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D E C I S I O N
of 20 October 2000

Case Number: T 0956/98 - 3.5.2

Application Number: 90114887.4

Publication Number: 0412442

IPC: H01B 12/06

Language of the proceedings: EN

Title of invention:
Superconductive conductor

Patentee:
SUMITOMO ELECTRIC INDUSTRIES, LTD.

Opponent:
Siemens AG

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56

Keyword:
"Novelty (yes)"
"Inventive step (no)"
"Twofold problem, whereby the non-inventive solution to a
problem is also suitable to the solution of the other problem
("Bonus effect")"

Decisions cited:
T 0021/81, T 0069/83

Catchword:
-



Case Number: T 0956/98 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 20 October 2000

Appellant: Sumitomo Electric Industries, Ltd.
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Respondent: Siemens Ag
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Representative: -

Decision under appeal: Decision of the Opposition Division of the
European Patent Office posted 16 July 1998
revoking European patent No. 0 412 442 pursuant
to Article 102(1) EPC.

Composition of the Board:

Chairman: W. J. L. Wheeler
Members: M. R. J. Villemin
B. J. Schachenmann

Summary of Facts and Submissions

- I. The appellant contests the decision of the opposition division to revoke European patent No. 0 412 442. The reason given for the revocation was that the subject-matter of claim 1 of the main request and claim 1 of the auxiliary request then on file did not involve an inventive step, having regard to the prior art cited by the opponent.
- II. In reply to the summons to attend oral proceedings, the appellant filed with the letter dated 12 September 2000 new claims 1 and 2 in replacement of the claims considered in the decision under appeal, and new pages 2, 2a, 2b, 3 and 4 of the description in replacement of pages 2, 3 and 4 of the patent specification. With the letter dated 11 October 2000 the appellant filed a further set of claims 1 and 2 in respect of an auxiliary request.
- III. In the oral proceedings held on 20 October 2000 the appellant filed an amended page 2 of the description for the main request and for the auxiliary request.
- IV. Claim 1 of the main request is worded as follows:

"A superconductive conductor (8) comprising
at least three longitudinal superconducting wires (3)
extending parallel to each other;

a longitudinal supporting member (9) having a
symmetrical cross-section, for supporting said
superconducting wires (3) which are arranged parallel
to said supporting member and which partially or

entirely cover the periphery thereof, such that the superconducting wires (3) are symmetrically arranged when viewed in cross-section, and

each superconductive wire (3) comprises a superconductive member (4) and a stabilizing member (5) enclosing said superconductive member (4),

characterized in that

said superconducting wires (3) are tape-shaped wires,

said superconductive members (4) are oxide superconductors,

each superconductive wire (3) is extending linearly in the longitudinal direction of said supporting member (9),

wherein said supporting member (9) is a hollow tube of polygonal cross-section, and said superconducting wires (3) are arranged on the outer periphery of said hollow tube,

the surfaces of said tape-shaped superconducting wires (3) are disposed to face radially from the center of the polygonal cross section so that each of said tape-shaped superconducting wires (3) is disposed completely on a side of the polygonal cross section, and

said tape-shaped superconducting wires (3) are disposed adjoining to one another, the width dimension of each of said tape-shaped superconducting wires (3) being approximately equal to the side dimension of each side of the polygonal cross-section."

Claim 1 of the auxiliary request differs from claim 1 of the main request in that the superconductive conductor (8) comprises "at least five longitudinal superconducting wires" and in that the polygonal cross-section of the hollow tube is specified as "having at least five sides".

Claim 2 is dependent on claim 1 of each request.

V. The following documents cited in support of the opposition have been taken into consideration in the appeal procedure:

D1: DE-A-2 035 654,

D2: Takeshi HIKATA et al., "Ag-Sheathed Bi-Pb-Sr-Ca-Cu-O Superconducting Wires with High Critical Current Density", Japanese Journal of Applied Physics, Vol. 28, No. 1, January 1989; pages L82 to L84,

D4: DE-A-2 749 052,

D10: DE-B-1 952 148,

D11: DE-A-2 029 076,

D12: DE-A-2 136 019.

