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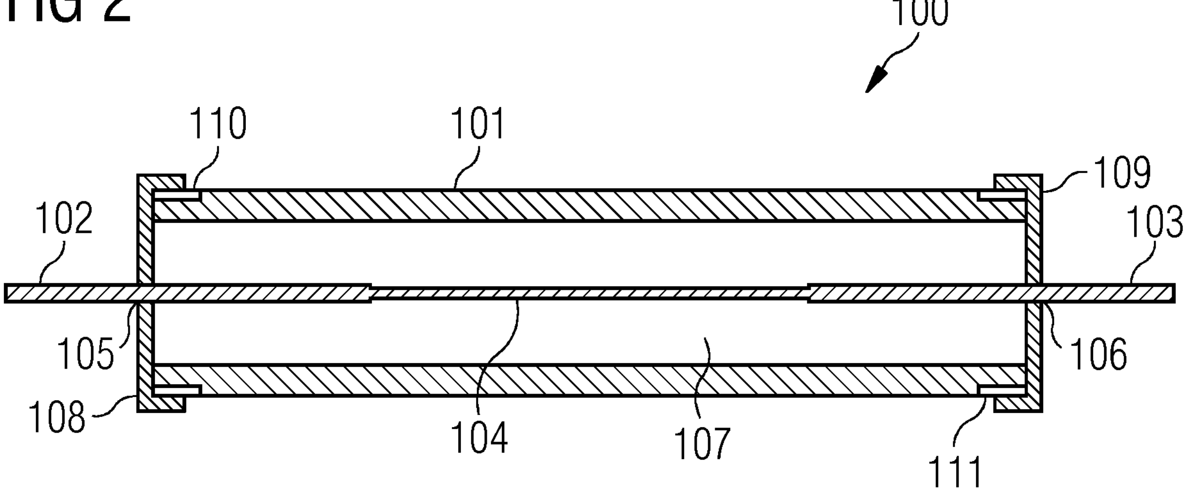
(54) **SUBSEA FUSE DEVICE**

(57) The present invention relates to a subsea fuse device and a subsea device comprising such subsea fuse device. In more detail, the present invention relates a subsea fuse device (100, 200) exposed to a high ambient pressure when deployed, comprising a fuse housing and a fuse wire comprising a first end section (102, 202), a second end section (103, 203), and a central section (104, 204, 404). The fuse housing comprises a pressure-resistant outer envelope (101, 201) made of an isolating material enclosing a low-pressure hollow space (107, 207), a first metalized feedthrough (105, 205) and a second metalized feedthrough (106, 206) which is electrically isolated from the first feedthrough (105, 205) by the outer envelope. The central section (104, 204) of the fuse wire is arranged within the low-pressure hollow space (107, 207). The end sections of the fuse wire extend through the metalized feedthroughs, and the metalized feedthroughs are electrically and mechanically connected to the end sections of the fuse wire thereby sealing the feedthroughs.

FIG 2



EP 3 355 335 A1

Description

Field of the invention

[0001] The present invention relates to a subsea fuse device which may be used in electrical and electronic circuits in subsea equipment. Furthermore, the present invention relates to a subsea device comprising an electric circuitry comprising such subsea fuse device.

Background of the invention

[0002] In subsea applications, for example subsea oil production, subsea devices may comprise electric and electronic circuitry. The subsea devices, which may comprise for example so-called subsea canisters, may be arranged at depths of several hundred or even several thousand meters, for example at a depth of 3000 m. Subsea devices may be pressure compensated such that the inside pressure essentially corresponds to an environmental pressure which may be in a range of a several hundred bars, for example 300 bars at 3000 m. Such pressure compensated subsea devices may be filled with a fluid, for example oil, which may be pressurized at the ambient pressure. Consequently, the very high ambient pressure is also acting on the electric or electronic circuitry arranged within the subsea device.

[0003] In electronic and electrical circuitry fuses are used to protect components or (sub-) circuits from overloads and short circuits. Commonly used disposable fuse arrangements comprise a conductive element which will melt or vaporize if (for example in case of a fault) the current flow in the conductive element exceeds a predefined value. By melting or vaporizing the conductive element the fuse becomes not conducting and isolates the component or (sub-) circuit from the rest of the circuitry or system.

[0004] Using off-the-shelf fuses in pressure-compensated subsea devices is prohibitive for at least two reasons. Firstly, trials have shown that fuses fail to reliably melt or vaporize when immersed in oil at high ambient pressures. And secondly, the oil is typically used as an isolating fluid and would be contaminated and become conductive by the melted or vaporized residue of the conductive element of the fuse.

[0005] Consequently there exists a need for a fuse which operates reliably in an oil-filled subsea device at high pressures.

