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(54) SAFETY VALVE FOR A COMPRESSED GAS CONTAINER

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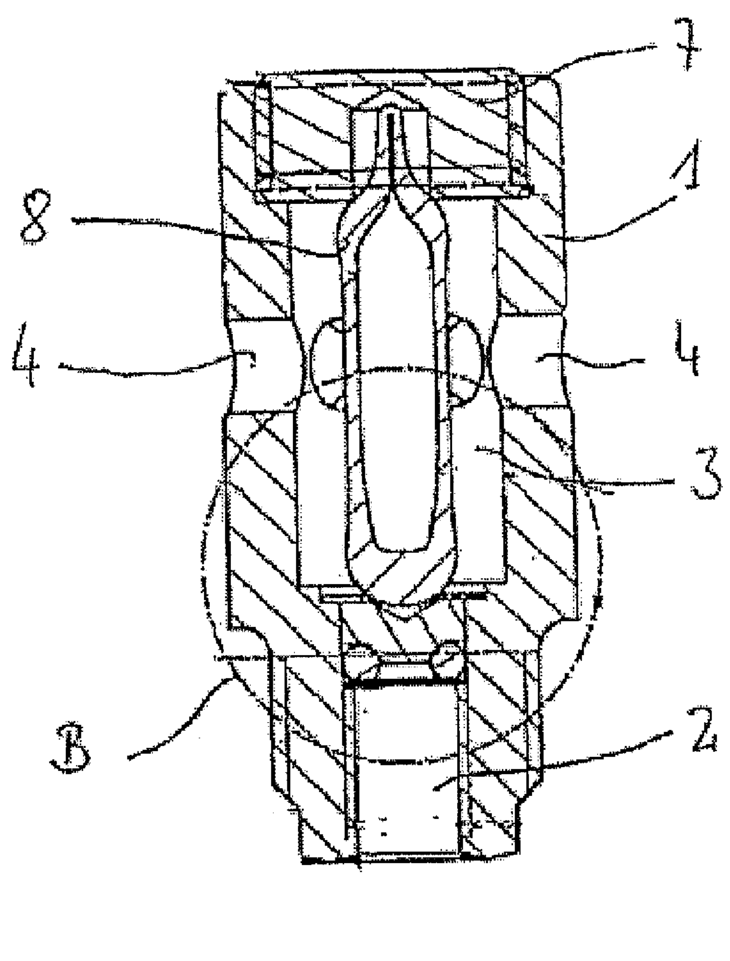
(57) ABSTRACT

A safety valve for a compressed gas container having an overflow duct (**2**) connected to the compressed gas container and having an outlet duct (**3**) and having a thermal triggering unit which comprises a closure body (**15**; **20**) that is displaceable out of a standby position in which it holds the overflow duct tightly sealed with respect to the outlet duct in cooperation with a sealing element (**9**), into a release position in which the overflow duct (**2**) is connected to the outlet duct and also comprises a burst body (**8**) which is arranged between an abutment and a closure body (**15**; **20**) to hold the latter in the standby position, such that the thermal triggering unit comprises a spring element (**10**; **11**; **21**) which exerts a spring force directed in the direction of the abutment on the burst body (**8**), characterized in that the closure body (**15**; **20**) is an element having an essentially wedge-shaped cross section and having rotational symmetry about a central axis, said element engaging in the inside diameter of the O ring and pressing it at least radially against a wall of the overflow duct (**2**) with its sealing surface (**28**) which is designed in a wedge shape, being broader at its wider diameter than the inside diameter of the O ring as the sealing element (**9**).



