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Application No.: 84 303 052.9  
Publication No.: 0 125 856  
Title of invention: Compound-superconducting coil

Classification: H01F 5/08

D E C I S I O N  
of 30 April 1991

Proprietor of the patent: Kabushiki Kaisha Toshiba  
Opponent: Siemens Aktiengesellschaft, Berlin und München

Headword:

EPC Article 56

Keyword: "Inventive step affirmed"

Headnote



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Boards of Appeal

Chambres de recours

Case Number : T 485/90 - 3.5.2

D E C I S I O N  
of the Technical Board of Appeal 3.5.2  
of 30 April 1991

Appellant :  
(Proprietor of the patent)

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(Opponent)

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Decision under appeal :

Decision of Opposition Division of the European  
Patent Office dated 20 April 1990 revoking  
European patent No. 0 125 856 pursuant to Article  
102(1) EPC.

Composition of the Board :

Chairman : E. Persson  
Members : W.J.L. Wheeler  
W. Riewald

## Summary of Facts and Submissions

I. The Appellant contests the decision of the Opposition Division revoking European patent No. 125 856 on the ground that Claim 1 did not involve an inventive step.

II. Claim 1, as amended during the proceedings before the Opposition Division, is worded as follows:

"A compound-superconducting coil (10) comprising:

a plurality of wires of compound-superconducting material;  
and

a tube (20) which receives said plural wires (12) and is provided with void spaces allowing for the passage of a coolant; characterised in that

the void fraction of the tube (20) is 45% to 70% of the tube interior space, so that, in a superconductive condition, the coil allows the passage of a current whose magnitude is at least 80% of the critical current observable when the wire (12) is in a strain-free state."

III. The following prior art documents were considered in the proceedings before the Opposition Division:

- (a) DE-A-2 029 076
- (b) DE-B-1 908 885
- (c) IEEE Transactions on Magnetism, Vol. MAG-17, No. 5, September 1981, pages 2209 to 2212
- (d) IEEE Transactions on Magnetism, Vol. MAG-15, No. 1, January 1979, pages 351 to 354
- (e) IEEE Transactions on Magnetism, Vol. MAG-15, No. 1, January 1979, pages 337 to 339
- (f) DE-A-2 626 914

(g) IEEE Transactions on Magnetics, Vol. MAG-15, No. 1, January 1979, pages 789 to 791

(h) DE-A-2 908 879

(i) EP-A-0 045 604.

- IV. The gist of the Opposition Division's reasoning was that Claim 1 defined an obvious combination of known features, it being known from (g) to use compound-superconducting material in cable-in-conduit type coils of large magnets, and it being known from (b) to have a void fraction of 50% or more in the interior of the conduit for allowing the passage of coolant to obtain a high current carrying capacity under strain. The reference in the claim to the coil allowing the passage of at least 80% of the critical current observable when the wire is in the strain-free state was considered to be arbitrary.
- V. After preliminary correspondence between the Board and the parties, oral proceedings were held on 30 April 1991. The parties were in agreement over the way in which the relevant art had developed. Briefly, it was discovered in the late 1950's that Nb-Ti alloy and Nb<sub>3</sub>Sn compound were superconductors. Nb<sub>3</sub>Sn had better critical values than the alloy but was extremely brittle, so that at first only the alloy (which was ductile) was used for practical purposes. Compound-superconducting material (e.g. Nb<sub>3</sub>Sn embedded in a copper or bronze matrix to give it some mechanical strength) became commercially available at about the end of the 1970's. Documents (e) and (g) concerned compound-superconducting coils which had actually been constructed as part of the so called "Large Coil Program" at Oak Ridge. The parties were in agreement that these coils represented the closest prior art and were in accordance with the prior art part of Claim 1 of the patent in suit. The parties were also in agreement that the expression "compound-superconducting material" appearing in Claim 1

of the patent in suit referred to true compounds such as  $Nb_3Sn$ ,  $Nb_3Al$  and  $Nb_3Ge$  and excluded alloys.

VI. Concerning inventive step, the Appellant argued in effect that in both documents (e) and (g) the void fraction was stated to be 40%.  $Nb_3Sn$  was used rather than an alloy to obtain a higher magnetic field with a given size of coil. It was not obvious to increase the void fraction because that would necessitate an undesirable increase in the size of the coil. If a small radius coil was required for a particular purpose, a person skilled in the art would automatically choose an alloy superconductor (e.g. Nb-Ti) because it was more ductile and could withstand a higher bending strain. The cable-in-conduit type coils disclosed in document (b) had alloy superconductors and would not help the person skilled in the art to solve the problem explained in the fourth paragraph of column 1 of the patent in suit, namely, that when  $Nb_3Sn$  was continually subjected to great bending strain, the critical current dropped, and, if it fell below 80% of its magnitude in the strain-free state, the wire failed to retrieve a superconducting property even after the current load was released. The inventors discovered that by increasing the void fraction to 45% or more the decline in the critical current at a certain bending strain could be suppressed. This could be seen from results published in a paper in Cryogenics, January 1985, pages 13 to 18: "Strain effects of cable-in-conduit  $Nb_3Sn$  conductors" (which will be referred to as document (j)). It was also discovered that the coil became unstable if the void fraction was 70% or more. The range 45% to 70% was higher than the void fractions previously used with compound-superconducting coils.

