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

(11) EP 1 942 514 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
09.07.2008 Bulletin 2008/28

(21) Application number: **07100125.9**

(22) Date of filing: **04.01.2007**

(51) Int Cl.:
H01H 33/66 *(2006.01)*
H02G 15/14 *(2006.01)*
H01H 9/04 *(2006.01)*
H01B 7/14 *(2006.01)*
H02B 13/00 *(2006.01)*

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

(71) Applicant: **Eaton Electric B.V.**
7559 SC Hengelo (NL)

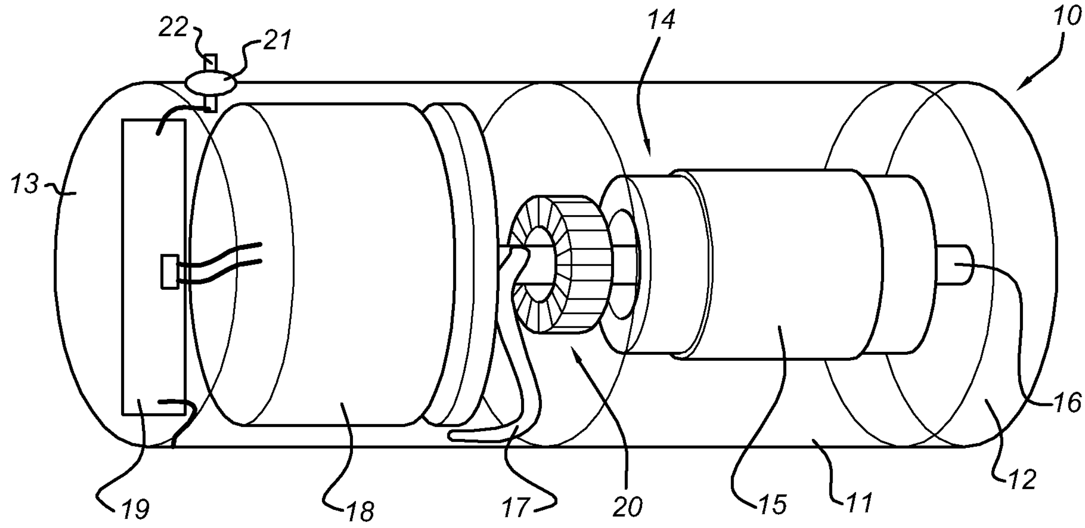
(72) Inventors:
- **Van den Akker, Wouter Franciscus**
  7552 EK, Hengelo (NL)
- **Lammers, Arend Jan Willem**
  7558 TV, Hengelo (NL)
- **Schoonenberg, Gerard Cornelis**
  7559 CR, Hengelo (NL)

(74) Representative: **Hutter, Jacobus Johannes**
Nederlandsch Octrooibureau
P.O. Box 29720
2502 LS Den Haag (NL)

(54) **Switchgear for high pressure environments**

(57) Vacuum circuit breaker assembly with a housing (11, 12, 13) in which a vacuum circuit breaker (15) is accommodated. The housing (11, 12, 13) is fluid tight and arranged to maintain a pressure inside the housing (11, 12, 13) at a predetermined level which is independent of a pressure outside the housing (11, 12, 13).The vacuum circuit breaker assembly (10) may be used in a switchgear assembly with an external housing (25, 35). The external housing (25, 35) has an inner space (31) sealed from an external environment (30), in which the inner space (31) is filled with a substantially non-compressible material such that, in operation, the pressure in the inner space (31) is substantially equal to the pressure of the external environment (30). The switchgear assembly may be advantageously used in sub sea or deep sea environments.

Fig 1



EP 1 942 514 A1

Description

Field of the invention

[0001] The present invention relates to a vacuum circuit breaker assembly and a switchgear assembly intended to be used in higher pressure environments such as sub sea and deep sea.

Prior art

[0002] American patent publication US2004/0232113 discloses an interrupter unit arranged inside a housing, which is filled with an insulating material in the form of a soft (thixotropic) gel. This material allows an improved heat transfer through the insulating material, and also allows for easier disassembly of the units in the housing.

[0003] American patent US 4,972,055 discloses a switch gear installation in which a plurality of vacuum interrupters is immersed in oil. The housing is not completely filled with oil.

[0004] European patent application EP 0 293 323 A discloses a vacuum circuit breaker having an encapsulation of fibers and a thermal isolation layer, to make the vacuum circuit breaker weather and explosion resistant. It is noted that not the entire vacuum circuit breaker is encapsulated, to allow operation of the moving contact.

Summary of the invention

[0005] The present invention seeks to provide a vacuum circuit breaker assembly which is suitable to be used in under water or high pressure environment applications. Apart from the harsh environment, equipment at the bottom of the sea is also subjected to very high pressures up to several 100 bar. One of the demands posed upon the switchgear under consideration is a long maintenance free life in a completely closed enclosure, suited for harsh environments. This implies that the most suitable switching technology is based on vacuum interrupters, the core of a vacuum circuit breaker. All other switching media, like oil, SF6 and air become polluted due to switching actions with a degradation of the switching medium as a result. A solution is to be provided to protect the pressure sensitive bellows of a vacuum circuit breaker. Commercially and technically available vacuum circuit breakers are only suitable for use in environments with pressures up to a few bar.

