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(54) SEALING CAP

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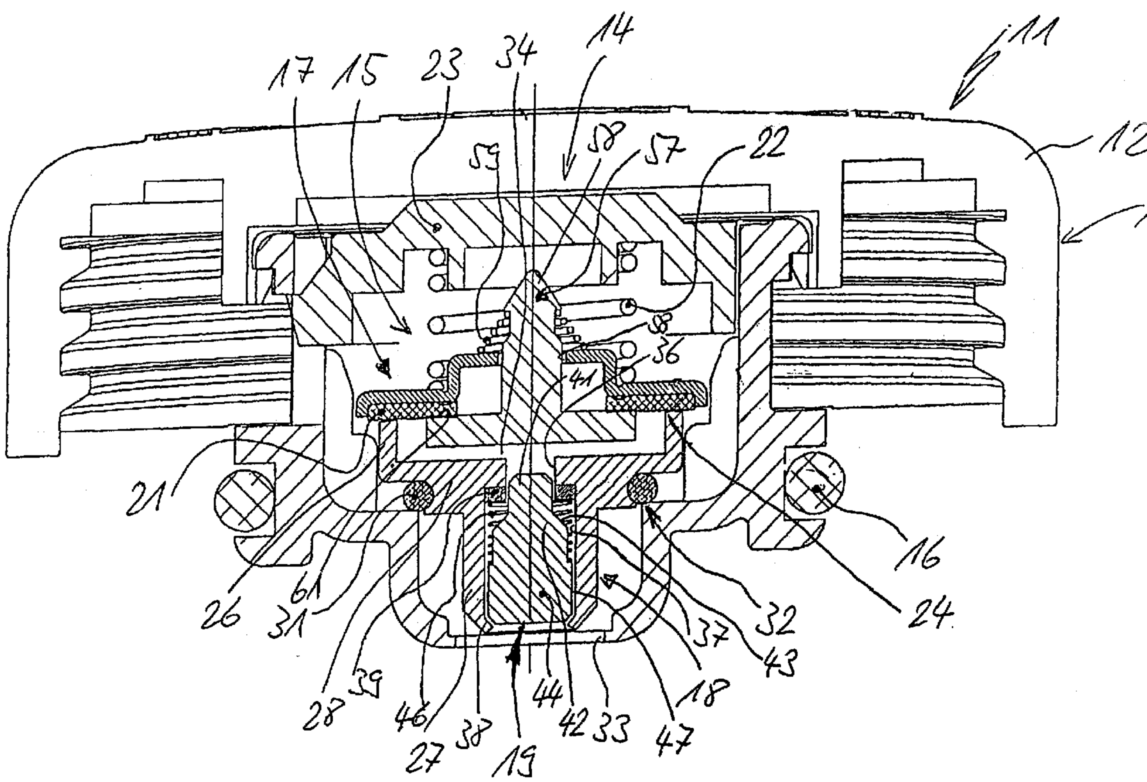
(57) **ABSTRACT**

The invention relates to a pressure cap **(11)** for openings in tanks, particularly in motor-vehicle radiators, which has an internal cap component **(14)** that is provided with at least one flow connection between the inside and the outside of the tank, and with a valve arrangement **(15)** for releasing and blocking the flow connection. The said valve arrangement **(15)** has a first and a second valve body **(17, 18)** that can be moved back and forth. The first valve body **(17)** is biased in the direction of the inside of the tank against a first sealing seat **(24)** on the second valve body **(18)**, which is pressed against a second sealing seat **(32)** on the interior cap component **(14)**. Furthermore, the first and second valve bodies **(17, 18)** can be lifted when a respective threshold value of the inside tank pressure is exceeded and the flow connection **(50, 51)** between the inside and the outside of the tank is released. To simplify the manufacture and installation of the pressure cap and also to improve the hysteresis behaviour, inside the second valve body **(18)** a third valve body **(19)** is placed, between which and the second valve body **(18)** a first flow connection **(50)**, designed in that section as a throttle gap **(47)**, is provided between the inside of the tank and the first valve body **(17)**.



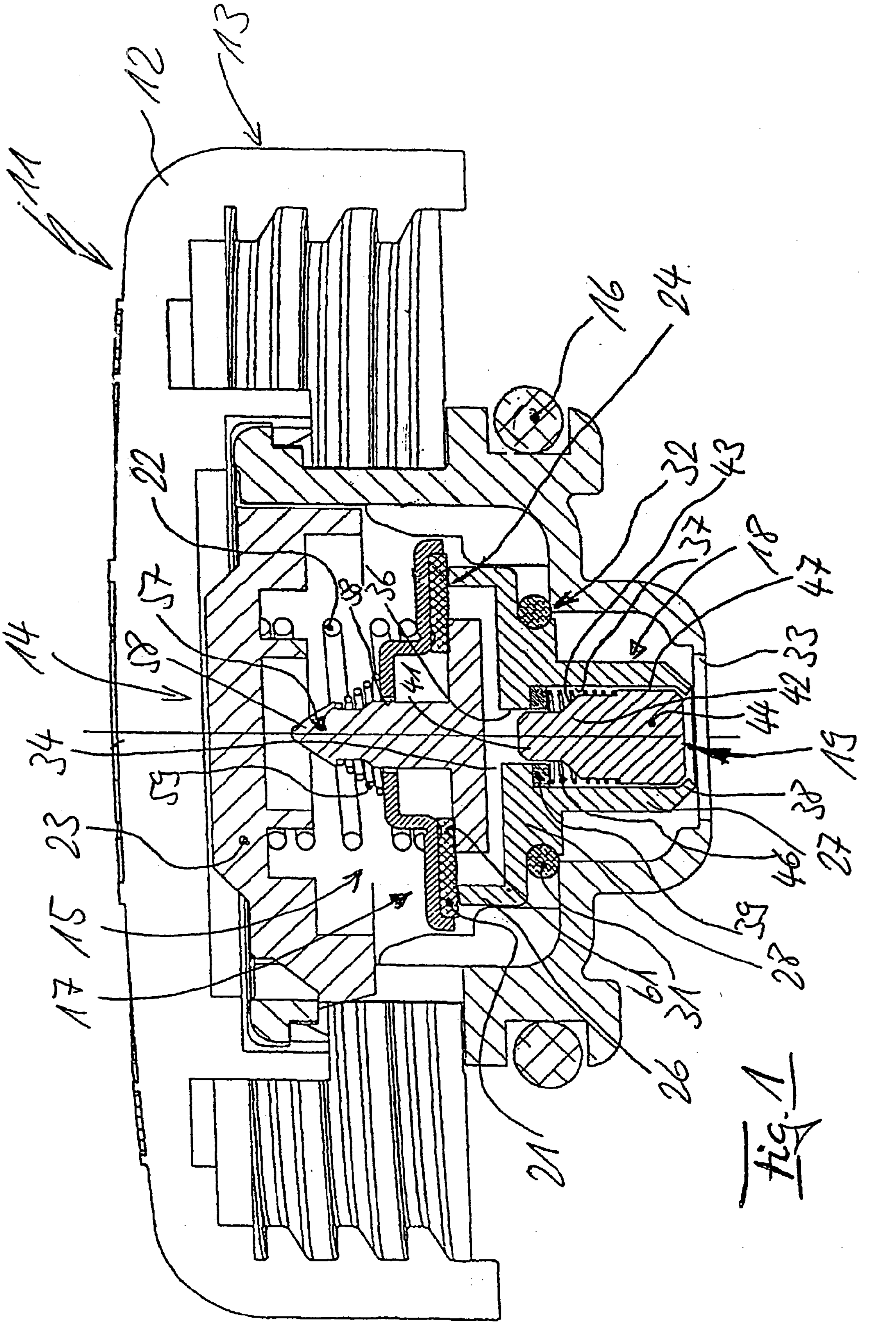

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Fig. 1

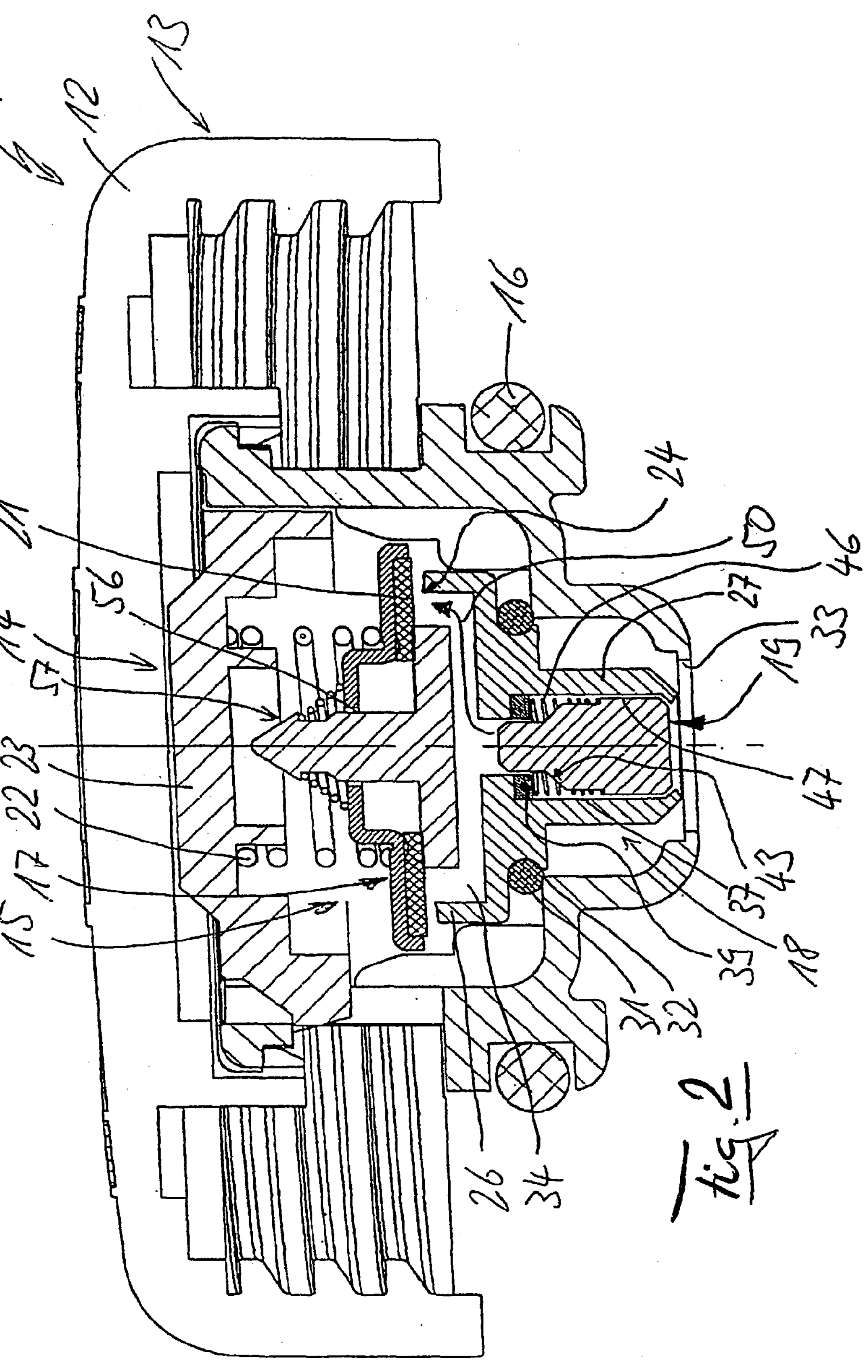
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Fig. 2

