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D E C I S I O N
of 31 May 2001

Case Number: T 1009/96 - 3.4.1

Application Number: 90203494.1

Publication Number: 0439867

IPC: H01S 3/06

Language of the proceedings: EN

Title of invention:
Optical power amplifier with doped active fibre

Patentee:
Pirelli Cavi S.p.A.

Opponent:
Robert Bosch GmbH

Headword:
Alcatel N.V.

Relevant legal provisions:
EPC Art. 100(a), 52(1), 56, 102(1)

Keyword:
"EPC Art. 100(a): Opposition grounds - lack of patentability"
"EPC Art. 102(1): Revocation - on substantive grounds"

Decisions cited:
T 0989/93, T 0686/91, T 0059/90

Catchword:
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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 1009/96 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 31 May 2001

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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 24 September 1996 rejecting the opposition filed against European patent No. 0 439 867 pursuant to Article 102(2) EPC.**

Composition of the Board:

Chairman: G. Davies
Members: G. Assi
M. G. L. Rognoni

Summary of Facts and Submissions

I. The appellant I (opponent I) lodged an appeal, received on 15 November 1996, against the decision of the Opposition Division, dispatched on 24 September 1996, rejecting the oppositions against European patent No. 0 439 867. The fee for the appeal was paid on 15 November 1996. The statement setting out the grounds of appeal was received on 4 February 1997.

The appellant II (opponent II) also lodged an appeal, received on 21 November 1996, against the decision of the Opposition Division. The fee for the appeal was paid on the same day. The statement setting out the grounds of appeal was received on 4 February 1997. With a letter dated 16 May 2001, the appellant II withdrew both opposition and appeal.

II. Oppositions had been filed by opponents I and II against the patent as a whole on the grounds set out in Article 100(a) EPC, but had only been substantiated on the ground of lack of inventive step.

The Opposition Division held that the ground for opposition did not prejudice the maintenance of the patent as granted, having regard, *inter alia*, to the following documents:

(D6) R.I. Laming *et al.*: "Erbium-doped fibre amplifiers operating at 1.5 µm", OCTIMA International Workshop, 24-26 January 1989, Rome (IT), pages 204 to 209, and

(D11) R.I. Laming *et al.*: "Pump excited-state absorption in erbium-doped fibers", Optics

Letters, Vol. 13, No. 12, December 1988, pages 1084 to 1086.

III. In appeal proceedings, the following further documents were considered:

(D22) R.I. Laming *et al.*: "Multichannel crosstalk and pump noise characterisation of Er^{3+}-doped fibre amplifier pumped at 980 nm", Electronics Letters, Vol. 25, No. 7, March 1989, pages 455 to 456, and

(D25) P. Urquhart: "Review of rare earth doped fibre lasers and amplifiers", IEE Proceedings, Vol. 135, Pt. J, No. 6, December 1988, pages 385 to 407.

IV. Oral proceedings were held on 31 May 2001.

V. The appellant I requested that the decision under appeal be set aside and the patent be revoked.

The respondent requested that the appeal be dismissed and that the patent be maintained as granted.

VI. Claim 1 reads as follows:

"*An optical power amplifier (4) comprising an active doped fibre (8) containing Al_2O_3 as refractive index modifying dopant and Erbium as fluorescent dopant in the core, supplied with pump light from one or two pumping lasers (7, 12) through a dichroic coupler (5, 13) and connecting a transmission signals emitter (1) to an optical fibre telecommunication line (2), characterised in that said emitter (1) provides a high*

power input signal to the fibre (8) such that the amplifier (4) operates in saturation conditions for the stimulated output of said fluorescent doping material and said pumping lasers (7, 12) exhibit a pumping wavelength of 980 nm."

Claims 2 to 6 are dependent.

VII. The appellant I's arguments may be summarised as follows:

Document D6 was the closest state of the art. The subject-matter of claim 1 differed from the optical power amplifier known from D6 only in that the fibre contained Al_2O_3 as refractive index modifying dopant. However, D6, Table 1, already gave a hint at this feature, so that D6 alone deprived the claimed subject-matter of inventive step.

The same conclusion could also be drawn from the combination of D6 with D11. The technical problem addressed by the patent in suit consisted in the need to improve the pumping efficiency, which was limited by the occurrence of ESA (excited-state absorption) in the active material, as known from D6 and D11. A solution proposed by D11 for minimising the negative effect of ESA was to use an Al_2O_3-doped Erbium containing fibre pumped at a wavelength of 980 nm. The skilled person would apply the teaching of D11 to the amplifier of D6 in order to improve the pumping efficiency, thus arriving at the subject-matter of Claim 1 without any inventive activity.

VIII. The respondent's arguments may be summarised as follows:

The present invention should be considered as a "*problem invention*" in the sense that none of the cited documents dealt with the unknown technical problem underlying the invention, which consisted in optimising the amplification efficiency K, defined as the ratio of the output power to the pumping power, so as to approach the quantum efficiency E_q, defined as the ratio of the pumping wavelength to the output signal wavelength. In this respect, the mathematical definitions concerning K and E_q should be considered as an essential and novel feature of the invention.

