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File No.: T 0660/91 - 3.4.1
Application No.: 85 301 661.6
Publication No.: 0 155 167
Classification: G21C 3/20
Title of invention: Cladding tubes for containing nuclear fuel material

D E C I S I O N
of 23 July 1993

Applicant:

Proprietor of the patent: WESTINGHOUSE ELECTRIC CORPORATION

Opponent: Siemens Aktiengesellschaft

Headword:

EPC: Art. 56

Keyword: "Obvious optimisation of known contradictory properties in realising a further solution of a known problem" - "Inventive step (no)"

Headnote
Catchwords



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Boards of Appeal

Chambres de recours

Case Number: T 0660/91 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 23 July 1993

Appellant:
(Opponent)

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Representative:

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Respondent:
(Proprietor of the patent)

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Decision under appeal:

Decision of the Opposition Division of the
European Patent Office dated 28 June 1991
rejecting the opposition filed against European
patent No. 0 155 167 pursuant to Article 102(2)
EPC.

Composition of the Board:

Chairman: G.D. Paterson
Members: H.J. Reich
R.K. Shukla

Summary of Facts and Submissions

I. The Respondent is owner of European patent No. 0 155 167.

The independent Claims 1, 6 and 7 as granted read as follows:

"1. A cladding tube for containing nuclear fuel material, that comprises an inner tubular member located inside of an outer tubular member, the outer circumferential surface of said inner tubular member being bonded to the inner circumferential surface of said outer tubular member over essentially the entire outer circumferential surface of said inner tubular member, and said outer tubular member being composed of a first alloy selected from Zircaloy-2 and Zircaloy-4 type alloys, and Zr-Nb alloys containing from 1.0 to 3.0 w/o Nb while the inner tubular member is composed of a second alloy containing from 0.1 to 0.6 w/o tin, from 0.07 to 0.24 w/o iron, from 0.05 to 0.15 w/o chromium, and up to 0.05 w/o nickel, with the balance zirconium and incidental impurities of which oxygen comprises less than 350 ppm of said alloy and having a fully recrystallized grain structure and a wall thickness of at least 0.008 cm.

6. A process for fabricating a composite cladding tube as claimed in any of the preceding claims characterized by producing a composite cladding tube of intermediate size, then surface beta treating an outer layer of its outer tubular member, then cold working said intermediate size composite cladding tube in one step to substantially final size, and then annealing said composite cladding tube at a temperature below 600°C to produce a fine fully recrystallized grain size in its inner tubular member.

7. A water reactor nuclear fuel element characterized in that said element comprises a nuclear fuel material comprising substantially cylindrically shaped pellets sealed within a composite cladding tube as claimed in any of claims 1 to 5 with the total amount of incidental impurities in said second alloy being less than 1500 ppm, said pellets having an outside diameter smaller than the inside diameter of the inner tubular member to form a clearance space within the composite cladding tube which is filled with a pressurized inert gas."

Claims 2 to 5 are dependent on Claim 1 and Claim 8 is dependent on Claim 7.

II. This patent was opposed by the Appellant on the ground of lack of inventive step in view of *inter alia* the prior art documents:

- D3: "Proceedings of the USA E Symposium on Zirconium Alloy development" Castlewood, Pleasantan, California, November 12-14, 1962 GEAP-4089, (Vol. I), pages 1-6 to 1-15, USAEC - Division of Technical Information;
- D5: DE-A-3 224 686; and
- D6: US-A-4 390 497.

During the opposition procedure the Appellant filed a further document:

- D7: "Ullmanns Encyclopädie der technischen Chemie" 4th edition, vol. 24, 1983, page 691.

III. The Opposition Division rejected the opposition since it considered that the posing of the problem addressed by the patent in suit itself was inventive. A metal barrier (second) alloy having the chemical formula as described in Claim 1 would not have been obvious to the skilled

person in view of the cited seven documents unless the problem to be solved would have been known. It was the discovery of the unrecognised problem - that is, making the inner layer which was already crack resistant, additionally corrosion resistant - which gave rise to patentable subject-matter in the specific alloy composition as claimed in Claim 1. The allowability of independent Claims 6 and 7 was based on the inventive step underlying the composite cladding tube and its composition as claimed in Claim 1.

- IV. The Appellant lodged an appeal against the decision of the Opposition Division.
- V. In reply to the notice of appeal the **Respondent** made the following submissions:

- (a) Document D6 is solely concerned with using an inner tubular member (barrier layer) to protect the outer tubular member (cladding tube) from corrosive fission products and to relieve pellet-induced stresses and, like the other cited prior art documents, fails to recognise the need to protect the inner tubular member itself from the effects of aqueous corrosion should a breach in the outer tubular member develop.
- (b) Document D3 discusses the effect on aqueous corrosion resistance (ACR) of the relationship between the amount of tin and the nitrogen content of zirconium-tin alloys but says nothing about oxygen content. Also document D6 does not disclose a combination of an oxygen content of less than 350 ppm and a tin content of between 0.1 and 0.6 w/o.

