

ELECTRICAL PENETRATOR ASSEMBLY

Field of the invention

The present invention generally relates to an electrical penetrator assembly for feed-through of electrical power through a wall of a pressurized vessel or the like, and is particularly concerned with an electrical penetrator assembly for subsea use.

In particular, the present invention relates to an electrical penetrator assembly comprising:

- a penetrator housing comprising a through-bore and an internal support surface;
- a compression member which is attached to the penetrator housing and comprises a compression surface; and
- a ceramic sleeve assembly sealingly providing a feed-through for an electrical conductor, which sleeve assembly is positioned in the through-bore of the penetrator housing and comprises a first, outer support surface interacting with the internal support surface, and a second, outer support surface interacting with the compression surface.

The present invention also relates to a method of manufacturing such an electrical penetrator assembly.

Background

Electrical penetrators are used to power subsea electric submersible pump (ESP) equipment, compressor stations and the like which pressurize hydrocarbons in oil well installations at seabed, and also in other applications such as high pressure downhole electrical penetrations and other penetrations to provide power to various types of subsea equipment, as separation equipment, metering equipment and or monitoring and safety equipment. The penetrator extends through the wall or bulkhead of the vessel in which the equipment is located, and is normally connected to power cables at one end for connecting the equipment to an external power source. Penetrators may be connecting an electric line into an environment with well pressure or pressurized fluid or from an environment at large water depths. This creates an extreme environment for the connection or penetrator in terms of pressure, temperature, and high voltage. The penetrator must transfer power through the barrier as well as maintaining a pressure barrier for both internal pressure and external pressure caused by for instance the depth in seawater.

Consequently, an electrical penetrator assembly shall be capable of operating at high differential pressures and at elevated temperatures.

In a typical electrical penetrator, a one-piece or multi-piece electrical conductor extends through a bore in an insulating sleeve or body. The insulating sleeve, in turn, extends through a penetrator body or housing which is connected to the vessel through which the penetrator extends.

In high temperature and high pressure applications, the insulating sleeve is usually made of a ceramic material.

The sealing between the electrical conductor and the ceramic insulator, and between the ceramic insulator and the penetrator housing or body, shall be designed to withstand loads associated with manufacturing, testing, storage, transportation and, ultimately, operation at elevated temperatures and high pressures.

Normally, the penetrator body is made from a corrosion resistant metal in order to be connected to a metal wall or a bulkhead of the equipment to be provided with the penetrator. This produces the problem of providing a robust and reliable seal between the metal penetrator housing and the ceramic insulating sleeve.

US 2,872,985 B discloses a brazing and welding technique for creating a seal between the electrical conductor and the ceramic insulator. However, the same technique is not suitable for creating a seal between the ceramic insulator and the penetrator housing. Creating such a seal is challenging. Elastomer or thermoplastic seals may not be an acceptable option for specific application and metal seals are difficult to implement for this application. Therefore, an alternative, reliable solution is needed.

US 2013/183853 A1 discloses an electrical penetrator assembly having a ceramic housing with a through bore, a first electrical conductor extending through at least part of the bore and terminating and having an outer end outside the bore and a second end, and a second electrical conductor having a first end in electrical communication with the second end of the first conductor and an outer end.

US 2012/217057 A1 discloses a system for transmitting electric power through a wall, including a housing intended for being rigidly connected to the wall, and two penetrator sub-units on either side of the housing, each including a conductive element and an insulating element rigidly connected to one another.

WO 2012/038102 A1 discloses an electrical through connector providing an electrical connection from an interior of a subsea container to an exterior of the subsea container, wherein the connector extends partially into or fully through a hole in the subsea container. The connector comprises a conductive bolt having a conical bolt portion with an outer diameter increasing in a longitudinal direction. Further, the connector comprises an electrical insulator having a conical insulator portion with an inner surface, facing the conical bolt portion of the bolt, and an outer surface having an outer diameter which increases in the longitudinal direction.

US 2013/065429 A1 discloses feed-through pins of a multiple-phase, high voltage plugpin connector. The connector comprises at least one conductor having a first insulation layer extending along at least part of its length, the insulation layer having an enlarged, load-bearing portion of non-circular cross-section having oppositely directed projections, configured for engagement in a correspondingly shaped bore portion of the connector

shell. The pins are spaced around the central longitudinal axis of the shell with the shorter diagonal of each load-bearing portion extending radially and the oppositely directed projections extending into the radial spaces in the shell between adjacent pins.

DE 2201348 A1 discloses an electrical feedthrough bushing in which an electrically conductive pin is surrounded by an insulating body which is connected to a metal flange. At its ends, the pin is connected to the insulating body in a vacuum-tight manner.

According to one aspect of the present invention, an object of the invention is to provide a method of manufacturing a robust and reliable electrical penetrator assembly which is capable of withstanding high differential pressure and wide range between minimum and maximum temperature.

According to another aspect of the present invention, an object of the invention is to provide an electric penetrator assembly which comprises a robust and reliable seal between a sleeve assembly and the penetrator housing. A further object is to provide an electrical penetrator assembly which is capable of withstanding high differential pressure and wide range between minimum and maximum temperatures. Yet a further object is to provide an electric penetrator assembly which allows for a design which minimizes the space required to implement the seal between the sleeve assembly and the penetrator housing.