[0006] Co-pending European patent application EP16159003 discloses a fuse device for a pressure-compensated subsea device wherein the fuse device comprises a housing which allows the fuse's conductive element to be arranged inside the housing at much lower pressures (for example 0-2 bar) than present in the pressure-compensated device (for example 300 bar). The design disclosed in EP16159003 works well with glass housings in which case the subsea fuse device may be manufactured as follows. The fuse wire may be passed through the opposite ends of a glass tube such that the central section is arranged within the glass tube and a first end section and a second end section of the fuse wire are arranged at the opposite ends of the glass tube. The ends of the glass tube are heated to melting point so as to form seals around the first and second end sections, respectively.

[0007] It has been found that this heating process may damage the conductive element of the fuse or alter its characteristics so that the conductive element may melt or vaporize at a lower or higher current than the predetermined maximum current.

[0008] It is therefore an object of the present invention to provide an improved subsea fuse design.

Summary of the invention

[0009] In accordance with the present invention there is provided a subsea fuse device exposed to a high ambient pressure when deployed comprising a fuse housing and a fuse wire.

[0010] The fuse wire comprises a first end section, a second end section, and a central section.

[0011] The fuse housing comprises a pressure-resistant outer envelope made of an isolating material enclosing a low-pressure hollow space. The fuse housing further comprises a first metalized feedthrough and a second metalized feedthrough which is electrically isolated from the first feedthrough by the outer envelope.

[0012] The central section of the fuse wire is arranged within the low-pressure hollow space. The first end section of the fuse wire extends through the first metalized feedthrough which is electrically and mechanically connected to the first end section of the fuse wire thereby sealing the first feedthrough.

[0013] The second end section of the fuse wire extends through the second metalized feedthrough and is electrically and mechanically connected to the second end section of the fuse wire thereby sealing the second feedthrough.

[0014] In other words, the interior of the fuse housing comprising the central section of the fuse wire is completely sealed from an outside of the fuse housing. Thus, the central section of the fuse wire does not come into contact with, for example, a dielectric fluid surrounding the fuse housing, and the interior of the fuse housing is protected from high pressure outside the fuse housing. Therefore, operation of the fuse wire inside the fuse housing becomes reliable, and an isolating dielectric fluid outside the fuse housing will not be contaminated by a melting or vaporizing fuse wire. Moreover, as the fuse housing is prefabricated to have two metalized feedthroughs the sealing can be accomplished by lower temperature operations such as soldering thereby avoiding the extremely high temperatures required to melt the glass feedthroughs disclosed in EP16159003 and thus reducing the risk of damaging the fuse wire or altering its characteristics.

[0015] The outer envelope is pressure resistant which means that in a sealed state the pressure inside the fuse housing is independent from an environmental pressure prevailing outside the fuse housing. For example, the pressure inside the fuse housing may be 0..2 bars independent of an outside pressure which (upon deployment of the fuse) may be in a range from 10 to several hundred bars. A subsea fuse device constructed in accordance with the present invention is more expensive than conventional fuse devices designed for surface deployment. It can advantageously provide the same precision and reliability at any depth and will therefore typically be deployed in installations which are, unlike surface installations, practically inaccessible to routine maintenance.

[0016] In embodiments of the invention the outer envelope may be comprised of a single piece or comprise at least a first and a second section which are glued together.

[0017] At least one of the metalized feedthroughs may be constructed in the form of a metal cap (matching the shape of the respective outer end of the envelope) which seals an end of the outer envelope.

[0018] The isolating material used for the outer envelope may preferably be ceramic material or resin or a combination thereof.

[0019] The housing described above may also accommodate a standard fuse designed to operate at surface conditions.

[0020] In an embodiment the outer envelope has an essentially tubular form as this geometry best withstands pressure differences. In that case the first and second metalized feedthroughs are arranged at opposite ends of the essentially tubular envelope.

[0021] The hollow space may in embodiments either be evacuated (0 bar), have a gas filling at standard atmospheric pressure (around 1 bar) or double atmospheric pressure (around 2 bars) and/or be filled with sand to quench the electric arc created during the melting/vaporizing of the central section of the fuse wire.

[0022] Preferably the end sections and the central section of the fuse wire are made from different materials to ensure that only the central section melts/vaporizes. Suitable materials include zinc, copper, silver, and aluminum and their composites.

[0023] According to the invention there is also provided a subsea device comprising an enclosure and an electric circuitry arranged within the enclosure wherein the electric circuitry comprises at least one subsea fuse device according to the invention.

[0024] The subsea device may be filled with a fluid such as oil and may comprise a volume/pressure compensator which balances the pressure in the enclosure to the pressure prevailing in an environment of the enclosure.

[0025] Although specific features are described in the above summary and the following detailed description in connection with specific embodiments and aspects of the present invention it is to be understood that the features of the embodiments and aspects may be combined with each other unless specifically noted otherwise.

Brief description of the drawings

[0026] The present invention will now be described in more detail with reference to the accompanying drawings.

Fig. 1 shows a schematic representation of a subsea device according to an embodiment of the present invention.

Figs. 2-4 show schematic representations of subsea fuse devices according to different embodiments of the present invention.

