(19) DANMARK

(10) **DK/EP 3150868 T3**

(12) Oversættelse af europæisk patentskrift

Patent- og Varemærkestyrelsen

(51) Int.Cl.: ***F 16 B 31/02 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2018-01-02**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2017-09-13**

(86) Europæisk ansøgning nr.: **15187980.6**

(86) Europæisk indleveringsdag: **2015-10-01**

(87) Den europæiske ansøgnings publiceringsdag: **2017-04-05**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

(73) Patenthaver: **Volborth, Thomas, Waldweg 7, 58553 Halver, Tyskland**

(72) Opfinder: **Volborth, Thomas, Waldweg 7, 58553 Halver, Tyskland**

(74) Fuldmægtig i Danmark: **Budde Schou A/S, Hausergade 3, 1128 København K, Danmark**

(54) Benævnelse: **Indretning til kontrol af skrueforbindelser**

(56) Fremdragne publikationer:
DE-A1- 19 831 372
DE-A1-102007 027 218
DE-A1-102009 047 396
US-A- 2 850 937
US-A- 4 483 648

The invention concerns a device for checking screwed connections in accordance with the characterising section of claim 1. The invention concerns furthermore a method of manufacturing a device as described in patent claim 9. Screwed connections are known in very diverse applications. They are used for detachably connecting two or more parts. To reliably fasten the parts, sufficient axial force is required of the screwed connection. The torque acting on the screw thread when the screwed connection is screwed in causes axial force or pre-stressing force to be exerted through the screw thread.

Particularly in the case of safety-critical screwed connections of the kind used in, for example, power station construction, motor vehicle manufacture, mining and the like knowledge of the reliability of the screwed connection set up is of great importance. For this reason safety-critical screwed connections are usually made with torque wrenches to ensure that the tightening torque required for a screwed connection is generated. Because the pre-stressing force could be determined only by effortful measuring methods, that tightening torque is precautionarily employed that is generated to achieve the screwed connection. This kind of check is fundamentally reliable but carries the proviso that, taking into consideration coefficients of friction, the tightening torque is only an auxiliary quantity for ensuring that the required pre-stressing force is generated for the screwed connection. Scatter with regard to the pre-stressing force resulting from the tightening torque is caused by, amongst other things, the construction and quality of the connecting elements with regard to screw thread form, screw thread screwing action, etc., and the tolerance of the measuring means (torque wrench) and the friction coefficient scatter of the screwed connection elements. To this extent considerable scatter or risk potential results from the use of the derived value “torque” instead of the desired value “pre-stressing force”. However, it does not offer the possibility of identifying direct during subsequent check of the screwed connection whether the required torque was generated when the screwed connection was made.

To enable a check of this kind to be carried out, various solutions are known from the state of the art. So, for example, a washer unit is known from DE 31 48 730 C2 in which a measuring means formed of balls of different diameters embedded in an elastic layer is provided for between two washers. Furthermore, DE 198 31 372 A1 offers a device for checking non-positive connections in which a measuring system having two disk-shaped component parts and comprising a measuring layer made of, for example, piezoelectric material is provided for. From US 4,483,648 a washer is also known that incorporates an angled section that, when the nut or the screw is tightened, is pressed continuously against the component part. A similar principle is disclosed in US 6,152,665. Here the washer is provided with notches that delimit bulging strips that are continuously pressed against the component part by the nut or screw when these are being tightened. The strips here are dimensioned so as to protrude beyond the outside diameter of the washer when pressed. A generic device is described in US 2,850,937.

The known devices fulfil their function but are either difficult to design, because they require a relatively large number of additional component parts or the device concerned requires a supply of electric power, or they do not enable the presence of a specified pre-stressing force (or a specified tightening torque) to be identified with the naked eye.

The purpose of the invention is to remedy this disadvantage. The invention is based on the problem of creating a device for checking screwed connections that reliably indicates to the naked eye when a specified pre-stressing force has been reached, is simple to construct and functions purely mechanically. In accordance with the invention this purpose is fulfilled by the features described in the characterising section of claim 1.

