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Bezeichnung der Erfindung: Apparatus for detecting and measuring
Title of invention: nuclear flux density within a nuclear reactor
Titre de l'invention :

Klassifikation / Classification / Classement : GO1T 3/00

ENTSCHEIDUNG / DECISION

vom / of / du 13 October 1986

Anmelder / Applicant / Demandeur : The Babcock & Wilcox Company

Patentinhaber / Proprietor of the patent /
Titulaire du brevet :

Einsprechender / Opponent / Opposant :

Stichwort / Headword / Référence :

EPU / EPC / CBE Articles 52 and 56

Kennwort / Keyword / Mot clé : Inventive step

Leitsatz / Headnote / Sommaire

**Europäisches
Patentamt**

Beschwerdekammern

**European Patent
Office**

Boards of Appeal

**Office européen
des brevets**

Chambres de recours



Case Number : T 44 /86

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 13 October 1986

Appellant : The Babcock & Wilcox Company
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Decision under appeal : Decision of Examining Division 061 of the
European Patent Office dated 27.09.1985
refusing European patent application
No 81 305 076.2 pursuant to Article 97(1)
EPC

Composition of the Board :

Chairman : K. Lederer
Member : J. Roscoe
Member : O. Bossung

Summary of Facts and Submissions

- I. European patent application No. 81 305 076.2 filed on 27 October 1981, (publication No. 0 052 445) was refused by decision of Examining Division 061 of the European Patent Office dated 27 September 1985 on the basis of Claims 1 to 3 filed on 15 December 1984 which read as follows:
1. Apparatus for detecting and measuring nuclear flux density within a nuclear reactor, the apparatus comprising a plurality of pairs of detectors (20) positioned within the reactor, each of the pairs comprising a prompt responding detector (20') and a delayed response detector (20") whereby the delayed response detector may provide a continuous calibration signal to the prompt responding detector, characterised in that each detector (20', 20") of each pair comprises an emitter (44), a sheath (42) and an insulator (46) interposed between the emitter and sheath, the emitter (44) of each prompt responding detector (20') is composed of hafnium, and the detectors (20', 20") making up each pair are juxtapositioned with one another to sense the same neutron flux field.
 2. Apparatus according to Claim 1, wherein the emitter (44) of each delayed response detector (20") is made of rhodium.
 3. Apparatus according to Claim 1 or Claim 2, wherein the pairs of detectors (20) are spaced axially along the active fuel height of a fuel assembly reactor.
- II. The reason given for the refusal was that the subject-matter of Claim 1 did not involve an inventive step having regard to the disclosure in US-A-4 103 161 (A) and US-A-3 603 793 (B).

- III. On 21 November 1985 the Appellant lodged an appeal against the decision. The appeal fee and the statement setting out the grounds of appeal were received in due time.
- IV. The Appellant requested that the impugned decision be cancelled in its entirety and a patent granted on the basis of the claims on which the refusal was based (main request) or, failing that, on the basis of one of four sets of claims forming the basis of first to fourth conditional submissions.

The only independent claims (in each case numbered I) of the first to third sets of claims are combinations of Claim 1 of the main request with Claims 2 (first set), 3 (second set) and 2 and 3 (third set) respectively of the main request. Claim 1, the only independent claim of the fourth set, is derived from Claim 1 of the main request by cancelling "and" after "of hafnium" and by inserting "and the pairs of detectors (20) constitute a composite detector assembly (12) that is inserted into an incore instrumentation tube of the reactor" at the end of the claim.

- V. In a communication issued pursuant to Article 110(2) EPC the rapporteur expressed the opinion that in the light of the available documents and the arguments so far presented neither the subject-matter of Claim 1 of the main request nor that of Claim 1 of any of the conditional submissions could be seen to involve an inventive step.

Attention was also drawn to the following documents new to the procedure:

US-A-3 760 183 (C)

US-A-3 400 289 (D)

US-A-4 087 693 (E)

US-A-3 375 370 (F)

US-A-3 879 612 (G)

US-A-3 751 333 (H)

and the following extracts from books:

- (1) "Introduction to Nuclear Engineering", 2nd Ed., by John R. Lamarsh (Nov. 1982) - Table II.3 (where the cross-sections are derived from BNL - 325 3rd Ed. 1973)
- (2) "Handbook of Materials Science", Vol. I by C.T. Lynch (page 21)
- and (3) "Werkstoffe der Kerntechnik" by Karl Kummerer, July 1980 (pages 146 and 151).

