(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 195 415 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
14.06.2023 Bulletin 2023/24

(21) Application number: **21213050.4**

(22) Date of filing: **08.12.2021**

(51) International Patent Classification (IPC):
H01R 4/30 *(2006.01)* ***H01R 9/16*** *(2006.01)*
F01N 13/00 *(2010.01)* ***H01B 17/30*** *(2006.01)*
H01R 4/34 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
H01R 9/16; F01N 13/00; H01R 4/302; H01R 4/304;
H01B 17/308; H01R 4/34

(84) Designated Contracting States:
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
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) ELECTRIC CONNECTION

(57) The invention relates to an electrical connection comprising an electrical conductor (30), an insulating layer (40), and a bushing (50), wherein the electrical conductor (30) is passed through the bushing (50), wherein the insulating layer (40) electrically insulates the electrical conductor (30) from the bushing (50), wherein the electrical conductor (30), the insulating layer (40) and the bushing (50) are pressed together to hold the electrical conductor (30) axially immovable and non-rotatable in the bushing (50), and wherein the electrical conductor (30) protrudes from the bushing (50) at at least one of its longitudinal ends. For a reliable electrical connection it is suggested that the electrical conductor (30) projects out of the bushing (50) at one longitudinal end and forms a contact connection (33) there with an integrally formed thread (33.1), in that a distance section (34) of the electrical conductor (30) is provided in the region between the thread (33.1) and the bushing (50), in that the distance section (34) has a flange (36) which is integrally formed in one piece, has a cross section which is enlarged in comparison with the cross section of the distance section (34) and has, towards the thread (33.1), a supporting surface (37) for the abutment and the electrical contacting of a cable connection piece (60).

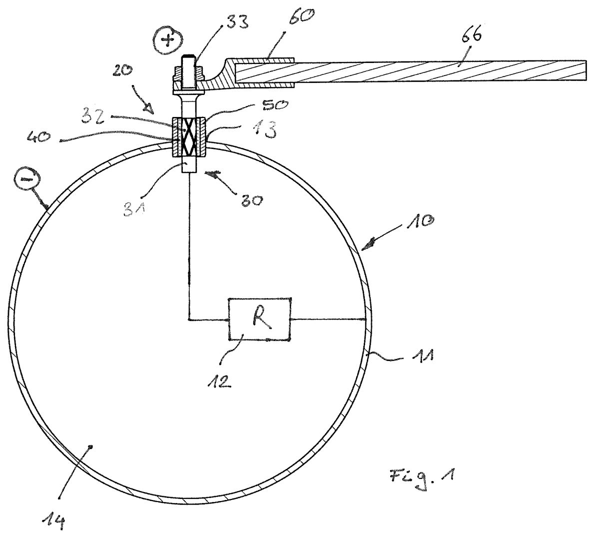

Fig. 1

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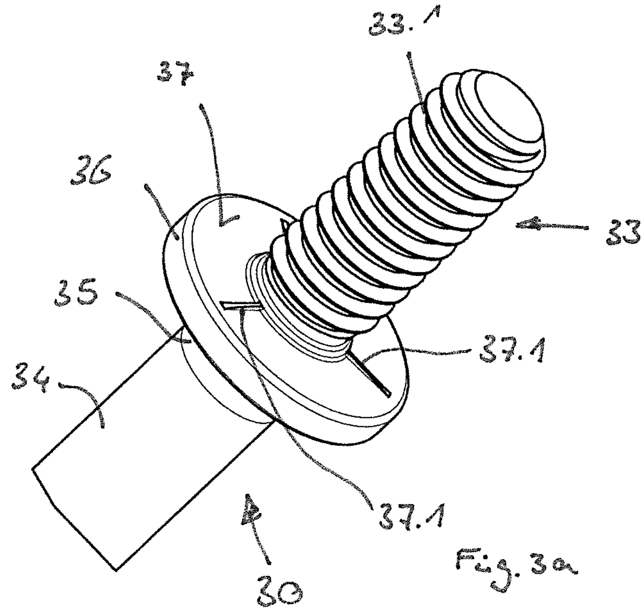

Fig. 3a

Description

[0001] The present invention refers to an electrical connection comprising an electrical conductor, an insulating layer, and a bushing, wherein the electrical conductor is passed through the bushing, wherein the insulating layer electrically insulates the electrical conductor from the bushing, wherein the electrical conductor, the insulating layer and the bushing are pressed together to hold the electrical conductor axially immovable and non-rotatable in the bushing, and wherein the electrical conductor protrudes from the bushing at at least one of its longitudinal ends.

[0002] Such an electrical connection is known from WO 2021/144055. This known electrical connection is used to electrify a catalytic converter of an internal combustion engine. The catalytic converter has a housing with an opening. The electrical connection with its bushing is inserted into this opening. To fix the bushing, a welded joint is provided which holds the bushing in the opening. The insulated conductor in the bushing can be connected to an electric power source from the outside of the catalytic converter. The part of the conductor held inside the catalytic converter serves to contact an electrical component in the catalytic converter, in particular a heating device. This heating device can be used to preheat the catalytic converter.

[0003] During operation, high temperatures occur in the area of the catalytic converter. In addition, strong vibrations act on the electrical connection. Finally, it is also necessary for the electrical connection to absorb high forces, especially torsional forces and tensile forces. In order to ensure a permanently safe operation, the electrical connection must therefore be reliably connected.

[0004] It is the object of the invention to provide an electrical connection of the type mentioned above, which guarantees reliable operation even at strongly fluctuating operating temperatures and high mechanical alternating forces.

[0005] This object is solved by an electrical connection wherein the electrical conductor projects out of the bushing at one longitudinal end and forms a contact connection there with an integrally formed thread, in that a distancing section of the electrical conductor is provided in the region between the thread and the bushing, in that the distancing section has a flange which is integrally formed in one piece, has a cross section which is enlarged in comparison with the cross section of the distancing section and provides, towards the thread, a supporting surface for the abutment and the electrical contacting of a cable connection piece.

