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File Number: T 153/90 - 3.5.2
Application No.: 82 104 600.0
Publication No.: 0 067 330
Title of invention: Coil for a superconducting magnet device

Classification: H01F 7/22

D E C I S I O N
of 22 January 1991

Proprietor of the patent: Hitachi, Ltd.
Opponent: Siemens Aktiengesellschaft, Berlin und München

Headword:

EPC Article 56

Keyword: "Inventive step (confirmed) - Re-assessment of the state of the art"

Headnote



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Boards of Appeal

Chambres de recours

Case Number : T 153/90 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 22 January 1991

Appellant :
(Opponent)

Siemens Aktiengesellschaft,
Berlin und München
Postfach 22 16 34
W-8000 München 22
DE

Representative :

Schwalm, A.
Siemens AG

Respondent :
(Proprietor of the patent)

Hitachi, Ltd.
5-1, Marunouchi 1-chome
Chiyoda-ku
Tokyo 100
JAPAN

Representative :

Mayr, C.-M., Dipl.-Phys. Dr.rer.nat.
Steinsdorfstrasse 10
W-8000 München 22
DE

Decision under appeal :

Interlocutory decision of the Opposition Division
of the European Patent Office dated
5 January 1990 concerning maintenance of European
patent No. 0 067 330 in amended form.

Composition of the Board :

Chairman : E. Persson
Members : A. Hagenbucher
J. van Voorthuizen

Summary of Facts and Submissions

I. European patent No. 0 067 330 was granted on European patent application No. 82 104 600.0. As granted, the patent had five claims.

II. The Appellant filed a Notice of Opposition against the European patent requesting revocation of the patent on the grounds that its subject-matter lacked an inventive step and was not sufficiently disclosed.

Fifteen prior art documents were cited in support of the opposition, of which the following remain relevant in this appeal:

- a) CH-A-514 223;
- b₁) Proceedings "The Third International Conference on Magnet Technology" (MT3), Hamburg 1970, pages 1071-1092;
- b₂) as before; pages 950-965;
- c) "Cryogenics" October 1968, pages 317-319;
- d) "Proceedings of the Eighth International Cryogenic Engineering Conference" (ICEC8), Genf 1980, pages 720-723;
- f) "Advances in Cryogenic Engineering", Volume 22, Plenum Press, 1977, pages 463-471;
- g) Proceedings "The Second International Conference on Magnet Technology" (MT2), Oxford 1967, pages 519-524 (article ends on page 523);

- h) "VDI-Z", Zeitschrift des Vereins Deutscher Ingenieure für Maschinenbau und Metallbearbeitung, Band 121 (1979), No. 1/2, Januar I/II, pages 50-53;
- k) "Siemens Zeitschrift", Volume 49, No. 11, 1975, pages 739-741;
- m) DE-A-2 907 083;
- n) INDUSTRIES ATOMIQUES, No. 5/6, 1970, pages 3-16: "La réalisation de l'aimant supraconducteur ...";
- o) DE-A-1 564 688.

III. By an interlocutory decision within the meaning of Article 106(3) the Opposition Division decided to maintain the patent on the basis of new Claims 1 to 3 and an adapted description submitted on 21 July 1988 and further amended during oral proceedings held on 9 March 1989. According to a communication pursuant to Rule 58(4) EPC, dated 11 May 1989, the term "yielded" on drawing sheet 2 was amended to "yield". Sheets 1, 3 and 4 of the patent specification remained unamended.

IV. The independent Claim 1 reads as follows:

1. Coil for a superconducting magnet device in which coil intermetallic compound superconducting conductors (21) are wound upon the core of said coil (1) in parallel and in multiple layers together with copper conductors (22) without being metallurgically bonded to said intermetallic compound superconducting conductors (21), which copper conductors (22) thermally stabilize said superconducting conductors (21),

characterized in that

said copper conductors (22) are made of oxygen-free copper which is hardened by a cold working process before the conductors are wound upon said coil core, and said copper conductors (22) are wound superimposed on said intermetallic compound superconducting conductors (21) with a higher winding tension than that being applied to the intermetallic compound superconducting conductors (21).

- V. The Appellant (Opponent) lodged an appeal against the interlocutory decision.

In the Statement of Grounds, document

s) Cryogenics, June 1965, pages 152-158

was cited in addition to the twelve documents indicated in paragraph II above.

The Appellant requested that the decision under appeal be set aside and the patent be revoked on the grounds that its subject-matter was not sufficiently disclosed and lacked an inventive step.

