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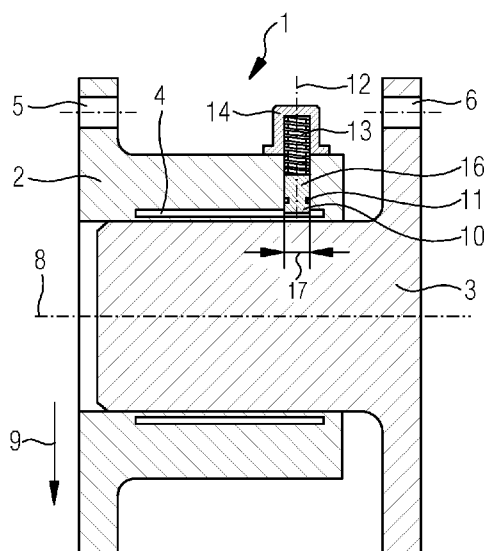
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(54) Title: SAFETY COUPLING WITH PRESSURE REGULATION

Fig.1



(57) Abstract: The invention relates to a safety coupling having an input shaft (2) and an output shaft (3), wherein the input shaft (2) and the output shaft (3) are arranged coaxially to one another, and the input shaft (2) and the output shaft (3) can be connected in a force-fitting manner by means of pressurization of a pressure chamber (4) formed in the safety coupling. The pressure chamber (4) has a volume V_0 . To change the volume of the pressure chamber, there is provided a variable element (10) by means of which the resulting volume of the pressure chamber can be varied. The hydraulic medium situated in the pressure chamber is constant. Influences, such as for example temperature fluctuations, can be compensated for by varying the volume of the pressure chamber.



Safety coupling with pressure regulation

The invention relates to a safety coupling. The safety coupling has an input shaft,
5 wherein this input shaft or drive flange is connected to an output shaft in a force-
fitting manner. The safety coupling comprises a pressure chamber. This pressure
chamber can be pressurized with a hydraulic medium. A release torque, also
referred to as predetermined torque, is set in such safety couplings by means of the
pressure in the pressure chamber. A relative movement of input shaft and output
10 shaft results at a torque which exceeds the predetermined torque. For example, a
safety coupling, designated as SmartSet, is known from Voith, in which coupling a
pressure relief of the pressure chamber is provided by a relative movement of input
shaft and output shaft.

15 The input shaft and the output shaft are no longer or virtually no longer in operative
connection as a result of the pressure relief of the pressure chamber and can rotate
freely from one another.

A disadvantage with the known solutions is that the release torque can vary due to
20 external influences. Thus, for example, an increased ambient temperature can result
in a pressure increase in the pressure chamber. This pressure increase can then
result in a delayed release of the safety coupling at a torque which exceeds the
predetermined torque.

25 Furthermore, it may be advantageous in some applications if, even during operation,
the torque which can be transmitted by the safety coupling can still be adjusted and
regulated.

The object of the invention is to develop the safety coupling such that the safety
30 coupling releases reliably at a predetermined release torque.

The object is achieved according to the invention by an embodiment according to Claim 1. Further advantageous features of the embodiment according to the invention can be found in the dependent claims.

- 5 In the embodiment according to the invention, the safety coupling comprises an input shaft and an output shaft. The input shaft and the output shaft are arranged coaxially to one another. The input shaft and the output shaft can be connected in a force-fitting manner by means of pressurization of a pressure chamber provided in the safety coupling. The pressure chamber can be formed both in the input shaft
- 10 and in the output shaft. This pressure chamber has a volume V_0 . To vary the volume of the pressure chamber, a variable element is provided. This variable element acts on the pressure chamber. The volume and hence the pressure in the pressure chamber can be varied by this variable element.
- 15 Given an increase in temperature, the hydraulic medium enclosed in the pressure chamber expands. This expansion results in a pressure increase in the pressure chamber. This pressure increase increases the force-fitting engagement, and the safety coupling would only release at a relatively high torque. This pressure increase can be compensated for by the variable element. As a result, a more precise release
- 20 of the safety coupling is achieved. Moreover, there can also be provision that the volume of the pressure chamber is varied in a targeted manner by means of the variable element in order to perform an adjustment on a release torque.

In a preferred embodiment, there is provision that the variable element is arranged

25 such that it can be pushed into the pressure chamber. A volume variation is achieved directly as a result. This arrangement is particularly simple and cost-effective.

In a preferred embodiment, there is provision that force is applied to the variable

30 element by a spring element. This arrangement has the advantage that the variable element is self-adjusting. That is to say, with a pressure increase in the pressure chamber, an increased force is applied to the spring element, thereby causing a

compression of the spring element and a displacement of the variable element. An increase in the volume of the pressure chamber is achieved as a result of the displacement. It has been found to be advantageous to use a spring element having a flat spring characteristic.

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In a preferred exemplary embodiment, a bolt is provided as variable element. The bolt is arranged so as to be displaceable. A variation of the volume of the pressure chamber can be set by displacing the bolt. The bolt is preferably arranged in the shaft in which the pressure chamber is formed so as to be displaceable along the

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In one exemplary embodiment, there is provision that the variable element is a screw element. The screw element is displaceable by a rotary movement of the screw element. The thread of the screw element thus constitutes a transmission

15

stage of the actuating force. If, for example, a motorized drive of the variable element is provided, a motor with a relatively small power can be used.

In a preferred embodiment, there is provision that the pressure chamber is closed off and designed with a thin-walled region. The thin walled region has the function

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of a membrane. The variable element acts on the thin-walled region of the pressure chamber. As a result, this thin-walled region is deflected and produces a variation in the volume of the pressure chamber. The variable element acts indirectly on the pressure chamber through the formation of the thin-walled region. Sealing between the variable element and the pressure chamber is not required. No leakage can thus

25

occur as a result of the variable element. This construction is thus particularly durable.

In a preferred embodiment, there is provision that the variable element is made from piezo elements. By applying electric voltage from the outside the element inside the

30

pressure chamber change volume by the effect of reverse piezo electricity, thus compensating the change in pressure inside the chamber. Since there is only electrical connection from the outside to the inside of the chamber, no leakage can

occur as a result of the variable element. This construction is thus particularly durable.

In an advantageous development, there is provision to provide a safety coupling in
5 which the release torque can be regulated even still during operation.

Adjustability of the release torque is possible by the provision of a drive. In an embodiment variant, the drive is assigned to the variable element. The position of the variable element can be varied by means of the drive in order to vary the volume
10 of the pressure chamber. As a result, the pressure in the pressure chamber can be actively set. An active control and/or regulation of the volume of the pressure chamber is possible. The position of the variable element can be set by the drive on the basis of stored data. If in particular a pressure sensor is provided, the pressure in the pressure chamber can be regulated to a predetermined pressure by activating
15 the drive. Particularly exact release of the safety coupling can be achieved as a result. A release torque can also be actively set during operation.

If different torques are permissible in a drive train in dependence on the operating mode, the release torque of the safety coupling can also be set during operation
20 using such a safety coupling.

In a preferred embodiment, there is provision that the safety coupling is provided with a temperature sensor. The pressures in the pressure chamber that are dependent on the temperature can be stored and the position of the variable
25 element can be set by an available drive. The release torque can thus be set particularly exactly in dependence on the temperature. In a particularly preferred embodiment, the temperature measurement is provided within the pressure chamber. As a result, the accuracy of the pressure determination of the pressure in the pressure chamber is again possible on the basis of the temperature.