Of these documents (C) to (F) were intended to demonstrate inter alia that the challenged statement of the Examining Division that the detector construction specified in the various claims was well known at the priority date was in fact justified, and the references (G) and (H) to illustrate the known use of a group of detectors of this general construction in guide tubes of reactors.

On the other hand, the book references were to corroborate statements made by the rapporteur himself concerning the known properties of hafnium.

- VI. In a telex, duly confirmed by letter, the Appellant declined the invitation to file observations on the communication of the rapporteur, withdrew an earlier request for oral proceedings, and asked that the appeal be decided on the basis of the main and conditional submissions.

VII. The Appellant therefore requests cancellation of the decision and grant of a patent on the basis of either the claims on file at the time of refusal or those of one or other of the four conditional submissions (hereafter auxiliary request) contained in the statement of grounds and discussed above.

Reasons for the Decision

1. The appeal complies with Articles 106 to 108 and Rule 64 EPC and is therefore admissible.
2. An examination of the citations revealed by the search and of the documents introduced into the proceedings by the Board shows that none of them discloses an apparatus for detecting and measuring nuclear flux density having all the features set out in Claim 1 of the main request. Since this has never been alleged, no detailed substantiation of the matter is required here. Therefore the subject-matter as set forth in Claim 1 of the main request is to be considered novel (Article 54). The same is true of the subject-matter of the Claims 1 of the four auxiliary requests since all of these also have all the features of Claim 1 of the main request.
3. It remains to be examined therefore whether the subject-matter of any of the Claims 1 involves an inventive step. In this examination the subject-matter of Claim 1 of the main request will be considered first.
 - 3.1 The pre-characterising part of this claim comprises those features which are also disclosed in combination in document A, which in the Board's opinion represents the closest prior art. In this document delayed and prompt responding detectors (there referred to as sensors) are designated 1 and 2 respectively, their use

in pairs at selected critical points throughout the reactor core is mentioned at col. 2, lines 30-32 and the use of the delayed response detector to provide a continuous calibration signal to the prompt responding detector of a pair is discussed at col. 1, lines 39-44 and 55-60 and also with reference to the drawings.

3.2 The only features of Claim 1 of the main request that document A fails to disclose are:

- (i) that each detector of each pair comprises an emitter, a sheath and an insulator interposed between the emitter and sheath;
- (ii) that the emitter of each prompt responding detector is composed of hafnium; and
- (iii) that the detectors making up each pair are juxtapositioned with one another to sense the same neutron flux.

3.3 In fact the document neither explicitly indicates the position of the detectors of a pair in relation to one another nor does it propose any particular construction for any of the detectors. On the other hand, it states that the ytterbium sensor is typical of prompt responding detectors which may not possess an acceptable degree of initial accuracy, or a predetermined functional relationship between neutron flux density and signal output and are therefore in need of calibration, and that it is such a detector which is diagrammatically represented at 1 in the drawing. It is plain from this that the author of the document contemplates the use of the apparatus with other prompt response detectors having similar properties.

3.4 In the opening passages of the description of the present application reference is made to problems associated with certain prior art arrangements for determining neutron flux density which utilised prompt or delayed response detectors alone, or prompt response detectors in combination with a movable calibration detector system. It is evident however that these problems are already solved by the measures proposed in document A and the description gives no indication of problems associated with the apparatus described in that document which are solved by adoption of the characterising features of Claim 1.

3.5 Thus having regard to the prior art as disclosed in document A, the problem to be solved is how to put into practise the teaching of document A, i.e. how to select an appropriate physical construction for the individual detectors and to decide on a relative positioning of the detectors of a pair consistent with their stated function.

It is quite evident that if the prompt and delayed response detectors are to respond to the same neutron flux, which is essential to the function of the one calibrating the other, then they should ideally be in the same place. Juxtaposition of the detectors enables one to approach this ideal as closely as possible. The feature (iii) can therefore only be seen as a natural consequence of the requirements of the measuring system as described in document A.