- (c) The opinion of the Opposition Division is agreed with, according to which the combination of making the inner tubular member which is already resistant to pellet cladding interaction (PCI) crack propagation, more resistant to aqueous corrosion and providing the claimed alloy composition to achieve this end which constitutes inventive subject-matter.

VI. Both parties requested oral proceedings on an auxiliary basis. In a communication accompanying a summons to oral proceedings the Board introduced document:

D8: GB-A-2 119 559, cited in the European Search Report,

into the proceedings under Article 114(1) EPC and informed the parties of its following provisional view:

- (a) The problem as stated in point IV(a) and IV(b) was disclosed in document D8, page 2, lines 101 to 104, and page 3, lines 10 to 14 and 29 to 32.
- (b) Furthermore, document D8, page 4, lines 35 to 40 in combination with page 2, lines 94 to 104 disclosed that the addition of *inter alia* Fe plus Cr to a sponge zirconium liner improves ACR. The document thus disclosed some of the claimed additives which are alloyed with zirconium for ACR-improvement of the inner tubular member. The document D8 thus represented the nearest prior art.
- (c) Starting from document D8 the following measures were required to arrive at the subject-matter of Claim 1: Replacing the second alloy (inner tubular member) disclosed in document D8 by Zircaloy-2

disclosed in document D3, page 1-15 in view of its disclosed excellent ACR-properties; lowering the Zircaloy-2 tin content in view of the teaching of document D8, page 4, lines 46 to 54 as an acceptable compromise between the contradictory properties ACR and PCI crack propagation (a compromise regarded as not constituting an inventive step in decision T 36/82, OJ EPO 1983, 289); lowering the oxygen content according to document D6, column 2, lines 63 to 65; providing a fully recrystallised grain structure as disclosed in D6, column 5, lines 36 to 39; and determining the claimed wall thickness on the basis of the thickness range disclosed in document D8, page 3, lines 8 to 10. These measures appeared to be obvious.

- (d) The disclosure of ZrNb_{2.5} disclosed in document D7 might hint to use alternatively Zr-Nb alloys instead of Zircaloy for the first alloy (outer tubular member) as claimed in Claim 1.
- (e) The measures defined in Claim 6 might be obvious in view of document D5, in particular page 7, line 29 to page 8, line 4.

VII. In reply to the above communication the **Respondent** declared in a letter dated 20 May 1993 that he had decided not to attend or be represented at the oral proceedings and **requested** that the Technical Board of Appeal arrive at a decision based on the documents presently on file and any submissions the Appellants might make.

VIII. In a letter dated 8 June 1993 the **Appellant** withdrew his auxiliary request for oral proceedings, cited for the first time document

D9: "Reaktortagung" Berlin, 2 April-5 April 1977,
edited by Kerntechnische Gesellschaft im Deutschen
Atomforum e.V., pages 320 to 323,

to demonstrate the obviousness of independent Claim 7 and
maintained his **request** that the decision under appeal be
set aside and that the European patent No. 0 155 167 be
revoked.

IX. In a notification dated 14 June 1993 the parties were
informed that the oral proceedings due to take place on
24 June 1993 were cancelled.

Reasons for the Decision

1. *Inventive step - Claim 1*

1.1 From the closest prior art according to document D8 it is
known in the wording of Claim 1:

"a cladding tube for containing nuclear fuel material
that comprises an inner tubular member (D8, liner 22)
located inside of an outer tubular member (substrate 21),
the outer circumferential surface of said inner tubular
member being bonded (D8, page 3, line 115) to the inner
circumferential surface of outer tubular member over
essentially the entire outer circumferential surface of
said inner tubular member, and said outer tubular member
being composed of a first alloy selected from Zircaloy-2
and Zircaloy-4 type alloys (page 4, lines 114 to 116)
while the inner tubular member is composed of a second
alloy containing ... iron and ... chromium ... with the
balance zirconium and incidental impurities of which
oxygen comprises less than 1000 ppm" (page 4, line 104).

1.2 Document D8, page 2, lines 101 to 104 reads: "... if a breach in the cladding (i.e. the outer tubular member) should occur, allowing water and/or steam to enter the fuel rod, the zirconium liner (i.e. the inner tubular member) tends to oxidise rapidly." and thus discloses that the inner tubular member of a composite cladding tube has not only to withstand pellet cladding interaction crack propagation (see D8, page 3, lines 8 to 14) but also has to be resistant to aqueous corrosion. Hence, contrary to the view of the Opposition Division as set out in paragraph III above and to that of the Respondent in paragraphs V(a) and (c) above, the prior art already recommends to have the inner tubular member of a composite cladding tube crack and corrosion resistant. Hence, the technical aim to avoid the liner (inner tubular member) oxidation in the event of a breach in a cladding (outer tubular member) as disclosed in the patent under appeal, page 2, lines 38 to 44, is already known in the prior art and cannot contribute to an inventive step underlying the subject-matter of Claim 1.