Detailed description of the drawings

[0027] Fig. 1 shows a subsea device 10, for example a subsea canister, which may be arranged in a subsea environment for housing electrical components or electric circuitry 11. For communicating with other components arranged in other subsea devices and for supplying the electric circuitry 11 with electrical energy, a data and energy supply connection 12 may be provided extending from an interior of the subsea device 10 to an exterior of the subsea device 10. The subsea device 10 may be arranged and operated in deepwater environments, for example at a depth of 3000 m. Subsea device 10 comprises an enclosure 13 which protects the interior of the enclosure 13 from the environment, for example from salt water.

[0028] For the construction of such subsea devices two principal designs exist to account for the high pressures present in deep sea environments. In a first principal design, a massive pressure resistant outer enclosure is provided for shielding the interior from the high pressure. The interior will then be at a much lower pressure, for example at atmospheric pressure, to facilitate use of electric and electronic components designed for surface use without additional measures. Such enclosures have to have a certain minimum wall strength in order to withstand high differential pressures and are consequently bulky and heavy. This first principal design variant is of no further interest here as standard fuses can be used therein.

[0029] In a second principal design shown in Fig. 1 pressurized (or pressure compensated) enclosures 13 are used which comprise a volume/pressure compensator 14 for balancing the pressure in the enclosure to the pressure prevailing in the ambient seawater. The pressure compensated enclosure 13 is generally filled with a fluid 17, usually oil, because it is a good thermal conductor, incompressible and electrically isolating so that electrical components in enclosure need not be isolated from contact with the fluid. Pressure/volume compensator 14 compensates variations in the volume of fluid 17 filling enclosure 13, which may occur due to variations in ambient pressure or in temperature. Temperature changes can be caused by deployment at the subsea location or by internal heating, for example due to electric power dissipation.

[0030] One of the key challenges with the second principal design is that each component within pressure compensated enclosure 13 needs to be operable under high pressures, as discussed above.

[0031] Electric circuitry 11 may comprise sub circuits 15 and 16. Some of the sub circuits 15, 16 may have to be protected from overload and short circuits. Therefore, in the power supply connection 12 to the sub circuit 15 a subsea fuse device 100/200 is provided. The electric circuitry 11 may comprise for example a printed circuit board on which the subsea fuse device 100/200 and the sub circuits 15, 16 are arranged.

[0032] As described above, the interior of enclosure 13 may be filled with a fluid 17, for example dielectric oil. Therefore subsea fuse device 100/200, when deployed, will in most cases be surrounded by and be in direct contact with fluid 17. Furthermore, due to the pressure compensation of enclosure 13 via pressure compensator 14, fluid 17 may be pressurized at essentially the same pressure as prevailing outside the enclosure 13. In subsea applications this pressure may for example be 300 bars. Therefore subsea fuse device 100/200 has to operate reliably under such pressure conditions.

[0033] Fig. 2 shows a first embodiment of a suitable subsea fuse device 100 in more detail. Subsea fuse device 100 comprises a fuse housing 101 and a fuse wire. The fuse wire is composed of three sections: a first end section 102, a second end section 103 and a central section 104. The different sections of the fuse wire may each have different properties. For example, end sections 102 and 103 may have different cross sections than central section 104. Furthermore, end sections 102 and 103 may be made of a different material than the central section 104. In other embodiments sections 102, 103 and 104 may be made of the same material and may also otherwise have similar properties such that the whole fuse wire is made of a continuous and homogeneous material.

[0034] Fuse housing 101 may have a tubular form and may be a ceramic tube having metal rings 110, 111 attached to the outer periphery at the tube ends. Metal caps 108, 109 are provided at the tube ends for sealing the hollow space 107 enclosed by fuse housing 101 and for providing metalized feedthroughs 105, 106 for the fuse wire.

[0035] In more detail, fuse housing 101 may be a one-piece tubular envelope which encloses hollow space 107 through which the fuse wire is extending. Tubular housing 101 has at each end an opening upon which metal caps 108, 109 reside. First metal cap 108 has a first feedthrough opening 105 and second metal cap 109 has a second feedthrough opening 106. Central section 104 of the fuse wire is arranged within hollow space 107 of fuse housing 101. First end section 102 of the fuse wire extends through first feedthrough opening 105. Second end section 103 of the fuse wire extends through second feedthrough opening 106. At the both openings of tubular housing 101 a section of the housing's outer circumferential surface is metalized to form metal rings 110, 111, for example by mechanically, physically or chemically depositing metal on the outer surface of the tube ends.

[0036] First end section 102 is fed through first feedthrough opening 105 in first metal cap 108. First feedthrough opening 105 is sealed by soldering first end section 102 to first feedthrough opening 105 along the circumference of first feedthrough opening 105.

[0037] Second end section 103 is fed through second feedthrough opening 106 in second metal cap 109. Second feedthrough opening 106 is sealed by soldering second end section 103 to second feedthrough opening 106 along the circumference of second feedthrough opening 106.

[0038] First metal cap 108 is attached to the first opening of tubular housing 101. The first opening of tubular housing 101 is sealed by soldering first metal cap 108 to first metal ring 110 along its entire circumference.