By the invention a device for checking screwed connections is created that reliably indicates to the naked eye when a specified pre-stressing force has

been reached, is simple to construct and functions purely mechanically. The metastable state of the indicating element achieved by mechanical pre-stress causes this indicating element to undergo significant, sudden deformation visible to the naked eye when a specified pre-stressing force acts on the device. This kind of construction has the advantage that deformation of the indicating element does not take place until the specified tightening torque is achieved. In this way the indicating element is prevented from changing when only approximately sufficient pre-stress is applied that is not yet precisely that set at the design stage. This ensures that the device according to the invention does not send a confirmation signal until the specified tightening torque in the screwed connection or the specified pre-stress has been reached. Furthermore, triggering of the transition from the metastable state to the stable state is accompanied by an acoustic noise giving an additional indication that the specified tightening torque has been reached.

An essential feature of the invention is provision for pre-stress in the washer, whereby a “force reservoir” is set up that enables the washer or part of the washer to deform suddenly (transition from metastable state to stable state) when the required pre-stressing force is reached. Here, instead of the continuous deformation known to the state of the art, where such deformation cannot be identified with the naked eye and cannot sufficiently indicate that a specific tightening torque or a specific pre-stressing force has been reached, a sudden significant change from a first state to a second state is undergone that enables immediate identification that a specified pre-stressing force required to trigger the transition from the metastable state to the stable state has been reached. The washer is preferably manufactured from a spring steel.

The device is constructed in one single piece. The device in accordance with the invention therefore needs only one additional component part, namely, the washer. If a washer is already provided for for the screwed connection, the number of component parts actually remains unchanged.

The indicating element here is formed by a radial section of the washers. This likewise enables the sudden deformation to be clearly visually identified. The material of the radial section is preferably entirely or partly reduced in thickness.

In one embodiment of the invention an outer radial section is pre-stressed relative to an inner radial section that is shaped like a funnel extending axially outwards. This sets up a lever mechanism that because of the specified pre-stressing force enables a change from a metastable state to a stable state, even with greater material thicknesses. In an embodiment of the invention the outer edge of the inner radial section is stamped in such a way as to form a virtually level horizontal surface. This reduces the distance required to initiate the sudden deformation.

In a further embodiment of the invention a level inner ring surface is arranged which a collar extending axially and conically from the plane of the inner ring surface adjoins, which collar is formed on the inner ring section in such a way that a ring-shaped circumferential bulge is formed by the inner ring section and the collar, the cross-section of this bulge being shaped preferably like an inverted V. This enables lateral triggering of the sudden deformation of the pre-stressed outer area by the screw head or nut body resting against a circumferential bulge, so minimising the distance required for triggering.

In a further embodiment of the invention one or more arc-shaped, preferably ring-shaped, grooves that extends or extend between two radial sections is provided. By this the sudden deformation of the outer section forming the indicating element is supported.

In an advantageous embodiment of the invention the washer is ≤ 0.8 mm, preferably ≤ 0.7 mm, thick. It has been shown that by this reliable triggering

of the transition from the metastable to the stable state is guaranteed. Good results were achieved if the washer was manufactured from a spring steel.

The invention is further based on the problem of providing a method of manufacturing a device for checking screwed connections that reliably indicates when a specified pre-stressing force has been reached, is simply constructed and functions purely mechanically. According to the invention this purpose is fulfilled by the features described in claim 9. (The shape of the washer before the axial force is applied represents the stable condition, as can be seen from figure 4 and figure 9) Through the application of the axial force the washer enters a metastable state, as is shown in figure 5 and figure 8. By the process in accordance with the invention a washer is made to enter a metastable state so that, when a specified pre-stress is applied by a specified tightening torque on the screw or nut of the screwed connection in a specified area, a sudden, significant deformation that can be clearly seen with the naked eye takes place.

In a further development of the invention the second funnel-shaped section is at least twice, preferably at least four times, or more preferably at least five times the width of the first funnel-shaped section. This causes a clearly visible, sudden deformation to take place on transition from a metastable state to a stable state.

Other developments and embodiments of the invention are set out in the remaining subclaims. Practical embodiments of the invention are shown in the drawings and are described in detail below. The following are shown in the drawings:

Figure 1 a schematic diagram of a screwed connection with a checking device in a clamped condition;

Figure 2 a schematic diagram of the screwed connection shown in figure 2 before the nut is tightened (unclamped condition);

Figure 3 a schematic diagram of the washer of the screwed connection shown in figure 2 in plan view;

Figure 4 a schematic diagram of a screwed connection with a checking device in a further embodiment (unclamped condition);

Figure 5 a schematic diagram of a washer for a screwed connection in a third embodiment (metastable, unclamped condition)

a) in a spatial view;
b) in plan view;
c) in cross-section A-A;

Figure 6 a schematic diagram of the washer shown in figure 5 in the stable, clamped condition

a) in a spatial view;
b) in plan view;
c) in cross-section A-A.