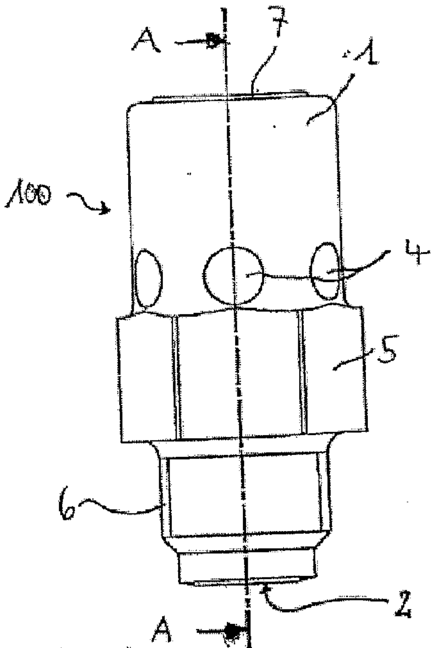


Fig. 1

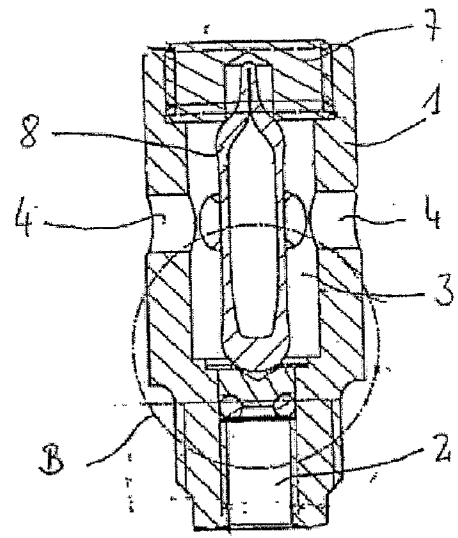


Fig. 2a

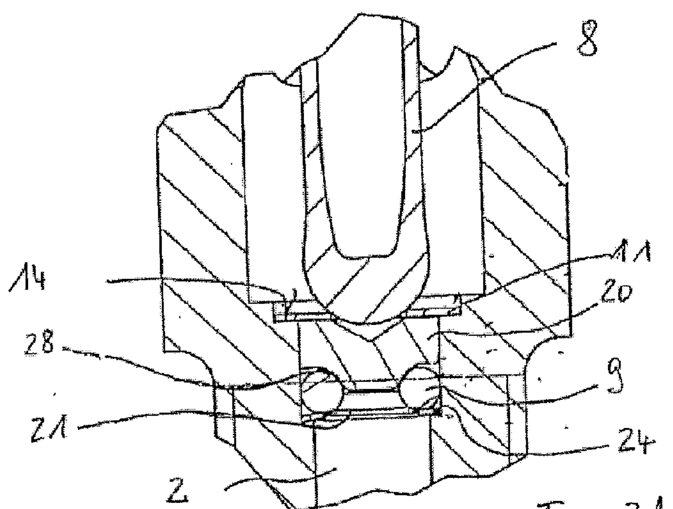


Fig. 2b

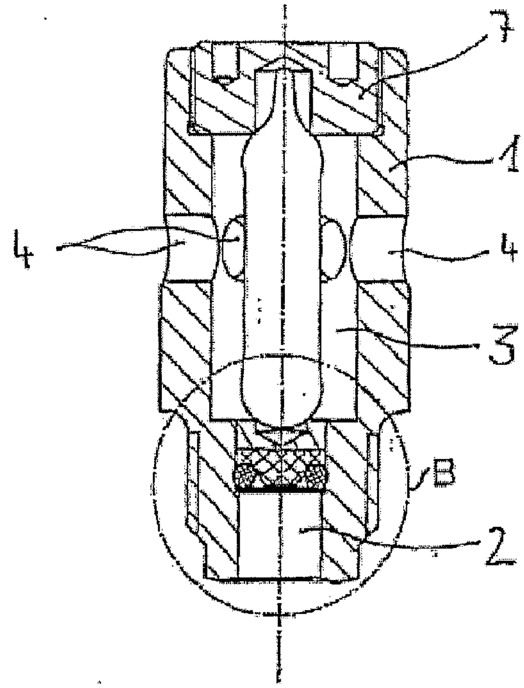


Fig. 3a

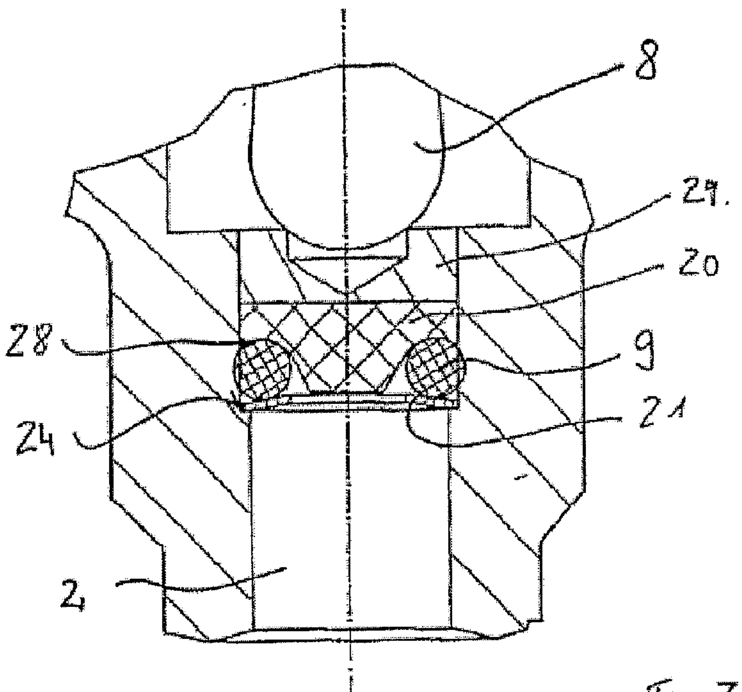


Fig. 3b

