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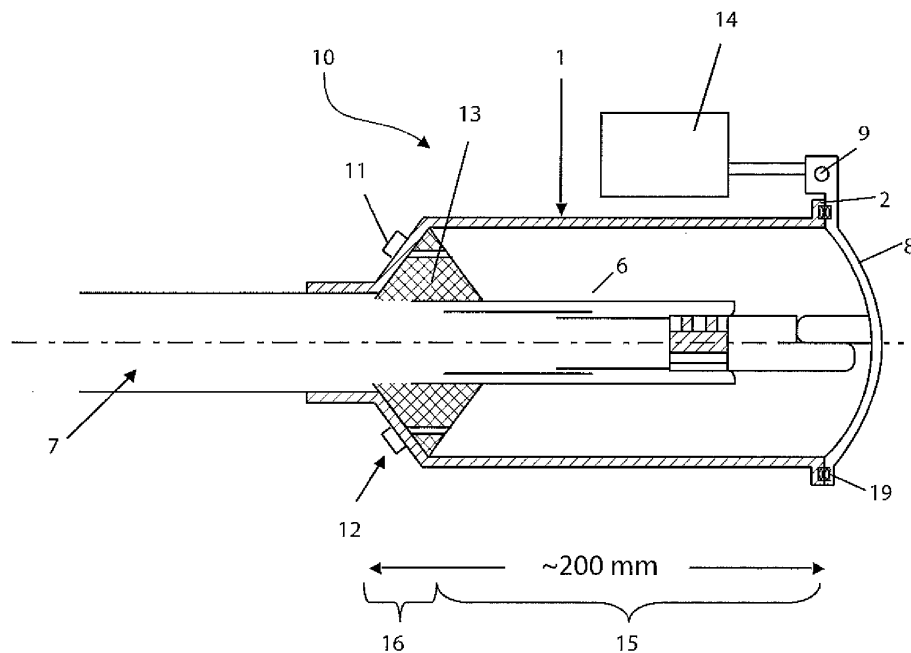
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BA ME(30) Priority: **21.09.2012 GB 201216913**(71) Applicant: **Thornley, David William Maute****Minety Wiltshire SN16 9QS (GB)**(72) Inventor: **Thornley, David William Maute****Minety Wiltshire SN16 9QS (GB)**(74) Representative: **Ward, David Ian et al****Marks & Clerk LLP****Alpha Tower****Suffolk Street****Queensway****Birmingham****B1 1TT (GB)**(54) **High voltage coupler**

(57) A high voltage electrical coupler (10), comprising a contact element (3) and a housing (1). The contact element (3) is securable to an end of an elongate electrical conductor (7), and engageable with a corresponding contact element of a corresponding coupler to make an electrical connection. The housing (1) is securable to

the elongate conductor (7) to house the contact element (3) secured thereto, and is engageable with the housing of the corresponding coupler to form an airtight volume around the engaged contact elements for insulating the electrical connection with pressurised gas. Rolling stock is disclosed, comprising the coupler.

**Fig 1****EP 2 711 262 A1**

Description

[0001] The present invention relates to a high voltage coupler, and more particularly but not exclusively to a high voltage rolling stock coupler.

[0002] Electrically powered train sets are typically equipped with roof mounted pantographs for taking electrical current at high voltage (for instance 15-50kV) from an overhead contact wire. The overhead contact wire may be suspended from a further catenary wire (so named because it typically approximates the natural curve of a wire between each pair of mounting points). This current is carried, via a circuit breaker and down-lead, to a high voltage transformer which transforms the voltage, reducing it to a lower voltage suitable for the power, control and auxiliary systems of the train.

[0003] High speed passenger train sets, comprising multiple coaches, typically have two such pantographs, separated by several coaches (without pantographs). A train set may therefore comprise two pantographs, two circuit breakers and two power transformers.

[0004] When a train is travelling at high speed (for example, over 180 km/hr), the pressure of the pantograph on the contact wire may result in oscillation of the contact wire that makes it difficult for a closely following pantograph (such as the second pantograph of a train set) to follow the movements without intermittently breaking contact. As a result, it is known to have a high voltage (for example 25kV) roof line cable that couples each of the two pantographs to both of the transformers. This roof line requires high voltage jumpers for connecting the cable from coach to coach, and to accommodate movement between the coaches due to track curves and gradients.