In the example embodiment shown in figure 1 a screwed connection having a threaded bolt 1 protruding from a component part 2 (indicated). A nut 3 has been screwed onto the screw thread of the threaded bolt 1. A washer 5 serving as a checking device is visibly arranged between the component part 2 and the nut 3.

The washer 5 has been formed essentially circular in the example embodiment, with an inner ring section 51 incorporating a through-hole 52 and having an outer ring section 53. In this example embodiment the indicating element is formed by the outer ring section.

The washer 5 is constructed pre-stressed, so putting it into a metastable state. In this state the outer ring section 53 forms a level ring surface from which the inner ring section 51 projects in the form of a hollow truncated cone. When the screwed connection is in the unclamped condition, the nut rests on this inner ring section 51 shaped like a hollow truncated cone (cf. figure 2). In the example embodiment the inner ring section 51 is constructed stamped on its edge oriented towards the nut 3 so that the

edge 54, when the ring section 51 is in this hollow truncated cone-shaped state, forms a level contact surface parallel to the nut 3. By this the axial distance to be travelled by the nut 3 to trigger the washer is reduced.

If the nut is screwed further in, the inner ring section 51 is pushed towards the component part 2 until the ring section 51 lies flat on the component part 2. For this the pre-stress of the washer 4 has to be completely overcome. When the pre-stress has been overcome, the washer is “triggered”, so that it is suddenly restored to the stable state. At the same time the outer ring section 53 shifts to a state in which it widens conically towards the nut 3 and encloses the nut 3 like a collar (cf. figure 1). This stable state also continues when the nut is later loosened, so that in this embodiment the outer ring section 53 forms a reliable indicating element that indicates clearly to the naked eye whether the nut was originally tightened to the required, specified torque or with the specified pre-stressing force.

In the example embodiment shown in figure 4 the chcecking device is formed by a washer 6 in a further embodiment. Here an extension identical to the inner ring section of the washer 6 is formed on the inner ring section of the washer 6, so forming an inner ring surface 64 inside that is disposed in the plane of the outer ring section 63 and incorporates a through-hole 62 and that is connected to the edge of the inner ring section 61 by way of a collar 65 that widens conically outwards. The inner ring surface 64 is here dimensioned smaller than the circumference of the nut 3, so that, when the nut 3 is tightened, part of the pre-stressing force acts on the collar 65 by way of which the force required to trigger the washer 6 is finally transmitted to the inner ring section 61. This arrangement enables a device in accordance with the invention to be realised even for very high required tightening torques, because only part of the pre-stressing force is transmitted into the inner ring section 61 as a triggering force.

In the example embodiment shown in figure 5 a washer 7 incorporating an inner ring section that incorporates a through-hole 72 and that is connected to an outer ring section 73 is also used as a checking device in the screwed connection. In this example embodiment too the indicating element is formed by the outer ring section.

The washer 7 is likewise constructed pre-stressed so as to be put into a metastable state. In this state the inner ring section 71 is formed in the shape of a hollow truncated cone widening from the inside outwards and upwards and passes into the outer ring section 73 that forms a ring surface rising towards the outside (figure 5). Arranged between the inner ring section 71 and the outer ring section 73 is an undulate intermediate section 74 having a cross-section shaped like an “S lying on its side”. This intermediate section 74 rises first against the upward slope of the inner ring section 71 and then passes through a turning point into the upward slope of the outer section 73. When the screwed connection is in the unclamped condition, the nut (not shown in figure 5) lies on the intermediate section 74.