[0006] With such an arrangement, the cable connection piece can be contacted safely and reliably on the electrical conductor. For this purpose, the cable connection piece is placed on the support surface of the flange so that it can make electrical contact with the electric conductor here. A fastening part with a counter-thread can be screwed onto the thread. If the thread of the electrical conductor is an external thread, the fastening part can be a nut that is screwed onto the thread. If the thread of the electrical conductor is an internal thread, the fastening part can be a screw that is screwed into the internal thread with an external thread. The nut or the screw can be reliably clamped against the integrally moulded flange, with the cable connector clamped between the nut/screw and the supporting surface of the flange. In particular, a sufficiently high pretension can be applied here without play, which also ensures that a minimum pretensioning force is not fallen short of in case of changing temperatures during operation. The fact that the flange is moulded onto the electrical conductor in one piece makes cost-effective production possible. On the other hand, this guarantees that particularly high pretensioning forces can be transmitted via the thread. Furthermore, the enlarged diameter of the flange provides a large contact surface for introducing the current into the electrical conductor.

[0007] Advantageously, the flange with the increased diameter is formed directly onto the electrical conductor by means of a forming process, for example by upsetting. Due to the resulting material deformation processes, the flange has a high toughness, which on the one hand supports the secure fixing of the cable connecting piece and on the other hand is also suitable for safely transmitting high forces acting on the electrical conductor.

[0008] It is in particular of advantage when the electric conductor is formed as a cold roll formed form piece. This results in a robust design and high tightening torques can be transmitted whereby the flange provides a high stiffness for a durable securement of the cable connecting piece.

[0009] Furthermore, the invention offers the advantage that the flange is positioned accurately on the electrical conductor, so that a precisely fitting and reproducible positioning of the cable connecting piece is guaranteed.

[0010] According to a preferred embodiment of the invention, it is suggested that the flange is formed onto the distance section via a forming region, and in that the forming region widens the cross-section of the distance section, preferably continuously, towards the flange, at least in a partial region. This achieves a stress-optimized transition of the flange to the distance section. Especially when a continuous transition is provided, notch stresses are reduced or prevented.

[0011] According to a further preferred embodiment of the invention, it is suggested that the supporting surface of the flange extends radially to the central longitudinal axis of the thread. This measure provides a large-area and secure contact for the cable connecting piece and thus guarantees a reliable contact transition.

[0012] According to another preferred embodiment of the invention, it is suggested that the distance section has a circular cross-section, and in that the cross-section of the forming region, when cut along the central longitudinal axis of the thread, merges in a continuously differentiable manner into the contour of the distance section, the forming region being rotationally symmetrical. Such a configuration is easy to produce and has a low parts cost. Furthermore, high mechanical loads, especially torsional stresses, can be reliably transferred with such a design.

[0013] In case it is provided that at least one integrally formed projection is provided on the flange in the region of the supporting surface, which projection projects beyond the supporting surface, a reliable fastening of the cable connecting piece can be achieved. The projections can dig into the material of the cable connecting piece. A positive connection is then created in the circumferential direction of the thread by means of the projections. The cable connector, once fastened, can then no longer twist or rotate. This prevents the screw connection from loosening, especially when strong vibrations or temperature fluctuations act. Accordingly the risk of overheating can be securely be prevented.

[0014] A possible design of the electrical connection can be such, that the at least one projection is rib-shaped and preferably extends radially or in that the at least one projection protrudes from the supporting surface as a knob-shaped projection. The rib-shaped projections or the knob-shaped projections can be easily formed on the electrical conductor in a forming process.

[0015] According to a preferred embodiment of the invention it is provided that the thread is designed as an external thread, in that the external thread is passed through a connection eyelet of the cable connection piece, in that the cable connection piece bears with a contact surface on the supporting surface, and in that the contact surface is pressed onto the supporting surface by means of a nut screwed onto the external thread. The external thread can simply be formed onto the electrical conductor in the forming process, which simplifies production considerably. It is in particular of advantage when the electric conductor with its external thread is formed as a cold roll formed form piece. This results in a robust design and high tightening torques can be transmitted. Furthermore, the proposed electrical connection is easy and reliable to assemble; in particular incorrect assembly is almost impossible.

[0016] A particularly preferred variant of the invention is such that the electrical conductor has a transitioning section between the end of the thread and the flange, it preferably being provided that the transitioning section is continuously transferred into the supporting surface.

[0017] According to another preferred embodiment of the invention it is suggested, that the connecting section of the electrical conductor has an external circumferential surface with at least one of an arithmetic average roughness of at least Ra = 1 μm, protrusions and recesses on at least part of the external circumferential surface of the electrical conductor, which is covered by the insulating layer and/or the bushing has an inner wall with at least one of an arithmetic average roughness of at least Ra = 1 μm, protrusions and recesses on at least part of an inner wall of the bushing, which covers the insulating layer.

[0018] The electrical connector, the insulating layer and the bushing can be pressed together e.g. to achieve a mechanical cold transformation. Due to the mechanical cold transformation the interconnection between the bushing and the insulating layer and between the insulating layer and the electric conductor is significantly increased. The electrical connection can absorb much higher force and torque values without damage. In particular, the mechanical interconnection between the electric conductor and the insulating layer and/or between the insulating layer and the bushing does not loosen and break up, even if high force and torque values are applied to the electrical connection.

[0019] The bushing, the insulating layer and the electrical conductor are preferably rotationally symmetric in respect to the geometric central axis. In particular, in a cross sectional view the bushing, the insulating layer and the electrical conductor all have a circular or a circular ring form.

[0020] The electrical conductor is dimensioned such that it can withstand a minimum voltage of 52 V DC and a current of up to 200 A. To this end, it is suggested that the diameter of the conductor is between 5.0 mm and 8.0 mm, preferably between 6.0 mm and 7.5 mm. The external diameter of the bushing of the electrical connection is dictated by the dimensions of a mounting flange or opening, into which the bushing is fixed, and/or the intended use of the electrical connection. In particular, the bushing should neatly fit into the opening in the jacket or casing. Typical examples for the external diameter of the bushing are between 12.0 mm and 18.0 mm, preferably around 14.0 mm. In a cross section, the bushing preferably has a thickness between the internal circumferential surface and the external circumferential surface of between 1.0 mm to 5.0 mm, preferably of about 2.0 mm. The thickness of the insulating layer depends of the given diameters of the electrical conductor and of the bushing, as well as of the electrical properties to be achieved by the electrical connection. For example, the insulating layer should achieve an insulation resistance of more than 10 MΩ (preferably up to a couple of GΩ) under ambient environmental conditions (e.g. temperature 22°C +/-2°C, pressure around 1,000 hPa and relative humidity 35% - 70%) and at 500 V DC-voltage. In order to achieve these insulating characteristics, depending on the material used for the insulating layer, it has a thickness of at least 1.2 mm, preferably around 1.6 mm.