[0039] Second metal cap 109 is attached to the second opening of tubular housing 101. The second opening of tubular housing 101 is sealed by soldering second metal cap 109 to second metal ring 111 along its entire circumference.

[0040] The design of subsea fuse device 100 of Fig. 2 and the use of a soldering method for sealing the outer envelope ensures that the fuse wire is at no time during manufacture exposed to the high temperatures needed to melt glass.

[0041] It should be noted that the above-identified steps for manufacturing subsea fuse device 100 may be carried out in any order.

[0042] The parameters of central section 104 (such as diameter, length, and composition) of the fuse wire are chosen such that central section 104 melts or vaporizes when a predetermined electrical current flowing through the fuse wire is exceeded.

[0043] As housing 101 is completely sealed the oil or other fluid 17 typically present in a pressure-compensated subsea enclosure 13 cannot enter hollow space 107. Thus, the properties of the fuse device remain unaffected by the presence of fluid 17. Also, central section 104 may melt or vaporize without contaminating fluid 17.

[0044] Housing 101 and caps 108, 109 are designed to withstand high ambient pressures. Preferably a tubular form is chosen for housing 101 as it provides significant pressure resistance. In order to improve pressure resistance housing 101 may be filled with sand. Filling housing 101 with sand however has a more important benefit: it quenches the electric arc created during the melting/vaporizing of the central section of the fuse wire. In alternative embodiments, hollow space 107 of fuse housing 101 may be filled with a gas or produced with vacuum depending on the voltage level which is used for supplying the sub circuit 15.

[0045] A variant of the embodiment of the present invention described with reference to Fig. 2 is shown in Fig. 4 and denoted with reference numeral 100'. In this variant central section 104 of the fuse wire is replaced with an off-the-shelf fuse 404 designed to operate at surface pressure conditions. Since fuse housing 101 can maintain surface pressure conditions in hollow space 107 even if fuse device 100' is deployed at great depths the performance of conventional fuse 404 will be within its specification. Otherwise considerations discussed with reference to Fig. 2 apply mutatis mutandis to the embodiment shown in Fig. 4.

[0046] A different design 200 of subsea fuse device in accordance with the present invention is shown in Fig. 3. Subsea fuse device 200 comprises a fuse housing 201 and a fuse wire. In embodiments fuse housing 201 may comprise two sections 201a, 201b. In yet other embodiments these sections may be identical to save manufacturing cost. It should be noted that also the design 100 as discussed with reference to Figs. 2, 4 may comprise a two-part housing 101. It should further be noted that designs involving three or more housing sections are also possible.

[0047] Housing sections 201a, 201b are glued together (shown schematically by a line separating sections 201a and 201b). As with the previously discussed principal embodiment, the fuse wire is composed of three sections: a first end section 202, a second end section 203 and a central section 204. The different sections of the fuse wire may each have different properties. For example, end sections 202 and 203 may have different cross sections than central section 204. Furthermore, end sections 202 and 203 may be made of a different material than the central section 204. In other embodiments sections 202, 203 and 204 may be made of the same material and may also otherwise have similar properties such that the whole fuse wire is made of a continuous and homogeneous material.

[0048] Two-part fuse housing 201 may have a tubular form the cross-section of which becomes smaller towards both ends. At each end a metalized feedthrough 205, 206 is provided for the fuse wire.

[0049] In more detail, two-part fuse housing 201 may be a tubular envelope which encloses hollow space 207 through which the fuse wire is extending. Tubular housing 201 has at its first end a first feedthrough opening 205 and at its second end a second feedthrough opening 206. Central section 204 of the fuse wire is arranged within hollow space 207 of fuse housing 201. First end section 202 of the fuse wire extends through first feedthrough opening 205. Second end section 203 of the fuse wire extends through second feedthrough opening 206. Both feedthrough openings 205, 206 of tubular housing 201 are metalized at least on their inner circumferential surface, for example by mechanically, physically or chemically depositing metal on the inner surface of the feedthrough openings.

[0050] First end section 202 is fed through first feedthrough opening 205 which is sealed by soldering first end section 202 to first feedthrough opening 205 along the circumference of first feedthrough opening 205.

[0051] Second end section 203 is fed through second feedthrough opening 206 which is sealed by soldering second end section 203 to second feedthrough opening 206 along the circumference of second feedthrough opening 206.

[0052] The design of subsea fuse device 200 of Fig. 3 and the use of a soldering method for sealing the outer envelope ensures that the fuse wire is at no time during manufacture exposed to the high temperatures needed to melt glass.

[0053] The parameters of central section 204 (such as diameter, length, and composition) of the fuse wire are chosen such that central section 204 melts or vaporizes when a predetermined electrical current flowing through the fuse wire is exceeded.

[0054] As housing 201 is completely sealed the oil or other fluid 17 typically present in a pressure-compensated subsea enclosure 13 cannot enter hollow space 207. Thus, the properties of the fuse device remain unaffected by the presence of fluid 17. Also, central section 204 may melt or vaporize without contaminating fluid 17.