If the nut is screwed further in, the intermediate section 74 is pushed towards the component part 2 (not shown in figure 6) until the pre-stress of the washer has been overcome and “triggers” it so that it passes suddenly to the stable state. The outer ring section 73 meanwhile assumes a shape that widens conically towards the component part (not shown) on which the outer ring section 73 lies by its outer edge area. The inner ring section 71 now no longer lies on the component part but is pressed against the nut (not shown) by the outer ring section 73 (cf. figure 6). This in turn causes a pre-stress to be set up that acts to compensate for any settling and creeping of the screwed connection. In this example embodiment the outer ring section 73 forms, as it were, a reliable indicating element, because this outer ring element 73 does not come to rest on the component part until the stable state has been reached. Hereby it can be seen with the naked

eye whether the nut was originally tightened to the required, specified torque or with the specified pre-stressing force.

Visual support of the indicating element formed hereby can be achieved by providing the outer edge of the outer ring section 73 at least partly with a colorant reservoir that is broken by the sudden changeover of the outer ring section 73, so causing the colorant in the outer ring section to be released all the way round.

The invention enables screwed connections to be easily and at the same time reliably checked. Because after triggering the indicating element formed by the outer ring section 53, 63, 73 is flipped up or raised by the pre-stressing force stored in the washer, a visual means of checking is created that enables the screwed connection to be checked with the naked eye without any further assistance. Because of the stable state entered into by the indicating element after triggering the indication is a permanent one, so at any time well after the making of the screw connection and by which the pre-stressing force may have begun to diminish a reliable check can be carried out to determine whether the required pre-stressing force or the applied tightening torque was being exerted when the screwed connection was made.

The example embodiment shown in figures 5 and 6 also has the advantage that, after the stable state has been reached, pre-stress to additionally secure the screwed connection is set up. Further, the support surface on the washer 7 shown in this example embodiment changes from the inside outwards, so preventing the washer 7 from being forced into the surface of the component part. This washer 7 is therefore also especially suited for soft component part materials.

PATENTKRAV

1. Indretning til kontrol af skrueforbindelser, omfattende en underlagsskive til anbringelse på en gevindbolt, som omfatter i det mindste ét visningselement, idet underlagsskiven (5, 6, 7) i ubelastet tilstand i det mindste områdevis er mekanisk forspændt, hvorved denne har en metastabil tilstand, idet indretningen er dannet af nøjagtigt én underlagsskive (5, 6, 7) i ét stykke, og at visningselementet er dannet af et radialt afsnit af underlagsskiven (5, 6, 7), **kendetegnet ved, at** et udvendigt radialt afsnit (53, 63, 73) er forspændt i forhold til et indvendigt radialt afsnit (51, 61, 71), som strækker sig enten tragtformet aksialt ud fra planet for det udvendige radiale afsnit (53, 63) eller med en større stigning aksialt ud fra det udvendige radiale afsnit (73).

2. Indretning ifølge krav 1, **kendetegnet ved, at** det radiale afsnit i det mindste områdevis har en reduceret materialetykkelse.

3. Indretning ifølge krav 1 eller 2, **kendetegnet ved, at** den udvendige kant (54) på det indvendige radiale afsnit (51) er udformet præget således, at det har en tilnærmelsesvis plan horisontal flade.

4. Indretning ifølge ethvert af de foregående krav, **kendetegnet ved, at** en plan indvendig ringflade (64) er anbragt efterfulgt af en aksial konisk ud fra planet for den indvendige ringflade (64) udstikkende krave (65), som er dannet på det indvendige ringafsnit (61), således at der af det indvendige ringafsnit (61) og kraven (65) er dannet en ringformet rundtgående hvælving, som fortrinsvis har et tværsnit i form af et omvendt V.

5. Indretning ifølge krav 1, **kendetegnet ved, at** der imellem det udvendige radiale afsnit (73) og det indvendige radiale afsnit (71) er anbragt et bølgeformet mellemafsnit (74), som har et tværsnit i form af et "liggende S", og som først forløber modsatrettet stigningen for det indvendige ringafsnit (71) og derefter via et vendepunkt overgår til stigningen for det udvendige ringafsnit (73).

6. Indretning ifølge ethvert af de foregående krav, **kendetegnet ved, at** der på en side af underlagsskiven (5, 6, 7) er udformet i det mindste en bueformet, fortrinsvis ringformet fuge, som forløber imellem to radiale afsnit.

7. Indretning ifølge ethvert af de foregående krav, **kendetegnet ved, at** den udvendige kontur på underlagsskiven (5, 6, 7) er udformet cirkel- eller ellipseformet.

