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D E C I S I O N
of 13 December 2001

Case Number: T 1126/97 - 3.4.1
Application Number: 91909735.2
Publication Number: 0535002
IPC: H01S 3/06
Language of the proceedings: EN

Title of invention:
Erbium-doped fibre amplifier with shaped spectral gain

Patentee:
THE UNIVERSITY OF SOUTHAMPTON

Opponent:
ALCATEL ALSTHOM
Robert Bosch GmbH

Headword:
-

Relevant legal provisions:
EPC Art. 56, 66(1), 86(3)

Keyword:
"Inventive step - no (main request)"
"Late-filed requests - not admitted"

Decisions cited:
T 0153/85, T 0095/83, T 0406/86, T 0831/92, T 0092/93,
T 0063/86, T 0840/93

Catchword:
-



Case Number: T 1126/97 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 13 December 2001

Appellants:
(Opponent 01)

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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 posted 17 October 1997
rejecting the opposition filed against European
patent No. 0 535 002 pursuant to Article 102(2)
EPC.

Composition of the Board:

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

Summary of Facts and Submissions

- I. The appellant (opponent 01) lodged an appeal, received on 14 November 1997, against the decision of the opposition division, despatched on 17 October 1997, rejecting the oppositions against the European Patent No. 0 535 002. The appeal fee was paid on 14 November 1997 and the statement setting out the grounds of appeal was received on 25 February 1998.
- II. The non-appealing opponent 02 was a party as of right to the appeal proceedings according to Article 107 EPC.
- III. The oppositions had been filed against the patent as a whole, based on Article 100 EPC and Articles 100(a) and (c) EPC, respectively. However, both opponents 01 and 02 had requested the revocation of the patent because of lack of inventive step (Article 56 EPC).
- IV. In the decision under appeal, the opposition division held, *inter alia*, that an optical amplifier as specified in claim 1 of the contested patent involved an inventive step, having regard, in particular, to the following prior art documents:

D5: H. Masuda *et al.*: "HIGH GAIN TWO-STAGE AMPLIFICATION WITH ERBIUM-DOPED FIBRE AMPLIFIER", ELECTRONICS LETTERS, vol. 26, No. 10, 10th May 1990, pages 661 and 662;

D6: C.G. Atkins *et al.*: "HIGH-GAIN, BROAD SPECTRAL BANDWIDTH ERBIUM-DOPED FIBRE AMPLIFIER PUMPED NEAR 1.5 μm ", ELECTRONICS LETTERS, Vol. 25, No. 14, 6th July 1989, pages 910 and 911.

V. Oral proceedings were held on 13 December 2001 in the presence of the representatives of all parties involved.

VI. The appellant requested that the decision of the opposition division be set aside and the patent be revoked.

The respondent (patentee) requested that the appeal be dismissed (**main request**) or that the patent be maintained on the basis of claims 1 to 4 submitted by way of **first auxiliary request** during the oral proceedings or of claims 1 to 4 submitted by way of **second auxiliary request** during the oral proceedings.

VII. The wording of claim 1 of the patent as granted (**main request**) reads as follows:

"1. An optical amplifier for amplifying optical signals throughout a spectral window, comprising a length of optical waveguide means (10) having a gain spectrum in said window having a peak, characterised in that an optical band-rejection filter (12, 30), the band-rejection of which is substantially matched to the wavelength of said peak, is disposed at at least one location along the length of said waveguide means and spaced from the ends thereof for reducing gain at said peak wavelength to thereby modify the overall gain spectrum in said window."

Claims 2 to 8 are directly or indirectly dependent on claim 1 and claim 9 refers to an optical fibre telecommunication link incorporating an optical amplifier according to claims 1 to 8.

The wording of claim 1 of the **first auxiliary request** reads as follows:

"1. An optical amplifier for amplifying optical signals throughout a spectral window, comprising a length of optical waveguide means (10) having a gain spectrum in said window having a peak, characterised in that an optical band-rejection filter (12, 30), the band-rejection of which is substantially matched to the wavelength of said peak, is disposed at at least one location along the length of said waveguide means and spaced from the ends thereof for reducing gain at said peak wavelength to thereby modify the overall gain spectrum in said window to a more uniform shape as compared with the gain spectrum in said window without said filter."