[0005] This coupling may comprise an unscreened helical cable, for example those supplied by Tyco Electronics Ltd or Leoni GmbH, or a screened flexible HV conduit as made by Alpha Technik of Switzerland (www.alpha-et.ch). For reasons of safety where unscreened couplings are used the roof line connections are always made at roof level. Flexible conduit couplings may use, at each end, a modified version of the screened connectors which are in large scale use on utility electrical distribution systems and which are described by standards EN 50180 and EN 50181. A screened coupling system may be used either at roof level or at a lower conventional coupling level as there are fewer safety concerns.

[0006] Passenger trains are often supplied in subsets comprising a plurality of coaches, which may be connected together for combined operation from a front cab. For example, a subset may comprise four coaches, a pantograph, transformer and cab. Two of such subsets may be coupled together to form an eight coach set, or three could be coupled to form a twelve coach set. Automatic couplers may be used between the units (for example a Dellner coupler), with automatic coupling arrangements for low voltage electrical and pneumatic systems. These couplings enable the whole assembled train to be con-

trolled from the front cab of a single subset. However, main power to each of the individual coach subsets is independent and still has to come from the pantographs and transformers of these each subset. This limits the speed that such trains can run to up to around 160 km/hr, because of the potential for intermittent loss of power to some coach subsets at higher speeds due to contact wire oscillation.

[0007] It would be desirable to couple the high voltage electrical power supply from one coach subset to the next, in the same way that the present low voltage and pneumatic supplies are connected. Although systems exist for coupling train subsets to form a semi-permanent train set, these systems are only suitable for occasional coupling and decoupling in controlled, clean conditions in a maintenance shed. High voltage train subset connection systems typically comprise an electrically stressed interface seal of a special grease, applied between two sliding surfaces. The sliding surfaces may be rubber to rubber, rubber to metal, or rubber to resin. The contact interface has to be made in clean conditions, and the grease has to be replenished or replaced every time the interface is opened and resealed.

[0008] It is an desirable to provide a high voltage coupler that overcomes at least some of the foregoing problems.

[0009] According to the present invention, there is provided a high voltage electrical coupler, comprising a contact element and a housing, wherein: the contact element is securable to an end of an elongate electrical conductor, and engageable with a corresponding contact element of a corresponding coupler to make an electrical connection; and the housing is securable to the elongate conductor to house the contact element secured thereto, and is engageable with the housing of the corresponding coupler to form an airtight volume around the engaged contact elements for insulating the electrical connection with pressurised gas.

[0010] The housing may have a circular cross section defining a body axis.

[0011] The housing may have a first substantially axial opening for accepting the elongate electrical conductor and a second substantially axial opening for accepting the contacting element of the corresponding coupler.

[0012] The housing may have a substantially cylindrical region adjacent to the second axial opening, and a tapering region adjacent to the first axial opening.

[0013] The housing may be securable to the elongate conductor by a settable material, to form an airtight seal therebetween.

[0014] The coupler may further comprise a settable material for securing the housing to the elongate conductor, for example an epoxy resin.

[0015] The housing may be secured to the conductor by a hardened settable material, the hardened settable material further providing mechanical support for a region of the elongate electrical conductor within the housing.

[0016] The coupler may further comprise an electrical-

ly insulating support tube for supporting a region of the elongate electrical conductor within the housing.

[0017] The housing may comprise a fluid coupling to allow the introduction of a gas into the airtight volume for pressurising the coupling with the gas, in use.

[0018] The fluid coupling may be arranged so that gas may be flowed through the housing via the coupling to purge contaminants from the housing.

[0019] The coupler may further comprise a pressure sensor for monitoring a gas pressure within the housing.

[0020] The housing may comprise a resilient sealing element for sealing engagement with the corresponding coupler.

[0021] The housing may comprise a flange which carries the resilient sealing element.

[0022] The housing may be adapted to be engageable with a substantially identical corresponding housing.

