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Datasheet for the decision of 5 December 2023

Case Number: T 3241/19 - 3.4.03

Application Number: 16156803.5

Publication Number: 3211980

IPC: H05K7/20

Language of the proceedings: EN

Title of invention:
ARRANGEMENT FOR SUBSEA COOLING OF POWER ELECTRONIC CELLS

Applicant:
ABB Schweiz AG

Relevant legal provisions:
EPC Art. 52(1), 56, 83
RPBA 2020 Art. 13(1), 13(2)
RPBA Art. 12(4)

Keyword:
Sufficiency of disclosure - main request (no)
Amendment after summons - third auxiliary request - taken into account (no)
Late-filed first auxiliary request - request could have been filed in first instance proceedings - admitted (no)
Inventive step - second auxiliary request - obvious alternative

Decisions cited:

G 0010/93

Catchword:

If an applicant wishes to use the appeal to pursue a higher-ranking request which has not been granted, it must be aware of the risk that the board might refuse the application in toto, whereas the first instance had considered a lower-ranking auxiliary request to be grantable (see Reasons 5.3).

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Case Number: T 3241/19 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 5 December 2023

Appellant: (Applicant)	ABB Schweiz AG Brown Boveri Strasse 6 5400 Baden (CH)
Representative:	Kolster Oy Ab (Salmisaarenaukio 1) P.O. Box 204 00181 Helsinki (FI)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 29 October 2019 refusing European patent application No. 16156803.5 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	T. Häusser
Members:	M. Ley
	G. Decker

Summary of Facts and Submissions

I. The appeal is against the decision of the examining division to refuse European patent application No. 16 156 803 pursuant to Article 97(2) EPC.

II. At the end of the oral proceedings on 16 July 2019, the examining division informed the applicant about its intention to propose a grant on the basis of the former second auxiliary request filed on 12 June 2019.

On 11 September 2019 the examining division issued a communication under Rule 71(3) EPC. The text intended for grant was based on said second auxiliary request and included an amendment requested by the applicant by e-mail of 23 July 2019 as well as minor amendments made by the examining division regarding the reference signs in the claims. In an annex, the examining division informed the applicant about the reasons why the higher ranking requests were not allowable.

With a letter dated 1 October 2019 the applicant indicated that:

- it did not accept the text intended for grant,
- it maintained the request for a grant based on the set of claims of the main request, and
- it requested an appealable decision.

In accordance with Rule 71(6) EPC, the examining division subsequently resumed the examination proceedings and issued the impugned decision.

III. The following documents were cited during the examination proceedings:

D1 EP 2 931 012 A1
D2 EP 2 958 411 A1
D3 EP 2 928 275 A1
D4 EP 2 825 008 A1

IV. The examining division decided that the former main request and the former third and fourth auxiliary requests did not meet the requirements of Article 83 EPC and that the subject-matter of the former first auxiliary request did not involve an inventive step (Article 56 EPC) over D1 in combination with D4. Under point 29 of the Reasons, the examining division mentioned that a proposal for grant according to the former second auxiliary request was not accepted by the applicant.

V. The appellant requests that the impugned decision be set aside and a European patent be granted (in this order of preference) on the basis of the claims according to the main request filed with the statement setting out the grounds of appeal, or according to the third auxiliary request filed with the letter dated 3 November 2023, or according to the first or the second auxiliary request, both filed with the statement setting out the grounds of appeal.

VI. Claim 1 according to the main request has the following wording:

An arrangement (15a, 15b, 15c, 15d) for subsea cooling of a power electronic cell (12), the arrangement (15a, 15b, 15c, 15d) comprising:

a tank (10), the tank (10) being filled with a dielectric fluid (11); and
at least one power electronic cell (12) placed in the tank (10), each at least one power electronic cell (12) comprising semiconductor elements (1, 2) and capacitor elements (5),
wherein the at least one power electronic cell (12) is oriented such that, when the arrangement (15a, 15b, 15c, 15d) is installed, a majority of the semiconductor elements (1, 2) are positioned in an upper part (7a) of the tank (10) and a majority of the capacitor elements (5) are positioned in a lower part (7b) of the tank (10),
characterized in that the arrangement (15a, 15b, 15c, 15d) is configured to result in a natural convection cooling loop (13a) limited to the upper part (7a) of the tank (10).

Claim 1 according to the third auxiliary request corresponds to claim 1 of the main request with the characterising portion amended as follows:

characterized in that the arrangement (15a, 15b, 15c, 15d) is configured to result in a natural convection cooling loop (13a) generated by the semiconductors positioned in an upper part (7a) of the tank (10) being limited to the upper part (7a) of the tank (10).

