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D E C I S I O N
of 8 November 1999

Case Number: T 0742/98 - 3.5.1

Application Number: 91108162.8

Publication Number: 0458256

IPC: H04B 10/16

Language of the proceedings: EN

Title of invention:
Unit for amplifying signals of light in optical fiber transmission lines

Applicant:
PIRELLI CAVI E SISTEMI S.p.A.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

Catchword:
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Case Number: T 0742/98 - 3.5.1

D E C I S I O N
of the Technical Board of Appeal 3.5.1
of 8 November 1999

Appellant: PIRELLI CAVI E SISTEMI S.p.A.
Viale Sarca, 222
I-20126 Milano (IT)

Representative: HOFFMANN - EITLE
Patent- und Rechtsanwälte
Postfach 81 04 20
D-81904 München (DE)

Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 9 February 1998 refusing European patent application No. 91 108 162.8 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: P. K. J. van den Berg
Members: R. S. Wibergh
S. C. Perryman

Summary of Facts and Submissions

I. This appeal is against the decision of the Examining Division to refuse European patent application No. 91 108 162.8.

II. The Examining Division held that the subject-matter of the then claim 1 was obvious having regard to the documents

D2: Proceedings of the 15th European Conference on Optical Communication ECOC '89, 10 to 14 October 1989, pages 42 to 45, and

D6: Gimlet at al. "Impact of multiple reflection noise in Gbit/s lightwave systems with optical fibre amplifiers", Electronics Letters, Vol. 25, No. 20, 1989, pages 1393,1394.

III. On 24 September 1999 the appellant filed two new sets of claims according to a main request and an auxiliary request.

IV. Claim 1 of the *main request* read as follows:

"An optical fiber telecommunication line, in which an optical transmission signal is brought from one end of the line to the other end without any electrical conversion, along which line

- at least an optical amplifier is present comprising an active optical fiber length having a doped core in which the doping is carried out by fluorescent substances

- said line further comprising reflecting limiting means optically connected upstream and downstream the active fibre

- wherein the reflectivity seen from each of the ends of the active fiber is

  a) at least 15 dB higher - in absolute value - than the expected amplifier gain and

  b) lower than about -45 dB".

Claim 1 according to the *auxiliary request* contained additionally the feature that the amplifier is designed so that its saturation level is lower than the amplifier input signal. This feature had been taken from the description.

V. Oral proceedings before the Board were held on 8 November 1999. The appellant argued that the invention was new and inventive over all the cited prior art, the closest document being D2.

VI. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the main request or the auxiliary request submitted on 24 September 1999.

Reasons for the Decision

The main request

1. *The invention*

The invention according to claim 1 is an optical fibre telecommunication line comprising an optical amplifier. The amplification is obtained by means of an active optical fibre containing fluorescent substances in accordance with known principles. The amplifier comprises reflection limiting means upstream and downstream of the active fibre in order to reduce noise due to interference between the transmitted signal and undesired reflections. Such reflections are generated at optical interfaces but may also be caused by so-called Rayleigh scattering in the line.

Claim 1 first requires that the reflectivity as seen from each of the ends of the active fibre is sufficiently low with respect to the amplification of the amplifier. Essentially, the higher the gain is, the lower the reflectivity should be. (Claim 1 refers to the *absolute* - ie positive - value of the reflectivity in decibels (dB). The reflectivity expressed in dB is a negative number which grows more and more negative as the reflectivity decreases, which means that the absolute value increases. Therefore the above condition is expressed in the form that the absolute reflectivity value should be *greater* than the gain.) Claim 1 in fact requires that the absolute value of the reflectivity should be at least 15 dB higher than the gain value.

Second, claim 1 states that the reflectivity (the actual negative value this time) should in any case be lower than about -45 dB.

2. *Amendments*

Claim 1 contains the feature that the reflectivity should be lower than about -45 dB. In the application as filed the limit was expressed somewhat differently, namely as "15 dB /lower/ than the reflectivity corresponding to the Rayleigh scattering in the fiber at the transmission wavelength" (see eg original claim 2). There is however a statement at column 7, lines 45 to 48 which puts the typical value for the reflection due to Rayleigh scattering at some -30 dB. The figure -45 dB is therefore regarded as sufficiently supported by the original application.

3. *The closest prior art*

3.1 The Examining Division found that D6 represents the closest prior art, and the Board agrees. However, since at the appeal stage the appellant has argued that D6 is less relevant than initially thought, it should first be considered what this document can be regarded as actually disclosing.

3.2 D6 is an article published in a scientific journal. It comprises four sections, titled Introduction, Theory, Experiment and Conclusion.