VII. The Respondent argued that the question to be decided was simply whether it was obvious to use a higher void

fraction than the 40% disclosed in documents (e) and (g). The characterising part of Claim 1 of the patent in suit amounted, in effect, to merely specifying a void fraction of 45% to 70%. The words "so that" indicated that the effect of allowing the passage of a current whose amplitude was at least 80% of the critical current in a strain-free state was a consequence of the higher void fraction. The claim contained no details as to how the cable was constructed. Without such details, there was no absolute causality between the void fraction and bending radius. The brittleness problem had already been solved by embedding Nb<sub>3</sub>Sn in copper or bronze. The reason why document (b) mentioned only alloys as superconducting material was simply that at that time (1970) compound-superconducting material was not yet available commercially. When it became available, it was obvious to use it in view of its better critical current and temperature values, which were known to persons skilled in the art, see the text book "Superconductor Materials Science - Metallurgy, Fabrication, and Applications" by Foner and Schwartz, Plenum Press, 1981, pages 63 to 67 and 256 and 257 (which will be referred to as document (k)). Referring to document (e), the Respondent argued that there was no dogma about having a 40% void fraction, it had been chosen in view of the requirements set for that particular project. The void fraction was an open parameter which could be chosen to obtain a desired compromise between cooling and current carrying capacity. It was obvious that a higher void fraction than 40% could be used if the circumstances - a more slowly flowing coolant for example - warranted it, indeed, void fractions of 50% or more were disclosed in document (b) for a different set of requirements.

VIII. The Appellant requested that the decision of the Opposition Division be set aside and that the patent be

maintained on the basis of Claims 1 to 8 as they appeared in the annex to the decision under appeal.

IX. The Respondent requested dismissal of the appeal.

X. After deciding that the patent could be maintained on the basis of Claims 1 to 8 as they appear in the annex to the decision under appeal, the Board agreed to the following amendments to the description of the printed patent specification:

1. Column 1, at the end of line 5, insert the sentence:  
"A compound-superconducting coil is a superconducting coil of compound-superconducting material."
2. Column 1, line 59, amend to read: "a plurality of wires of compound-superconducting material;"
3. Column 2, line 3, delete "(12)"
4. Column 2, delete lines 5 to 8
5. Column 2, at the end of line 42, insert " $V_3Ga$ "
6. Column 5, line 6, change "bending strain of" to "a bending strain and having, respectively, void fractions of"
7. Column 5, line 7, change "or" to "and".

#### Reasons for the Decision

1. The appeal is admissible.

2. The main question to be decided by the Board is whether Claim 1 (see paragraph II above) involves an inventive step.
- 2.1 It is common ground between the parties that the closest prior art is disclosed in documents (e) and (g). The Board also shares this view. Each of those documents discloses a coil in accordance with the prior art part of Claim 1 of the patent in suit comprising a plurality of wires of compound-superconducting material (stabilised Nb<sub>3</sub>Sn) in a tube with void spaces for the passage of a coolant (liquid helium). As disclosed in documents (e) and (g), the void fraction is 40%.
- 2.2 The parties disagree as to whether the subject-matter of Claim 1 of the patent in suit actually solves the problem explained in the fourth paragraph of column 1 of the patent in suit.
- 2.3 According to the Appellant, previously known Nb<sub>3</sub>Sn coils suffer from the drawback that when they are continually subjected to great bending strains (as a result of small coil diameters), the critical current drops, and when the bending strain is so great that the critical current of the coil drops to less than 80% of that observed in the strain-free state of the wire, the superconducting wire is permanently damaged and fails to retrieve a superconducting property even after the current load is released. Furthermore, according to the Appellant, in line with the explanation at column 3, lines 52 to 58, and column 4, line 54 to column 5, line 41, of the patent in suit, the inventors have discovered that by increasing the void fraction to 45% or more, the decline in the magnitude of critical current in dependence on the bending strain can be reduced, so that coils can be manufactured with

smaller diameters. However, as explained at column 3, lines 59 to 61, and column 5, lines 42 to 65, of the patent in suit, it was also discovered that if the void fraction is increased to 70% or more the coil becomes unstable. Thus, according to the Appellant, the inventors have discovered that 45% to 70% is an advantageous range of void fraction for manufacturing a compound-superconducting coil with a small diameter without incurring instability. This range is higher than the void fractions previously used with compound-superconducting material, which were not above 40%.