Summary of the invention

The method according to the invention is characterised by the steps of:

- sealingly attaching at least one metal, annular sealing member to a section of the sleeve assembly;
- positioning the sleeve assembly in the through-bore of the penetrator housing such that the first, outer support surface is brought into contact with the internal support surface;
- attaching the compression member to the penetrator housing such that the compression surface is brought into contact with the second, outer support surface;
- by means of the compression member, directly or indirectly preloading the sleeve assembly by applying a force onto the sleeve assembly such that a predetermined contact pressure is obtained between the first, outer support surface and the internal support surface; and
- directly or indirectly, sealingly connecting the at least one sealing member to the penetrator housing.

The electrical penetrator assembly according to the invention is characterised in that the assembly comprises:

- at least one metal, annular sealing member which is sealingly attached to a section of the sleeve assembly;

wherein the compression member is configured to apply a preloading force onto the sleeve assembly such that a predetermined contact pressure is obtained between the

first, outer support surface and the internal support surface, and wherein the at least one sealing member is directly or indirectly sealingly connected to the penetrator housing.

According to the invention, a metal, annular sealing member, e.g. a metal membrane, is used as a sealing element between the ceramic sleeve assembly, i.e. the insulator, and the penetrator housing. This configuration allows the sealing member to be brazed to the sleeve assembly, which creates a strong, sealing bond between the sealing member and the sleeve assembly.

According to the invention, the sealing members only act as a seal and do not provide any substantial structural support for the ceramic sleeve assembly when the penetrator assembly is subjected to differential pressure during operation.

During the manufacturing of the penetrator assembly, the sleeve assembly is preloaded by means of the compression member, whereafter the sealing members are sealingly connected, directly or indirectly, to the penetrator housing. The preloading reduces or eliminates stress on the sealing members due to differential pressure induced movement of the ceramic sleeve assembly during operation.

The configuration according to the invention allows a small diameter of the sealing members which, in turn, reduces the force transferred to the ceramic sleeve assembly during operation. This, in turn, allows for a compact design of the penetrator assembly since load-carrying shoulders or surfaces of the ceramic sleeve assembly can be reduced as compared to prior art designs.

In addition, the configuration according to the invention allows for a low profile of the compression member, where the outer diameter of the compression member may be almost equal to the maximum outer diameter of the ceramic sleeve assembly.

During said step of sealingly attaching the at least one sealing member to the sleeve assembly, it may be advantageous to braze the at least one sealing member to a mantle surface of the sleeve assembly.

During said step of sealingly attaching the at least one sealing member to a section of the sleeve assembly, it may be advantageous to:

- sealingly attach a first metal, annular sealing member to a first section of the sleeve assembly; and
- sealingly attach a second metal, annular sealing member to a second section of the sleeve assembly.

During said step of sealingly attaching the first sealing member to the first section of the sleeve assembly, it may be advantageous to braze the first sealing member to a first mantle surface of the first section, and during said step of sealingly attaching the second sealing

member to the second section of the sleeve assembly, it may be advantageous to braze the second sealing member to a second mantle surface of the second section.

During said step of sealingly connecting the at least one sealing member to the penetrator housing, it may be advantageous to attach the at least one sealing member directly to the penetrator housing.

During said step of sealingly attaching the at least one sealing member directly to the penetrator housing, it may be advantageous to create a first seal by welding the at least one sealing member to the penetrator housing.

During said step of sealingly connecting the at least one sealing member to the penetrator housing, it may be advantageous to indirectly connect the at least one sealing member to the penetrator housing via the compression member.

During said step of sealingly connecting the at least one sealing member indirectly to the penetrator housing, it may be advantageous to create a second seal by welding the at least one sealing member to the compression member, and create a third seal by welding the compression member to the penetrator housing.

During said step of sealingly connecting the at least one sealing member to the penetrator housing, it may be advantageous to:

- at a first end surface of the penetrator housing, attach a first sealing member directly to the penetrator housing, and create a first seal by welding the first sealing member to the penetrator housing; and
- at a second end surface of the penetrator housing, connect a second sealing member to the penetrator housing via the compression member, create a second seal by welding the second sealing member directly to the penetrator housing, and create a third seal by welding the compression member to the penetrator housing.

During said step of preloading the sleeve assembly, it may be advantageous to create a contact stress upon the sleeve assembly which is equal to the contact stress expected to arise during operation of the penetrator assembly.

It may be advantageous to arrange the compression member to comprise an annular bolt which is threaded into the penetrator housing and preload the sleeve assembly by applying a torque onto the annular bolt.

The sleeve assembly may advantageously comprise a central section positioned between said first and second sections, which central section comprises said first and second outer support surfaces, and a third, central mantle surface displaying a diameter which is larger than the diameters of said first and second mantle surfaces.

Said first and second support surfaces may advantageously be cone-shaped and face away from each other.

The penetrator assembly may advantageously comprise a spacer which is positioned between said at least one sealing member and a stop surface of the sleeve assembly.