Claim 1 according to the first auxiliary request has the following wording (board's feature labelling):

An arrangement (15a, 15b, 15c, 15d) for subsea cooling of a power electronic cell (12), the arrangement (15a, 15b, 15c, 15d) comprising:
***(a)** a tank (10), **(a1)** the tank (10) being filled with a dielectric fluid (11); and*

(b) *at least one power electronic cell (12) placed in the tank (10),* ***(b1)*** *each at least one power electronic cell (12) comprising semiconductor elements (1, 2) and capacitor elements (5),*
(c) *an imagined horizontal plane (3) dividing the tank (10) in a height direction into an upper part (7a) and a lower part (7b),*
(d) *wherein the at least one power electronic cell (12) is oriented such that, when the arrangement (15a, 15b, 15c, 15d) is installed,* ***(d1)*** *the semiconductor elements (1, 2) are positioned in the upper part (7a) of the tank (10) vertically above the imagined horizontal plane (3) and* ***(d2)*** *the capacitor elements (5) are positioned in the lower part (7b) of the tank (10) vertically below the imagined horizontal plane (3), characterized in that*
(e) *a vertical height of the upper part (7a) of the tank (10) is greater than a vertical height of the lower part (7b) of the tank (10),*
(f) *a vertical distance from a top of the tank (10) to a top of the power electronic cell (12) is greater than a vertical distance from a bottom of the tank (10) to a bottom of the power electronic cell (12),*
(g) *wherein, during operation of the at least one power electronic cell (12), the upper part (7a) of the tank (10) contains hot fluid with large natural convection (13a) and the lower part (7b) of the tank (10) is cold with less natural flow convection (13b) or nearly stagnant fluid.*

Claim 1 according to the second auxiliary request has the following wording (board's feature labelling):

An arrangement (15c, 15d) for subsea cooling of a power electronic cell (12), the arrangement (15c, 15d) comprising:

(a) *a tank (10),* ***(a1)*** *the tank (10) being filled with a dielectric fluid (11); and*
(b) *at least one power electronic cell (12) placed in the tank (10),* ***(b1)*** *each at least one power electronic cell (12) comprising semiconductor elements (1, 2) and capacitor elements (5),*
(d) *wherein the at least one power electronic cell (12) is oriented such that, when the arrangement (15c, 15d) is installed,* ***(d1*)*** *a majority of the semiconductor elements (1, 2) are positioned in an upper part (7a) of the tank (10) and* ***(d2*)*** *a majority of the capacitor elements (5) are positioned in a lower part (7b) of the tank (10)*
characterized by ***(h)*** *a heat exchanger (8) attached to an outside of the tank (10), the heat exchanger (8) comprising:* ***(h1)*** *an inlet (9a) for receiving dielectric fluid (11) from the tank (10); and* ***(h2)*** *an outlet (9b) for providing dielectric fluid (11) to the tank (10), wherein* ***(h3)*** *the outlet (9b) is placed, when the arrangement (15c, 15d) is installed, vertically higher than the majority of the capacitor elements (5), and* ***(h4)*** *wherein the heat exchanger (8) is oriented such that, when the arrangement (15c, 15d) is installed, the heat exchanger (8) is positioned outside the upper part (7a) of the tank (10).*

VII. The appellant's arguments can be summarised as follows:

- The application enabled the skilled person to carry out the invention as defined in claim 1 according to the main request. The requirements of Article 83 EPC were thus met.
- The third and first auxiliary requests should be admitted into the appeal proceedings.

- The subject-matter of claim 1 according to the second auxiliary request involved an inventive step (Article 56 EPC).

Reasons for the Decision

1. The claimed invention

The invention concerns an arrangement for subsea cooling of power electronic cells.

Electric subsea installations and devices usually demand high standards regarding durability, long-term functionality and independence during operation. Electric subsea installations that need to be cooled during operation, such as subsea converters, require an autonomous and durable cooling of their components. It is known in the art to use a dielectric fluid (also known as liquid dielectric) such as for example oil as a cooling fluid. In general, electric subsea installations need to be pressurised with the dielectric fluid, thus said fluid (preferably a liquid) should be, at least almost, incompressible. In general terms, the dielectric fluid is thus used to provide an incompressible medium and additionally an electric insulation medium of components, such as power electronics building blocks (PEBBs), placed in the electric installation.

According to the invention as claimed an arrangement for subsea cooling of a power electronic cell comprises a tank filled with a dielectric fluid and at least one power electronic cell placed in the tank. Each power electronic cell comprises semiconductor elements and capacitor elements. The power electronic cells are oriented such that, when the arrangement is installed, a majority of the semiconductor elements are positioned in an upper part of the tank and a majority of the capacitor elements are positioned in a lower part of the tank. The arrangement is configured to result in a natural convection cooling loop. Cooling of the power electronic cells in the arrangement is provided by natural convection, as indicated e.g. by arrows 13a and 13b in Figures 2 to 5.

2. Main request - sufficiency of disclosure - Article 83 EPC

2.1 The main request corresponds to the main request underlying the impugned decision.

The examining division held that the invention defined in claim 1 was not sufficiently disclosed contrary to the requirements of Article 83 EPC.

The skilled person would have little difficulty in implementing the arrangement according to the preamble of claim 1. In view of page 4, line 5 to page 5, line 11 of the description of the application, the skilled person would be able to configure the arrangement so that a natural convection cooling loop was established within the tank.