30

In a further embodiment, there is provision that a pressure sensor for detecting the pressure in the pressure chamber is provided. This pressure sensor is preferably

integrated in the variable element. Thus, for example, the pressure sensor can be integrated in the bolt which projects into the pressure chamber. A particularly compact design is possible as a result.

5 In an embodiment variant, there is provision that the safety coupling is provided with a torque sensor. This makes it possible to understand at what torque the safety coupling has released. It is thus also possible to actively support a release of the safety coupling by actively lowering the pressure in the pressure chamber. The measurement of the torque transmitted to the output shaft has been found to be
10 particularly advantageous. It is thus possible to understand what torque has still occurred via the safety coupling. Such an arrangement makes it possible subsequently to determine malfunctions of the safety couplings and to adapt the design of the safety coupling and also to support or carry out a release of the safety coupling with an actively positionable variable element upon exceeding the
15 predetermined torque.

In one embodiment, there is provision that at least one rotational speed sensor is
20 provided for detecting the rotational speed of the input shaft and/or of the output shaft. There can also be provision that the rotational speeds are forwarded to an assigned controller.

In a preferred embodiment, there is provision that the variable element is arranged
25 so as to be displaceable in the axial direction. As a result, the influence of the rotational speed by the centrifugal force acting on the variable element is prevented or at least considerably reduced.

In one embodiment, there is provision that the variable element is provided with a
30 tothing, wherein the tothing is in engagement with an output, in the form of a gearwheel, of the drive. Consequently, a further transmission stage is integrated,

with the result that weaker-torque drives can also be used. As a result, such an embodiment is particularly compact.

5 In a further embodiment variant, a controller is provided. The controller is provided in or on the safety coupling and controls or regulates a deflection of the variable element. There is particularly advantageously provision for an energy recovery for supplying the required energy for provided sensors and the drive. It is thus possible to design the safety coupling as an autonomous unit. In particular, a power supply for an electric motor as drive is not required, thus contributing to a simple
10 construction.

The invention relates to a method for controlling or regulating the pressure in a pressure chamber of a safety coupling, wherein a controller is provided, and the controller is provided with data from a temperature sensor, pressure sensor,
15 rotational speed sensors and/or torque sensor, and a drive is activated to set the position of a variable element. The volume of a pressure chamber provided in the safety coupling is set by the position of the variable element.

Further advantageous forms of the invention will be explained on the basis of
20 exemplary embodiments with reference to the drawings. The stated features can be advantageously implemented not only in the illustrated combination but can also be individually combined with one another. In the figures, specifically:

Fig. 1: Shows a safety coupling with radially arranged variable element for
25 automatic pressure regulation,

Fig. 2: Shows a safety coupling with thin-walled region and variable element,

Fig. 3: Shows a safety coupling with radially arranged bolts and drive,

Fig. 4: Shows a safety coupling with thin-walled region and drive,

Fig. 5: Shows a safety coupling with axially arranged variable element,

30 **Fig. 6:** Shows a safety coupling with axially arranged element in a compact design,

Fig. 7: Shows a section along B-B through the embodiment illustrated in Figure 6,

Fig. 8: Shows a safety coupling with axially arranged variable element and drive,

Fig. 9: Shows a section along B-B through the embodiment illustrated in Figure 8,
Fig. 10: Shows a safety coupling with variable element and sensor system and an assigned control unit.

5 The figures will be described in more detail below.

A safety coupling 1 is shown in Figure 1. An input shaft 2 is arranged coaxially to an output shaft 3 in the safety coupling 1. The input shaft is configured as a hollow shaft in the example and outwardly surrounds the output shaft 3. The output shaft could
10 also be configured as a hollow shaft, and the arrangement of input shaft and output shaft could be reversed. In the safety coupling, a pressure chamber 4 is formed in the input shaft 2. A frictional connection 24 between input shaft 2 and output shaft 3 is producible by the pressure in the pressure chamber 4. In such safety couplings, a connection (not shown) is provided for filling the safety couplings with hydraulic
15 medium. The torque which can be transmitted can be set through the choice of the pressure. The pressure chamber could also be formed in the output shaft. To connect the safety coupling to a drive train, the input shaft 2 is formed with a flange 5, and the output shaft 3 is formed with a flange 6.

20 In this embodiment, a variable element 10 is provided. The variable element is designed in the form of a bolt 16. The bolt is mounted in the shaft in which the pressure chamber 4 is formed. A free end of the bolt 16 acts on the hydraulic medium situated in the pressure chamber 4. To ensure that the hydraulic medium remains in the pressure chamber 4, the seal 11 is provided. On the side of the bolt
25 16 that faces away from the pressure chamber 4 there is provided a spring element 13. The spring element 13 is supported against a cover 14 fixedly connected to the input shaft 2. The other end of the spring element 13 acts on the end of the bolt 16 that faces away from the pressure chamber 4. The spring element 13 preloads the bolt 16 in the direction of the pressure chamber 4. If the pressure in the pressure
30 chamber 4 increases, this pressure acts on one end of the bolt 16 and, via the bolt, on the spring element 13. This acting force compresses the spring element 13 and causes the bolt 16 to be displaced radially outwardly in the radial direction 9 along

the longitudinal axis 12 of the variable element 10. As a result, the volume of the pressure chamber 4 is increased.

The following holds:

$$V_{DK} = V_0 + f_1 \cdot \Delta x_1$$

- 5 Here, V_{DK} is the resulting volume of the pressure chamber 4 and f_1 is the area of the bolt 16 that faces the pressure chamber 4. Δx_1 is the displacement of the bolt 16 in the radial direction. The displacement results from the changed pressure conditions in the pressure chamber 4 and from the counteracting spring force of the spring element 13. An equilibrium of forces is again established. It is possible to ensure
10 through the selection of the spring element 13 that the resulting pressure in the pressure chamber 4 remains constant.

If the pressure in the pressure chamber 4 drops, the bolt 16 is pressed into the pressure chamber 4 by the acting spring force, and the resulting volume of the pressure chamber 4 is reduced by the bolt 16. Consequently, the predetermined
15 pressure is set again. With slow conditional variations, such as external temperature fluctuations, the variation by the variable element 10 can be virtually immediately compensated for and a constantly prevailing pressure is achieved in the pressure chamber 4.

20

If for example a pressure p_0 of 1000 bar prevails in the pressure chamber and the bolt 13 has a diameter of $d_1 = 10$ mm, a force on the bolt of about 7.9 kN results. This is thus the force which has to be applied by the spring element 13. If the pressure in the pressure chamber 4 increases, the force on the bolt 16 and
25 accordingly also on the spring element 13 thus increases. The spring element 13 is compressed, and the bolt 16 moves radially outwards, with the result that the volume of the pressure chamber is increased until an equilibrium between spring force and chamber pressure of the pressure chamber 4 is established again. The chamber pressure can thus be kept virtually constant. It is to be sought with the design of the
30 spring that as flat a spring characteristic as possible is realized, that is to say that a "soft" spring is used. A self-adjusting pressure chamber volume is thus realized without an additional pump or an additional energy supply or control being required.

Consequently, such a solution is significantly cost-effective. The illustration in Figure 1 is only one possible embodiment. In principle, all known kinds of spring types can be used (disc springs, flat springs, pneumatic springs, etc.). Moreover, the spring/bolt system is arranged radially in Figure 1. This has the disadvantage that the centrifugal force in the rotating coupling also has to be taken into consideration in the design. Alternatively, the spring/bolt system can also be arranged axially in order to eliminate the influence of centrifugal force. Furthermore, the number of the spring element/bolt units is arbitrary depending on the safety coupling 1. With a larger number, the spring deflection decreases upon pressure changes, with the result that the change in the spring force is likewise reduced. As a result, the predetermined pressure, also referred to as setpoint pressure, can be kept within a tighter tolerance.