In an aspect, there is provided a method of manufacturing an electrical penetrator assembly comprising:

- a penetrator housing comprising a through-bore and an internal support surface;
- a ceramic sleeve assembly sealingly providing a feed-through for an electrical conductor, which sleeve assembly comprises a first section displaying a first mantle surface, a second section displaying a second mantle surface, and a central section positioned between the first section and the second section, which central section comprises a first, outer support surface and second, outer support surface, and a third, central mantle surface, which is positioned between the outer support surfaces and displays a diameter which is larger than the diameters of the first and second mantle surfaces; and

- a compression member comprising a compressions surface;

said method comprising the steps of:

- sealingly attaching a metal, annular sealing member to the second section of the sleeve assembly;
- positioning the sleeve assembly in the through-bore of the penetrator housing such that the first, outer support surface is brought into contact with the internal support surface;
- attaching the compression member to the penetrator housing such that the compression surface is brought into contact with the second, outer support surface;
- by means of the compression member, directly or indirectly preloading the sleeve assembly by applying a force onto the sleeve assembly such that a predetermined contact pressure is obtained between the first, outer support surface and the internal support surface; and
- sealingly connecting the sealing member to the penetrator housing indirectly via the compression member after said step of preloading the sleeve assembly.

In another aspect, there is provided an electrical penetrator assembly comprising:

- a penetrator housing comprising a through-bore and an internal support surface;
- a compression member which is attached to the penetrator housing and comprises a compression surface; and
- a ceramic sleeve assembly sealingly providing a feed-through for an electrical conductor, which sleeve assembly is positioned in the through-bore of the penetrator housing and comprises a first section displaying a first mantle surface, a second section displaying a second mantle surface, and a central section positioned between the first section and the second section, which central section comprises a first, outer support surface interacting with the internal support surface, and a second, outer support surface interacting with the compression surface, and a third, central mantle surface which is positioned between the outer support surfaces and displays a diameter which is larger than the diameters of the first and second mantle surfaces;

wherein the penetrator assembly comprises:

- an annular sealing member which is sealingly attached to the second section of the sleeve assembly; wherein the compression member is configured to apply a preloading force onto the sleeve assembly such that a predetermined contact pressure is obtained between the first, outer support surface and the internal support surface, and wherein the sealing member is sealingly connected to the penetrator housing indirectly via the compression member.

Description of the drawings

In the following, the invention will be disclosed in more detail with reference to the appended drawings.

Fig. 1 is a schematic drawing of an electrical penetrator assembly according to a first embodiment of the invention.

Fig. 2 is a schematic drawing of a ceramic sleeve assembly according to Fig. 1.

Fig. 3 is a schematic drawing of the ceramic sleeve assembly according to Fig. 1 having sealing members sealingly attached to its mantle surfaces.

Fig. 4 is a schematic drawing of a penetrator housing according to Fig. 1.

Fig. 5 is a schematic drawing of a penetrator housing according to Fig. 1 and the ceramic sleeve assembly inserted into a through-bore of the penetrator housing.

Fig. 6 is a schematic drawing of a compression member applying a pressure onto the ceramic sleeve assembly according to Fig. 1.

Fig. 7 is a schematic drawing of an electrical penetrator assembly according to a second embodiment of the invention.

Fig. 8 is a schematic drawing of an electrical penetrator assembly according to a third embodiment of the invention.

Detailed description of the invention

Fig. 1 discloses an electrical penetrator assembly 1 according to a first embodiment of the invention. The penetrator assembly 1 comprises an elongated and generally rotational symmetric ceramic sleeve assembly 2 which provides a feed-trough for an electrical conductor 29 in a manner which is, as such, known in the art. The penetrator assembly 1 further comprises a metal penetrator housing 3 in which the sleeve assembly 2 is sealingly arranged. The penetrator assembly 1 also comprises first and second metal, annular sealing members 4, 5, e.g. in the form of metal membranes, which are sealingly attached to the surface of the sleeve assembly 2. The penetrator assembly 1 also comprises an annular

compression member 6 which is attached to the penetrator housing 3 and imparts a pre-determined compressive force upon the sleeve assembly 2. In the disclosed embodiment, the compression member 6 comprises a metal annular bolt or nut having external threads which form a threaded joint with corresponding internal threads of the penetrator housing 2.

A pre-determined, preloading compressive force is imparted upon the sleeve assembly 2 by the penetrator housing 3 and the compression member 6.

The first sealing member 4 is sealingly connected to the penetrator housing 3 by means of a first seal 40, and the second sealing member 5 is sealingly connected to the compression member 6 by means of a second seal 41. The compression member 6, in turn, is sealingly connected to the penetrator housing 3 by means of a third seal 42. The seals 40 and 41 may comprise an annular weld joint, e.g. produced using a suitable electron beam welding technique. It may be advantageous to effectuate also the seal 42 in the same way.

The first seal 40 is located at a first end surface 21 the penetrator housing 3, and the second and third seals 41, 42 are located at a second, opposite end surface 22 of the penetrator housing 3, thus allowing the positioning of the first seal 40 and the second and third seals 41, 42 on opposite sides of a wall or bulkhead.