However, the examining division considered that the description (in particular, page 5, lines 5 to 7 and page 8, lines 2 to 4) did not contain any teaching as to how the claimed natural convection loop which was "limited to the upper part of the tank" could be achieved. The characteristics of a natural convection loop depended on a large number of system parameters (dimensions of the tank, properties of the dielectric fluid, number of semiconductor elements and of capacitor elements, vertical distance between said elements as well as on operational parameters such as the amount of heat generated by said semiconductor elements and capacitor elements, the conditions outside the tank such as the temperature of sea water). The application did not discuss the influence of these parameters on the cooling and did not disclose any working example.

In the absence of any relevant teaching in the application, the skilled person would need to develop a simulation model and possibly a working prototype as well and would need to experiment with a plurality of parameters without having received any guidance that would lead them directly to success. This amounted to an undue burden or undue experimentation for the skilled person. Reference was made to *Case Law of the Boards of Appeal of the European Patent Office*, 8th Edition, 2016, section II.C.5.6.1.

2.2 The appellant argued that the disclosure of the application enabled the skilled person to carry out the invention without undue experimentation.

The appellant pointed out that, based on page 8, lines 2 to 4, Figure 2 and the related description, the wording of claim 1 did not exclude other additional natural convection loops, e.g. those that are limited to the lower part of the tank such as the ("insignificant") natural convection loop 13b shown in Figures 2 to 5. For example, in Figure 2, two separate circulations of fluid were depicted, the large flow circulation 13a of the hot fluid (generated by the "high loss components") in the upper part 7a of the tank 10, and the less or nearly zero circulation (nearly stagnant fluid) 13b of the cold fluid (caused by the "low loss components") in the lower part 7b of the tank 10.

The inventors had established the function according to the invention by means of computer simulations, and further by constructing a working prototype on the basis of the simulation results. The simulation contained a thermal network according to Figure 1 shown on page 7 of the statement setting out the grounds of appeal and led to a natural convection-related mass flow of 0,75 kg/s in the upper part. Said model confirmed that circulation flows according to Figure 2 of the application were created within the modelled system. Creating a thermal network or another simulation model was within customary practice of a skilled person.

The description and the figures in the original application documents provided enough guidance for a skilled person to produce an arrangement as defined in claim 1. This might be done by altering the arrangement of the semiconductor elements and the capacitor elements as compared to those of the prior art devices. Reference was made to the Guidelines F-III, point 1. As the application was in a very specific and narrow field, one example was enough.

Figures 2 to 5 in the original application showed different embodiments of the invention. The figures showed that the arrangement should be such that a vertical height of the upper part of the tank was greater than a vertical height of the lower part of the tank. The figures further showed that a vertical distance from a top of the tank to a top of the power electronic cell should be greater than a vertical distance from a bottom of the tank to a bottom of the power electronic cell. Having the power components arranged in the upper part of the tank and the capacitors in the lower part (see page 6, line 28 to page 7, line 3 of the description of the application), the large external cooling surface, i.e. the higher vertical height, of the upper part was needed and provided for limiting cooling of the hot fluid to the upper part of the tank, while the already cold lower part of the tank could be smaller, i.e. large enough to accommodate the capacitor elements, see page 7, lines 5 to 13 of the description of the application.

A person skilled in the art would directly and unambiguously infer that the natural convection cooling loop 13a of the hot fluid was intended to be limited to the hot upper part 7a of the tank 10 in order to achieve the desired reduced size of the tank (see e.g. page 7, lines 10 to 13 of the description of the application) and keep the temperature sensitive capacitor elements in a cold environment, as confirmed by page 8, lines 4 to 6 of the description of the application. Dimensioning the external cooling surface of the upper part of tank to limit the natural convection cooling loop to its upper part belongs to the normal design work of a person skilled in the art, while the already cold lower part of the tank could be designed to be large enough to accommodate the capacitor elements.

More specifically, a person skilled in the art would directly and unambiguously infer that the upper part of the tank as such had to be high and large enough to encompass the natural convection cooling loop 13a needed for transferring the heat generated by the semiconductor elements out of the tank. Figures 2 to 5 taught the skilled person to locate the heat-generating semiconductor elements in the upper part of the power electronic cell close to the bottom of the upper part of the tank and at a distance from the top of the tank so that the heated fluid flows first upwards towards the top of the tank and then downwards along the side wall of the tank to transfer heat from the cooling liquid to the surrounding sea water. The distance from the top of the power electronic cell to the top of the tank ensured sufficient height and cooling surface of the tank to cool the fluid in the downstream portion of the natural convection cooling loop 13a to a temperature at which the upstream portion of the natural convection cooling loop 13a could start within the upper part of the tank. Thereby, the natural convection cooling loop 13a was limited to the upper part of the tank.

A skilled person would figure out the relative dimensions of the tank on the basis of Figures 2 to 5 and know the properties of the dielectric fluid (e.g. a dielectric oil), the number of semiconductor elements and capacitor elements in a power cell and the amount of heat generated by them, the required cooling capacity as well as the temperature of sea water on the sea bed. The exact vertical distance between the semiconductor elements and the capacitor elements was not critical and Figures 2 to 5 showed that a certain vertical distance was advantageous. Taking into account all these elements belonged to the normal design work for the skilled person.