[0006] According to the present invention, a vacuum circuit breaker assembly according to the preamble defined above is provided, comprising a housing in which a vacuum circuit breaker is accommodated, in which the housing is fluid tight and arranged to maintain a pressure inside the housing at a predetermined level which is independent of a pressure outside the housing. As the entire vacuum circuit breaker is enclosed in the housing, also the pressure sensitive bellows of the vacuum circuit breaker is in a lower pressure environment, which will enable the use of a commercially available vacuum circuit breaker. Fluid tight means that substantially no gas or liquid can enter or exit the housing.

[0007] The housing is in an embodiment arranged to maintain an internal pressure of substantially one bar (10^5 Pa) when the pressure outside the enclosure is higher than 1 x 10^5 Pa, e.g. higher than 100 x 10^5 Pa, e.g. 300 x 10^5 Pa. This provides an environment of the vacuum circuit breaker which is comparable to the environment for which many vacuum circuit breakers are designed, i.e. a normal atmospheric pressure. Furthermore, the housing may be filled with air, and the fluid tight and rigid housing will then be able to provide a 'normal' operating environment at least for the vacuum circuit breaker.

[0008] In a particular embodiment, the housing comprises a tube, or cylinder, of isolating material, e.g. a ceramic material. Furthermore, two terminals (e.g. in the form of end caps) are provided of conducting material (e.g. copper or aluminium), the terminals being attached (e.g. welded) to the tube. The two terminals are connected to terminals of the vacuum circuit breaker. The housing is not limited to any specific form, and may be round, square, triangular, multi-facetted, etc. Such a vacuum circuit breaker assembly is easy and efficient to manufacture.

[0009] In a further embodiment, the housing further accommodates a drive mechanism for operating the vacuum circuit breaker, e.g. an electromechanical drive mechanism. By also including the drive mechanism inside the housing, no moving parts penetrate the housing, as a result of which it is easier to manufacture the housing and vacuum circuit breaker assembly.

[0010] The housing may further accommodate an electronics module, which e.g. implements a network protection function and/or control and supply function of the electromechanical drive.

[0011] In an even further embodiment, the housing further accommodates a current sensor, a voltage sensor, or a combination of a current sensor and voltage sensor. Such sensors may be used for network protection functions and/or control functions of the vacuum circuit breaker.

[0012] The housing, in a further embodiment, further comprises an additional feed through terminal. This feed through terminal may be provided as a through hole in one of the parts of the housing (e.g. a hole in one of the metal end caps, using an isolated and sealed off feed through, or a hole in the insulating tube). In a further embodiment, the feed through terminal may be provided in a coaxial manner, when the housing comprises at least two isolating tubes, two terminals, and a conducting ring connecting two axially aligned isolating tubes.

[0013] Operation of the vacuum circuit breaker may be accomplished by wireless techniques, or in an alternative embodiment, using power line carrier techniques. Alternative wired communication technologies e.g. optical fibers may also be applied by using a feed through.

[0014] In a further aspect, the present invention relates to a switchgear assembly, comprising an external housing (or outer tube) and at least one vacuum circuit breaker assembly according to an embodiment of the present invention, in which the external housing has an inner space sealed from an external environment, the inner space comprising the at least one vacuum circuit breaker assembly, in which the inner space is filled with a substantially non-compressible material, such that, in operation, the pressure in the inner space is substantially equal to the pressure of the external environment. The substantially non-compressible material may be a fluid, e.g. oil, or another substance, such as cast resin, silicone rubber, etc. The non-compressible material is e.g. an insulating material. This controlled environment inside the external housing allows to use a vacuum circuit breaker assembly according to the present invention, in which the actual vacuum circuit breaker operates in a well defined environment of its own.

[0015] The external housing may act as a pressure compensation arrangement, e.g. due to deformation of the external housing, the pressure inside is substantially the same as outside of the external housing. For this, the external housing is deformable, e.g. is the form of a stainless steel tube or a combination of a plurality of such tubes.

[0016] In a further embodiment, the external housing further accommodates a transformer for auxiliary supply at a service voltage level. This transformer can be positioned e.g. between the associated busbars or connection and ground, to provide a (lower) voltage than the busbar voltage, e.g. for the electronics module in the vacuum circuit breaker assembly. Alternatively, an auxiliary supply transformer may be positioned between two phases of the busbar system, which would allow to provide a (lower) supply voltage to the two associated vacuum circuit breaker assemblies using a single transformer.

[0017] In a further embodiment, the switchgear assembly further comprises a busbar system connected to the at least one vacuum circuit breaker assembly, in which the busbars and connections to the vacuum circuit breaker assemblies are also accommodated in the external housing. The entire deep sea switchgear may be provided in a single external housing, alternatively, the housing may comprise a plurality of interconnected tubes, which together form the external housing.