It should also be taken into consideration that the sealing of the bolt 16, illustrated by way of example as an O-ring in Figure 1, generates friction. On account of the friction, the entire spring/bolt system is affected with hysteresis with respect to the force required for a displacement of the bolt. The hysteresis can be influenced via the selection of the seal and also via the selection of the diameter of the bolt 16 and thus the resulting force. It is possible via these control variables to obtain a precisely tailored design of the self-regulating system.

It is the aim to keep the hysteresis as small as possible. However, since the seal 11 shown in Figure 1 always causes friction and thus hysteresis, the embodiment explained below on the basis of Figure 2 can be advantageous.

Figure 2 shows a safety coupling 1 in which the variable element 10 shown acts on a thin-walled region. The thin-walled region 7 constitutes a wall region of the pressure chamber 4. It is possible by means of the thin-walled region 7 to design the pressure chamber as a closed chamber and nevertheless to allow a variation of the volume of the pressure chamber 4 by an elastic deformation of the thin-walled region. Sealing of the variable element is thus not required. Seals are subject to ageing and thus constitute potential leakage points. Moreover, in this embodiment,

the hysteresis caused by the seal/friction is prevented. The operation does not otherwise differ from the operating principle described on the basis of Figure 1.

Figure 3 shows an alternative embodiment. In this embodiment, the variable
5 element 10 is arranged so as to be displaceable in the radial direction 9 along the longitudinal axis 12 of the variable element 10 by means of a provided drive 30. The variable element 10 is provided with a thread 19 such that a rotational movement by a drive 30 results in a linear movement of the variable element 10. Activating the
10 drive 30 makes it possible to set the volume of the pressure chamber 4 and thus the pressure in a targeted manner. The drive provided is an electric motor which is arranged on the input shaft in a positionally fixed manner. In order to activate the electric motor, a controller and assigned sensors, as shown in particular in Figure 10, can be provided.

15 The embodiment shown in Figure 4 corresponds to the embodiment shown in Figure 2 with a thin-walled region. However, in the embodiment shown in Figure 4, a drive 30 is provided for positioning the variable element. A drive for driving the variable element and the associated advantages are described in more detail below on the basis of Figure 10.

20

If a further threaded bolt (not shown) is provided for preloading, the spring preloading travel by this threaded bolt can be varied in a targeted manner. It is thus possible to be able to set pressures in a targeted manner via the spring preloading.

25 The energy supply of the motor can occur via energy harvesting 32. Thus, a generator which recovers electrical energy from the rotational energy of the safety coupling can make this energy available to the motor. A further alternative for the energy supply of the motor is the energy transfer from a stationary element to the rotating motor. This can occur for example via a slip ring or via contactless energy
30 transfer, such as for example an inductive or capacitive energy transfer or via laser or microwaves.

Figure 5 shows an embodiment in which the bolt 16 provided as variable element 10 is arranged parallel to the axis of rotation 8. The end of the bolt 16 that faces away from the spring element 13 is connected to the pressure chamber 4 via a connecting duct 23. The arrangement of the variable element 10 parallel to the axis of rotation 8 eliminates the influence of the rotational speed-dependent centrifugal force on the variable element 10 and the spring element 13, apart from acting frictional forces. The axial length of the safety coupling 1 is increased by this arrangement of the variable element 10. The basic mode of operation corresponds to the operation described on the basis of Figure 1.

The oil column of height h of course continues to be subject to the influence of centrifugal force. That is to say that the pressure of the oil column at the point B will be less than the pressure at the point A on account of the centrifugal force. In order to keep this influence as small as possible, the height h and thus also the bolt diameter 17 are to be chosen to be as small as possible. Accordingly, it can be expedient from the point of view of minimizing the influence of centrifugal force to choose a variable element 10 with as small a diameter as possible. A plurality of variable elements distributed over the circumference can be used.

A further embodiment is explained on the basis of Figures 6 and 7. More variable elements 10 are provided in this embodiment. The variable elements take the form of bolts 16 and are arranged so as to be distributed over the circumference. Each variable element is assigned a respective spring element 13. By virtue of the assigned spring element 13, force is applied to each variable element 10 in the direction of the pressure chamber 4. The variable elements are mounted in the input shaft so as to be displaceable in the axial direction. Seals 11 are provided such that no hydraulic medium can escape from the pressure chamber. This embodiment is distinguished by a particularly compact design and a short axial overall length even with an axial arrangement of the variable elements. Instead of the plurality of variable elements 10, the variable element 10 could also be provided in the form of a ring by means of which the pressure chamber 4 is closed off at an axial end. For application of force, a plurality of spring elements or one spring element could be

provided. To prevent rotation of the variable element 10, a guide 15 is provided. A rotation of the variable element 10 about the axis of rotation 8 would be disadvantageous on the one hand for the seals 11 because of increased wear and also for the spring elements.

5

An exemplary embodiment with axially arranged variable element with assigned drive is explained on the basis of Figures 8 and 9. The drive 30 provided is an electric motor. The motor is fixedly connected to the input shaft 2. A gearwheel 33 is seated on a rotationally driveable output shaft of the motor 30. The gearwheel 33 meshes with a toothing 21 of the variable element 10. The variable element 10 is arranged coaxially to the output shaft and is mounted so as to be axially displaceable in the input shaft. One end acts on the pressure chamber 4 arranged in the input shaft. In this embodiment variant, one end projects directly into the pressure chamber. In this embodiment, sealing is provided by two seals 11a, 11b, with the result that no hydraulic medium can escape from the pressure chamber 4 in the region of the variable element 10. One of the seals 11a is provided for sealing the inner lateral surface, and the second seal 11b is provided for sealing the outer lateral surface. The variable element 10 as screw element 18 is provided with a thread 19. The thread 19 engages in a thread formed in the input shaft 2. By virtue of this thread, an axial movement of the variable element 10 results from the rotational movement of the variable element 10. That is to say that the variable element 10 simultaneously carries out a rotational movement and an axial movement 8 parallel to the axis of rotation. The gearwheel with the toothing 21 of the variable element 10 constitutes a first transmission stage, and the thread constitutes a second transmission stage. This construction with the drive is of compact design, and the axial lengthening of the safety coupling brought about by the variable element is less than 10% of the length of a comparable safety coupling without variable element.

30 A safety coupling with assigned sensor system is explained on the basis of Figure 10. For active control of the position of the variable element 10, signals from assigned sensors are forwarded to a controller. A temperature sensor 51 can be

provided. In this exemplary embodiment, the temperature sensor is arranged to detect the ambient temperature on the outer circumference of the input shaft 2. As a result, it is possible for an increase in volume of the hydraulic medium enclosed in the pressure chamber 4 to be inferred in dependence on the detected temperature on the basis of data stored in a controller. There can also be provision to directly detect the temperature of the hydraulic medium by a temperature sensor. The advantage with a temperature sensor 51 arranged on the outer circumference is that it can be readily replaced in the event of a defect. The coefficients of thermal expansion of oil (about $70 \mu\text{m}/(\text{mK})$) and steel (about $12 \mu\text{m}/(\text{mK})$) are virtually independent of the actual temperature. The thermal dependency of the coefficient of expansion can thus be disregarded. If the coupling is filled at room temperature of 25°C and the desired pressure is set, the pressure will increase at temperatures $> 25^\circ\text{C}$ as a result of the greater expansion of the oil. At temperatures $< 25^\circ\text{C}$, the pressure will lower on account of the fact that the oil volume decreases more than the volume of the pressure chamber.