In the following, the particulars of the penetrator assembly 1 will be discussed in more detail with reference to Figs. 2-6. Also, an embodiment of a method of manufacturing the penetrator assembly 1 will be discussed.

Fig. 2 discloses the ceramic sleeve assembly 2 of Fig. 1. As discussed above, the sleeve assembly 2 provides a feed-trough for an electrical conductor (not disclosed) in a manner which is, as such, known in the art. For example US 2,872,985 B discloses such a ceramic sleeve assembly. The sleeve assembly 2 is sealed to the electrical conductor using a suitable prior art technique, e.g. the technique disclosed in US 2,872,985 B.

The sleeve assembly 2 comprises a first cylindrical section 7, a second cylindrical section 8 and a third, central cylindrical section 9 positioned between sections 7 and 8. Each section 7-9 displays a generally cylindrical outer, or mantle, surface 10, 11, 12. However, the outer diameter of the central section 9 is larger than the diameter of the neighbouring sections 7 and 8 such that the central mantle surface 12 displays a diameter which is larger than the diameters of the neighbouring mantle surfaces 10 and 11. The central section 9 further displays first and second cone-shaped outer support surfaces 13, 14, which face away from each other, and first and second stop surfaces 15, 16, which connect the central mantle surface 12 to the neighbouring mantle surfaces 10 and 11 such that the stop surfaces 15, 16 form transition surfaces between the mantle surface 10 and the support surface 13 and the mantle surface 11 and the support surface 14, respectively. The stop surfaces 15, 16 are generally orthogonal to the longitudinal axis of the sleeve assembly 2.

The method of manufacturing the electrical penetrator assembly 1 comprises sealingly attaching the first and second sealing members 4, 5 to the outer surface of the sleeve assembly 2, i.e. on the first and second mantle surface 10, 11, respectively. Consequently, sealing members 4, 5 are attached to the sleeve assembly 2 on either side of the central section 9, as is disclosed in Fig. 3, such that the interface between each sealing member 4,

5 and the sleeve assembly 2 is formed by a cylindrical surface. This enables the formation of a strong, sealing bond between the sealing members 4, 5 and the sleeve assembly 2.

Preferably, the metal sealing members 4, 5 are brazed to the surface of the ceramic sleeve assembly 2.

Spacers 17, 18 may be arranged between the stop surfaces 15, 16 and the sealing members 4, 5 in order to position the sealing members 4, 5 longitudinally on the sleeve assembly 2 (c.f. Fig. 3). The spacers 15, 16 can also be used to prevent the sealing members 4, 5 from attaching to the stop surfaces 15, 16 during the step of sealingly attaching the sealing members 4, 5 to the sleeve assembly 2. Alternatively, the sealing members 4, 5 are not supported in the longitudinal direction of the sleeve assembly 2, in which case the sealing members 4, 5 are positioned such that they do not interact with spacers or the stop surfaces 15, 16.

After the step of sealingly attaching the sealing members 4, 5 to the sleeve assembly 2, the sleeve and sealing member sub-assembly is inserted into a through-bore 19 of the penetrator housing 3 such that the first support surface 13 of the sleeve assembly 2 is brought into contact with a corresponding internal, cone-shaped support surface 20 of the penetrator housing 3 (cf. Fig. 4), and such that the first and second sealing members 4, 5 are generally aligned with first and second end surfaces 21, 22, respectively, of the penetrator housing 3 (c.f. Fig. 4).

Next, the compression member 6 is attached to the penetrator housing 3 such that a compression surface 23 of the compression member 6 is brought to interact with the second support surface 14 of the sleeve assembly 2 and such that the first support surface 13 of the sleeve assembly 2 is brought to interact with the internal support surface 20 of the penetrator housing 3 (cf. Figs. 2 and 5). In the present embodiment, the compression member 6 comprises an annular bolt or nut which is threaded into the penetrator housing 3. This will allow a controlled tightening of the compression member 6 by the application of a torque onto the annular bolt such that a pre-determined, preloading compressive stress is imparted upon the sleeve assembly 2 by the penetrator housing 3 and the compression member 6.

The compression member 6 may be split in two components (not disclosed) to prevent rotation between the compression surface 23 and the second support surface 14 during preloading of the sleeve assembly 2. The angle between the two components shall be higher than angle of the second support surface 14 (from horizontal) to ensure that relative rotation occurs between the two components and not between the surfaces 14 and 23 (assuming similar coefficient of friction between ceramic/metal and metal/metal).

The preloading stress will eliminate relative movement between the ceramic sleeve assembly 2 and the compression member 6 and penetrator housing 3 when a differential pressure is applied over the penetrator assembly 1 during operation. This, in turn, will

reduce the stress brought upon the interface between the sealing members 4, 5 and the sleeve assembly 2 during operation.

When the sleeve assembly 2 has been preloaded to the desired, pre-determined compressive stress, the seals 40 and 41 are applied such that the first sealing member 4 is sealingly attached to the penetrator housing 3, and such the second sealing member 5 is sealingly attached to the compression member 6 (cf. Fig. 1). Also, the seal 42 is applied such that the compression member 6 is sealingly attached to the penetrator housing 3. As discussed above, each seal 40, 41, 42 may advantageously comprise an annular weld joint, e.g. produced using a suitable electron beam welding technique.