In the "Introduction" it is mentioned that the interferometric noise increases with the amplifier gain. Furthermore, "even if discrete reflections at

connectors, splices, and couplers are made negligible, the aggregate reflection due to Rayleigh backscattering ultimately restricts the amount of amplifier gain that can be employed in in-line amplifier systems unless optical isolators are incorporated".

The part "Theory" includes a finding as to the necessary relationship between a certain reflection value R and the amplifier gain G expressed as "GR < 0.02". This linear form can be translated as

$R_{abs}(dB) > G(dB) + 17dB,$

where R_{abs} signifies the absolute value of R if R is expressed in dB. R is defined as the geometric mean (ie the arithmetic mean of the dB values) of the reflections at each end of the optical fibre (see Figure 1). It is furthermore pointed out that Rayleigh scattering will cause an (equivalent) R value of about -31 to -34 dB for a long fibre, and that this "limits the maximum tolerable gain to about G = 19 dB if no optical isolator is incorporated in the amplifier".

The part "Experiment" refers to the laboratory set-up shown in Figure 1. An amplifier is connected to attenuators which simulate the line attenuation. There is an isolator only at the upstream side of the active fibre. At the downstream side there is a dichroic coupler which serves to connect a pump laser to the fibre. The reflection at the coupler interface is given as 0.02 (or -17 dB). The reflection at the isolator is much lower, namely 0.00016 (or -38 dB). The average reflectivity R is thus about -27 dB. The gain is 18 dB and the product GR (in linear units) is 0.11. It is

said that since this value is much higher than 0.02 high error ratio floors are to be expected, and Figures 3 and 4 indeed show this.

In the "Conclusion" it is repeated that noise imposes stringent limits on the tolerable amounts of gain and reflection in fibre transmission systems: "Reflections due to Rayleigh scattering limit the usable amplifier gain to less than 20 dB, unless optical isolators are employed".

3.3 Normally, a prior art document should be considered in its entirety. This is to avoid passages being quoted without proper consideration of their context, which could lead to distortions of the meaning. In the present case, however, the appellant has argued that D6 discloses two very different "embodiments", namely an experimental system (where no Rayleigh backscattering occurs) and a telecommunication system (where Rayleigh backscattering does occur). According to the appellant the systems have to be considered separately, ie effectively as two pieces of prior art.

3.4 The Board cannot accept this view. It is true that according to the jurisprudence of the Boards of Appeal features belonging to different "embodiments" described in a single prior art document cannot normally be mixed when assessing the novelty of an invention. It must however be considered that the word "embodiment" has a particular meaning in the EPC: it refers to subject-matter set out in dependent claims of a patent application (cf Rule 29(3) EPC). But D6 is not a patent document. It is an article containing theoretical considerations, a description of an experimental set-

up, and conclusions drawn with respect to an hypothetical communication line (including Rayleigh noise). None of these parts can be seen in isolation. On the contrary, it can be reasonably assumed that they have been included by the authors for the very purpose of being read together. In particular, the inequality quoted at point 3.2 above will be understood by the skilled person as a theoretical prediction expected to be valid for any implementation, hypothetical or not.

3.5 Thus the Board will assess D6 in its entirety and not as two separate teachings.

4. *Novelty*

4.1 The Board finds that D6 clearly discloses:

- an optical fibre telecommunication line,

- an optical amplifier comprising an active optical fibre length having a doped core in which the doping is carried out by fluorescent substances,

- reflecting limiting means optically connected upstream of the active fibre,

- wherein the mean of the reflectivities seen from each of the ends of the active fibre is at least 17 dB higher - in absolute value - than the amplifier gain.

Furthermore, the Board takes the view that there is an implicit disclosure of a downstream isolator. This

follows from the observation made in D6 that a real-life transmission system subject to Rayleigh noise and having a gain greater than 20 dB would not function properly "unless optical isolators are employed". A *single* optical isolator cannot be intended since the experimental system, which has a single (upstream) isolator, is shown not to work in a satisfactory manner even in the absence of Rayleigh noise. What is suggested can therefore only be that, generally, also a downstream isolator must be used. Even if not stated explicitly in the article such an overall conclusion must be regarded as having been disclosed.

4.2 The differences between the invention and D6 are the following. First, while claim 1 defines the reflectivities as seen from *each* end of the optical fibre, D6 refers to the average value of these reflectivities. Second, according to claim 1 the absolute value of the reflectivity should be at least 15 dB higher than the amplifier gain but according to D6 it should be at least 17 dB higher. Third, the claimed maximum reflectivity value of -45 dB is not disclosed in D6.