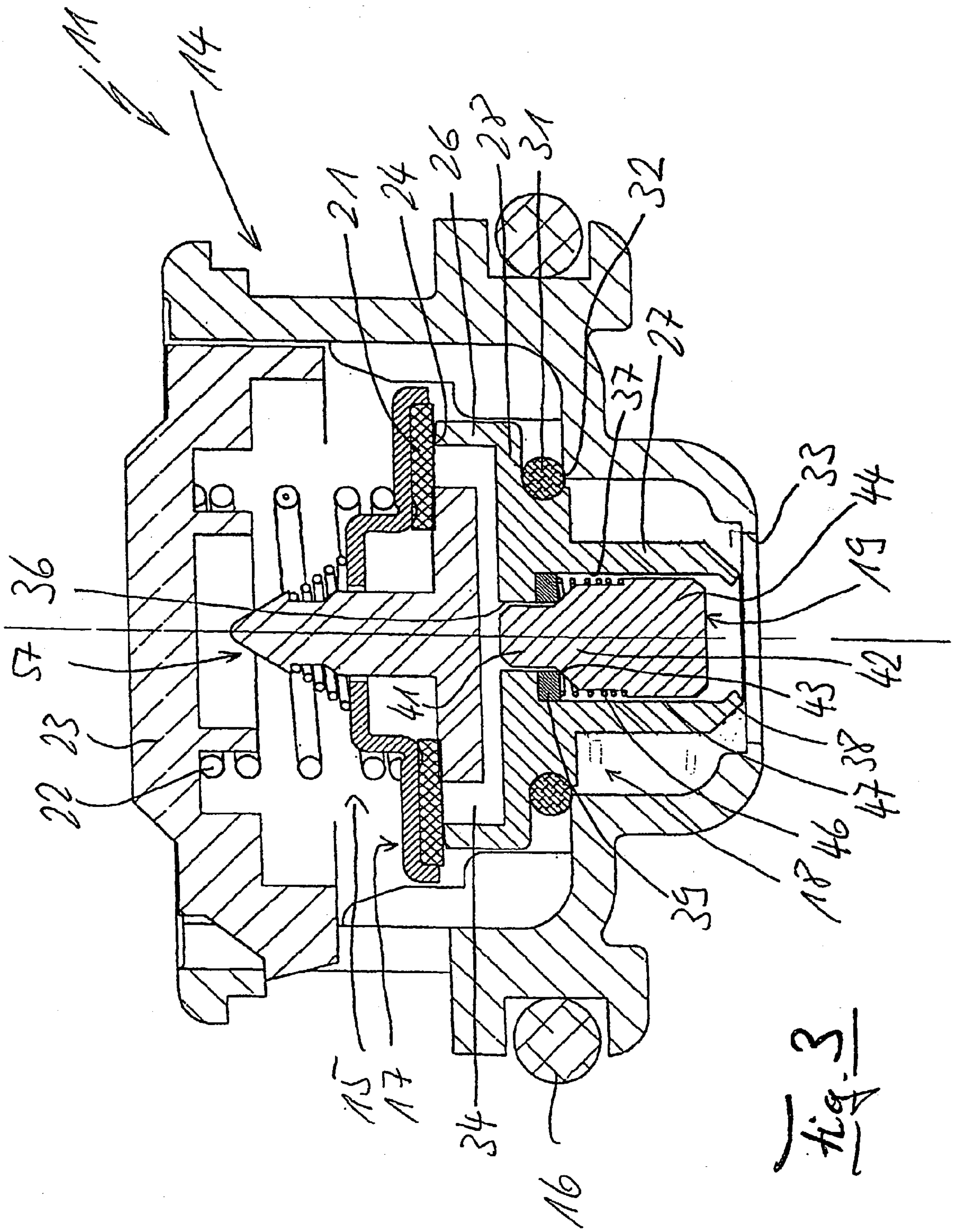
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Fig. 3

