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D E C I S I O N
of 7 February 2002

Case Number: T 0807/99 - 3.5.2

Application Number: 91105089.6

Publication Number: 0449316

IPC: H01B 12/10

Language of the proceedings: EN

Title of invention:
Oxide superconducting wire, method of preparing the same, and method of handling the same

Patentee:
Sumitomo Electric Industries, Ltd.

Opponent:
Siemens AG

Headword:
-

Relevant legal provisions:
EPC Art. 54(1)(2)

Keyword:
-

Decisions cited:
-

Catchword:
-

Case Number: T 0807/99 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 7 February 2002

Appellant: (Proprietor of the patent)	Sumitomo Electric Industries, Ltd. 5-33, Kitahama 4-chome Chuo-ku Osaka-shi Osaka 541 (JP)
Representative:	Winter, Brandl, Fürniss, Hübner, Röss, Kaiser, Polte Partnerschaft Patent- und Rechtsanwaltskanzlei Alois-Steinecker-Strasse 22 D-85354 Freising (DE)
Respondent: (Opponent)	Siemens AG Postfach 22 16 34 D-80506 München (DE)
Representative:	Patentanwälte Westphal, Mussgnug & Partner Waldstrasse 33 D-78048 Villingen-Schwenningen (DE)

Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 1 June 1999 revoking European patent No. 0 449 316 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: W. J. L. Wheeler
Members: F. Edlinger
J. H. P. Willems

Summary of Facts and Submissions

I. This appeal is against the decision of the opposition division revoking the European patent No. 449 316.

II. The appellant proprietor filed amended claims with the statement of grounds of appeal. With a letter dated 7 January 2002, the appellant filed two sets of claims according to auxiliary requests I and II and a graph showing the critical current density J_c/J_{C0} [%] of embodiments of the opposed patent as a function of distortion [%] for different thickness ratios (referred to in the following as "Annex 1"). A new claim 1 (main request) and an insert to column 1 of the description were filed in the oral proceedings which were held before the Board on 7 February 2002.

III. Claim 1 of the main request now has the following wording:

"A superconducting wire (6; 7) comprising:

a metal sheath (4; 5); and

a plurality of oxide superconductors (1) distributed in said metal sheath (4; 5) on a cross-section perpendicular to the longitudinal axis of said metal sheath,

said oxide superconductors (1) being bismuth oxide superconductors having components of Bi-Sr-Ca-Cu-O or (Bi,Pb)-Sr-Ca-Cu-O and having a 2223 phase,

said oxide superconductors (1) being c-axis oriented in the thickness direction of the superconducting wire

(6; 7), along the cross-section perpendicular to the length direction of the superconducting wire (6; 7), and

the a-b plane of the 2223 phase of the bismuth oxide superconductors (1) being oriented in the direction of current flow, that is the length direction of the superconducting wire (6; 7),

characterized in that

said plurality of oxid superconductors (1) are independently distributed in said metal sheath, and

the thickness of each said oxide superconductor (1) being set to be not more than 5% of the overall thickness of said metal sheath (4; 5)."

Claim 1 of auxiliary request I includes the additional feature that "the distortion (thickness of metal sheath/bend diameter) of said wire is not more than 0.5%". Claim 1 of auxiliary request II limits the distortion to "not more than 0.3%".

Claims 2 and 3 of all the requests are dependent on claim 1. Claims 4 to 11 and claim 12 of all the requests respectively relate to methods of preparing an oxide superconductor and a method of handling a superconducting wire as claimed in claim 1.

IV. The subject-matter of claim 1 of the main request on which the decision under appeal is based was substantially the same as that of claim 1 of the present main request. The opposition division, in the decision under appeal, expressed the opinion that the subject-matter of claim 1 of the requests then on file did not involve an inventive step having regard to the prior art disclosed in the following documents:

D1: EP-A-0 357 779

D3: EP-A-0 352 424 and

D6: Japanese Journal of Applied Physics; Vol. 28, No. 7, July 1989; pages 1185 - 1188; Sekine, H. et al: "Metallurgical Studies and Optimization of Critical Current Density in Bi-(Pb)-Sr-Ca-Cu-O Superconductors".