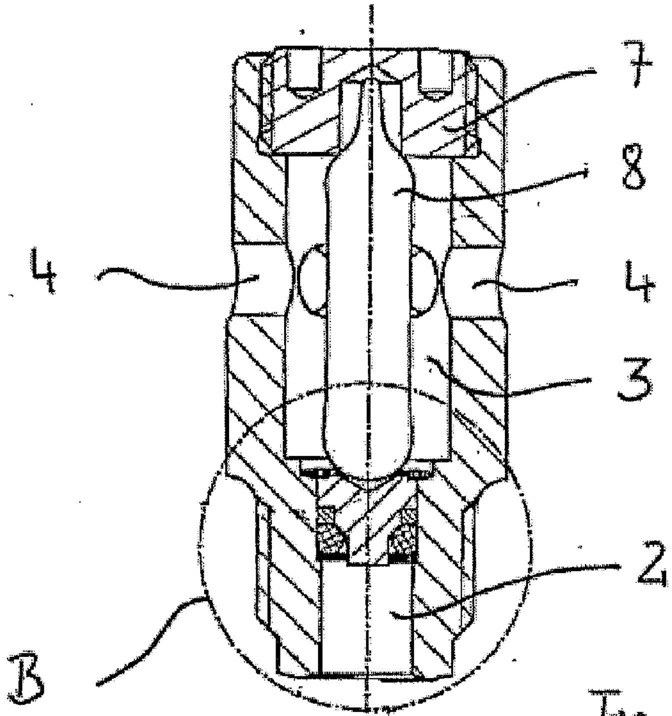


Fig. 4a

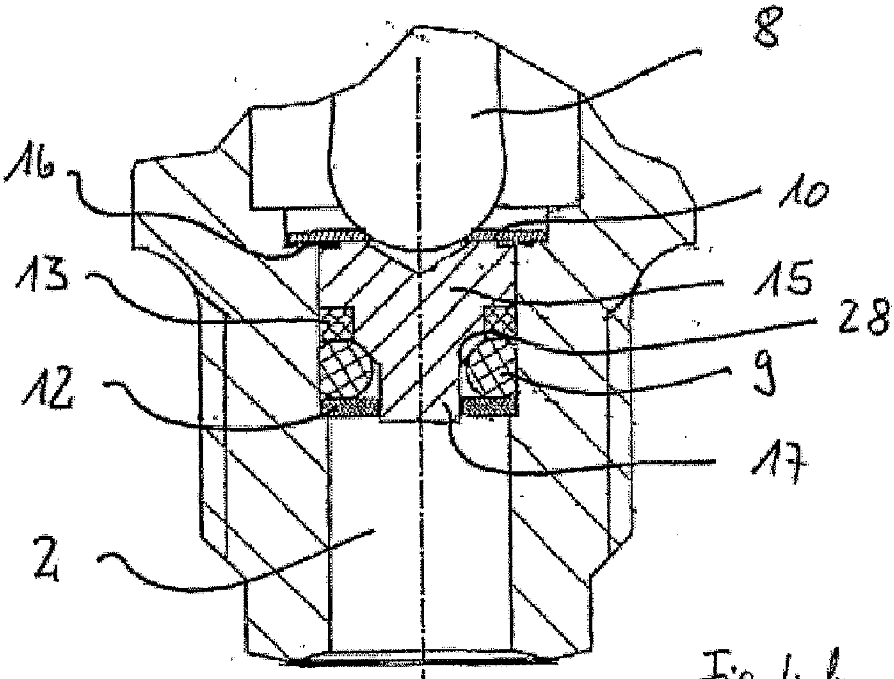


Fig. 4b

SAFETY VALVE FOR A COMPRESSED GAS CONTAINER

[0001] The invention relates to a safety valve for a compressed gas container according to the preamble of Claim **1**.