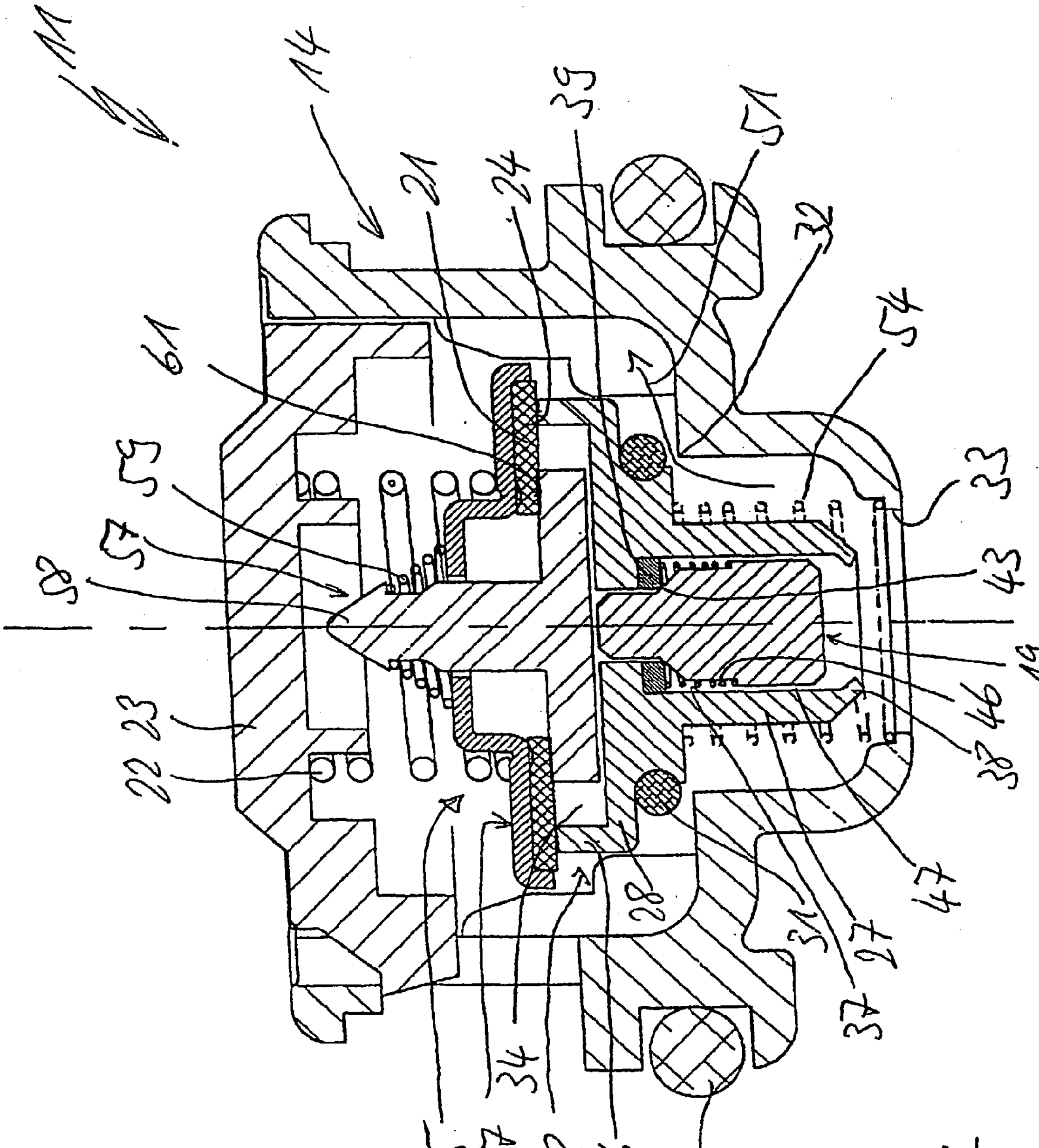

Fig. 4

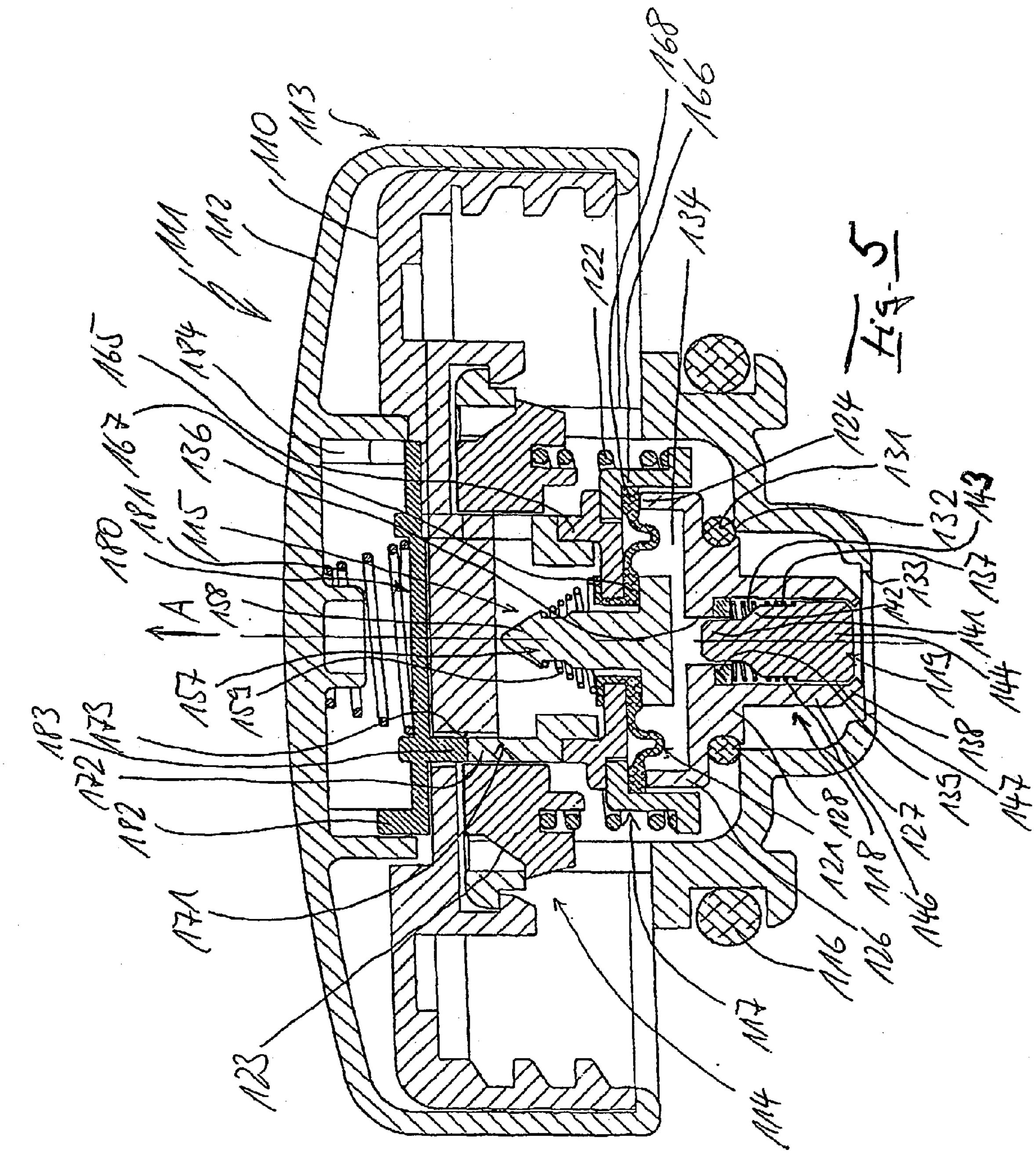

Fig. 5

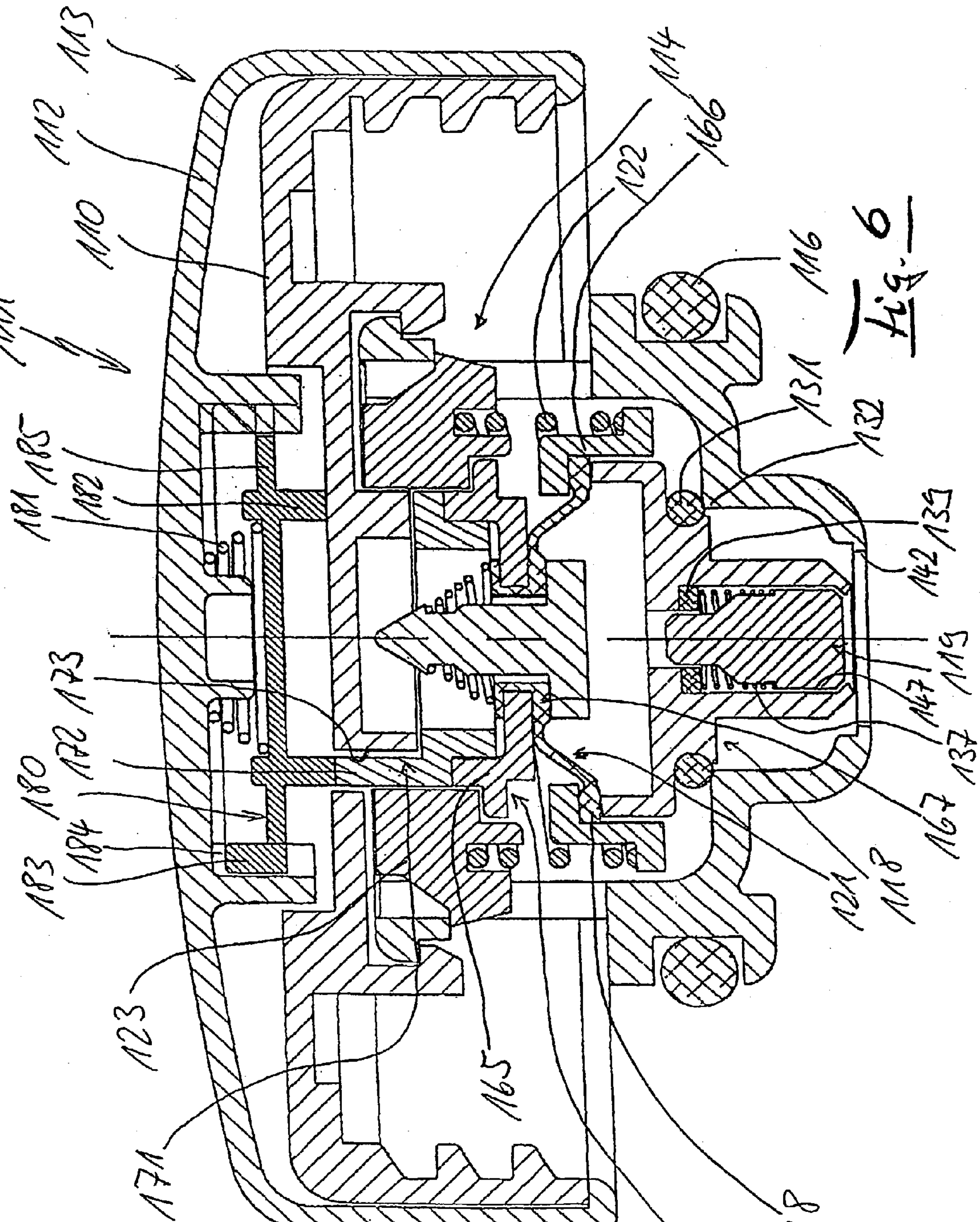

Fig. 6

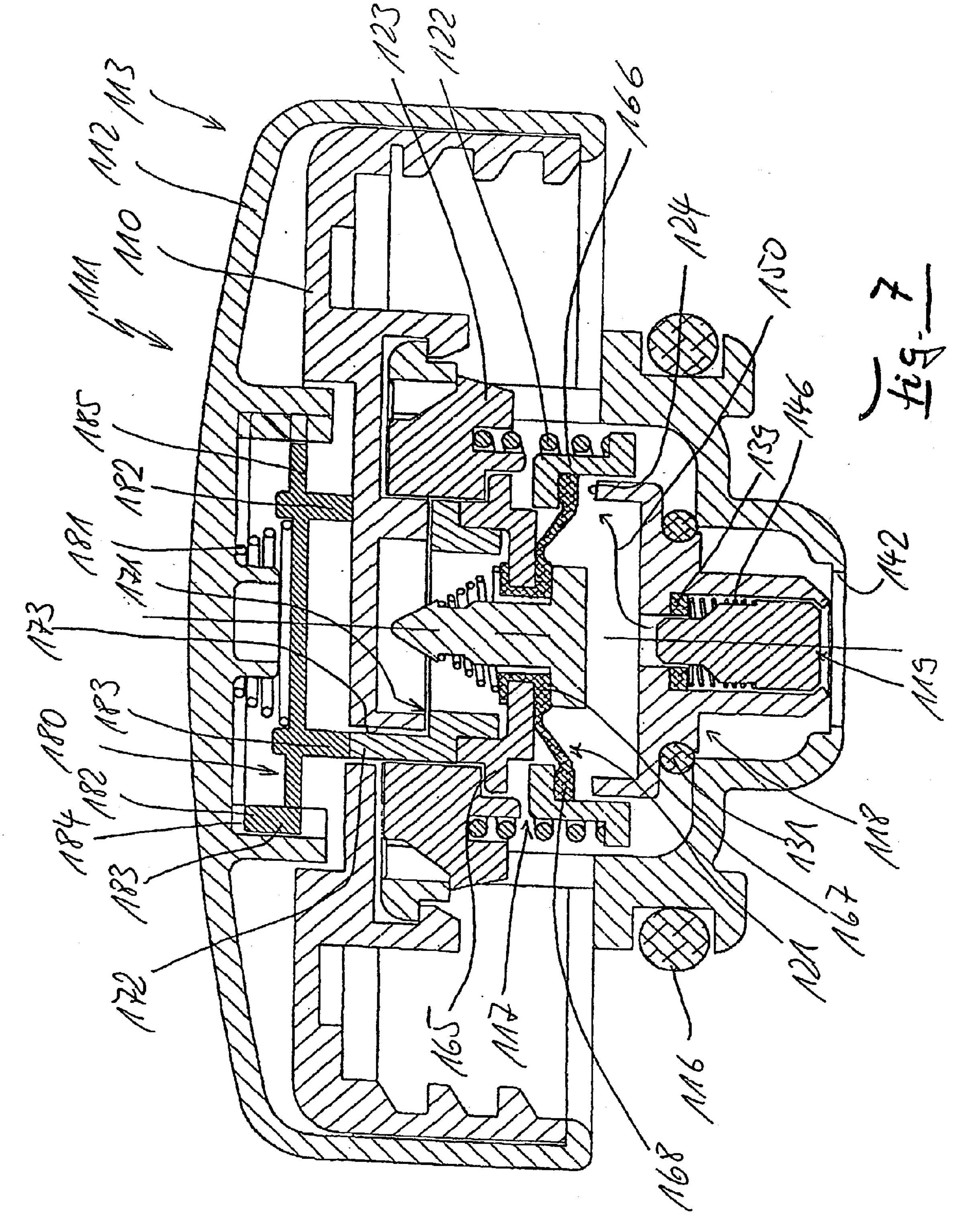

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Fig. 7

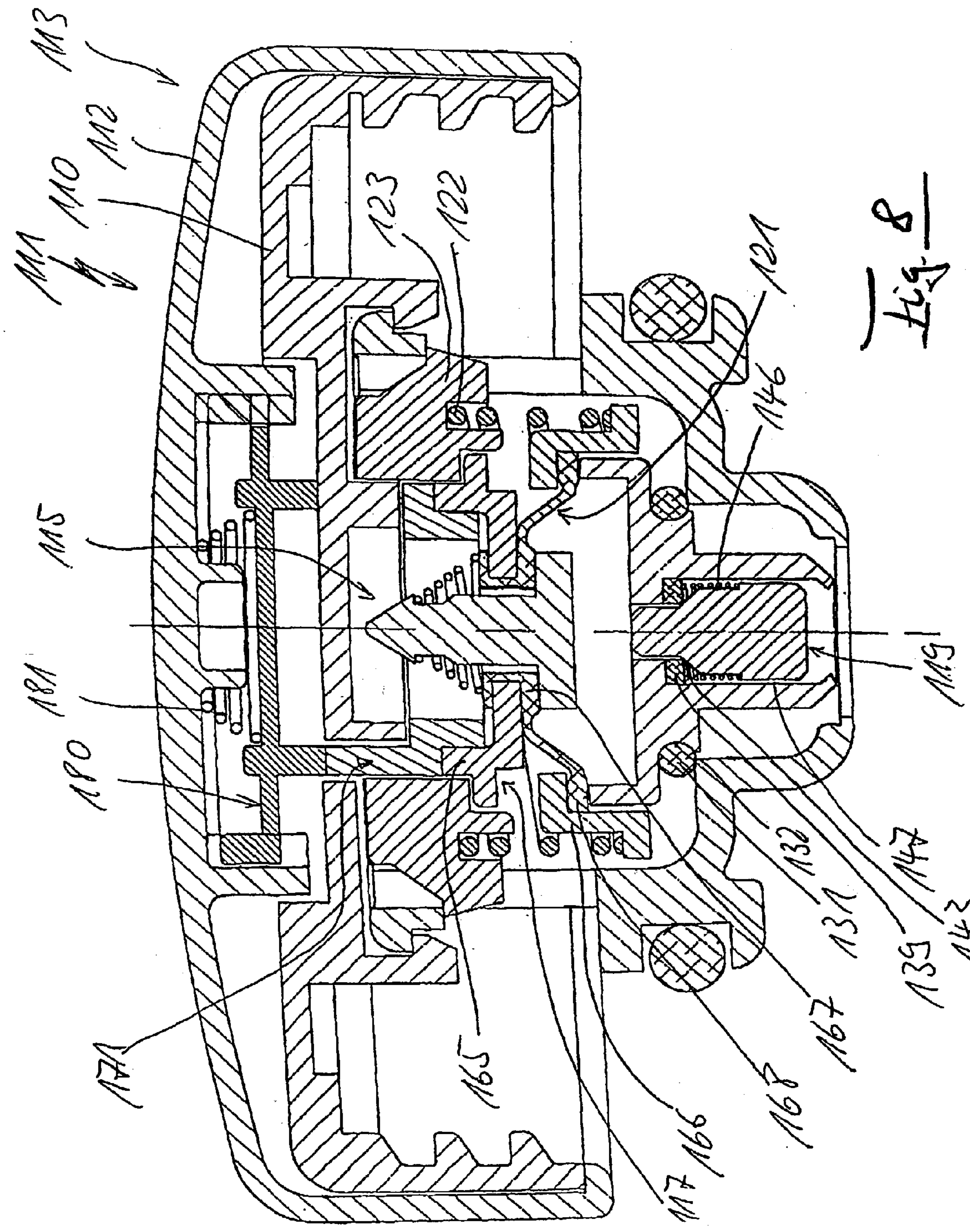
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Fig. 8

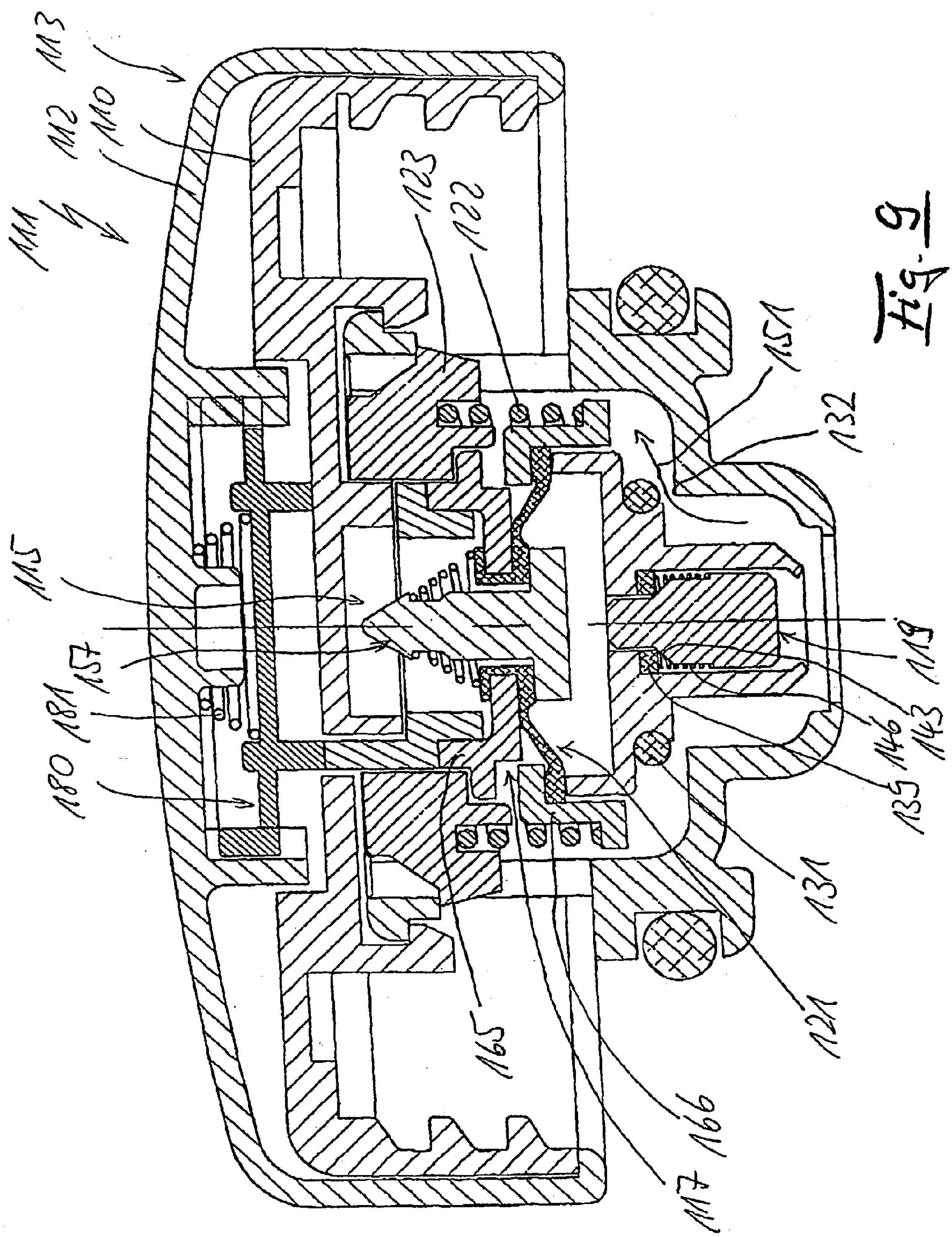
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Fig. 9

# SEALING CAP

## DESCRIPTION

[0001] The present invention relates to a pressure cap for openings in tanks, in particular motor-vehicle radiators, according to the generic part of claim 1.

[0002] In a pressure cap of this kind, which is known from DE 41 07 525 C1, the first and the second valve bodies are concentrically nested in each other, whereby the second valve body can be axially moved back and forth between two end positions limited by a sealing seat or an axially opposite sealing surface of the internal cap component, and whereby in rest position the first valve body is provided with spring-loaded support by the second valve body which is supported by the internal cap component. The sealing surface of the second valve body, which is supported by the sealing seat of the interior cap component, lies radially outside in relation to the sealing seat of the second valve body which supports the sealing surface of the first valve body. This results in the following two-step operating state for the reduction of overpressure: When a first threshold value of the interior tank pressure is exceeded, the radially exterior effective surface of the second valve body causes it to be lifted off the sealing seat of the interior cap component, which facilitates the reduction of overpressure via a first flow connection. As the second valve body is lifted off, the first valve body is lifted as well against the effect of its first pressure spring. If the interior tank pressure continues to rise, the second valve body is moved against the axially upper sealing surface of the interior cap component, which causes the first flow connection to close again, thus preventing the liquid medium, such as a coolant, to erupt. The second valve stage, which is represented by the first valve body, affects the safety function of the pressure cap in such a way that the first valve body is lifted off the second valve body if the internal tank pressure continues to rise and the safe threshold value is exceeded, causing a second flow connection between the interior and the exterior of the tank to open.

