTD [KR]; BAEK JONG-TAE [KR]; LIM TAE-YOUNG [KR]) 5 July 2012 (2012-07-05) * fig.2, (30), (20), (40), (10) *	1-10	
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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
Munich	21 June 2018	Ott, Thomas

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