The skilled person had knowledge about the parameters considered by the examining division and might thus realise the invention on the basis of simple computer simulations without any undue burden.

2.3 The board agrees with the examining division that the application does not disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

2.3.1 The board accepts the appellant's view that the characterising portion of claim 1 implies that there is a natural convection cooling loop which occurs only in the upper part of the tank, where the majority of the semiconductors elements are positioned, but that other natural convection loops are not excluded. In particular, a natural convection loop in the lower part, where the majority of the capacitor elements are positioned, or even a natural convection loop extending in both the upper and lower part, are not excluded by the wording of claim 1.

2.3.2 However, the board does not follow the argument that positioning semiconductor elements, which release a higher amount of heat in operation, in the upper part of the tank and capacitor elements, which release a lower amount of heat, in its lower part would result in the claimed natural convection cooling loop. The arrangement according to claim 1 is not limited to this configuration.

It is common ground that, in general, in a power electronic cell, a semiconductor element releases more heat in operation than a capacitor element, as also explained by the appellant in its letter dated 3 November 2023, page 11, fourth paragraph. This is also mentioned in the description of the application, see page 6, lines 9 to 13, page 6, line 28 to page 7, line 1 and known from the prior art, see e.g. paragraphs [0016] and [0017] of D4. Both types of elements generate heat to be dissipated, see page 4, lines 19 to 23 of the description of the application.

The appellant also confirmed that there are several types of semiconductor elements, which do not generate the same amount of heat. In other words, there are semiconductor elements that release a higher amount of heat than other semiconductor elements, see also page 7, lines 14 to 24 of the description of the application, which discloses the example that diodes may have lower heat losses than insulated-gate bipolar transistors.

The wording of claim 1 does not require all semiconductor elements to be positioned in the upper part of the tank and all capacitor elements in its lower part.
The claim explicitly states that a majority of the semiconductor elements (i.e. more than 50% in number) are positioned in said upper part and a majority of the capacitor elements (i.e. more than 50% in number) are positioned in said lower part. Hence, an arrangement with slightly less than 50% of the semiconductor elements in said lower part is covered by the scope of claim 1. For example, a power electronic cell with four semiconductor elements in the upper part and three semiconductor elements and two capacitors in the lower part is an embodiment within the scope of claim 1. However, it is well possible that said three semiconductor elements with said two capacitors release more heat in operation than said four semiconductor elements. The board is of the view that the skilled person would consider this configuration as a possible arrangement covered by claim 1, and not as an example that would not work.

As another example, claim 1 encompasses an arrangement with ten semiconductor elements in the upper part and twenty-five capacitor elements in the lower part, wherein said capacitors together generate more heat than said ten semiconductor elements.

In other words, claim 1 encompasses arrangements with more heat generated in the lower than in the upper part of the tank. Said configurations would produce a natural convection cooling loop due to the difference of temperatures in the two parts of the tank. However, the appellant did not provide any explanations how the skilled person should configure this arrangement so that a natural convection cooling loop "limited to the upper part of the tank" is achieved.

2.3.3 Furthermore, the board assumes in the following - for the sake of argument - that in operation the group of all components in the upper part of the tank release more heat into the surrounding dielectric fluid than the group of all components in its lower part. A temperature in the upper part is thus higher than in the lower part of the tank. Although not claimed, this type of arrangement is used throughout the description (see page 6, lines 9 to 15, "high loss, high temperature components", "low loss, low temperature components"; page 6, line 28 to page 7, line 1; page 7, lines 18 to 22; page 7, line 31 to page 8, line 4).

The board supposes that the examining division made the same assumption.

2.3.4 As pointed out by the examining division, the description of the application teaches (see page 4, line 5 to page 5, line 31) that a natural convection loop (see Figure 1, arrow 13) is established because the dielectric fluid in the vicinity of a heat generating component experienced a buoyancy force upwards, whereas the dielectric fluid in the vicinity of the tank walls experienced a buoyancy force downwards. The appellant agrees as it stated that a natural convection loop would occur as soon as there was a negative temperature difference in a vertical direction within a fluid, i.e. cold fluid on top of warm fluid. The force of gravity of the warm fluid was smaller than that of the cold fluid.

The board shares the examining division's view that the skilled person would be able to configure the arrangement so that a natural convection cooling loop was established within the tank.

None of the embodiments depicted in Figures 2 to 5 show the claimed arrangement. Page 8, lines 2 to 4 states that "[t]he resulting natural convection cooling loop **may** only encompass the upper part 7a of the tank 10 (above the imagined horizontal plane 3) as defined by arrow 13a" (emphasis by the board). The skilled person would thus understand that arranging the components as shown in Figure 2 (see page 6, line 1 to page 8, line 2) does not necessarily provide the natural convection loop according to the characterising portion of claim 1. Reading the application, the skilled person would assume that the natural convection loop 13a normally extends to the lower part 7b of the tank.

In the board's view, there is no information in the application as a whole how the example of Figure 2 or the examples of Figures 3 to 5 have to be modified so that the downward flow of dielectric fluid essentially stops above the imaginary line separating the upper and lower part of the tank, while the upwards flow starts above said imaginary line such that the natural convection loop does not extend into the lower part of the tank.