3.6 With regard to the physical form of the detector the skilled man must be expected to select a form compatible with the system in which it has to be located and which will ensure that juxtaposition of two detectors will bring their neutron flux responsive elements as close as

possible to one another. Hitherto, in measuring neutron flux density within the core of a reactor, it has been proposed to locate the detectors in long protective tubes (13 in Fig. 1 of document C) or pipes (11 in Fig. 1 of document H), just as proposed in the present application, and to use a form of detector (Figs. 5 and 6 of document C with the associated description, and Fig. 2 and associated description of document H) which readily fits in the tubes or pipes. Such a detector having the constructional features (i) of the detector set out in Claim 1 is disclosed not only in documents C and H, where it has a rhodium emitter and exhibits a delayed response, but also in a number of other documents. Thus prompt responding detectors of this form (i) are also disclosed in document B (11, 12, 13 in Fig. 1), delayed response detectors in document D (3, 5, 7 in the only figure) and in document E (11, 13, 14 in Fig. 1) and the Russian reference therein, and both prompt and delayed response detectors in document F (11, 12, 13 in Fig. 1).

- 3.7 In the Statement of Grounds the Appellant objected that the existence of document B alone did not establish that the construction in question was well known and that since that document discussed only prompt detectors and explained how the construction enabled such a prompt response to be obtained it could not be obvious to use the same construction for the delayed response detector. The documentation referred to above shows that the same construction has in fact been proposed for both delayed and prompt response detectors and also that it was well known at the priority date. Moreover the Appellant has produced no evidence to show what other constructional

forms were available at that date or why such forms should have been selected by a skilled man in preference to the type claimed when concretising the proposal of document A.

Therefore, in the Board's opinion the skilled man would be doing no more than exercising his normal skills in deciding to use detectors of the configuration referred to in (i) as rapid and delayed response detectors.

3.8 Turning now to the selection of hafnium as the material for the emitter of the prompt response detector it is first noted that the only information regarding hafnium in the application as originally filed (at page 2, lines 23-29 and page 5, lines 3-13) is that it is prompt responding and can provide prompt three-dimensional power distributions in conjunction with an on-line computer system. There is no suggestion that these properties are peculiar to it, and indeed the prompt response characteristic is shown by the prior art, e.g. documents A and F, not to be a special feature of Hafnium.

3.9 That hafnium has already been proposed as a material for use in the emitters of a prompt detector in which it is separated from a sheath (collector) by insulating material is established from document B. There the use of hafnium or ytterbium as emitter material is proposed, the reason for choosing these materials being that the delayed electrons from neutron capture beta decay are emitted at a primary energy level less than that of the prompt electrons emitted as a result of incident gamma radiation and secondary gamma radiation on neutron capture. The role of the insulating material is to absorb substantially all of the delayed electrons while not affecting the prompt ones.

Though describing the use of ytterbium in the example, the document nowhere suggests that hafnium is in any way inferior. Detectors of both materials are said to be capable of extended incore service in a power reactor because the emitters are far less subject to burn up than emitters of other materials used in prior art detectors. While it is not stated what these other materials are the document refers to US-A-3 375 370 (document F) which discloses a number of other materials for use in prompt response detectors. Of the five materials mentioned in that document, three, namely cadmium and two isotopes of gadolinium, are stated to have burn out rates under a given thermal neutron flux of 1.7, 4.9 and 21% per day respectively, which means a rapid fall off in sensitivity with time.

- 3.11 Though the Appellant complains in the statement of grounds that in relying in its deliberations exclusively on documents made available to it by the search report, the Examining Division failed to take account of the actual state of the art he himself, though having had ample opportunity, and, as a skilled man, being in a position to do so, has produced no documentary or other evidence to show that materials other than hafnium and ytterbium, and in particular those contained in the table in item 12 of the Statement of Grounds, were in fact under consideration for use in prompt detectors for insertion in the cores of nuclear reactors, still less documents which would suggest to the skilled man that for the application in question hafnium would not be suitable, that there was a prejudice against using it, or that other materials would be superior. As was observed by the Examining Division, the co-inventor Warren, in his affidavit, also refers to no such documents and offers no explanation as to why, in spite

of his knowledge of the proposal in document B to use hafnium, this was not singled out (with ytterbium) for the earlier consideration which would have demonstrated its suitability, nor yet why the good performance of hafnium was found surprising, especially bearing in mind that the basic properties of hafnium pointed out by him, which result in its superiority to ytterbium, were known long before the priority date.

3.12 The Board has itself unearthed document F which does propose the use of some other materials for prompt detectors, including 2 of the 5 materials in the aforementioned table which the Appellant presents as potential rivals for hafnium.

3.13 It was known before the priority date that hafnium had a large thermal neutron capture cross-section, was annealable and strongly resistant to corrosion, and had a history of application in nuclear reactors as control rods. Corroboration of this is to be found in documents (1), (2) and (3).

