A REINFORCING DEVICE FOR UNIDIRECTIONAL OR CHAOTIC FIBRE-REINFORCED PLASTIC PROFILES

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TECHNICAL FIELD

The present invention describes a reinforcing device (1), consisting of a plastic profile with a profile end section, which can be pressed into a recess in a clamp body, and also a method of securing a plastic profile in a recess in a clamp body.

BACKGROUND ART

Fibre-reinforced plastics are being used increasingly in virtually all areas of technology, on account of their low weight and very high strength. Metal fittings are the connecting links between plastic profiles and the adjacent components. Reinforcements always reduce the specifically mechanical strength of reinforced plastic profiles.

In general, these types of reinforcements are used in the area of mechanical engineering, bridge construction, civil engineering, aircraft construction, etc. There are specific requirements in electrical engineering, where reinforcements are assigned as functional components in composite products even during production. Such composite products are often vulcanised together at relatively high temperatures, due to the production techniques.

For composite products, the optimum vulcanisation temperatures are usually higher than the softening point of the fibre-reinforced plastic profiles, for physical reasons. The customary reinforcement techniques for plastic profiles are based on permanent tensioning against the metal fitting. Superimposed on this basic stress are extreme temperature cycles during operation, for example in deserts with very high daytime temperatures and very low night-time temperatures. In addition to this there are temporary loads arising from the pairing of materials with different temperature expansion coefficients. Consequently, the plastic profile contracts more than the fitting at sub-zero temperatures, which favours slippage of the plastic profiles.

The plastic tends to undergo a plastic, time-dependent deformation, referred to as creep. Apart from the creep, flow processes also occur due to the restructuring of the plastic molecules, which leads to stress relaxation.

High electrical field strengths often exist in the case of the force application zones on plastic profiles into the fittings of high-energy technology components. Consequently, measures aimed at freedom from partial discharge are essential, otherwise chemical destruction processes may occur. Another phenomenon not to be underestimated is that of glass fibres in the form of nano-tubes in electrical engineering. These glass fibre capillary tubes may cause leakage currents when liquid enters and end as a breakdown. With suitable fitting technology, the emergence of the earlier destruction mechanisms can be demonstrably prevented by design engineering.

The types of reinforcement generally used on fibre-reinforced plastic profiles are: thread-type screw connections, traditional clamped connections, different bonding techniques, anchoring with cast resin sealing, clamping cones, coaxial shrinkage with matrices or multiple-cornered pressing.

Coaxial shrinkage and multiple-corned pressing are related. Radial eight-edge pressings have become established as the state of the art for insulators in high-energy technology, although stress peaks can be demonstrated on the stressed plastic profile area with computer-aided theoretical calculation models.

Consequently, these stress amplitudes are infinitely small or zero or quite simply absent in the case of coaxial technology. In the case of coaxial technology and multiple-cornered pressing technology, the fitting completely surrounds the plastic profile. A frictional connection is achieved in that the radial forces of the tools acting on the fitting produce plastic deformation on the fitting and elastic deformation on the inner plastic profile. The elastically deformed plastic profile wants to move back into its initial position after the pressing cycle, but cannot, because the fitting surrounding the profile has become plastically deformed. The result is permanent deformation and a non-positive or frictional connection.

As part of a large-scale practical trial undertaken by a reputable institute in the United States, reinforcements were compared after the following customary manufacturing procedures: multiple-cornered pressing technology, coaxial shrinkage method and clamping cone mechanics. The concluding assessment was that the coaxial technology achieved the best test result by far. On the other hand, the results achieved with the multiple-cornered pressing technology and cone mechanics are adequate for practical requirements, based on this short-time test. The breaking forces achieved as a function of defined nested load parameters were then extrapolated using mathematical calculation models to the breaking forces or extraction forces that can probably be expected in decades. The forecast drop in breaking force is massive, because with these types of reinforcement permanent, friction-based deformation is assumed and the so-called creep properties of reinforced plastics reduce the deformation, which is why the characteristics cannot really be predicted with any authority. Recent findings have demonstrated that calculation models which predetermine long-term behaviour must be interpreted with the greatest of care, because the functions of the consequences from the consequences of reciprocal influences of those parameters taken into account and not taken into account are themselves virtually impossible, empirically speaking.

The quality of the friction connection is directly dependent on the permanent mechanical prestress of the plastic profile to the fitting. The reason for this practical study was therefore to predict the anticipated life expectancy of the end products for these technologies without any genuine long-time experience. The life expectancy required of outdoor insulators, for example, is well in excess of 50 years. In addition to this, in the case of high-tension insulators, a rupture could have devastating consequences. The correct functioning of high-tension insulators can only be checked during operation with the greatest difficulty, since the high-voltage insulators are not readily accessible and are under a high electrical charge, which cannot usually be switched off.

Despite this, the types of reinforcement tested have proved successful in practice and represent the state of the art. For economic reasons, multiple-cornered pressing technology dominates, which is why the following deliberations focus on this. From an analytical viewpoint, however, the mechanical connection in this process always depends on a radial force being permanently present, otherwise the plastic profile slides from the fitting due to the absence of a friction connection with said fitting.

In the state of the art, the friction connection is defined by a friction surface running parallel to the direction of force, on which a permanent transverse force acts on the extraction force. The extraction force in the case of the friction connection is calculated by multiplying the force acting perpendicular to the friction surface with the roughness factor of the sliding surfaces. If the friction force approaches zero, due to the creeping away of the plastic under mechanical stress, the extraction force also approaches zero.