VI. With the statement of grounds of appeal the appellant patent proprietor submitted a sheet of explanatory Figures A, B, C and D, and referred to the following documents:

Document A: KEN-ICHI SATO et al., "Electromagnetic

Properties and Structures of BiPbSrCaCuO Superconducting Wires", Advances in Superconductivity II, Proceedings of the 2nd International Symposium on Superconductivity (ISS '89), 14-17 November 1989, Tsukuba, Springer-Verlag Tokyo 1990,

Document B: Munetsugu Ueyama et al., "Transport Properties of Silver-sheathed Bi(2223) Superconducting Wires and Coils for High-Field", Proceedings of the 9th US-Japan Workshop on HIGH-FIELD SUPERCONDUCTING MATERIALS, WIRES AND CONDUCTORS and STANDARD PROCEDURES FOR HIGH-FIELD SUPERCONDUCTING WIRES TESTING, 13-15 March 1995, Holiday Inn Kyoto, K. Osamura et al. Editors.

VII. With the letter dated 11 September 2000 the respondent opponent cited the following additional documents:

D13: G.A. Whitlow et al. "SILVER ENCASED HIGH TEMPERATURE SUPERCONDUCTOR RIBBONS PRODUCED BY ROLLING", IEEE TRANSACTIONS ON MAGNETICS, VOL. 25. NO. 2, MARCH 1989, pages 2317 to 2319.

D14: M. MIMURA et al. : "Improvement of the critical current density in the silver sheathed Bi-Pb-Sr-Ca-Cu-O superconducting tape", Applied Physics Letters, 54 (16), 17 April 1989, pages 1582 to 1584.

VIII. The appellant argued essentially as follows:

D1 described a superconductive conductor according to the pre-characterizing part of claim 1 of the main request. Document A (Figure 7) and document B (Figure 2) showed that the critical current density in

oxide superconductors greatly decreased under the influence of a magnetic field applied in a direction perpendicular to the plane of a tape-shaped wire as compared with the decrease of critical current density produced by a magnetic field applied in a direction parallel to the plane of the tape-shaped wire. The detrimental influence of this field anisotropy in oxide high-temperature superconductive materials did not occur in the low-temperature superconductive materials mentioned in documents D1, D4, D10, D11 and D12, so the skilled person seeking to eliminate or reduce this influence in oxide superconductors would not look for a solution in the field of conventional low-temperature superconductors.

The arrangement specified in claim 1 was efficient in that it minimized the spacing between adjacent tape-shaped wires and provided for the width dimension of each of the tape-shaped wires to be approximately equal to the side dimension of each side of the polygonal cross-section of the supporting member, as depicted for example in Figure D of the sheet submitted with the statement of grounds of appeal. This arrangement insured a substantial cancellation of the vertical components of the magnetic field produced by current flowing in the conductor and resulted in a higher value of the critical current density.

The field anisotropy problem did not arise in the low-temperature tape-shaped metal superconductors disclosed in D4 and D10. In D4 (see in particular Figure 5) the superconductors were accommodated in recesses and were not disposed adjoining to one another as specified in claim 1. In D10, although the superconductors were disposed adjoining to one another, their width was not

equal to the side dimension of each side of the rectangular cross-section. Even if it was admitted that a person skilled in the art might by chance arrange tape-shaped oxide superconductors in one of the geometrical arrangements of the tape-shaped metal superconductors wires disclosed in D4 or D10, he could not have expected to obtain the field anisotropy compensation effects obtained by the present invention. This conclusion also applied when considering the arrangements which could be obtained from various combinations of the teachings of other documents such as D11 which dealt with low-temperature metal superconductors.

IX. The respondent's arguments can be summarised as follows:

The problem underlying the alleged invention should first be correctly defined. It was known from the prior art disclosed in D2, for example, that a problem might be seen in the fact that the component of the magnetic field perpendicular to the plane of a tape-shaped oxide superconductive wire heavily reduced the value of the critical current density in this wire. It was known to the skilled person that a current flowing through a conductor produced a magnetic field, including the vertical field component referred to by the appellant as being responsible for the decrease of the value of the critical current density in a tape-shaped oxide superconductive conductor. It was obvious that the effect of this component should be eliminated or reduced.

It was known that the strength of the magnetic field produced by an electric current flowing through a wire

decreased with increasing distance from the wire. According to the appellant, the desired reduction of the net vertical magnetic field component was obtained by adjoining the tape-shaped wires to one another on the sides of the polygonal support member. However, the only material with superconductive properties was the oxide enclosed in the stabilizing metal matrix, not the metal matrix itself. Since claim 1 did not define the spacing between neighbouring oxide superconductive zones or of the value of the angle formed by the adjoining extremities of the tape-shaped wires, the geometry of the arrangement according to claim 1 did not differ from that known from D10, which described a superconductive conductor comprising tape-shaped superconductive metal wires disposed on the sides of a hollow supporting member having a polygonal cross-section (see claim 5 of D10) in such a manner that the wires adjoined to one another and the width of each wire was approximately equal to the side dimension of each side of the supporting member. D10 had to be considered as the document representing the prior art closest to the invention.