[0023] The housing may be adapted to contain gas, in use, at a pressure of at least 0.3 MPa (3 bar). The housing may be adapted to contain gas at up to 1 MPa (10 bar).

[0024] The housing may be adapted to, in use, safely insulate a nominal voltage of 25kV.

[0025] The coupler may further comprise a lid which is engageable with the housing in a closed position to form a substantially sealed volume around the contact element.

[0026] The lid may be pivotally attached to the housing.

[0027] The lid may be pivotally moveable between the closed position and an open position in which the lid does not obstruct the engagement of the housing with the corresponding coupler.

[0028] The lid may be arranged to engage with a lid of an engaged corresponding coupler in the open position, thereby forming a substantially sealed volume that protects the interior surface of both of the lids from contamination.

[0029] The lid may be substantially dome shaped.

[0030] The lid may have a contact engaging member that corresponds with the contact element, and cooperates therewith when the lid is in the closed position.

[0031] The lid may be arranged, in use, to electrically connect the elongate conductor to the housing when the lid is in the closed position.

[0032] The contact engaging member of the lid may be arranged, when the lid is in the open position, to cooperate with a contact engaging member of the lid of a substantially identical engaged coupler.

[0033] The contact element may comprise a shear bolt connector for mechanically and electrically clamping the contact element to the elongate conductor.

[0034] The contact element may be arranged to engage with an identical corresponding contact element.

[0035] The contact element may comprise a hermaphroditic arrangement of protrusions and recesses.

[0036] According to a second aspect of the invention, there is provided an elongate conductor comprising the coupler according to the first aspect of the invention.

[0037] According to a third aspect of the invention,

there is provided rolling stock, comprising a coupler according to the first aspect of the invention.

[0038] The rolling stock may comprise a plurality of coach subsets and the coupler of any of claims 1 to 30, wherein: each coach subset may have a pantograph, and the coupler may be arranged to provide a high voltage interconnection between coach subsets.

[0039] According to a fourth aspect of the invention, there is provided a housing of the coupler according to the first aspect of the invention.

[0040] The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic sectional view of an embodiment of the invention;

Figure 2 is a detail sectional view of an embodiment of the invention; and

Figure 3 is a sectional view showing an embodiment with a lid in both closed position, and a further view of an engaged pair of couplers.

[0041] Figure 1 shows an elongate electrical conductor 7 with a high voltage coupler 10 secured around its end. The coupler 10 comprises a housing 1 with a lid 8, and an electrical contact element 3 which is secured to the end of the elongate electrical conductor 7.

[0042] The elongate electrical conductor 7 is a conventional 25kV screened high voltage electrical cable, with a stranded copper core. The stranded copper core of the elongate electrical conductor 7 is sealed against the ingress of fluid (such as compressed air), thereby preventing it from providing a conduit for conveying the fluid along the elongate conductor 7, which may result in problems. It will be appreciated that a component that is said to be suitable for use with a nominal voltage of 25kV will, in practise may be suitable for higher voltages, since a nominal 25kV may actually be closer to 30kV near to a substation. Similarly, it will be appreciated that a nominal voltage of 25kV relates to the root mean square voltage of an alternating current supply, which may for instance have a nominal frequency of 50Hz or 60Hz. In other embodiments, the coupler may be designed for a 50kV nominal voltage.

[0043] The contact element 3 is electrically conducting. The housing 1 comprises an electrically conducting material, such as aluminium alloy, and has a circular cross section and a first and second axial opening. The first axial opening is dimensioned to receive the elongate conductor 7 and is at the narrow end of a substantially conical tapering portion 16 of the housing 1. Adjacent to the tapering region 16 is a substantially cylindrical portion 15, the second axial opening being defined by the flanged open end of this cylindrical portion 15. The housing 1 has relatively thin walls, and the cylindrical portion 15 thereby has a substantially cylindrical internal volume that houses

a portion of the elongate conductor 7 that protrudes from the first axial opening into the interior of the housing 1.