The reasons given in the decision under appeal essentially followed the opponent's arguments that D3 disclosed an yttrium based (YBCO) superconducting wire with a final thickness of each oxide superconductor of 2.5% of the overall thickness of the metal sheath. The superconducting wire specified in claim 1 differed from the wire disclosed in D3 in that it had a 2223 phase of a bismuth based (BSCCO) superconductor with a c-axis oriented in the thickness direction of the wire. The person skilled in the art had a strong incentive to use BSCCO material because it had a high critical current density and did not include any poisonous elements. D6 and D1 disclosed superconducting wires comprising a plurality of BSCCO superconductors in a metal sheath with the c-axis oriented in the thickness direction of the superconducting wire. The person skilled in the art, trying to improve the superconducting wire known from D3, would thus arrive at the subject-matter of claim 1 without involving an inventive step.

V. In an annex to the summons to attend oral proceedings, the Board expressed the provisional opinion that, following the appellant's arguments in the statement of grounds of appeal, D6 could be considered as the closest prior art. Although the thickness of the superconductor filaments was not explicitly disclosed in D6 as a percentage of the thickness of the metal sheath, the Board drew attention to the fact that the 1330-filament wire shown in Figure 6 of D6 appeared to have filaments of a thickness which was less than 5% of the overall thickness of the metal sheath because otherwise it seemed impossible to fit such a large number of filaments within the metal sheath. The Board therefore expressed doubts as to the novelty of the superconducting wire of claim 1.

VI. The appellant proprietor requested that the decision under appeal be set aside and that the patent be maintained on the basis of claim 1 as filed in the oral proceedings of 7 February 2002, claims 2 to 12 as filed with the statement of grounds of appeal dated 6 October 1999, description as granted with an insert in column 1 as filed in the oral proceedings of 7 February 2002, figures as granted (main request), alternatively with claims 1 to 12 of the auxiliary request I or the auxiliary request II, both filed with letter of 7 January 2002, description and figures as in the main request.

VII. The respondent opponent requested that the appeal be dismissed.

VIII. The appellant essentially argued as follows:

The opposition division had not correctly applied the problem-solution approach because D6, not D3, represented the closest prior art. None of the documents considered in the decision under appeal disclosed the problem and technical effect achieved by the opposed patent, ie "to provide an oxide superconducting wire, whose critical current density is not much reduced even if the same is distorted" (patent specification, column 1, line 57 to column 2, line 2). The superconducting wires disclosed in D6 had more features in common with the wire specified in claim 1 than the wire disclosed in D3 had. However, D6 did not disclose that the thickness of each superconductor was not more than 5% of the overall thickness of the metal sheath. The 1330-filament wire (D6, Figure 6) did not have identical filament diameters. Therefore, it could not be derived from the number of filaments contained within the metal sheath that each superconductor filament had a thickness ratio of not more than 5%. Moreover, the 1330-filament wire of D6 was arranged in 19 bundles, each containing 70 filaments. The diameter of each filament (0.5 mm) represented 6.7% of the diameter of the silver sheath (7.5 mm) containing the 70 filaments before it was cold worked (D6, page 1185, right-hand column, second paragraph). This value of thickness ratio could only be increased in the ensuing cold working process since the deformability of silver was much higher than that of BSCCO material. Because of the arrangement in bundles, the plurality of superconductor wires were not "independently distributed in said metal sheath" (claim 1) as was the case in the "multicore structure" of the opposed patent (cf patent specification, column 2, lines 8 to 12).

These differences also justified the presence of an inventive step because a superconducting wire as specified in claim 1 showed the surprising effect that its critical current density was hardly reduced when the distortion of the wire was less than 0.5%. Annex 1, which graphically showed the values taken from Table 1 in column 6 of the patent specification, clearly demonstrated that the bending behaviour of wires with a thickness of each superconductor as specified in claim 1 was significantly different from the behaviour of those samples which had a thickness ratio of 6.2% or more. It was important that the thickness of each of the superconductors was set to be not more than 5% because individual thicker filaments would have a smaller critical current density and, through local heating, would reduce the critical current density of the wire as a whole. Since none of the prior art documents dealt with the bending behaviour of BSCCO wires, the person skilled in the art did not get any hint from the other documents to independently distribute oxide superconductors having a thickness as specified in claim 1.