Moreover, as an alternative to the temperature sensor 51, a pressure sensor 52 can be provided for detecting the pressure in the pressure chamber 4. The sensor can also be integrated in the variable element 10, this not being shown. Consequently, in the event of a defect, it can be possible by exchanging the variable element to exchange the pressure sensor. There can also be provision to introduce the pressure sensor 52 with the variable element demounted. To accommodate a pressure sensor, a recess (not shown) could be provided in the pressure chamber.

In the illustrated embodiment, a torque sensor 53 is provided on the output shaft. It is thus possible to detect what torques are transmitted via the safety coupling. Consequently, it is possible, when a predetermined pressure or predetermined transmittable torque has been exceeded, to correct or adapt the pressure in the pressure chamber by means of an active activation. However, since the variable element is inert, this information can be provided in particular for a self-learning system for maintaining the transmission of the predetermined torque.

Alternatively or additionally, rotational speed sensors 54 can be provided on the input shaft and/or output shaft, or the rotational speed information can be made available by adjoining units, such as a drive assigned to the input shaft 2.

- 5 The data from the sensors are forwarded to and processed by an assigned controller 22. The controller 22 can be arranged on the safety coupling 1 or be integrated in a separately arranged control unit 55.

10 For supply with electrical energy, an energy recovery unit 32 is provided, with preferably the part supplying the electrical energy being arranged to corotate with the safety coupling. Coils can thus be arranged on the outer shaft that corotate with the shaft and are surrounded by magnets arranged in a positionally fixed manner. Other units for energy recovery, such as for example ones based on piezo elements, can also be provided.

15

Figures 11 discloses an embodiment with a thin walled region .The thin-walled region 7 can also be designed as separate part in form of a membrane 107. This membrane 107 can be attached to the Safety coupling with for example a force-fit (e.g.screws) or with a bonded connection (e.g. welding, soldering, glue, ...). The
20 sealing between the membrane and the Safety coupling can be done for example with a rubber sealing ring. If a bondend connection is used, as shown in furgure 12, the bonding itself can also be able to seal the application.

The membrane 107 of figure 11 is shown in detail in figure 11d. The membrane 107
25 can be deflected by a bolt 16. Wherein the bolt 16 can be moved by a drive, not shown. In figure 11b the bolt 16 and the membrane 107 is shown in more detail. For increase of the pressure in the pressure chamber 4, the bolt 16 is moved radial inwardly, figure 11c. Then membrane 107 is supported by the surface of the bolt 16 to decrease the strain of the membrane 107.

30

In figure 12 a similar embodiment is shown, wherein the membrane is not secured by the use of a flange connection. In this embodiment the membrane 107 is secured by a welded connection.

- 5 In Figure 13 another embodiment comprising an alternative form of the membrane 107. The membrane 107 has a bellows form. It is possible to support the membrane in the deformed position with a stiff structure in order to decrease the stresses in the membrane, wherein stress occurs in dependence of the pressure in the pressure chamber and the force applied by the stem 16. In this embodiment the membrane
- 10 107 is secured in a bolt which is connected to the output shaft 3 by a screw 118. The pressure in the pressure chamber 4 is changed in dependence of a radial movement of the bolt 16. A drive for movement of the bolt is not shown.

The embodiment of figure 14 shows an embodiment, wherein an outer section of

15 the pressure chamber is designed as a thin-walled sleeve. As a result, this thin-walled sleeve is deflected and produces a variation in the volume of the pressure chamber. No leakage can thus occur because the pressure chamber 4 is a closed chamber. The variable element 10 influences the volume of the pressure chamber 4 indirectly. Especially this construction is thus particularly durable. Surrounding the

20 thin-walled sleeve by a stripe 110 with a bolt 16 as a clamping device to control its deflection, thus controlling the pressure in the chamber 4. The clamping force can come from a mechanical screw connection or an electric drive 30 or hydraulic actuator.

25 Further it is possible to have a variable element, wherein the variable element is made from piezo elements. By applying electric voltage from the outside the element inside the pressure chamber changes volume by the effect of reverse piezo electricity. Thus the pressure inside the pressure chamber 4 can be changed. Since there is only electrical connection from the outside to the inside of the chamber, no

30 leakage can occur as a result of this kind of variable element. This construction is thus particularly durable.

List of reference signs

	1	safety coupling
	2	input shaft
5	3	output shaft
	4	pressure chamber
	5	flange of the input shaft
	6	flange of the output shaft
	7	thin-walled region
10	8	axis of rotation/axial direction
	9	radial direction
	10	variable element
	11	seal
	11a	seal on the inner circumference
15	11b	seal on the outer circumference
	12	longitudinal axis of the variable element
	13	spring element
	14	cover
	15	guide of the variable element
20	16	bolt/stem
	17	bolt diameter
	18	screw element
	19	thread of the variable element
25	21	toothing
	22	controller
	23	connecting duct
	24	frictional connection/force-fitting connection of 2 and 3
30	30	drive, electric motor
	32	energy recovery unit; harvesting unit (generator/piezo element)

- 33 gearwheel of the output shaft of the drive
 - 51 temperature sensor
 - 52 pressure sensor
 - 53 torque sensor
 - 5 54 rotational speed sensor
 - 55 central control unit
 - 107 membrane
 - 108 welding joint
 - 116 surface of the bolt
- 10

Patent Claims

1. Safety coupling (1) comprising an input shaft (2) and an output shaft (3), wherein the input shaft (2) and the output shaft (3) are arranged coaxially to one another, and the input shaft (2) and the output shaft (3) can be connected to one another in a force-fitting manner by means of pressurization of a pressure chamber (4) formed in the safety coupling,

characterized

in that the pressure chamber (4) has a volume V_0 , wherein, to vary the volume of the pressure chamber (4), a variable element (10) acts on the pressure chamber (4).

2. Device according to Claim 1,

characterized

in that the variable element (10) is arranged such that it can be pushed into the pressure chamber (4).

3. Device according to Claim 1 or 2,

characterized

in that force is applied to the variable element by a spring element (13).

4. Device according to one of the preceding claims,

characterized

in that the variable element (10) is a bolt (16).

5. Device according to one of the preceding claims,

characterized

in that the variable element (10) is a screw element (18).

6. Safety coupling according to one of the preceding claims,

characterized

in that the pressure chamber (4) is closed off and designed with a thin-walled region (7), and the variable element (4) acts on the thin-walled region (7) of the pressure chamber (4) to vary the volume of the pressure chamber (4).

- 5 7. Safety coupling (1) according to one of the preceding claims,
characterized

in that the variable element (10) is assigned a drive (30), wherein the position of the variable element (10) can be varied by the drive (30) in order to vary the volume of the pressure chamber (4).

10

8. Safety coupling (1) according to one of the preceding claims,
characterized

in that the safety coupling (1) is provided with a temperature sensor (51).

- 15 9. Safety coupling (1) according to one of the preceding claims,
characterized

in that a pressure sensor (52) for detecting the pressure in the pressure chamber (4) is provided, wherein the variable element (4) is preferably provided with a pressure sensor (52).

20

10. Safety coupling (1) according to one of the preceding claims,
characterized

in that the safety coupling (1) is provided with a torque sensor (53), wherein the torque sensor (53) preferably detects the torque transmitted to the output shaft (3).

25

11. Safety coupling (1) according to one of the preceding claims,
characterized

in that a rotational speed sensor (54) is provided for detecting the rotational speed of the input shaft (2) and/or of the output shaft (3).