The unknown problem was solved by the combination of all features according to claim 1. This combination was not taught by any of the cited prior art documents, although sub-groups of features were disclosed in some documents.

As to the choice of the closest state of the art, following T686/91 and T59/90 (not published in the OJ EPO) it should be concluded that none of the cited documents could represent the closest prior art because they did not deal with the specific problem of the invention.

Furthermore, at the priority date of the invention, the skilled person was not aware of the mathematical formulae reflecting the technical problem, and had no experience of the operating conditions of an optical amplifier in a real telecommunication system, in particular with regard to permanent operation of a power amplifier in saturation. Operation in saturation would have been regarded as undesirable because of the gain drop in the saturation region, which was in contradiction to the function of a power amplifier at

the beginning of a telecommunication line.

As to D6, this document did not teach that optical power amplifiers should be used in saturation conditions. It rather focused on optimising the gain. Furthermore, it did not disclose doping the amplifier with Al_2O_3.

Reasons for the Decision

1. The appeal is admissible.

2. *Novelty*

No objection has been raised under Article 100(a) EPC on the ground that the subject-matter of granted claim 1 is not patentable within the terms of Articles 52(1) and 54 EPC. The Board takes the same view that the claimed subject-matter is new, having regard to all the documents cited.

3. *Inventive step*

3.1 Closest prior art

3.1.1 In selecting the closest prior art, a document should be considered, which is directed to the same purpose or effect as the invention. This means that the document should relate to the same or a similar technical problem or, at least, to the same or a closely related technical field as that of the patent in suit (see T 989/93, not published in OJ EPO, point 12 of the reasons).

In the present case, the invention relates to an optical power amplifier with an active fibre (see the patent specification, column 1, lines 3 to 5). According to column 2, lines 43 to 47, the object of the invention is to provide such an amplifier "*that has a high amplification efficiency in correspondence with relatively high pumping wavelengths, substantially more than 520 nm*", the term "*amplification efficiency*" being defined in column 2, lines 2 to 4, as "*the ratio between the power of the transmission signal in output with respect to the supplied pumping power*". The Board notes that prior art documents (see, for example, D6 or D11), while describing the properties of an optical amplifier, often mention, besides other parameters like the gain or the pumping wavelength, the "*pumping efficiency*", which is commonly used for estimating the output signal power that can be obtained with the available pump power (for a given input signal). In the Board's view, the amplification efficiency $K=P_{out}/P_{pump}$, as defined in the patent in suit, and the pumping efficiency mentioned in the prior art documents refer to the same physical aspect concerning power conversion, although different terminologies are used. Therefore, the closest prior art should be chosen among the cited documents which refer to an optical power amplifier with high pumping efficiency at relatively long pumping wavelengths.

Document D6 relates to Erbium-doped fibre amplifiers operating at 1.5 µm, which are suitable for telecommunication applications, in particular as in-line repeaters, power and pre-amplifiers. D6 teaches that a pumping wavelength of 980 nm is particularly advantageous because it ensures greater pumping efficiencies (see page 207, Conclusions). Thus,

document D6 is regarded as an appropriate starting point for assessing inventive step since it discloses an optical amplifier of the kind claimed and addresses the problem of having a high pumping efficiency.

3.1.2 The respondent cites T 686/91 and T 59/90 (*supra*) in support of his statement that none of the cited documents could represent the closest prior art.

In T 686/91 (see point 4 of the reasons), the board concluded that "*a document not mentioning a technical problem that is at least related to that derivable from the patent specification, does not normally qualify as a description of the closest state of the art on the basis of which the inventive step is to be assessed, regardless of the number of technical features it may have in common with the subject-matter of the patent concerned.*" Thus, rather than supporting the respondent's statement, this decision leads to the opposite conclusion that D6 can be regarded as the closest prior art document, because, as already mentioned, it discloses an Erbium-doped fibre amplifier with a high pumping efficiency.

As to T 59/90 (see points 4-8 of the reasons), the board, after having identified the closest prior art, formulated the technical problem underlying the invention. The addressed problem was then considered not to be known from the closest prior art, and the solution to the problem was regarded as involving an inventive step. Thus, the closest prior art document was identified independently of whether or not the case dealt with a "*problem invention*".

3.2 Problem to be solved and solution

3.2.1 Document D6 discloses an optical power amplifier suitable for use in an optical fibre telecommunication line (see page 204, end of second paragraph, end of third paragraph, page 205, last paragraph, page 206, last paragraph, page 207, Conclusions, last sentence). The amplifier comprises an active doped fibre containing GeO_2 as refractive index modifying dopant and Erbium as fluorescent dopant in the core (see page 208, Table 1, in particular line 2). It is supplied with pump light from one pumping laser through a dichroic coupler, the pumping wavelength being 980 nm (see page 204, last paragraph, Figure 1, Table 1, line 2). Moreover, since D6 specifies that the large signal gain saturates at a certain value, it is implicit that the power amplifier may operate in saturation conditions (see page 205, end of third paragraph).