Consequently, the ceramic sleeve assembly 2 is preloaded before to the seals 40 and 41 are applied. This will reduce the load on the seals 40, 41 when pressure is applied to penetrator assembly 1 during operation. Also, the design according to the invention allows locating the sealing members 4, 5 on the smaller diameter of the ceramic sleeve assembly 2, i.e. on sections 7 and 8 (cf. Fig. 2). This significantly reduces the load on the ceramic sleeve assembly 2 and the stop surfaces 15, 16 when pressure is applied to the penetrator assembly 1 during operation.

It is to be understood that the amount of preloading should advantageously be adapted to the intended operation pressure range of the penetrator assembly. In general, the preloading should advantageously create a contact stress between surfaces 13 and 20, and between surfaces 14 and 23, equal to the contact stress expected during operation. This is, however, not always achievable, but even a relatively small preloading stress will reduce the stress on the penetrator assembly during operation. In practice, preloading entails maximising the preloading stress within the design limitations of penetrator assembly. However, there is generally no reason to allow the preloading to exceed stresses expected to be encountered during operation.

Fig. 7 discloses a second embodiment of a penetrator assembly 24 according to the invention. The penetrator assembly 23 is generally identical to the above-disclosed penetrator assembly 1. However, the penetrator assembly 24 comprises a spacer 25 which is wider than the previously disclosed spacer 18 and, consequently, more capable of resolving thermal expansion. Fig. 7 also illustrates how the width of the spacer can be adjusted to position a sealing member level with the compression member 6 and/or the penetrator housing 3.

Fig. 8 discloses yet another embodiment of a penetrator assembly 26 according to the invention, which embodiment comprises a sealing member 27 and a spacer 28 in the form of annular, low profile rings which provide for a compact design of the penetrator assembly 26.

The spacers 17, 18, 25, 28 may be made of a ceramic material and can be formed as an integral part of the sleeve assembly.

In the preceding description, various aspects of the invention have been described with reference to illustrative embodiments. However, this description is not intended to be construed in a limiting sense. Various modifications and variations of the illustrative embodiments, as well as other embodiments of the invention, which are apparent to persons skilled in the art to which the disclosed subject matter pertains, are deemed to lie within the scope of the present invention.

Claims

1. A method of manufacturing an electrical penetrator assembly (1) comprising:
 - a penetrator housing (3) comprising a through-bore (19) and an internal support surface (20);
 - a ceramic sleeve assembly (2) sealingly providing a feed-through for an electrical conductor (29), which sleeve assembly (2) comprises a first section (7) displaying a first mantle surface (10), a second section (8) displaying a second mantle surface (11), and a central section (9) positioned between the first section (7) and the second (8) section, which central section (9) comprises a first, outer support surface (13) and second, outer support surface (14), and a third, central mantle surface (12), which is positioned between the outer support surfaces (13, 14) and displays a diameter which is larger than the diameters of the first and second mantle surfaces (10, 11); and
 - a compression member (6) comprising a compressions surface (23);
 said method comprising the steps of:
 - sealingly attaching a metal, annular sealing member (5) to the second section (8) of the sleeve assembly (2);
 - positioning the sleeve assembly (2) in the through-bore (19) of the penetrator housing (3) such that the first, outer support surface (13) is brought into contact with the internal support surface (20);
 - attaching the compression member (6) to the penetrator housing (3) such that the compression surface (23) is brought into contact with the second, outer support surface (14);
 - by means of the compression member (6), directly or indirectly preloading the sleeve assembly (2) by applying a force onto the sleeve assembly (2) such that a predetermined contact pressure is obtained between the first, outer support surface (13) and the internal support surface (20); and
 - sealingly connecting the sealing member (5) to the penetrator housing (3) indirectly via the compression member (6) after said step of preloading the sleeve assembly (2).
2. The method according to claim 1, wherein said step of sealingly attaching the sealing member (5) to the sleeve assembly (2) comprises brazing the sealing member (5) to the mantle surface (11) of the second section (8) of the sleeve assembly (2).
3. The method according to any one of claims 1 and 2, wherein said step of sealingly connecting the sealing member (5) to the penetrator housing (3) indirectly via the compression member (6) comprises creating a first seal (41) by welding the sealing member (5) to the compression member (6), and creating a second seal (42) by welding the compression member (6) to the penetrator housing (3).
4. The method according to any one of claims 1-3, comprising the steps of:

- sealingly attaching a metal, annular sealing member (4) to the first section (7) of the sleeve assembly (2); and
 - sealingly connecting the sealing member (4) attached to the first section (7) of the sleeve assembly (2) directly to the penetrator housing (3) after said step of preloading the sleeve assembly (2).
5. The method according to claim 4, wherein said step of sealingly attaching the sealing member (4) to the first section (7) of the sleeve assembly (2) comprises brazing the sealing member (4) to the mantle surface (10) of the first section (7) of the sleeve assembly (2).
 6. The method according to any one of claims 4 and 5, wherein said step of sealingly connecting the sealing member (4) attached to the first section (7) of the sleeve assembly (2) directly to the penetrator housing (3) comprises creating a third seal (40) by welding the sealing member (4) to the penetrator housing (3).
 7. The method according to any one of the preceding claims, wherein said step of preloading the sleeve assembly (2) comprises creating a contact stress upon the sleeve assembly (2) which is equal to the contact stress expected to arise during operation of the penetrator assembly (1).
 8. The method according to any one of the preceding claims, wherein said compression member comprises an annular bolt (6) which is threaded into the penetrator housing (3), and wherein said step of preloading the sleeve assembly (2) comprises applying a torque onto the annular bolt (6).
 9. An electrical penetrator assembly (1) comprising:
 - a penetrator housing (3) comprising a through-bore (19) and an internal support surface (20);
 - a compression member (6) which is attached to the penetrator housing (3) and comprises a compression surface (23); and
 - a ceramic sleeve assembly (2) sealingly providing a feed-through for an electrical conductor, which sleeve assembly (2) is positioned in the through-bore (19) of the penetrator housing (3) and comprises a first section (7) displaying a first mantle surface (10), a second section (8) displaying a second mantle surface (11), and a central section (9) positioned between the first section (7) and the second (8) section, which central section (9) comprises a first, outer support surface (13) interacting with the internal support surface (20), and a second, outer support surface (14) interacting with the compression surface (23), and a third, central mantle surface (12) which is positioned between the outer support surfaces (13, 14) and displays a diameter which is larger than the diameters of the first and second mantle surfaces (10, 11);

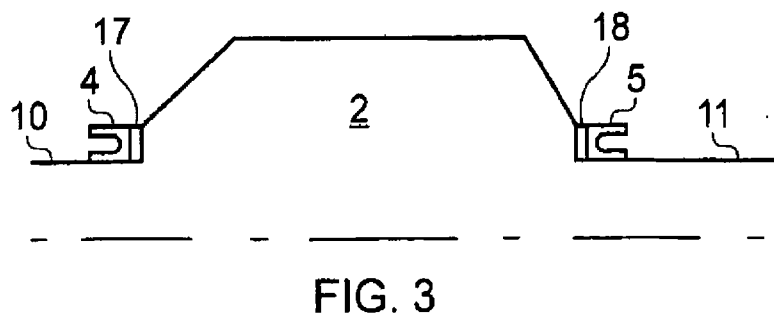
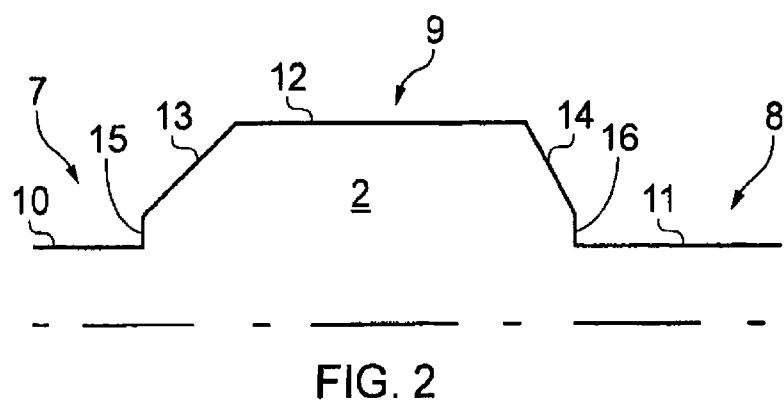
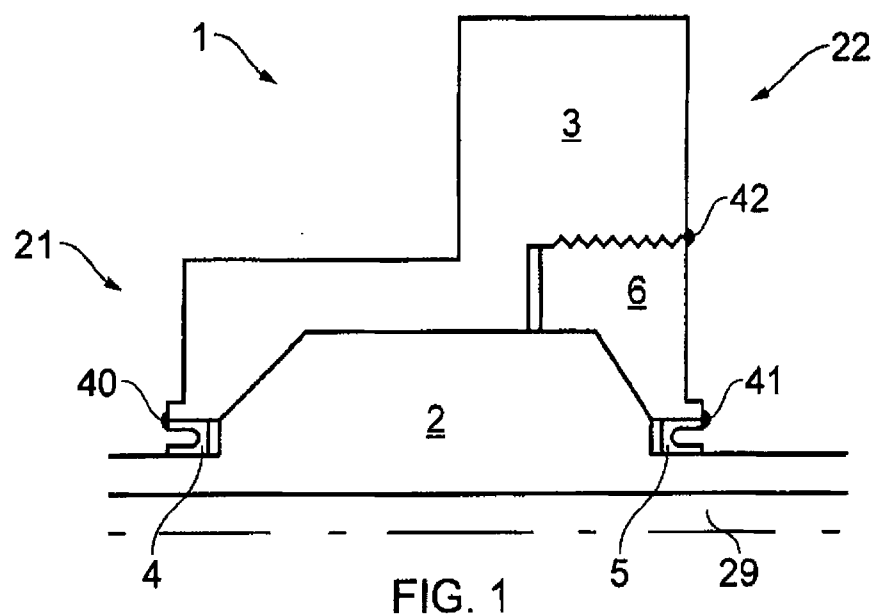
characterised in that the that penetrator assembly (1) comprises:

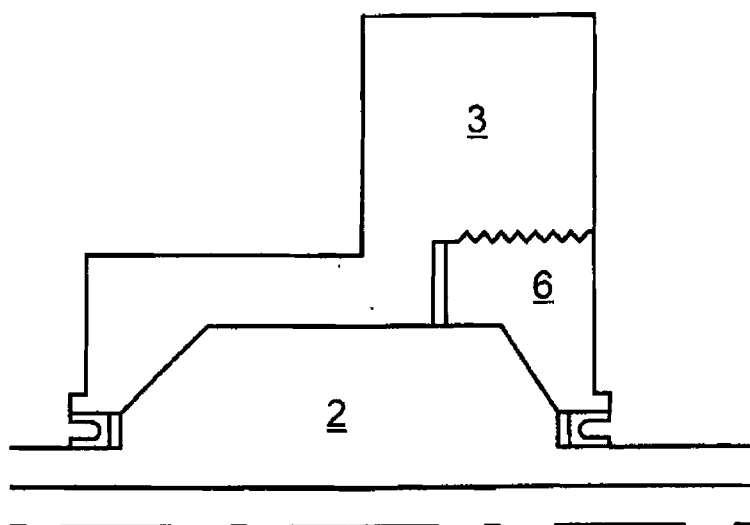
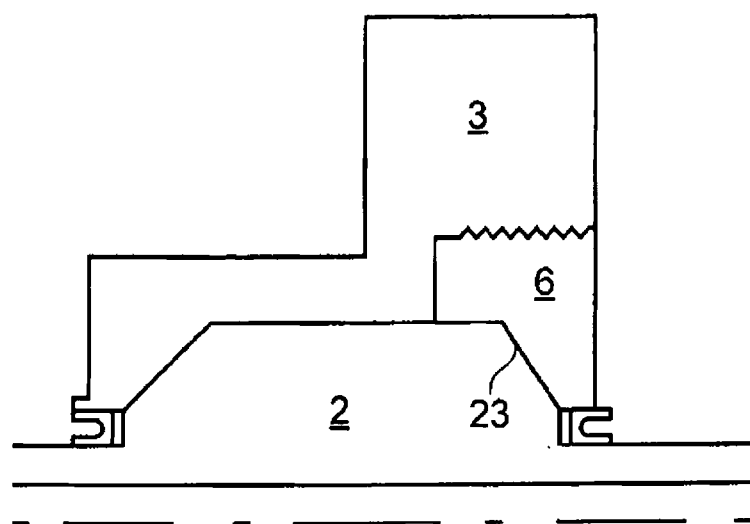
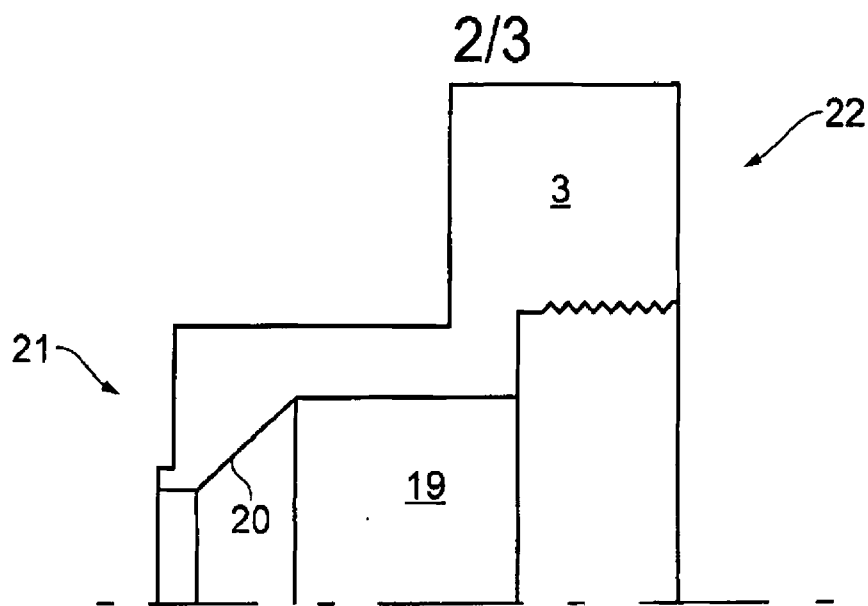
- an annular sealing member (5, 27) which is sealingly attached to the second section (8) of the sleeve assembly (2);

wherein the compression member (6) is configured to apply a preloading force onto the sleeve assembly (2) such that a predetermined contact pressure is obtained between the first, outer support surface (13) and the internal support surface (20), and wherein the sealing member (5) is sealingly connected to the penetrator housing (3) indirectly via the compression member (6).