[0055] Housing 201 is designed to withstand high ambient pressures. Preferably a tubular form is chosen for housing 201 as it provides significant pressure resistance. In order to improve pressure resistance housing 201 may be filled with sand. Filling housing 201 with sand however has a more important benefit: it quenches the electric arc created during the melting/vaporizing of the central section of the fuse wire. In alternative embodiments, hollow space 207 of fuse housing 201 may be filled with a gas or produced with vacuum depending on the voltage level which is used for supplying the sub circuit 15.

[0056] A variant of the embodiment of the present invention described with reference to Fig. 3 is shown in Fig. 5 and denoted with reference numeral 200'. In this variant central section 204 of the fuse wire is replaced with an off-the-shelf fuse 404 designed to operate at surface pressure conditions. Since fuse housing 201 can maintain surface pressure conditions in hollow space 207 even if fuse device 200' is deployed at great depths the performance of conventional fuse 404 will be within its specification. In this design variant the otherwise optional two-part design housing 201 becomes a necessity: housing sections 201a, 201b are applied during manufacture of the fuse device from both sides onto off-the-shelf fuse 404, glued together and later sealed at the feedthrough openings by way of soldering as described above. Otherwise considerations discussed with reference to Fig. 3 apply mutatis mutandis to the embodiment shown in Fig. 5.

[0057] Subsea fuse device 100, 200 enables the isolation of a faulty sub circuit 15 in an oil-filled and pressurized environment. However subsea fuse device 100, 200 may be used for other applications in subsea devices, for example for the implementation of redundancy and/or for providing overcurrent protection. Using the subsea fuse device 100, 200 may avoid an interrupted service, the high cost of replacing the oil in case of contamination or a total failure of larger systems, for example if a fuse does not break as intended, in particular in subsea devices which are often placed in high ambient pressure environments which are inaccessible, for example at the seabed, and which may make maintenance difficult and expensive.

[0058] While the invention is particularly useful for deepwater subsea applications it may of course also be applied in systems where the pressure difference is smaller.

[0059] It should be noted that it is possible to combine the different embodiments shown in Figs. 2-5. For example a subsea fuse device could have a one-piece or multipiece tubular fuse housing which at one end is sealed using a metal cap as shown in Fig. 2 and at the other end has a feedthrough as shown in Fig. 3.

[0060] It should also be noted that a subsea fuse device in accordance with the invention may in principle also be exposed to seawater provided the electrical connections are sufficiently insulated when deployed.

[0061] Further it should be noted that the invention can be employed in any environment where there is a significant differential pressure between the pressure at which the fuse reliably operates and its (target) environment. For the purpose of this description, a differential pressure is significant if it exceeds 25 bar. Consequently a high ambient pressure is 25 bar or more in excess of the low pressure in hollow space 107, 207. In embodiments the low pressure can be 0-2 bar and the high pressure can be any pressure greater than 25 bar approximately corresponding to water depths of 250 m or greater, with preferred embodiments having ambient pressures greater than 100 bar approximately corresponding to water depths of 1000 m or greater.

[0062] In other embodiments hollow space 107, 207 may be pressurized to a pressure that is high when compared to atmospheric pressure but low in comparison to the ambient pressure. For example a gas-filled fuse housing may be pressurized at 100 bar and deployed at water depths of 3000 m approximately corresponding to an ambient pressure of 300 bar. In this example the differential pressure is 200 bar and thus significant. Advantageously the fuse housing only has to withstand a maximum differential pressure of 200 bar instead of 300 bar which allows a more cost-efficient production. The gas for filling the fuse housing must be then chosen such that it does not impede the fuse's performance.

Claims

1. A subsea fuse device (100, 200) exposed to a high ambient pressure when deployed, comprising:

   - a fuse housing, and
   - a fuse wire comprising a first end section (102, 202), a second end section (103, 203), and a central section (104, 204, 404),

   the fuse housing comprising:

   - a pressure-resistant outer envelope (101, 201) made of an isolating material enclosing a low-pressure hollow space (107, 207),
   - a first metalized feedthrough (105, 205),
   - a second metalized feedthrough (106, 206) which is electrically isolated from the first feedthrough (105, 205) by the outer envelope, wherein
   - the central section (104, 204) of the fuse wire is arranged within the low-pressure hollow space (107, 207),
   - the first end section (102, 202) of the fuse wire is extending through the first metalized feedthrough (105, 205),
   - the first metalized feedthrough (105, 205) is electrically and mechanically connected to the first end section (102, 202) of the fuse wire thereby sealing the first feedthrough (105, 205),
   - the second end section (103, 203) of the fuse wire is extending through the second metalized feedthrough (106, 206), and
   - the second metalized feedthrough (106, 206) is electrically and mechanically connected to the second end section (103, 203) of the fuse wire thereby sealing the second feedthrough (106, 206).

2. The subsea fuse device of claim 1, wherein the outer envelope (201) completely encloses the low-pressure hollow space (207).

