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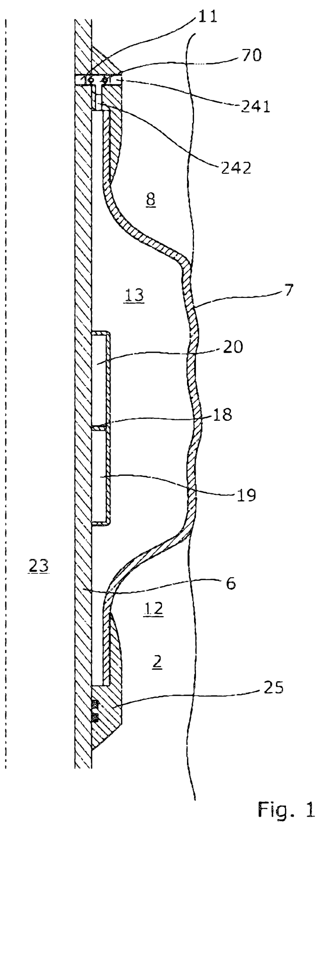

Fig. 11

(57) Abstract: The present invention relates to an annular barrier to be expanded in an annulus between a well tubular structure and an inside wall of a borehole downhole for providing zone isolation between a first zone and a second zone of the borehole, comprising a tubular part for mounting as part of the well tubular structure, the tubular part having a longitudinal axis, an expandable sleeve surrounding the tubular part and defining a space being in fluid communication with an inside of the tubular part, each end of the expandable sleeve being connected with the tubular part, and an aperture for letting fluid into the space to expand the expandable sleeve, wherein the barrier further comprises a compensation device arranged in the space between the expandable sleeve and the tubular part, the compensation device having a chamber in which a piston is arranged dividing the chamber in a first and a second chamber part, the first chamber part being in fluid communication with the space and the second chamber part comprising gas.

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ANNULAR BARRIER WITH COMPENSATION DEVICE

Field of the invention

The present invention relates to an annular barrier to be expanded in an annulus between a well tubular structure and an inside wall of a borehole downhole for providing zone isolation between a first zone and a second zone of the borehole. The invention furthermore relates to a well system and to a method for maintaining a pressure within the annular barrier.

Background art

In wellbores, annular barriers are used for different purposes, such as for providing a barrier for flow between an inner and an outer tubular structure or between an inner tubular structure and the inner wall of the borehole. The annular barriers are mounted as part of the well tubular structure. An annular barrier has an inner wall surrounded by an annular expandable sleeve. The expandable sleeve is typically made of an elastomeric material, but may also be made of metal. The sleeve is fastened at its ends to the inner wall of the annular barrier.

In order to seal off a zone between an inner and an outer tubular structure or a well tubular structure and the borehole, a second annular barrier is used. The first annular barrier is expanded on one side of the zone to be sealed off, and the second annular barrier is expanded on the other side of that zone, and in this way, the zone is sealed off.

When expanded, annular barriers may be subjected to a continuous pressure or a periodic high pressure from the outside, either in the form of hydraulic pressure within the well environment or in the form of formation pressure. In some circumstances, such pressure may cause the annular barrier to collapse, which may have severe consequences for the area which the barrier is to seal off, as the sealing properties are lost due to the collapse. A similar problem may arise when the expandable sleeve is expanded by means of e.g. a pressurised fluid. If the fluid leaks from the sleeve, the back pressure may fade, and the sleeve itself may thus collapse.

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The ability of the expanded sleeve of an annular barrier to withstand the collapse pressure is thus influenced by many variables, such as strength of material, wall thickness, surface area exposed to the collapse pressure, temperature, well fluids, etc.

The collapse rating currently achievable by the expanded sleeve within certain well environments is insufficient for all well applications. Thus, it is desirable to increase the collapse rating to enable use of annular barriers in all wells, specifically in wells that are exposed to a high drawdown pressure during production and depletion. The collapse rating may be increased by increasing the wall thickness or the strength of the material; however, this would increase the expansion pressure, which, as mentioned, is not desirable.

OBJECT OF THE INVENTION

It is an object of the present invention to substantially overcome or ameliorate one or more of the above disadvantages, or at least provide a useful alternative.

SUMMARY OF THE INVENTION

In accordance with an aspect of the present invention, there is provided an annular barrier to be expanded in an annulus between a well tubular structure and an inside wall of a borehole downhole for providing zone isolation between a first zone and a second zone of the borehole, comprising:

- a tubular part for mounting as part of the well tubular structure, the tubular part having a longitudinal axis,
- an expandable sleeve surrounding the tubular part and defining a space being in fluid communication with an inside of the tubular part, each end of the expandable sleeve being connected with the tubular part, and
- an aperture for letting fluid into the space to expand the expandable sleeve,

wherein the barrier further comprises a compensation device arranged in the space between the expandable sleeve and the tubular part, the compensation device having a chamber in which a piston is arranged dividing the chamber in a first and a second chamber part, the first chamber part being in fluid communication with the space and the second chamber part comprising gas.

The gas may be nitrogen, neon, argon, krypton or xenon.

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By having the compensation device inside the space, any leak of gas from the second chamber will result in gas accumulating inside the space defined by the expandable sleeve. By retaining any leaking gas, the gas will still have the ability to expand and thus equalise the pressure in the space to maintain the expandable sleeve in a sealing position and ensure the sealing capabilities of the annular barrier.

In another embodiment, the compensation device may be arranged as part of a connection part connecting the expandable sleeve with the tubular part.

Further, the annular barrier may comprise an additional connection part wherein a second compensation device is arranged.

Also, the chamber of the compensation device may be annular and surround the tubular part.

The compensation device may have several chambers in which pistons are arranged.

This plurality of chambers may be spaced along a circumference of the tubular part.

Moreover, one end of the sleeve may be fixedly fastened to the tubular part and the other end may be slidably fastened to the tubular part, and the second chamber part containing the gas may be arranged closest to the fixedly connected end of the sleeve.

In addition, the second chamber part may comprise a valve which is accessible from the inside of the tubular part, allowing refill of the second chamber part with gas.

Furthermore, the piston may comprise sealing means for sealing the second chamber part from the first chamber part.

The annular barrier may further comprise an annulus pressure compensator comprising a cylinder wherein a piston is arranged, a first end of the cylinder being in fluid communication with the annulus and a second end of the cylinder being in fluid communication with the space defined by the expandable sleeve.

In an embodiment, the annulus pressure compensator may be integrated in one of the connection parts or arranged in connection with a wall of the expandable sleeve.

Hereby, the pressure inside the space defined by the expandable sleeve may be at least substantially equal to the pressure in the annulus to maintain the expandable sleeve in a sealing position.

The annular barrier may further comprise a check valve fluidly connecting the annulus with the space defined by the expandable sleeve.

In one embodiment, the check valve may be integrated in one of the connection parts or in a wall of the expandable sleeve.

The annular barrier may further comprise a directional three-way valve incorporating the check valve, the directional three-way being adapted to control the flow of fluid into the space from the annulus and from the inside of the tubular part.

Moreover, the directional three-way valve may be integrated in one of the connection parts.

Furthermore, a first inlet of the directional three-way valve may be in fluid communication with the annulus, a second inlet of the directional three-way may be in fluid communication with the inside of the tubular part, and an outlet may be in fluid communication with the space defined by the expandable sleeve.

In accordance with another aspect of the present invention, there is provided a well system comprising the well tubular structure and the annular barrier described above.

The well system may further have a tool comprising isolation means isolating an isolated part of the inside of the tubular part outside the aperture to pressurise the isolated part of the inside and the space to expand the expandable sleeve.

The tool may further comprise a pumping device for pumping fluid from the inside of the tubular part being outside the isolated part and into the isolated part to expand the expandable sleeve.