[0021] According to a preferred embodiment of the present invention, it is suggested that the electrical conductor has an external circumferential surface with at least one of an arithmetic average roughness of at least Ra = 1 μm (or higher), protrusions and recesses on at least part of an external circumferential surface of the electrical conductor, which is covered by the insulating layer. The roughness of the circumferential surface is such that it provides protrusions (i.e. positive peaks) and/or recesses (i.e. negative peaks or troughs) in an irregular distribution in respect to a mean surface extension. The desired roughness may be achieved during manufacturing, e.g. during cold roll forming of the electrical conductor.

[0022] During the pressing, e.g. the mechanical cold transformation, pressure acts in a radial direction onto the external circumferential surface of the bushing. The bushing transfers at least part of the radial pressure onto the insulating layer which is pressed onto the external circumferential surface of the electrical conductor. Some of the insulating material is pressed into the recesses provided on the external circumferential surface of the electrical conductor and/or the protrusions provided on the external circumferential surface of the electrical conductor are pressed into the insulating material. Thus, an interlocking connection is established between the electrical conductor and the insulating layer. This can further increase the force and torque values which the electrical connection can absorb without damage. In particular, the mechanical interconnection between the electric conductor and the insulating layer does not loosen and break up, even if high force and torque values are applied to the electrical connection.

[0023] In order to facilitate the material of the insulating layer entering and spreading in the grooves and/or the protrusions entering into the material of the insulating layer, it is suggested that the insulating layer is made of a material having a lower hardness than the material of which the electrical conductor is made. In particular, it is preferred that the material of the insulating layer has a hardness lower than 5.5 on the Mohs scale, preferably a lower hardness than magnesium oxide (MgO). Preferably, the material of the insulating layer has a hardness on the Mohs scale of approximately 1.5 to 4.0, in particular of 2.0 to 3.0. The material of the electrical conductor has a larger hardness than the insulating material.

[0024] According to a preferred embodiment of the invention, it is suggested that the bushing and/or the electrical conductor is made of a stainless steel, in particular of a nickel-chromium-iron alloy. In principle, the bushing and/or the electrical conductor could be made of any suitable material provided that it has the necessary physical, mechanical, electrical and thermal properties of the bushing and/or the electrical conductor required for the electrical connection.

[0025] According to another preferred embodiment of the invention, it is suggested that the insulating layer is made of a material comprising at least 50% of a phyllosilicate mineral. Preferably, the insulating material comprises more than 70%, in particular around 90% of a phyllosilicate mineral. The rest of the material may be a laminate or bonding material. Preferably, the material of the insulting layer is less hygroscopic than magnesium oxide (MgO). In principle any material may be used for the insulating layer provided that it has the necessary physical, mechanical, electrical and thermal properties of the insulating material required for the electrical connection. In particular, the material should be elastic enough to compensate for the thermal expansion of the different materials used in the electrical connection due to the large range of thermal variation during the intended use of the electrical connection, without breaking or cracking. Hence, a high degree and long lasting air tightness of the electrical connection can be guaranteed.

[0026] Further features and advantages of the present invention are described hereinafter with reference to the accompanying drawings. It is noted that each of the features shown in the drawings and described hereinafter may be important for the present invention on its own, even if not explicitly shown in the drawings or mentioned in the description. Furthermore, a combination of any of the features shown in the drawings and described hereinafter may be important for the present invention, even if that combination of features is not explicitly shown in the drawings or mentioned in the description. The drawings show:

Figure 1 is a schematic representation of a catalytic converter with an electrical connection according to the invention.

Figure 2 is an enlarged representation of the electrical connection taken from Figure 1,

Figures 3a to 5b show various configurations of an electrical conductor of the electrical connection,

Figure 6 a magnified representation of a detail of Figure 2,

Figure 7 an exploded view of a part of the electrical connection and

Figure 8 an enlarged view of the detail marked A in Figure 7.

[0027] Figure 1 shows a schematic representation of a catalytic converter 10 for an internal combustion engine (not shown). The catalytic converter 10 has a casing 11. A unit is held in the casing which has the catalytically active surfaces. This unit is associated with an electrical component 12 in the form of a heating device. The heating device 12 is shown schematically in Figure 1. In particular, it can be designed as a heating grid which can be heated electrically.

[0028] The electrical component 12 is connected to the casing 11 by means of an electrical connection line and, via this casing 11, for example to the negative pole of a voltage supply, in particular a battery.

[0029] Furthermore, the electrical component 12 is connected to an electrical connection 20 via an electrical conductor. Via the electrical connection 20, the electrical component 12 can be connected to a voltage supply, for example a battery, in particular to its positive pole.

[0030] As shown in Fig 2 the electrical connection 20 is inserted into a mounting flange or opening 13 of the casing 11, and the bushing 50 is fixed in the mounting flange or opening 13, e.g. by welding to the casing 11. Alternatively, the bushing 50 could also be fixed in the mounting flange or opening 13 to the casing 11 in any other way, e.g. by means of a threading or the like.

[0031] The electrical connection 20 is shown in more detail in Figure 2. As this figure illustrates, the electrical connection 20 comprises an electrical conductor 30 which is passed through a bushing 50.

[0032] The electrical conductor 30 is made of a metal material, in particular stainless steel. The electrical conductor 30 has a connection section 32 in the lead-through region through the bushing 50. The electrical conductor 30 protrudes from the bushing 50 on one side by means of an end region 31. The end region 31 projects into the receiving space 14 of the housing 11.

[0033] Facing away from the end region 31, a contact section 33 is formed on the connecting section 32. The contact section 33 has a thread 33.1. The thread 33.1 is in the form of an external thread.

[0034] The electrical conductor 30 has a distance section 34 between the contact section 33 and the connecting section 32. This distance section 34 merges into a flange 36 via a forming area 35.

[0035] The distance section 34 can be circular in cross-section in particular. However, another cross-sectional shape is also conceivable.

[0036] As Figure 2 shows, the forming area 35 can advantageously be designed in such a way that it transitions the outer contour of the distance section 34 into the flange 36, in particular continuously and preferably without continuity jumps. The forming area 35 can preferably be designed as a rotationally symmetrical body. As Figure 2 shows, the generating contour of this rotational body can be an ellipse or a circle, so that in cross-section through the central longitudinal axis of the electrical conductor 30, an elliptical or circular outer contour results at the forming area 35. This enables a stress-optimized transition between the distance section 34 and the flange 36.