On the strength of these well-known properties and those for which hafnium and ytterbium are singled out for special mention in document B, hafnium would appear to have been a prime candidate for use in the prompt detectors in the apparatus of document A as an alternative to ytterbium. In relation to that material it has certain tangible advantages. Thus, as the skilled man could have readily ascertained from standard reference works, it is extremely corrosion resistant whereas ytterbium is normally kept in closed containers to protect it from air and moisture with which it reacts. It was also considerably cheaper at the relevant time,

was a material which had already been used in the environment of a nuclear reactor with success, and was known to have a thermal neutron capture cross-section greater than that of ytterbium.

- 3.14 Of the materials proposed in document F on the other hand, cadmium and gadolinium 155 and 157, as stated in the document, both exhibit high burn out rates, leading to rapid decrease in sensitivity and short life, and would not recommend themselves for practical use on that score alone. In addition cadmium melts at 321°C which is below the maximum temperature attained in pressure water reactors, thus ruling it out for such applications. Cobalt and scandium on the other hand both have thermal neutron capture cross-sections, 37.2 and 26.5 respectively, much smaller than that of hafnium, 105, (see doc. (1) based on BNL-325, 3rd edition 1973) and would thus be expected to have much lower sensitivities. Of the remaining materials in the aforementioned table platinum has a relatively low capture cross-section of 37.2 likely to lead to a low amplitude prompt response signal (sensitivity), which is confirmed by its failure to meet criterion A in the table.

With regard to erbium, no documentary evidence has been produced that prompt detectors made of this were available or had been proposed at the priority date of the claims. It is, in any case, a material which had no history of application in nuclear reactors and would not therefore recommend itself for consideration in preference to hafnium despite its higher neutron capture cross-section.

- 3.15 For the above reasons it is considered that it must have been obvious to try hafnium as emitter material in the apparatus of document A.

Since it was already known that hafnium was capable of extended incore service, routine experiments would, in a relatively short time, have confirmed its suitability even in the situation, to which the claims are not limited, where the instrumentation tube design imposed an upper limit on the outside diameter of the detector.

In view of this and since no surprising effects have been shown to result from combining the individual features (i) to (iii) the Board concludes that the subject-matter of claim 1 of the main request is lacking in inventive step. The claim is therefore not allowable and as the remaining claims of the main request are dependent on it the request as a whole has to be refused.

4. Before proceeding to the auxiliary requests, the Board wishes to make the following observations on arguments presented by the Applicant (Appellant).

4.1 The Appellant contends that one of the problems he faced was that in many reactors the restricted space within the core instrumentation guide tubes limits the outside diameter of the detector assembly to 7.6 mm which in turn imposes an upper limit of 1.4 mm on the outside diameter of each individual detector if there are to be 5 pairs of them. In respect to this it is noted that Claims 1 of the main and of first three auxiliary requests do not require the use of guide tubes and that of the fourth auxiliary request imposes no dimensional constraints on the instrumentation tube. Furthermore, none of the claims imposes any lower limit on the number of detector pairs or any restriction on the disposition of the detectors apart from juxtaposition of those of each pair.

However, if such dimensional limitations had to be met, the Board considers that the skilled man, having decided to try hafnium, would require no more than his routine skills to scale down the prior art detector by the appropriate amount.

Hafnium would be seen to be more suitable than ytterbium for a sealed-down detector of acceptable sensitivity because of its higher thermal neutron capture cross-section. In addition, the somewhat lower energy of its beta decay electrons (see col. 3, line 11 of document B) would indicate that the insulator used to absorb them could be less thick.

4.2 As to the relationship between the response characteristics and the dimensions there is no suggestion either in the prior art or in the application itself of the need for equal response to gamma rays and neutrons, and the application neither teaches how this is to be achieved nor discloses a detector satisfying the need. It cannot therefore be considered in support of the inventiveness of what is claimed.

4.3 The argument based on the sworn affidavit of Howard D. Warren assumes correctly that he was aware of document B at the time of making the invention (presumably the priority date or shortly before). It is stated that "he did not consider doc. B as obviously representing the avenue on which to proceed otherwise the Applicants would not have spent ...". "In the particular circumstances of this case it has been demonstrated as a matter of fact that Mr. Warren (....) knew about document B and did not consider it as obviously providing the required solution". All that Mr. Warren in fact said which is pertinent to the choice

of hafnium was that he was (at the time of the affidavit) familiar with document A and the Canadian equivalent of document B, and that the use of hafnium instead of ytterbium as the emitter material for the fast responding sensors of document A provides new and unexpected results which render the use of hafnium as emitter of the prompt response detector unobvious at the time of application to a man of ordinary skill in the art. He makes no reference to protracted or expensive investigations having established the superiority of hafnium nor does he say whether and if so for how long he had been seeking to implement the apparatus of document A before the priority date nor when the idea of using hafnium first came to him nor, alternatively, why he considered hafnium might not be suitable or the best material. Therefore the Board finds the affidavit unpersuasive.