[0018] In an even further embodiment, the switchgear assembly further comprises a disconnector connected in series between one of the terminals of the vacuum circuit breaker assembly and an associated busbar, for isolating a faulty vacuum circuit breaker assembly from the busbar system. The disconnector may be operable from the outside of the external housing, in a mechanical or remotely operated manner. The disconnector may be of a simple type, and for isolating a faulty vacuum circuit breaker assembly a disconnector having a one time action is sufficient (e.g. operating with an explosive actuator).

Short description of drawings

[0019] The present invention will be discussed in more detail below, using a number of exemplary embodiments, with reference to the attached drawings, in which

Fig. 1 shows a schematic view of a vacuum circuit breaker assembly according to an embodiment of the present invention, in which the elements internal to the housing are visible;
Fig. 2 shows a schematic perspective view of a second embodiment of the vacuum circuit breaker assembly of the present invention;
Fig. 3 shows a schematic, perspective view of a deep see switchgear assembly according to an embodiment of the present invention;
Fig. 4 shows the electrical diagram of an auxiliary supply unit used in the deep sea switchgear of the present invention;
Fig. 5 shows a more detailed internal view of a part of the deep sea switchgear assembly of Fig. 3; and
Fig. 6 shows a diagrammatic view of a part of a deep sea switchgear assembly according to a further embodiment of the present invention.

Detailed description of exemplary embodiments

[0020] Due to the continuous use of this planet's energy resources Oil and LNG (Liquefied Natural Gas) companies are forced to exploit wells located in the bottom of what is called Deep Sea (i.e. at depths over 1000m). Traditional exploitation technology (oil rigs) no longer is feasible and all pumps, compressors and medium voltage (MV) switchgear will be placed on the bottom of the sea. Apart from the harsh environment the equipment at the bottom of the sea is also subjected to very high pressures of up to several 100 bar.

[0021] One of the demands posed upon switchgear for medium voltage applications in sea environments is a long maintenance free life in a completely closed enclosure, suited for harsh environments. This implies that the most suitable switching technology is based on vacuum interrupters. All other switching media like oil, SF6 and air become polluted due to switching actions with a degradation over time of the switching medium as a result.

[0022] The vacuum interruption technology is based on the use of vacuum circuit breakers, which in general are equipped with a pressure sensitive bellows to allow movement of one contact (or both contacts). Commercially and technically available vacuum circuit breakers are only suitable for use in environments with pressures up to several bar (10^5 Pa).

[0023] To protect the mechanically vulnerable vacuum interrupter bellows, it would be possible to accommodate the circuit breaker in a pressure proof enclosure or housing. However, due to the harsh conditions and large pressure, the complete enclosure would have to withstand several 100 bar of pressure leading to a very thick, very strong and very heavy enclosure. This enclosure not only increases production costs and material use but also increases transporting cost, installation costs, etc. and therefore is unwanted.

[0024] According to an embodiment of the present invention, use is made of pressure compensation. To design economically feasible switchgear it is important to make use of pressure compensation (e.g., due to deformation of the enclosure the pressure inside the enclosure is kept the same as outside the enclosure).

[0025] An exemplary embodiment is shown in an exploded view in Fig. 1. The vacuum circuit breaker assembly 10 comprises a standard vacuum circuit breaker 15 which is positioned inside a housing 14. To be able to use the vacuum circuit breaker 15 inside a pressure compensated enclosure the vacuum circuit breaker 15 has to have its own little pressure proof housing 14 that shields the pressure sensitive bellows and keeps it around 1 bar (10^5 Pa). In this embodiment, a vacuum circuit breaker assembly 10 is provided comprising a housing 14 in which a vacuum circuit breaker 15 is accommodated, in which the housing 14 is air tight and arranged to maintain a pressure inside the housing which is lower than a pressure outside the housing. E.g. the housing 14 is constructed in such a manner that it is possible to maintain an internal pressure of substantially one bar (10^5 Pa) when the pressure outside the housing 14 is higher than ten bar (10×10^5 Pa), or even higher than 100 bar (100×10^5 Pa), e.g. 300 bar (300×10^5 Pa). In other words, the vacuum circuit breaker 15 is enclosed in a pressure proof housing of its own.

[0026] A pressure proof housing of the vacuum circuit breaker 15 alone however will present further problems due to the fact that moving parts have to penetrate the pressure proof housing in order to operate the vacuum circuit breaker 15. In further embodiments, the pressure proof vacuum circuit breaker assembly 10 therefore has a number of further features. The housing 14 has as little as possible moving penetrations, or even has no moving penetrations at all. As penetrations are weak spots of the housing 14, the number of penetrations is as low as possible. Furthermore, the housing 14 is as small as possible to make it economically attractive.

[0027] These features are all present in the embodiment of the vacuum circuit breaker assembly 10 shown in Fig. 1. The housing 14 is formed by a tube 11 of isolating material (e.g. ceramic) and two end caps 12, 13 of conductive material (e.g. copper or aluminum). The end caps 12, 13 are attached to the tube 11 in order to form a sealed housing 14, e.g. by welding the end caps 12, 13 to the tube 11. One terminal 16 (e.g. a fixed terminal) of the vacuum circuit breaker 15 is (electrically) connected to end cap 12, and the other (moving) terminal is connected to the other end cap 13 (e.g. using a flexible wire 17), such that the end caps 12, 13 act as electrical terminals of the vacuum circuit breaker assembly 10.