30

12. Safety coupling (1) according to one of the preceding claims,
characterized

in that the variable element (10) is arranged so as to be displaceable in the axial direction (8).

13. Safety coupling (1) according to one of the preceding claims,

5 **characterized**

in that the variable element (10) is provided with a toothing (21).

14. Safety coupling (1) according to one of the preceding claims,

characterized

10 in that, in an embodiment with a drive (30) for deflecting the variable element (10), a controller for controlling and/or regulating the pressure in the pressure chamber (4) is provided.

15. Method for controlling or regulating the pressure in a pressure chamber (4)

15 of a safety coupling (1) according to one of the preceding claims,

characterized

in that a controller (22) is provided, and the controller (22) is supplied with data from at least one of the following sensors, such as a temperature sensor (51), pressure sensor (52), rotational speed sensor (54) and/or torque sensor (53), and the drive

20 is activated to set the position of the variable element (10).

Fig.1

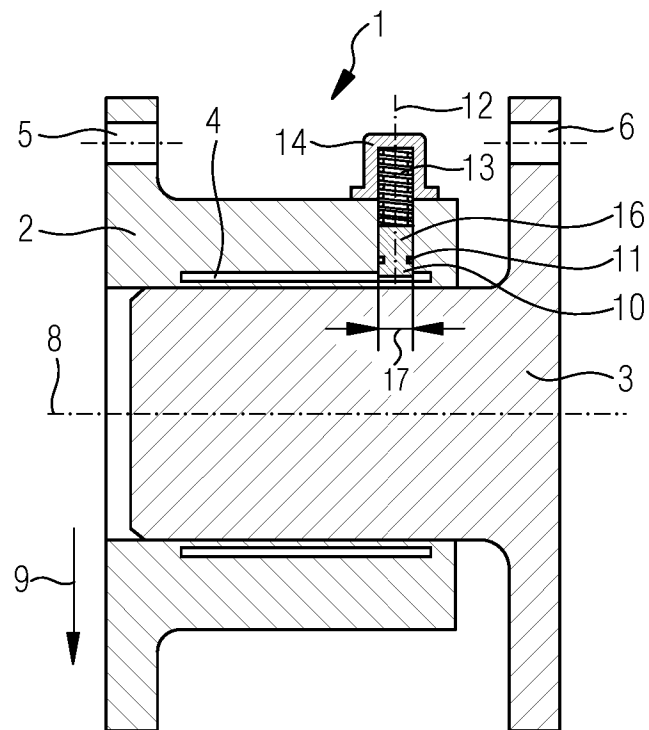


Fig.2

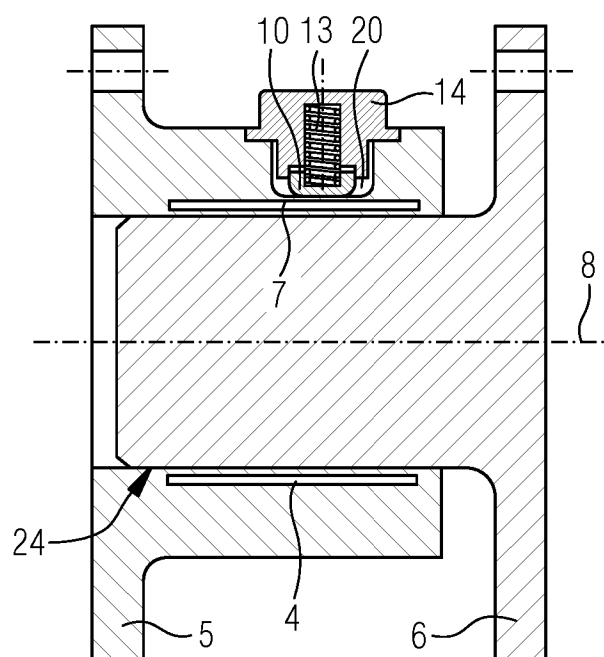


Fig.3

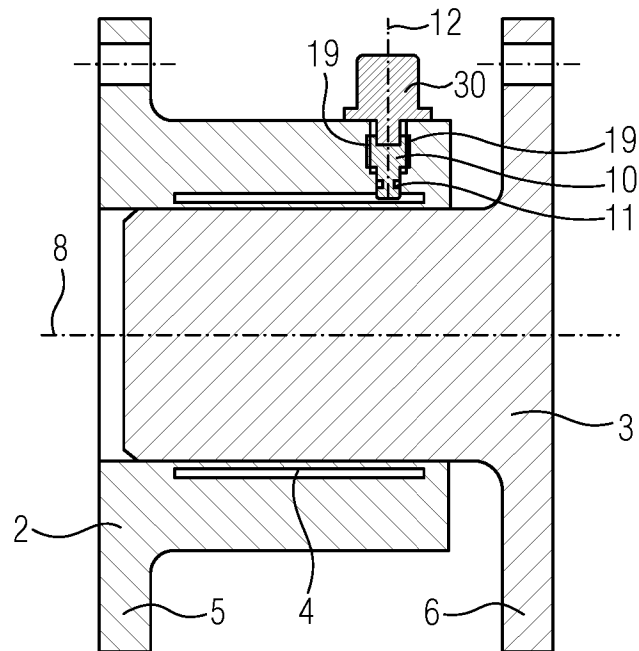


Fig.4

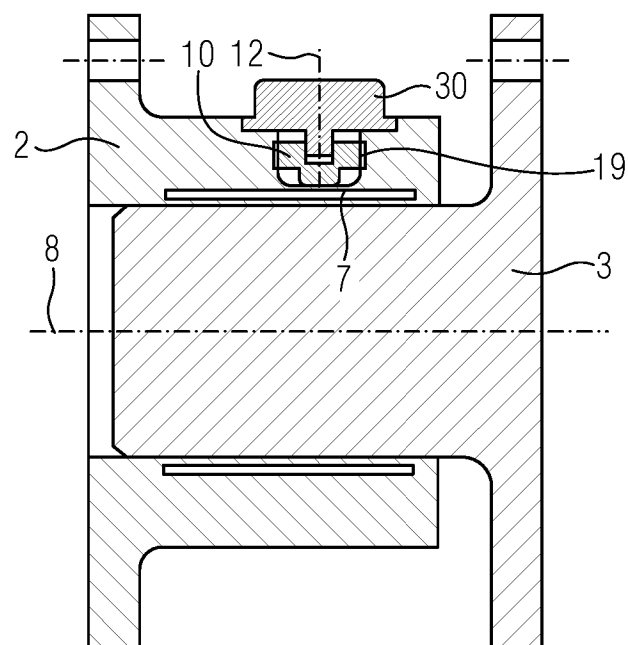


Fig.5

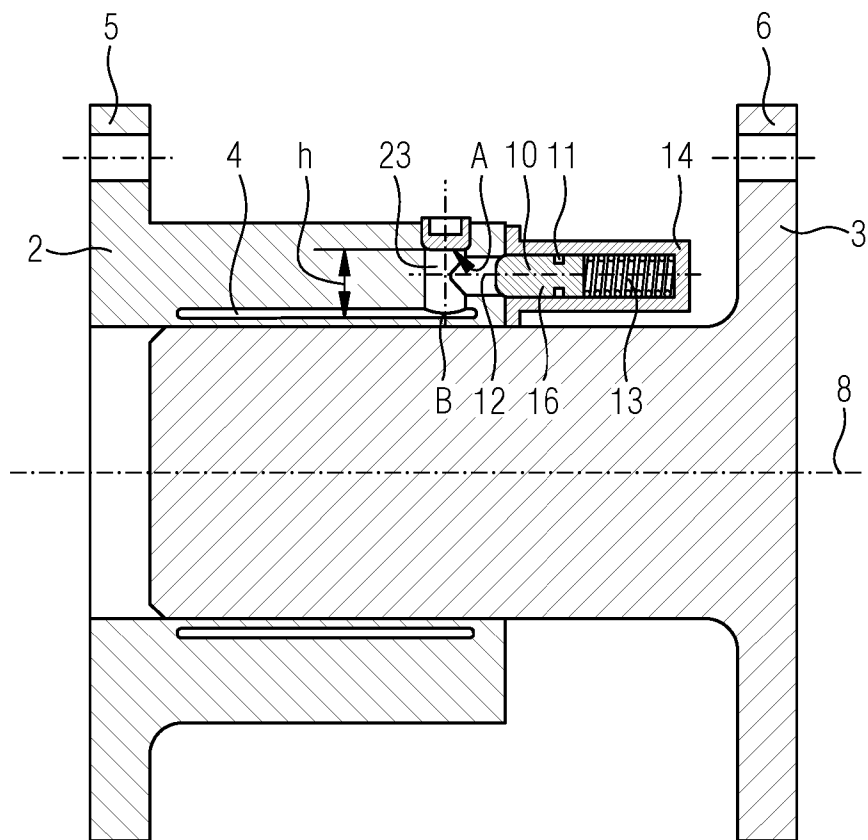


Fig.6

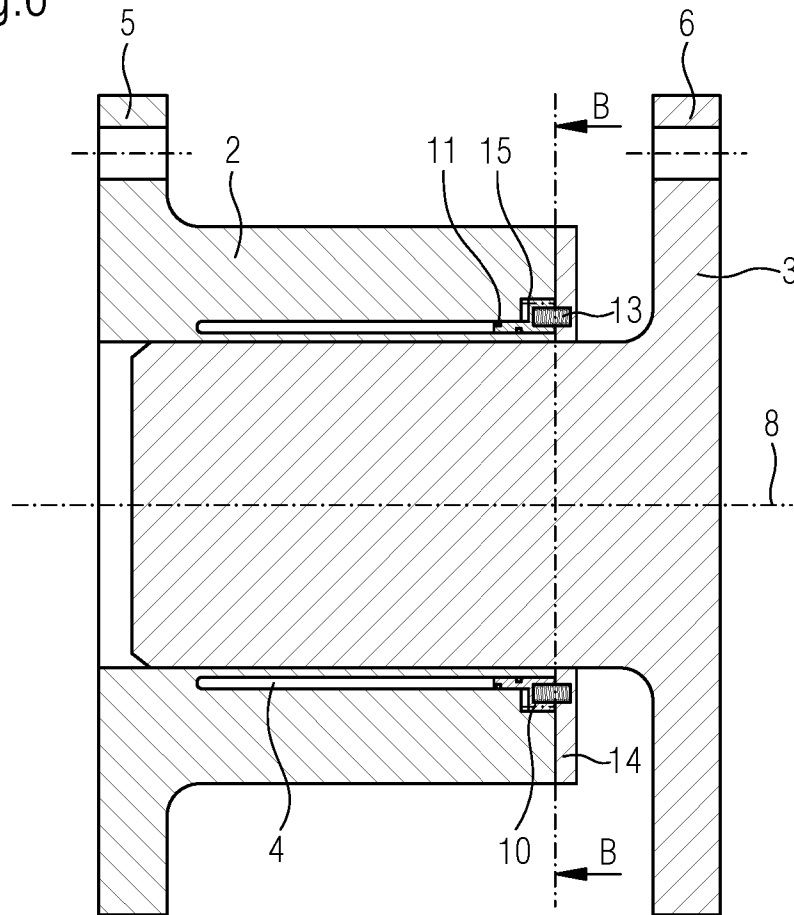


Fig.7

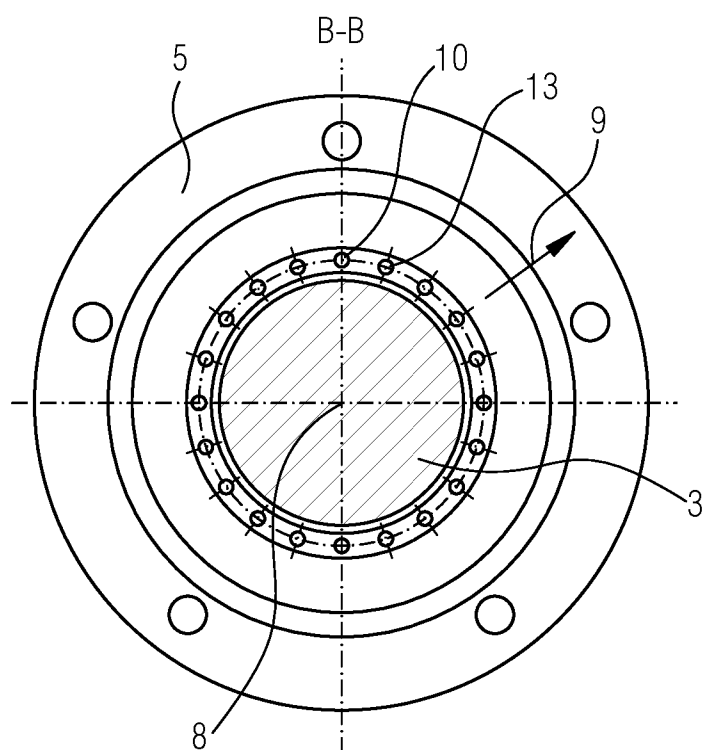


Fig.8

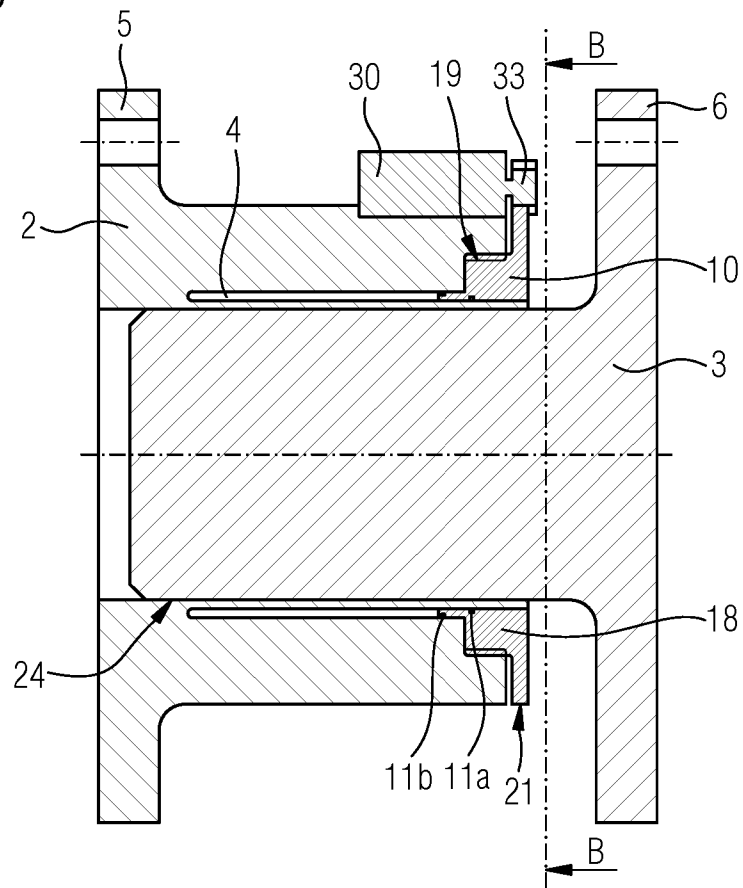


Fig.9

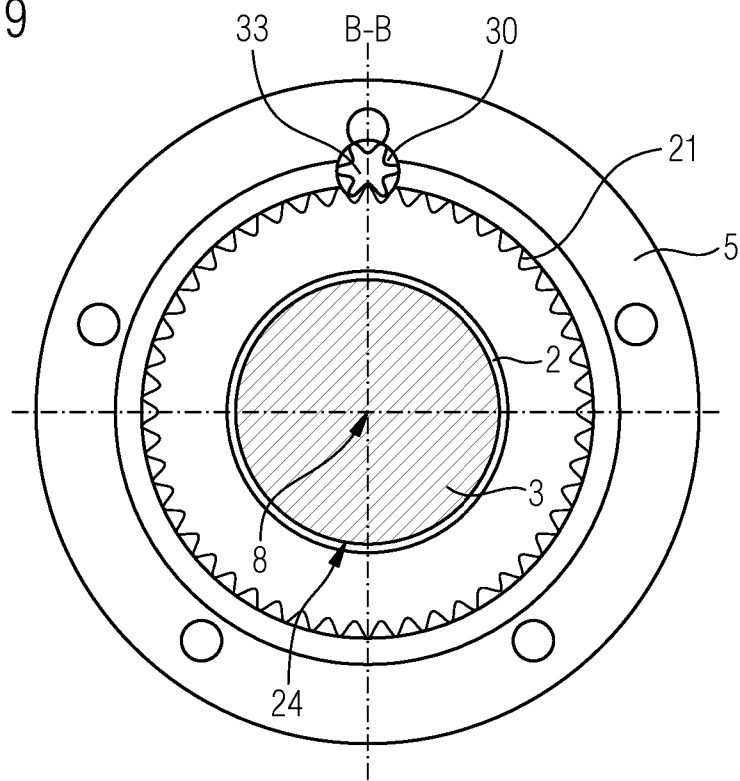