2.3.5 In particular, the application as a whole does not explain how the claimed natural convection could be obtained by merely selecting a vertical height of the upper part of the tank greater than a vertical height of the lower part of the tank and/or by selecting a vertical distance from a top of the tank to a top of the power electronic cell greater than a vertical distance from a bottom of the tank to a bottom of the power electronic cell.

The board finds it questionable whether the position of the power cell with respect to the tank can be directly and unambiguously derived from Figures 2 to 5, which are not more than schematic cross-sectional drawings of the cooling arrangement. In any case, the text of the description appears to be silent about this arrangement. There is no indication in the application at all that said vertical heights and vertical distances would be crucial in order to obtain the claimed natural convection cooling loop.

2.3.6 Moreover, the board agrees with the examining division that in order to provide the arrangement according to the characterising portion a number of parameters are to be taken into account by the skilled person.

The board notes that Figure 1 on page 7 of the statement setting out the grounds of appeal apparently concerns a model with mass flow rate of 0.03 kg/s in the lower part of the tank. As pointed out by the appellant in its letter dated 3 November 2023, "the natural convection cooling loop of the fluid is limited to the hot upper part of the tank in practice, as 96 % of the downwards mass flow (0.72 kg/s) is directed horizontally to the opposite side of the tank and upwards above the lower part of the tank containing the capacitors". The board takes the view that according to the appellant's own explanations, it thus seems that the 4% of the simulated convection loop extend into the lower part of the tank. It is questionable whether this corresponds to the claimed convection loop.

In any case, the application as a whole is entirely silent about how to simulate or model by a computer a thermal network and to construct a working prototype on the basis of the simulation results.

2.3.7 In order to carry out the invention as claimed, more than normal design work is necessary for the skilled person, who might be aware of all parameters indicated by the examining division and the appellant and of simulation and modelling methods. In view of the numerous parameters to be taken into account, the complexity of the task set and the lack of information provided in the application, the skilled person would have to perform a research program in order to be able to obtain all embodiments falling within the ambit of the claims.

2.3.8 Therefore, the disclosure of the invention does not allow the skilled person to perform, without undue burden, essentially all the embodiments covered by the claimed invention.

3. Third auxiliary request - admission, Article 13(1) and (2) RPBA 2020

3.1 The third auxiliary request was filed with the appellant's letter dated 3 November 2023, i.e. after notification of the summons to attend oral proceedings before the board.

3.2 The appellant mainly argued that said auxiliary request was submitted in response to the objection pursuant to Article 123(2) EPC raised by the board against claim 1 of the main request and that it removed the scenario that the lower part of the tank could be hotter than the upper part.

3.3 The board is of the view that the effected amendments do not overcome the issues raised by the board against the main request in relation to insufficiency of the disclosure. Hence, relying on the criteria set out in Article 13(1) RPBA 2020, the board does not admit the third auxiliary request into the appeal proceedings under Article 13(2) RPBA 2020.

4. First auxiliary request - admission, Article 12(4) RPBA 2007

4.1 Claim 1 introduces features (c), (d1), (d2), (e), (f), and (g), which had not been included in any claims during the examining procedure.

4.2 According to point 2.2 of the statement setting out the grounds of appeal, the first auxiliary request was filed as a response to the examining division's objection under Article 83 EPC in the impugned decision regarding the characterising portion of claim 1 of the main request.

4.3 Objections under Article 83 EPC were raised in the communication dated 26 September 2018 (point 1) and the annex to the summons to attend oral proceedings (point 1). These objections, however, appear to be different from the objection of point 26.2 of the impugned decision as they do not specifically address the characterising portion of claim 1 of the present main request.

According to the result of a telephone consultation dated 27 June 2019 between the appellant's representative and the primary examiner, the latter suggested that, to overcome an objection under Article 84 EPC, the feature later objected under Article 83 EPC should be included into claim 1 in order to arrive at an allowable claim (see points 2 to 4). Hence, the objection under Article 83 EPC in point 26.2 of the impugned decision was discussed for the first time during oral proceedings before the examining division on 16 July 2019, see pages 1 and 2 of the minutes and the annex to the communication under Rule 71(3) EPC, point 1.

4.4 The appellant argued that the first auxiliary request was *prima facie* allowable and should be admitted. Moreover, the appellant stated that, while they could have filed it before the examining division, they have not been able yet to come up with this wording at that time, also in view of the several possible options to address the objections raised by the examining division. There was also a change of representative.

4.5 The board is of the view that between the oral proceedings before the examining division on 16 July 2019 and the expiry of the time limit set in the communication under Rule 71(3) EPC issued on

11 September 2019, there was sufficient time to draft a set of claims to address the objections raised against the main request. The change of its representative is not a valid reason to prevent the appellant from doing so.

Therefore, the appellant could and should have filed the first auxiliary request already during oral proceedings or at the lastest with its letter dated 1 October 2019 as a reply to the examining division's communication under Rule 71(3) EPC, to overcome the examining division's objection under Article 83 EPC.