- VI. The Respondent (Patentee) requested rejection of the appeal and maintainance of the patent as amended during the opposition proceedings.
- VII. In view of the disputes concerning insufficiency of disclosure and the closest state of the art, a communication was issued by the Board, drawing attention to the following further documents:

p) US-A-3 733 692 (cited in the patent in suit);

- q) Die Kälte, January 1974, pages 6 to 17;
- r) Cryogenics, June 1964, pages 153 to 165 (cited on page 6 of document m)).

VIII. During oral proceedings before the Board the Appellant, as to the alleged insufficient disclosure, submitted that the reply by the Respondent dated 21 December 1990 to the communication of the Board of Appeal was confusing, because in contrast to the patent documents this reply considered the superconducting conductor as comprising both the superconductor and the copper conductor. Moreover, it emphasised that the superconductor of the present invention was usually a multifilamentary superconductor containing stabilising copper as a matrix. According to the Appellant's opinion, this was not disclosed in the documents of the patent in suit. Furthermore, the statement that according to the present invention hardened oxygen-free copper having a large specific resistance was used so as to have the effect of a reinforcing material rather than the effect of a stabilising material gave the misleading impression that, in contrast to Claim 1 and the description, the copper conductors (22) would only serve for reinforcement and not for stabilisation, whereas a non-disclosed copper matrix of the multifilamentary superconductors was used for stabilisation.

Regarding the alleged lack of inventive step, the Appellant considered document b₂) (especially page 953, second paragraph, page 963, first paragraph and page 964, second paragraph) to be the most relevant prior art, because it disclosed all the features in the prior art portion of Claim 1 and hinted at the need for reinforcement in a coil for a superconducting magnet

device. Such necessity to compensate for hoop stress was also clearly shown in document n) (cf. ruban de renfort in Figure 6B). Document b₂) explained on page 964, lines 5 and 6 that high conductivity normal materials such as copper, which was generally used for stabilisation, introduced mechanical limitations. From b₁) (especially page 1075, the last two paragraphs) it became clear, however, that stabilising copper (which is normally in the soft state) could additionally serve for reinforcement (in the hard state) in magnets if a reliable compromise was found.

Documents c) and d) showed that a cold working process led to a hard state.

If a person skilled in the art recognised that normal copper was not suitable for stabilisation and reinforcement he would treat copper in a cold working process according to the compromise indicated in b₂ and use such treated copper as a stabilising and reinforcement layer in a magnet device as described in b₂).

A person skilled in the art would automatically apply a higher winding tension to the copper conductors than to the superconducting conductors because of the lower tensile strength of the superconducting conductors on the one hand and because of the function of the hard copper conductors for reinforcement on the other hand.

Claim 8 of document o) taught the simultaneous winding of a superconducting conductor and a reinforcement tape with respectively adapted tensions.

The only difference between the solution according to document o) and that of the claimed subject-matter could be seen in the fact that according to the patent in suit the reinforcement tape of document o) was also used for stabilisation.

IX. The Respondent relied essentially on the following arguments:

He accepted that the reply dated 21 December 1990 was partly misleading. As far as the distinction between superconductor and copper conductor according to the invention was concerned, the Figure at the bottom of page 2 of this reply was clear, however. Regarding the statement on page 3, first paragraph of the reply, he agreed that the patent documents did not disclose that the claimed superconductor was of a multifilamentary type containing a matrix of stabilising copper and that one should preferably rely on Claim 1 and on column 3, lines 52 to 54 of the patent specification and not be misled by the statement in paragraph 2.2, last sentence of this reply.

Regarding the inventive step objection, he pointed out that the Appellant had referred to a large number of documents but had failed to show that the use of non-bonded cold worked oxygen-free copper conductors for both purposes, namely reinforcement and stabilisation, the conductors being wound with a higher winding tension than that being applied to the intermetallic compound superconducting conductors, was obvious. No motivation could be derived from the prior art documents for the claimed synthesis of these features. Regarding the essential differences between the cited prior art and the claimed subject-matter, he referred to the arguments

brought forward in the opposition proceedings and to his reply dated 21 December 1990.

As b₂) was the most relevant prior art, the Respondent requested to replace the reference to DE-A-2 907 083 on description pages 1 and 2 filed on 9 March 1989 by a reference to b₂).