- 2.4 Although the Respondent has contested the Appellant's explanation, no evidence has been produced to show that the alleged advantage is in fact not obtained. On the other hand, the Appellant referred to document (j), which was published after the filing date of the application for the patent in suit, and so does not belong to the prior art. The document discloses the results of tests performed on cable-in-conduit conductors having different void fractions. The individual strands consisted of Nb<sub>3</sub>Sn fibres embedded in a copper matrix. The tests showed that with a void fraction of 50%, the critical bending strain was 0.9%, nearly equal to that of the strand, whereas with a void fraction below 40% the conductor behaved like a monolithic conductor with a critical bending strain below 0.5%. Document (j) explains that this is because the conduit restricts free motion of the strands, see page 16, under "Bending strain versus void fraction." Thus, document (j) appears to support the Appellant's argument, in particular that there is a causality between the void fraction and the critical bending strain. However, the Board notes that two of its authors are named as inventors in the patent in suit so that it cannot be considered as independent confirmation.

- 2.5 In line with the established practice of the Boards of Appeal, if the parties to opposition proceedings make contrary assertions which they cannot substantiate and the European Patent Office is unable to establish the facts of its own motion, the patent proprietor is given the benefit of the doubt (see decision T 219/83, OJ EPO, 1986, 211).
- 2.6 In view of the considerations outlined in paragraphs 2.3 to 2.5 above, the Board will assume that the Appellant is correct and that choosing the void fraction of the tube to be in the range of 45% to 70% allows the passage of a current whose magnitude is at least 80% of the critical current observable when the wire is in a strain-free state, in a compound-superconducting coil with a smaller diameter than was possible in the prior art.
- 2.7 It appears to the Board that, although document (b) discloses superconductive cable-in-conduit structures with a void fraction of 50% (or more) and states that a readily flexible conductor which can be used for windings of small bending radius can be obtained, it does so entirely in the context of alloy superconductors, which are ductile and not subject to the problem underlying the present invention. In document (b), the void fraction appears to have been chosen to give adequate cooling (alloys need more cooling than compound-superconducting material, since they have a lower critical temperature, see e.g. document (k), page 67, lines 7 to 9). The Board can find nothing in document (b) which might suggest to the person skilled in the art that he could expect to suppress the decline in the magnitude of the critical current of Nb<sub>3</sub>Sn (or other compound-superconducting material) by increasing the void fraction.

- 2.8 Documents (a), (c), (d), (f), (h) and (i) are clearly less relevant and have played no role in the appeal proceedings.
- 2.9 The Board has considered whether it might have been obvious to increase the void fraction for some other reason, such as to increase the volume of coolant for example. However, it appears to the Board that, since compound-superconducting material is generally more difficult to use than alloy superconductors, it would only be used when its higher critical values were needed to obtain a higher current density than is possible with alloy superconductors. With this in mind, it does not appear to be obvious to increase the void fraction beyond what is necessary to ensure adequate cooling, as this would lead to an unwanted reduction in the effective current density. Given that, as noted in paragraph 2.7 above, compound-superconducting materials need less cooling than alloys, and 40% void fraction gives satisfactory cooling in the coils disclosed in documents (e) and (g), it does not appear to be obvious to choose, in an arbitrary way, a higher void fraction.
3. The Board therefore agrees with the Appellant that the subject-matter of Claim 1 involves an inventive step within the meaning of Article 56 EPC, so that ground (a) in Article 100 EPC does not prejudice maintenance of the patent in suit on the basis of that claim. The same applies to the dependent Claims 2 to 8 which relate to particular embodiments of the subject-matter of Claim 1.
4. As concerns the amendment to Claim 1 (made before the Opposition Division) and the amendments to the description (made before the Board, see paragraph X above), the amendment to the claim (which corresponds to amendment 2 to the description) and amendments 1 and 2 to the

description make it absolutely clear that Claim 1 is limited to compound-superconducting coils comprising a plurality of wires of compound-superconducting material. Amendment 3 is trivial. Amendment 4 deletes a statement which cannot be maintained in the light of document (b). Amendment 5 corrects a printer's error. Amendments 6 and 7 correct obvious errors. In the opinion of the Board, these amendments comply with Article 123(2) and (3) EPC.

5. In the result, the Board is of the opinion that the patent may be maintained in the amended form requested by the Appellant.

**Order**

For these reasons, it is decided that:

The decision under appeal is set aside.

The case is remitted to the first instance to maintain the patent in amended form on the basis of:

Claims 1 to 8 as they appear in the annex to the decision under appeal;

Description as printed in EP-B1-0 125 856 with the amendments specified in paragraph X above;

Drawings as printed in EP-B1-0 125 856.

The Registrar:



M. Kiehl

The Chairman:



E. Persson