[0002] Such a safety valve is disclosed in EP 0 960 634 A2, namely in the exemplary embodiment according to FIG. 4 there. Another safety valve designed differently from the preamble of Claim **1** is disclosed in the patent DE 199 11 530 C2.

[0003] According to the industrial standards for compressed gases, e.g., TTRG381, compressed gas containers must be equipped with a cut-out fuse or a similar acting fuse to reliably prevent excess pressure in the event of a fire, which could lead to rupture of the container.

[0004] This is also true, for example, of compressed gas containers in motor vehicles to hold, e.g., natural gas, hydrogen or other combustible gases for use as a fuel.

[0005] The variant of such a safety valve known previously from DE 199 11 530 C3, which was cited above, contains a closure body, which is supported in a standby position directly on the metal of a housing in which an overflow duct is formed. Then the burst body, which in this example is a glass ampoule, is then in turn supported directly on the closure body itself. According to the teaching disclosed in the aforementioned publication, the glass ampoule is ultimately clamped between two rigidly connected supports. With this arrangement, the differences between the thermal expansion coefficients of the metal of which the closure body and the housing are made and the glass material of the burst body result in the risk that the burst body may rupture during cooling and/or heating, e.g., because the metal of the closure body and the housing expands or contracts to a greater extent than the glass material of the burst body and therefore compresses it, especially during cooling. The problem of different temperatures and thus different expansions of the aforementioned materials occurs in particular with compressed gas containers accommodated in vehicles and/or safety valves provided on them. Especially when a motor vehicle is parked outdoors, it is exposed to temperatures ranging from −50° C. in the winter up to 50° C. or more (if in direct sun) in the summer, and temperature may even fall far below the aforementioned ambient temperatures during the operation of filling the pressure vessel. Because of this wide temperature range of 100° C. or more, the different thermal expansion coefficients of metal and glass are definitely manifested. In other words, there may be unintentional triggering of the safety valve, resulting in an outflow of the gas contained in the compressed gas container. However, the same considerations with regard to the thermal expansion coefficients also apply to other compressed gas containers and/or the safety valves arranged in them, which are exposed to high temperature fluctuations.

[0006] FIG. 4 in DE 199 11 530 C2 shows another variant of a safety valve which deviates in its features from the preamble of Claim **1**. In this case, a film forms the closure for the overflow duct, this film being punctured by a plunger that is under spring tension when the burst body ruptures, thereby connecting the overflow duct to the outlet duct. One problem with this approach is that the film can be damaged during installation of the safety valve and can thus become permeable, resulting in unintentional leakage of the contents of the pressure vessel through the safety valve without rupturing the burst body due to high temperatures and without triggering the safety valve. Furthermore, gases under high pressures (often several hundred bar) are stored in the compressed gas containers for which the safety valves are to be used, so that a simple film is often inadequate to reliably withstand such pressures.

[0007] In the EP 0 960 634 A2 cited in the introductory part, a remedy is given for the disadvantages of the safety valves according to DE 199 11 530 C3. However, a burst disk that might trigger the safety valve is required here.

[0008] The object of the present invention is therefore to improve upon a safety valve for compressed gas containers of the type defined in the introductory part so that the advantages of the buffering of different thermal expansions as described in EP 0 960 634 A2 can be utilized without the requirement of a burst disk as an additional safety-relevant part.

[0009] This object is achieved by a safety valve having the features of Patent Claim **1**.

[0010] Advantageous further embodiments of the invention are characterized in the dependent Claims **2** through **7**.