Reasons for the Decision

1. The appeal is admissible.
2. There is no objection under Articles 123(2) or 123(3) EPC to the current version of the claims. In view of the disclosure in the original description filed 26 May 1982 (cf. especially page 1, lines 8 to 10; page 3, second paragraph; page 7, lines 16 and 17; page 18, last paragraph) Claim 1 as granted was directed to a "coil for a superconducting magnet device" instead of the original designation "superconducting magnet device comprising a coil". The present Claim 1 is essentially a combination of Claims 1, 3 and 4 as granted. The additional term "superimposed" reflects the overlay winding technique described on original page 7, lines 5 to 9 (patent specification, column 2, line 65 to column 3, line 1) and shown in Figure 1.
3. Disclosure of the invention

According to the Appellant's opinion, the patent documents would not allow a clear interpretation of the term "superimposed" in Claim 1, with the consequence that the invention is not disclosed in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

The Board, however, agrees with the Respondent's view that the term "superimposed" will be understood by the person skilled in the art as reflecting the overlay winding technique described in the last paragraph of column 2 and especially in the first line of column 3 of the patent specification and shown in Figure 1. Hence, there is no ground for opposition under Article 100(b) EPC.

4. Novelty

- 4.1 Documents a) and p) do not disclose a coil according to the first portion of Claim 1 because they concern tape-like superconductors sandwiched between copper tapes by metallic bonding. They do not suggest the utilisation of hardened oxygen-free copper for stabilisation.
- 4.2 Documents b₁) (cf. especially page 1075, the last two paragraphs) and c) refer to superconducting conductors with superconducting filaments embedded in a thermally stabilising metal matrix. This means that the superconducting conductors and the stabilising copper are bonded together. b₁) (cf. page 1075) points to the fact, however, that for thermal stabilisation the soft state of a matrix metal such as copper is essential whereas for higher strength the hard state of the metal is required and that in application to large volume magnets a reliable compromise is essential. In the context of multifilaments, no different winding tensions between the copper conductors and the superconducting conductors seem possible, however.
- 4.3 Document b₂) describes the construction of a coil according to the first part of Claim 1. Non-bonded thermally stabilising copper may be interleaved with the superconductors (cf. page 963). b₂) points to the

mechanical limitation introduced by normal stabilising copper, however, and teaches armouring with stainless steel (cf. page 964).

- 4.4 Documents d) and f) concern hardening of copper by means of a cold working process and its usefulness in multifilamentary superconductor fabrication.
- 4.5 Document g) discloses a Nb_3Sn tape sandwiched between two copper tapes or clad by a copper tape. There is no disclosure of treating copper by a cold working process or applying different tensions to the stabilising copper tape and the superconducting tape. Regarding degradation (as a consequence of hoop stress) only the use of a specific winding technique is mentioned on page 522, first two lines.
- 4.6 Documents h), k) and s) are mainly concerned with superconducting filaments embedded in a thermally stabilising copper matrix and mention cold working of stabilising copper. The addition of separate copper wires for further stabilisation is recommended in document h).
- 4.7 Document m) describes a coil with the features in the prior art part of Claim 1 but does not disclose the features in its characterising part. This document does not mention a separate cold working process for the stabilising copper nor the application of different winding tensions for copper conductors and intermetallic compound superconducting conductors.
- 4.8 According to document n) (cf. Chapter 6) copper is considered not appropriate as a material for armouring. A separate armouring tape (preferably made of stainless steel) is used in addition to stabilising copper around the superconducting conductors (cf. Chapter 5).

4.9 Document o) describes the use of a copper tape for reinforcement. This reinforcement tape is isolated from the superconducting conductor which is additionally surrounded by separate stabilising copper. The functions of stabilisation and reinforcement are, therefore, performed by separate copper portions.

Claim 8 of document o) hints at respectively adjustable winding tensions for the supply reels of the superconducting conductors and the reinforcing material.

4.10 Document q) provides a survey of the various stabilisation techniques such as adiabatic, dynamic and cryogenic stabilisation. Cold working of stabilising copper is only mentioned in connection with multifilament wires containing the stabilising copper as a matrix.

4.11 Document r) mainly relates to energy exclusion, after a superconducting coil is quenched (cryogenic stabilisation). The subject-matter of Claim 1 is related to dynamic stabilisation, however. The features in the characterising part of Claim 1 are not known from document r). There are no superimposed layers.

4.12 In view of the above, the subject-matter of Claim 1 is new within the meaning of Article 54 EPC.

5. Inventive step

5.1 The Board agrees with the Appellant's opinion that the closest prior art is disclosed in b₂) (especially pages 952 to 954, 963 and 964) since it is concerned with coils which are, like the claimed coil, strip wound, i.e. intermetallic compound superconducting conductors (niobium-tin strip conductors, cf. page 952) are wound

upon the core of a coil in multiple layers together with thermally stabilising high conductivity copper conductors (cf. page 953, second paragraph; page 954, first paragraph). The stabilising copper conductors need not be bonded to the superconducting conductors (cf. page 963, lines 6, 9 and 10).