[0028] In various embodiments, further elements and components may be added to the vacuum circuit breaker assembly 10. E.g. a current sensor 17 may be added, which, in the embodiment of Fig. 1 is implemented as a ring shaped sensor around the moving terminal for the vacuum circuit breaker 15. The current sensor 17 (e.g. a current transformer or Rogowski coil) is in this embodiment located at the primary side of the vacuum circuit breaker 15, to be at approximately same potential as possible integrated protection and supply electronics (see below).

[0029] In another embodiment, a drive mechanism 18, e.g. an electromechanical drive mechanism, is added, which operates on the moving terminal of the vacuum circuit breaker 15. The vacuum circuit breaker 15 is operated by the drive mechanism 18, e.g. using an electromagnetic actuator (coil construction), which is a very compact, and maintenance free mechanism for a vacuum circuit breaker 15.

[0030] Also, an electronics module 19, e.g. in the form of a printed circuit board, may be added, which may be arranged to perform various functions. These functions are e.g. protection circuitry, supply for the drive mechanism 18, communication/control interface, etc.

[0031] The embodiment shown in Fig. 1 is also provided with a feed through hole 21, which allows to provide an external connection 22, e.g. for routing a control signal for the vacuum circuit breaker 15 to the electronic module 19, or for inputting an auxiliary voltage supply. The feed through hole 21 may be implemented as a penetration in the end cap 13 as shown, but may also be provided in the other end cap 12, or in the tube 11. In a metallic end cap 13, the sealed housing 14 is sealed at the position of the feed through terminal 21. As in the case of the main isolator ceramic, glass or other pressure resistant insulating material can be welded in a pressure proof construction.

[0032] In Fig. 2 a further embodiment is shown schematically in a perspective view. In this case, the housing 14 is formed by two tube parts 11a, 11b, two end caps 12, 13 and a coaxial ring 22a of conductive material. The various parts are connected to each other, e.g. using welding techniques, to form the sealed housing 14. The ring 22a may then be used as feed through terminal.

[0033] The embodiment of Fig. 2 is also provided with additional medium voltage terminations 12a, 13a. These terminations may be separate elements, or integrally formed in the end caps 12, 13.

[0034] Due to the low power consumption of the electronics module 19 this terminal in the form of external connection 22 or additional conducting ring 22a, can be kept very small.

[0035] As indicated in Fig. 1, the power supply of the electronics module 19 (electronic protection and EM drive) is connected to the mains at one side (connected internally to end cap 13, thus no extra penetration) and to the external connector 22 at the other side. This external connector 22 may be connected to an external transformer 29 (see below), providing a low voltage level (e.g. 100 V) with respect to the main terminal (end cap

13).

[0036] Although the electronic protection and control function provided by the electronics module 19 acts autonomously it also has to communicate for remote on/off commands, etc. For communication this embodiment uses either wireless or Power Line Carrier technology. Both technologies have the advantage that no extra penetrations are necessary through the housing 14, thereby increasing reliability and decreasing costs.

[0037] The pressure proof vacuum circuit breaker assemblies 10 as described relating to the various embodiments above can be used in a number of construction principles, a first one of which is shown schematically in Fig. 3.

[0038] The pressure proof vacuum circuit breaker assemblies 10, a busbar system 26 and other assembly components are enclosed by a pressure compensated enclosure, formed by a number of tubes like enclosures 25, 35 (i.e. a number of vacuum circuit breaker compartments 25 and a busbar compartment 35, connected to each other). The enclosures 25, 35, e.g. made as stainless steel tubes, are filled with an insulating, virtually non-compressible fluid like oil. Advantage of this fluid filled enclosure 25, 35 is that a small deformation of the enclosure 25, 35 is sufficient for a huge rise in internal pressure. A small deformation is important to keep the mechanical stresses in the enclosure material low. Second advantage of the insulating fluid is the good insulating properties that enable a compact and economic design.

[0039] The outer walls of the enclosures 25, 35 are resistant to the harsh environments, that might be present at the bottom of the sea (depth from 0 to several km). Generally a metallic layer or wall is foreseen, intended to be grounded if necessary.

[0040] The main busbar system 26 can be either single-phase or multiphase. No moving components are foreseen in the main busbar compartment 35, to have maximum reliability and therefore maximum availability.

[0041] The pressure compensated enclosures for the switching (i.e. the bottom three enclosures 25 as shown in Fig. 3) might be single phase to allow for maximum (rotational) symmetry. However, multiphase design allows for integrated voltage transformers between phases as auxiliary voltage supply, as shown e.g. in Fig. 4. As shown there, a voltage transformer 29 is connected between two phases X, Y of a three phase busbar system 26, allowing to supply a lower auxiliary voltage level ($U_{aux,x}$, $U_{aux,y}$) to both the X-phase vacuum circuit breaker assembly 10 and the Y-phase vacuum circuit breaker assembly 10. At the outside of enclosures 25, cable terminals 27 are provided, which are internally connected to the vacuum circuit breaker assemblies 10, e.g. to the medium voltage terminations 12a as shown in Fig. 2.