[0003] A disadvantage with this prior-art pressure cap is that the sealing seats and sealing surfaces of the two valve bodies and the interior cap component as well as the axial path of the second valve body must be adapted to each other with close tolerances. Furthermore, the individual components must be of a relatively complex design, which also applies to the installation of the components. Furthermore, the hysteresis behaviour in opening and closing of the flow connection(s) between pressure rise and pressure fall is unsatisfactory.

[0004] Also known from DE 197 53 592 A1 is a pressure cap of the type named above, in which in rest position the first valve body is directly contiguous to a sealing seat of the interior cap component, and the second valve body, which in rest position is pressed by a first pressure spring of the first valve body against a second pressure spring, is in the first valve step, after the first threshold value of the interior tank pressure is exceeded, pressed against another axially opposite sealing seat on the interior cap component when the second threshold value is reached, whereby the first valve body is lifted off its sealing seat on the interior cap component. This determines the first flow connection between the two valve seats on the interior cap component on one side and the first or second valve body on the other side, and it is closed first by the first valve body and then by the second valve body. When the point of safe overpressure is exceeded, the first valve body is lifted axially by a thus affected vacuum valve body which establishes the second flow connection by lifting off the second valve body. In this case, it is not as critical to adapt the individual components to each other with close tolerances, but the design of the interior cap component is somewhat more complex.

[0005] It is the objective of the present invention to create a pressure cap of the type mentioned above, which is simpler to manufacture and easier to install while it has a better hysteresis behaviour.

[0006] This objective is achieved with a pressure cap of the type mentioned above which has the characteristics named in claim 1.

[0007] With the measures according to the invention it can be achieved that the tolerances required in manufacturing the individual components and adapting them to each other do not have to be as close, and that assembly can be quicker. The hysteresis behaviour is improved as the result of a throttle gap arranged ahead of the seal. Furthermore, the flow connection between the second and third valve body is achieved primarily due to the presence of liquid coolant and not because of a higher gas pressure. In other words, when the interior tank pressure is increased, the air cushion above the liquid coolant can flow off and contribute to pressure equalization until it is eliminated and the liquid coolant is in place.

[0008] Advantageous embodiments of the configuration of the third valve body in the second valve body result from the characteristics named in one or more of claims 2 to 5.

[0009] With the characteristics according to claim 6 it is achieved that the second valve body is pressed against the sealing seat on the interior cap component by the pressure existing in the chamber above the throttle gap between the second and the third valve bodies.

[0010] Advantageous configurations of the individual sealing seats in relation to each other result from the characteristics named in one or more of claims 7 to 9.

[0011] With the characteristics according to claim 10 and/or 11, an advantageous configuration of the vacuum valve body in the pressure cap is achieved.

[0012] Also known from DE 197 32 885 A1 is a pressure cap with a safety locking means for openings in tanks. This safety locking means makes it possible to prevent the pressure cap being unscrewed when positive pressure prevails, namely by locking the pressure cap so that the filler neck on the tank cannot be rotated. This prior-art safety lock uses an axially movable insert which surrounds the interior cap component and/or its valve assembly, and which is therefore directly exposed to the positive pressure prevailing in the tank, since its inner floor is arranged in the opening of the filler neck. This axially movable insert is held in an additional tubular interior component so that it is axially movable while the pressure cap cannot be rotated against it. When positive pressure occurs in the tank, the insert is moved axially in the direction of the pressure cap and engages in same but cannot be rotated. This results in the anti-rotational locking of the pressure cap via the insert and the additional interior component with the filler neck of the tank.

[0013] The measures to be taken in accordance with that prior art, to ensure anti-rotation and/or a safety lock, are complex in terms of the design, and they require a large number of components. Furthermore, the axially movable insert as well as the additional tubular interior component increase the diameter of the internal cap component of the pressure cap or reduce the effective surface of the valve arrangement of the pressure cap, which has negative implications for the response behaviour of the valve arrangement.

[0014] To remedy this situation, such a pressure cap is provided with the characteristics according to claim 12, which means that its anti-rotation at positive pressure can be ensured in a manner that is simple to design and to manufacture and is therefore more cost-effective to produce. This is the case because thanks to the direct deflection of movement from the first valve body, no additional components are necessary, but instead, at positive pressure, an idling connection is created between the cap component comprising the thread or such and the manipulating element or handling lid. This idling connection within the exterior cap component at positive pressure has the considerable advantage, in comparison with locking the pressure cap at positive pressure, that the activation of the anti-rotational means becomes evident, thus eliminating the possibility that force is used in case of a blockage.

[0015] Another space-saving feature for the valve arrangement results when the characteristics in accordance with claim 13 are provided. The characteristics according to claim 14 are provided to support a return movement of the coupling insert.

[0016] An advantageous embodiment of the coupling insert results from the characteristics according to claim 15. It can be practical to provide suitable claw elements having the characteristics in accordance with claim 16.

[0017] In accordance with the characteristics of claim 17, a guide element is provided for the direct transmission of movement from the first valve body to the coupling insert.

[0018] For the favourable control of the coupling insert even at low positive pressure, it is provided to design the first valve body in two parts in accordance with the characteristics of claim 18. Embodiments of this are based on the characteristics of one or more of claims 19 to 21.

[0019] Further details of the invention are described below, where the invention is described in with reference to the embodiments shown in the drawings, where

[0020] **FIG. 1** shows the partly longitudinal section of a pressure cap for a motor-vehicle radiator, with a positive-pressure/vacuum valve arrangement in closed initial position, in accordance with a first embodiment of the present invention;

[0021] **FIG. 2** shows the pressure cap according to **FIG. 1** in a position after the internal tank pressure has exceeded a first threshold value;

[0022] **FIG. 3** shows the pressure cap according to **FIG. 1** after the internal tank pressure has exceeded a second threshold value, or when dynamic pressure prevails;

[0023] **FIG. 4** shows the pressure cap according to **FIG. 1** when the internal tank pressure has exceeded a third safety threshold value;

[0024] **FIG. 5** shows the partly longitudinal section of a pressure cap for a motor-vehicle radiator, with a positive-pressure/vacuum valve arrangement in closed initial position and with an engaged anti-rotational means in accordance with a second embodiment of the present invention;

[0025] **FIG. 6** shows the pressure cap according to **FIG. 5** in a position at slight positive pressure inside the tank and a disengaged anti-rotational means;

[0026] **FIG. 7** shows the pressure cap according to **FIG. 1** in a position after the interior tank pressure has exceeded a first threshold value;

[0027] **FIG. 8** shows the pressure cap according to **FIG. 1** after the interior tank pressure has reached a second threshold value or when dynamic pressure prevails; and

[0028] **FIG. 9** shows the pressure cap according to **FIG. 5** when the interior tank pressure has exceeded a third safety threshold value.

[0029] The pressure cap **11** for tanks such as motor-vehicle radiators, shown in FIGS. **1** to **4** in accordance with a first embodiment, has an exterior cap component **13** which is provided with a handling lid **12** and to which an interior cap component **14** with a vacuum/positive-pressure valve arrangement **15** is mounted. When in use, the pressure cap **11** is fixed, for example screwed, to a radiator neck (not shown). The interior cap component **14** extends inside the radiator neck toward the interior of the radiator.

[0030] An O ring **16** seals the interior cap component against the wall of the radiator neck. The overpressure part of the valve arrangement **15** is designed in two steps, and it has the purpose of preventing the radiator from boiling over in a first overpressure stage and protecting the radiator system against damage due to excessive overpressure in a second overpressure stage.

[0031] Inside the interior cap component, the overpressure part of the valve arrangement **15** has a first valve body **17** and a second valve body **18** as well as a third valve body **19**.

[0032] The first valve body **17** is arranged in the direction of the outside of the cap above the second valve body **18**, while the third valve body **19** is placed coaxially inside the second valve body **18**,

[0033] The first valve body **17** is designed in the form of an upside-down valve disk, the side of which facing the inside of the radiator is provided with a ring seal **21** whose sealing surface faces axially inside. The first valve body **17**, at its side facing away from the inside of the radiator, is compressed by a recoil spring **22** whose end facing away from the first valve body **17** is supported by a spring plate **23**, which in turn is supported by the interior cap component **14**. The first valve body **17** is biased by the recoil spring **22** in the direction of the inside of the radiator. Over seal **21**, which is designed as a flat ring seal, the first valve body **17** bears on a first ring-shaped sealing seat **24** of the second valve body **18**.

[0034] The one-piece second valve body **18** has a hood element **26**, whose free face is provided with the first sealing seat **24**, and a concentric hollow cylindrical receptacle **27** for the third valve body **19** pointing from the floor **28** of the hood element **26** to the inside of the radiator. Floor **28** between hood element **26** and receptacle **27** is provided around its outer circumference with a flange whose peripheral groove incorporates a second ring seal in the form of an O ring **31**. Added to this O ring **31** is a second sealing seat **32** which is designed as a collar rim on interior cap component **14**. This collar rim **32** is formed between an upper section of interior cap component **14** (the hollow cylindrical section that has a greater interior diameter and accommodates the first valve body **17** and the hood element **26** of the second valve body **18**) and a lower section of interior cap component **14** (the section that has a smaller interior diameter and surrounds the receptacle **27** of the second valve body **18**). On this lower section, the interior cap component **14** is provided with an axial opening **33**. By means of recoil spring **22**, the first ring seal **21** of first valve body **17** is pressed against the first sealing seat **24** of the second valve body **18**, whose second ring seal **31** in turn is pressed against interior cap component **14**. Between the underside of the first ring seal **21** of the first valve body **17** and the upper side of floor **28** of the second valve body **18** is a cylindrical chamber **34** whose outer circumference in axial direction between floor **28** and the underside of the first ring seal **21** is constant. In the middle, chamber **34** is in communication with recess **37** in the second valve body **18** via a hole **35** in floor **28**. At a cone-shaped section **38** at one free end of receptacle **27**, recess **37** opens into the axial opening **33** of the interior cap component **14**. Between hole **36** and recess **37**, the second valve body **18** is provided with a shoulder which points toward the inside of the radiator and holds a third flat ring seal **39**.