4.6 Hence, in view of the above considerations, the board decided that the first auxiliary request is not admitted into the appeal proceedings (Articles 12(4) RPBA 2007).

5. Second auxiliary request - inventive step, Article 56 EPC

5.1 The second auxiliary request is identical to the second auxiliary request underlying the impugned decision. It also corresponds to the second auxiliary request according to the examining division's communication under Rule 71(3) EPC.

Claim 1 according to the second auxiliary request is based on a combination of claims 1, 10 and 12 as originally filed, wherein it is specified that "the outlet is placed [...] vertically higher than the majority of the capacitor elements" (in view of page 6, lines 15 to 20 in combination with page 9, lines 18 to 20 of the description and Figure 4).

5.2 The appellant pointed to the fact that the examining division had issued a communication under Rule 71(3) EPC, wherein the text intended for grant was based on the claims according to the second auxiliary request.

In the invention, the cooling loop 13a encompassed the upper part of the tank above the capacitive elements, while the lower part of the tank housing the capacitive elements was cold. By having the outlet of the heat exchanger 8 in the upper part of the tank above the capacitive elements and the inlet of the heat exchanger at the top of the upper part, the heat exchanger would take in hot fluid from the top of the cooling loop 13a and output cooled fluid to the bottom of the cooling loop 13a in the upper part of the tank, thereby enhancing the cooling of the hot upper part of the tank. This might even allow a smaller size (height) of the upper part of the tank as less cooling surface might be needed.

There was no need to enhance cooling of the lower part of the tank. To the contrary, if the heat exchanger was installed as in Figure 1, it would deteriorate the cold environment in the lower part of the tank. The cooled fluid coming from the heat exchanger would interfere with the less or nearly zero circulation 13b (nearly stagnant fluid) of the cold fluid in the lower part of the tank and cause mixing the hot fluid of the upper cooling loop 13a and the cold fluid in the lower part of the tank and thereby heat the cold fluid. The incoming fluid from the heat exchanger was likely to be warmer than the cold fluid in the lower part of the tank and would therefore heat the cold fluid in the lower part of tank. Consequently the capacitors in the lower part of tank would be heated rather than cooled.

D1 and D2 had a different approach for dissipating heat generated by the high loss components, namely a heat sink which effectively transferred the heat directly from high loss component module to the outside of the tank. The fluid in the tank was primarily intended for adapting the pressure inside the tank very close to the outside sea water pressure so that the housing was not exposed to a pressure difference or differential pressure and thus was not exposed to high forces exerted on it from outside. As the heat of the semiconductors was evacuated by the heat sink, there was no reason to provide further cooling means.

Figure 6 in D1 disclosed a stack of capacitors 11 arranged in a capacitor enclosure 10. The stack of capacitors 11 was connected with busbars 110 to a converter unit 120 positioned in a metal housing vertically above the stack of capacitors 11. A filter membrane 17 was positioned between the capacitor enclosure 10 and the metal housing of the converter unit 120. Said filter 17 prevented any contact between the power supply module 120 and the fluid in portion F_{main} so that there was no convection at all. An electrically insulating and thermally conductive layer 230 was positioned on the upper surface of the metal housing of the converter unit 120 and a heat sink 23 was positioned on the layer 230. The heat sink 23 was in contact with the inner surface of the wall of the power supply module 20, see paragraph [0040]. The capacitor enclosure 10 was supported via springs 22 on a support 21 in the power supply module 20. The purpose of the springs 22 was to keep the heat sink 23 continuously in contact with the inner surface of the wall of the power supply module 20 (see column 10, lines 46 to 52). The heat sink 23 dissipated heat from the converter unit 120 via the wall of the power supply module 20 to sea water outside the power supply module 20.

The dielectric fluid in the upper part of the power supply module 20 would thus be heated only to a limited extent. The volume of the lower part of the power supply module 20 below the imagined horizontal plane formed the major part of the whole volume of the power supply module 20. It was not possible to achieve a situation in which hot fluid with a large natural convection would be positioned in the upper part of the power supply module 20, the lower part of the power supply module 20 being cold with less natural flow convection or nearly stagnant fluid.

The converter unit 120 would dissipate heat only through its lateral edges into the dielectric fluid F_{main} in the power supply module 20. The heat sink 23 might also dissipate some heat through the lateral edges to the dielectric fluid. This heat dissipated from the converter unit 120 and the heat sink 23 to the dielectric fluid F_{main} might cause a natural upper convection in the power supply module 20. This natural upper convection would, however, not be limited to the upper part of the power supply module 20 as the volume of the power supply module 20 above the imaginary horizontal plane was too small. This natural upper convection would also circulate downwards along the stack of capacitors 11.

D2 did not contain any clear and unambiguous information regarding the orientation of the figures. Figure 2 in D2 could present a vertical or a horizontal cross section or some other cross section of the converter module 26. Even if Figure 2 in D2 presented a vertical cross section of the converter module 26, the same arguments as presented in relation to D1 would still apply to Figure 2 in D2. The imagined horizontal line between the capacitor bank 43 and the power supply 42, 44 was positioned in the upper part of the enclosure 46. The power supply 42, 44 was arranged at an inside surface of the wall 54 of the enclosure 46. A heat sink 53 was positioned at an opposite surface of the wall 54 of the enclosure 46. The capacitor bank 43 was positioned far from the bottom of the enclosure 46.