[0042] Each of the vacuum circuit breaker compartments 25 is provided with a pressure relief 36, which is constructed in such a manner that in case of an internal arc in a vacuum circuit breaker compartment 25, none of the other elements in the switchgear assembly or other elements, such as connected cables, are affected.

[0043] In Fig. 5, the internal components in an enclosure 25 as discussed above in relation to the embodiment of Fig. 3 are shown. Outside of the enclosure 25, the external environment (indicated by 30) is present, e.g. sea water at 300 bar pressure. Inside the enclosure 25 (indicate by 31) oil is present, and the material of the enclosure 25 allows this oil to be at the same pressure, i.e. also 300 bar. Three vacuum circuit breaker assemblies 10 are located inside the enclosure 25, which allow to close or open the circuit connected to the external cable connectors 27.

[0044] A busbar connector assembly 28 provides for connecting the vacuum circuit breaker assemblies 10 to each phase of a busbar system 26 (see Fig. 3). The busbar connector assembly 28 also acts as a pressure proof shielding, in order to protect the busbar compartment 35 from a rise in pressure in one of the vacuum circuit breaker compartments 25, e.g. as a result of an internal fault.

[0045] As an alternative to the arrangement of transformer 29 of the embodiment in Fig. 4, in this embodiment, for each phase a separate transformer 29 is present, connected between the respective phase and the (grounded) enclosure 25. Each transformer 29 provides the supply voltage via a feed through hole 21.

[0046] Furthermore, the rails running from the end cap 13 to the busbar connector assembly 28 are provided with disconnectors 32. These (optional) disconnectors 32 allow to isolate a vacuum circuit breaker assembly 10 from the busbar system 26, e.g. in the case of a faulty vacuum circuit breaker 15 (short circuit). The disconnector 32 may be any form, e.g. remotely operable, or (mechanically) operable from the location of the switch gear using a remotely operated vehicle (ROV). Furthermore, the disconnector 32 may be in the form of a normally closed switch, which can be opened a single time (e.g. using an explosive charge) or multiple times. This embodiment is particularly useful to increase the reliability of the switch gear system, e.g. in an embodiment in which a spare vacuum circuit breaker assembly 10 is provided as shown schematically in Fig. 6. Here, an enclosure 25 is provided around a single phase busbar system 26, as well as two vacuum circuit breaker assemblies 10, in further enclosures 25. In the enclosure 25 surrounding the busbar system 26 furthermore two disconnectors 32 are provided, of which one is closed, and one is opened. In case of a failure of the connected vacuum circuit breaker assembly 10, the associated disconnector 32 should be opened, thereby isolating the faulty circuit breaker assembly from the busbar and allowing the remaining switchgear assembly to return to normal service conditions.

[0047] In a further embodiment, the vacuum circuit breaker assemblies 10, busbar system 26 and other assembly components are moulded into a solid insulation material (e.g. cast resin, silicone rubber). In this embodiment the construction does not contain any compressible gas filled chambers. The lack of compressible chambers makes it possible to use a relatively thin layer of insulation material. This thin layer of insulating material is designed mainly on isolating (dielectric) aspects instead of mechanical aspects dealing with the high pressure of the surrounding water.

[0048] For this embodiment, a single phase construction has the preference due to the simplicity of moulding compared to the moulding of a three phase construction.

[0049] In an alternative embodiment, the solid insulation is constructed to bear part of the mechanical stresses on the vacuum circuit breaker assemblies 10. As further mechanical structure is then not needed, this embodiment results in a lower total weight.

Claims

1. Vacuum circuit breaker assembly, comprising a housing (11, 12, 13) in which a vacuum circuit breaker (15) is accommodated, in which the housing (11, 12, 13) is fluid tight and arranged to maintain a pressure inside the housing (11, 12, 13) at a predetermined level which is independent of a pressure outside the housing (11, 12, 13)

2. Vacuum circuit breaker assembly according to claim 1, in which the housing (11, 12, 13) is arranged to maintain an internal pressure of substantially one bar (10^5 Pa) when the pressure outside the housing (11, 12, 13) is higher than 1 x 10^5 Pa, e.g. higher than 100 x 10^5 Pa, e.g. up to 300 x 10^5 Pa.

3. Vacuum circuit breaker assembly according to claim 1 or 2, in which the housing (11, 12, 13) is filled with air.

4. Vacuum circuit breaker assembly according to any one of claims 1-3, in which the housing comprises a tube (11; 11a, 11b) of isolating material and two terminals (12, 13) of conducting material, the terminals (12, 13) being attached to the tube (11), in which the two terminals (12, 13) are connected to terminals (16, 17) of the vacuum circuit breaker (15).