As already mentioned, the friction force drops due to the creep properties, flow processes and reforming properties of the plastics under mechanical stress, constant mechanical load and sharp temperature fluctuations.

Demonstrated in summary, in the case of the friction connection, a cylindrical plastic profile is enclosed or clamped in cross-section in a non-positive manner by a metal fitting with a likewise cylindrical bore, thereby producing a friction connection.

If, following the connection of the metal fitting and the plastic profiles, further components have to be vulcanised on, such high temperatures must be used that the stressed plastic profiles become detached in parts. Particularly in the case of insulators, the finished product is repressed, in order to re-establish the initial functional load. The state of the art therefore switches to slow, expensive vulcanisation procedures in the low-temperature range, particularly for the production of hermetic, non-porous (TE) fitting seals or corona shields.

The invention disclosed here deals explicitly with the elimination of the problems described with the relative friction connection.

The creep properties of the plastic fibre material and the reforming properties after the pressing of the plastic components lead to the loosening and detachment of the force fit of the known, cylindrically shaped component ends in the known clamp bodies. In order to increase the friction forces between the outer surface of the component and the inner surface of the clamp body, it is customary for the surfaces to be roughened accordingly. Although this leads to an improved friction connection in the short term, it cannot prevent a loosening of the force fit in the long term.

DESCRIPTION OF THE INVENTION

The problem addressed by the present invention is that of creating a reinforcing device that guarantees a force fit of a plastic profile in a clamp body, which also guarantees a stable, creep-resistant connection between the clamp body and plastic profile, even over long periods of time and following ageing due to temperature fluctuations and other environmental influences. The problem to be solved by the invention involves the provision of a reinforcing device, which offers a force fit that is independent of the creep and flow behaviour of the fibre-reinforced plastic material being used; this is solved by the features of the independent patent claim.

The reinforcing device according to the invention does not require repressing of the reinforcing device, if exposure to a thermal load, through the vulcanisation of additional plastic material, for instance, has taken place.

These problems and, in addition, the creation of a method of reinforcing plastic profiles in clamp bodies, is solved by the features of the independent process claim.

BRIEF DESCRIPTION OF THE DRAWINGS

The object of the invention is described below in association with the attached drawings in the form of two embodiments based on examples of insulator technology.

Figure 1 shows a side view, depicted partly in section, of a reinforcing device according to the invention based on the example of a tension insulator.

Figures 2a to 2d each show sectional views of the clamp body into which a profile end section of a plastic profile is introduced and pressed there to create a positive-locking connection.

Figures 3a and 3b show a pressing tool comprising several press jaws in a sectional view, in the open and pressing state.

Figure 4a shows a side view, depicted partly in section, of a further reinforcing device according to the invention based on the example of a pin-type insulator, while

Figure 4b shows a detail cross-sectional view of a clamp body as part of a flange.

Figure 5 shows a longitudinal section through a flange of the pin-type insulator according to Figure 4a, wherein a depicted profile end section is already pressed by means of a press jaw.

Figure 6 shows a perspective view of an embodiment of the profile end section.

Figure 7 shows a cross-section through a flange of the pin-type insulator according to Figure 4a or Figure 5, wherein a profile end section is irreversibly pressed by means of a press jaw.

Figures 8a to 8d each show sectional views of a clamp body with a conically shaped recess, into which a profile end section of a plastic profile is introduced and pressed there to create a positive-locking connection.

DESCRIPTION

The present invention describes a reinforcing device 1 encompassing a clamp body 2, in which at least one plastic profile 3 with fibres running particularly unidirec-tionally, these being chemically linked to a matrix surrounding them, is held. The reinforcing possibility is described in detail below based on examples from electrical engineering, specifically insulator construction, wherein the reinforcing devices 1 described can also be used in other fields of technology.

By way of example, a tension insulator 4 is illustrated in Figure 1, which encompasses the plastic profile 3 in the form of a concentric plastic rod 3, wherein a profile end section 30 is inserted in a longitudinal direction into the clamp body 2 of the metal reinforcing device 1 and pressed. The tension insulator 4 is enclosed in a layer of insulation, which is applied by vulcanisation after the joining and pressing of the clamp body 2 and the plastic profile 3.

The clamp body 2 exhibits a recess 20 in the form of a blind hole 20, usually consisting of a cylindrical hole, wherein the blind hole 20 may also have a conical design. The profile end section 30 can be introduced through an opening 21.

As emerges from Figures 2, the profile end section 30 is designed in such a way that at least one conical area 34 is recessed, at least in a side view. In one embodiment, the profile end section 30 according to Figures 2 is designed complete, encompassing the entire periphery, conical and rotationally symmetrical. This means that the largest diameter 31 is formed on the side facing away from a cylindrical section 33 of the plastic profile 3 and the smallest diameter 32 close to an undercut 35 completely encompassing the periphery.

In order to secure the plastic profile 3 in the clamp body 2, the profile end section 30 is introduced up to the end of the blind hole 20. A gap 22 is discernible between the at least partly conical outer surface of the profile end section 30 and the inner surfaces of the clamp body 2. So that the profile end section 30 can be introduced far enough into the blind hole 20, the diameter of the blind hole 20 must be adjusted to the largest diameter 31 accordingly.

With press jaws 60 of a pressing tool 6 shown in Figures 3 for use of the multiple-cornered pressing technology described, the clamp body 2 is pressed in a press area P, wherein the diameter of the blind hole 20 is at least partly reduced and the walls of the clamp body 2 at least partly bent in the direction of the longitudinal axis L of the profile end section 30. There is an irreversible plastic deformation of the walls of the clamp body 2, which results in a positive and non-positive connection of the profile end section 30 in the clamp body 2.