Annex 1 and Table 1 demonstrated that the effect provided by a thickness ratio of not more than 5% was further significantly improved if the distortion of the superconducting wire was made less than 0.5%, or 0.3%, respectively, as specified in auxiliary requests I and II. Surprisingly, such superconducting wires showed a strongly non-linear effect with almost no reduction of the critical current density if distortion was controlled to be less than the above values.

IX. The respondent essentially argued as follows:

D6 disclosed all the features of claim 1 of the main request. Since the thickness of each superconductor with respect to the overall thickness was determined by the number of filaments contained in the metal sheath of a given diameter (cf patent specification, column 4, lines 3 to 8) and since the number of filaments (1330 in D6, and 1260 in the patent) and the outer diameters (1.5 mm in D6 and 1 mm in the patent) were almost the same, the thickness ratios would be substantially the same in both cases (cf D6, page 1185, right-hand column, second paragraph; opposed patent, Examples 4 and 5). If one calculated the upper limit of the area available for each of the 1330 filaments in the metal sheath, one obtained a maximum thickness ratio of 2.7%. The individual filaments were homogeneously deformed in the manufacturing process so that each of the superconductors had essentially the same diameter, resulting in a thickness of not more than 5% of the overall thickness of the metal sheath. The feature of claim 1 specifying that the plurality of superconductors were "independently distributed in said metal sheath" could not confer novelty on claim 1 either. It was not clear what "independently distributed" meant and, in any case, it could not be construed as meaning that all the filaments were uniformly distributed in a single bundle. The opposed patent did not disclose that any effects, in particular those presented in the context of Table 1, were attributable to forming a single bundle of filaments. Column 4, lines 3 to 8, of the patent specification explained that the thickness could be adjusted "by varying the number of strands", in other words, by distributing a varying number of separate individual strands in the metal sheath.

Should the Board decide that D6 did not disclose a thickness of each superconductor as specified in claim 1 of the main request, the wire as claimed was, at least, not inventively distinguished from that disclosed in D6. The opposition division had rightly set out that filaments of 25 µ diameter (resulting in a thickness ratio of 2.5%) were not arbitrarily chosen in D3. The person skilled in the art would try to improve the current carrying capability of the known wire by arranging thin filaments as disclosed in D3. He would thus arrive at the subject-matter of claim 1 of the main request without involving an inventive step.

The additional features in claim 1 of auxiliary requests I and II did not characterise a superconducting wire as such, but related to the handling of the wire. The distortion ranges of "not more than 0.5%" and "not more than 0.3%" included zero distortion. Therefore, these features did not contribute anything to distinguish the superconducting wire as claimed in auxiliary requests I and II. Thus, the subject-matter of the respective claim 1 of these requests, at least, did not involve an inventive step either.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request*

2.1 The parties agree that D6 discloses a superconducting wire comprising the features of the precharacterising portion of claim 1 of the present main request, in particular a BSCCO wire having a 2223 phase and oxide superconductors which are c-axis oriented in the thickness direction as specified in claim 1.

2.2 The 1330-filament wire shown in Figure 6 of D6 was manufactured by packing 70 monofilamentary Bi-Pb-Sr-Ca-Cu-O wires into a silver sheath (7.5 mm), cold working the sheath (to 0.7 mm) and packing again 19 pieces of the cold worked 70-filament wire into a further silver sheath (5 mm) which was cold worked again into a wire of 1.5 mm outer diameter (see D6, page 1185, right-hand column, second paragraph). Figure 6 of D6 shows a cross section of the wire in which the 19 bundles are spaced apart. On the reasonable assumption that all the 1330 monofilamentary superconductors have at least approximately the same cross-sectional area, the minimum area of the inner cross section of the outer silver sheath would be 1330 times the average cross-sectional area of the individual monofilamentary superconductors, if they were arranged without any interstices within or between the bundles of superconductors. This would necessitate an average diameter of the monofilamentary superconductors of less than 2.7% of the inner diameter of the outer sheath. If allowance is made for the fact that as shown in Figure 6 of D6 the 19 bundles are markedly separated and there are also interstices within each bundle, the thickness ratio would be further reduced, ie the superconductors would be thinner than 2.7% of the inner diameter of the outer sheath. This simple estimate of the thickness of the superconductors based on the available area for 1330 superconductors in a given metal sheath is confirmed by the photograph and scale of Figure 6 of D6 which show that at least more than five superconductors, in the finished state, fit within the length of the 0.2 mm scale. The average diameter of the superconductors derivable therefrom is thus, at least, less than 40 μ which results in a thickness ratio of roughly the same percentage when this diameter is set in relation to 1.5 mm outer diameter of the outer silver sheath as the overall thickness of the metal sheath. Moreover, five superconductors of any of the 19 bundles fit within the scale shown in Figure 6 of D6, which supports the respondent's argument that the superconductors are homogeneously deformed so that each of them has a thickness of not more than 5% of the overall thickness of the metal sheath, as required by the last feature of claim 1 of the main request.