4.3 Already the first of these differences suffices to render the subject-matter of claim 1 new with respect to D6.

5. *Inventive step*

5.1 D6 refers to an *average* of the reflectivities seen from the ends of the optical fibre. The present inventors have allegedly gone a step further by recognising that not only should the average be below a certain value

but *each* of the reflectivity values must be sufficiently low. This, it has been submitted, the skilled person would have had no reason for requiring after having studied D6.

5.2 The Board accepts that this feature indeed involves a further consideration as compared with D6, but not that it is an inventive one. D6 shows that the geometric average of two entities (in linear units) should be sufficiently low for a good result. The geometric mean of two numbers is defined as the square-root of their product. Elementary mathematics yields the necessary relation between the two reflectivity values if the given condition is to hold. One possibility is trivially that each value should be below the limit set for the mean. If this particular choice should be inventive it must be shown that it has (unexpected) advantages, ie that a selection invention has been made.

Such evidence is however missing. The patent application refers for the first time to the reflectivities in column 6. An inequality is presented which, except for a constant, is identical with the one in D6. In the following paragraph of the text it is said that "substantially, the foregoing means that the achievement of high gains in the amplifier is limited by the reflection characteristics at the ends of the amplifier itself, or in other words, that in order to achieve high amplification gains it is necessary to have high reflectivities R1 and R2" (where the last "high" obviously should read "low" in accordance with the priority document). This suggests that the inventors themselves saw nothing special in going from requiring a certain geometric mean to requiring the corresponding individual reflectivities - the one more or less implied the other.

The appellants have pointed out that the relation in column 6 refers to the lasing condition rather than to the constraints imposed by the presence of interferometric noise. This is not denied. Still, this is the part of the description where a condition for the two individual reflectivity values - as opposed to their average - is introduced. If this form of the condition had served to solve a technical problem or had had any advantage, this would have been the most likely place to find such an indication.

The Board thus concludes that the required condition involves nothing more than simple arithmetic and was therefore obvious to the skilled person from D6.

5.3 The appellant's second main argument is that the

invention provides an extra safety margin for the reflectivity values. According to the appellant the inventors have recognised that the relation given in D6 is insufficient since the amplifier gain - except for comparatively high nominal values - will in practise vary strongly. This would be implied by the expression "*expected* amplifier gain" in claim 1. The reflectivities must therefore be kept beneath the limit given in D6 by a margin corresponding to the (maximal) gain variation. Claim 1 ensures this by requiring that each reflectivity value should be below -45 dB also for low gains.

5.4 The Board first notes that claim 1 sets no limit for the amplifier gain G. With G = 28 dB, for example, D6 teaches that R should be below -45 dB. This is in agreement with claim 1 without any extra margin at all. Furthermore, in the application as filed the value -45 dB was merely preferred. Original claim 1 had instead (the equivalence of) -40 dB. In D6 this value is recommended for a gain as small as 23 dB.

But even if the claim were limited to gain values well below 28 or 23 dB, the appellant's arguments would not convince. The application as filed does not mention gain variations at all and the expression "expected" amplifier gain is given no particular significance. The offered technical problem thus has no basis in the application.

It appears in fact from the description, column 7, lines 37 to 54 that the value -45 dB was not chosen because it offers a high margin at low gains but because it provides a moderate margin at high gains. In

this passage it is said that isolators ensure correct operation at "gains usually achievable with fiber amplifiers which are about 30 dB, which value substantially corresponds to the absolute value of the reflectivity given by the Rayleigh scattering. In order to achieve higher gains a corresponding low reflectivity value is required, which reflectivity in accordance with the invention must at all events have an absolute value higher by at least 10 dB, and preferably at least 15 dB, than the expected amplifier value". Thus the inventors appear to have arrived at the (absolute) value of 45 dB because this value is 15 dB higher than a gain value of 30 dB. This reasoning is in agreement with, and adding nothing to, the teaching of D6.

5.5 Thus the Board cannot accept the appellant's arguments on this point either.

5.6 For these reasons the main request must be refused.

The auxiliary request

6. *Inventive step*

6.1 Claim 1 according to the auxiliary request contains additionally the feature that the amplifier is designed such that its saturation level is lower than the amplifier input signal. The appellant has argued that the effect of gain variations is particularly strong in the saturation region.

6.2 However, as explained above, the Board is not prepared to accept an argument based on the assumption that the

technical problem concerns gain variations since such a problem has no support in the application as filed and could not reasonably be derived from it by a skilled person.

6.3 The appellant does not deny that optical amplifiers have previously been operated in the saturation region, eg as power amplifiers. D2 in fact mentions such an experimental set-up ("the first experiment"). The invention according to claim 1 is thus nothing more than an example of this known mode of operation.

6.4 Therefore also the auxiliary request has to be refused.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Kiehl P. K. J. van den Berg