[0044] The cylindrical interior volume of the housing 1 of the present embodiment has an internal diameter of approximately 100mm, and a length of approximately 200mm. The housing 1 is dimensioned to insulate the 25kV conductor 7 using dry air at a pressure of approximately 0.3 MPa (3 bar). Dry air may consist of air with a dew point that is lower than 0°C. In other embodiments, for example where space is limited, the housing 1 may have smaller dimensions and operate with an increased pressure such as 1 MPa (10 bar), or with reduced voltages. In the context of an electrical link between coaches, 1 MPa (10 bar) may represent an upper limit of the train pneumatic supply.

[0045] The portion of the elongate conductor 7 within the housing is stripped of its jacket, metal screen and conductive rubber screen. Within the housing 1, a suitable system of electrical stress control (such as a stress cone or non linear stress control system) is arranged to control the electrical field at the end of the earthed screen. The housing 1 is electrically connected to the metal screen and is thereby earthed.

[0046] The elongate conductor 7 is secured to the housing 1 by an epoxy potting/sealing element 13 that substantially fills the interior volume of the tapering region 16 of the housing 1 around the conductor 7, thereby sealing the interface between the conductor 7 and first axial opening, and preventing fluid from penetrating the stranded cable screen under the outer cable jacket.

[0047] A non-conducting support tube 6 is arranged around the protruding portion of the conductor 7 to assist in supporting the conductor 7 and the contact element 3 secured thereto co-incident with the axis of the housing 1. The support tube 6 may, for example, comprise a glass fibre reinforced polymer, and may be bonded to the elongate conductor 7, thereby preventing fluid ingress into the conductor 7 in the case that the elongate conductor 7 comprises a plurality of strands.

[0048] The housing 1 further comprises a fluid coupling 12 and a pressure sensor 11, disposed through the wall of the tapering region 16 and communicating with the interior volume of the cylindrical portion 15. The fluid coupling 12 allows pressurised gas to be introduced to the interior volume, and the pressure sensor 11 outputs a signal in response to a fluid pressure within the interior volume so that the pressure may be monitored. The fluid coupling 12 and pressure sensor 11 are disposed in a region of the tapering portion 16 of the housing 1 that has low electrical stress. The fluid coupling 12 is further arranged to allow compressed gas to be flowed through the housing 1 to remove dust and other contaminants from the interior volume. Although the fluid coupling 12 and pressure sensor 11 are depicted in this embodiment as being disposed through the epoxy potting/sealing element 13, this is not essential and this may not be the area with lowest electrical stress. The fluid coupling 12 and/or pressure sensor 11 may alternatively be located

in a clear region of the housing, facing into clear air, which may be advantageous for removing dust and other contaminants.

[0049] The flanged open end of the housing 1 has a circular groove, concentric with the second opening, within which is retained a captive resilient sealing element 2. A lid 8 is pivotally attached to the housing by a hinge 9 and is thereby pivotally moveable between a closed position in which it closes the second opening of the housing 1, and an open position in which the opening is not obstructed by the lid 8. As can be seen more clearly in Figure 3, the hinge 9 is adjacent to the flanged opening with the pivot axis on the plane of the opening, and offset from a diameter of the housing 1 so that the hinges 9 of engaged couplers 10 do not interfere with each other. The closed and open positions of the lid 8 are 180 degrees apart. The lid 8 may comprise a position sensor to monitor the position of the lid 8.

[0050] As shown in Figures 1 and 2, the lid 8 is provided with a resilient lid sealing element 19 that cooperates, in the closed position, with the housing sealing element 2 to substantially seal the interior volume of the housing 1 when the lid 8 is in the closed position. The lid 8 has a domed shape, so that it can accommodate the contact element 3 which projects slightly beyond the plane of the second opening of the housing. The interior face of the lid 8 is provided with a contact engaging member 22 for supporting the contact element 3 when the lid 8 is in the closed position. The contact engaging member 22 may have an external profile that corresponds with that of the contact element 3 so that it inter-engages therewith in the closed position. The contact engaging member 22 comprises an electrically conducting material so that the elongate conductor core 7 is earthed by the housing 1 with the lid 8 in the closed position.

[0051] As shown in Figure 1, the lid 8 may further comprise an actuator 14 for moving it between open and closed positions.