3. The subsea fuse device of claim 1 or 2, wherein the outer envelope (201) comprises a first section (201a) and a second section (201b) which are glued together.

4. The subsea fuse device of any of the preceding claims, wherein at least one of the metalized feedthroughs (105, 106) is constructed as a metal cap which seals an end of the outer envelope (101).

5. The subsea fuse device of any of the preceding claims, wherein the isolating material is ceramic material or resin or a combination thereof.

6. The subsea fuse device of any of the preceding claims, wherein the central section (104, 204) is a standard fuse (404) designed to operate at surface conditions.

7. The subsea fuse device of any of the preceding claims, wherein the outer envelope (101, 201) has

an essentially tubular form and wherein the first and second metalized feedthroughs (105, 106, 205, 206) are arranged at opposite ends of the essentially tubular envelope (101, 201).

8. The subsea fuse device of any of the preceding claims, wherein the hollow space (107, 207) is filled with sand.

9. The subsea fuse device of any of the preceding claims, wherein the central section (104, 204) of the fuse wire comprises a first material and at least one of the first and second end sections (102, 103, 202, 203) of the fuse wire comprises a second material, wherein the first and second materials are different.

10. The subsea fuse device of claim 9, wherein the first and second materials each comprise at least one of the group comprising:

- zinc,
- copper,
- silver, and
- aluminum.

11. A subsea device (10), comprising:

- an enclosure (13), and
- an electric circuitry (11) arranged within the enclosure (13),

wherein the electric circuitry (11) comprises a subsea fuse device (100, 200) according to any of the preceding claims.

12. The subsea device of claim 11, wherein the enclosure (13) is filled with a fluid (17) and comprises a volume/pressure compensator (14) which balances the pressure in the enclosure (13) to the pressure prevailing in an environment of the enclosure (13).