[0037] The flange 36 can have a support surface 37 at its side facing away from the end region 31 or at its end facing away from the bushing 50. Preferably, the supporting surface 37 is annular and, particularly preferably, radially aligned with the central longitudinal axis of the electrical conductor 30 and/or, in particular, radially aligned with the central longitudinal axis of the thread 33.1.

[0038] As figures 3a to 5b illustrate, the supporting surface 37 can be configured differently in different embodiments of the invention. Figures 3a and 3b show that the supporting surface 37 can be equipped with at least one projection 37.1. In particular, the projection 37.1 can protrude over the supporting surface 37 as a rib-shaped projection 37.1 and, in particular, be integrally formed thereon. Preferably, the rib-shaped projections 37.1 are oriented in the radial direction.

[0039] Figures 4a and 4b illustrate that one or more projections 37.1 in the form of knob-like projections may be provided on the support surface 37.

[0040] Figures 5a and 5b illustrate that the support surface 37 can also be designed without projections 37.1.

[0041] Figures 3a to 5b also illustrate that the thread 33.1 preferably does not directly connect to the supporting surface 37. Preferably, the thread 33.1 is indirectly connected to the supporting surface 37 via a transition section 33.2 in order to reduce possible notch stresses and thus create a stress-optimized transition. It may be the case that the transition section 33.2 has a cylindrical region and/or a region which widens continuously or discontinuously in the direction of the supporting surface 37.

[0042] Figures 1 and 2 further illustrate that a cable connecting piece 60 may be connected to the electrical conductor 30. The cable connecting piece 60 comprises a cable receptacle 61. In the cable receptacle 61, a cable 66 is fixed at the end and electrically contacted.

[0043] Preferably, the cable connection piece 60 has a connection eyelet 62 indirectly or directly adjacent to the cable receptacle 61. The connection eyelet 62 forms a contact surface 63 and a connection surface 64 on opposite sides. The contact surface 63 and preferably also the connection surface 64 are designed and arranged to be able to establish an electrical connection with an adjoining component.

[0044] As Figure 6 illustrates, the cable connector 60 has a hole 65 in the area of the connecting eylet. Hole 65 passes through the connecting surface 64 and through contact surface 63, whereby it can be provided that the connecting surface 64 and the contact surface 63 encircle the hole 65 completely and are advantageously coplanar to each other.

[0045] Figure 2 shows that the cable connector 60 is pushed with hole 65 of connecting eyelet onto the thread 33.1, whereby the hole is slightly larger than the outer diameter of the thread. In the assembled state, the contact surface 63 of the cable connecting piece 60 lies flat against the supporting surface 37 of the flange 36.

[0046] A nut 38 is screwed onto the thread 33.1. The nut 38 has a press piece 38.1 which has a lower clamping surface 39. In the assembled state, the nut 38 sits with its clamping surface 39 on the connecting surface 64.

[0047] With the nut 38 and the thread 33.1, onto which the nut 38 is screwed, the connection eyelet 62 can be pressed and electrically connected to the electrical conductor 30. The nut 38 has a tool receptacle 38.2 adjacent to the press piece 38.1. A suitable screwing tool can be applied to this tool receptacle 38.2 and the nut 38 can be turned with it. Preferably, the cross-section of the pressing piece 38.1 is enlarged compared to the cross-section of the tool receptacle 38.2.

[0048] The electrical connection 20 has an insulating layer 40 in the area between the electrical conductor 30 and the bushing 50.

[0049] The structure of the electrical connection 20 is detailed in Figures 7 and 8.

[0050] As shown in these drawings the electrical connection 20 comprises the bushing 50 having a geometric central axis. The bushing 50 has the form of a hollow cylinder. Further, the connection 20 comprises an electrical conductor 30 passing through said bushing 50 along the geometric central axis and an insulating layer 40 electrically insulating said bushing 50 from said conductor 30.

[0051] The bushing 50, the insulating layer 40 and the electrical conductor 30 are preferably rotationally symmetric in respect to the geometric central axis. In particular, in a cross sectional view the bushing 50, the insulating layer 40 and the electrical conductor 30 all have a circular or a circular ring form.

[0052] The bushing 50, the insulating layer 40 and the electric conductor 30 are pressed together e.g. in order to achieve a mechanical cold transformation. First, the bushing 50, the insulating layer 40 and the electric conductor 30 are arranged coaxially in respect to the geometric central axis of the bushing 50 (see Figure 7). To this end, before the mechanical cold transformation, an internal diameter of an inner wall 51 of the bushing 50 is slightly larger than an external diameter of the insulating layer 40. For example, the internal diameter of the bushing 50 may be larger by approximately 0.1 mm than the external diameter of the insulating layer 40, in order to be able to slip the bushing 50 over the insulating layer 40. Similarly, an external diameter of an external circumferential surface 32.3 of the electrical conductor 30 is slightly smaller than an internal diameter of the insulating layer 40, e.g. smaller by approximately 0.1 mm.

[0053] After arranging the bushing 50, the insulating layer 40 and the electric conductor 30 coaxially in respect to the geometric central axis of the bushing 50, these components are pressed together in order to achieve a mechanical deformation e.g. a cold transformation.

[0054] The bushing 50, the insulating layer 40 and the electric conductor 30 are preferably pressed together during a rotary forging process thereby achieving the mechanical cold transformation. The pressure acts on the outer wall 52 of the bushing 50 of the electrical connection 20.

[0055] It is suggested that the electrical conductor 30 has an external circumferential surface 32.3 with an arithmetic average roughness of at least Ra = 1 μm (or higher) and/or protrusions and/or recesses 32.1, 32.2, 32.4 on at least part of the external circumferential surface 32.3 which is covered by the insulating layer 40 when assembled. The roughness of the circumferential surface 32.3 is such that it provides protrusions (i.e. positive peaks) 32.4 and/or recesses (i.e. negative peaks or troughs) 32.1, 32.2.