[**0035**] The third valve body **19**, which can be designed for example as a rotating element stepped in axial direction around the periphery, is axially movable in recess **37** of the second valve body **18**. The third valve body **19** has a neck section **41** of small diameter, which is movable within hole **36** and inside the third ring seal **39**, as well as a shoulder section **42** whose slanted shoulder area forms a third sealing seat **43** allocated to the third ring seal **39** on the second valve body **18**, and also a cylindrical bulge section **44** which is supported in a manner not shown in detail by the inner wall of cone-shaped section **38** of the second valve body **18**. For this purpose, inside recess **37**, a second pressure spring **46** is provided, one end of which is supported by the underside of the third ring seal **39** of the second valve body **18**, while the other end is supported by a shoulder between shoulder section **42** and the bulge section **44** of the third valve body **19**. The third valve body **19** is biased toward the inside of the radiator by means of the second pressure spring **46**. Between the bulge section **44** of the third valve body **19** and the interior circumference of recess **37** of the second valve body **18**, a very narrow annular gap is provided whose width is in the magnitude of just a few hundredths of a millimeter. This annular gap **47**, as are hole **36** and chamber **34**, forms part of a first flow connection **50** between the inside and the outside of the cap. A second flow connection **51** bypasses the outer circumference of the second valve body **18** (see **FIG. 4**).

[**0036**] In the centre of the first valve body **17** is an opening **56** which on the side facing the inside of the radiator is closed by a vacuum valve body **57** of valve arrangement **15**. The main section **58** of this vacuum valve body **57** extends through the central opening **56**. The end of the main section is under pressure from a third pressure spring **59**, the one end of which is supported by a shoulder of the main section **58** and the other end of which is supported by the surface of valve body **17** that faces the outside of the cap. In that manner, the annular sealing seat **61** of vacuum valve body **57** seals and is contiguous to the underside of the first ring seal **21** of the first valve body **17**. The sealing seat **61** of the vacuum valve body **57** lies radially inside the first sealing seat **24** of the second valve body **18**, while the latter lies radially outside the second sealing seat **32** of the interior cap component **14**, and the latter in turn lies radially outside the third sealing seat **43** on the third valve body **19**. All sealing seats **24, 32, 43, 61** point axially outside, while all sealing surfaces **21, 31, 39** point axially inside.

[**0037**] In the initial operating position shown in **FIG. 1**, in which a first threshold value of the inside tank pressure is not yet exceeded, the first flow connection **50** is closed by the sealing contiguity of the first valve body **17** with its first ring seal **21** on the first sealing seat **24** of the second valve body. In other words, in chamber **34** and thus on the underside of the first ring seal **41** of the first valve body **17**, the pressure prevailing inside the tank extends through annular gap **47** in the form of the air cushion existing over the liquid coolant. The second flow connection **51** along the outer periphery of the second valve body **18** is closed by the sealing contiguity of the second seal **31** of the second valve body **18** on the second sealing seat **32** of the interior cap component **14**.

[**0038**] If the inside tank pressure rises above a predetermined first threshold value, the pressure cap **11** reaches the operating state shown in **FIG. 2**, in which due to the increased inside tank pressure, the first valve body **17** is lifted against the effect of its first pressure spring **22** with its first ring seal **21** from the first sealing seat **24** of the second valve body **18**, thus opening the first flow connection **50**, so that air can flow outside from the air cushion over the liquid coolant and thus can compensate or reduce the overpressure. Due to the overpressure in chamber **34**, the second valve body **18** with its second ring seal **31** continues to be pressed against the second sealing seat **32** of the interior cap component **14**. If this causes the overpressure to be reduced again below the first threshold value, the first valve body **17** again seals and is contiguous to the second valve body **18**.

[**0039**] If on the other hand the inside tank pressure continues to rise during or after the deflation of the air cushion, and if this leads to a state where the liquid coolant reaches the underside of the second and third valve bodies **18, 19**, the liquid coolant will accumulate at the entrance of annular gap **47**, due to the very narrow width of the latter, thus causing the accumulation of dynamic pressure on the full-surface underside of the third valve body **19**. This dynamic pressure results in an axial movement of the third valve body **19** against the effect of its third pressure spring **59** at the end of which the third sealing seat **43** of the third valve body **19** is contiguous to the third ring seal **39** of the second valve body **18**, closing the first flow connection **50** (see **FIG. 3**).

[**0040**] The closing of the first flow connection **50** between the second and third valve bodies **18, 19** results in the reduction of pressure in chamber **34** to below the above named predetermined threshold value, so that the first valve body **17** is moved toward the second valve body **18** by the effect of its first pressure spring **22**. This state is shown in

FIG. 3 as well. If the inside tank pressure is reduced because the radiator is cooling down, and the liquid coolant is therefore returned, the third valve body **19** is returned under the effect of its second pressure spring **46**, so that the first flow connection **50** in this section opens again, as shown in **FIG. 1**

[**0041**] If, on the other hand, the inside tank pressure continues to rise and exceeds an upper safety value, the second valve body **18** is lifted (against the first pressure spring **22** that presses upon valve body **17**) from the second sealing seat **32** on the interior cap component **14**, so that the second flow connection **51** is opened, which allows the reduction of the said overpressure (see **FIG. 4**). The lifting of the second valve body **18** from the inside cap component **14** can be supported by an additional (fourth) pressure spring **54** surrounding the receptacle **27**. This fourth spring is supported at one end by the underside of the floor **28** of the second valve body **18** and at the other end by an inner shoulder of the lower section of the interior cap component **14** (drawn as a dotted line in **FIG. 4**).

[**0042**] Valve arrangement **15** assumes the initial position shown in **FIG. 1** when the pressure inside the radiator varies between a vacuum and a first overpressure value. Such pressure conditions occur, for example, in a vehicle that has been parked for some time, or when the coolant inside the radiator of a moving vehicle is sufficiently cooled by the outside wind stream and/or with support from the fan. If, for example, the vehicle is parked after a long drive, pressure may rise so much inside the radiator that the valve arrangement **15** is supplied with coolant (air, water or water vapour). If due to this after-heating effect, the coolant volume expands so much that it exceeds the tank volume, this would necessarily result in the expulsion of coolant. As described above, this undesirable effect can be prevented by valve arrangement **15** assuming the operating state shown in **FIGS. 2 and 3**. If there is any further uncontrolled pressure increase in the cooling system in that operating state, the eruption of coolant and other detrimental effects caused by excessive demands on the radiator tank and/or the hose connections must be prevented. Such effects can be prevented by the second valve stage according to the state shown in **FIG. 4**, which limits the tank pressure to a predetermined safety value.

[**0043**] If there is vacuum pressure inside the radiator, and if this vacuum exceeds a predetermined vacuum threshold value, the vacuum valve body **57** with its sealing seat **61** will be lifted—starting from the operational state according to **FIG. 1**—from the underside of the first ring seal **21** of the first valve body **17** to the inside of the radiator. The vacuum valve body **57** is lowered against the bias of the third pressure spring **59**, so that a flow connection path will open (in a manner not shown) between the inside and the outside of the radiator.

[**0044**] The pressure cap **111** shown in FIGS. **5** to **9** according to another embodiment, for example for a motor vehicle radiator, has an exterior cap component **113** provided with a manipulating element or handling lid **112**, from which an interior cap component **114** with a vacuum/overpressure valve arrangement **115** is suspended. When in use, the pressure cap **111** is fixed, for example screwed, to a radiator neck (not shown). The interior cap component **114** extends inside the radiator neck toward the interior of the radiator. An O ring **116** seals the interior cap component **114** against the wall of the radiator neck.

[**0045**] In the case of the two-part exterior cap component **113**, the cap-like manipulating element or handling lid **112** is axially fixed to the pressure cap element **113**, here designed as a screw cap element, but it can be rotated in circumferential direction. This rotatability is blocked when pressure inside the radiator is normal, by means of an axially movable coupling insert **180** for screwing and unscrewing the pressure cap **111**.

[**0046**] The overpressure part of the valve arrangement **115** is formed in two steps and has the purpose of preventing the radiator from boiling over in a first overpressure stage, and of ensuring protection against damage to the radiator system due to excessive overpressure in a second overpressure stage. Inside the interior cap component **114**, the overpressure part of valve arrangement **115** has a first valve body **117** and a second valve body **118**, as well as a third valve body **119**. The first valve body **117** is arranged in the direction of the cap's outside above the second valve body **118**, while the third valve body **119** is accommodated coaxially inside the second valve body **118**.

[**0047**] The first valve body **117**, designed in two parts, is provided with a radially interior valve body part **165** roughly in the form of a valve disk, and a radially exterior valve body part **166**; these overlap on the edges, whereby the radially interior part sits on top of the radially exterior valve body part. On the side of the two valve body parts **165**, **166** facing the inside of the radiator, an annular membrane seal **121** is provided with sealing surfaces axially turned inward. The radially exterior stepped valve body part **166** of the first valve body **117** is compressed by a recoil spring **122** on the side facing away from the inside of the radiator. The end of this spring which faces away from the first valve body **117** is supported by a valve disk **123** which in turn is supported by the interior cap component **114**. By means of the recoil spring **122**, the radially exterior valve body part **166** of the first valve body **117** is biased in the direction of the inside of the radiator. Over the radially exterior flat sealing rim **168** of annular membrane seal **121**, the radially exterior valve body part **166** sits on a first annular sealing seat **124** of the second valve body **118**. The radially interior valve body part **165** of the first valve body **117** is provided with a central recess **137** whose annular limiting edge is surrounded by the interior part of annular membrane seal **121**. Toward the inside of the radiator, this radially interior U-shaped sealing rim **167** of annular membrane seal **121** forms a sealing surface for a vacuum valve **157** still to be described. On the side of the outer edge, the radially interior valve body part **165** bears directly on the inner edge of the radially exterior valve body part **166** of the first valve body **117**.