D1 and D2 did not have a natural convection cooling loop limited to the upper part of the tank.

The appellant further argued that the objective problem was to enhance the cooling of semiconductors and reduce the size of the fluid tank.

D1 or D2 did not provide the skilled person in the art with any teaching or motivation that would have guided it towards the claimed invention.

A skilled person starting from D1 or D2 as the closest state of the art would have enhanced the cooling by improving the heat transfer from the semiconductors to the heat sink and further outside the tank. Obvious ways to achieve this would have been to improve the thermal contact between the semiconductors and the heat sink and/or to increase the size of the heat sink and/or to enhance the heat transfer from the heat sink to the medium outside the tank. The last alternative could include providing the heat sink with cooling ribs and/or providing an external heat exchanger (e.g. heat exchanger 22 of D4) attached to the heat sink so that the cooling medium of the external heat exchanger flowed along the heat sink, thereby cooling the heat sink.

There was no need for enhancing the cooling of the upper part of the tank by a heat exchanger circulating and cooling the fluid in the tank, particularly with the outlet of the heat exchanger being arranged vertically higher than the majority of capacitor elements. The size of the upper part of the tank was already minimised by using the heat sink. To the contrary, the skilled person would have considered that any such heat exchanger would only have increased the complexity, size and cost of the tank without offering any significant benefits.

As the heat sinks used in D1 or D2 and the heat exchangers known from D3 or D4 were completely different technologies, the skilled person would not combine these documents. Including a heat exchanger in the tank of D1 or D2 would require significant modifications that the skilled person would not do.

An inventive step was thus to be acknowledged.

5.3 The board notes that the appellant indicated in its letter dated 1 October 2019 that it did not accept the grant of a patent on the basis of the second auxiliary request. The examining division then resumed the examination proceedings in accordance with Rule 71(6) EPC and issued the impugned decision refusing the application pursuant to Article 97(2) EPC.

If the applicant wishes to use the appeal to pursue a higher-ranking request which has not been granted (i.e. the main request underlying the impugned decision), it must be aware of the risk that the board might refuse the application in toto, whereas the first instance had considered the lower-ranking second auxiliary request to be grantable. As per G 10/93, OJ EPO 1995, 172, Headnote, in an appeal from a decision of an examining division in which a European patent application was refused the board of appeal has the power to examine whether the application or the invention to which it relates meets the requirements of the EPC. The same is true for requirements which the examining division did not take into consideration in the examination proceedings or which it regarded as having been met. If there is reason to believe that such a requirement has not been met, the board should include this ground in the proceedings.

For the board, the subject-matter of claim 1 according to the second auxiliary request does not involve an inventive step (Article 56 EPC) for the following reasons.

5.3.1 The board notes that the wording of claim 1 does not explicitly require any natural convection cooling loop. Moreover, neither the number of semiconductor elements and capacitor elements in the upper and lower part of the tank nor the amount of heat generated by said elements are mentioned in claim 1. Thus, it cannot be said that, in operation, the group of all components in the upper part of the tank release more heat into the surrounding dielectric fluid than the group of all components in its lower part, see point 2.3.2 above, or that a natural convection loop might be implicitly present in the claimed arrangement.

The wording of claim 1 leaves it open in which part of the tank the biggest amount of heat is generated.

5.3.2 Document D1 (Figures 1, 2 and 6) discloses the preamble of claim 1: power cell (120, 11, Figures 1 and 2), tank (20), semiconductor elements (120, 122) positioned vertically above capacitor elements (11), imagined horizontal plane (Figure 6).

According to D1 (see paragraphs [0031], [0040]), in operation, the components in the upper part of the tank (i.e. the semiconductor elements) release more heat into the surrounding dielectric fluid than the components in the lower part of the tank (i.e. the capacitor elements) so that a heat sink 23 is provided. The presence of a heat sink is not excluded in claim 1. Even in the presence of the heat sink 23, the temperature of the fluid close to the semiconductor elements (i.e. converter unit 120, 122) is higher than the fluid close to the upper wall of the tank so that natural convection is present. According to paragraph [0040] of D1, filter membrane 17 ensures that *contamination* cannot spread between the circuit fluid volume F_{cct} and the main fluid volume F_{main}, while the fluid volume F_{cct} is free to mix with the main fluid volume F_{main}. Hence, the fluid close to the converter unit 120 is in thermal communication via convection with the dielectric fluid in the tank, contrary to the appellant's explanations during oral proceedings before the board.

The skilled person would understand that close to the capacitor elements 11, natural convection must be very limited as there is hardly any temperature difference within housing 10, the fluid being able to flow only through perforations H, see Figure 7.

The temperature and the convection in the upper part close to converter unit 120 and heat sink 23 of the tank is higher than the temperature and convection close to the capacitor elements 11.