[0052] Figure 2 shows the end of the electrical conductor 7 more clearly. The contact element 3 has a first end which is electrically and mechanically engaged with the end of the core of the conductor 7 a second end with an electrical contact 4 for cooperating with an identical corresponding contact element 3. The contact element 3 comprises a plurality of shear bolts 18 that are tightened to engage the contact element with the conductor core. The contact element electrical contact 4 is hermaphroditic, having a protrusion and corresponding recess for receiving the substantially identical protrusion of a corresponding contact element 3. There may be a plurality of such protruding features (with corresponding recesses to accommodate those of the cooperating contact element). In one embodiment, there is an axial protrusion with a semi-circular section extending from the front of the contact element 3, and an adjacent void for receiving the co-operating protrusion of the corresponding contact element 3. In other embodiments there may be plurality of inter-engaging features on each contact element 3, for

example each contact element 3 may have two diagonally opposite axial protrusions with circular quadrant shaped sections.

[0053] The external profile of the contact element 3 is arranged so that co-operating contact elements 3 have a substantially cylindrical external profile for reducing electrical stresses in the region of the contact element 3.

[0054] The contact element 3 is positioned in the coupler 10 so that it will electrically engage the contact element 3 of a corresponding coupler 10 when the two couplers are engaged, as will be more fully explained below. The contact element 3 may, for example, comprise silver plated copper.

[0055] Figure 3 shows a sectional view of a pair of engaged identical couplers 20. The flanges of each housing 1 are butted together, and the sealing elements 2 are in cooperation to seal the combined internal volume of the engaged couplers 20. The seal elements 19 of the lids 8 of the engaged couplers 20 are similarly engaged to seal the interior of the lids 8 from contamination. The contact engaging members 22 of the lids 8 cooperate with each other with the lids 8 in the open position. The lids 8 may be constrained by their hinges to a maximum opening angle of 180 degrees, or a clamping mechanism may be provided to ensure that the lids 8 of the engaged couplers 20 cooperate to sealingly engage in the open position.

[0056] In use, dry compressed air is introduced into the interior volume of the housing 1. As is well known, the electrical strength of air increases with increasing pressure over a large pressure range (according to Paschen's Law). The pressurised air insulates the conducting elements of the engaged couplers 20. Furthermore, the sealed internal volume of the couplers 20, both in the engaged position with the lids 8 open, and in the disengaged position with the lids 8 closed, ensures that the connection remains free from contamination.

[0057] The coupler described hereinbefore eliminates the problematic interfacial seals of prior art high voltage couplers, and is suitable for being coupled in an automatic fashion, and for being repeatedly coupled and recoupled thousands of times. The coupler described hereinbefore is both economic and safe, being based on a proven method of insulating high voltages with compressed gas.

[0058] The coupler is suitable for coupling high voltage electrical power between rolling stock, for instance between coach subsets as described hereinbefore. The coupler may be mounted on an automatic coach coupling with a similar amount of longitudinal and lateral compliance to existing low voltage couplers so that, as the automatic coach coupling mechanically engages, an embodiment of the high voltage coupler mechanically engages and seals and the air pressure builds up to the minimum functioning level (for instance 0.3 MPa or 3 bar). When the pressure within the housing is at the minimum functioning level, the conductor may safely be made live.

[0059] Sensors on the coupler may be connected to a control system, for instance to monitor the pressure, lid

position and engagement of the coupler.

[0060] Embodiments of the present invention may be used to enable trains comprising multiple coach subsets to overcome the speed limitations imposed by the lack of power coupling between their independent pantographs.

[0061] One specific application of the coupler has been described above relating to interconnecting high voltage power supplies between rolling stock. The present applicant has appreciated the particular suitability of such a coupler in this situation in view of the pneumatic system already in place. However, it will of course be appreciated that other applications are possible, so that the coupler is not limited to interconnecting high voltage power supplies between rolling stock.

[0062] Example embodiments have been described in which the coupler is pressurised with dry air, but other gases may be used, such as nitrogen. In other embodiments the coupler may be designed to insulate up to 15kV, rather than 25kV.