In accordance with another aspect of the present invention, there is provided a method for maintaining a pressure within the annular barrier described above, comprising the steps of:

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- expanding the expandable sleeve until the sleeve seals against the inside wall of the borehole, and
- equalising the pressure inside the space when the temperature decreases or increases in the borehole by moving the piston and letting the gas in the second chamber part expand or diminish.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will be described hereinafter, by way of examples only, with reference to the accompanying drawings, wherein:

Fig. 1 shows a cross-sectional view of an annular barrier with a compensation device in its unexpanded condition,

Fig. 2 shows the annular barrier of Fig. 1 in its expanded condition,

Fig. 3 shows the annular barrier of Fig. 1 in its expanded condition while the compensation device has equalised the pressure in relation to Fig. 2,

Fig. 4 shows a cross-sectional view of another embodiment of the annular barrier in a vertical well,

Fig. 5 shows a cross-sectional view of yet another embodiment of the annular barrier,

Fig. 6 shows a cross-sectional view of yet another embodiment of the annular barrier and a well system,

Fig. 7 shows a cross-sectional view of the connection part of yet another embodiment of the annular barrier,

Fig. 8 shows a cross-sectional view of the compensation device,

Fig. 9 shows a cross-sectional view of an embodiment of the annular barrier comprising an annulus pressure compensator,

Fig. 10 shows a cross-sectional view of an embodiment of the annular barrier comprising a check valve,

Fig. 11 shows a cross-sectional view of an embodiment of the annular barrier comprising a directional three-way valve, and

Fig. 12 shows a cross-sectional view of an embodiment of the directional three-way valve shown in Fig. 11.

All the figures are highly schematic and not necessarily to scale, and they show only those parts which are necessary in order to elucidate the invention, other parts being omitted or merely suggested.

Detailed description of the invention

Fig. 1 shows an annular barrier 1 to be expanded in an annulus 2 between a well tubular structure 3 and an inside wall 4 of a borehole 5 downhole for providing zone isolation between a first zone 8 and a second zone 12 of the borehole 5. The tubular structure 3 may be a production casing. The annular barrier 1 comprises a tubular part 6 mounted as part of the well tubular structure 3. The tubular part 6 has a longitudinal axis 14 coaxial with the longitudinal axis of the well tubular structure 3. The annular barrier 1 comprises an expandable sleeve 7 surrounding the tubular part 6 and defining a space 13 which is in fluid communication with an inside 23 of the tubular part 6. Each end 9, 10 of the expandable sleeve 7 is connected with the tubular part 6, one end being fixedly fastened to the tubular part and the other end being slidably fastened to the tubular part.

The annular barrier 1 has an aperture 11 for letting fluid into the space to expand the expandable sleeve, the aperture 11 being arranged in the tubular part 6 so that the fluid is let directly into the space. In another embodiment, the aperture may be arranged so that the fluid is led from the inside of the tubular part through a connection part 15 fastening the expandable sleeve 7 to the tubular part into the space. A valve, such as a one-way valve, may also be arranged in the aperture, and when the aperture is in the connection part, a two-way valve or three-way valve may also be used. The expandable sleeve is typically expanded by pressurising the well tubular structure 3 from the top of the well and in this way inflate several annular barriers at a time.

The annular barrier further comprises a compensation device 16 having a chamber 17 in which a piston 18 is arranged dividing the chamber 17 into a first chamber part 19 and a second chamber part 20. The first chamber part 19 is in fluid communication with the space 13 through an opening 21, and the second chamber part 20 comprises gas, such as nitrogen. The gas may also be neon, argon, krypton or xenon. The compensation device 16 is arranged in the space 13 between the expandable sleeve 7 and the tubular part 6.

In Fig. 2, the annular barrier 1 has been expanded by pressurising the inside of the tubular part, and fluid is now flowing into the aperture to pressurise the space 13 to expand the expandable sleeve 7. When the temperature in the annulus drops, the pressure in the space may drop equally and thus cause a pressure drop in relation to the formation pressure and the pressure in the annulus. Thus, a temperature drop may cause the expandable sleeve to collapse locally, undermining its strength, and the pressure to make it collapse, also called the collapse pressure, is somewhat decreased. In order to avoid the pressure dropping and thus the collapse pressure decreasing, the piston 18 of the compensation device moves towards the opening, as shown in Fig. 3, due to the pressure inside the first chamber part 19 being the same decreased pressure as the pressure inside the space 13. The gas inside the second chamber part 20 expands to equalise the pressure difference between the first and the second chamber part. In this way, the compensation device lets fluid out into the space to equalise the pressure until it reaches the same level as before the temperature drop.

When the temperature in the borehole increases, the piston is forced to move to reduce the second chamber part 20, 20B due to the fact that the gas in the second chamber part diminishes to equalise the pressure inside the space.

In Fig. 4, the annular barrier 1 is arranged in a vertical part of the well. The second chamber part 20 is arranged closest to the fixedly connected end of the expandable sleeve 7. By having the compensation device inside the space 13 and the second chamber part 20 arranged closest to the fixedly connected end of the expandable sleeve, any leak of gas 40 in the compensation device 16 will result in an accumulation of gas 40 in the top part of the space 13. By having the gas arranged in the top part, the gas will still have the ability to expand and thus equalise the pressure during a temperature drop in the fluid in the annulus.

The annular barrier 1 may also be arranged in the horizontal part of the well, and when this is the case the gas will accumulate underneath the expandable sleeve closest to the borehole wall 4 and will, in the same way as in Fig. 4, have the ability to expand and thus equalise the pressure.

In Fig. 5, the compensation device is arranged as part of the fixed connection part 24 connecting the expandable sleeve 7 with the tubular part 6. This is due to the fact that the slidable connection part 25 slidably connecting the expandable sleeve with the tubular part moves during expansion and thus moves in relation to the aperture in the tubular part if the aperture is arranged in connection with the connection part. Thus, the expansion fluid is let in through that connection part. The position of the aperture is thus optional.

In Fig. 6, the annular barrier comprises an additional connection part being the slidable connection part 25 in which a second compensation device 16B is arranged. The second compensation device 16B comprises a chamber 17B in which a piston 18B is arranged dividing the chamber 17B into a first chamber part 19B and a second chamber part 20B. The first chamber part 19B is in fluid communication with the space 13 through an opening 21B, and the second chamber part 20B also comprises gas, such as nitrogen. The gas may also be neon, argon, krypton or xenon. The compensation device 16B is arranged in the space 13 between the expandable sleeve 7 and the tubular part 6.

As can be seen from the cross-sectional views of Figs. 1-6, the chamber is annular and surrounds the tubular part. Thus, the first chamber part 19, 19B and the second chamber part 20, 20B are also annular, and the piston 18, 18B moving inside the chamber 17, 17B is a ring-shaped piston surrounding the tubular part 6.

In Fig. 7, the compensation device 16, 16B has a plurality of chambers 17, 17B spaced along a circumference of the tubular part and the connection part 15. A piston 18, 18B is arranged in each chamber 17, 17B, dividing the chamber into a first and a second chamber part, as mentioned above. Fig. 7 is a cross-sectional view of the connection part 15, and by having several chambers instead of only one annular chamber, the connection part becomes more rigid and solid and thus capable of withstanding the pressure difference occurring downhole and the bumping when lowering the well tubular structure in order to complete the well.

In Fig. 8, an embodiment of the compensation device is shown. As can be seen, the piston 18, 18B comprises a sealing means 26, such as an O-ring, to seal the second chamber part 20, 20B from the first chamber part 19, 19B. The second chamber part comprises a valve 27 which is accessible from the inside 23 of the tubular part to be able to refill the second chamber part 20, 20B with gas at a later stage if required. The valve may be any kind of suitable valve.

The method for maintaining a pressure within the annular barrier 1 mentioned above entails expanding the expandable sleeve until the it seals against the inside wall 4 of the borehole, and subsequently, when the temperature decreases or increases in the borehole, equalising the pressure inside the space by moving the piston 18, 18B and let the gas in the second chamber part expand or diminish.