The wording of claim 1 according to the **second auxiliary request** reads as follows:

"1. An optical amplifier for amplifying optical signals throughout a spectral window, comprising a length of optical waveguide means (10) having a gain spectrum in said window having a peak, characterised in that an optical band-rejection filter (12, 30) having a rejection band substantially matched to the wavelength of said peak is disposed at at least one location along the length of said waveguide means and spaced from the ends thereof for reducing gain at wavelengths within said rejection band and increasing gain at wavelengths outside said rejection band to thereby flatten the overall gain spectrum in said window as compared with the overall gain spectrum in said window without said filter."

VIII. The appellant's arguments can be summarised as follows:

The closest prior art document D5 related to an erbium-doped fibre amplifier comprising a filter which removed

wavelengths corresponding to the spectral gain peak of the doped fibre. The amplifier according to D5 differed from the claimed invention essentially in that the former was designed to amplify signals only within a narrow band and therefore used a band-pass filter instead of a band-rejection filter. However, there was no substantial difference between such filters, since a band-pass filter behaved as a band-rejection filter outside its transmission band. Furthermore, a skilled person familiar with optical filters knew that different kinds of filters were available to modify the spectrum characteristics of an optical system. Since the subject-matter of claim 1 was based on an obvious combination of the teaching of D5 with the skilled person's general knowledge, it was not inventive under Article 56 EPC.

As to the auxiliary requests submitted at the end of the oral proceedings, they should be refused as inadmissible because they were filed late and did not overcome the objections raised.

IX. The respondent argued essentially as follows:

The contested patent addressed the problem of increasing the bandwidth of an optical fibre amplifier and solved it by flattening the gain spectrum of the doped fibre by means of a band-rejection filter matched to the wavelength of the gain spectrum peak. Though D5 showed an amplifier comprising a filter which modified the spectrum of an amplified signal, this document was essentially concerned with the realisation of a two-stage narrow-band fibre amplifier with high gain and, thus, it could offer no contribution to the development of a broad-band optical amplifier according to the present invention. In fact, the filter shown in D5 had a band-pass characteristic and was located at the end of the first amplification stage in order to remove

from the amplified signal all frequencies located on either side of the narrow signal frequency band before feeding such signal into a second amplification stage.

The proper starting point of the present invention was D6 which related to a broad-band erbium-doped fibre amplifier and dealt with the problem of suppressing the amplified spontaneous emission (ASE) inherent in such fibre amplifiers in order to achieve a flatter gain spectrum. However, D6 solved this problem by using a particular pumping light scheme and, thus, provided no incentive to use a band-rejection filter to attenuate the peak of the gain spectrum.

Since the prior art teaching in combination with the skilled person's general knowledge did not suggest an amplifier according to claim 1 of the contested patent, the subject-matter of this claim involved an inventive step within the meaning of Article 56 EPC.

The auxiliary requests had not been filed before the oral proceedings because the communication of the Board gave the respondent no reason to believe that the decision of the opposition division might be overturned. Hence, such requests should not be refused as late-filed.

- X. At the oral proceedings the opponent 02 essentially confirmed the submissions made by the appellant.

Reasons for the Decision

1. The appeal is admissible.
2. *Main request*
 - 2.1.1 The patent in suit relates to an optical amplifier for wideband amplification of optical signals. As pointed out in the description of the patent as published (column 1, lines 30 to 51), it is well-known that erbium-doped-fibre amplifiers (EDFA) have irregular spectrum-gain characteristics with a peak response which varies from 1530 nm to 1535 nm, depending on the host glass material. Though the narrow spectral gain may be an advantage if the amplifier is intended to be used in a telecommunications system which employs a single signal wavelength corresponding to the peak gain of the EDFA, the large variation in gain across the spectrum can cause problems when the telecommunications link is required to operate a number of optical wavelengths to exploit the available low-loss window offered by telecommunications fibres.
 - 2.1.2 As observed in the contested patent (column 2, lines 4 to 14), it would be possible to operate a fibre amplifier between wavelengths of 1540 nm and 1560 nm since within this band the gain spectrum offers a broad gain plateau. However, the presence of an adjacent high-gain region at 1531 nm presents a number of disadvantages, such as a large value of amplified-spontaneous-emission (ASE) and saturation at the wavelength of the gain peak (cf. patent as published, column 2, line 14 to column 3, line 15).
 - 2.1.3 The description of the patent in suit refers to a first embodiment of the invention comprising a continuous doped fibre and a filter applied at approximately the