[0063] It will be appreciated that the description above refers to the use of a pressurised gas to provide electrical insulation around the electrical connection, but it is also feasible that an electrically insulating liquid could instead be used (with the term 'fluid' covering both gas and liquid).

[0064] Whilst specific embodiments of the invention are described hereinbefore, it will be appreciated that a number of modifications and alterations may be made thereto without departing from the scope of the invention.

Claims

1. A high voltage electrical coupler (10), comprising a contact element (3) and a housing (1), wherein:

the contact element is securable to an end of an elongate electrical conductor (7), and engageable with a corresponding contact element of a corresponding coupler to make an electrical connection; and

the housing is securable to the elongate conductor to house the contact element secured thereto, and is engageable with the housing of the corresponding coupler to form an airtight volume around the engaged contact elements for insulating the electrical connection with pressurised gas.

2. The coupler of claim 1, wherein the housing has a circular cross section defining a body axis and optionally the housing has a first substantially axial opening for accepting the elongate electrical conductor and a second substantially axial opening for accepting the contacting element of the corresponding coupler and optionally the housing has a substantially cylindrical region (15) adjacent to the second axial opening, and a tapering region (16) adja-

- cent to the first axial opening.
3. The coupler of any preceding claim, further comprising a settable material (13), optionally an epoxy resin, for securing the housing to the elongate conductor, the hardened settable material optionally providing mechanical support for a region of the elongate electrical conductor within the housing.
 4. The coupler of any preceding claim, further comprising an electrically insulating support tube (6) for supporting a region of the elongate electrical conductor within the housing.
 5. The coupler of any preceding claim, wherein the housing comprises a fluid coupling (12) to allow the introduction of a gas into the airtight volume for pressurising the coupling with the gas, in use, the fluid coupling optionally being arranged so that gas may be flowed through the housing via the coupling to purge contaminants from the housing.
 6. The coupler of any preceding claim, further comprising a pressure sensor (11) for monitoring a gas pressure within the housing.
 7. The coupler of any preceding claim, wherein the housing comprises a resilient sealing element (2) for sealing engagement with the corresponding coupler, and optionally a flange which when present carries the resilient sealing element.
 8. The coupler of any preceding claim, further comprising a lid (8) which is engageable with the housing in a closed position to form a substantially sealed volume around the contact element, the lid optionally being pivotally attached to the housing.
 9. The coupler of claim 8, wherein the lid is pivotally moveable between the closed position and an open position in which the lid does not obstruct the engagement of the housing with the corresponding coupler and optionally wherein the lid is arranged to engage with a lid of an engaged corresponding coupler in the open position, thereby forming a substantially sealed volume that protects the interior surface of both of the lids from contamination.
 10. The coupler of claim 8 or 9, wherein the lid has a contact engaging member (22) that corresponds with the contact element, and cooperates therewith when the lid is in the closed position and the lid is optionally arranged, in use, to electrically connect the elongate conductor to the housing when the lid is in the closed position.
 11. The coupler of claim 10, wherein the contact engaging member of the lid is arranged, when the lid is in the open position, to cooperate with a contact engaging member of the lid of a substantially identical engaged coupler.
 12. The coupler of any preceding claim, wherein the contact element comprises a shear bolt connector (18) for mechanically and electrically clamping the contact element to the elongate conductor.
 13. The coupler of any preceding claim, wherein the contact element is arranged to engage with an identical corresponding contact element, the contact element optionally comprising a hermaphroditic arrangement of protrusions and recesses.
 14. Rolling stock, comprising the coupler of any of claims 1 to 13.
 15. The rolling stock of claim 14, comprising a plurality of coach subsets and the coupler of any of claims 1 to 13, wherein: each coach subset has a pantograph, and the coupler is arranged to provide a high voltage interconnection between coach subsets.