D10 was relevant to the claimed superconductive conductor because it concerned the problem of cooling which was a problem common to all types of superconductor. Superconductive conductors using tape-shaped oxide superconductive materials were known from the prior art disclosed in D2. Once they became available, it was obvious to try them instead of the low-temperature superconductors in D10. This was a mere analogous substitution, cf Guidelines for examination in the European Patent Office, Part C, Chapter IV-Annex, 1.1 (iv). Since efficient cooling was important in high-temperature oxide superconductive devices as

well as in low-temperature metal devices, the skilled person would have tried arranging the tape-shaped oxide superconductive materials in the same or a similar manner as that taught by D10 for superconductive conductors with metal tape-shaped wires, in the expectation of obtaining efficient cooling.

- X. The appellant requested that the decision under appeal be set aside and the patent be maintained as amended
- with claims 1 and 2 and pages 2a, 2b, 3 and 4 of the description filed with the letter dated 12 September 2000, page 2 of the description submitted during the oral proceedings before the Board and the drawings of the patent specification (main request), or
 - with claims 1 and 2 filed with the letter dated 11 October 2000, description and drawings as per main request (auxiliary request).

XI. The respondent requested that the appeal be dismissed.

Reasons for the Decision

1. The appeal is admissible.
2. The Board considers that document D10 discloses the closest prior art, namely a superconductive conductor having the following features:
 - four longitudinal superconductive wires 3 extending parallel to each other,

- a longitudinal supporting member 1 having a symmetrical cross-section, for supporting said superconducting wires 3 which are arranged parallel to said supporting member 1 and which entirely cover the periphery thereof, such that the superconducting wires 3 are symmetrically arranged when viewed in cross-section, whereby
- each superconducting wire 3 comprises superconductive members 4 and a stabilizing member enclosing said superconductive members 4,
- said superconducting wires 3 are tape-shaped wires, each superconductive wire 3 extending linearly in the longitudinal direction of said supporting member 1, wherein said supporting member 1 is a hollow tube of polygonal cross-section (see Figure 1, column 4, lines 19 to 22 and claim 5 of D10) and said superconducting wires 3 are arranged on the outer periphery of said hollow tube,
- the surfaces of said tape-shaped superconducting wires 3 are disposed to face radially from the center of the polygonal cross-section so that each of said tape-shaped superconducting wires 3 is disposed on a side of the polygonal cross-section, and
- said tape-shaped superconducting wires 3 are disposed adjoining to one another, the width dimension of each of said tape-shaped superconducting wires 3 being approximately equal to the side dimension of each side of the polygonal cross-section.

3. *Novelty*

3.1 The subject-matter of claim 1 of the main request differs from the superconductive conductor disclosed in D10 in that:

- according to claim 1, the superconductive members are oxide superconductors, whereas in D1 they are metal superconductors, and

- according to claim 1 each of the tape-shaped superconducting wires is disposed completely on a side of the polygonal cross-section, whereas in D10 they are shown in Figure 1 as each extending beyond one edge of the side of the cross-section by an amount equal to the thickness of the adjoining tape.

3.2 Therefore, the subject-matter of claim 1 of the main request is new.

4. *Inventive step*

4.1 It is stated in the contested patent (see the printed patent specification, column 2, lines 31 to 36) that the object of the present invention is to provide a superconductive conductor capable of implementing a superconductive cable or a current lead, which can suppress the amount of evaporation of a cooling medium absolutely or substantially with no Joule loss caused by energization. It is also stated at column 3, lines 6 to 16 that according to the invention the superconducting wires are arranged ... so that the electromagnetic force and magnetic fields provided by the superconducting wires cancel each other. Therefore

it is possible to reduce distortion and influence by applied magnetic fields. Thus, according to the present invention, it is possible to obtain a superconductive conductor which has excellent superconduction properties such as a critical current.