5. Vacuum circuit breaker assembly according to any one of claims 1-4, in which the housing (11, 12, 13) further accommodates a drive mechanism (18) for operating the vacuum circuit breaker.

6. Vacuum circuit breaker assembly according to any one of claims 1-5, in which the housing (11, 12, 13) further accommodates an electronics module (19).

7. Vacuum circuit breaker assembly according to any one of claims 1-6, in which the housing (11, 12, 13) further accommodates a current sensor (20), a voltage sensor (20), or a combination of a current sensor (20) and voltage sensor (20).

8. Vacuum circuit breaker assembly according to any one of claims 1-7, in which the housing (11, 12, 13) further comprises an additional feed through terminal (22; 22a).

9. Vacuum circuit breaker assembly according to any one of claims 1-8, in which the operation of the vacuum circuit breaker (15) is accomplished by wireless techniques.

10. Vacuum circuit breaker assembly according to any one of claims 1-8, in which the operation of the vacuum circuit breaker (15) is accomplished using power line carrier techniques.

11. Switchgear assembly, comprising an external housing (25, 35) and at least one vacuum circuit breaker assembly (10) according to any one of claims 1-10, in which the external housing (25, 35) has an inner space (31) sealed from an external environment (30), the inner space (31) comprising the at least one vacuum circuit breaker assembly (10), in which the inner space (31) is filled with a substantially non-compressible material such that, in operation, the pressure in the inner space (31) is substantially equal to the pressure of the external environment (30).

12. Switchgear assembly according to claim 11, in which the external housing (25, 35) is deformable.

13. Switchgear assembly according to claim 11 or 12, in which the external housing (25, 35) further accommodates a transformer (29) for auxiliary supply at service voltage level.

14. Switchgear assembly according to any one of claims 11-13, further comprising a busbar system (26) connected to the at least one vacuum circuit breaker assembly (10).

15. Switchgear assembly according to claim 14, further comprising a disconnector (32) connected in series between one of the terminals (12, 13) of the vacuum circuit breaker assembly (10) and an associated busbar (26), for isolating a faulty vacuum circuit breaker assembly (10) from the busbar system (26).

16. Switchgear assembly according to claim 15, comprising a pressure proof shielding (28) between a busbar compartment (35) and a vacuum circuit breaker compartment (25).

17. Switchgear assembly according to claim 16, in which the vacuum circuit breaker compartment (25) comprises a pressure relief (36).