Therefore, the subject-matter of granted claim 1 differs from the amplifier disclosed in D6 only in that Al_2O_3 is used as refractive index modifying dopant.

3.2.2 The use of Al_2O_3 as refractive index modifying dopant in combination with a high pumping wavelength is related to the problem of improving the pumping efficiency. This follows from the fact that the pumping efficiency is negatively affected by ESA (see D11, page 1084, left-hand column, first paragraph, and D25, page 403, right-hand column, lines 1, 2), whereby ESA is influenced by factors like the pumping wavelength and the fibre glass composition, as is well-known to the skilled person (see D25, page 403, right-hand column, second paragraph). Indeed, considering the energy level diagram of the Er^{3+} ion and the associated transitions (see D11, Figure 1), non-radiative decays to intermediate levels causing undue pumping energy losses

may take place depending on the pumping wavelength, whereas the fibre glass composition determines the location of the energy levels and their broadening.

Document D6 addresses the problem of ESA, although it does not clearly indicate to which extent its negative effects can be avoided merely by using the 980 nm pumping band (see page 205, line 6, "*relatively clear of ESA*", and line 10, "*entirely free of ESA*"). In any case, D6, Table 1, second line, discloses the combination of 980 nm as pumping wavelength with SiO_2/GeO_2 as fibre type. According to D11, ESA can be **completely** avoided by using fibres containing Al_2O_3, instead of GeO_2, for a pumping wavelength of 980 nm (see page 1085, Table 2, last line, page 1086, right-hand column, first paragraph). Therefore, following the teaching of D11, the pumping efficiency or, using the terminology of the patent in suit, the amplification efficiency of the power amplifier according to D6 can be further improved.

3.2.3 Summarising, starting from the power amplifier disclosed in D6, which is pumped at a wavelength of 980 nm, the skilled person would, in the Board's view, consider to use Al_2O_3 instead of GeO_2 as refractive index modifying dopant because, according to document D11, no ESA at all would be present and a higher pumping efficiency could be achieved. Therefore, in combining D6 with D11, the skilled person would arrive at the subject-matter of granted claim 1 without any inventive activity.

3.2.4 The Board notes that high values of the amplification efficiency, which the respondent presents as an essential feature of the present invention, have

already been achieved in the prior art. Document D22 (see page 455, Experiment and results, Figure 1) discloses an experimental configuration including an Er^{3+}-doped fibre optical amplifier operating at 1.535 µm. The gain characteristics of the amplifier pumped with 15 mW at 980 nm is shown in Figure 2. For large input signals, when the amplifier is operated in saturation, a maximum saturated output power of 8.5 mW is achieved. As the appellant I points out in the letter of 1 August 1996, this gives an amplification efficiency $K = P_{out}/P_{pump}$ = 8.5 mW/15 mW = 0.57, whereas the quantum efficiency is $E_q = ë_{pump}/ë_{out}$ = 980 nm/1535 nm = 0.64. Thus, K is 89% of E_q. This result is not far from that achieved by the patent in suit (see column 7, lines 37-39), which cannot, therefore, be considered as surprising.

As regards this calculation, the Board does not agree with the respondent's objection, that it reflects an *ex post facto* analysis. Indeed, it is legitimate to rely on the definition of amplification efficiency given in the patent in suit in order to compare the amplifier known from D22 with that of the invention.

3.3 The Board does not share the respondent's view that the idea itself of optimising the amplification efficiency K to approach the quantum efficiency E_q, while designing an optical fibre power amplifier, had not been known in the state of the art at the priority date of the invention. It is admitted that the mathematical definitions concerning K and E_q are not *per se* disclosed in the cited prior art documents. However, the physical concepts underlying these definitions can indeed be found in the cited documents, although under a different terminology (see above). As regards the

theoretical maximum value of K, *i.e.* E_q, the skilled person can easily infer from the energy level diagram of the Er^{3+} ion, that, for the signal wavelength of 1.5 µm, the pumping band at 980 nm provides the highest value of E_q that can be achieved, when compared with the other possible pumping wavelengths of 532 nm, 670 nm and 807 nm mentioned in D6, page 204, last paragraph.

3.4 The respondent's argument that, at the priority date of the invention, operation of fibre-based optical power amplifiers had not yet been investigated in detail in real telecommunication systems, is not convincing. Indeed, the Board notes that both D6 and D11 make numerous references to application of Erbium-doped fibre amplifiers in telecommunications systems. The respondent also underlines that "*permanent*" operation of the claimed amplifier should be regarded as a distinguishing feature over the prior art. Such a feature, however, is not mentioned in the granted claim 1, and, therefore, does not need further consideration.

4. In conclusion, having regard to the patent documents according to the respondent's request, the ground of lack of inventive step set out in Article 100(a) EPC prejudices the maintenance of the European patent.

Order

For these reasons it is decided that:

1. The decision of the Opposition Division is set aside.

2. The patent is revoked.

The Registrar: The Chairman:

R. Schumacher G. Davies