In the embodiment shown in Fig. 9, the annular barrier comprises an annulus pressure compensator 50. The annulus pressure compensator 50 comprises a cylinder 51 defined by the connection part, and inside the cylinder, a piston 52 is slidably arranged. A first end 511 of the cylinder is in fluid communication with the annulus and a second end 512 of the cylinder is in fluid communication with the space defined by the expandable sleeve. The pressure in the annulus acts on a first piston face 521 to force the piston in a direction towards the second end 512 of the cylinder. Conversely, the pressure in the space acts on a second piston faces 522 to force the piston in an opposite direction. Thus, if the differential pressure between the pressure in the space and the pressure in the annulus on one side of the inflated annular barrier exceeds a certain limit, the piston is forced towards either the first or the second end of the cylinder to compensate for the differences in pressure. The piston may be designed so that the area of the first piston face and the area of the second piston face mutually adjusted based on specific requirements to allow for proper compensation. For example, if an excess pressure in the space is requested, the area of the first piston face 521 on which the annulus pressure acts may be larger than the area of the second piston face 522.

In the embodiment shown in Fig 10, the annular barrier comprises a check valve allowing fluid from the annulus to flow into the space defined by the expandable sleeve. As shown, the check valve is mounted in the expandable sleeve 7, however, the check valve may alternatively be integrated in one of the connection parts 24, 25. In Fig. 10, only one check valve is shown, however, the annular barrier may comprise multiple check valves allowing fluid to flow into the space from both the first zone 8 and the second zone 12 of the borehole seperated by the annular barrier.

In the embodiment shown in Fig 11, the annular barrier comprises a directional three-way valve 70 controlling the flow of fluid into the space from the annulus as well as from the inside of the tubular part. The directional three-way valve shown in further detail in Fig. 12 comprises a first inlet 71 in fluid communication with the annulus via an aperture 241 in the fixed connection part, a second inlet 72 in fluid communication with the inside of the tubular part via the aperture 11 in the tubular part and an outlet 73 in fluid communication with the space 13 via conduit 242. In the shown embodiment, the directional three-way valve is integrated in the fixed connection part. However, it is envisaged by the skilled person that the directional three-way valve may be arranged in a number of other ways without departing from the invention.

Fig. 12 shows the directional three-way valve having two inlets 71, 72 and a single outlet 73. The directional three-way valve comprises to check valves 74 controlling the direction of flow. Fluid may flow from the inlets 71, 72 to the outlet 73, but not in the opposite direction. Hereby, fluid may flow from the annulus into the space, but fluid will never flow from the space, which would reduce the pressure in the space and possible reduce the sealing capabilities of the expandable sleeve.

The expandable sleeve 7 has an outer face facing the wall 4 of the borehole. Different kinds of sealing elements may be arranged on the outer face to increase the sealing ability of the expandable sleeve towards the wall of the borehole.

As can be seen in Fig. 6, the invention also relates to a well system 100 comprising the well tubular structure 3 and the annular barrier 1. The well system 100 further comprises a tool 29 having an isolation means 30 isolating an isolated part 28 of the inside 23 of the tubular part outside the aperture 11 to pressurise the isolated part 28 of the inside 23 and thus the space 13 to expand the expandable sleeve. The isolation means 30 may be an inflatable elastomeric element or a metal packer. The tool further comprises a pumping device 31 for pumping fluid from the inside of the tubular part being outside the isolated part 28 and into the isolated part 28 to expand the expandable sleeve 7. The well system may also have several annular barriers 1.

The tool may also use coiled tubing for expanding the expandable sleeve of one annular barrier or two annular barriers at the same time. A tool with coiled tubing can pressurise the fluid in the well tubular structure without having to isolate a section of the well tubular structure. However, the tool may need to plug the well tubular structure further down the borehole for the two annular barriers to be operated.

In one embodiment, the tool comprises a reservoir containing the pressurised fluid, e.g. when the fluid used for expanding the expandable sleeve is cement, gas or a two-component compound. The space 13 may also be prefilled with some kind of fluid, such as a hardening agent, cement or the like.

An annular barrier may also be called a packer or similar expandable means. The well tubular structure can be the production tubing or casing or a similar kind of tubing downhole in a well or a borehole. The annular barrier can be used both in between the inner production tubing and an outer tubing in the borehole or between a tubing and the inner wall of the borehole. A well may have several kinds of tubing and the annular barrier of the present invention can be mounted for use in all of them.

The valves disclosed may be any kind of valves capable of controlling flow, such as a ball valve, butterfly valve, choke valve, check valve or non-return valve, diaphragm valve, expansion valve, gate valve, globe valve, knife valve, needle valve, piston valve, pinch valve, or plug valve.

The expandable tubular metal sleeve may be a cold-drawn or hot-drawn tubular structure.

When the expandable sleeve 7 of the annular barrier 1 is expanded, the diameter of the expandable sleeve is expanded from its initial unexpanded diameter to a larger diameter. The expandable sleeve 7 has an outside diameter D and is capable of expanding to an at least 10% larger diameter, preferably an at least 15% larger diameter, more preferably an at least 30% larger diameter than that of an unexpanded expandable sleeve.

Furthermore, the expandable sleeve 7 has a wall thickness t which is thinner than a length L of the expandable sleeve, the thickness preferably being less than 25% of the length, more preferably less than 15% of the length, and even more preferably less than 10% of the length.

The expandable sleeve 7 of the annular barrier 1 may be made of metal, polymers, an elastomeric material, silicone or natural or synthetic rubber.

In order to increase the thickness of the expandable sleeve 7, additional material may be applied (not shown) onto the expandable sleeve, e.g. by adding welded material onto the outer face.

In another embodiment, the thickness of the expandable sleeve 7 is increased by fastening a ring-shaped part onto the expandable sleeve (not shown).

In yet another embodiment, the increased thickness of the expandable sleeve 7 is facilitated using a varying thickness sleeve (not shown). To obtain an expandable sleeve of varying thickness, techniques such as rolling, extrusion or die-casting may be used.

The fluid used for expanding the expandable n may be any kind of well fluid present in the borehole surrounding the tool and/or the well tubular structure 3.

Also, the fluid may be cement, gas, water, polymers, or a two-component compound, such as powder or particles mixing or reacting with a binding or hardening agent. Part of the fluid, such as the hardening agent, may be present in the cavity between the tubular part and the expandable sleeve before injecting a subsequent fluid into the cavity.

By fluid or well fluid is meant any kind of fluid that may be present in oil or gas wells downhole, such as natural gas, oil, oil mud, crude oil, water, etc. By gas is meant any kind of gas composition present in a well, completion, or open hole, and by oil is meant any kind of oil composition, such as crude oil, an oil-containing fluid, etc. Gas, oil, and water fluids may thus all comprise other elements or substances than gas, oil, and/or water, respectively.

By a casing is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production.

In the event that the tool is not submergible all the way into the casing, a downhole tractor can be used to push the tools all the way into position in the well. A downhole tractor is any kind of driving tool capable of pushing or pulling tools in a well downhole, such as a Well Tractor®. A downhole tractor may have wheels on arms projecting from a tool housing of the tractor, or driving belts for moving the tractor forward in the well.

Although the invention has been described in the above in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

CLAIMS

1. An annular barrier to be expanded in an annulus between a well tubular structure and an inside wall of a borehole downhole for providing zone isolation between a first zone and a second zone of the borehole, comprising:

- a tubular part for mounting as part of the well tubular structure, the tubular part having a longitudinal axis,
- an expandable sleeve surrounding the tubular part and defining a space being in fluid communication with an inside of the tubular part, each end of the expandable sleeve being connected with the tubular part, and
- an aperture for letting fluid into the space to expand the expandable sleeve,

wherein the barrier further comprises a compensation device arranged in the space between the expandable sleeve and the tubular part, the compensation device having a chamber in which a piston is arranged dividing the chamber into a first and a second chamber part, the first chamber part being in fluid communication with the space and the second chamber part comprising gas.