[0056] During the mechanical cold transformation, pressure acts in a radial direction onto the outer wall 52 of the bushing 50. The bushing 50 transfers at least part of the radial pressure onto the insulating layer 40 which is pressed onto the external circumferential surface 32.3 of the electrical conductor 30. Some of the insulating material is pressed into the recesses 32.2 provided on the electrical conductor 30 and/or the protrusions 32.1, 32.2 provided on the electrical conductor 30 are pressed into the insulating material of this insulating layer 40. Thus, an interlocking connection is established between the electrical conductor 30 and the insulating layer 40. This can further increase the force and torque values which the electrical conductor 30 can absorb without damage. In particular, the mechanical interconnection between the electric conductor 30 and the insulating layer 40 does not loosen and break up, even if high force and torque values are applied to the electrical connection 20.

[0057] Further, it is suggested that the bushing 50 has inner wall 50 with at least one of an arithmetic average roughness of at least Ra = 1 μm (or higher), protrusions and recesses 53 on at least part of the inner wall 52, which covers the insulating layer 40 when assembled. Hence, the bushing 50 may have the form of a hollow cylinder and the inner wall 52 of the bushing 50, where the insulating layer 40 is located, comprises the desired roughness, protrusions and/or recesses 53.

[0058] During mechanical cold transformation pressure acts in a radial direction onto the outer wall 52 of the bushing 50. The inner wall 51 of the bushing 50 is pressed in a radial direction onto the insulating layer 40. Some of the insulating material of the insulating layer 40 is pressed into the recesses 53 and/or the protrusions provided on the inner wall 51 are pressed into the insulating material of the insulating layer 40. Thus, an interlocking connection is established between the bushing 50 and the insulating layer 40. This can further increase the force and torque values which the electrical conductor 30 can absorb without damage. In particular, the mechanical interconnection between the bushing 50 and the insulating layer 40 does not loosen and break up, even if high force and torque values are applied to the electrical connection 20.

Claims

1. An electrical connection comprising an electrical conductor (30), an insulating layer (40), and a bushing (50),

   wherein the electrical conductor (30) is passed through the bushing (50),
   wherein the insulating layer (40) electrically insulates the electrical conductor (30) from the bushing (50),
   wherein the electrical conductor (30), the insulating layer (40) and the bushing (50) are pressed together to hold the electrical conductor (30) axially immovable and non-rotatable in the bushing (50),
   and wherein the electrical conductor (30) protrudes from the bushing (50) at at least one of its longitudinal ends,
   characterized in

that the electrical conductor (30) projects out of the bushing (50) at one longitudinal end and forms a contact connection (33) there with an integrally formed thread (33.1),
in that a distance section (34) of the electrical conductor (30) is provided in the region between the thread (33.1) and the bushing (50),
in that the distance section (34) has a flange (36) which is integrally formed in one piece, has a cross section which is enlarged in comparison with the cross section of the distance section (34) and has, towards the thread (33.1), a supporting surface (37) for the abutment and the electrical contacting of a cable connection piece (60).

2. Electrical connection according to claim 1, **characterised in that** the flange (36) is formed onto the distance section (34) via a forming region (35), and **in that** the forming region (35) widens the cross-section of the distance section (34), preferably continuously, towards the flange (36), at least in a partial region.

3. Electrical connection according to claim 2, **characterised in that** the supporting surface (37) of the flange (36) extends radially to the central longitudinal axis of the thread (33.1).

4. Electrical connection according to one of the claims 1 to 3, **characterised in that** the distance section (34) has a circular cross-section, and **in that** the cross-section of the forming region (35), when cut along the central longitudinal axis of the thread (33.1), merges in a continuously differentiable manner into the contour of the distance section (34), the forming region (35) being rotationally symmetrical.

5. Electrical connection according to one of claims 1 to 4, **characterised in that** at least one integrally formed projection (37.1) is provided on the flange (36) in the region of the supporting surface (37), which projection (37.1) projects beyond the supporting surface (37).

6. Electrical connection according to claim 5, **characterised in that** the at least one projection (37.1) is rib-shaped and preferably extends radially or **in that** the at least one projection (37.1) protrudes from the supporting surface (37) as a knob-shaped projection.

7. Electrical connection according to one of the claims 1 to 6, **characterized in that** the thread (33.1) is designed as an external thread, **in that** the external thread is passed through a connection eyelet (62) of the cable connection piece (60), **in that** the cable connection piece (60) bears with a contact surface (63) on the supporting surface (37), and **in that** the contact surface (63) is pressed onto the supporting surface (37) by means of a nut (38) screwed onto the external thread.

8. Electrical connection according to claim 7, **characterized in that** the nut (38) has a pressing piece (38.1), **in that** the pressing piece (38.1) has a clamping surface (39) with which it rests on a connecting surface (64) of the cable connection piece (60), **in that** a tool receptacle (38.1) extends from the pressing piece (38.1), and **in that** the pressing piece (38.1) has a larger cross-sectional area perpendicular to the central longitudinal axis of the thread (33.1) than the tool receptacle (38.2).

9. Electrical connection according to any one of claims 1 to 8, **characterised in that** the electrical conductor (30) has a transitioning section (33.2) between the end of the thread (33.1) and the flange (36), it preferably being provided that the transitioning section (33.2) is continuously transferred into the supporting surface (37).

10. The electrical connection according to one of claims 1 to 9, wherein

the connecting section (32) of the electrical conductor (30) has an external circumferential surface (32.3) with at least one of an arithmetic average roughness of at least Ra = 1 μm,protrusions and recesses (32.4 32.1; 32.2) on at least part of the external circumferential surface (32.3) of the electrical conductor (30), which is covered by the insulating layer (40)
and/or the bushing (50) has an inner wall (51) with at least one of an arithmetic average roughness of at least Ra = 1 μm,protrusions and recesses (53) on at least part of an inner wall (51) of the bushing (50), which covers the insulating layer (40).

11. The electrical connection according to claim 10, wherein
at least one of the protrusions and recesses (32.4, 32.1; 32.2, 53) have at least one of a circumferential extension and an axial extension.

12. The electrical connection according to one of the preceding claims, wherein
the insulating layer (40) is made of a material having a lower hardness than the material of which the electrical conductor (30) is made and/or a lower hardness than the material of which the bushing (50) is made.

13. The electrical connection according to one of the preceding claims, wherein
at least one of the bushing (50) and the electrical

conductor (30) is made of a stainless steel, in particular of a nickel-chromium-iron alloy and or the insulating material (40) is made of a material comprising at least 50% of a phyllosilicate mineral.