[0011] The inventive safety valve is characterized in that it comprises a sealing element with which the closure body cooperates to seal the overflow duct, in addition to having such a closure body as in some of the variants disclosed in DE 199 11 530 C2. Unlike sprinkler systems, for example, in which a line under pressure is usually sealed directly by a closing body held in position by a burst body without another sealing element, this is impossible with compressed gas containers filled with gases under high pressure. The pressure in water lines of sprinkler systems is usually max. 12 bar. In the compressed gas containers equipped with the inventive safety valves, gases with pressures of several hundred bar, e.g., 300 bar, are stored. At these pressures, reliable sealing of the overflow line is possible with the help of a sealing element in the form of an O ring. This design variant is also described in one of the embodiments of a previously known safety valve described in DE 199 11 530 C2 which was cited above.

[0012] O rings are commercially available parts which can be acquired easily and inexpensively and offer a good seal with respect to the particular sealing surfaces. The material of the O ring should be selected so that it is suitable for the corresponding temperature ranges and does not tend to stick on the sealing surfaces, for example, which might lead to delayed triggering of the safety valve, or in the worst case might even prevent triggering of the safety valve if the O ring holds the closure body cooperating with it in sealing contact with the sealing surfaces even if the burst body has already ruptured.

[0013] In addition to the features known from DE 199 11 530 C2, the inventive safety valve, as shown in FIG. 4 of EP 0 960 634 A2 comprises a spring element which exerts a spring force on the burst body acting in the direction of the abutment. This spring element serves specifically to absorb the stresses, i.e., forces occurring due to different thermal expansion coefficients of the housing and the safety valve and/or the closing body and/or the abutment and the burst body and thus serves to prevent the burst body from rupturing inadvertently before reaching a triggering temperature and thereby inadvertently triggering the safety valve.

[0014] To compensate for loads acting on the burst body due to different thermal expansion coefficients, it would essentially also be possible to provide a spring element which prestresses the burst body in the opposite direction. However, such an approach would have the significant disadvantage that the spring element that prestresses the burst element in the direction of the closing body which closes the outlet duct must counteract a maximum pressure to be expected. In other words, the spring element would have to apply a force to the burst body which can withstand, e.g., a maximum pressure of 300 bar and test pressures of up to 1000 bar or even more. The burst body would thus be exposed to a high force over the entire lifetime of the safety valve which could alter the burst body over a long period of time. In particular a burst body made of glass (e.g., a glass ampoule) would have a tendency to “yield,” under such conditions, i.e., the glass would change its shape. This could ultimately result in leakage and malfunction of the safety valve, with all the safety-relevant consequences thereof.

[0015] However, the selected direction of the spring force allows only a comparatively low prestress of the burst body because the spring force in this direction acts like the force due to the pressure in the pressure vessel. In the normal case, only pressure loads amounting to a fraction of the maximum load are then acting on the burst body, which leads to a definite increase in the lifetime of the burst body and thus also the safety valve.

[0016] The closure body shaped as indicated in Claim **1** is ultimately especially suitable for applying a sufficiently high pressing force to the O ring and thus achieving a reliable seal of the overflow duct in the standby position and thus making the burst disk provided in EP 0 960 634 A2 superfluous.

[0017] An especially good seal can be achieved if the sealing surface of the sealing element is designed with a concave curvature (Claim **2**) in particular when the concave curvature of the sealing surface corresponds to the curvature of a sealing surface of the O ring in at least one section (Claim **3**).

[0018] The variant of this preferred embodiment characterized in Claim **4** offers especially good spring support for changes in length due to different thermal expansions and thus a safety valve, which is especially stable at temperatures below the triggering temperature, and does so through a total of two plate springs arranged in the overflow duct.

[0019] In a preferred variant of the invention, the spring element is a spring placed on a shoulder in the overflow duct, in particular such a plate spring. This then acts on an end of the burst body opposite the abutment to act on it with a spring force in the direction of the abutment. A plate spring is a small effective component that does not prevent reliable triggering of the safety valve.

[0020] A fluid-filled glass ampoule clamped between the closure body and the abutment is preferred as the burst body. Through an appropriate choice of the thickness of the glass and the type of fluid, a defined triggering temperature in a comparatively narrow window can be preselected for such a burst body so that safety valves can be implemented with a wide variety of triggering temperatures through the choice of a concrete glass ampoule and/or a corresponding fluid filling.