Moreover, the Respondent has filed no comparative tests with regard to the PCI- and ACR-properties of the second alloy disclosed in document D8 and those of the second alloy claimed in Claim 1. Hence, starting from the closest prior art according to document D8, the objective problem underlying Claim 1 can only be seen in the indication of an alternative solution of a known problem. However, such aim is regarded as obvious to a skilled person and does not contribute to an inventive step in the subject-matter of Claim 1.

1.3 The above problem is solved by the features distinguishing the subject-matter of Claim 1 from that of the prior art disclosed in document D8; i.e. by the features:

- (a) the second alloy contains:
 - from 0.1 to 0.6 w/o tin;
 - from 0.07 to 0.24 w/o iron;
 - from 0.05 to 0.15 w/o chromium;
 - up to 0.05 w/o nickel, with the balance zirconium, and oxygen (as incidental impurity) less than 350 ppm; and that

- (b) the inner tubular member has a fully recrystallised grain structure and a wall thickness of at least 0.008 cm.

1.4 Due to the fact, that document D3 discloses on page 1-5, lines 26 and 27 that "Zircaloy-2 has an excellent corrosion resistance in high temperature water", it is obvious for a skilled person to use Zircaloy-2 for replacing the inner tubular member material disclosed in document D8. Document D8 teaches already, that the upper amount of each alloying material is given by the failure to further enhance ACR and by the exclusive reduction of the softness and durability of the second alloy; see page 4, lines 46 to 54. Moreover, as pointed out by the Appellant in the proceedings before the Opposition Division, it followed from the disclosure in textbook D7, left column, paragraph 4, that it was generally known to the skilled person that in Zircaloy-2 the alloying metals Fe, Cr and Ni improve the corrosion resistance of Zr, whereas tin not only increases the strength, i.e. decreases the ductility of the material but also the resistance to PCI crack propagation. Thus, the skilled person is aware of the fact that it is the content of tin which has to be adapted to a particularly desired optimum between the contradictory properties ACR and PCI crack propagation. Starting from the Zircaloy-2 tin content of 1.2 to 1.7 w/o, document D3, Figure 1-5, disclosing a maximum corrosion resistance of sponge zirconium at 0.5 w/o tin, gives the skilled person a hint to lower the

tin content of Zircaloy-2 for the desired optimisation. For the above reason, in the Board's view, a skilled person is not surprised by the result of trial and error experiments that for his particular requirements, a tin content within the range of 0.2 to 0.6 w/o gives the best results. The Respondent is followed in his view according to point IV(b) that document D3 is silent about the appropriate oxygen content in Zircaloy-2. However, filling out this gap of information in document D3 by the teaching of document D6, column 2, lines 63 to 65 - which recommends that in Zircaloy-2 the oxygen content should be in a range of 200 ppm or less to a maximum of about 1200 ppm - can be expected from a skilled person. The claimed oxygen content of less than 350 ppm lies within the range recommended in document D6 and thus has to be regarded as obvious to a skilled person, particularly because no unexpected effects have been submitted by the Respondent.

- 1.5 The feature of Claim 1 concerning the provision of the inner tubular member material in a fully recrystallised grain structure is known from document D6, column 5, lines 36 to 39. The positive mechanical properties of such grain structure - in particular an increased resistance to stress corrosion cracking as disclosed in D6, column 5, lines 54 to 60 - gives a hint to a skilled person also to anneal Zircaloy-2 when modified according to point 4.4.
- 1.6 Claim 1 claims a wall thickness of "at least 0.008 cm" for the inner tubular member. The claimed lower limit falls within the explicit thickness range of 0.0086 ± 0.0008 cm disclosed on the bottom of the title page of document D6. This value as claimed is obvious in view of document D8, page 3, lines 8 to 10, which recommends an inner tubular member wall thickness up to

20% of that of the inner tubular layer and thus hints to double the known explicit value.

1.7 As an alternative to Zircaloy-2 and Zircaloy-4 which are known as material for the outer tubular member from document D8 (see point 4.1), Claim 1 claims a ZrNb alloy containing from 1.0 to 3.0 w/o Nb. Replacing the first alloys used in document D8 by ZrNb containing 2.5 w/o Nb disclosed in Table 5 of document D7 (Table 5 disclosing alternatively also Zircaloy-2 and Zircaloy-4) as an alloy which is known to be of importance in the nuclear reactor field, is obvious to a skilled person. No particular unexpected properties are disclosed in the patent under appeal within the claimed range of Nb content.

1.8 For the reasons set out in detail above, the subject-matter of Claim 1 is held to be the result of an analogous use in the cladding tube disclosed in document D8 of the known excellent ACR properties of Zircaloy-2 as disclosed in document D3, followed by an optimisation of its tin content and some further minor adaptation measures which have to be expected from a skilled person in view of the prior art. Therefore, in the Board's judgment, Claim 1 lacks an inventive step within the meaning of Article 56 EPC.

2. In view of the above finding with respect to Claim 1, and in the absence of any auxiliary requests from the Respondent, the patent has to be revoked in accordance with Article 113(2) EPC.

Order

For these reasons, it is decided that:

1. The decision of the Opposition Division is set aside.
2. European patent No. 0 155 167 is revoked.

The Registrar:



M. Beer

The Chairman:



G.D. Paterson

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