centre of the fibre by periodically perturbing the fibre (cf. column 7, lines 5 to 7, and Figure 5), and to a second implementation comprising at least two separate sections of erbium-doped fibre and a filter inserted between them (column 7, lines 39 to 42, and Figure 6). When pumped at a suitable wavelength, each fibre section is capable of optical amplification by means of stimulated emission with the typical gain spectrum of an erbium-doped fibre amplifier. The attenuation characteristic of the band-rejection filter which operates at the peak wavelength of the gain spectrum is chosen so that it cancels the larger gain of the peak wavelength and thus modifies the overall gain spectrum to a more uniform shape (cf. Figure 2 of the contested patent).

- 2.1.4 In other words, the present invention seeks to flatten the gain spectrum of an optical fibre amplifier by amplifying the input signals in successive sections of the doped fibre and by using a filter to attenuate the wavelengths which experience the largest gain before the amplified signal is fed into the following fibre section.
- 2.2.1 According to the respondent and to the opposition division the closest prior art is represented by document D6 which relates to a "high-gain broad spectral bandwidth erbium-doped fibre amplifier pumped near 1.5 μm ".
- 2.2.2 D6 reports gain measurements between 1.5 μm and 1.6 μm in erbium-doped silica fibres employing a pump wavelength in the region of 1.47 μm to 1.50 μm and essentially teaches that a high-gain, broad-band amplifier can be obtained by using a 1.47 - 1.5 μm pump laser. This pump wavelength has the advantages of a favourable quantum efficiency and compatibility with available high-power GaInAsP semiconductor laser pumps,

it is free from pump ESA (Excited State Absorption) and gives great flexibility in the use of conventional components such as fibre couplers, since the fibre used is single-mode at both the pump and signal wavelengths (cf, D6, page 910, right-hand column, second paragraph).

A typical set of results given in Figure 3 for a fibre pumped at $1.49 \mu\text{m}$ shows the presence of a peak gain of 25 dB for 50 mW pump power and gains above 22 dB over a bandwidth of 35 nm. According to D6, the gain available on the $1.53 \mu\text{m}$ peak increases for shorter pump wavelengths, whereas longer pump wavelengths produce a slightly lower gain (20 dB at $1.5 \mu\text{m}$ for 50 mW pump power) but flatter spectrum (page 911, left-hand column, last paragraph).

2.3.1 D5 provides an example of an erbium-doped fibre amplifier pumped at a wavelength of $1.5 \mu\text{m}$, i.e. at the wavelength referred to in D6, and, thus, it incorporates an essential aspect of the teaching of D6. As pointed out in D5, the Er-doped fibre is required to be forward pumped with signal light in order to obtain a lower noise figure. However, the signal gain of a forward pumped Er-doped fibre is limited both by the gain saturation caused by large amplified spontaneous emission (ASE) and by a decrease of pumping power in the rear part of the Er-doped fibre. Hence, it is realized in D5 that the ASE at wavelengths corresponding to the peak of the spectral gain is amplified more than signal wavelengths located outside the peak region, and that, consequently, the following problems arise:

- (i) the ASE absorbs pumping power which would otherwise be available to transitions within the signal band;

- (ii) the ASE's higher amplification factor may drive the amplifier into saturation and thus limit the operating gain.

2.3.2 In order to overcome the above problems, D5 proposes an optical amplifier comprising two sections of Er-doped optical fibre which are linked together by an optical fibre where an optical filter is located. The input signal undergoes a first amplification in the first section of the doped fibre, passes through the optical filter and is further amplified in the second fibre section. Though the filter has a band-pass characteristic with a transmission bandwidth matching the input signal, its function consists essentially in removing the ASE, "which is mainly concentrated at a wavelength of 1.535 μm " (i.e. at the peak of the spectral gain) (cf. D5, page 661, right-hand column, second paragraph), from the output of the first amplification stage. This results in the elimination of gain saturation in the second amplification stage which would be caused by the amplification of the ASE generated in the first amplification stage.