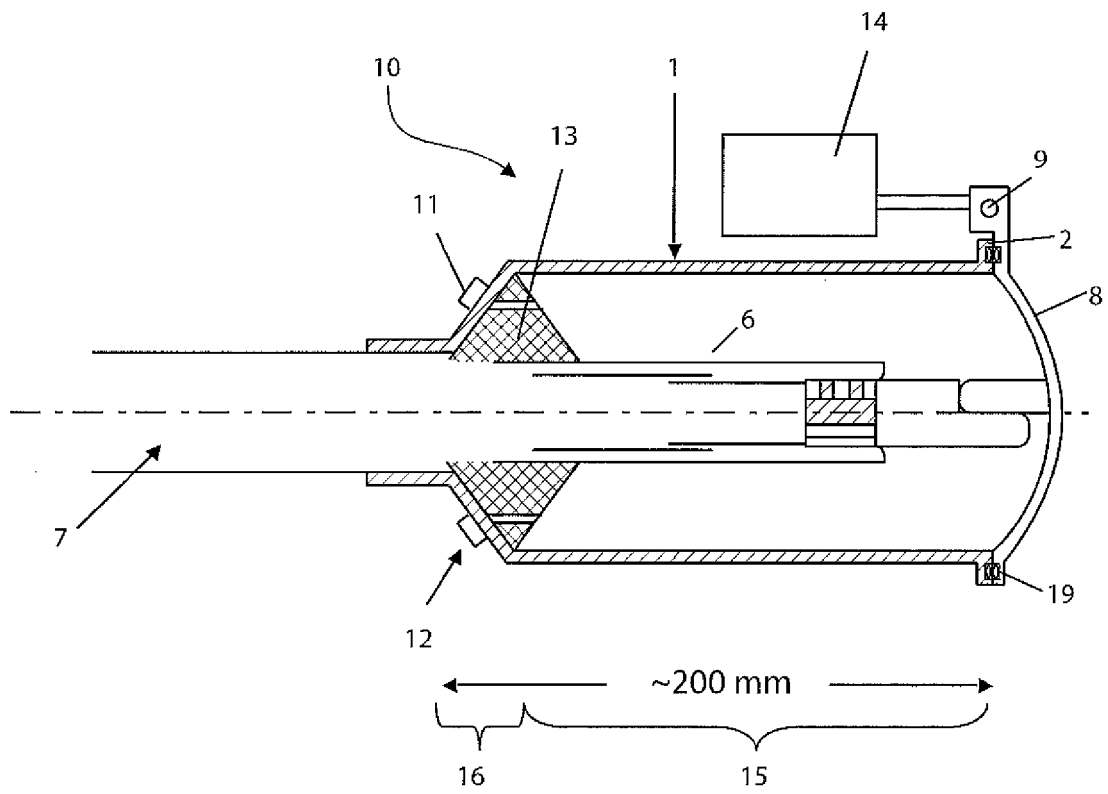


Fig 1

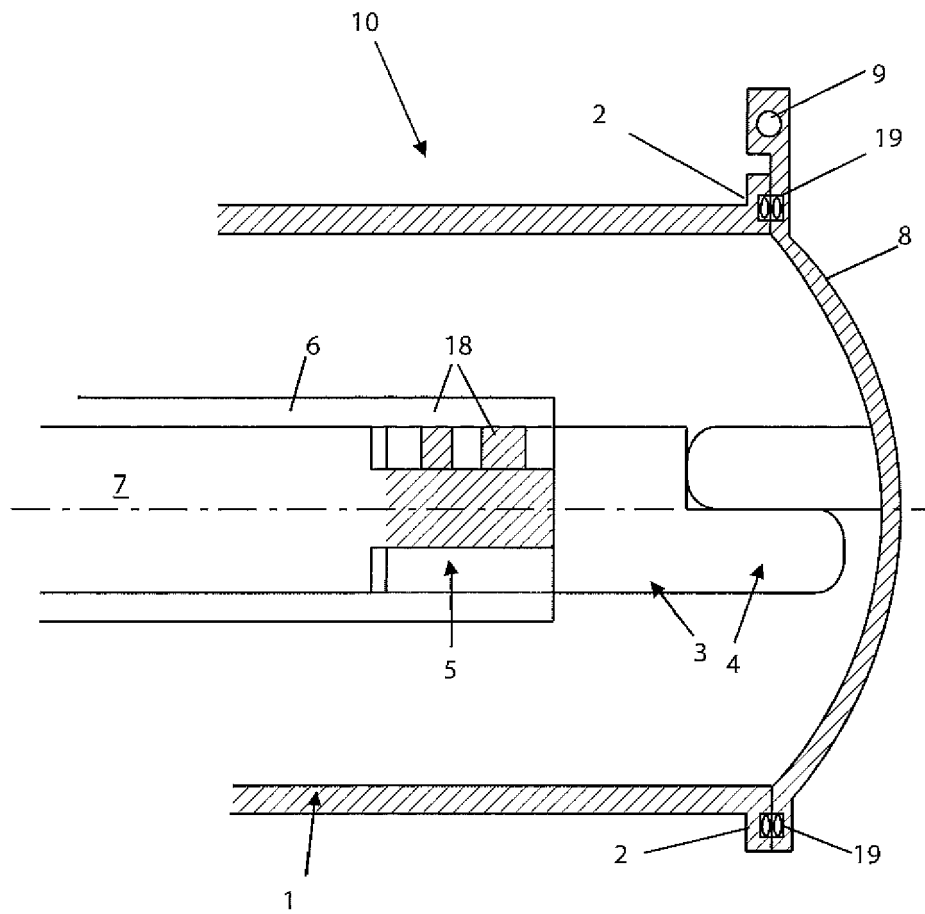


Fig 2

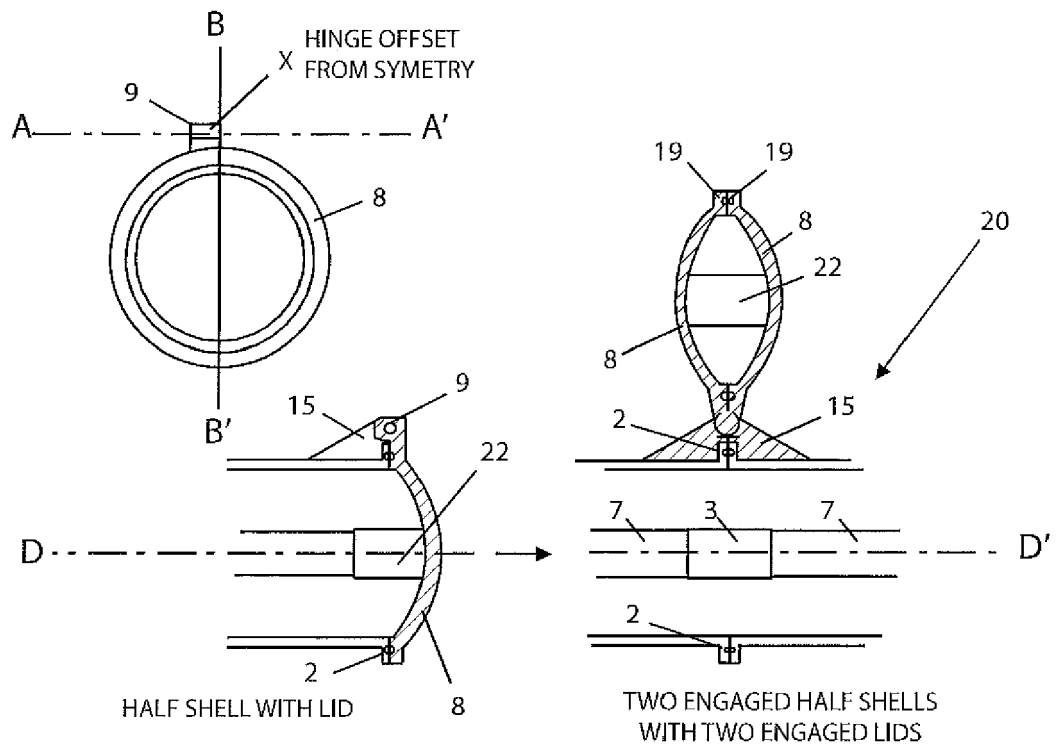


Fig 3



EUROPEAN SEARCH REPORT

Application Number
EP 13 18 3810

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 17 December 2013	Examiner Pugliese, Sandro
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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