FIG 1

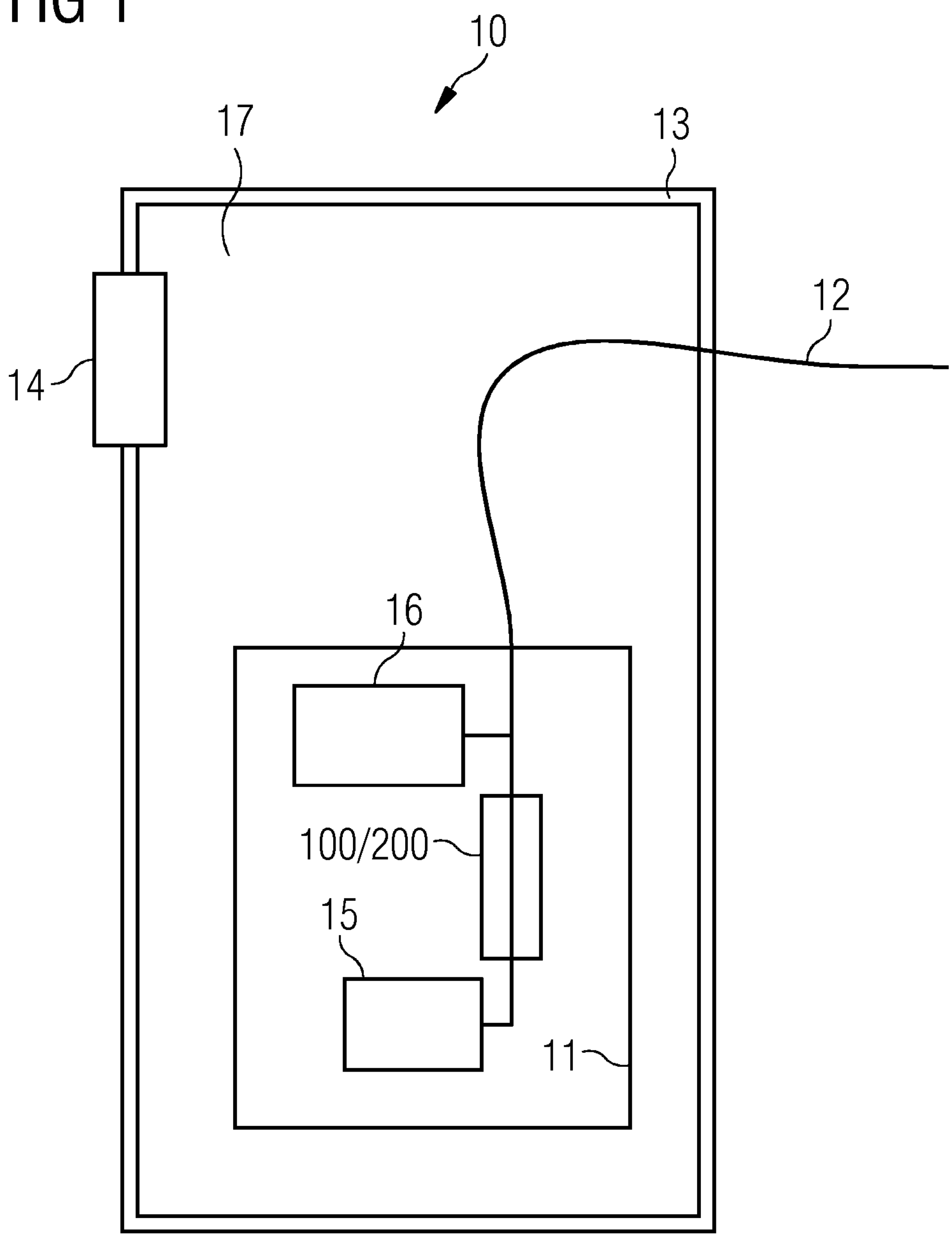


FIG 2

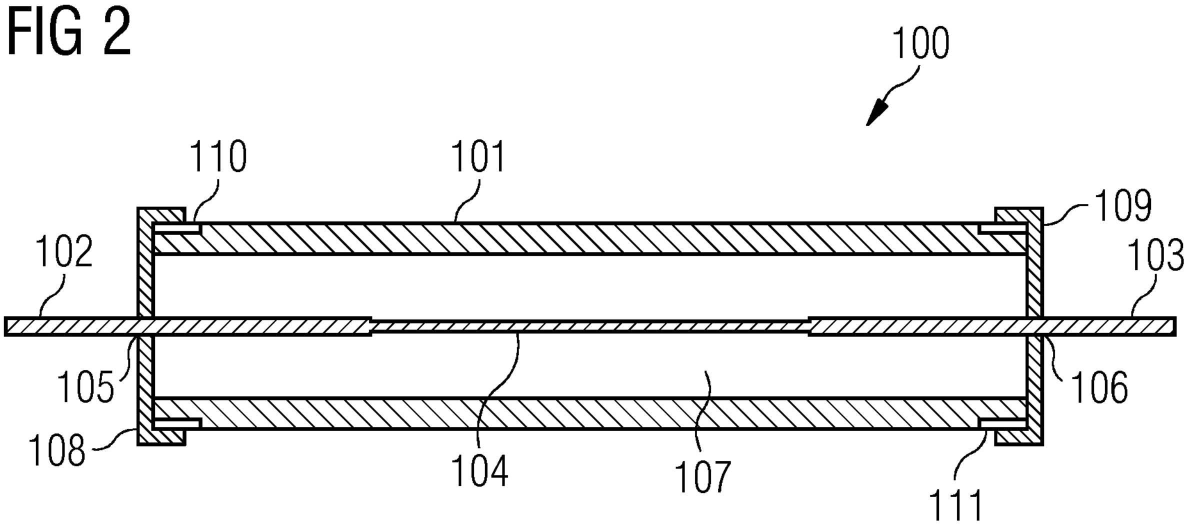

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FIG 3

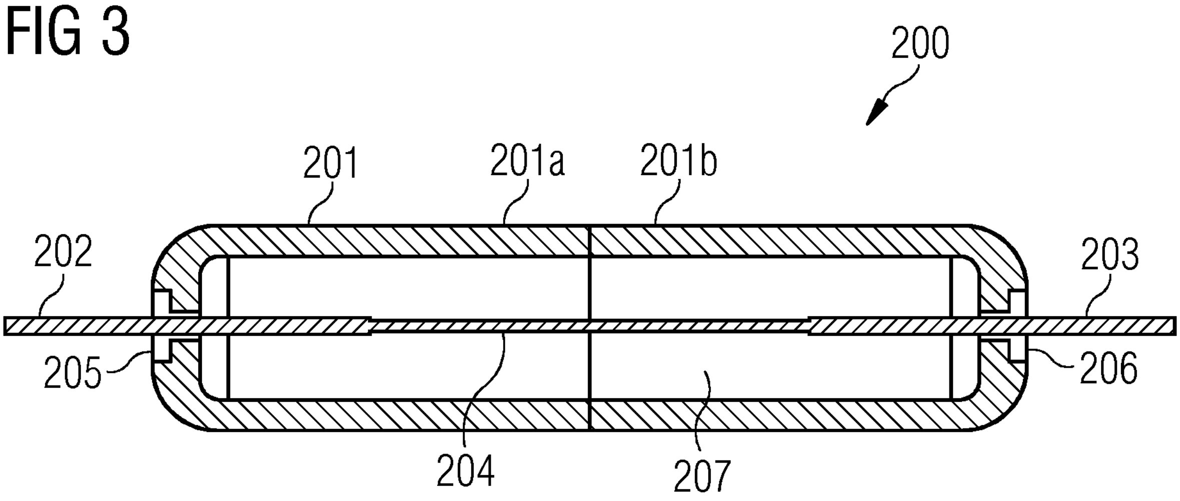
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FIG 4