5.3.3 D2 also discloses an arrangement according to the preamble of claim 1: tank (Figure 2, 46), fluid ([0022]), at least one power cell (26, Figure 2, [0023], 42, 44, 43, Figure 1: elements 26 to 29), semiconductor elements (42, 44, Figure 2, [0023]), capacitor elements (43, Figure 2). Heat is dissipated mainly from the semiconductor elements (see paragraph [0024]).

5.3.4 Hence, documents D1 and D2 disclose the preamble of claim 1 according to the second auxiliary request.

Both D1 and D2 disclose a heat sink. In D1, a heat sink 23 is attached to an inside of the upper part of the tank 20, see Figure 6. In D2, a heat sink 53 is attached to an outside of the upper part of the tank 54, see Figure 2.

The distinguishing feature is the heat exchanger according to the characterising portion of claim 1. This is not disputed by the appellant.

5.3.5 It is common ground that claim 1 does not contain any features that would necessarily reduce the size of the tank. On the contrary, adding an external heat exchanger outside the tank would rather increase the total size of the arrangement. The distinguishing features thus to not contribute to any size reduction.

5.3.6 The appellant argued that the objective problem was to provide an arrangement in which cooling efficiency of the components of the power electronic cell may be improved or enhanced.

The board notes that there is no indication in the application as originally filed that a heat exchanger would provide better cooling of electronic components in a tank filled with a dielectric fluid when compared to a heat sink. In the application as originally filed, the use of an external heat exchanger (with an inlet and an outlet) attached to a tank filled with dielectric fluid is presented as conventional cooling means, see Figure 1 and page 4, line 5 to page 5, line 31. No particular enhancement is mentioned.

Page 9, lines 8 to 26 do not disclose any technical effect related to the position of the heat exchanger and its inlet and outlet, when compared to a cooling arrangement according to Figures 2 and 3 without any heat exchanger.

In particular, claim 1 does not include any indication that the dielectric fluid is directly sent towards the semiconductor elements by positioning the outlet higher than the capacitor elements so as to improve the overall cooling efficiency, as argued by the appellant.

Moreover, since in the arrangements of D1 and D2 the heat generated by the respective semiconductor elements is evacuated by the respective heat sink, adding an additional external heat exchanger or replacing the heat sink by such a heat exchanger would not necessarily further improve the cooling.

In view of these considerations, the objective technical problem solved by the characterising portion is not more than to provide alternative cooling means for the arrangements already known from D1 and D2.

5.3.7 According to Figure 1 of the application it is already known in the art to provide a heat exchanger according to the characterising portion of claim 1, see page 4, lines 12 to 18 and page 4, line 32 to page 5, line 4. Such heat exchangers are also known from D3 (Figure 1, tank 2, fluid 3, electric component 4a, heat exchanger 5a, sea water 6, pump 7a; paragraph [0026]) or from D4 (Figure 1, tank 2, electric modules 4, heat exchanger 22). This was not contested by the appellant. In other words, external heat exchangers with an inlet and an outlet are already known as alternative cooling means, regardless of the fact that there may be other ways to improve the cooling by a heat sink (as argued by the appellant).

It is obvious for the skilled person wishing to solve the objective technical problem to integrate this type of heat exchanger in the tank of D1 or D2.

As discussed above and as explicitly disclosed in paragraphs [0016] and [0017] of D4, the semiconductor elements generate the largest amount of heat. It would be obvious to provide the in- and outlets of the heat exchanger close to the semiconductor elements dissipating heat and outside the upper part of the tank, i.e. vertically higher than the capacitor elements. It should be noted that claim 1 does not exclude the use of a pump for providing the dielectric fluid to or from the heat exchanger.

The board is of the opinion that the skilled person would have no technical difficulties to add an external heat exchanger known from Figure 1 of the application, D3 or D4 to the tanks known from D1 or D2. It is noted that the application as a whole does not describe any particular means to connect a heat exchanger to a tank, see e.g. page 4, lines 12 to 18, page 4, line 32 to page 5, line 4, page 9, lines 8 to 26. The board assumes that the skilled person, using their common

general knowledge, is in a position to add a heat exchanger to the outside of a tank filled with a dielectric fluid.
The board does not agree with the appellant that documents D3 and D4 describe technologies different from D1 or D2, because all four documents concern the cooling of power electronic modules positioned in tanks filled with a dielectric fluid for subsea applications.

5.3.8 Wishing to solve the objective technical problem, the skilled person would thus replace the heat sink known from D1 or D2 by a heat exchanger attached to an outside of the tank, the heat exchanger comprising an inlet for receiving dielectric fluid from the tank and an outlet for providing dielectric fluid to the tank, wherein the outlet is placed, when the arrangement is installed, vertically higher than the majority of the capacitor elements, wherein the heat exchanger is oriented such that, when the arrangement is installed, the heat exchanger is positioned outside the upper part of the tank.

Hence, the skilled person would arrive at the claimed arrangement in an obvious manner. The subject-matter of claim 1 thus lacks an inventive step (Articles 52(1) and 56 EPC).

6. As no admissible and allowable request is on file, the appeal must fail.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

S. Sánchez Chiquero T. Häusser

Decision electronically authenticated