2.3 The setting of the thickness of each superconductor as specified in claim 1 of the main request is achieved, according to the teaching of the opposed patent, by varying the number of the superconductors filled in the metal sheath (see claim 8; column 3, lines 43 to 48; column 4, lines 3 to 10; column 7, lines 11 to 17). The maximum number of superconductors filled in a metal sheath ("silver pipe") in accordance with Example 2 is given as "1296 cores" (patent specification, column 7, lines 43 to 47). Packing this number of cores into a metal sheath would thus yield a similar upper limit of thickness ratio as for the 1330-filament wire of D6. Since the thickness ratio could be expected to be increased in the cold working process because the ductility of silver is much higher than that of the BSCCO material, as argued by the appellant in the case of the wire disclosed in D6, the final ratio of thickness will have a similar magnitude in Example 2 of the patent and in the 1330-filament wire of D6. The opposed patent does not disclose any measures for further reducing the thickness ratio or for obtaining a more uniform reduction of the diameter of each of the filaments in the cold working process. Therefore, the feature of claim 1 of the main request specifying that the thickness of each said oxide superconductor is set to be not more than 5% of the overall thickness of the metal sheath does not distinguish the wire of claim 1 from that disclosed in D6.

2.4 The appellant has argued that the plurality of superconductors in the wire shown in Figure 6 of D6 are not "independently distributed in said metal sheath" as required by claim 1 of the main request because the 1330 filaments are arranged in 19 bundles. However, neither the term "independently distributed" nor its antonym "dependently distributed" has a clear meaning in this context. The left-hand part of Figures 1 and 2 of the patent specification show metal sheaths in which 7 and 19 strands, respectively, are uniformly arranged in close packing before the metal sheath is cold worked. The thickness ratio in these examples is indicated as 30% and 15%, respectively, and thus outside the range specified in claim 1 (patent specification, column 6, line 54 to column 7, line 10). This arrangement is comparable to that of one of the 19 bundles (70 filaments) in the 1330-filament wire of D6, or that of the 36-filament tape shown in Figure 7 of D6 (page 1185, right-hand column, second paragraph). However, the opposed patent does not disclose that the much larger number of 1296 superconductors would likewise be arranged in a single bundle, nor does it hint at a particular effect achieved by bundling the large number of superconductors only once instead of making several bundles. Therefore, this feature does not allow a distinction to be made between the wire disclosed in D6 and that specified in claim 1 of the main request. Thus, the subject-matter of claim 1 of the main request is not considered to be new and forms part of the state of the art (Article 54(1) and (2) EPC).

3. *Auxiliary requests I and II*

In accordance with the disclosure of the opposed patent (column 2, lines 39 to 45; claim 12), reduction of the critical current density caused by distortion is prevented by improving the distortion resistance of the wire (by reducing the thickness ratio) and by keeping distortion below 0.3% during handling of the wire. Limiting the distortion of the superconducting wire to be not more than a certain amount as specified in claim 1 of each of the auxiliary requests I and II defines a parameter for a specific use of the wire, eg for delivering the wire from a reel after preparation (see eg column 4, lines 11 to 25). Although such handling of the wire may include process steps for preparing the superconducting wire (into a wound state), the feature specifying a distortion of not more than 0.5% or 0.3% respectively does not characterise a process step which inevitably leads to a different wire product, but rather defines a precaution to prevent a manufactured wire from losing desired properties through bending too tightly, for example when the wire is used for the manufacture of a coil (opposed patent, column 4, lines 11 to 25). Furthermore, the claims cover straight wires which are not distorted by any bending. Therefore, the subject-matter of claim 1 of both auxiliary requests I and II likewise lacks novelty in view of the prior art disclosed in D6.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Hörnell W. J. L. Wheeler