[0021] Other advantages and features of the inventive safety valve are derived from the following description of the exemplary embodiments depicted in the accompanying figures, in which

[0022] FIG. **1** shows a view of an inventive safety valve

[0023] FIG. **2***a* shows a sectional view along line A-A in FIG. **1** of the safety valve in a first variant in an enlarged diagram;

[0024] FIG. **2***b* shows a detail according to the area labeled as B in FIG. **2***a* on an enlarged scale

[0025] FIG. **3***a* shows a sectional diagram of the second variant of an inventive safety valve shown along line A-A in FIG. **1**

[0026] FIG. **3***b* shows in an enlarged diagram the area of the safety valve labeled as B in FIG. **3***a* according to this embodiment

[0027] FIG. **4***a* shows a sectional diagram of a third embodiment of an inventive safety valve along line A-A in FIG. **1** and

[0028] FIG. **4***b* shows an enlarged diagram of the area of the safety valve according to this embodiment, labeled as B in FIG. **4***a*.

[0029] The figures are drawn schematically and not true to scale. The same or similar element are provided with the same or similar reference numerals in the figures.

[0030] FIG. **1** shows an inventive safety valve **100** in one possible embodiment. The inventive valve **100** is formed in a housing **1**. In the interior of the housing the safety valve **100** has an overflow duct **2** in the area shown at the bottom of FIG. **1**, said overflow duct being optionally connected to a corresponding tapping duct of a compressed gas container. To do so, the housing **1** is provided with an outside thread **6** in the area of the overflow duct with which it can be screwed into a corresponding inside thread of a connection of a compressed gas container and/or a compressed gas valve. For screw mounting, a hex-head screw **5** on which a commercial wrench may be used is provided on the housing **1** of the safety valve **100**. On its end opposite the outside thread **6** the housing **1** is sealed with a screwed in abutment **7**. In a middle section, the housing **1** has outflow openings **4** in the form of boreholes leading radially into the housing.

[0031] FIGS. **2***a* and **2***b*, **3***a* and **3***b* show two different possible embodiment variants of an inventive safety valve in sectional diagrams according to sectional line A-A in FIG. **1**. The embodiment variants shown here differ only in the internal design of the safety valve **100** but not from the outside, so the diagram in FIG. **1** is equally valid for both variants.

[0032] First the variant shown in FIGS. **2***a* and **2***b* will be described with reference to these figures. These figures show again clearly the overflow duct **2**, as formed in the interior of the housing **1** of the safety valve **100**. A closure body **20** is provided in the overflow duct **2**. The closure body **20** is wedge shaped in cross section, namely V-shaped in this example and is rotationally symmetrical about a longitudinal axis. The closure body **20** abuts on the one hand against a plate spring **11** which is supported on a shoulder **14** in the overflow duct **2**.

[0033] On its side facing away from the plate spring **11**, the closure body **20** has a sealing surface **28** with a concave shape, having a larger diameter at its widest than the O ring **9**. The smallest diameter of the sealing surface is smaller than the diameter of the O ring **9** so the closure body with its sealing surface **28** extends into the O ring **9** in a wedge shape. The concave shape of the sealing surface **28** is adapted in its curvature to the curvature of the sealing surfaces of the O ring **9** at least in some areas so that an optimal seal can be achieved between the sealing surface **28** of the closure body and the O ring **9**. The O ring **9** rests on a second plate spring **21** which is in turn supported on a shoulder **24** in the overflow duct **2**.

[0034] On the side of the plate spring **11** opposite the closure body **20**, the under side of a fluid-filled glass ampoule **8** is in contact with the plate spring. The fluid-filled glass ampoule **8** is supported at its other end in a blind hole in the abutment **7** axially opposite the closure body **20**.

[0035] The diagram in FIGS. **2**_a_ and **2**_b_ shows the standby position of the closure body **20** in which it reliably seals the overflow duct **2** with respect to an outlet duct **3** in cooperation with the O ring **9**, which opens into the outflow openings **4**. The shape of the closure body **20** shown in this exemplary embodiment produces an especially good seal of the overflow duct **2** in the standby position of the closure body **20**.

[0036] The plate spring **11** situated between the closure body **20** and the glass ampoule **8** on the shoulder **14** in the overflow duct **2** exerts a spring force on the glass ampoule **8** in the axial direction, directed at the abutment **7**.