2.3.3 In other words, document D5 teaches to amplify an input signal in the first stage of a fibre amplifier and to use an optical filter to remove unwanted frequencies from the signal before feeding it into the second amplification stage. In the opinion of the Board, the result of this operation can be defined as "gain shaping" in the sense that the overall gain of the amplifier is optimized within the frequency band of the input signal and reduced outside such band.

2.3.4 According to the respondent, D5 should not be considered as relevant prior art because:

- (a) it deals with the problem of maximizing the gain within a very narrow band and it does not consider

the possibility of increasing the amplifier's bandwidth by flattening the spectral gain characteristic, and

- (b) it teaches to locate an optical filter at the output of a fibre amplifier (cf. EDF-1, Figure 1) and not along its length.

2.3.5 As to (a), the Board agrees with the respondent that D5 and the contested patent seek to achieve different results in the sense that the former is concerned with the amplification of an input signal centred on a single frequency whereas the latter aims at providing an amplifier for multi-channel applications. However, the underlying teachings are similar: as pointed out above, both in D5 and in the contested patent an input signal is amplified in two stages and the output of the first stage passes through a filter which has the function of removing or attenuating wavelengths corresponding to the peak of the spectral gain.

As to (b), claim 1 relates to an optical amplifier comprising "a length of optical waveguide means having a gain spectrum" and specifies that the filter is disposed at "one location along the length of said waveguide means and spaced from the ends thereof". The term "waveguide means" may cover arrangements comprising lengths of Er-doped fibre linked together by undoped sections of optical fibre (as in D5) or by optical means (as in the embodiment of the invention shown in Figure 6). Furthermore, claim 1 is not limited to an optical amplifier which comprises only one pump laser but covers amplifiers comprising sections which may be pumped independently by different pump lasers.

2.3.6 For the above reasons, the Board shares the appellant's view that D5 constitutes the closest prior art document.

2.4.1 D5 shows an optical waveguide means comprising the following features recited in claim 1 of the contested patent:

- a length of optical waveguide means having a gain spectrum in a spectral window having a peak;
- an optical filter disposed at one location along the length of the waveguide means and spaced from the ends thereof to thereby modify the overall gain spectrum in the spectral window.

2.4.2 The optical amplifier according to claim 1 of the patent in suit differs from the optical amplifier shown in D5 essentially in that the former comprises a band-rejection filter whereas the latter relies on a band-pass filter.

2.4.3 Starting from document D5 the problem addressed in the contested patent could be defined as modifying the known high-gain narrow-band amplifier for use in multi-channel applications, *i.e.* with input signals at different wavelengths within the spectral window of the doped fibre.

2.4.4 Figure 2 b of D5 shows an increase of the net gain of the disclosed amplifier with respect to an amplifier without band-pass filter. As explained in D5 (page 661, right-hand column), this increase of the net gain "is caused by the elimination of gain saturation in EDF-2 (*note of the Board: the second amplification stage*) caused by the ASE from the first-stage amplifier". Since the ASE is concentrated around the wavelengths corresponding to the peak of the spectral gain, the implementation of the teaching of D5 will require the use of a filter that essentially attenuates wavelengths around said peak. In other words, the filter must have "a band-rejection matched to the wavelength of said

peak" (cf. claim 1 of the contested patent), in the sense that the filter must remove wavelengths around the gain peak but transmit all other wavelengths within the spectral window of the signals to be amplified.

2.4.5 Hence, in the opinion of the Board, a person skilled in the art realizes that the choice of the transmission characteristics of the filter for an amplifier according to D5 is essentially determined by the bandwidth of the input signal and by the requirement of avoiding the saturation of the second amplification stage caused by the ASE generated in the first amplification stage. The obvious choice for narrow-band applications would be a filter with a band-pass characteristic matching the signal band. On the other hand, when applied to an amplifier for amplifying signals throughout the spectral window of an Er-dope fibre amplifier, the teaching of D5 would necessarily direct the skilled person to selecting a filter which essentially attenuates wavelengths located on the peak of the gain spectrum, *i.e.* to a filter with a band-rejection characteristic matched to the wavelength of said peak.