- 4.4 The Board, had it been presented with the reasons (if any) which were given by the US Patent Office for granting a patent on the basis of claims similar to those of the main request, would of course have given them proper consideration. Doubtless, had they been thought more persuasive than the arguments put to the Examining Division, they would have been adopted in the present proceedings. The mere fact that a patent was granted cannot however influence the Board, particularly since its own decision is based on information going beyond that relied on by the Examining Division, and presumably by the US Office.
- 4.5 Presentation of the "IR.100 Award" to the Applicants for the development of the new commercial product "Prompt/Delayed Incore Detector Assembly Mk I", which the panel of experts described as one of the 100 most significant new technical products of 1984 cannot be seen to be a

pointer to inventive step in the contribution made to it by the present invention. The product in question clearly makes use of the teaching of the prior art document A and employs in the prompt detectors of an assembly according to that document detectors as proposed and claimed in the present application. Both the teaching and the proposal are of course to the credit of Babcock and Wilcox who received the award. However, it is impossible to determine from the information available which aspects weighed most heavily with the members of the panel in reaching their decision. In these circumstances the Board cannot give any weight to the presentation in its deliberations.

5. The only feature which distinguishes Claim 1 of the first auxiliary request from that of the main request is (a) that the emitter of each delayed response detector is made of rhodium.

Delayed response detectors having a rhodium emitter and of the form required in the claim under consideration are known from documents C, D, E and F, and in document A itself reference is made to rhodium sensors as accurate enough but slow responding. In these circumstances and in the absence of any surprising effect attributable to the specific combination of a rhodium delayed response and a hafnium fast response detector the subject-matter of this claim is also deemed to lack an inventive step. The claim is therefore not allowable and thus, since Claim 2 is dependent on it, the first auxiliary request must be refused.

6. The sole feature distinguishing Claim 1 of the second auxiliary request from that of the main request is (b) that the pairs of detectors are axially spaced along the active fuel height of a fuel assembly of the reactor.

That it is known to want to make measurements of neutron flux density at different points spaced axially along the fuel height of the fuel assembly, and to dispose detectors at such points for the purpose, is demonstrated by document G, Fig. 1 and col. 3, lines 7 to 27; by document C, Fig. 1 and col. 2, lines 43-61; and by document H, col. 3 line 37 to col. 4, line 13. In view of this it is considered to be obvious to deploy pairs, each consisting of a rapid response and a delayed response detector in the same way. Consequently the subject-matter of this claim also lacks inventive step. The claim is thus not allowable. Hence Claim 2, which is dependent on it, is likewise not allowable and therefore the second auxiliary request must be refused.

7. Claim 1 of the third auxiliary request is distinguished from that of the main request by the combination of the features (a) and (b) referred to in items 4 and 5 above. Since the association of each of these features has already been found not to involve an inventive step and the combination of the features themselves, which relate to different aspects of the apparatus, has not been shown to produce an unexpected effect, this claim must also be rejected for lack of inventive step in its subject-matter. The third auxiliary request is therefore refused.
8. Turning finally to the fourth and last auxiliary request, this differs from Claim 1 of the main request by the additional requirement that the pairs of detectors constitute a composite detector assembly that is inserted into an incore instrumentation tube of the reactor.

In document H insertion of composite detector assemblies X, each comprising a plurality of detectors 23-29 of the same configuration as those of Claim 1 into instrumentation tubes within the core 12 of a reactor (see col. 2 line 69 to col. 3 lines 5-9; and col. 3 lines 25-36) is described. Having regard to this it would be obvious for the skilled man, needing to make similar measurements with the paired detectors of document A, to embody the detectors in a similar composite assembly, particularly since the types of detectors are structurally similar.

Therefore the subject-matter of Claim 1 of the fourth auxiliary request is lacking in inventive step. The claim is hence not allowable so that the fourth auxiliary request has also to be refused.

Order

It is decided that:

The appeal is dismissed.

Registrar

Chairman

Rückerl

Lederer