2. An annular barrier according to claim 1, wherein the gas is nitrogen, neon, argon, krypton or xenon.

3. An annular barrier according to claim 1 or 2, wherein the chamber is annular and surrounds the tubular part.

4. An annular barrier according to claim 1 or 2, wherein the compensation device has several chambers in which pistons are arranged.

5. An annular barrier according to any one of the preceding claims, wherein one end of the sleeve is fixedly fastened to the tubular part and the other end is slidably fastened to the tubular part, and wherein the second chamber part containing the gas is arranged closest to the fixedly connected end of the sleeve.

6. An annular barrier according to any one of the preceding claims, wherein the second chamber part comprises a valve which is accessible from the inside of the tubular part, allowing refill of the second chamber part with gas.

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7. An annular barrier according to any one of the preceding claims, wherein the piston comprises sealing means for sealing the second chamber part from the first chamber part.

8. An annular barrier according to any one of the preceding claims, further comprising an annulus pressure compensator comprising a cylinder wherein a piston is arranged, a first end of the cylinder being in fluid communication with the annulus and a second end of the cylinder being in fluid communication with the space defined by the expandable sleeve.

9. An annular barrier according to any one of the preceding claims, further comprising a check valve fluidly connecting the annulus with the space defined by the expandable sleeve.

10. An annular barrier according to claim 9, wherein the check valve is integrated in one of the connection parts or in a wall of the expandable sleeve.

11. An annular barrier according to claim 9, comprising a directional three-way valve incorporating the check valve, the directional three-way being adapted to control the flow of fluid into the space from the annulus and from the inside of the tubular part.

12. A well system comprising the well tubular structure and the annular barrier according to any one of claims 1 to 11.

13. A well system according to claim 12, further having a tool comprising isolation means isolating an isolated part of the inside of the tubular part outside the aperture to pressurise the isolated part of the inside and the space to expand the expandable sleeve.

14. A well system according to claim 13, wherein the tool further comprises a pumping device for pumping fluid from the inside of the tubular part being outside the isolated part and into the isolated part to expand the expandable sleeve.

15. A method for maintaining a pressure within the annular barrier according to any one of claims 1 to 10, comprising the steps of:

- expanding the expandable sleeve until the sleeve seals against the inside wall of the borehole, and

- equalising the pressure inside the space when the temperature decreases or increases in the borehole by moving the piston and letting the gas in the second chamber part expand or diminish.

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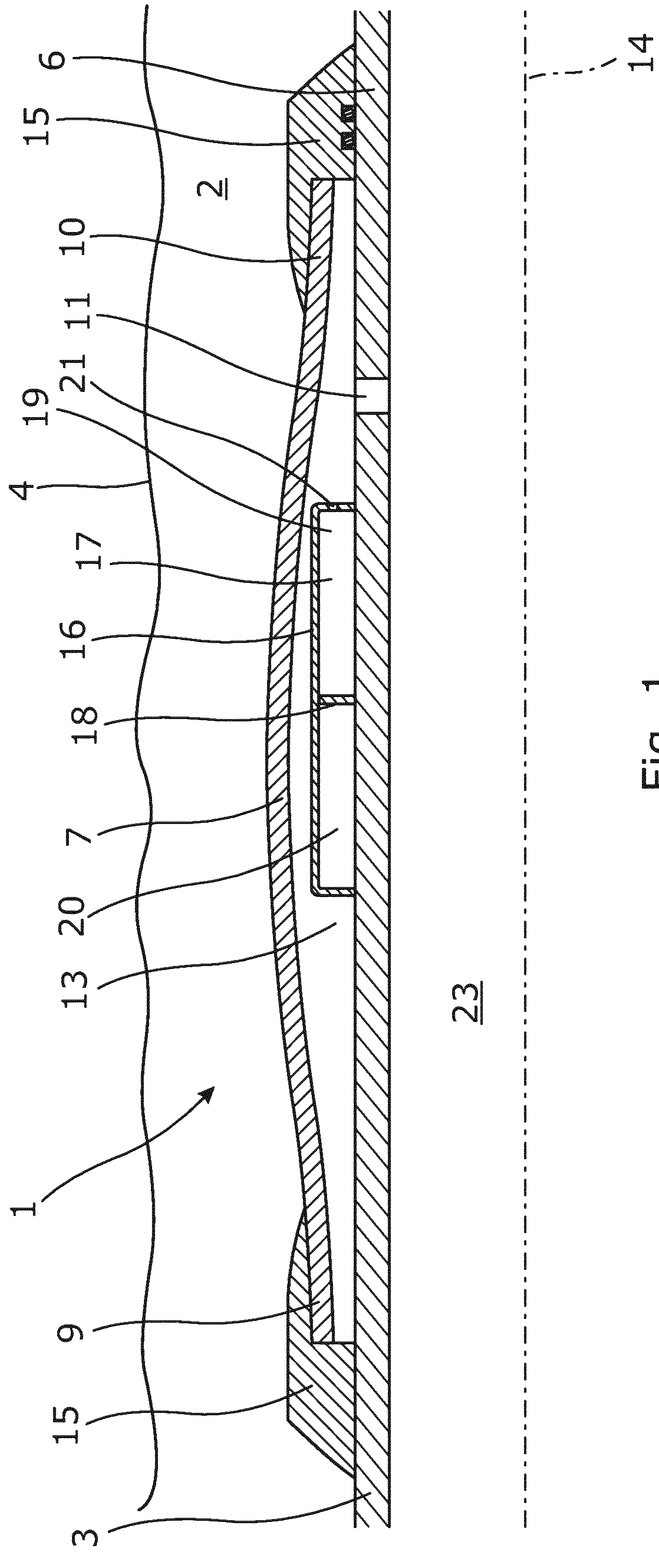