Fig.10

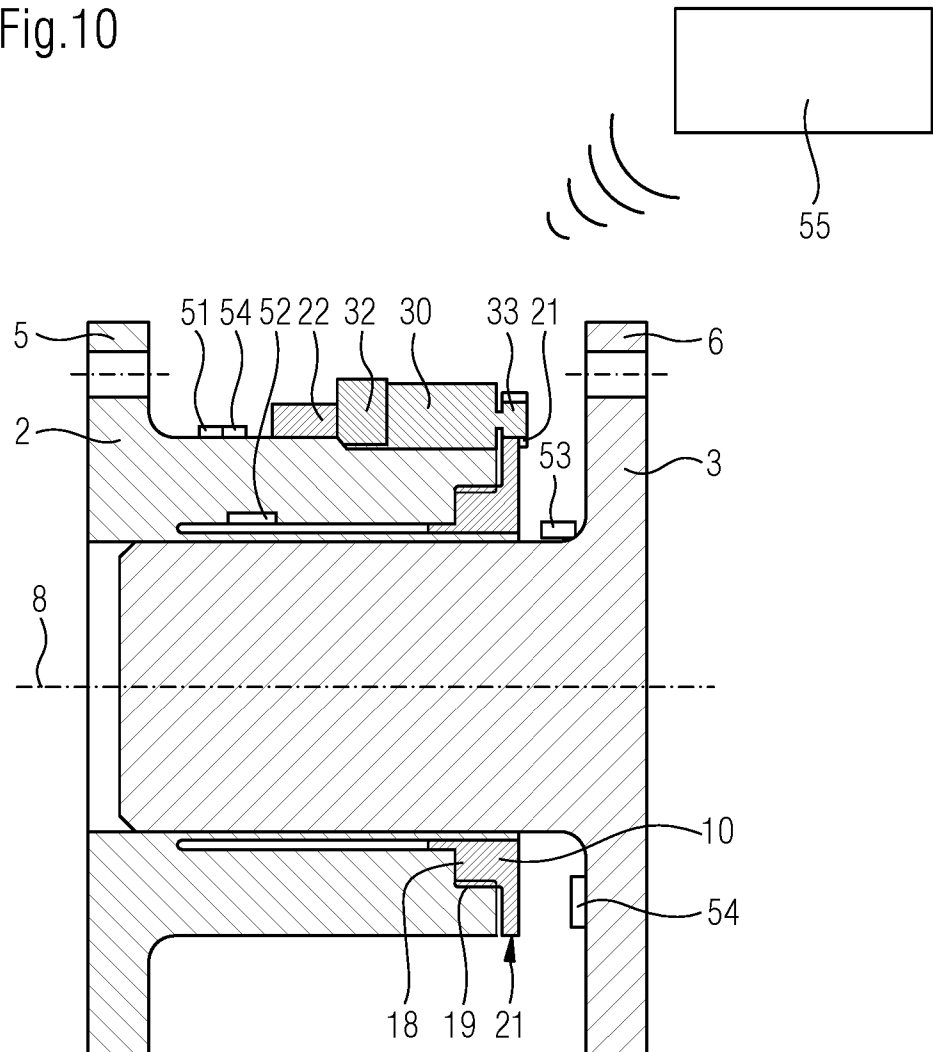


Fig.11a

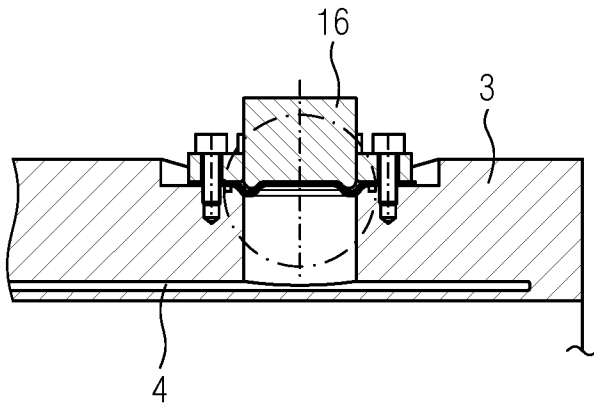


Fig.11b

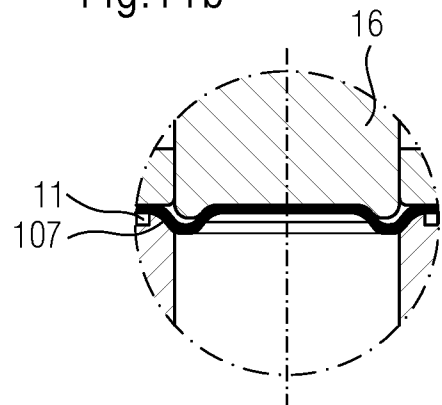


Fig.11c

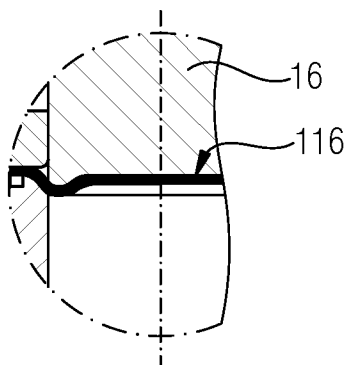


Fig.11d

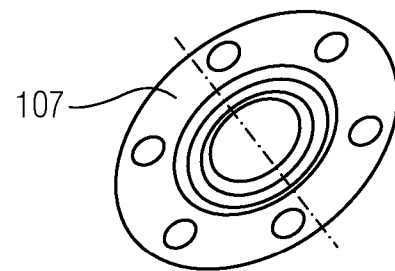


Fig.12a

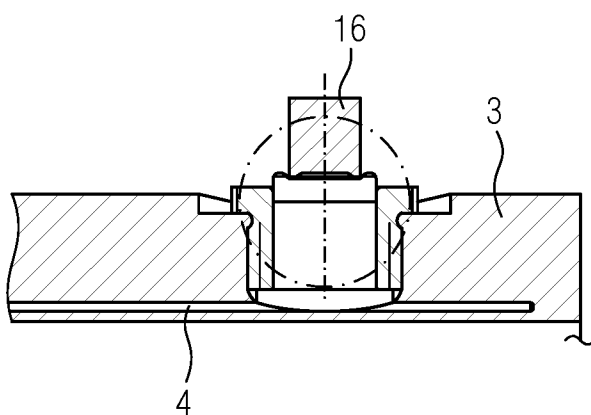


Fig.12b

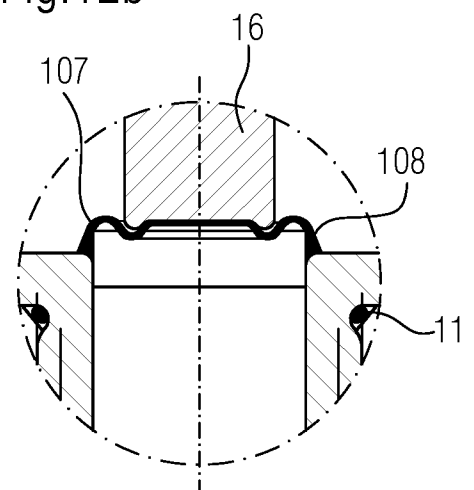


Fig.13

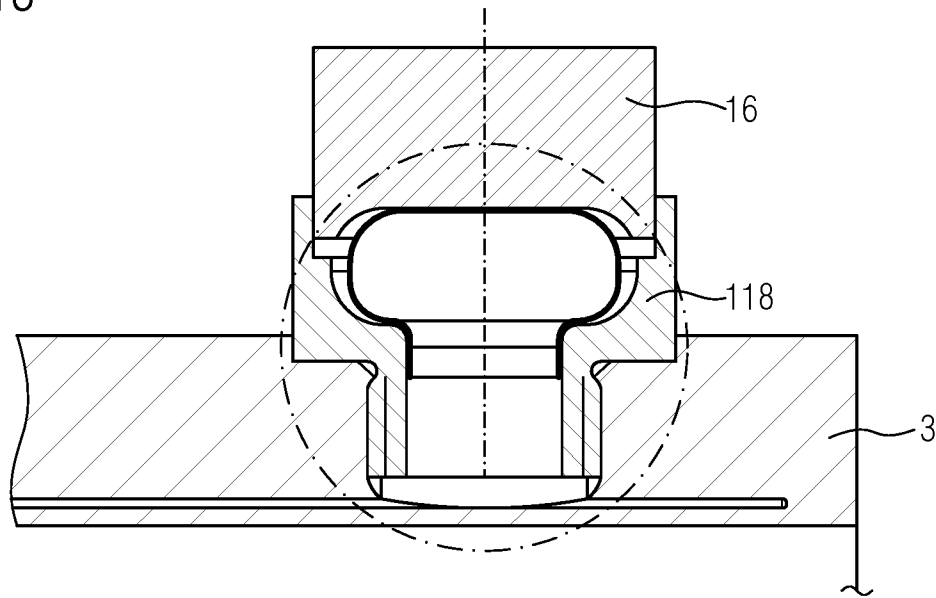
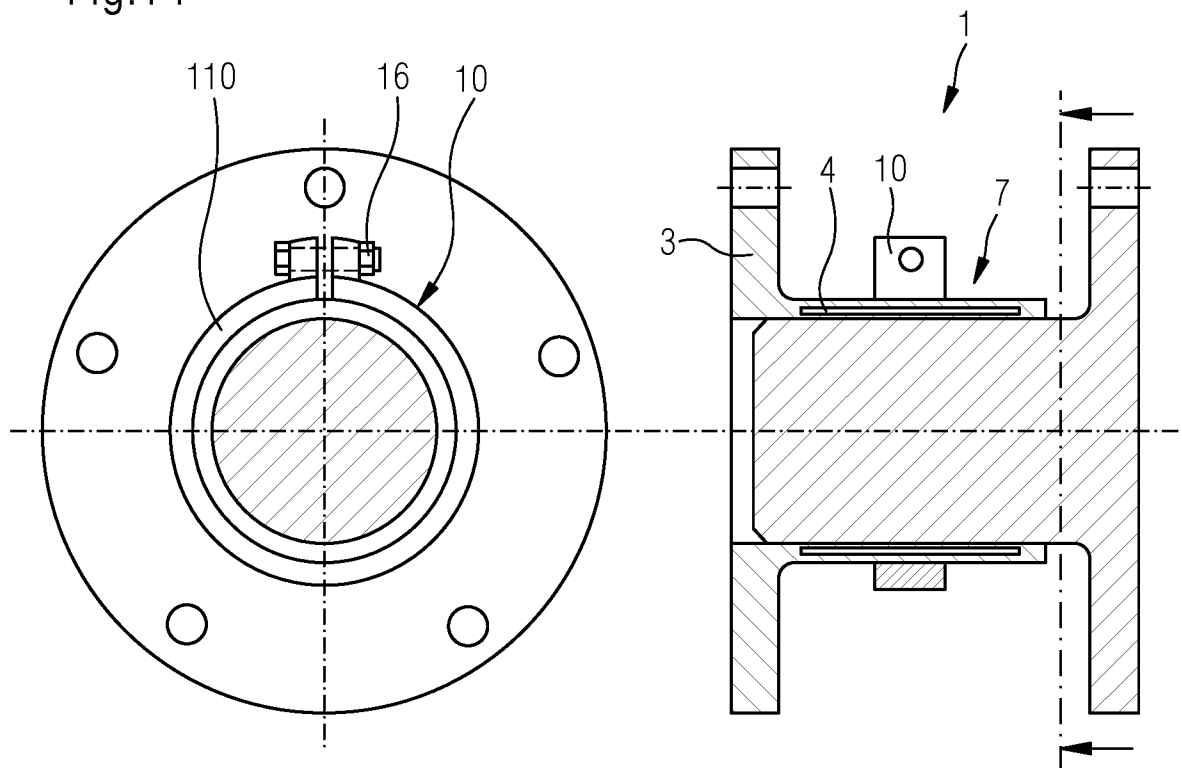


Fig.14



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/056645

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16D13/10 F16D25/04 F16D1/08 F16D48/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 27 07 530 A1 (FOERENADE FABRIKSVERKEN) 25 August 1977 (1977-08-25)	1-13
A	figures 3,4	14,15
X	DE 24 03 337 A1 (METALFORM AB) 1 August 1974 (1974-08-01)	1-13
Y	figures 2,3,4 page 8, paragraph 2	14,15
X	US 5 201 842 A (ELSNER ERNST [DE]) 13 April 1993 (1993-04-13)	1-4,14
Y	figure 1 column 3, line 20 - line 22	14,15
X	WO 2017/140506 A1 (VOITH PATENT GMBH [DE]) 24 August 2017 (2017-08-24)	1,8-11, 14,15
	figures 1,3 the whole document	
	- / - -	



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

17 June 2020

Date of mailing of the international search report

26/06/2020

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Authorized officer

Michel, Aaron

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2020/056645

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International application No

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