8. Indretning ifølge ethvert af de foregående krav, **kendetegnet ved, at** underlagsskiven (5, 6) har en tykkelse på mindre end 0,8 mm, fortrinsvis mindre end 0,7 mm.

9. Fremgangsmåde til fremstilling af en forspændt underlagsskive, ved hvilken først en cirkelformet eller oval ringformet skive deformeres således, at den har en indvendig tragtformet ringflade med en første stigning, som overgår til et i forhold til det første afsnit bredere andet tragtformede afsnit, som har en mindre hældning end det første tragtformede afsnit, efterfølgende anbringes den således udformede skive med sin udvendige kant på en plan flade, og efterfølgende bliver den indvendige ringflade påvirket således med en aksial kraft, at det andet tragtformede afsnit folder om i forhold til det første afsnit, hvorved forholdet imellem stigningen for den indvendige ringflade og den udvendige ringflade er ændret, og hvorved underlagsskiven antager en metastabil tilstand.

10. Fremgangsmåde ifølge krav 9, **kendetegnet ved, at** det andet tragtformede afsnit udgør i det mindste to gange, fortrinsvis i det mindste fire gange, særlig foretrukkent i det mindste 5 gange bredden af det første tragtformede afsnit.

Fig. 1

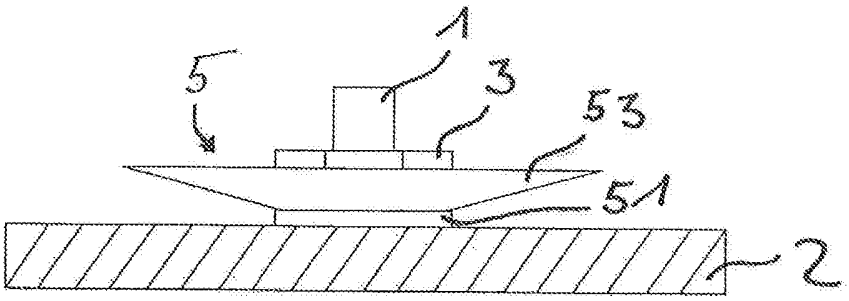


Fig. 2

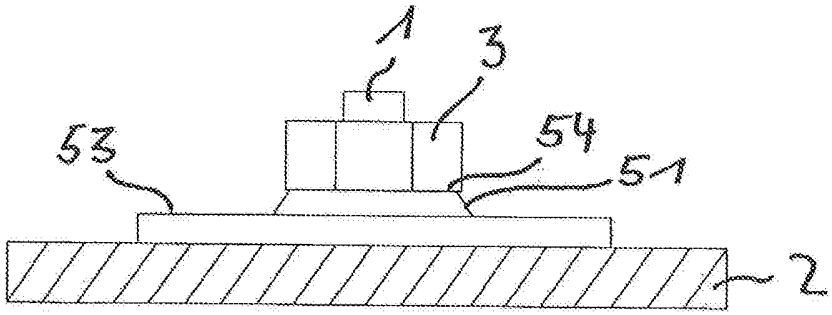


Fig. 3

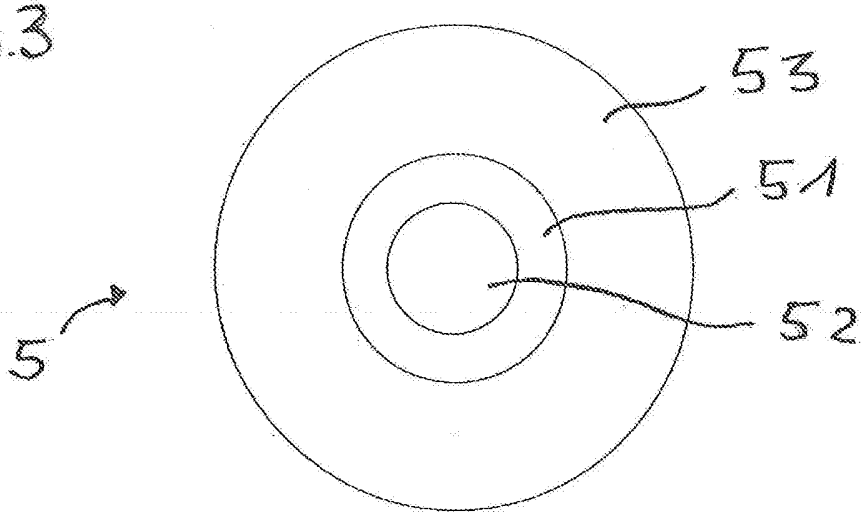


Fig. 4

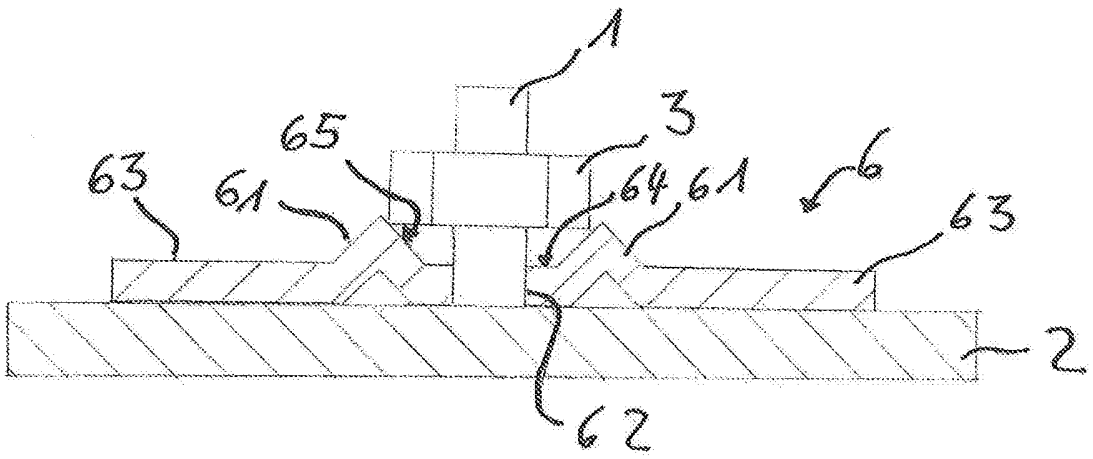


Fig. 5

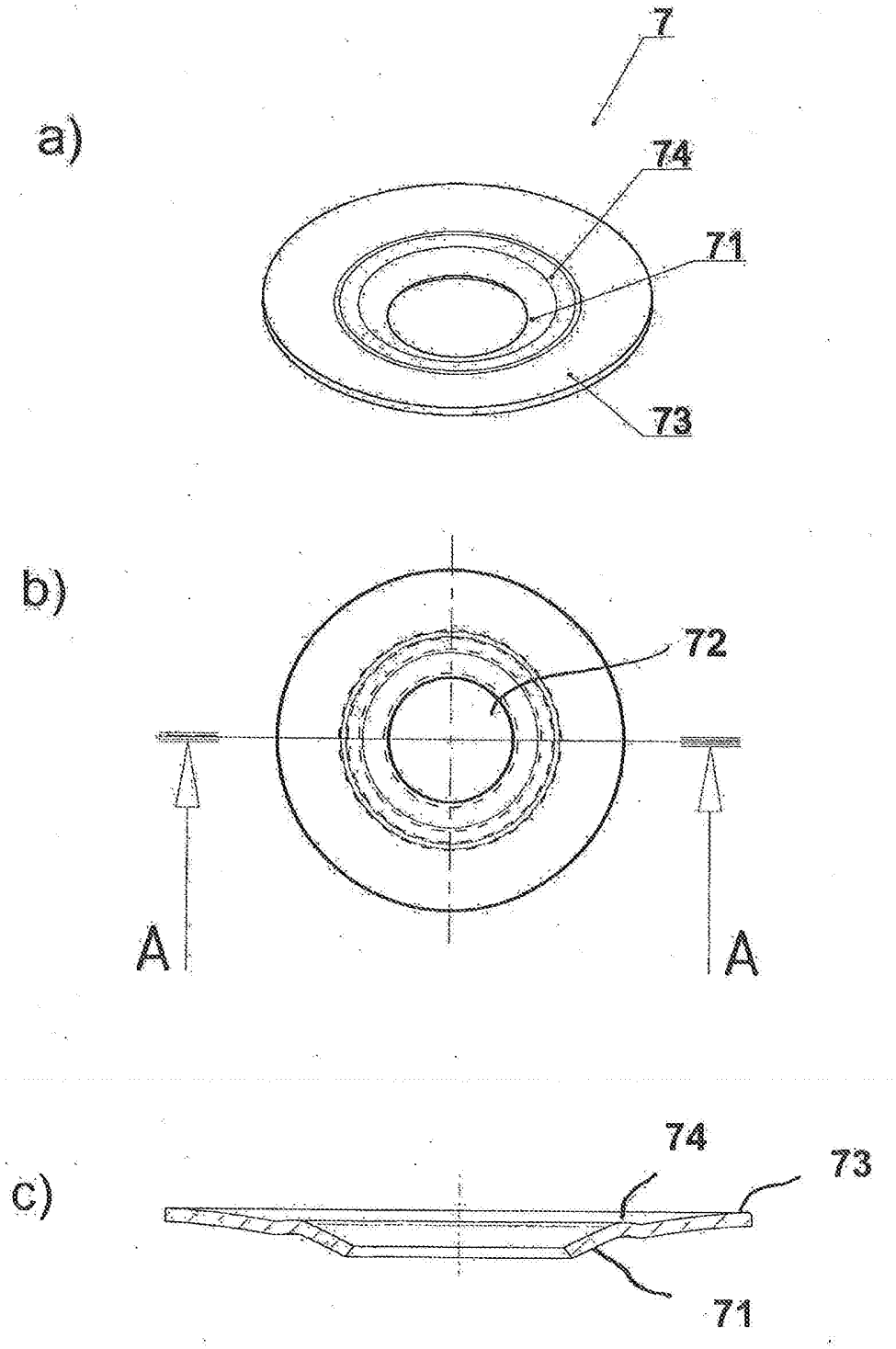
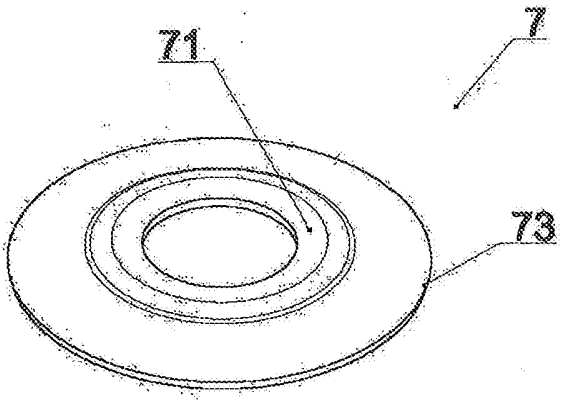
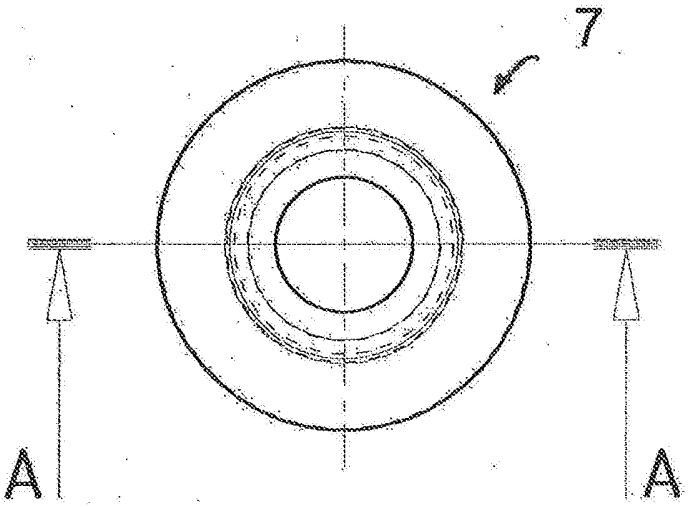
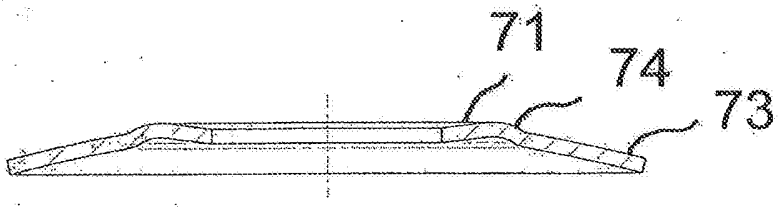


Fig. 6

a)



b)



c)