14. An exhaust-gas system of an internal combustion engine comprising a casing (11) with at least one opening (13) and an electrical connection mounted therein, wherein the electrical connection being introduced into the casing (11) through the opening (13) and fixedly attached to the casing (11),
characterized in that
the electrical connection is in accordance with one of the claims 1 to 13

15. The exhaust-gas system according to claim 14, wherein

the exhaust-gas system comprises a catalytic converter (10), the casing (11) being part of the catalytic converter (10) and housing an electrical component (12) in the form of an electrically heatable grid or honeycomb body,
the electrical conductor (30) of the electrical connection introduced into the casing (11) through the opening (13) and fixedly attached to the casing (11) is electrically connected to the grid or honeycomb body inside the casing (11).

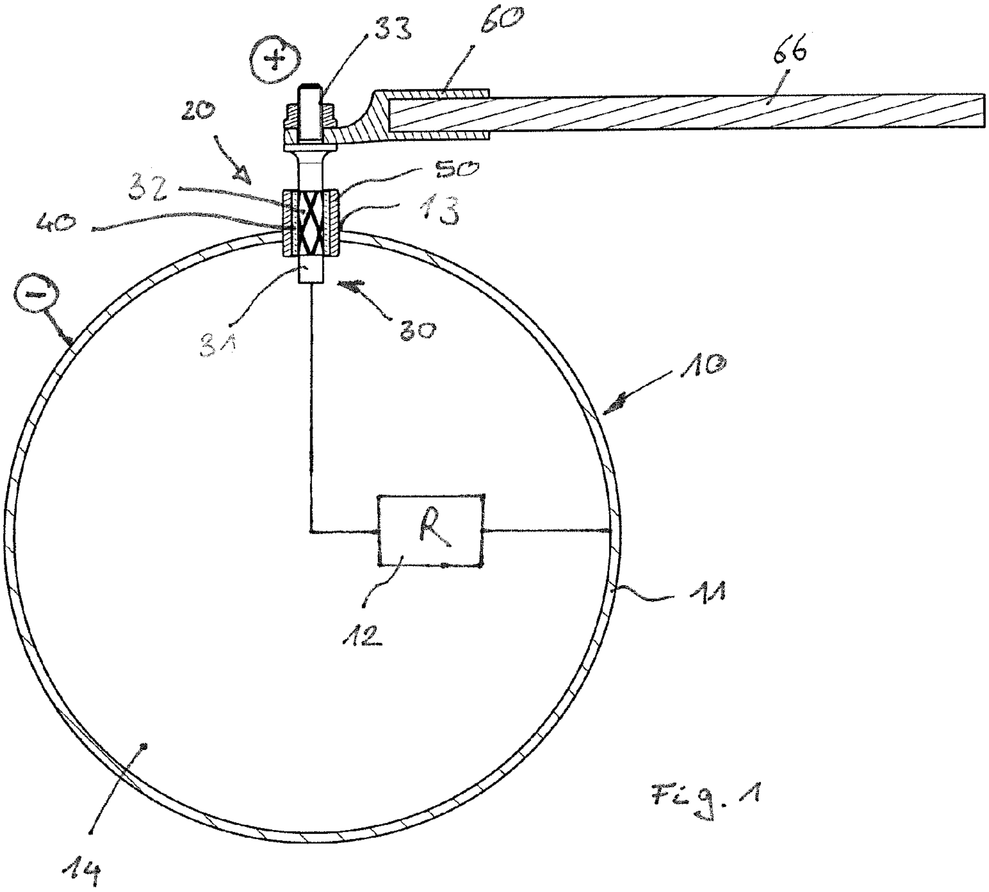
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Fig. 1

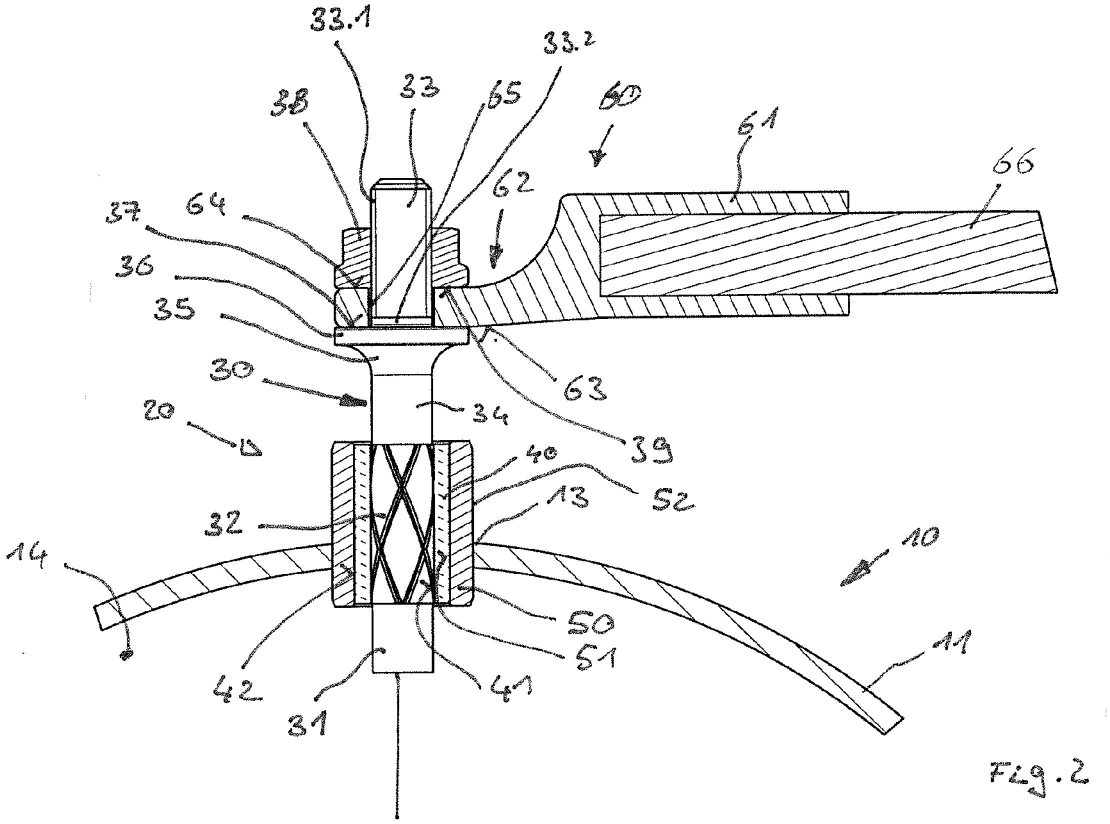
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Fig. 2