[0037] The plate spring **11** can in particular absorb through deformation a stress occurring due to the difference in thermal expansion of the metal parts of the housing **1**, closure body **20**, abutment **7** and glass ampoule **8** [sic; **8**] thereby preventing premature rupture of the glass ampoule **8** occurring due to such difference in thermal expansion, and thus premature triggering of the safety valve **100**.

[0038] Due to the arrangement of the plate spring **11** on the side opposite the abutment **7**, no forces resulting from the gas pressure need be absorbed by the glass ampule **8**. In addition, stresses created due to differences in thermal expansion can be absorbed by the plate spring **21**, thus resulting in a further improvement in the compensation of such forces and/or stresses and thus ensuring even more reliably that the safety valve **100** will not cause mechanical stresses due to differences in thermal expansion coefficient of the glass material of the glass ampoule **8** and the material of the housing **1** of the abutment **7** and/or the closure body **20**.

[0039] In assembling this variant of the inventive safety valve **100**, the glass ampoule **8** is clamped between the plate spring **11** and the abutment **7** with a defined force in that the abutment **7** is bolted to the housing **1** of the safety valve **11** at a predetermined torque with the glass ampule **8** inserted.

[0040] FIGS. **3**_a_ and **3**_b_ show a sectional of a second exemplary embodiment of an inventive safety valve **100** which is again shown in its outside view in FIG. **1**.

[0041] This exemplary embodiment corresponds in essential design details to the exemplary embodiment shown in FIGS. **2**_a_ and **2**_b_ so that reference can be made to the discussion of FIGS. **2**_a_ and **2**_b_ with regard to the description of this exemplary embodiment.

[0042] In contrast with the exemplary embodiment described previously, the variant shown here has only one plate spring **21**, which is arranged on the side of the closure body **20** facing the overflow duct **2**. A plate spring **14** arranged on the side of the closure body **20** facing the glass ampoule **8** as provided in the exemplary embodiment according to FIGS. **2**_a_ and **2**_b_ is omitted in the present exemplary embodiment.

[0043] Another particular detail of the exemplary embodiment illustrates in FIGS. **3**_a_ and **3**_b_ is that in addition to the closure body **20** an intermediate body **29** is arranged between the former and the glass ampoule **8**. The exemplary embodiment illustrated in FIGS. **3**_a_ and **3**_b_ may of course also be modified in the sense that the intermediate body **29** is omitted and/or becomes part of the closure body **20**.

[0044] Finally, FIGS. **4**_a_ and **4**_b_ illustrate a third embodiment variant of an inventive safety valve **100**. In this variant, the closure body **15** introduced into the overflow duct **2** is shaped somewhat differently in comparison with the closure bodies **20** in the previous embodiment variants. This closure body **15** also has essentially a wedge shape with an inclined sealing surface **28** with which it presses the O ring **9** radially against the wall of the overflow duct **2**, forming a seal. Instead of the plate springs **21** arranged on the side of the closure body **20** opposite the glass ampoule **8** in the preceding exemplary embodiments, the O ring **9** in this exemplary embodiment is supported on an essentially rigid disk **12** which the closure body **15** protrudes with a protrusion **17** through in a central opening. The O ring **9** is also secured by a ring **13**, which is in contact with the closure body **15** and O ring **9**.

[0045] The spring action on the glass ampoule **8** in the direction of the abutment **7** is exerted in this exemplary embodiment exclusively by the plate spring **10** which rests on a shoulder **16** formed in the overflow duct **2** and abuts against the glass ampoule **8** on one side and the closure body **15** on the other side.

[0046] In the function of prestressing the glass ampoule **8** and triggering of the safety element **100**, this variant also operates as described above with regard to the exemplary embodiment according to the FIGS. **2**_a_ and **2**_b_ so that reference can be made to this description in this regard.

[0047] It is clear from the exemplary embodiments illustrated here that the spring element (as at least one plate spring in the exemplary embodiments) can be arranged on the side of the closure body facing the burst body as well as on the side of the closure body facing the overflow duct as well as on both sides at the same time.

[0048] In the embodiment variant show in FIGS. **2**_a_-**2**_b_ the plate spring **11** which is in direct contact with the side of the glass ampoule **8** opposite the abutment **7** offers another advantage. Namely it additionally serve as another "sealing element" that prevents soiling of the overflow duct **2** whish is on the other side of same due to particle, foreign substances, gases or the like penetrating through the outflow openings **4**. This "seal" also prevents corrosion in the area on the side of the plate spring **11** opposite the glass ampoule **8** in that it also prevents corrosive media from penetrating into this area. The same thing is also true of the exemplary embodiment according to FIGS. **4**_a_ and **4**_b_. Again here, the plate spring **10** has the additional effect described above.