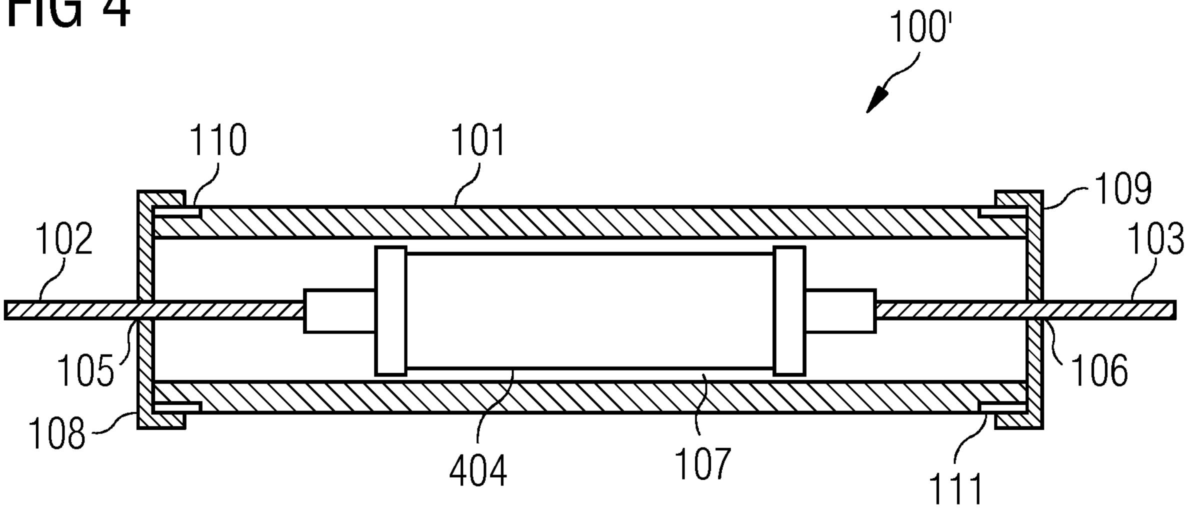
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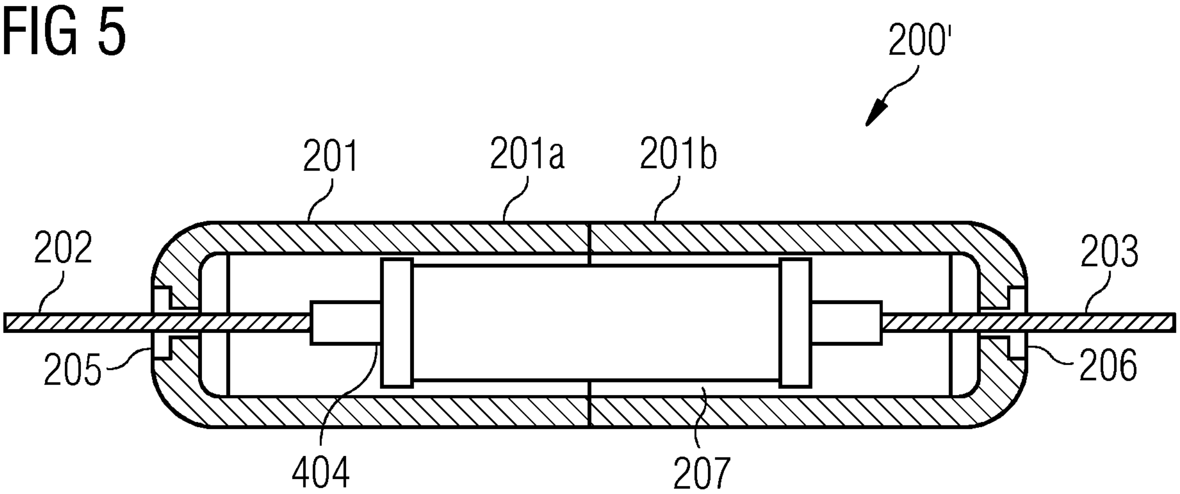
FIG 5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EUROPEAN SEARCH REPORT

Application Number
EP 17 15 3917

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 565 899 A1 (SIEMENS AG [DE]) 6 March 2013 (2013-03-06) * abstract; figure 3 * * paragraph [0054] - paragraph [0057] * -----	1,2,5,6, 8,11	INV. H01H85/00
A	EP 2 495 746 A1 (SIEMENS AG [DE]) 5 September 2012 (2012-09-05) * abstract; figures * * paragraph [0035] - paragraph [0049] * -----	1,11,12	
A	GB 2 525 631 A (SUBSEA 7 LTD [GB]) 4 November 2015 (2015-11-04) * abstract; figures * * page 7, line 12 - page 10, line 14 * -----	1,11	
A	US 1 562 984 A (MURRAY THOMAS E) 24 November 1925 (1925-11-24) * abstract; figures * * column 3, line 30 - column 6, line 6 * -----	1,3,6,12	
A	US 5 103 203 A (HUBER WILLIAM J [US]) 7 April 1992 (1992-04-07) * abstract; figures * * column 2, line 29 - column 3, line 26 * -----	1-12	TECHNICAL FIELDS SEARCHED (IPC): H01H H02B

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	1 June 2017	Serrano Funcia, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 15 3917

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