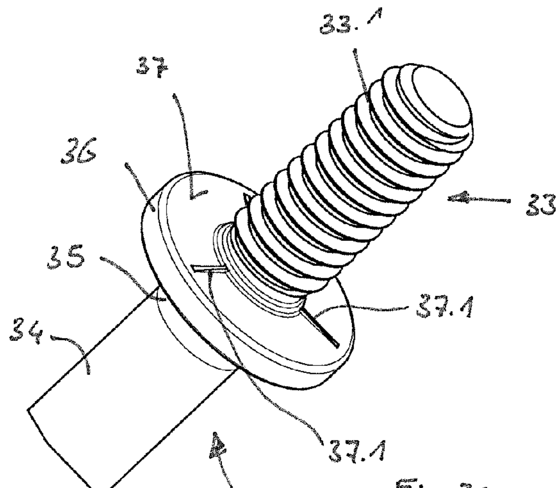


Fig. 3a

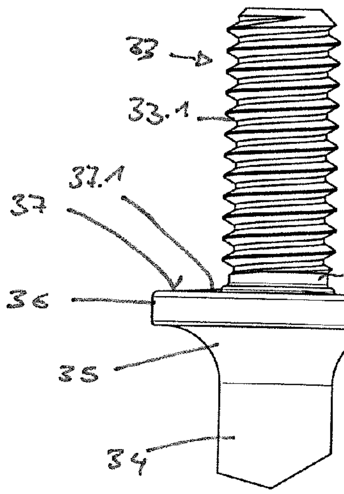


Fig. 3b

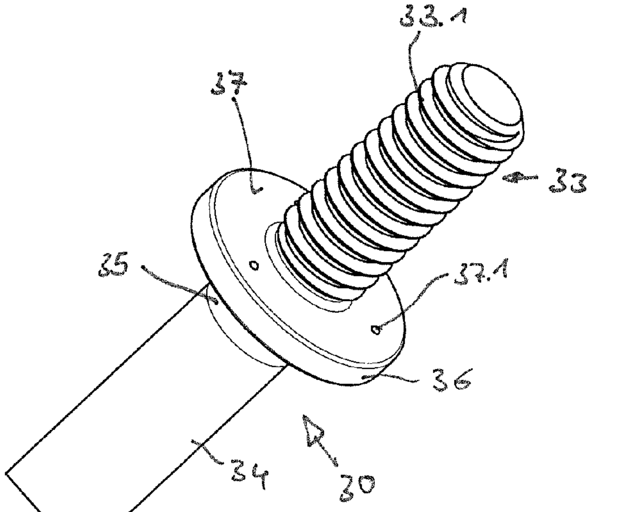


Fig. 4a

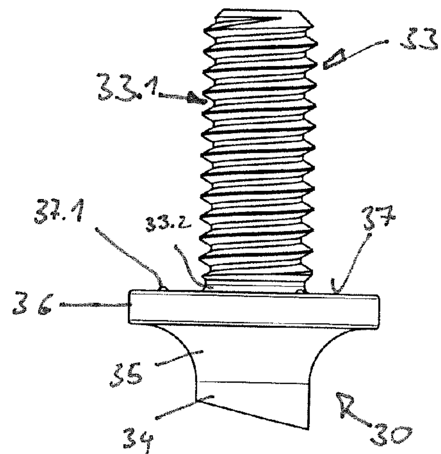


Fig. 4b

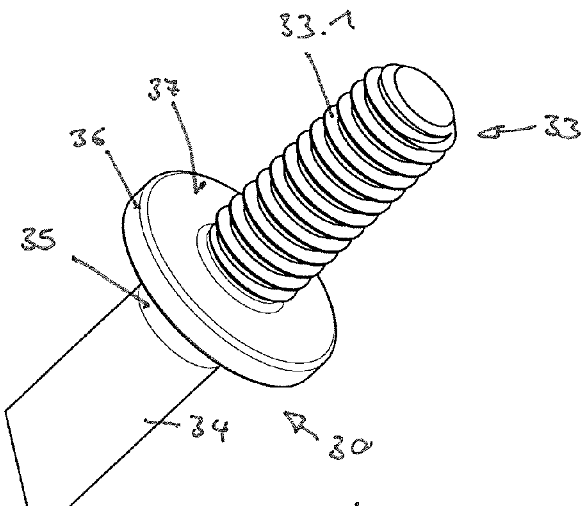


Fig. 5a

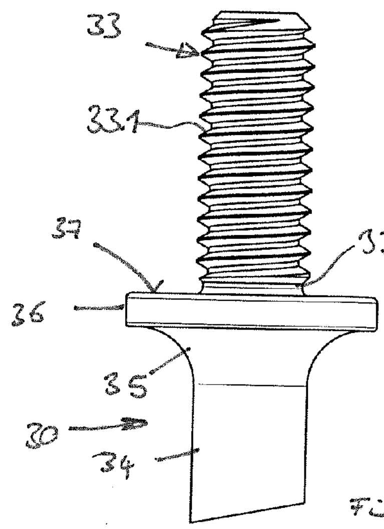


Fig. 5b

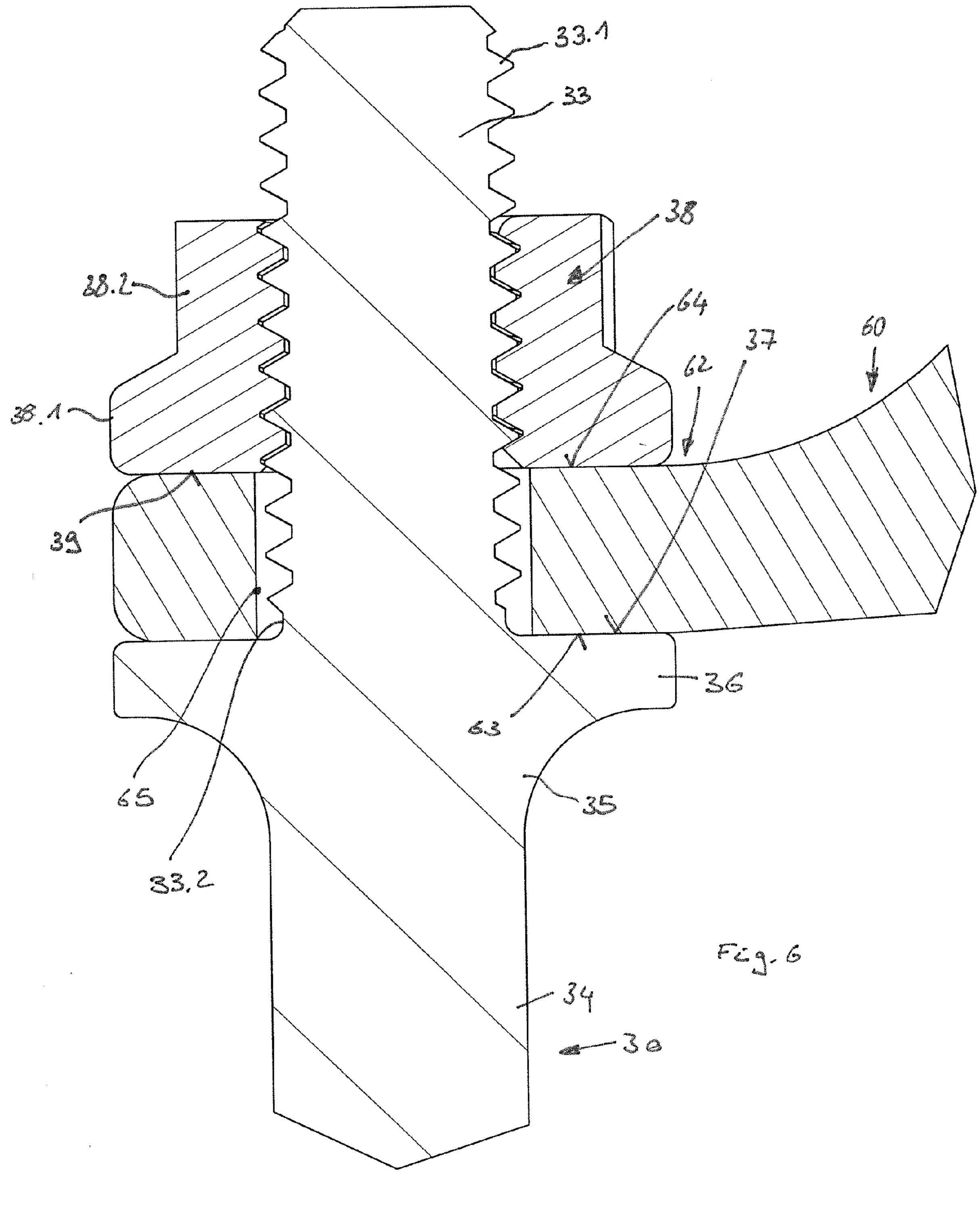
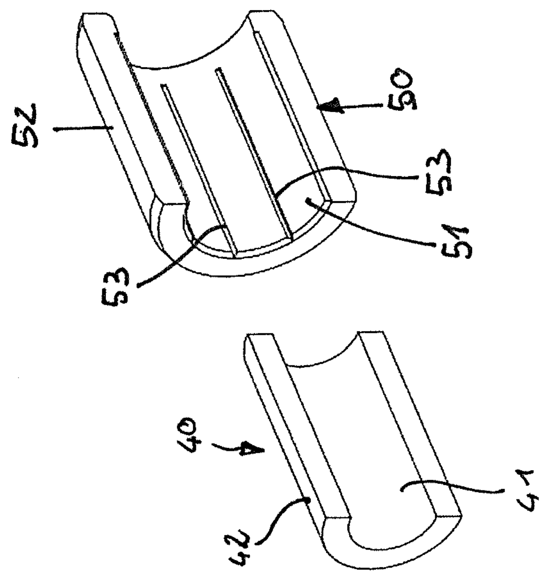


Fig. 6