The press jaws 60 exert a radial pressure on the clamp body 2 close to the press area P, which is held pressed for a few seconds, at least two seconds, by the pressing tool 6, as indicated in Figure 2c. A stable pressing is achieved by pressing into an end position of the clamp body 2 for several seconds, as the long-chain plastic molecules realign and the resetting elasticity of the clamp body 2 diminishes.

While Figure 3a shows the press jaws 60 not yet connected to the outer surface of the clamp body 2, the press jaws 60 according to Figure 3b lie on the outer surface of the clamp body 2 pressing in the direction of the longitudinal axis L.

In the case of radial pressing according to the known method using the at least one press jaw 60, with optional sensor monitoring, the surface geometry of the clamp body 2 is changed, while homogeneous positive locking between the profile end section 30 and the blind hole 20 results through plastic deformation of the blind hole 20 walls. Apart from the defined positive locking, additionally defined friction locking results, due to the tapering of the conical area 34.

After pressing, the press jaws 60 are removed from the clamp body 2. The result is a positive connection of the profile end section 30 in the clamp body 2 in the form of a force fit, wherein an optimum connection in the direction of the tensile force Z has been achieved.

Instead of the completely conical design of the one-piece profile end section 30, only partial tapering can also be formed by creating an undercut 35 only partly encompassing the periphery of the profile end section 30. A reinforcing device 1 comprising a profile end section 30 developed in this way is illustrated according to Figure 4a based on the example of a pin-type insulator 5. In the flange 50 of the pin-type insulator 5, at least one profile end section 30 of a plastic profile 3 is held eccentrically pressed in a positive locking manner in a moulded clamp body 2 in the flange 50.

As shown in the detailed sectional view according to Figure 4b, the plastic profile 3 exhibits a conical area 34 in the form of a rod or tube, which is held in a positive locking manner in the blind hole 20 within the flange 50, which represents the clamp body 2 in this case. In this case, the undercut 35 is only disposed on the side of the profile end section 30 facing away from the pin-type insulator 5 and is only visible in the side view depicted here. Again, the largest and smallest diameters 31, 32 can be defined and the pressing takes place in a press area, which approximates to the length of the conical area 34.

In the unpressed state, a gap 22 between the partly conical area 34 and the inner wall of the blind hole 20 is discernible here too. Through pressing by means of press jaws 60, this gap 22 is closed and the profile end section 30 is connected to the clamp body 2 by positive locking. The method according to the above description can be executed and produces permanently stable connections.

Using solid borne sound sensors facilitates serial monitoring during pressing to determine whether the solid borne sound signals move within the permitted bandwidth during pressing as a function of force. Novel hybrid sensors enable this interesting quality feature to be serially logged and assigned to the pressings produced.

The eccentric reinforcing device 1 is provided for, among other things, pin-type insulators 5, ducts and terminal boxes. The principle is that two metal fittings are spaced at the ends of several glass fibre-reinforced plastic profiles 3 in the form of plastic rods and surrounded by a silicon casing. These plastic rods 3 create reinforcement against pressure and tension for the elastic insulating body. The plastic rods 3 may be parallel or conical relative to the longitudinal axis of the insulating body. The angle of entry into the fittings is product-dependent in relation to the required moments of resistance. In relation to the force lines for moments of resistance, this configuration of plastic rods 3 is optimal for the CAD engineer.

The addition of plastic rods 3 in the reinforcement area is limited to an area in relation to the effective range of the press tool 6. The reinforcement length may be very short, as the compressive or tensile forces are small compared with tension insulators, the folding and bending strengths are more important. The rod arrangement is optimal from this perspective. Fig. 7 shows an exemplary configuration in process terms, before pressing on the right side, which corresponds to the right side according to Fig. 5. The pressing tool 6 with the press jaws 60 has already been moved over the profile end sections 30 and the pressing tool 6 is ready for the pressing process. On the left side of Figure 7, the irreversible reinforcement following the pressing process is illustrated accordingly.

Cost and strength-optimised calculations will each produce around 12 rods. The die head would then have to have over 12 press jaws 60. Another number of press jaws 60 is possible as follows. With the standard 8-way die heads, four press jaws 60 may be used for instance and three (one, two, etc.) plastic rods 3 assigned per press jaw 60; this means that a press jaw 60 has three chords of a dodecagon. A modular tool system may be created corresponding to this division. The suitable press surface contour of the chords must be determined by tests, with the aim of loading the plastic rods 3 as evenly as possible, thereby resulting in short, reliable press lengths.

The plastic profiles 3 may be designed as a plastic rod 3 or plastic tube 3, wherein the fibres in the case of the tubular design are, alternatively, mainly wound or mixed chaotically as short fibres. For reasons of stability, the plastic profile 3 is designed as a single piece, wherein the different areas, cylindrical section 33 and at least partial conical section 34 are correspondingly drawn out or integrally formed. The profile end section 30 should, where possible, display no large-scale damage to the fibres through bores or threads, for example, which impairs stability.

Glass fibres, carbon fibres, aramid fibres but also ceramic fibres as mixed fibres made from aluminium oxide and silicium oxide, as well as boron fibres and nylon fibres, are possible fibre components of the plastic profile 3 embedded in different matrix materials, wherein the fibres may be electrically conductive or insulating.

For reasons of stability, the clamp body 2 is formed from a metal, wherein the material and the wall thicknesses have to be selected in such a way that the walls in the press area P are bendable and can at least partly enclose the profile end section 30. It has proved beneficial for the outer surface of the reinforcing device to be likewise conically formed to complement the shape of the profile end section 30, so that the support of the press jaws 60 is optimised.