[**0048**] The radially interior valve body part **165** is provided, near its radial outer edge, with an axially projecting annular edge **169** on which sits a guidance sleeve **171** the inner end of which overlaps the annular edge **169** radially on the inside in offset fashion. Directly bearing on the other axial end of the guidance sleeve **171**, which is formed by one-piece projecting fingers **172**, is the coupling insert **180** under the effect of a pressure spring **181** which is supported by the inside of handling lid **112** of exterior cap component **113**. The coupling insert **180** is provided with a disk **185** in turn provided with axially downward extending finger-like claws **182** whose cross section corresponds to the fingers **172** of guidance sleeve **171**. As shown in **FIG. 5**, in s state without pressure, the fingers **172** of guidance sleeve **171** as well as the claws **182** of the coupling insert **180** engage in axial recesses **173** of closure element **110** of the exterior cap component **112**. Furthermore, axially toward the outside, i.e. facing away from claws **182**, the coupling insert disk **185** is provided with projecting claws **183** which in positive connection grasp between an axially aligned circumferential serration **184** of handling lid **112**. The inward facing claws **182** are lying on a radially interior ring, while the axially outward pointing claws **183** lie on a radially exterior ring. In the initial or normal position shown in **FIG. 5**, an anti-rotational connection exists between the handling lid **112** and the closure element **110** of exterior cap component **113**, so that the pressure cap **111** can be screwed to and unscrewed from the filler neck (not shown) of a tank.

[**0049**] The one-piece second valve body **118** is provided with a hood element **126** whose free face is provided with the first sealing seat **124**, and a concentric and hollow cylindrical receptacle **127** (pointing away from the floor **128** of hood element **126** and toward the inside of the radiator) for the third valve body **119**. The floor **128** between the hood element **126** and the receptacle **127** is provided with a flange in whose circumferential groove a second ring seal in the form of an O ring **131** is incorporated. Added to O ring **131** is a second sealing seat **132** which is designed as a collar rim on the interior cap component **114**. This collar rim **132** is formed between an upper section of interior cap component **114** (the hollow cylindrical section that has a greater interior diameter and accommodates the first valve body **117** and the hood element **126** of the second valve body **118**) and a lower section of interior cap component **114** (the section that has a smaller interior diameter and surrounds the receptacle **127** of the second valve body **118**). On this lower section, the interior cap component **114** is provided with an axial opening **133**. By means of recoil spring **122**, the first ring seal **121** of first valve body **17** is pressed against the first sealing seat **24** of the second valve body **118**, whose second ring seal **131** in turn is pressed against interior cap component **114**.

[**0050**] Between the underside of the first annular membrane seal **121** of the first valve body **117** and the upper side of floor **128** of the second valve body **118** is a cylindrical chamber **134** whose outer circumference in axial direction between floor **128** and the underside of the first annular membrane seal **121** is constant. In the middle, chamber **134** is in communication with recess **137** in the second valve body **118** via a hole **135** in floor **128**. At a cone-shaped section **138** at one free end of receptacle **127**, recess **137** opens into the axial opening **133** of the interior cap component **114**. Between hole **136** and recess **137**, the second valve body **118** is provided with a shoulder which points toward the inside of the radiator and holds a third flat ring seal **139**.

[**0051**] The third valve body **119**, which can be designed for example as a rotating element stepped in axial direction around the periphery, is axially movable in recess **137** of the second valve body **118**. The third valve body **119** has a neck section **141** of small diameter, which is movable within hole **136** and inside the third ring seal **139**, as well as a shoulder section **142** whose slanted shoulder area forms a third sealing seat **143** allocated to the third ring seal **139** on the second valve body **118**, and also a cylindrical bulge section **144** which is supported in a manner not shown in detail by the inner wall of cone-shaped section **138** of the second valve body **118**. For this purpose, inside recess **137**, a second pressure spring **146** is provided, one end of which is supported by the underside of the third ring seal **139** of the second valve body **118**, while the other end is supported by a shoulder between shoulder section **142** and the bulge section **144** of the third valve body **119**. The third valve body **119** is biased toward the inside of the radiator by means of the second pressure spring **146**. Between the bulge section **144** of the third valve body **119** and the interior circumference of recess **137** of the second valve body **118**, a very narrow annular gap is provided whose width is in the magnitude of just a few hundredths of a millimeter. This annular gap **147**, as are hole **136** and chamber **34**, forms part of a first flow connection **150** between the inside and the outside of the cap. A second flow connection **151** bypasses the outer circumference of the second valve body **118** (see **FIG. 9**).

[**0052**] In the centre of the radially interior valve body part **165** of the first valve body **117** is an opening **156** which on the side facing the inside of the radiator is closed by a vacuum valve body **157** of valve arrangement **115**. The main section **158** of this vacuum valve body **157** extends through the central opening **156**. The end of the main section is under pressure from a third pressure spring **159**, the one end of which is supported by a shoulder of the main section **158** and the other end of which is supported by the surface of valve body **117** that faces the outside of the cap. In that manner, the annular sealing seat **161** of vacuum valve body **157** seals and is contiguous to the underside of the first annular membrane seal **121** of the first valve body **117**. The sealing seat **161** of the vacuum valve body **157** lies radially inside the first sealing seat **124** of the second valve body **118**, while the latter lies radially outside the second sealing seat **132** of the interior cap component **114**, and the latter in turn lies radially outside the third sealing seat **143** on the third valve body **119**. All sealing seats **124, 132, 143, 161** point axially outside, while all sealing surfaces **121, 131, 139** point axially inside.

[**0053**] In the initial operating position shown in **FIG. 5**, in which a first threshold value of the inside tank pressure is not yet exceeded, the first flow connection **150** is closed by the sealing contiguity of the first valve body **117** with its first annular membrane seal **121** on the first sealing seat **124** of the second valve body **118**. In other words, in chamber **134** and thus on the underside of the first annular membrane seal **121** of the first valve body **117**, the pressure prevailing inside the tank extends through annular gap **147** in the form of the air cushion existing over the liquid coolant. The second flow connection **151** along the outer periphery of the second valve body **118** is closed by the sealing contiguity of the second seal **131** of the second valve body **118** on the second sealing seat **132** of the interior cap component **114**.

[**0054**] If the inside tank pressure rises to a certain value which lies above the normal or ambient pressure, but below a first threshold value of the inside tank pressure, the unscrew protection of pressure cap **111** is activated. As shown in **FIG. 6**, the radially interior valve body part **165** of the first valve body **117** is moved upward, while the second valve body **118** remains in its sealing position. Furthermore, the radially exterior valve body part **166** of the first valve body **117** remains in its sealing position in relation to the second valve body **118**. The annular membrane seal **121** allows this relative movement between the radially interior valve body part **165** and the radially exterior valve body part **166** due to the membrane seal's meandering shape between its two sealing rims **167** and **168**. The guidance sleeve **171**, which sits on the radially interior valve body part **165** is moved along with said part toward the outside in the direction indicated by arrow A. The said guidance sleeve **171** in turn moves the coupling insert **180** against the effect of pressure spring **181**, and the guidance sleeve's fingers **172** push the claws **183**, which are pointing axially inward, out of the recesses **183** in closure element **110**. This axial movement ends when the inner shoulder of guidance sleeve **171** strikes against closure element **110**. The disengagement of the coupling element **180** from the closure element **110** of exterior cap component **112** has the effect that the handling lid **112** idles in relation to the closure element **110**, so that starting at a certain predetermined overpressure (in this case, for example, 0.3 bar), it is no longer possible for the pressure cap **111** to unscrew from the filler neck.

[**0055**] If the inside tank pressure rises further, i.e. above the predetermined first threshold value (for example 1.4 bar), the valve arrangement **115** reaches the operating state shown in **FIG. 7**. In this state, due to the increased inside tank pressure, the radially exterior sealing rim **168** of the radially exterior valve body part **166** of the first valve body **117** lifts off the first sealing seat **124** of the second valve body **117** against the effect of its first pressure spring **122**, thus opening the first flow connection **150** and allowing air to flow outside from the air cushion above the liquid coolant, thus compensating or reducing the overpressure. Due to the overpressure in chamber **134**, the second valve body **118** with its second ring seal **131** continues to be pressed against the second sealing seat **132** of the interior cap component **114**. If this causes the overpressure to be reduced again below the first threshold value, the radially exterior valve body part **166** again is contiguous to the second valve body **118**. The unscrew protection remains activated as before.

[**0056**] If on the other hand the inside tank pressure continues to rise during or after the deflation of the air cushion, and if this leads to a state where the liquid coolant reaches the underside of the second and third valve bodies **118, 119**, the liquid coolant will accumulate at the entrance of annular gap **147**, due to the very narrow width of the latter, thus causing the accumulation of dynamic pressure on the full-surface underside of the third valve body **119**. This dynamic pressure results in an axial movement of the third valve body **119** against the effect of its second pressure spring **146** at the end of which the third sealing seat **143** of the third valve body **119** is contiguous to the third ring seal **139** of the second valve body **118**, closing the first flow connection **150** (see **FIG. 8**).

[**0057**] The closing of the first flow connection **150** between the second and third valve bodies **118, 119** results in the reduction of pressure in chamber **134** to below the above named predetermined threshold value, so that the radially exterior first valve body **117** is moved toward the second valve body **118** by the effect of its first pressure spring **122**. This state is shown in **FIG. 8** as well. If the inside tank pressure is reduced because the radiator is cooling down, and the liquid coolant is therefore returned, the third valve body **119** is returned under the effect of its second pressure spring **146**, so that the first flow connection **150** in this section opens again, as shown in **FIG. 5**.

[**0058**] If, on the other hand, the inside tank pressure continues to rise and exceeds an upper safety value, the second valve body **118** is lifted (against the first pressure spring **122** that presses upon valve body **117**) from the second sealing seat **132** on the interior cap component **114**, so that the second flow connection **151** is opened, which allows the reduction of the said overpressure (see **FIG. 9**). The unscrew protection remains activated as before. Thus, the said overpressure can be reduced via the second flow connection, after which it is possible to return the valve bodies via the various operating states through the individual pressure springs and coupling insert **180**, as shown in **FIG. 5**. If the lower claws **183** of the coupling insert **180** are radially offset in relation to the recesses **173** in the closure element **110**, it is enough to turn the handling lid **110**[sic] to bring the claws **183** and the recesses **173** into alignment again, so that the compressed pressure spring **181** brings the coupling element into he non-activated position again opposite to the direction indicated by arrow A.