Fig. 7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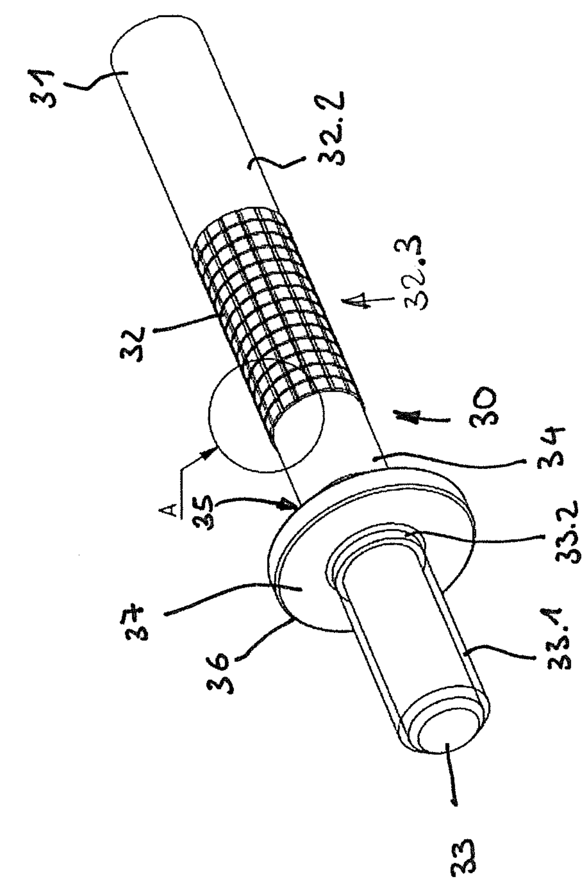
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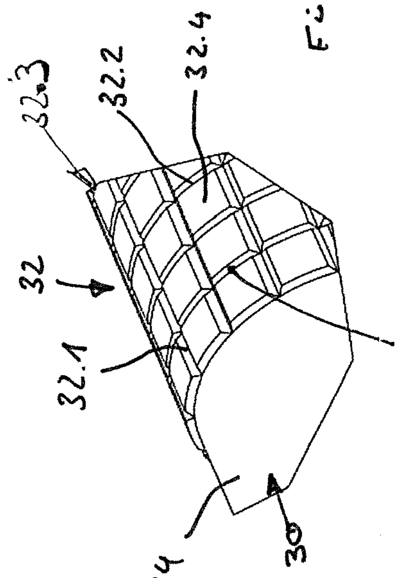
Fig. 8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EUROPEAN SEARCH REPORT

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H01R
F01N
H01B

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	12 May 2022	Gomes Sirenkov E M.

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