Due to the irreversible reinforcement according to the invention in the form of a positive-locking connection between the profile end section 30 and the clamp body 2, an additional fixing, with adhesives, for example, is not necessary, which means that further securing processes can be dispensed with.

Instead of the recess formed as a blind hole 20, through-holes 20 may also be made transversely to the clamp body 2, depending on the use of said clamp body 2.

Through the reinforcing device 1 according to the invention extraction forces can be calculated, which means that reinforcement lengths in electrical engineering are minimised or else reduced compared with the state of the art. This is desirable in order to maximise the flashover and arcing distances. The positive consequence of these longer distances is that the electrical field strengths in the force application zones are smaller. Small field strengths mean that partial discharges occur later or not at all, which means that defects are reduced. Higher flashover distances mean that the corona charging voltage is reached later, which also counteracts radio interference voltages and surface erosion.

With the reinforcement technology according to the invention, short reinforcement lengths comparable with porcelain insulators are now justifiable. From a production point of view, lower fitting weights and shorter processing times result. The prefabrication of the conical areas 34 on the contour of the plastic profiles 3 may be automated by series grinding. As a general rule, the production expenditure required is no greater than with mechanical prefabrication by roughening the plastic profiles in accordance with the state of the art.

The way in which the fitting is processed remains the same in relation to the state of the art, as do the useable press tools 6. From this point of view, no additional economic cost results from preparing the reinforcing mechanics according to the invention, on the contrary. There is not need for repressing on the finished product, because the positive locking remains the same, irrespective of the effects of heat, and the friction locking is a function of the slightly conical positive locking. Consequently, the friction locking is retained too.

In relation to the conical geometries, adjacent tensile forces involve a mild deformation from the plastic profile 3 towards the clamp body 2, because the deformation, mathematically speaking, is proportional to the current tensile force, depending on the conical positive locking acting simultaneously.

Compared with the state of the art, however, this deforming force may approach zero and is therefore no longer relevant. Consequently, it is irrelevant whether the critical softening point is reached during the production process or not. This is a significant advantage when device seals or corona shields are arranged subsequently or when silicon casings are extruded in one piece. Until now methods have had to be chosen, so as to avoid exceeding the softening point. With all vulcanisation methods applicable, the vulcanisation temperature is today around the softening point of the plastic profile 3. With the reinforcing technique according to the invention, significant uncertainty criteria disappear completely, because the friction locking is supplemented by the positive locking.

Paradoxically, the recessed cross-sectional reduction is economically advantageous, because according to the invention the traditional uncertainty factors can be used as certainty factors in engineering strength calculations with positive-locking reinforcement. No notching effect can be expected on the prefabricated press contours, because damage to a few fibres is not transmitted to the other intact fibres that are aligned unidirectionally. The interlaminar strength is retained. The projected flange surface of the cone section cannot be used for strength calculations, but instead the geometrically integrated replacement surface, from the action or reaction of the frictional force acting proportionally to the tensile force.

It is obvious to the CAD engineer that the certainty factors can now be significantly smaller than the traditional uncertainty factors. The consequence of this, paradoxically, is that a smaller diameter can be chosen for the plastic profile 3, despite the processing or despite the cross-sectional reduction, which points to a further economic advantage.

A conical design for the recess 20 in the form of a blind hole 20 is disclosed in Figures 8 a) to d), in which profile end sections 30 are pressed.

REFERENCE LIST

1 Reinforcing device

2 Clamp body

- 20 Recess/blind hole/through-hole
- 21 Opening
- 22 Gap

3 Plastic profile

- 30 Profile end section
- 31 Largest diameter
- 32 Smallest diameter
- 33 Cylindrical section
- 34 Conical area
- 35 Undercut

4 Tension insulator

5 Pin-type insulator

- 50 Flange

6 Pressing tool

- 60 Press jaw
- P Press area
- L Longitudinal axis
- Z Tensile force

PATENT CLAIMS

1. A reinforcing device (1), consisting of a plastic profile (3) with a profile end section (30), which can be pressed into a recess (20) in a clamp body (2),

   characterised in that

   the profile end section (30) is designed in such a way that it has at least one conical area (34), so that the profile end section (30) in the recess (20) can be connected to the clamp body (2) by positive locking.

2. The reinforcing device (1) according to claim 1, characterised in that in at least one side view of the profile end section (30) at least one undercut (35), defined by a smallest diameter (32) and a largest diameter (31) is defined

3. The reinforcing device (1) according to claim 2, characterised in that the difference between the largest diameter (31) and the smallest diameter (32) is between 1 mm and 2 mm.

4. The reinforcing device (1) according to claim 2, characterised in that the undercut (35) encompasses the entire periphery of the profile end section (30), which means that the conical area (34) is rotationally symmetrical.

5. The reinforcing device (1) according to claim 1, characterised in that the recess (20) is conically formed running in the direction of the opening (21).

6. The reinforcing device (1) according to claim 1, characterised in that the plastic profile (3) is a solid profile or a hollow profile with or with out a supporting insert.

7. The reinforcing device (1) according to one of the preceding claims, characterised in that the recess (20) is a blind hole (20) or a through-hole (20).

8. A method of securing a plastic profile (3) in a recess (20) of a clamp body (2),

   characterised by the steps:

   - introduction of a profile end section (30) with a conical area (34) into the recess (20)

   - pressing of at least one wall of the recess (20) radially to the longitudinal axis (L) of the profile end section (30) with at least one press jaw (60) in a press area (P)

   - holding of the pressing position for a period Δt

   - detachment and subsequent removal of the at least one press jaw (60).