Fig. 1

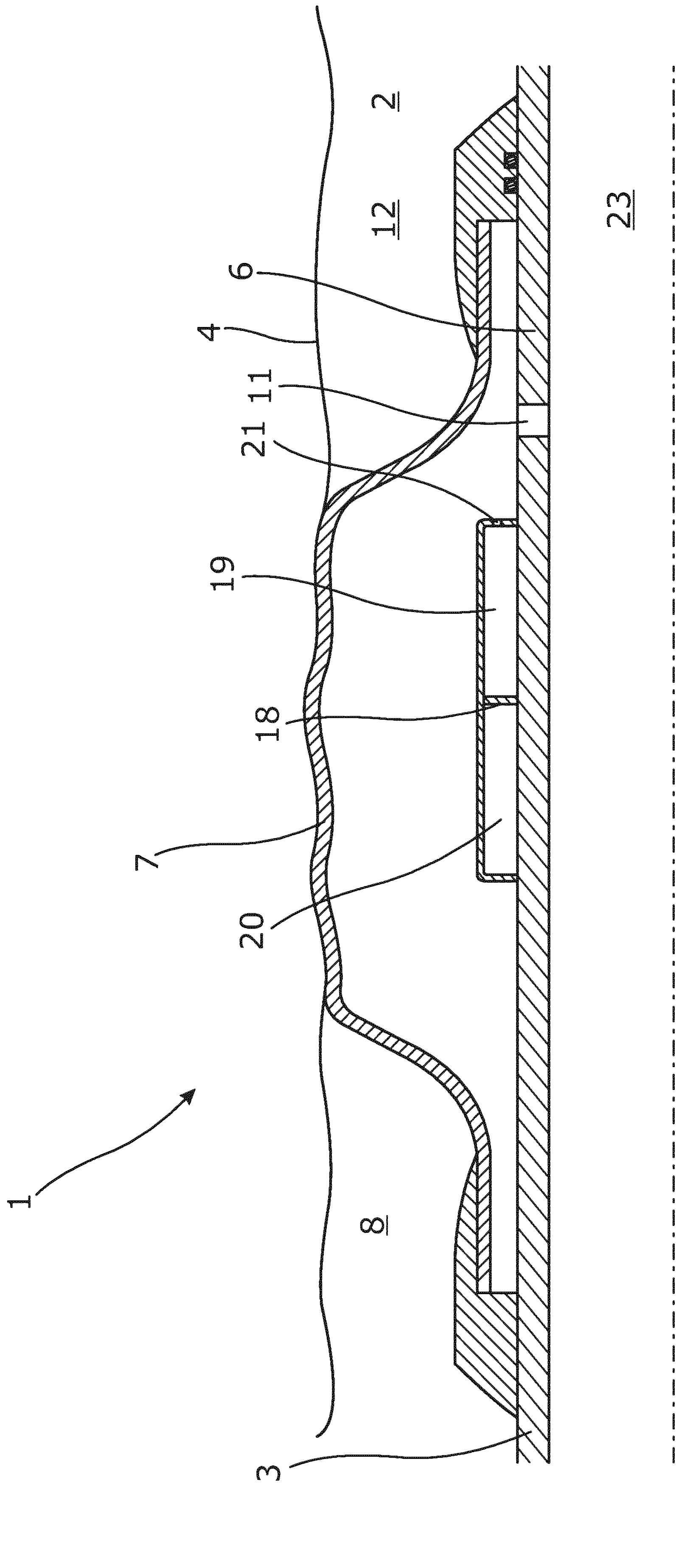


Fig. 2

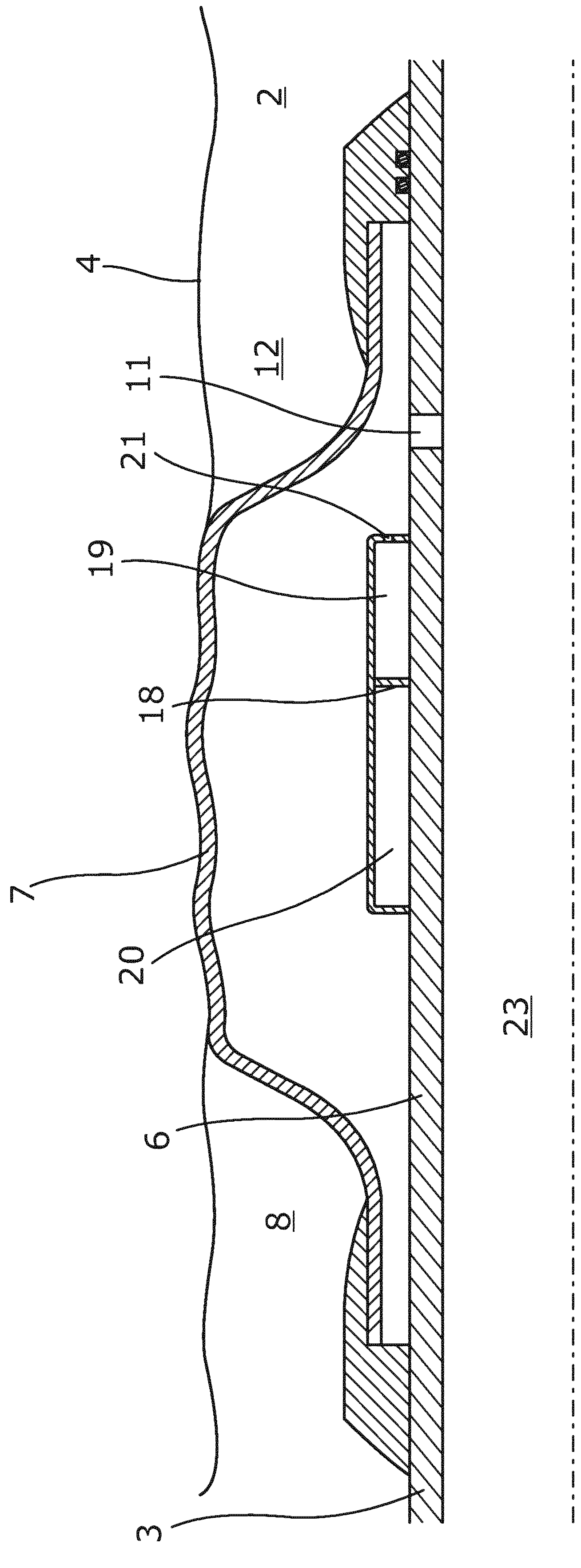


Fig. 3

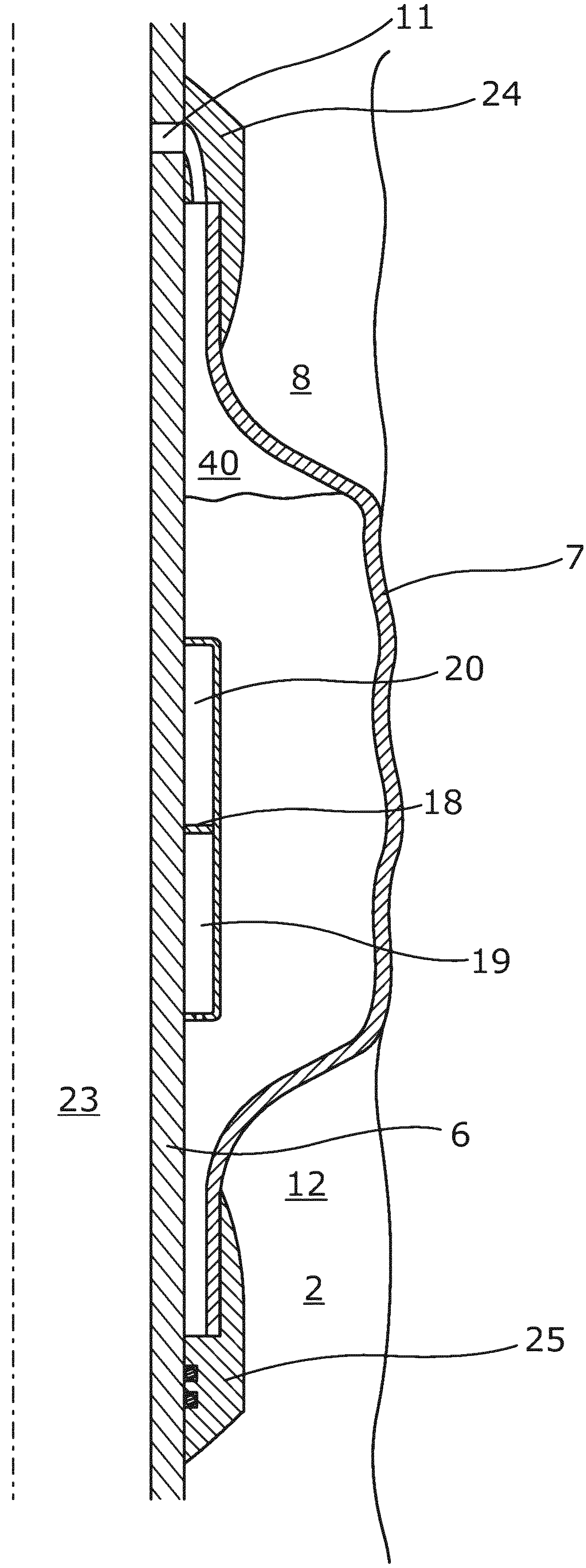


Fig. 4

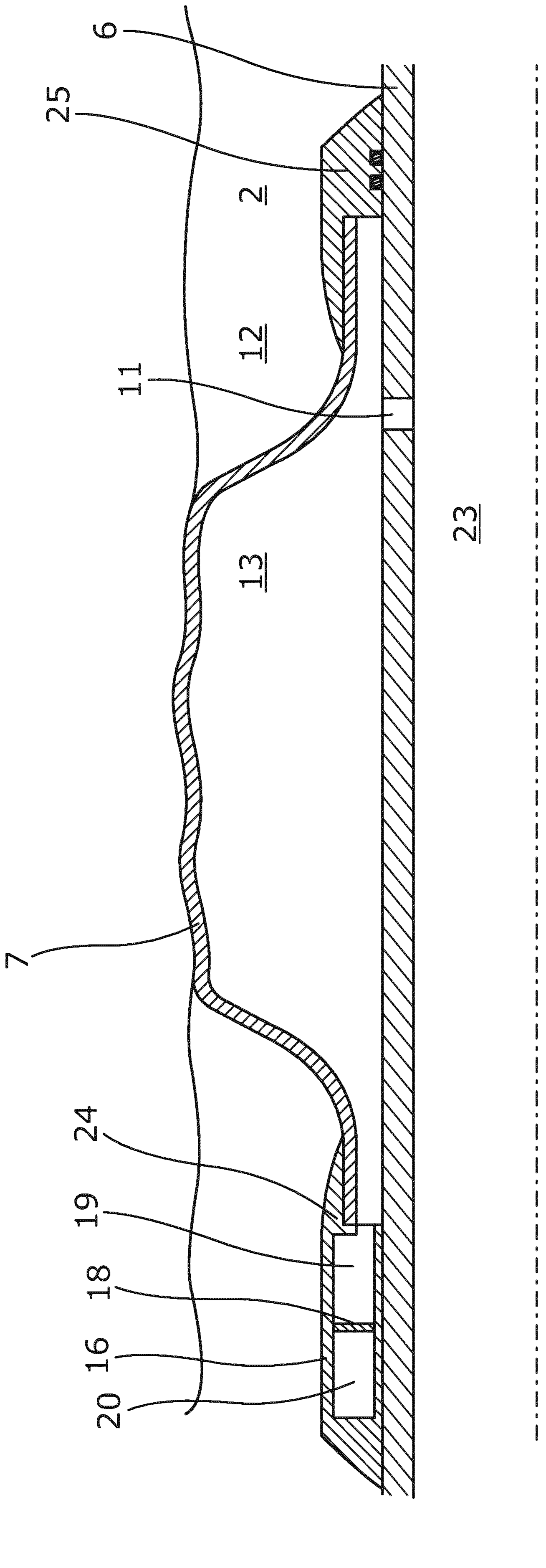