2.4.6 For the above reasons, the Board considers that it would be obvious to a person skilled in the art, starting from D5 and wishing to develop a high-gain wide-band optical amplifier, to replace the band-pass filter shown in D5 with a band-rejection filter as specified in the patent in suit, and thus arrive at an optical amplifier falling within the terms of claim 1 of the contested patent. Hence, the subject-matter of this claim does not involve an inventive step within the meaning of Article 56 EPC.

Admissibility of the auxiliary requests

3.1.1 According to the case law of the boards of appeal, the late filing of auxiliary requests should be refused, if the amended claims are not "clearly allowable" (cf. T 153/85 (OJ EPO 1998, 1). In particular, the filing of an auxiliary request in opposition proceedings during oral proceedings before a board of appeal should be regarded as contrary to procedural fairness, *inter alia*, because it is difficult for an opponent to deal properly with a request not presented in good time before oral proceedings (cf. T 831/92).

Late-filed amendments or auxiliary requests may, however, be admitted into the appeal procedure provided that the late filing is justified, the new requests are *bona fide* attempts to overcome the objections raised, and their allowability can be established without the board conducting investigations (cf. T 95/83 (OJ EPO 1985, 75), T 153/85 (OJ EPO 1988, 1), T 406/86 (OJ EPO 1989, 302).

On the other hand, late-filed requests containing subject-matter which has not previously been claimed (cf. T 92/93) or which is significantly different from the claims previously considered (T 95/83 (OJ EPO 1985, 75) are usually refused in accordance with the principle that a late-filed amendment may be admitted only if it is "clearly allowable" in the sense that it could quickly be seen by the board to introduce no objections under the EPC and to meet all outstanding objections.

3.1.2 Hence, the criteria applied by the boards of appeal for admitting amendments to claims filed at a late stage in the appeal procedure, in particular during oral proceedings, can be summarized as follows:

- (a) there should be some justification for the late filing;
- (b) the subject-matter of the new claims should not diverge considerably from the claims already filed, in particular they should not contain subject-matter which has not previously been claimed;
- (c) the new claims should be clearly allowable in the sense that they do not introduce new objections under the EPC and overcome all outstanding objections.

3.2.1 The Board accepts the respondent's argument that, in the present case, the late filing could be regarded as justified since the communication accompanying the summons to oral proceedings might have led the respondent to believe that there was no need to file auxiliary requests. However, the Board wishes to stress the fact that a board's communication accompanying a summons to oral proceedings merely serves the purpose of helping the parties in preparing for such proceedings and should not be construed as an anticipation of the board's final opinion.

3.2.2 As to criteria (b) and (c), claim 1 of the first auxiliary request contains the additional feature that the filter modifies the overall gain spectrum in the spectral window "to a more uniform shape as compared with the gain spectrum in said window without filter". In the opinion of the Board, this claim constitutes merely an attempt to clarify the subject-matter of claim 1 of the main request and does not deal with the objection of lack of inventive step under Article 56 EPC raised by the appellant. Hence, this request is not "clearly allowable" in the sense that it does not

overcome an essential objection against the maintenance of the contested patent.

On the other hand, claim 1 of the second auxiliary request is based on a combination of claim 1 of the main request with features taken from the description and relating to a particular embodiment of the invention. Since the subject-matter of this claim diverges considerably from the subject-matter discussed in the appeal procedure it is not directly and unequivocally clear that it could form the basis for an allowable claim.

- 3.2.3 Hence, in the exercise of its discretion under Rules 86(3) and 66(1) EPC to refuse late-filed requests (cf. T 63/86 (OJ EPO 1988, 224), T 840/93 (OJ EPO 1996, 335)), the Board decides that the auxiliary requests submitted by the respondent during the oral proceedings are not admissible.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The patent is revoked.

The Registrar:

The Chairman:

R. Schumacher

G. Davies