9. The method according to claim 8, characterised in that the press area (P) is smaller than the difference between a largest diameter (31) and a smallest diameter (32) of the profile end section (30).

10. The method according to claim 8, characterised in that the period Δt is at least two seconds.

11. The method according to claim 8, characterised in that a press jaw (60) is assigned to several profile sections (30).

ABSTRACT

A type of mechanical reinforcement of reinforced plastic profiles (3) in the form of rods or tubes in general and specifically for electrical engineering applications with an interdiscliplinary requirement profile is described. In a reinforcing device (1) a profile section (30) is held in a positive locking manner in a recess (20) of a clamp body (2) by pressing. An irreversible reinforcement of the profile end section (30) in the clamp body (2) is thereby achieved.

(Fig. 1)

FIG. 1

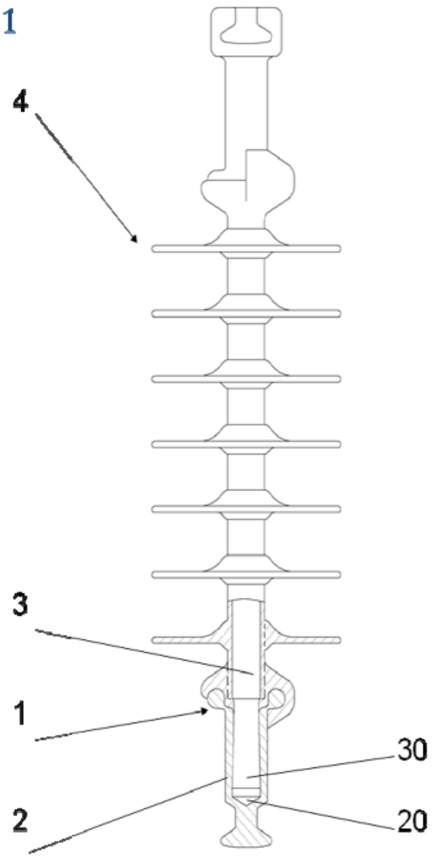

FIG. 2a

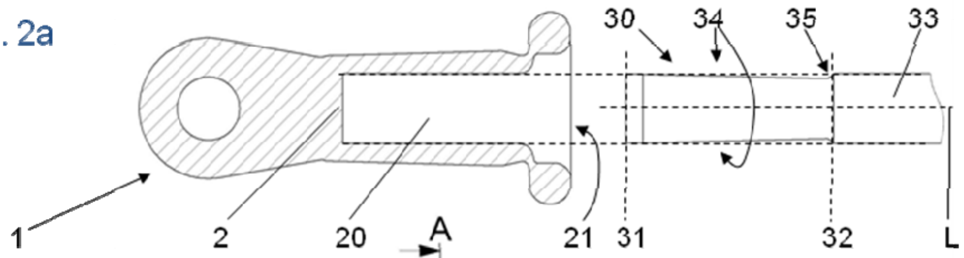

FIG. 2b

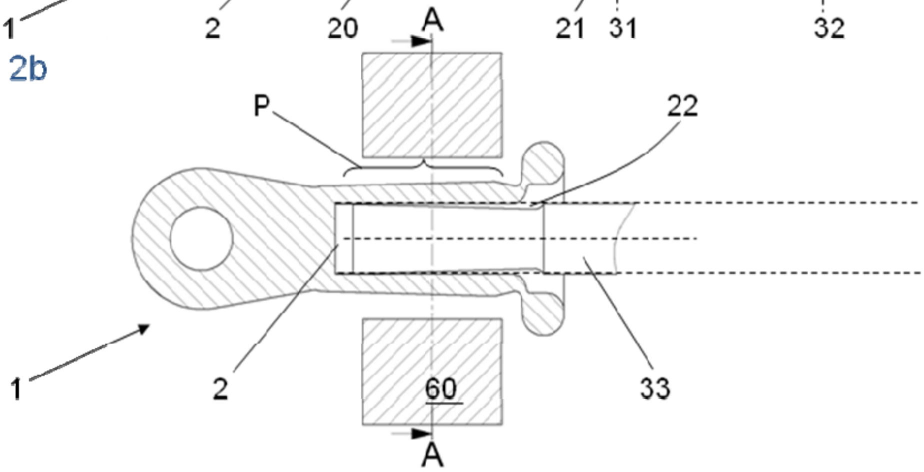

FIG. 2c

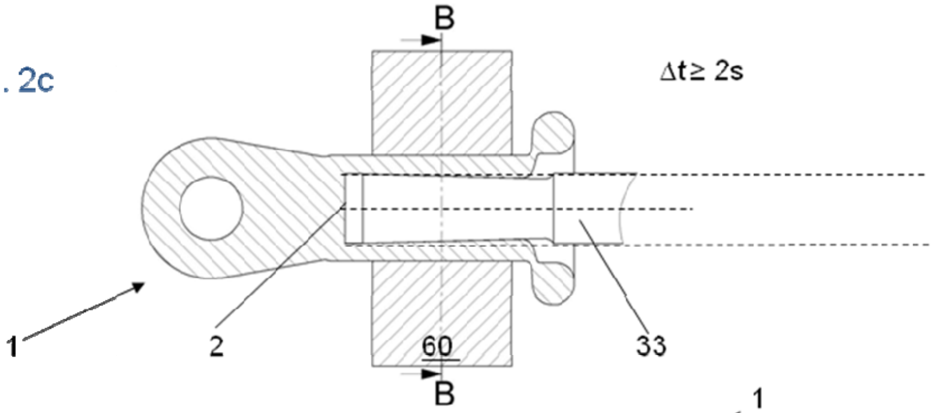

FIG. 2d

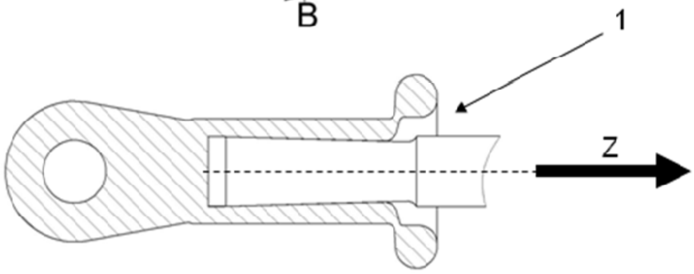

FIG. 3a

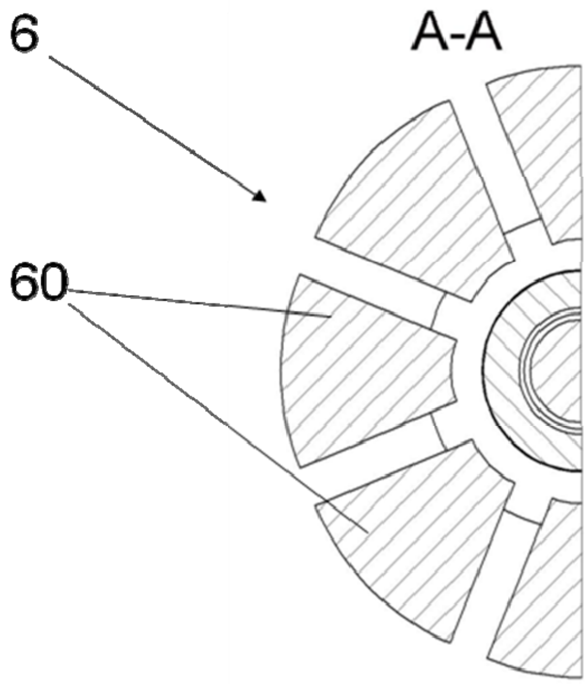

FIG. 3b

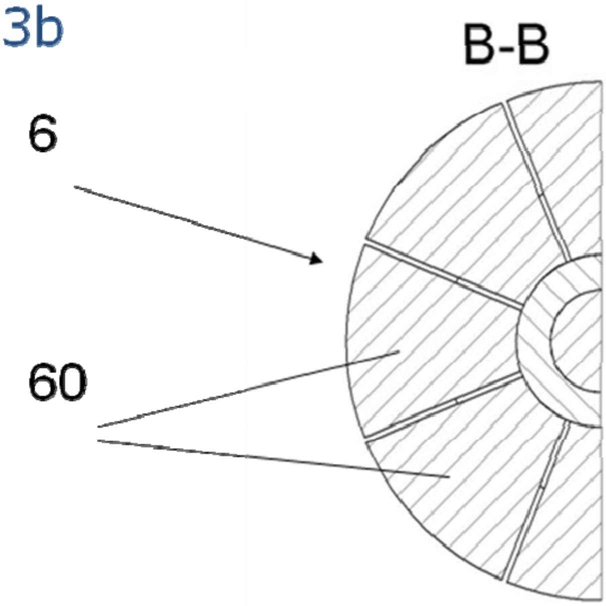