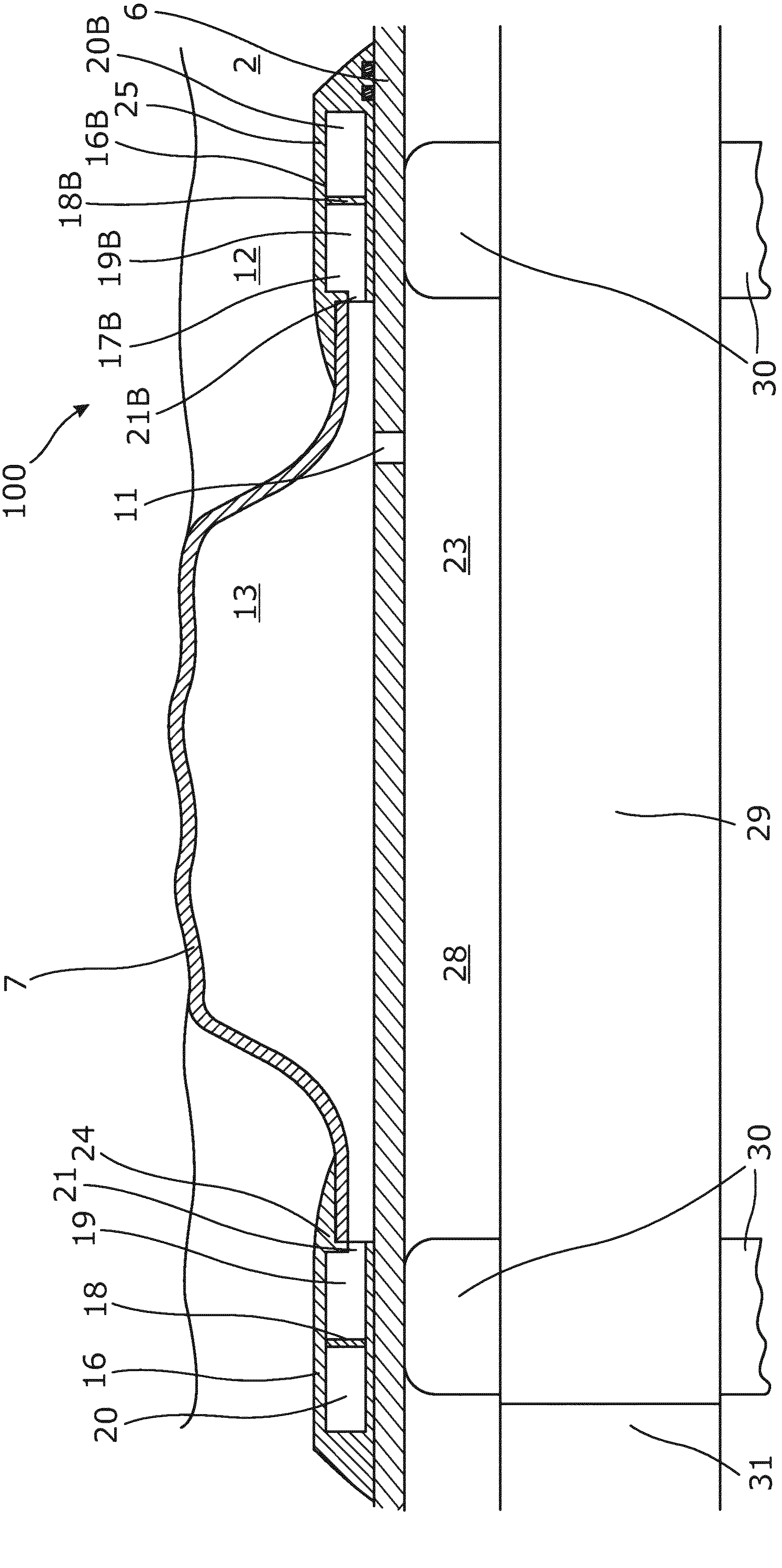


Fig. 5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21
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31