Fig 1

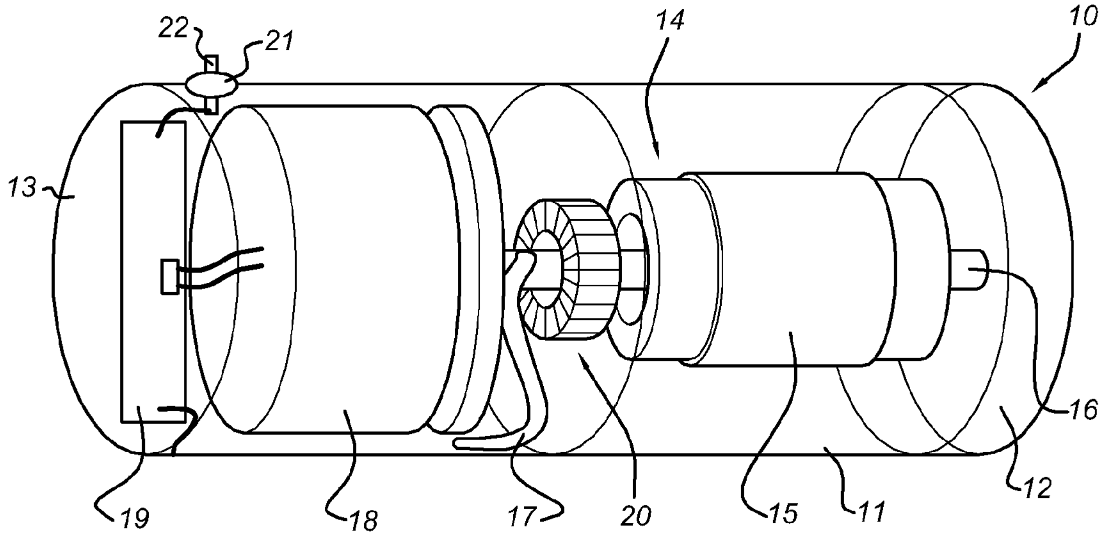


Fig 2

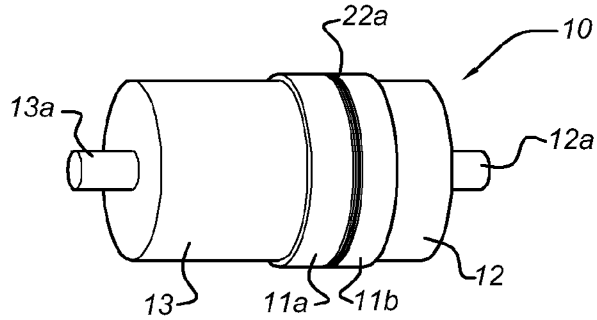


Fig 3

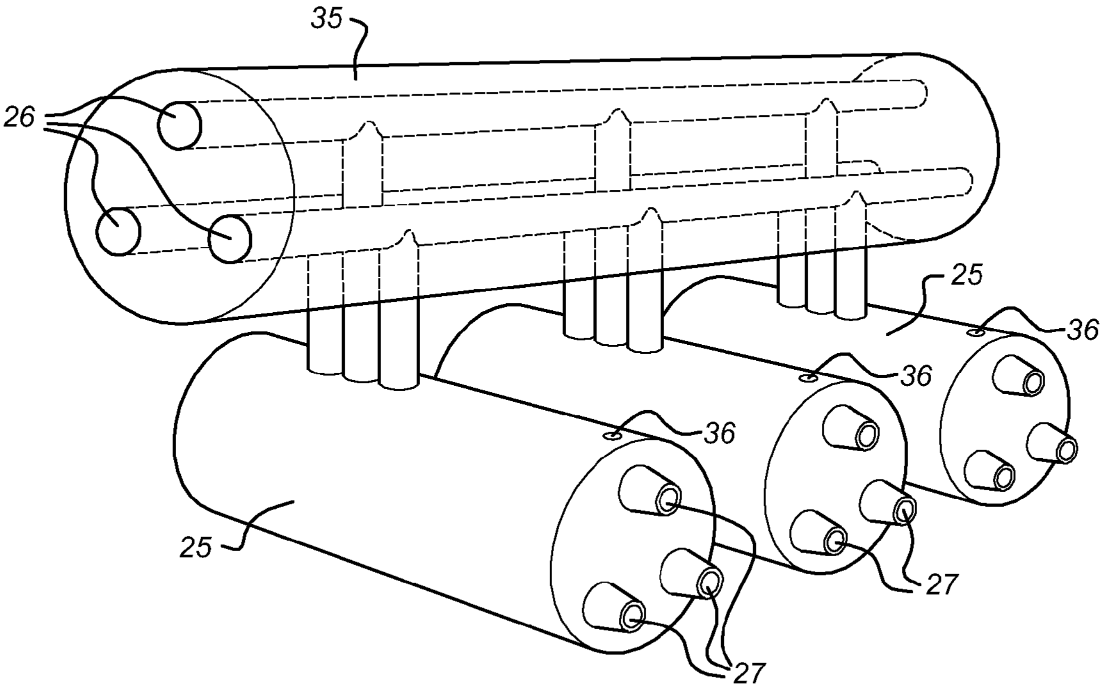


Fig 4

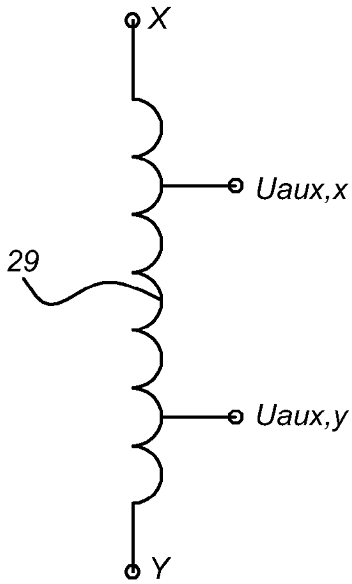


Fig 5

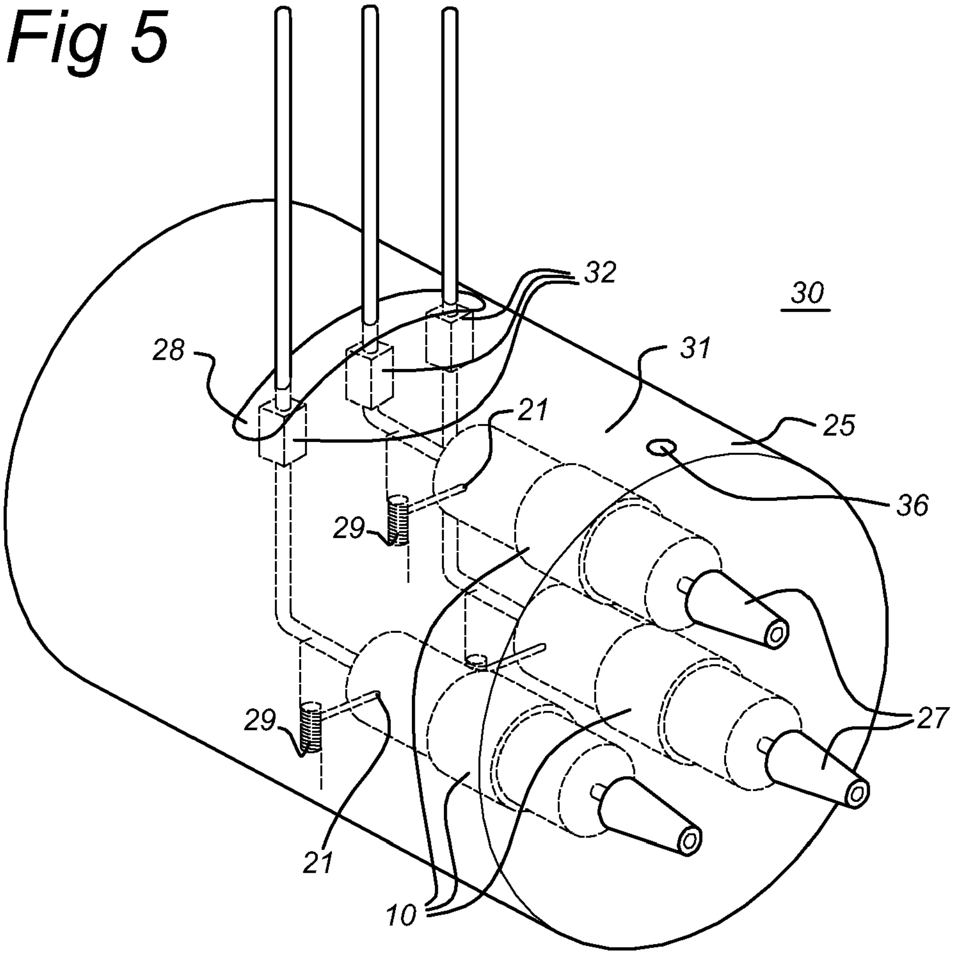
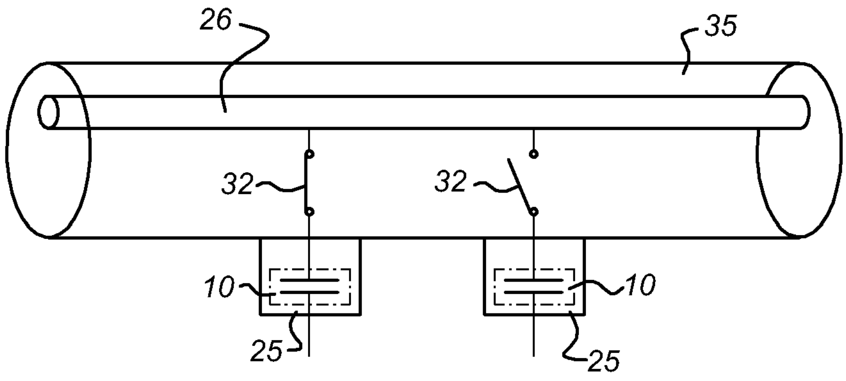


Fig 6



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 10 0125

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	LU S ET AL: "NEPTUNE Power System: Startup Power Supply for 10 kV to 400 V Dc-Dc Converters" APPLIED POWER ELECTRONICS CONFERENCE AND EXPOSITION, 2006. APEC '06. TWENTY-FIRST ANNUAL IEEE MARCH 19, 2006, PISCATAWAY, NJ, USA,IEEE, 19 March 2006 (2006-03-19), pages 1385-1389, XP010910126 ISBN: 0-7803-9547-6 * the whole document *	1-10 11-17	INV. H01H33/66 H02G15/14 H01H9/04 H01B7/14 H02B13/00
X Y	US 4 785 139 A (LYNCH JOHN F [US] ET AL) 15 November 1988 (1988-11-15) * column 9, line 18 - column 10, line 57 *	1-3 11-17	
X A	US 2 782 249 A (MARCEL MARTIN PAUL) 19 February 1957 (1957-02-19) * column 6, lines 58-67 * * column 3, lines 5-13 *	1-3 11	
X	US 2003/198027 A1 (TAKEDA TAIICHI [JP] ET AL) 23 October 2003 (2003-10-23) * paragraphs [0009], [0010], [0041] - [0046]; figure 8 *	1-3	TECHNICAL FIELDS SEARCHED (IPC) H01H H01B H02B H02G
X	EP 0 466 048 A2 (SACHSENWERK LICHT & KRAFT AG [DE] SACHSENWERK AG [DE]) 15 January 1992 (1992-01-15) * figure 1 *	1	
X	DE 35 29 386 A1 (CALOR EMAG ELEKTRIZITAETS AG [DE]) 26 February 1987 (1987-02-26) * figure 1 *	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	5 June 2007	Overdijk, Jaco

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

3

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 10 0125

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

05-06-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4785139 A	15-11-1988	AU 7345187 A	03-12-1987
		CA 1278056 C	18-12-1990
		EP 0247791 A2	02-12-1987
		JP 63024203 A	01-02-1988
US 2782249 A	19-02-1957	FR 992301 A	17-10-1951
		GB 615533 A	07-01-1949
US 2003198027 A1	23-10-2003	GB 2388729 A	19-11-2003
		GB 2413228 A	19-10-2005
		JP 2003317816 A	07-11-2003
EP 0466048 A2	15-01-1992	DE 4021945 A1	16-01-1992
		JP 4229918 A	19-08-1992
		US 5206616 A	27-04-1993
DE 3529386 A1	26-02-1987	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 20040232113 A **[0002]**
- US 4972055 A **[0003]**
- EP 0293323 A **[0004]**