4.2 In the prior art known from document D10 the superconducting wires are arranged so that the magnetic fields provided by the superconducting wires cancel each other, thereby promoting a high critical current density, at least to the extent achieved by the arrangement specified in claim 1 of the main request. Furthermore, the prior art known from document D10 provides good cooling efficiency. Thus, starting from the prior art known from document D10, the objective problem underlying the contested patent is to provide a superconductive conductor having lower Joule losses, while retaining a high critical current density.

4.3 Document D10 dates from the time before the discovery of high-temperature superconductive materials such as oxide superconductors. Thus it teaches how to provide effective cooling for "classical" low-temperature superconductors. Documents D2, D13 and D14, published nearly 20 years after the filing date in respect of D10, describe the manufacture of tape-shaped superconductive wires made of oxide superconductor embedded in a stabilizing metal member. Oxide superconductors are high-temperature superconductive materials whose transition temperatures are above 77°K, permitting them to be cooled with liquid nitrogen instead of requiring the more expensive liquid helium necessary for cooling classical superconductors. The Board agrees with the respondent that it was therefore obvious to any person skilled in the art to try to

substitute the recently available tape-shaped superconductive wires made of oxide superconductor embedded in a stabilizing metal member (D2, D13, D14) for the tape-shaped superconductive wires made of classical low-temperature superconductor embedded in a stabilizing metal members (D10). The skilled person would expect this to lead to lower Joule losses, and the teaching of D10 to dispose the plane surfaces of the tape-shaped wires on the plane sides of the polygonal cross-section of the hollow tube to obtain an optimum heat transfer from the wires to the cooling medium within the tube is quite obviously applicable independently of the nature of the superconductive material.

- 4.4 As shown in Figure 1 of D10, a small region at one edge of the surface of each of the superconductive wires extends beyond the edge of the side of the hollow tube by an amount equal to the thickness of the adjoining tape and is soldered to the end of the adjacent superconductive wire. It is obvious to the skilled person that this small region is not cooled as well as the rest of the tape because it is not in contact with the hollow tube and that the cooling efficiency would be improved if the tape-shaped superconductive wires were disposed completely on the sides of the tube.

- 4.5 As pointed out by the appellant, the problem of field anisotropy was not and could not be mentioned in D10 because this problem simply does not occur in low-temperature metal superconductors. The Board observes, however, that this problem is known from the prior art disclosed in D2, D13 and D14. An example indicated in D2 (page L83, right-hand column, second paragraph) shows that the value of the critical current density J_c

in a magnetic field of 0.1 T reduced to 900 A/cm² when the magnetic field is perpendicular to the plane of the tape-shape wire in comparison with its value (1660 A/cm²) when the field is parallel to this plane. As pointed out by the respondent, in reciting that "said tape-shaped superconducting wires (3) are disposed adjoining to one another", claim 1 specifies that the extremities of the adjacent stabilizing members, not those of the oxide superconductive members (4), are adjoining to one another. No information is given in the claim about the spacing between the extremities of the magnetic field producing oxide superconductive members, or about the angle subtended between adjacent superconductive wires.

- 4.6 Under such circumstances, the skilled person, starting from the prior art known from D10 and updating it to take advantage of the high-temperature oxide superconductor tape-shaped wires disclosed in D2, as explained in paragraphs 4.2 to 4.4 above, would also have obtained the additional advantageous effect, possibly unforeseen by this person, of a reduction of the vertical component of the magnetic field. According to the established jurisprudence of the Boards of Appeal of the EPO (see for example the published decisions T 21/81 (OJ EPO 1983, 15) and T 69/83 (OJ EPO 1984, 357)) such a "bonus effect" is not regarded as an indication of inventive step.
- 4.7 Summarising, the Board concludes that the subject-matter of claim 1 of the main request can be derived without inventive step from the prior art disclosed in D2 and D10.
- 4.8 Claim 1 of the auxiliary request differs from claim 1

of the main request only in that the superconductive conductor (8) comprises "at least five longitudinal superconducting wires" and in that the polygonal cross-section of the hollow tube is specified as "having at least five sides".

- 4.9 As was explained in the oral proceedings, the Board need not decide whether "polygonal", as used in the patent in suit, implies "at least five". If it doesn't, the auxiliary request would contravene Article 123(2) EPC because "at least five" is not disclosed *expressis verbis* in the application as originally filed. If "at least five" is implied by "polygonal", as used in the patent in suit, it is equally implied by "Polygonform" and "polygonförmig", as used in D10, see D10: claim 5 and column 4, lines 19 to 22. Thus this feature could not contribute to inventive step.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

M. Hörnell

W. J. L. Wheeler