Fig. 6

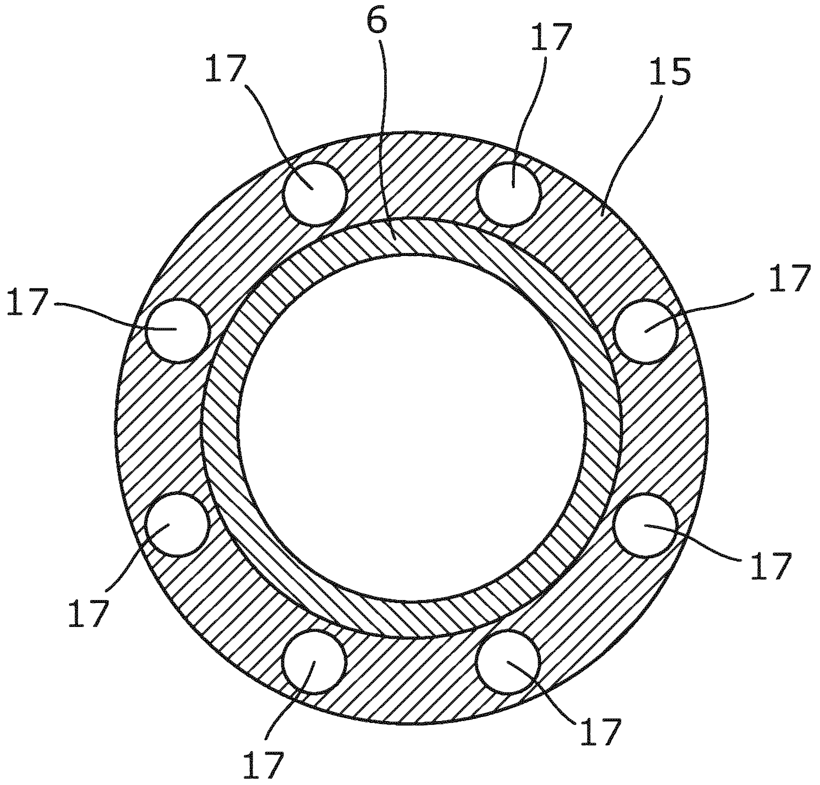
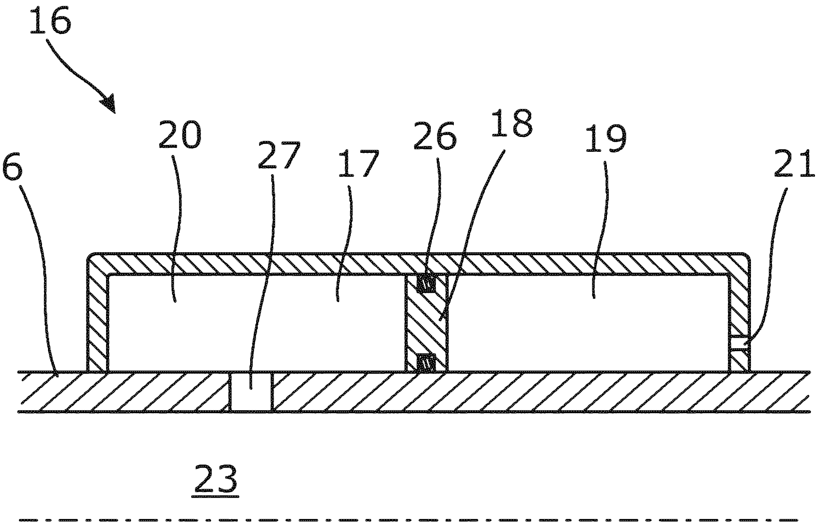


Fig. 7



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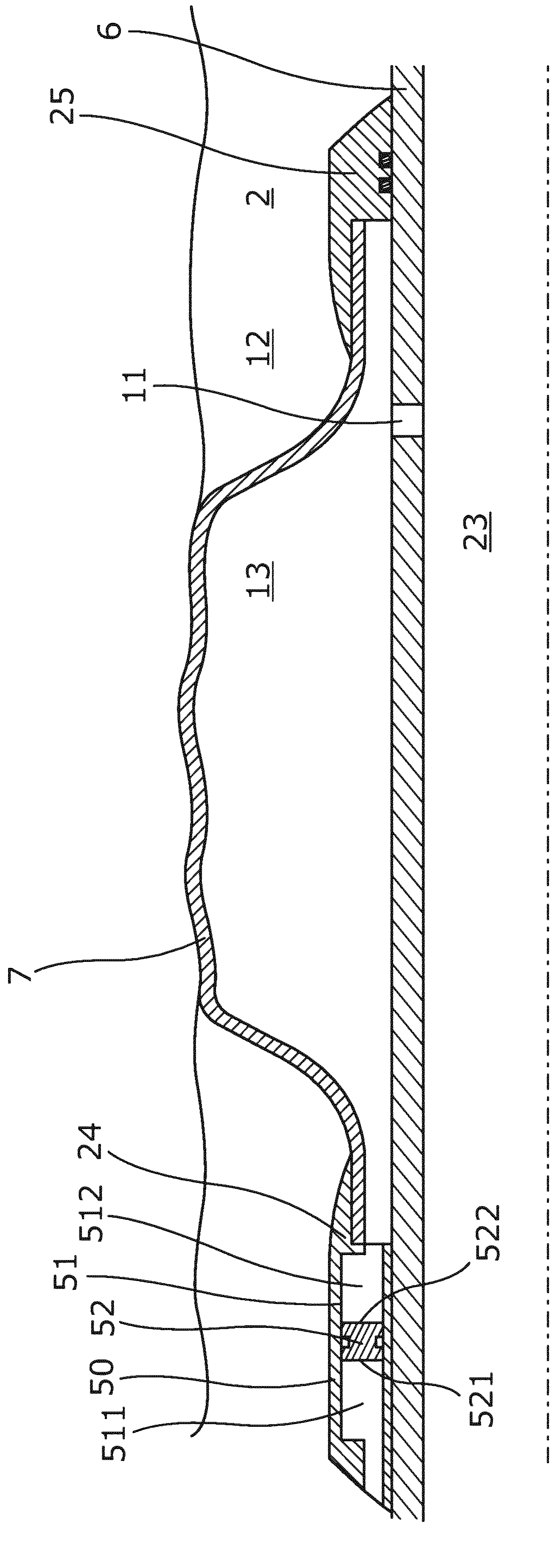