- 5.2 Document b₂) (cf. page 964) points to the fact that the use of high conductivity normal materials, such as copper, introduces mechanical limitations and suggests the addition of stainless steel for restraining hoop forces. Hence, according to b₂), an additional layer is necessary for reinforcement.

The objective problem underlying the present invention can, therefore, be seen in simplifying the construction of the known coil, making it at the same time more compact but, nevertheless, ensuring a strong and thermally stable wiring whereby the strain which is caused in the intermetallic compound superconductors during the winding and in particular during the operation of the superconducting coil shall be reduced as much as possible.

- 5.3 The above problem is essentially solved in the claimed coil by treating the high conductivity copper by a cold working process and using it as reinforcing and stabilising material and by applying a higher winding tension to the copper conductors than to the intermetallic compound superconducting conductors. A separate stainless steel layer is thus no longer necessary in order to reduce degradation and space is saved.
- 5.4 According to document b₂), a separate layer of stainless steel is used in addition to the stabilising copper because copper is considered as introducing mechanical

limitations. Hence, document b₂) clearly teaches away from the claimed solution.

The Appellant argues that the teaching of document b₂) should be considered together with that of document b₁). According to b₁) (especially page 1075, last two paragraphs), a reliable compromise between the hard state and the soft state of a metal such as copper is essential so that it could serve for both purposes, high strength and high conductivity. Document b₁) generally concerns superconducting filaments embedded in a stabilising metal matrix, however. Therefore, the indicated compromise concerns matrix copper which is necessarily bonded to the intermetallic compound superconducting conductors. Consequently, the same winding tension is applied to the intermetallic compound superconductors and the stabilising material so that strain during operation of the coil can only be reduced to a limited extent.

Documents c) and d) similarly teach that high purity copper strengthened by a cold working process is suitable for thermally and mechanically stabilising embedded superconducting conductors but do not suggest winding both types of conductors unbonded, superimposed and with different winding tensions.

Regarding armouring of coils, the Appellant also referred to documents n) and o). According to his opinion, armouring layers would necessarily be applied with a higher winding tension than that being applied to the intermetallic compound superconducting conductors. Specific reference was made to Claim 8 of document o).

The solutions in documents n) and o) provide separate layers for stabilisation and reinforcement. According to document n), stabilising copper is used as a matrix

embedding the intermetallic superconducting conductors (cf. Chapter 5) whereas a separate layer, preferably made of steel, should be used for reinforcement (cf. Chapter 6 and page 15, Annex). According to document o) (cf. especially Figures 5 and 6), superconducting filaments 7 are embedded in copper 8 (cf. Figure 2) for stabilisation whereas a separate copper conductor 9 may be used as a reinforcement tape. The reinforcement tape is isolated from the stabilising copper by a glass fibre tape. Document o) shows bonding of the thermally stabilising material and the superconductors. It does not teach that the thermally stabilising conductors should be treated such that they obtain a high tensile strength in order to fulfill both tasks - stabilising thermally and mechanically.

As already can be seen from paragraph 4 above, the other available documents a), f), g), h), k), m), p), q), r) and s) do not come any closer to the claimed invention than the above discussed documents b₁), b₂), c), d), n) and o) which were referred to by the Appellant during the oral proceedings.

Hence, the claimed combination of the following features:

- (a) Designing a coil for a superconducting magnet device with intermetallic compound superconductors in multiple layers and with thermally stabilising oxygen-free copper conductors which are not metallically bonded to the superconductors and
- (b) treating the thermally stabilising copper conductors in such a way that they can also be used for reinforcement and winding them superimposed on said intermetallic compound superconducting conductors with

a higher tension than that being applied to the intermetallic compound superconducting conductors,

is not obvious in the light of the prior art. Consequently, the subject-matter of Claim 1 of the patent in suit involves an inventive step.

The same applies to Claims 2 and 3, which are dependent on Claim 1.

The process steps defined therein have relevant and observable consequences for the strength and electrical resistance of the copper conductors (product by process features).

5.5 In view of the above, the patent can be maintained as amended.

Order

For these reasons, it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the first instance with the order to maintain the patent as decided by the Opposition Division subject to the replacement of pages 1 and 2 of the description by pages 1 and 2 filed in the oral proceedings (cf. paragraph IX above).

The Registrar:



M. Kiehl

The Chairman:



E. Persson

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