[0049] All the embodiment variants of the safety valve **100** shown here are triggered at a predetermined temperature (at which expansion of the fluid in the glass ampoule **8** causes the latter to rupture). At the triggering temperature, the glass ampoule **8** ruptures, so that the closure body **15** and/or **20** is displaced in the direction of the outlet duct **3** due to the pressure of the compressed gas applied to the overflow duct **2** and thus a connection is created between the overflow duct **2**, the outlet duct **3** and/or the outflow openings **4**.

[0050] In the exemplary embodiments, the thermal triggering unit is additionally formed by the abutment **7**, the glass ampoule **8**, the O ring **9**, the closure body **15** and/or **20** and the plate spring(s) **10**, **11** and/or **21** and in the case of the exemplary embodiment illustrated in FIGS. **3**_a_ and **3**_b_, it is additionally formed by the intermediate body **29** and in the case of the exemplary embodiment illustrated in FIGS. **4**_a_ through **4**_b_ it is additionally formed by the ring **13** and the disk **12**.

[0051] The preceding description of the exemplary embodiments has shown clearly again the advantages of the inventive insertion of a spring element, in particular a plate spring into a safety valve **100**. In addition, the advantages of the inventive form of the closure body are apparent.

LIST OF REFERENCE NUMERALS

[0052] **1** Housing

[0053] **2** Overflow duct

[0054] **3** Outlet duct

[0055] **4** Outflow openings

[0056] **5** Hex-head screw

[0057] **6** Outside thread

[0058] **7** Abutment

[0059] **8** Glass ampoule

[0060] **9** O ring

[0061] **10** Plate spring

[0062] **11** Plate spring

[0063] **12** Disk

[0064] **13** Ring

[0065] **14** Shoulder

[0066] **15** Closure body

[0067] **16** Shoulder

[0068] **17** Protrusion

[0069] **20** Closure body

[0070] **21** Plate spring

[0071] **24** Shoulder

[0072] **28** Sealing surface

[0073] **29** Intermediate body

[0074] **100** Safety valve

1. A safety valve for a compressed gas container having an overflow duct connected to the compressed gas container and an outlet duct and having a thermal triggering unit, which comprises a closure body that is displaceable out of a standby position in which it holds the overflow duct tightly sealed with respect to the outlet duct in cooperation with a sealing element, into a release position in which the overflow duct is connected to the outlet duct and also comprises a burst body, which is arranged between an abutment and a closure body to hold the latter in the standby position, such that the thermal triggering unit comprises a spring element which exerts a spring force directed in the direction of the abutment on the burst body, wherein the closure body is an element having an essentially wedge-shaped cross section and having rotational symmetry about a central axis, said element engaging in the inside diameter of the O ring and pressing it at least radially against a wall of the overflow duct with its sealing surface which is designed in a wedge shape, being broader at its wider diameter than the inside diameter of the O ring as the sealing element.

2. The safety valve according to claim **1** wherein the sealing surface has a concave curvature.

3. The safety valve according to claim **2** wherein the curvature of the sealing surface having a concave curvature corresponds in its curvature to the curvature of a sealing surface of the O ring in at least one section.

4. The safety valve according to claim **1** wherein a first shoulder is provided in the overflow duct, a first plate spring resting on said shoulder, the O ring resting on said first plate spring and supported thereon and on the wall of the overflow duct in a sealing manner, such that the closure body is in contact with the O ring on the side opposite the first plate spring and a second plate spring is arranged on the side of the closure body opposite the O ring, resting on a second shoulder formed in the overflow duct and the burst element being supported on the side thereof opposite the closure body.

5. The safety valve according to claim **1** wherein the spring element is arranged on the side of the burst body opposite the abutment.

6. The safety valve according to claim **1** wherein the spring element is a plate spring placed on a shoulder in the overflow duct.

7. The safety valve according to claim **1** wherein the burst body is a fluid-filled glass ampoule clamped axially between the closure body and the abutment.

* * * * *