FIG. 4a

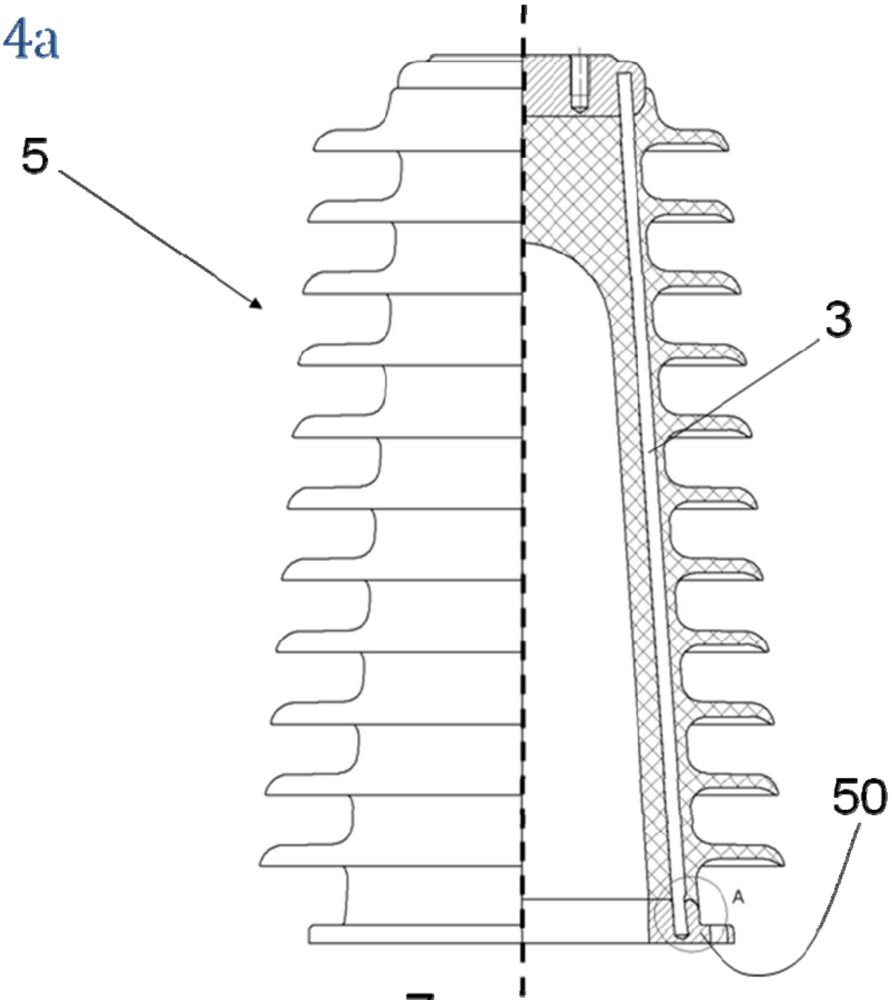

FIG. 4b

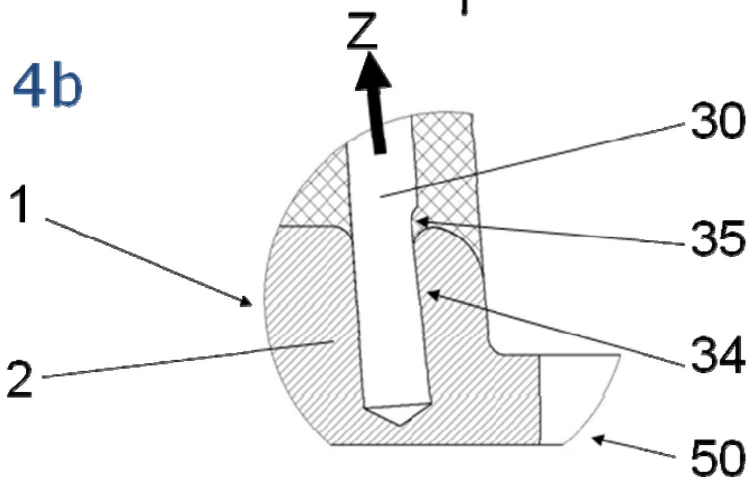

FIG. 5

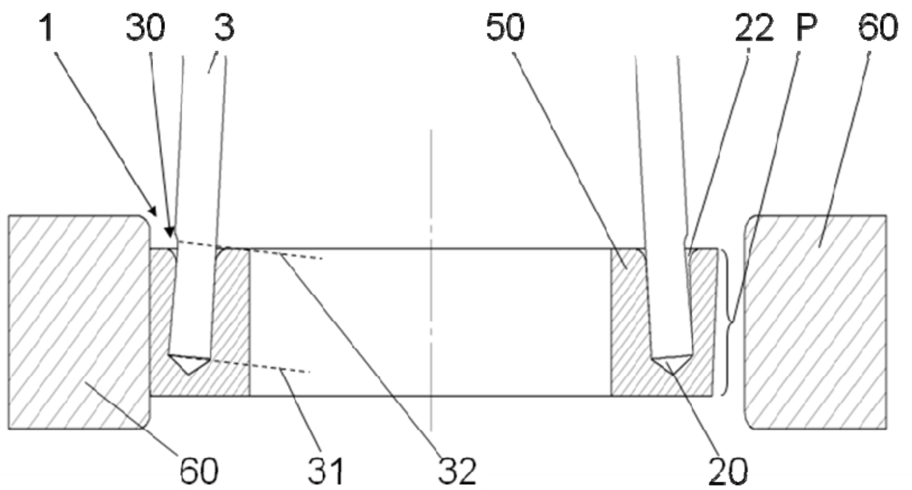

FIG. 6

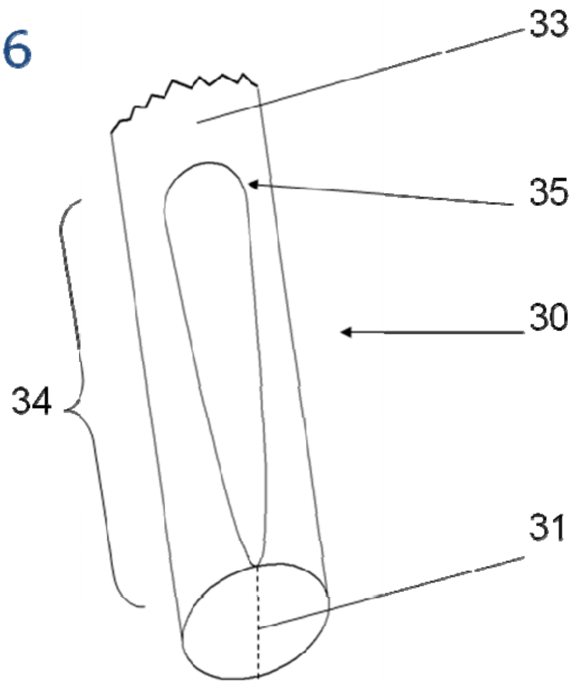

FIG. 7

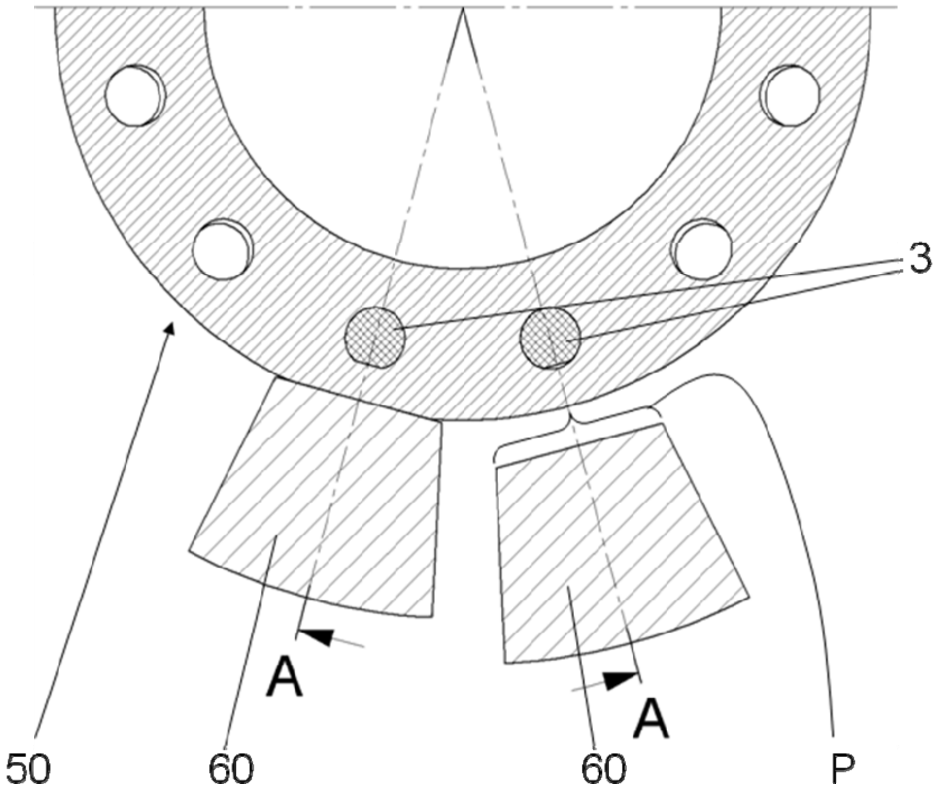

FIG. 8a

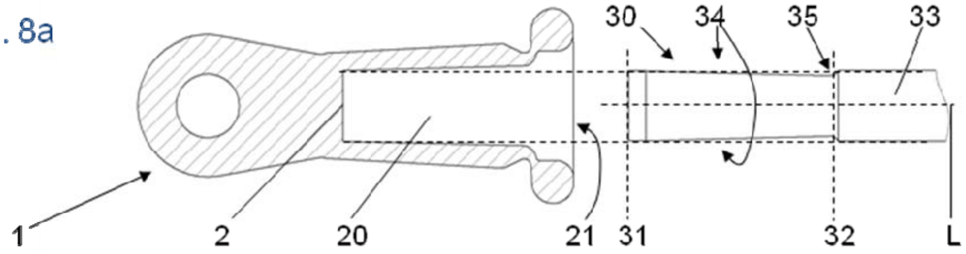

FIG. 8b

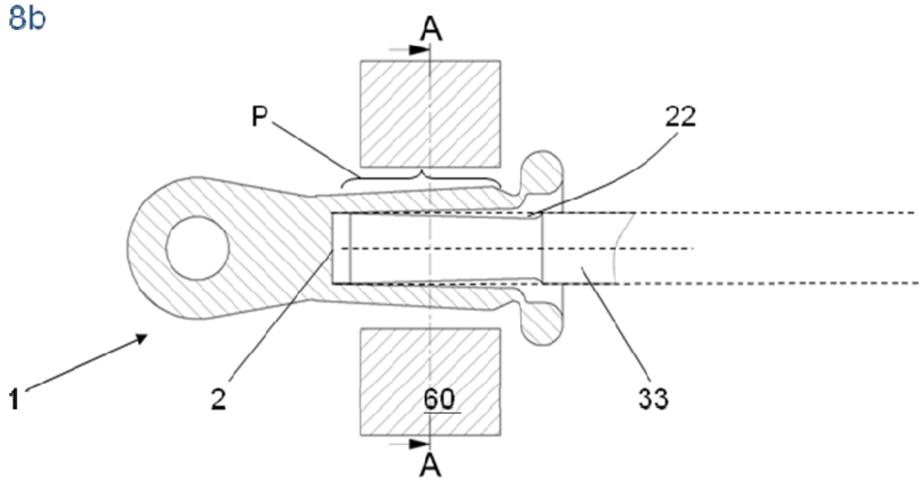

FIG. 8c

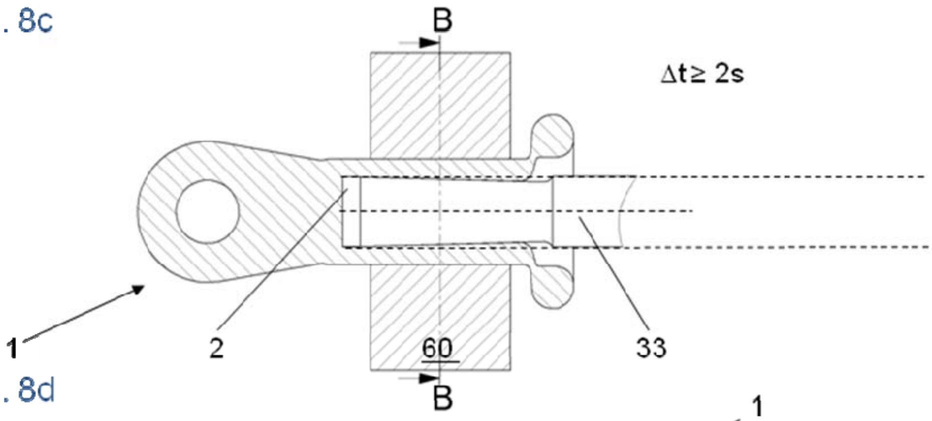

FIG. 8d