[**0059**] Valve arrangement **115** assumes the initial position shown in **FIG. 5** when the pressure inside the radiator varies between a vacuum and the first overpressure value. Such pressure conditions occur, for example, in a vehicle that has been parked for some time, or when the coolant inside the radiator of a moving vehicle is sufficiently cooled by the outside wind stream and/or with support from the fan. If, for example, the vehicle is parked after a long drive, pressure may rise so much inside the radiator that the valve arrangement **115** is supplied with coolant (air, water or water vapour). If due to this after-heating effect, the coolant volume expands so much that it exceeds the tank volume, this would necessarily result in the expulsion of coolant. As described above, this undesirable effect can be prevented by valve arrangement **115** assuming the operating state shown in FIGS. **6** to **8**. If there is any further uncontrolled pressure increase in the cooling system in that operating state, the eruption of coolant and other detrimental effects caused by excessive demands on the radiator tank and/or the hose connections must be prevented. Such effects can be prevented by the second valve stage according to the state shown in **FIG. 9**, which limits the tank pressure to a predetermined safety value.

[**0060**] If there is vacuum pressure inside the radiator, and if this vacuum exceeds a predetermined vacuum threshold value, the vacuum valve body **157** with its sealing seat **161** will be lifted—starting from the operational state according to **FIG. 5**—from the underside of the first annular membrane seal **121** of the first valve body **117** to the inside of the radiator. The vacuum valve body **157** is lowered against the bias of the third pressure spring **159**, so that a flow connection path will open (in a manner not shown) between the inside and the outside of the radiator.

[**0061**] In a version (not shown) of one or both of the above embodiments, the sealing seat **61** or **161** of the vacuum valve body **57, 157** is provided not on a level plate arranged in a chamber **34, 134**, but provided on a plate whose cross section toward the outer periphery is sawtooth-shaped and is arranged in a cylindrical chamber **34, 134**. Furthermore, in versions of one or both of the said embodiments, the second sealing seat **32, 132** for O ring **31, 131** is designed as a conical surface.

[0062] In accordance with another version (not shown) of one and/or the other embodiment of FIGS. **1** to **4** or **5** to **9**, the third valve body **19** or **119** is cup-shaped and able to open toward the opening into the cylindrical chamber **34** or **134**. The upper rim of this cup-shaped valve body forms a ring seat for a sealing gasket which surrounds the said opening into the cylindrical chamber **34**, **134**. The cup-shaped third valve body accommodates a pressure spring which corresponds to pressure spring **46**, **146** which presses it down and away from the said sealing gaket. The function of this third valve body remains the same as that of the third valve body **19**, **119** of the said embodiments. In other words, when the ring seat of this cup-shaped third valve body presses against the sealing gasket, the respective flow connection is closed.

What is claimed is:

**1**. Pressure cap (**11, 111**) for openings in tanks, particularly in motor-vehicle radiators, with an internal cap component (**14, 114**) that is provided with at least one flow connection between the inside and the outside of the tank, and with a valve arrangement (**15, 115**) for releasing and blocking the flow connection, whereby the said valve arrangement (**15, 115**) has a first and a second valve body (**17, 118; 18, 118**) that can be moved back and forth, whereby the first valve body (**17, 117**) is biased in the direction of the inside of the tank against a first sealing seat (**24, 124**) on the second valve body (**18, 118**), which is pressed against a second sealing seat (**32, 132**) on the interior cap component (**14, 114**), and whereby the first and second valve bodies (**17117; 18, 118**) can be lifted when a respective threshold value of the inside tank pressure is exceeded and the flow connection (**50, 150; 51, 151**) between the inside and the outside of the tank is released,

characterized in that inside the second valve body (**18, 118**) a third valve body (**19, 119**) is placed, between which and the second valve body (**18, 118**) a first flow connection (**50, 150**), designed in that section as a throttle gap (**47, 147**), is provided between the inside of the tank and the first valve body (**17, 117**),

that said valve body (**19, 119**) is movable between one end position opening the first flow connection (**50, 150**) and the other end position closing it when a second threshold value of the inside radiator pressure is reached or when a dynamic pressure occurs due to the presence of a liquid medium,

that the first valve body (**17, 117**) is lifted off the second valve body (**18, 118**) when a first threshold value is exceeded and comes to bear again on same after the flow connection (**50, 150**) closes, and that the second valve body (**18, 118**) is lifted off the second sealing seat (**32, 132**) on the interior cap component (**14, 114**) while releasing a second flow connection (**51, 151**) between the inside and the outside of the radiator when a third threshold value of the inside radiator pressure is exceeded, which is higher than the first and the second threshold value of the inside radiator pressure and also higher than the dynamic pressure.

**2**. Pressure cap according to claim 1, characterized in that the third valve body (**19, 119**) is held axially movable inside a concentric recess (**37, 137**) of the second valve body (**18, 118**), whereby said recess is in communication with the inside of the radiator.

**3**. Pressure cap according to claim 1 or **2**, characterized in that the third valve body (**19, 119**) in the second valve body (**18, 118**) is biased by a second spring (**46, 146**) in the direction of its opening position that is supported by the second valve body.

**4**. Pressure cap according to at least one of claims 1 to 3, characterized in that a third sealing seat (**43, 143**) on the third valve body (**19, 119**) is added to an axially inward pointing annular sealing surface (**39, 139**) of the second valve body (**18, 118**).

**5**. Pressure cap according to at least one of the previous claims, characterized in that the annular throttle gap (**47, 147**) of the first flow connection (**50, 150**) is so narrow that when pressure is applied through a liquid medium, a dynamic pressure occurs and overcomes the force of the second pressure spring (**46, 146**).

**6**. Pressure cap according to one of the previous claims, characterized in that between the first valve body (**17, 117**) and the second valve body (**18, 118**), a cylindrical chamber (**34, 134**) is provided which is in communication with the throttle gap (**47, 147**) between the second and third valve bodies (**18, 19; 118, 119**).

**7**. Pressure cap according to one at least one of the previous claims, characterized in that the first sealing seat (**24, 124**) on the second valve body (**18, 118**) lies radially outside the second sealing seat (**32, 132**) on the interior cap component (**14, 114**).

**8**. Pressure cap according to at least one of the previous claims, characterized in that the second sealing seat (**32, 132**) on the interior cap component (**14, 114**) lies radially outside the third sealing seat (**43, 143**) on the third valve body (**19, 119**).

**9**. Pressure cap according to at least one of the previous claims, characterized in that the sealing surfaces (**21, 31, 39; 121, 131, 139**) assigned to the respective sealing seats (**24, 32, 43; 124, 132, 143**) on the first valve body (**17, 117**), the second valve body (**18, 118**) or the third valve body (**19, 119**) point axially inward.

**10**. Pressure cap according to at least one of the previous claims, characterized in that the first valve body (**17, 117**) is provided with a central opening (**56, 156**) through which a vacuum valve body (**57, 157**) extends whose sealing seat (**61, 161**) surrounds the central opening and is contiguous to the sealing surface (**21, 121**) of the first valve body (**17, 117**).

**11**. Pressure cap according to claim 10, characterized in that the vacuum valve body (**57, 157**) is biased against the sealing surface (**21, 121**) of the first valve body (**17, 117**) with the aid of a spring (**59, 159**) supported by the top surface of the first valve body (**17, 117**).

**12**. Pressure cap according to at least one of the previous claims, characterized in that an exterior cap component (**113**) from which the interior component (**114**) is suspended, is formed by the handling lids or closure elements (**112, 110**) which are connected via an axially movable coupling insert (**180**) which makes the said elements releasable and anti-rotational and whose axial movement is derived from the pressure-controlled axial movement of the first valve body (**117**).

**13**. Pressure cap according to claim 12, characterized in that the axially movable coupling insert (**180**) is arranged axially above the first valve body (**117**) within the handling lid (**112**) of the exterior cap component (**113**).

**14**. Pressure cap according to claim 13, characterized in that the a coupling insert **(180)** inside the handling lid **(112)** is biased by a pressure spring **(181)** in the direction of the closure element **(110)**.

**15**. Pressure cap according to at least one of claims 12 to 14, characterized in that the coupling insert **(180)** is constantly in anti-rotational communication with the handling lid **(112)** and is axially movable for engaging in and disengaging from the closure element **(110)**.

**16**. Pressure cap according to claim 15, characterized in that the coupling insert **(180)** is provided with a disk **(185)**, from whose two surfaces claw elements **(182, 183)** extend which act jointly with axial recesses **(173)** in the handling lid or closure element **(110, 112)**.

**17**. Pressure cap according to at least one of claims 12 to 16, characterized in that a guidance element **(171)** for transferring the axial movement is provided between the coupling insert **(180)** and the first valve body **(117)**.

**18**. Pressure cap according to at least one of the previous claims, characterized in that the first valve body **(117)** is divided in two in radial connection and is provided with a radially interior valve body part **(165)** and a radially exterior valve body part **(166)** which are axially movable in relation to each other and are in communication with each other via an annular membrane seal **(121)**.

**19**. Pressure cap according to claim 18, characterized in that the guidance element **(171)** sits on the radially interior valve body part **(165)** of the first valve body **(117)**, and that the radially exterior valve body part **(166)** of the first valve body **(117)** is biased by the pressure spring **(122)** for the first valve body **(117)**.

**20**. Pressure cap according to claim 18 to **19**, characterized in that the sealing surface of the radially exterior valve body part **(166)** of the first valve body **(117)** bears on the sealing seat of the second valve body **(118)**.

**21**. Pressure cap according to at least one of claims 18 to 20, characterized in that the radially interior valve body part **(165)** of the first valve body **(117)** accommodates the vacuum valve body **(157)**.

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