Fig. 9

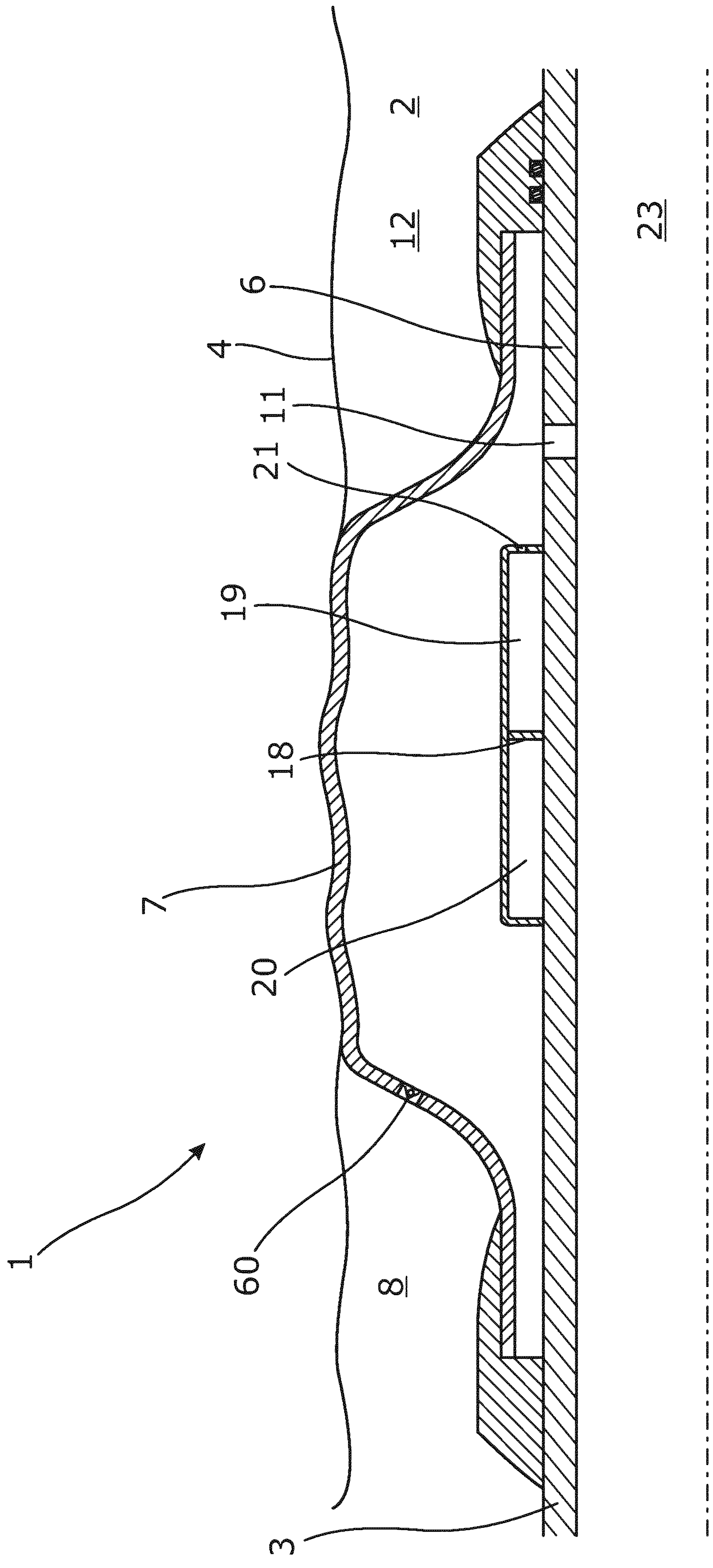

Fig. 10

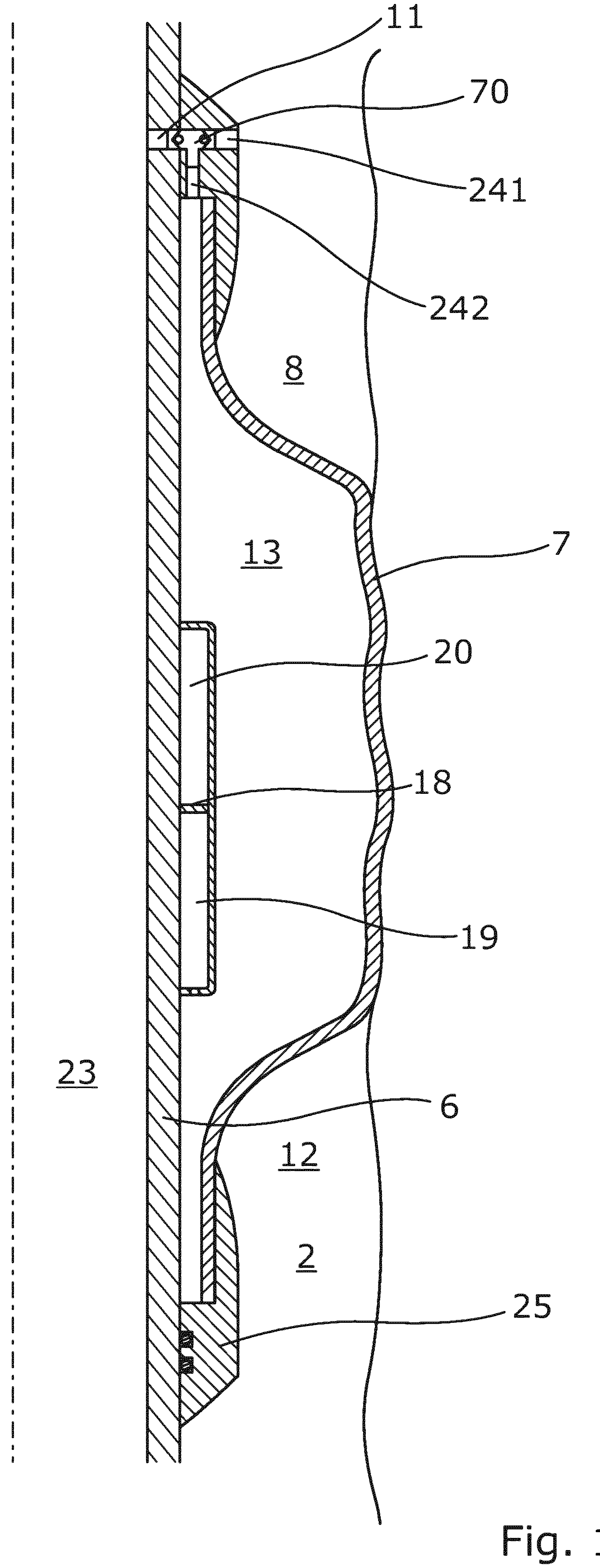

Fig. 11

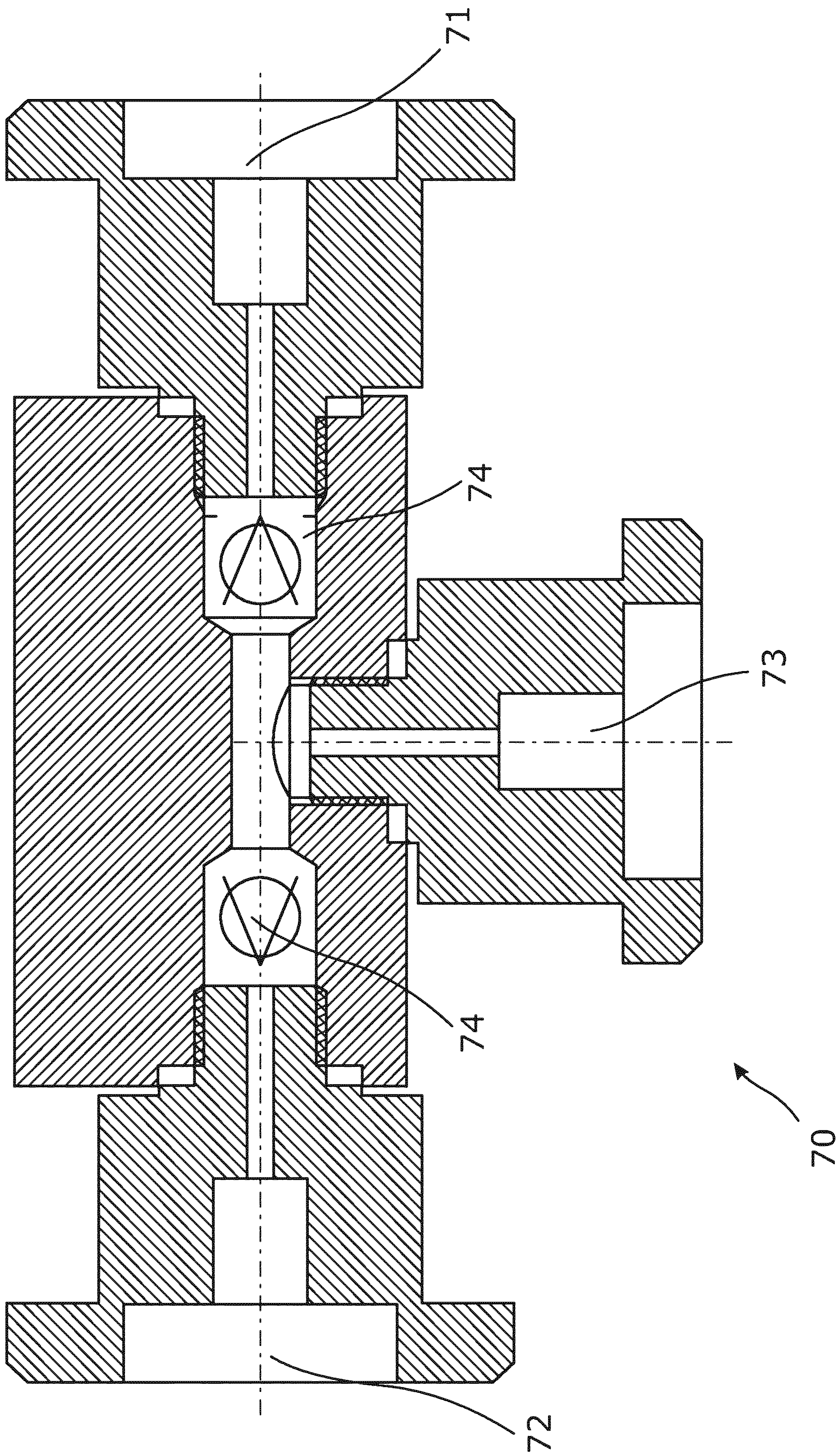

Fig. 12