10. The penetrator assembly (1) according to claim 9, **characterised in that** said sealing member (5, 27) is brazed to the mantle surface (11) of the second section (8) of the sleeve assembly (2).
11. The penetrator assembly (1) according to any one of claims 9 and 10, **characterised in that** said sealing member (5, 27) is sealingly attached to the compression member (6) by means of a first weld seal (41), and in that the compression member (6) is sealingly attached to the penetrator housing (3) by means of a second weld seal (42).
12. The penetrator assembly (1) according to any one of claims 9-11, **characterised in that** the penetrator assembly (1) comprises:
 - an annular sealing member (4) which is sealingly attached to the first section (7) of the sleeve assembly (2);
 wherein the sealing member (4) sealingly attached to the first section (7) of the sleeve assembly (2) is sealingly connected directly to the penetrator housing (3).
13. The penetrator assembly (1) according to claim 12, **characterised in that** said sealing member (4) sealingly attached to the first section (7) of the sleeve assembly (2) is brazed to the mantle surface (10) of the first section (7) of the sleeve assembly (2).
14. The penetrator assembly (1) according to any one of claims 12-13, **characterised in that** said sealing member (4) sealingly attached to the first section (7) of the sleeve assembly (2) is sealingly attached directly to the penetrator housing (3) by means of a third weld seal (40).
15. The penetrator assembly (1) according to any one of claims 9-14, **characterised in that** a spacer (18, 25, 28) is positioned between the sealing member (5, 27) sealingly attached to the second section (8) of the sleeve assembly (2) and a stop surface (16) of the sleeve assembly (2).

1/3





3/3

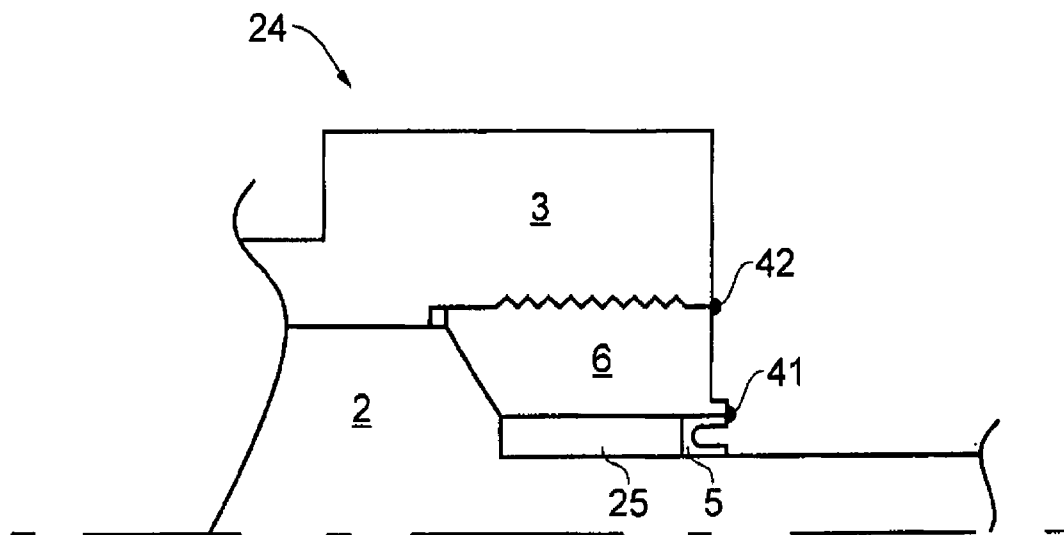


FIG. 7

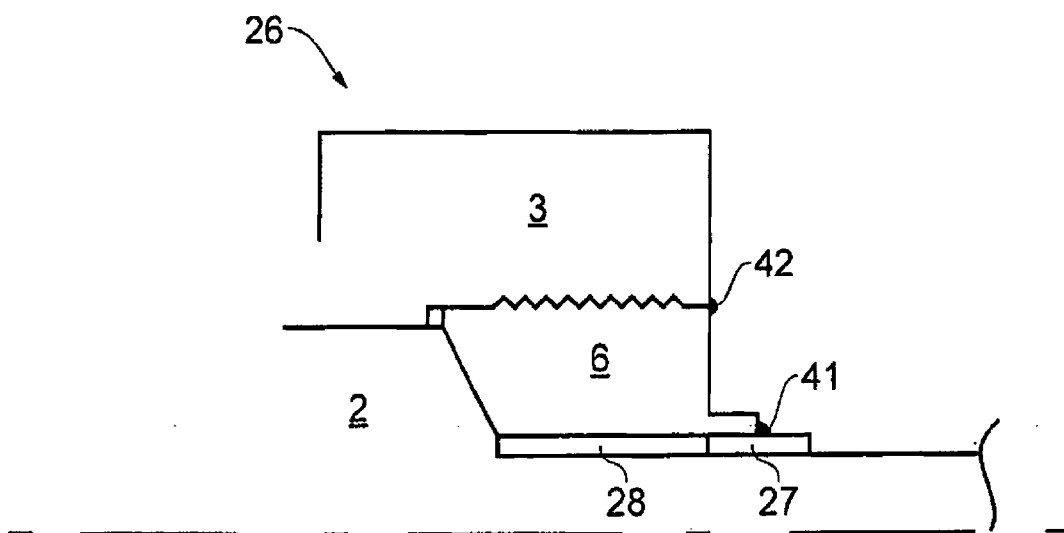


FIG. 8